LIFE CYCLE ASSESSMENT (LCA) BASED HOME RATING MODEL FOR IZMIR (HRM-IZMIR)

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ABSTRACT

LIFE CYCLE ASSESSMENT (LCA) BASED HOME RATING MODEL FOR IZMIR(HRM-IZMIR)

This thesis presents the development and application of Life Cycle Assessment (LCA) based home rating model for residential buildings in Izmir. It aims to develop building performance assessment within a single application. This new application supports various considerations throughout the building's life cycle in relation to performance domains such as site ecology, energy consumption, material selection, lighting availability, transportation and the rest of the performance indicators. It is intended to encourage initiatives toward achieving better housing performance.

ATHENA Canadian Software tool has been selected to calculate quantitive values for energy consumption, solid waste emission, air pollution index, water pollution index, global warming potential, weighted resource use. Then, thirty performance indicators, which were selected from the review of existing evaluation models has been grouped under four building life cycle stages, site selection, construction, operation, and demolition. The weights of each category and indicator has been calculated, and converted into a credit score. Then, the performance grades are divided into five levels, (excellent, good, average, below average and poor) and evaluation criteria are suggested based on statutory performance value.

Keywords: Sustainability, LCA, assessment, performance, rating, residential, case study.

ÖZET

YAŞAM DÖNGÜ DEĞERLENDİRME YÖNTEMİYLE İZMİR KENTİ İÇİN GELİŞTİRİLEN KONUT MODELİ

Bu tezde, Yaşam Döngü Değerlendirme yöntemiyle, Izmir Kenti için hazırlanan Konut Değerlendirme Modelini geliştirme süreci, teorideki aşamaları ile birlikte aktarılmakta ve daha sonra İzmir'den seçilen konutlar üzerinde denemesi yapılmaktadır

Geliştirilen Konut Değerlendirme Modelinde, ATHENA yazılım programı kullanarak, binalardaki enerji tüketimini, katı atık oluşturma durumu, su kirlilik endeksi, hava kirliliği endeksi, küresel ısınma potansiyeli ve doğal kaynak kullanımı konularında karşılaştırmalı analizler yapılmaktadır. İkinci aşama olarak, otuz adet değerlendirme ölçütü, dört yaşam döngü sürecine göre gruplandırılmaktadır; (1)Alan Seçimi, (2) İnşaat, (3) Kullanım, (4) Yıkım. Üçüncü aşama olarak, konutları sınıflandırmak için beşlik sistem kullanılmakta, –mükemmel (5 puan), iyi (4 puan), ortalama (3 puan), ortalamanın altı (2 puan) ve zayıf (1)- , değerlendirme kıstasları önerilmektedir. Çıkan sonuçlar bulundukları semtin getirim düzeyine göre değil, konut olarak performansları dikkate alınarak değerlendirilmişlerdir.

Anahtar Kelimeler: Sürdürebilirlik, Yaşam döngü değerlendirme, konut, performance sınıflandırma

To my parents, brother and wife

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CHAPTER 1

INTRODUCTION

The residential units are increasing rapidly and the society isn't well aware of their environmental risks. As the statistical information reveals, more than 60 % of the built environment in the whole world, and 79% in Turkey, consists of residential units. As the built environment mostly consist of residential units, and we spent most of our time at home, research should increase to focus on the home construction industry to minimise the environmental impacts caused by the built environment.

One of the main reasons of the current environmental impact is the current construction method; for instance the reinforced concrete with brick, and mechanical heating system. This method has increased the use of fossil fuels, and irreplaceable raw materials. This misuse of natural resources has been creating the current environmental problems like greenhouse effect, ozone layer, biodiversity etc.

Many decisions concerning the building process and choices in design are not the outcome of a rational assessment of alternatives, but have grown to be standard on a regional level. In almost every case, planning, designing and building involves a lot of different professionals, although it is organized in different ways in various countries.

During the building process, the content and the method of information will constantly change. For instance, the question of where a living room should be placed is quite different in substance to the question of the spatial concept of the building and different again to the problem of using plastic or aluminium window frames for the room. Many various parties will deal with these problems differently. Inevitably, the problems and the gathering of information depend on the people involved in construction process. These professionals will need a mutual guidance like a rating model in order to achieve an objective evaluation.

A rating model has to be designed in accordance with the features that will meet the local needs, in order to succeed in developing more sustainable society. Sustainability begins from the local environment which can cause effects on the global environment as well.

Designing a rating model has been attempted by various institutions like HERS[1], GB Tool (International)[2], BREEAM (UK)[3], HQI (UK)[4], and LEED Home (USA)[5] etc., however focus only one slice of the whole problem or performance of the structure. The aim of this study is to develop a rating model that covers many valuable indicators to deal with the most of the problem or performance.

The proposed rating model is developed by using Life Cycle Assessment (LCA) method that previously used for industrial products. LCA as a method used for analysing and assessing the environmental impact of the building process, throughout its entire life cycle. The chain of LCA begins with site selection, construction, operation, and demolition.

With the help of this model, the compatibility between the residential units will emerge rapidly, and the home users will be able to decide on the residential unit they are going to live in, just like they decide on the energy efficient light bulb they are going to buy.

While devising this rating model, I have chosen Izmir as my case study location. With the help of the rating model for Izmir (HRM-Izmir), the occupants will be aware of whether their residential units are responsive to the natural environment and whether their performance is enough. The local governments can plan their infrastructure according to these results. When the clients begin to see the benefits, they will demand better performances from their residential units.

1.1. Background

This study introduces a rating model, HRM-Izmir, for minimising the negative impacts of the residential units on the natural environment and improves the human comfort and health in these units. Today's environmental problems break out as a result of leaving the understanding that buildings should be in harmony with nature. Until industrial revolution, the residential buildings were built responsive to the local climate conditions; as a result the waste products were recycled and posed minimum threat to

[1] HERS: Home Energy Rating System.
[2] GBTool: Green Building Tool .
[3] BREEAM: Building Research Establishment Environmental Assessment Method.
[4] HQI: Housing Quality Indicator.
[5] LEED: Leadership in Energy and Environmental Design

the environment. After the Industrial Revolution, the need for shelter increased for various reasons such as migration, wars, increase in population, change in family structure, the sheer physical wear of existing buildings and their low capability to meet new developments.

Any model suggesting the improvement of the residential units' environmental performances, must comply with sustainability issues.

Sustainability issues are:

• To protect the environment, globally and locally, so that the critical life-support systems are maintained for present and future generations;

• To enable all people, now and in the future, to improve their quality of life through the pursuit of economic and social objectives, including social equity and environmental justice, in ways that simultaneously protect and enhance biodiversity, eco-systems, and the Earth's life-support systems, in particular:

- by reducing global warming emissions;

- by improving energy efficiency;

- by reducing the consumption of natural resources and utilizing renewable alternatives, and minimizing waste.

For environmental protection and sustainability, there have been many international meetings and agreements. The list and order of the international conferences and meetings is given in Table 1.1.

The protection of the environment was first discussed in the UN Conference, held in Stockholm in 1972, with the participation of 113 countries. This international conference has become a turning point on the environmental and ecological problems, and has affected the environmental policies of many countries with the development of the principles emphasing the relation between nature and social or economic developments.

Table 1.1. International milestones of environmental agreement or awareness (Edward 1999 and Chasek 1996).

Year	Activity
1972	'The Limits to Growth' Report
1972	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters.
1972	Stockholm Conference on the Human Environment (UN).
1973	Washington Convention on International Trade in Endangered Species.
1976	Barcelona Convention for the Protection of the Mediterrian Sea Against Pollution.
1978	Protocol to the 1973 International Convention for the Prevention of Pollution from Ships.
1979	Berne Convention on Habitat Protection (Council of Europe).
1979	Geneva Convention on Air Pollution (UN).
1980	Convention on the Conservation of Antarctic Marine Living Resources.
1980	World Conservation Strategy (IUCN).
1980	Global 2000 Report (USA).
1983	International Tropical Timber Agreement.
1983	Helsinki Protocol on Air Quality (UN).
1983	World Commission on Environment and Development (UN).
1987	Montreal Protocol on Substances that deplate the Ozon Layer (UN).
1987	Our Common Future (Brundtland Commission on behalf of the UN).
1988	The Intergovernment Panel on Climate Change.
1988	Toronto Conference on the Changing Atmosphere: Implications for Global Security
1989	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their disposal.
1990	Green Paper on the Urban Environment (EC).
1991	Second Session of the Intergovernmental Negotiating Committee for a Framework Convention Climate Change.
1992	Convention on Biological Diversity
1992	Framework Convention on Climate Change.
1992	Rio Summit Agreements (UN).
1992	Our Common Inheritance (UK).
1994	European Environment Agency established (EU).
1997	Kyoto Conference on Global Warming

In 1983 World Commission on Environment and Development was founded by United Nations (UN). In the following time, the 1987 Brundtland Report which correlate nature, and defines the sustainable development issue at international meetings, giving importance to the solutions of environmental problems. One of the most quoted definitions of sustainability comes from the report of the United Nations World Commission on Environment and Development (WCED) usually referred to as the Brundtland Report.

> "The concept of sustainability in its modern guise was first developed in response to impacts on the natural environment, where the loss of a certain species or even life as a whole became a threat." (WCED 1987)

In 1992 Rio Conference, the definition of the sustainable development is emphasised more than ever. It was agreed that emissions of greenhouse gases should be stabilised in an attempt to mitigate the threat of climate change. Many governments declared targets for the reduction in energy use in their own buildings. There are a number of benefits for the climate friendly technology industry both in governments declaring a national target for reduced national emissions of CO_2, and in locally applied targets set by governments for their own facilities, industry or other institutions.

In Turkey, in 1978, to be in charge of representing national and international environmental activities Environmental Secreterate was established (in 1991 became Environment and Forest Ministry), and for the first time environment issues became a government policy in Turkey. Environmental Law was accepted in 1983, to oversee nature as a whole not only to prevent environmental pollution, at the same time, to give permission for natural resources and soil management. Following this, there were regulations like Air Quality Control (1986), Noise Control (1986), Water Quality Control (1988), Solid Waste Control, and Environmental Impact Assessment (1991). Then, Medical Waste Control, Toxic Chemical Products Control and Hazardous Waste Control were come into action (Okumuş 2002).

On a global level, the reflection of the tendency on environmental protection was first mentioned in the third "Five Years Development Plan" (1973-1977). After 1978 Stockholm Conference, problems of the environment were first discussed in this plan, a mark of a development in environmental awareness in Turkey.

These international meetings and agreements, create a mutual understanding between the countries to improve the natural environment. Any model developed, obliged to consider their expectations; especially, sustainability. Sustainable development means minimising environmental pollution so that future generations can continue to live in healthy surroundings. Sustainable building contributes to this by ensuring more economical use of finite raw materials and by reducing and above all preventing the accumulation of pollutants and waste.

Over the past decade, various voluntary schemes for assessing the environmental performance of buildings have emerged in various parts of the world. It is becoming popular in order to have a standard method to evaluate new and existing building design. For instance, the U.S. Green Building Council developed the LEED Green Building Rating System as a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. The Japan Sustainable Building

Consortium developed the comprehensive assessment system for building environmental efficiency (CASBEE) system as a new environmental assessment system to meet both the political requirements and market needs for achieving a sustainable society.

1.2. Definition of the Study

This study focuses on the necessity of considering whole process of an architectural design from cradle to grave, following the fact that architect is not only responsible for completion stage of the building, but also for the operation and final disposal of it.

In this thesis, the usage of LCA which is not only used in building industry, but also in other fields, is supported to estimate the environmental problems of the buildings and to take necessary precautions beforehand. With the help this method, during design process, architects can create their own approach based on quantitive sustainability.

1.3. Method of the Study

The current study is a quantitive study. The purpose of HRM-Izmir Rating Model is to rank buildings according to their performance with regard to several aspects. HRM-Izmir has four levels to achieve the final rating result:

1. the data collection process which provides information about the studied unit,
2. use of the ATHENA software program, (Energy Consumption, Solid Waste, Air index, Water index, Global Warming Poetential, Resource Use).
3. implying 30 indicators (1.Site Selection 2. Construction 3. Operation 4. Demolition)
4. Final rating scores for the studied units.

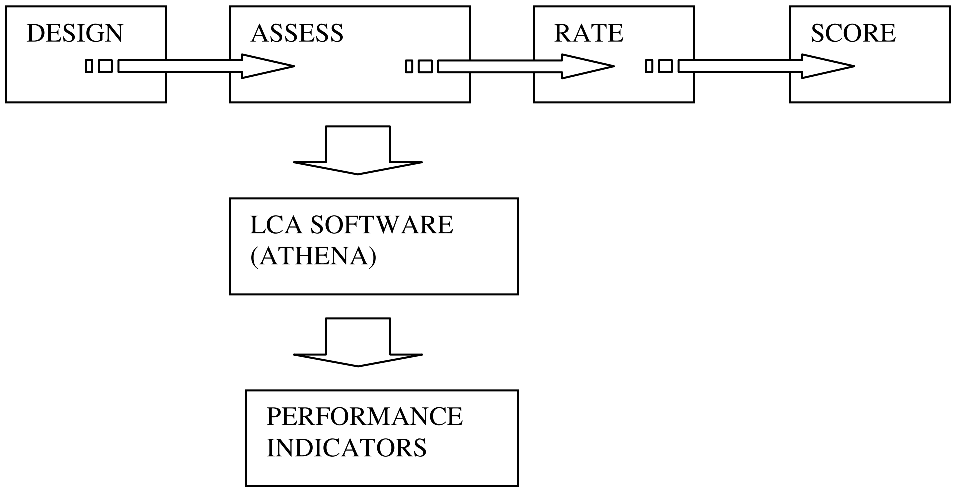

Figure 1.1. The working flow diagram of the HRM – Izmir

At the first stage (Figure 1.2), the data collection process initiates with the valuable information gathered from the local authority, clients, architects, consultants and the building inspection firms. This study analyses the computer programs that apply LCA and used the most convenient one, ATHENA. ATHENA software creates quantitive assessment system for building stock in Izmir, and with the help of this software, it targets to rate the residential units into 5 point (Excellent, Good, Average, Below Average, Poor) category rating model (HRM-Izmir) regarding the sustainability aspect.

The HRM-Izmir will work with the support of building LCA software program ATHENA. The results from this software program will be evaluated in six indicators. After applying the ATHENA, the chosen performance indicators will assess the building's performance, and final rating score will be completed. Later these results will be compared with a reference project.

Moreover, as a case study for HRM-Izmir Model, twenty residential units have been assessed, and their effects of the site selection, construction, operation, and demolition stages of the residential units discussed. The main factors of local environmental burden, heating, cooling, transport, and disposal of wastes are also evaluated with the proposed model as well. Assessment of these issues can be useful in selecting a location of a building and the planning of regional development.

In Chapter two, the building regulations of various countries will be emphasised with their current outlook, especially, the current trends towards residential units. Also in chapter two, the case study of the HRM-Izmir model will take place in Izmir, so the statistical information of the residential developments will be given.

Chapter three will explain the LCA method and the principles of the performance indicators. As the first step to selecting performance indicators, indicators have been analyzed in detail. Overlapped indicators have been integrated and their applicability has been considered by the interviews with experts and home owners. Some indicators have been excluded such as indicators which are difficult to apply to the home construction cases, indicators of which the evaluation result may be varied dependent on occupants' management, indicators which did not have any standardized criteria, and indicators which are likely to be evaluated depending on each evaluator's own opinion.

The Building LCA software tools were described following Royal Melbourne Institute of Technology's LCA software categorisation system. From these tools ATHENA software is the suitable tool for applying HRM-Izmir rating model.

In Chapter four, proposed rating model HRM-Izmir will be explained with the data forms and working principles. Data collection process, life cycle assessment with ATHENA software program and thirty performance indicators will be discussed as the key elements of the proposed HRM-Izmir model.

Chapter five will discuss the process of the case study conducted over twenty residential units in Izmir. The buildings cover typical architectural typologies, size and constructions, and installations, at different states of deterioration. The data used has been collected from site visits, personal interviews with the residential owners, architects and building inspection companies. The key elements, ATHENA software, performance indicators will be implied and their results will be evaluated and the work will be finalised with their final rating scores.

Chapter six will be the concluding remarks of the study. The achieved results will be discussed with findings from the case study. The future intentions and how this research will create a path for other researches in this subject will be stated.

1.4. Importance of the Study

The rapid urbanisation and modernisation of Turkey have increased the demand for housing. Most of the efforts to meet this demand have been directed toward improvements in quantitative shortage of housings, but currently the demand for improvements in qualitative aspects of housings is growing markedly with the increase of the housing supply rate. The focus of construction activities has been gradually shifting from the quantity of housings to the quality of housings. Also the performance of housing has become a matter of primary concern for homebuyers in Turkey. Another unique feature in Turkey is that the apartment building has become the common housing type in many cities.

The HRM-Model model can provide users more substantial and practical information about in-use housing performance, which is more closely related with their position, compared to those of other residential units. The presented results allow prospective occupants to rate and compare the residential buildings, according to their overall housing performance scores as well as partial scores of concerning lower-level performance features. This ability is considered to be significant since it helps them to estimate the strengths and the weaknesses of alternative residential buildings which they would like to purchase or lease. The HRM-Izmir model is expected to be able to stimulate building owners or managers to maintain high housing performance. The most desirable and anticipated role of the model would be to offer occupants more objective evaluation. The performance evaluation is also necessary to minimize the demands for rebuilding or remodelling as well as to serve as a fundamental measure for ensuring the longevity of buildings that offer good environment.

Architects have a large share of responsibility for reducing negative environmental impact and quantities of required energy to inhabit and maintain buildings. The structures of building, their service systems and their gradual adaptation to use directly influence the nature of impact on the environment. The evaluation of environmental measures is as important as issues of site planning, structure, services, spatial qualities and volumetric form. It is rather odd that architects do not seem to consider the subtle balance between buildings and climatic factors. It is probable that the technical issues of design work are conceived as being more dominant than the spatially architectural aspects. This rating model brings the opportunity for architects to judge the level of sustainability in the design process with quantitive values.

This model is also useful to the contractors, for instance, construction waste is one of the major problems faced by contractors; it leads to loss of profits and is a prime contributor to the total waste stream. Construction industry does not give due attention to waste related issues. It is important to cultivate a waste minimisation culture among the industry professionals and clients. The HRM-Izmir model can help to remind these to the professionals. The HRM-Izmir model can assess the building waste score which may represent the construction waste generation potential of a particular building design. Its main significance is to help designers to deliver the most viable design in terms of minimum waste generation on site. The LCA can influence the industry's progress towards waste awareness and minimisation by publicising the HRM-Izmir model and using it to educate clients and designers. Having in place benchmarks for the HRM-Izmir score will help to cultivate a waste minimisation culture in the industry.

Local characteristics; energy, waste, material issues; LCA method and ATHENA software findings have been collected together to form the desired rating model. With the help of this model, people will choose their house like how they carefully choose the efficient bulb.

Rating of residential units will help:

- in the design process; architect will know before hand how every design decision affects the sustainability of a residential unit.
- approval can be given by the municipality officer according the results of HRM-Izmir.
- building developers, Estate agents and owners can estimate the value of the property considering HRM-Izmir.
- insurance premiums can be reduced.
- in building sector, HRM-Izmir can create a new market for sustainable materials and components.
- influence energy consumption, efficient use of materials, reduce air and water pollution, minimise waste production
- influence design of environmentally sensitive units.
- assist future assumptions for the residential units.

The current literature in Turkey proves that HRM-Izmir is the first building rating tool developed in Turkey. Case study prepared is the testing ground for HRM-Izmir model. This thesis major goal is to explain the working principles of HRM-Izmir in theory, and also by implementing a case study with twenty residential units, it attempts to test the model in practice.

1.5. Limitations of the study

Before structuring the rating system, there are issues that need to be considered. This study will only cover the legal buildings that comply with the existing building regulations. It will consider the methods of similar researches; however it aims to find new solutions. There is not any intention to discuss the architectural qualities of the selected projects or the occupants' behaviours inside these units. The aim here is to evaluate the residential units' impact on the environment.

The cases are from the main residential district of Izmir with the distances to city centre is considered as valuable decision maker. The buildings life span kept as sixty years for each project. Only reinforced concrete structures were considered. The land purchasing, construction method, numbers of people living in the household initiate a constant value.

CHAPTER 2

TOWARDS A SUSTAINABLE HOME RATING MODEL

Sustainable development with the help of international agreements and meetings has been expanding in many fields as well as the home industry. However, before achieving a sustainable home industry, there must be a sustainable natural environment.

Chapter 2 aims to explain the improvements taken towards the natural environment around the world. For instance, the new amendments on the building regulations for energy, water, transport, waste and ecology topics are key issues for the sustainable development. Then, Turkey's move towards sustainable nature will be discussed with examples.

In the second part, Izmir's built environment as a local example, will be discussed and further in the thesis, twenty residential units from Izmir will be used part of the case study for HRM-Izmir Rating model.

2.1. Sustainable Development Issues Worldwide

The concept of sustainability has become a key idea in national and international discussions following the publication of the Brundtland Report and the 1992 Rio 'Earth Summit'. It was given further prominence in the context of the 2002 World Summit on Sustainable Development held in Johannesburg.

The World Commission on Environment and Development (WCED)[6] led by the former Prime Minister of Norway, Gro Harlem Brundtland. This Commission argued that the time had come to couple economy and ecology, so that the wider community would take responsibility for both the causes and the consequences of environmental damage. The commission defines sustainable development as:

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[6] World Commission on Environment and Development (WCED). Our common future. Oxford: Oxford UniversityPress; 1987.

'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland Report 1987)

For the European Union the key to sustainable development is that:

'Economic growth, social cohesion and environmental protection must go hand in hand'[7]

The built environment occupies a particularly significant position in sustaining and improving the quality of life, by virtue of its role in producing the infrastructure required for meeting growing human needs for food, transportation, energy and shelter.

A great challenge for researchers and practitioners is the development of products, systems, methodologies and organizational arrangements that can be used to respond to the challenges of sustainability. Thus, there is a need for more construction related research on environmental issues. Such research should typically span the entire building life cycle, and include such activities as: the extraction of raw materials, manufacture, transportation and storage of construction materials, planning, design and construction of buildings, operation and maintenance of buildings, demolition, recycling and, ultimately, final disposal of waste.

In the context of the built environment, the sustainable dimension requires that:

- critical natural resources should be conserved
- waste and pollution should be minimized
- the natural environment should not be disturbed.

A key problem here is determining the system boundary. The system boundary is where inputs and outputs are determined to be irrelevant. For example, disturbances to the natural environment that are associated with the building procurement process may occur within or remote from the building site, or perhaps even in another country, which complicates environmental management. From an economic point of view, however, the system boundary issue is rarely relevant because the costs of upstream requirements are rolled into the price of a product. Other requirements for sustainability in the built environment include:

[7] A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development. Commission's proposal to the Gothenburg Council.

- preserving the integrity and functionality of constructed facilities under changing environmental conditions

- preserving the health and productivity of users of constructed facilities development of environmental awareness for built environment practitioners.

Sustainable development issues begin from the larger perspective, an international attitude. For instance, Chapter 8 of Agenda 21 calls on countries to adopt national strategies for sustainable development (NSDS) that "should build upon and harmonize the various sectoral economic, social and environmental policies and plans that are operating in the country" (WEB_ 6.).

In 2002, the World Summit for Sustainable Development (WSSD) urged States not only to "take immediate steps to make progress in the formulation and elaboration of national strategies for sustainable development" but also to "begin their implementation by 2005"[8] (WEB_6.)

In addition, integrating the principles of sustainable development into country policies and programmes is one of the targets contained in the United Nations Millennium Declaration to reach the goal of environmental sustainability.

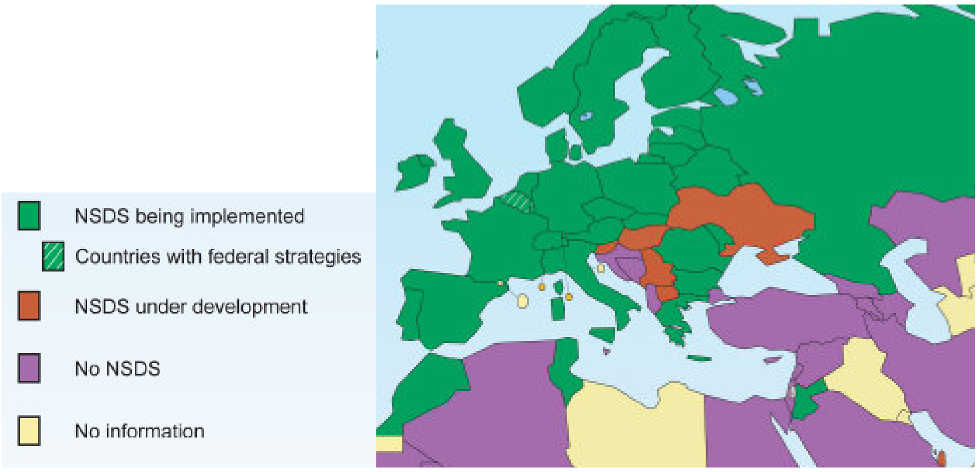

Figure 2.1. National Sustainable Development Strategies Map
(Source: UN Sustainable Development).

UN Nations developed a map (Figure 2.1.) to monitor the National Sustainable Development Strategies (NSDS). The map tracks progress towards the WSSD (2002) target for countries to formulate and begin implementation of national sustainable

[8] http://www.un.org/esa/sustdev/natlinfo/nsds/nsds.htm

development strategies by 2005. According to this map, Turkey has not yet developed the national strategies for sustainable development as well as the USA. However in the EU, NSDS is implemented or under development.

Following the Rio Conference in 1992 where all IEA member states except Turkey signed the UN Framework Convention on Climate Change, many governments declared targets for the reduction in energy use in their own buildings. There are a number of benefits for the climate friendly technology industry both in governments declaring a national target for reduced national emissions of CO^2, and in locally applied targets set by governments for their own facilities, industry or other institutions.

In the National Information Days 2000 Hotel IBIS Luxembourg-Findel meeting, C.J. Walsh affirmed that the building regulations exclue the social aspects of sustainability; that it is an environmental building tool and not a sustainable one.

Francesc Aragall explained "sustainable" as something that one can afford to maintain in a long run. In his mind, sustainable development is the way on how to organise the society in a way that it fits with our specific needs and to guaranty that future generations will have the same opportunity to do so.

Specific recommendations for each of the key sustainability issues are given in the matrix. Some more general recommendations are given below (WEB_7.):

- Government should undertake a fundamental review of the Building regulations in the context of sustainable development.
- Accepting that fundamental overhaul of the Building regulations will take some time to put in place, advantage should be taken of the significant opportunities for updating existing
- Existing regulations should be upgraded to keep in line with sustainable development targets.
- Building regulations should be kept in line with EU environmental targets.
- A revised Building Regulation Approved Document relating to materials should be introduced. This should require the use of materials with low environmental impacts and reused/recycled materials. The toxicity of materials should also be considered. This could be trialled by introducing requirements for minimum percentage of all new construction materials being
- **Additional funding, resources and training (where required) should be provided to local authorities to allow more stringent enforcement of existing and future housing standards.**
- There should be greater synergy between planning, building regulations and environmental health

The housing standards were emphised in the general recommendations. Local conditions need to be improved for better future.

Several countries have introduced stringent energy-related building regulations and have increased research efforts on energy-efficient and pollution-reducing technologies. Life cycle costing of certain categories of buildings at the building design approval stage has also become a statutory requirement in several countries. Life cycle energy and life cycle environmental assessments are still voluntary in almost all countries, yet being identified as an 'environmental-conscious' organisation now appears to have commercial advantages, and may be required for organisational survival.

Building regulations ensure acceptable minimum standards. There have been minimum projects that direct feedback from performance of real buildings into regulations. This has made it difficult to pick up new trends and assess the impact of changed regulations. Until the 1990s, the regulations were entirely about heating, not rapidly rising electricity use; despite its rapid growth since the early 1980s, AC is only now about to be included. Current Building Regulations is now under way and all the indications that are sustainable design will be promoted increasingly to ensure to meet EU commitments to environmental protection

In the last few years, with growing concern over the impact of emissions on the global environment from energy use, targets for reducing emissions have been adopted. Targets are often adopted by industries and institutions in conjunction with voluntary agreements with government to achieve improvements in energy use. This was mainly the result of better building design, materials, construction, and more efficient equipment, which are progressively being introduced to the market, and the restructuring of the new EU member states economies involving a more rational use of energy as a result of increasing fuel prices. Energy use in residential buildings accounted in 2000 is for about 65% of the total final energy demand in the buildings Sector.

Annual energy consumption in residential buildings averages 150–230 kWh/m^2. In eastern and central Europe, heating energy consumption is 250–400 kWh/m^2, often averaging about two to three times higher than that of similar buildings in Western Europe. In northern European countries, well-insulated buildings have an annual consumption of 120–150 kWh/m^2, while the so-called low energy buildings may even drop down to 60–80 kWh/m^2. According to the Danish Environmental Protection

Agency, the residential energy use per capita varies widely among European countries, for example, from 150–350 kWh/capita in south Europe, 500– 700 kWh/capita in most of northwest Europe, to over 700 kWh/capita in Scandinavian countries (Balaras 2000). Levels in most EU countries are fairly steady, fluctuating from year to year with the weather, but in some south European countries, like Spain, residential energy use increased steadily during the last decade.

The fuel and amount of energy used in residential buildings varies from country to country, depending on living and comfort standards, per capita income, natural resources and available energy infrastructure. In general, households in developed countries use more energy than those in transitional or developing nations. Space and water heating account for most of the energy used by households in the industrialized countries (North America, Western Europe and industrialized Asia). In European residential buildings, about 57% of the total final energy consumption is used for space heating, 25% for domestic hot water and 11% for electricity (Chwieduk 2003). The average consumption of electricity per capita in the household sector is also quite diverse, depending on the level of diffusion of electrical appliances and the use of electric space heating (WEC 2001), ranging from 1000 kWh/capita (i.e., Portugal, Italy) to around 2000 kWh/ capita (i.e., UK, France) and up to 4500 kWh/capita in some countries (i.e., Sweden, Canada).

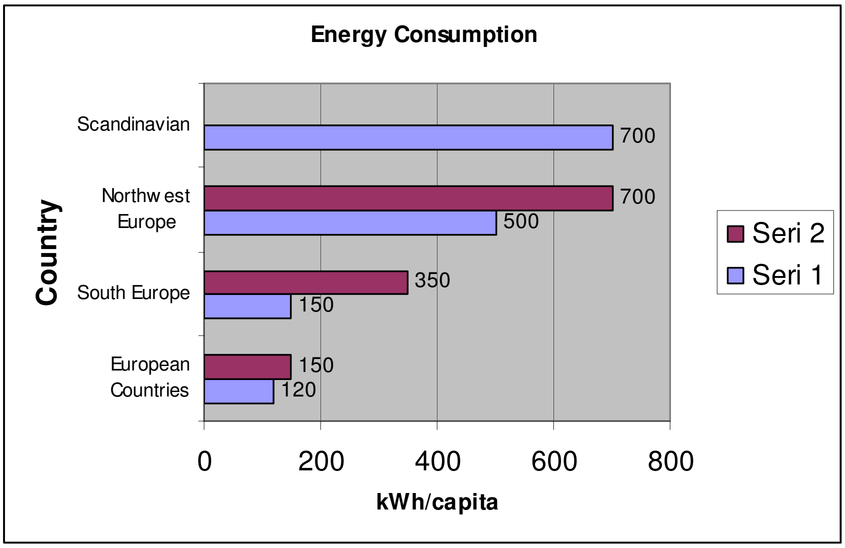

Figure 2.2. Energy Consumption in Europe.
(Source: Energy and Environment Agency)

Although the fuels used for space heating and the production of sanitary hot water varies from country to country, the recent trend has been toward natural gas and away from oil, coal and biomass (i.e., wood and peat).

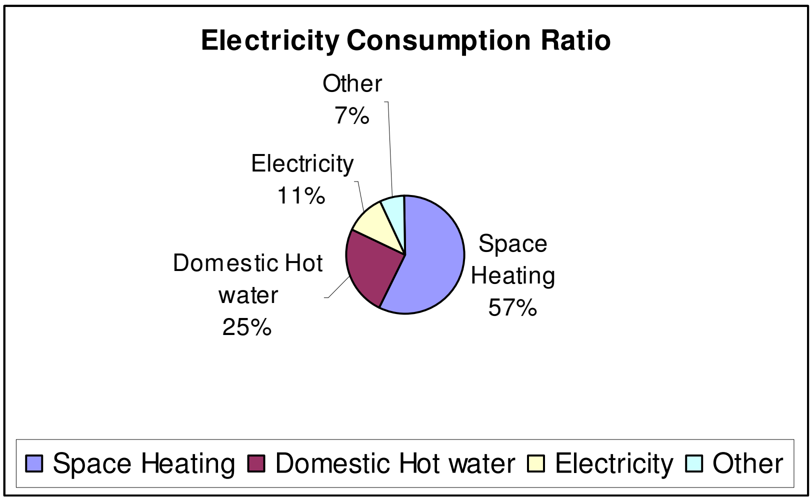

Figure 2.3. Electricity consumption ratio.
(Source: Energy and Environment Agency)

During the past decade, residential energy use has declined in Eastern Europe and the former Soviet Union, and space heating tends to be the most energy-intensive service. The use of coal and wood for space heating is more widespread than in the developed nations. In most developing countries(i.e., China, India, central and South America, Africa, the Middle East, and other developing countries in Asia), energy use for space heating is less important than it is in the industrialized nations, due in part to climate and dwelling size. Available wood, wood waste and other solid wastes are used for cooking, water heating and space heating where needed. Over time, however, as incomes rise and fuel distribution networks are established, switching to oil and natural gas is expected to displace some of the demand for traditional fuels (DOE 2004).

In Europe, national energy efficiency standards that mandate the use of thermal insulation in the construction of the building’s envelope have been introduced over the past few decades, starting from northern countries (Sweden, Norway and Germany) during the 1950s. Thermal building codes exist in many variants, relying on as many different approaches as there are countries and according to the World Energy Council (WEC 2001) can be classified in different categories including:

a. envelope component and/or entire building envelope approaches, which specify maximum thermal transmittance values for individual building components (i.e., walls, roof and windows) and/or the entire envelope with some flexibility on the individual components;

b. heating/cooling demand per unit floor area or volume, which specify maximum values while taking into account the contributions from ventilation losses/gains, passive solar gains and internal heat gains;

c. building energy performance per unit floor area or volume, which specify maximum annual

primary or final energy consumption for the entire building as a system and integrate the heating/cooling demand along with other equipment for heating and air conditioning systems, energy for ventilation, hot water production, pumps, elevators, etc., and other gains from solar energy (i.e., collectors and photovoltaic's);

d. building life cycle, which in addition to the building energy performance accounts for the embodied energy in buildings and is expected to be the future trend for standard evolution. (WEC 2001)

In Denmark the first building regulation about the thermal performance of building components was issued in 1961, resulting in reduction of energy consumption. National Danish Energy Information Centre report proves that energy consumption in households was reduced by approximately 25% during the period 1972–1999. Low-e double-glazing is a current standard practice and is also mandatory for any window which is replaced.

The most relevant regulations are the Building Act, the Working Environment Act and the Act of Environmental Protection. The regulations are both national regulations and EU regulations in directives.

Different health effects are concerned: severe illness as lung-cancer, asthma and allergy, irritations in the mucous membranes in the eyes and upper airways, irritations of the skin and common comfort. New regulations have to be based on some kind of scientific evidence to ensure the validity. One of the greatest difficulties in improving indoor climate legislation is the limited knowledge about the effect of chemical pollutants on the human organism in low doses combined with the exceedingly large number of pollutants found in the indoor climate.

In the past the Building regulations in Denmark have indoor climate legislation concerning pollutants from building materials like formaldehyde, asbestos, man-made-mineral-wool fibres, fly ash and clinker from coal firing and radon. The formaldehyde is until now the only pollutant being regulated with respect to a harmonised European standard (from 1. April 2003).

The regulations deal with:

- total bans,
- limits for contend,
- limits for release,
- performance for the building construction product or the whole building,
- specific code number for products,
- how to use the materials,
- an elaborate system for re-use.

In the two Building Regulations in force there is a long history for having a number of specified requirements concerning home layout, sanitary conditions, insulation for heat and sound, energy consumption, fire safety, recreational areas, provision for the disabled, structural conditions etc. From 1995 the Regulations also have an indoor climate chapter with specified requirements concerning ventilation, contamination from building materials, other contaminations and temperature.

In Netherlands: In the nineties, the Dutch government decided upon a stimulus for sustainable building. In 1995, the first Action Plan with fourteen actions and projects was presented. This marked the beginning of the Dutch government's programmed approach to sustainable building. It was aimed to give sustainability a stronger place in the decision-making process on the layout and use of buildings and their environment. In 1997, the second Action Plan followed with 28 actions and projects. Both plans were developed in consultation and close co-operation with the representative organs of all parties involved in the building process. Both plans have had much effect. By the end of 1999, sustainable building has become an important theme in the building process.

However, in 1999, The Government of the Netherlands and market parties concluded that they were still early to drop the programmed approach of sustainable building. More time is needed for wide application of sustainable building and embedding it in the daily practice of construction. Therefore the Policy Programme Sustainable Building 2000-2004, titled "Firmly Embedding", has been presented at the end of 1999. Aim of this programme is that, at the end of this period, sustainable building will be completely embedded in thought and deed of government and construction organizations and that the stimulus of the programmed approach will no longer be needed. The Policy Programme contains extra policy stimuli in three areas. Energy is one of them. The international agreements on reduction of emission of greenhouse gases require additional effort also from the building sector. Especially existing buildings offer opportunities for this. Therefore the instrument of the energy performance advice is being developed, based on voluntaries. A further impulse is also needed for sustainable urban development. Recent developments in the field of urban regeneration offer opportunities for sustainable building to make leaps forward. Third and last extra policy stimulus regards the approach of consumers in their role of demanders and users of buildings. There is still a great potential hidden in the consumer's increasing demand for quality. Promising is the possibility of linking sustainable building to other quality aspects such as comfort, availability of green space and water nearby, quality of life and public health.

Sustainable building in the Netherlands has become firmly embedded in governmental policy since 1995. Policy has been elaborated in successive action plans. The core of the action plans are actions grouped along four policy lines, namely: "harmonisation", "realisation", "consolidation" and "preparation". The policy line "harmonisation" is of crucial importance for the building sector. To achieve this, the building sector itself took the initiative to develop a series of so-called "national packages for sustainable building". However, the building sector prefers formulations in terms of performance requirements which allow designers and builders to choose freely from the solutions they want themselves. This approach is in compliance with Dutch building regulation.

Just as the case with determining the energy performance of a building, it should be possible to also as certain its environmental performance. Research into devising a determination method is presently going on and has meanwhile resulted in a prototype method for drawing up a building's material-based environmental profile, derived from the existing, performance-based Life Cycle Assessment (LCA) method. With the help of such a method, socially desirable minimum standards for sustainable use of materials can in due course be incorporated into the building regulations. The use of performance standards leaves room for innovation and creative solutions. This leaflet presents the method and provides background data and information on future developments in the Netherlands.

In France the first thermal regulation was introduced in 1975. The average energy consumption was up to 325 kWh/ m^2 in 1973, decreasing to 180.6 kWh/m^2 in 1998, due to the retrofit of old buildings and to the introduction of thermal regulations for new buildings (Herant 2001). Ordinary double-glazing is commonly used in all new buildings.

In Italy the first building thermal regulation was issued in 1976. Ordinary double-glazing is commonly used in the north and single glazing in the south.

In Germany the first building regulation on space heating (DIN 4108: thermal insulation in buildings) was introduced in 1952 and has undergone several amendments since then, by lowering the thermal transmittance values of walls, windows, roof etc. (Schuler, Weber and Fahl 2000). The thermal insulation ordinance became active in 1978, setting maximum thermal transmittance values, which were tightened in the 1984 revision and then further reduced in the 1995 revision with the addition of maximum values for the heating demand of buildings (World Energy Council 2001). As a result, buildings saved up to 70% in heating energy consumption compared to the average of the existing building stock and 50% compared to the first thermal insulation ordinance. The new German energy conservation ordinance, which entered into effect in 2002, is expected to reduce the energy consumption in new buildings by 25– 30%, introducing the so-called low-energy house standard for new buildings with annual heating energy demand for medium-size buildings that do not exceed 70 kWh/m^2 (Federal Ministry of Economic and Technology 2002). It unifies the previously separate thermal insulation and the heating installation ordinances. Even for existing buildings, the ordinance stiffens and expands the previous energy conservation requirements for major building modifications and additions, as well as for modernization and repair work, taking into account some economically acceptable requirements. Low-e double-glazing and argon filled is current standard practice and is also mandatory when 20% or more of windows in any facade are replaced. Municipal utilities, like in Frankfurt, subsidize compliance below 75 kWh/m^2 for single-family houses and below 65 kWh/m^2 for apartment buildings, according to the Frankfurt Energy Pass, which is based on the guide ‘‘Energy in building construction’’ of the state of Hessen and the Swiss standards.

Overall, more strict regulations on thermal insulation and increasingly efficient heating systems have lowered households’ energy consumption by an average of 1.2% annually from 1991 to 1997 (Federal Ministry of Economic and Technology, 2002). Given that 80% of the total German building stock was constructed before 1983, thus prior to the date when the second thermal insulation ordinance went into effect, the heating demand of these buildings is roughly two to three times the values now required for new buildings.

In Switzerland, there are twenty six building thermal regulations. The Swiss Association of Engineers and Architects (SIA 380/1) introduced regulations for construction elements during the 1970s and then for the building in 1988 and 2001 (Jegen and Wustenhagen 2001). Codes by cantonal authorities were introduced mainly during the 1980s, followed by harmonization in the 1990s. Typical total energy consumption in residential buildings before the energy norm averaged 220 kWh/m^2, decreasing to 120 kWh/m^2 after its implementation. Low-e double glazing is also standard practice in new buildings.

In Poland, according to the Polish National Energy Conservation Agency (KAPE), the corresponding regulation on the building components was first introduced in 1957 and has undergone several amendments since then, by lowering the thermal transmittance values of walls, windows, roof etc. The most recent regulation was introduced in 1999 by the thermal modernization act, which is mandatory only for investments that receive national funding. Typical heating demand in older buildings ranged between 240 and 300 kWh/m^2, reaching as much as 400 kWh/m^2, while according to the new Polish standards for new residential buildings, the average annual energy demand for space heating is in the range of 90–120 kWh/m^2 (Chwieduk 1996). Low-e double-glazing is standard practice in new buildings and is also mandatory for any window, which is replaced.

The origins of the building codes in the USA lie in the great fires of American cities for instance, Chigago developed a building code in 1875 after the fire of 1871. The various city codes and often conflicting codes have been refined over the years and began to be brought together by regional non governmental organisations to develop model codes. The first model codes were written from the point of view of insurance companies to reduce the fire risks. Model codes are developed by private code groups for subsequent adoption by local and state government agencies as legally enforceable regulations. The first major model code group was the Building Officials and Code Administrators (BOCA), founded in 1915 and currently located in Country Club Hills, Illinois. Next was the International Conference of the Building officials (ICBO), formed in 1922 and now located in Whittier, California. The first edition of their

Uniform Building Code Congress, founded in 1940 and headquartered in Birmingham, Alabama, published the Southern Building Code.

Over the past few years a real revolution has taken place in the development of model codes. There was recognition in the early 1990s that the USA would be best served by a comprehensive, coordinated national model building code developed a general consensus of code writers. There was also recognition that it would take time to reconcile the differences between the existing codes. To begin the reconciliation process, the three model codes were reformatted into a common format. The International Code council, made up of representatives from the three model-code groups, was formed in 1994 to develop a single model code using the information contained in the three current model codes. While detailed requirements still varied from code to code, the organisation of each code became essentially the same after the mid- 1990s. This allowed direct comparison of requirements in each code for similar design situations. Numerous drafts of the new International Building Code were reviewed by the model-code agencies along with code users. A single model code is formed, maintained by a group of representatives of the three model-code agencies, the International Code Congress, headquartered in Falls Church Virginia.

In addition to the International Building Code (IBC) is the International Residential Code (IRC). This code is meant to regulate construction of detached one- and two-family dwellings and townhouse that are not more than three stories in height with a separate means of egress.

There are also specific federal requirement that must be considered in design and construction in addition to the locally adopted version of model codes. Among these are the Americans with Disabilities Act of 1990 and the Federal Fair Housing Act of 1988.

Building energy regulations have been revised in several European countries, towards more strict and complex standards, considering the energy consumption of the entire building system. For instance, in Italy as of 1991, in Denmark as of 1996, in most Austrian Provinces as of 1997, in the Netherlands as of 2000, in Switzerland as of 2001 and in Germany as of 2002. More strict regulations have resulted in significant energy savings for heating, especially in northern Europe: for example, in Germany with up to 30% energy savings compared to the previous standards, in France with 10% savings and in Ireland with 22–33% savings. Thermal insulation of buildings (external walls, roof and floor) and double pane windows (even triple glazing with low-e and argon in northern countries like Baltic States, Finland and Sweden) reduce annual energy consumption for space heating, by lowering heat losses through the building's envelope, and improve thermal comfort conditions.

Throughout Europe, national regulations are underway in compliance to the new EU Directive on the energy performance of buildings (European Commission 2002). The Directive mandates that all EU member states bring into force national laws, regulations and administrative provisions for setting minimum requirements on the energy performance of new and existing buildings that are subject to major renovations, and the calculation of performance-based indicators for energy certification of buildings. Additional requirements include regular inspection of building systems and installations, an assessment of the existing facilities and advice on possible improvements and on alternative solutions. The cumulative energy saving achieved for new dwellings, compared to dwellings built before the 1970s, averages about 60% in the EU, while the additional savings that are targeted with future revisions in the national standards will range from 20 to 30% (WEC 2001). The impact of the new EU Directive on the energy performance of buildings by 2010 is estimated to be primary energy savings of 9 Mtoe (EC 2004).

Worldwide, building energy codes have been adopted in over 30 countries and regions including some developing economies like China, Taiwan and Argentina (Lee and Yik 2004). Other instruments for supporting building energy efficiency measures include incentive-based schemes that provide subsidies to reduce the costs of improvements and ecolabeling schemes and legally non-binding building energy codes and voluntary building environmental performance assessment schemes, and are being reviewed in Lee and Yik 2004.

Buildings are also a major pollution source. They account for about 50% of sulphur dioxide emissions, 22% of nitrous oxide emissions and about 10% of particulate emissions. They also contribute to about 35% of carbon dioxide emissions that is closely related to climate change (Vine 2003). The introduction of the Kyoto Protocol (KP) in 1997 represents the first serious step for the reduction of emissions of the six greenhouse gases (CO^2, CH^4, N^2O, HFCs, PFCs and SF^6). According to the agreed targets, total emissions of greenhouse gases (GHG) in developed countries during the first commitment period (2008–2012) must be reduced by at least 5% below 1990 levels. The EU has agreed to a total reduction of its emissions by 8% below 1990 levels. In 2000, the total GHG emissions (excluding land-use change and forestry) in the EU amounted to 4.1 Gton of CO^2eq with CO^2 accounting for more than 82% of the total GHG emissions. Approximately 17% of the total CO^2 emissions were generated from the residential and tertiary sector without taking into account the CO^2 emissions associated with electricity consumption in buildings. Therefore, buildings constitute an important sector in the effort to reduce environmental emissions. The environmental building emissions are related to the energy consumption during operation and to the use of materials during construction and throughout their lifetime as a result of renovation and refurbishment, or even demolition.

The most polluting fuel, in terms of CO^2, SO^2, NOx and particulate emissions, is coal, followed by oil. Natural gas burns much more cleanly, can be used more efficiently in domestic boilers and produces only 60% as much CO^2 per unit of energy as coal. Natural gas, oil and electricity are the most important energy sources in the domestic energy market (Griffin and Fawcett 2000). Natural gas has the largest share of the domestic energy market in The Netherlands (82%), the UK (66%), Italy (60%), Germany (35%) and France (34%). Oil is most commonly used in the residential fuel market in Luxembourg (54%), Belgium (42%), Spain (39%), Ireland (31%), Finland (28%) and Austria (25%). Electricity is the major energy source in Sweden (43%) and Finland (28%). The impact of the new EU Directive on the energy performance of buildings by 2010, as a result of the estimated primary energy savings of 9 Mtoe, is expected to reduce CO^2-emissions by 20 MtonCO^2eq (EU 2004). Recently, more attention is also been given to the embodied energy of building materials and components, and their assessment over a building's life cycle. Embodied energy results in considerable emissions of water pollutants to the rivers and oceans, and of air pollutants contributing to Green House Gas (GHG) emissions. The initial embodied energy in buildings includes the energy consumed in the acquisition of raw materials, their processing, manufacturing, transportation to the site and construction. The initial embodied energy has two components (Harris 1999). The direct energy used to manufacture and transport building products and equipment to the site and to construct and equip the building with the necessary installations. The indirect energy is the energy use associated with processing, transporting, converting and delivering fuel and energy to its point of use. Recurring embodied energy in buildings represents the non-renewable energy consumed to maintain, repair, restore, refurbish or replace materials, components or systems during the life of the building. As buildings become more energy-efficient the ratio of embodied energy to lifetime operating energy consumption becomes more significant. Embodied energy of a building may constitute 15% of its lifetime energy consumption (Harris 1999). In Germany, for example, new buildings already contain 30% of their lifetime energy consumption in the building materials, and this could rise to 50% with the next generation of low-energy houses (WEC 2001).

2.2. Sustainable Development Issues in Turkiye

Sustainable Development in Turkey accelerated after the International cooperation. For instance, a national policy discussion on changing production and consumption patterns was held in Turkey in 1993, together with the governmental authorities, consumer groups, NGOs at large, the media and the National Standardization Body. The importance of product standards, the adoption of a national scheme for an environmental quality management system and public awareness-raising were stressed as the means to achieve the objectives of changing consumption patterns. On the basis of the discussion, the Directorate General for the Protection of Consumers and Competition was set up in the Ministry of Industry and Trade, and the Act on the Protection of Competition, as well as several regulations on consumer protection, was adopted.

The Ministry of Environment and Forestry has signed declarations and protocols with different sectors of the economy to decrease their environmentally harmful loads. For instance, a declaration was signed with the Cement Industry Union whereby the cement industry representatives made a firm promise to decrease and control the environmental pollution produced by this sector[9]. In 1995, for the reduction of air pollution from transport, Turkey intends to follow the developments in the European Union, production of cars equipped with catalytic converters was initiated with a protocol between the Ministry of Environment and Forestry and the car manufacturers the number of cars by 2010 will be 20 millions and the total rate of CO 6.7 million tons annually. According to investigations the use of catalytic converters will decrease emission by 90 percent. After 1995 gradually the conversion of car production to catalytic converter equipped cars and after 2000 completely production of cars with

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9 http://www.tcma.org.tr

catalytic converter will decrease CO 2.4 times by 2010. Finally at 2010 the annually rate of CO will be 2.8 millions tone.[10]

In order to protect the atmosphere, the Government of Turkey promotes policies and programmes in the areas of energy efficiency (UN, EE 2000), environmentally sound and efficient transportation (EC, EURO 93), industrial pollution control, sound management of marine resources, and management of toxic and other hazardous waste.

In 1995, production of cars equipped with catalytic converters was initiated with a protocol between the Ministry of Environment and car manufacturers.

With regard to achieving sustainable energy development and efficiency, the Government considers the development and use of safe technologies, promotion of R&D relating to appropriate methodologies, public awareness-raising, product labelling, and EIA as the most important means. To reduce harmful emissions into the atmosphere from industrial activities, industries are encouraged to develop safe technologies. The Government gives high priority to the promotion of R&D relating to appropriate methodologies, EIA within industry as a whole, life-cycle analysis of products and eco-audits. Concerning the phase-out of CFCs and other ozone depleting substances, the phase-out of Annex A and Annex B substances is planned

The Ministry of Health is responsible for transboundary atmospheric pollution control. The Air Quality Control Regulation, which entered into force in 1986, has not been revised in the light of Agenda 21. Regulations related to industrial accidents are being planned.

The Ministry of Interior, State Institute of Statistics[11], Hacettepe University and the Institute of Demographic Studies[12] are primarily responsible for demographic issues in Turkey. In addition, the Ministry of Agriculture, the Ministry of Environment and Forestry, the State Planning Organization (SPO) and the State Institute of Statistics are engaged in integrated policy coordination in the field of population, environment and development. A Demographic Dynamics and Sustainability Working Group has been

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[10] http://www.obitet.gazi.edu.tr/makale/Makaleler/T33_Tahmin.htm

[11] State Institute of Statistics (SIS) is a technical and scientific institute which produces publications to fulfill Turkey's information needs on social, economic, and cultural subjects. The main function of SIS is to comprehensively determine information needs, collect and compile data, and finally, to present information to its users according to the highest international standards. http://www.tuik.gov.tr

[12] Hacettepe University, the Institute of Demographic Studies: http://www.hips.hacettepe.edu.tr/

set up under the National Environmental Action Plan (NEAP)[13] to coordinate the different actions in the field of population, environment and sustainable development.

Turkey has a NEAP for the years 1996-2000. It is a binding document to the public sector and serves as a guidance document to the private sector. In addition, certain sectors such as tourism, industry, energy, transport and agriculture are working for the integration of environmental considerations into this work.

In 1995, Turkey launched a preparatory process for the development of a National Agenda 21 under the UNDP[14] technical cooperation programme entitled the National Programme for Environmental Institution and Management in Turkey. The NEAP and the Seventh Five-Year Development Plan (1996-2000) are used as an important reference in the formulation of the National Agenda 21.

As part of the preparations, Agenda 21 was translated into Turkish, and a Task Force, with representatives from the Ministry of Environment and Forest, State Planning Organization, Non-Govermental Organisations (NGO), academic institutions, local authorities, private sector and the UNDP was established to lead the preparatory work. A National Committee involving representatives from all relevant government agencies, NGOs, local authorities, academic institutions, private sector and the media has also been set up to draft the action plan, and regional workshops have been organized to review the drafts.

Environmental impact assessment became a legally required procedure on 7 February 1993. 26 % of Turkey's surface area is covered by forests, and approximately 50% of these forests are already degraded. In addition to afforestation, an erosion control and range improvement measure, the National Mobilization and Erosion Control Act was put into force in 1995. The main objective of the act is to ensure participation and contribution of all related governmental and non-governmental organizations, private sector and local people, and to provide additional financial resources for combating deforestation and erosion control activities at national level.

Turkey supports the development of a legally binding instrument on management, conservation and sustainable development of all types of forests. The legislation related to forestry is the Forest Law No.6831, the National Park Law No.

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13 NEAP: National Environmental Action Plan for Turkey. http://www.unescap.org/stat/envstat/stwes-mo5.1.pdf

14 UNDP (United Nations Development Programme) is the Umited Nations' global development network, an organization advocating for change and connecting countries to knowledge, experience and resources to help people build a better life. http:/undp.org

2873, the Hunting Law No.3167, The National Mobilization Law for Afforestation and Erosion Control No.4122. The Ministry of Environment and Forestry is also the responsible body for sustainable management of mountain forests.

The First Forestry Assembly was held in 1993. The decisions taken by the Assembly were being considered all important forestry activities expressed by the UNCED at Rio, 1992. In 1997, the XI World Forestry Congress was held in Turkey.

Turkey is rich in terms of biodiversity. There are 250 wetlands with a total area of approx. one million hectares. More than 420 species of native and migratory birds nest there, and 9,000 plant species of which 3,000 are endemic, have been recorded in the various regions of Turkey.

Turkey has carried out a comprehensive baseline survey on the state of the biodiversity. Habitat destruction is the most serious cause of the loss of flora and fauna. Over-harvesting and pollution cause moderate losses. In addition, moderate fauna losses result from forest fires, and moderate flora losses, from urbanization.

The Convention on Biological Diversity (1996), and The Convention on International Trade in Endangered Species of Wild Fauna and Flora has been ratified in 1994.

The Global Environment Fund (GEF) has financed an in-situ Conservation of Genetic Biodiversity Project in Turkey. This five-year project, with the total costs of US$ 5.7 million, began in 1993, and it will identify and establish in-situ conservation areas for the protection of genetic resources and wild relatives of important crops and forest tree species not indigenous in Turkey. The project components include site surveys and inventories, gene management zones, data management, adopting a three-year national plan, and institutional strengthening.

The conservation of biological diversity in Turkey is provided by decisions of the Central Hunting Commission for animals, birds and reptiles, and by the establishment of protected areas such as national parks, nature reserves, nature parks, wildlife reserves and specially protected areas. The National Parks Law, the Hunting Law, the Forest Law and the Environment Law are the main legal instruments for this issue.

For the conservation and enhancement of biological diversity, natural regeneration remains the preferred method of regeneration in the forest ecosystems in Turkey. The establishment and conservation of forest-related species diversity are assisted by the techniques practiced under the management plans and programmes. In this context, the preservation of tax which is naturally associated with those occurring most frequently in the forests are encouraged. In order to maintain genetic diversity, monoculture is avoided and local provenance is preferred in afforestation works. Biological control methods are encouraged for combating insects in forests.

Turkey has signed and approved the decisions taken by the Helsinki Ministerial Conference on the Protection of Forests in Europe which includes a resolution on the Conservation of Biodiversity of European Forests.

A National Scientific Committee on the conservation of natural resources was established in 1995. This committee aims at supporting activities on research, inventory, extension, protection and sustainable use of biodiversity, and at providing better co-ordination among universities, governmental and non-governmental organizations and the private sector. This committee comprises representatives of universities and related governmental and non-governmental organizations.

In order to develop an integrated approach to the planning and management of land resources, the Government of Turkey has developed policies and policy instruments. Planning and management systems have been improved and public participation promoted.

With regard to the advancement of scientific understanding in this field, pilot projects to test research findings have been launched and information systems have been strengthened. Turkey promotes the integration of planning and management of land resources also through regional and international cooperation.

The Prime Ministers State Planning Organization, the Ministry of Public Works and Settlement, the Southeastern Regional Development Agency, local governments and municipalities, the Ministry of Environment and the Ministry of Agriculture are primarily responsible for the planning and management of land resources.

The relevant legislation in this field are the Planning Law No. 3194 (1985), the Environment Law No. 2872 (1983), the Law of Village No. 442 (1924), the Cabinet Decree No. 338 for SRDA (1989), the Law of Municipalities No. 1580 (1930) and the Law Related to the Administrations of Greater City Municipalities No. 3030 (1984).

The ever increasing population living in cities and the urban-rural disparity has become the top priority issues in Turkey. Among others, increasing housing demand and traffic problems result from this phenomenon. Due partially to the insufficient supply of serviced land for housing within or around the city, there has been an extreme increase in illegal housing, often without even the most basic amenities. Insufficient land supply and the lack of viable investment alternatives in the Turkish economy in general have given rise to speculative investments in the real estate markets, making it even more difficult for the low-income households to attain homes. Financing of housing, primarily by individual savings, is another aspect of the problem.

Local authorities are under pressure for the increased service requirements, ranging from the disposal of immense amounts of solid wastes to the provisions of parks and play areas. Due to their financial dependency on the central government and legislation limiting their capacity in decision-making, the local authorities in Turkey are unable to provide these services at the required level.

The Government of Turkey had a dual role in its preparatory work for the Habitat II Conference. Turkey prepared, in close cooperation with a considerable number of public agencies and NGOs, a National Plan of Action. It is based on an enabling strategy, addressing the issues of human settlements in both urban and rural areas, including the assessments of shelter, infrastructure and service needs, the review of the effectiveness of existing urban policies and the identification of issues and bottlenecks to local development that call for action.

Since the great initial public push created in 1984, housing cooperatives financial crediting power has diminished from a fixed percentage rate of 83 to below 30% in 1995. And while the inflation level has prompted the prices of construction materials to grow 154 times (within the same time period of 11 years), the housing co-operatives credit allowances have grown only 55 times. So the number of poor people in housing cooperatives has steadily been falling during the last decade, a fact contributing to the increase in slum construction and figures.

Apart from this, land is a very limited resource. Sixty-three percent of Turkey is affected by soil erosion. In addition, 92% of the total land area and 95% of the total population are under the risk of medium to high level seismic movements.

With regard to legislation in this field, the (City) Planning Law, No: 3194/1985; the Gecekondu (Squatter Housing) Law, No: 775/1966; the Mass Housing Law, No: 2985/1984 and the Public Housing Law, No: 2946/1983 are the main laws governing housing policies in Turkey.

A technical cooperation project to promote sustainable human settlement development was initiated in October 1994, between the Government of Turkey and the UNDP, and it is being executed and financed by the Prime Ministry Housing Development Administration.

Drinking water resource management is the most important subject for sustainable development. For this reason a project titled “Protection Sapanca Lake as a Drinking Water Resource" was implemented by the Ministry of Environment and Forestry. The philosophy of the project was integrated management of potable water resources and beneficial use and protection of the basin. On the basis of the project, a plan was prepared for the beneficial use and protection of the basin and presented as 1/25,000 scale maps. These maps, which included land use limitation criteria, will be used by land use planners during the preparation of a 1/25,000 scale basic land use plan.

The total amount of usable water is estimated to be 111 billion m3/year or 47 % of total resources. Major sources of pollution are domestic and industrial wastewater discharges and agricultural run off. Approximately 70 % of the population is adequately served, while 7 % of the population has no continuous supply.

Rapid growth of the urban population is leading to uncontrolled wastewater generation and pollution loads. Solid waste production in Turkey amounts to 61,137 tons/day in 1,974 municipalities (DIE 2000). About one per cent of this waste is deposited in a sanitary landfill, 1.71% is composted, approximately 81% is dumped into the municipal dumping sites, and approximately 16% is dumped into water bodies. The industrial solid waste production is estimated to be 5.379.000 tons per year. Out of 34 million people living in urban areas, only 6% are served with proper treatment facilities. Istanbul, Ankara and Izmir have sewage treatment projects by establishing a collection system in each city and building waste treatment plants.

Industrial wastewater is of much importance due to high loads and toxic nature. Only 20% of the industries have proper treatment facilities.

In Turkey the Regulation on Control of Solid Waste Management was published in the Official Paper dated 14 March 1991 (No. 20814). According to this regulation the municipalities are responsible for the collection, transportation, recycling and disposal of solid waste.

Deposit schemes and recycling rates are being applied effectively on packaging waste, and rates of up to 65 % are being achieved.

Since 1995, the World Bank in conjunction with the Ministry of Environment and Forestry has financed the Mediterranean Environmental Technical Assistance Programme (METAP) for developing a national solid waste management throughout Turkey. The objectives of the project are

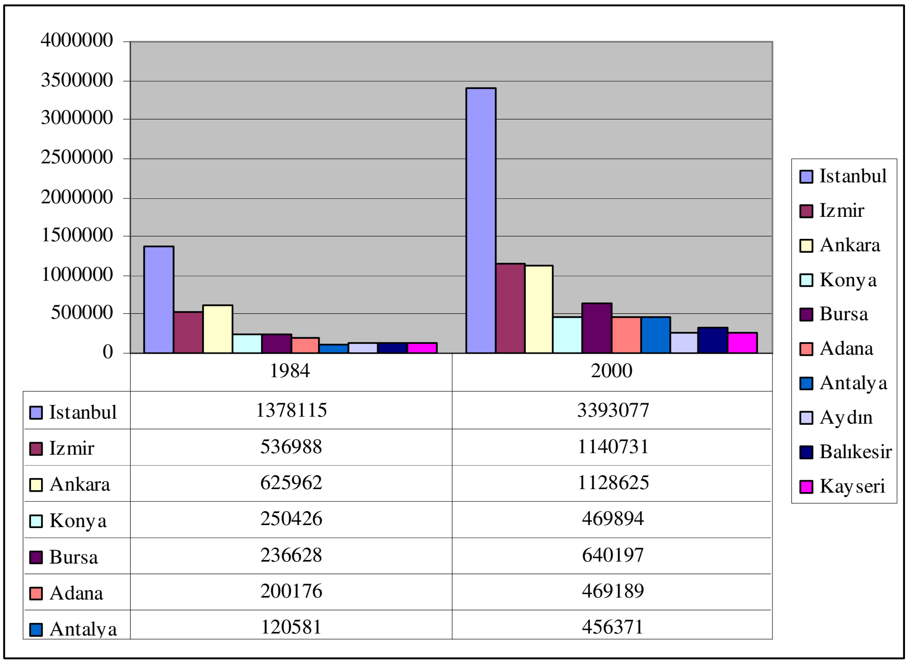
- to take a broad view of Turkish solid waste management institutions, policies and systems for administration and control;

- to identify barriers and constraints to successful implementation of solid waste management; and

- to propose strategies for removing those barriers and constraints in order to achieve consistent and improved practices and standards.

2.3. Local Study Area Izmir's Conditions

Turkish Statistical Institute has completed four building census research since 1923. According to Building Census 2000(forth in series) which was applied between 24th of April and 30th of September, inside boundaries of municipalities of Turkey, 7.838.675 buildings were counted. In Building Census 1984 (third in series), 4.387.971 buildings had been counted. Between two Building Census studies, the ratio of increase had been 79%. This means more than 79% of more energy, material, water use and waste production. If the current situation continues, the environmental impact will increase rapidly.



	1984	2000
Istanbul	1378115	3393077
Izmir	536988	1140731
Ankara	625962	1128625
Konya	250426	469894
Bursa	236628	640197
Adana	200176	469189
Antalya	120581	456371

Figure 2.4. The comparison of Building Consensus 1984 and 2000.
(Source: Building Census 2000)

The residential units are highest in number compare to other types of buildings like office, factory and hospital. In Turkey, the residential buildings total 5.959.113, occupy 74.9 per cent of the whole building stock and 461.970 in Izmir. The private sector in Izmir owns the 91% of residential buildings and public shares 7% (Figure 2.5.).

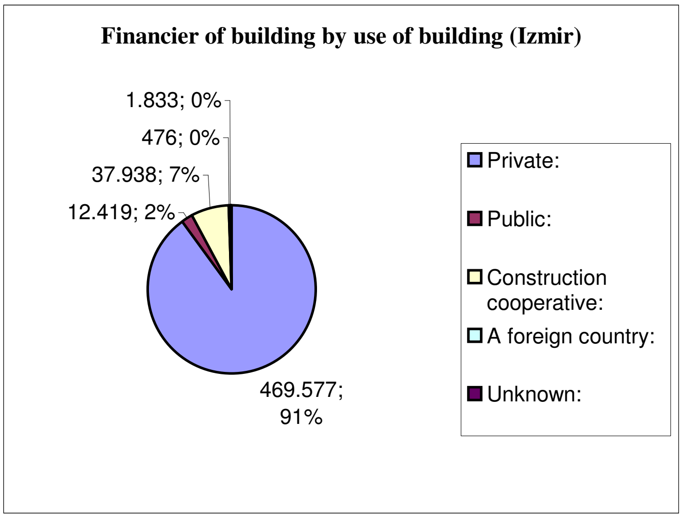


Figure 2.5. Financier of residential building (Izmir).
(Source:Building Census, 2000)

Building Census 2000 states that more than 74% percent of the residential units are one or two stories, and there 1 831 units more than ten floors high (Figure 2.6.).

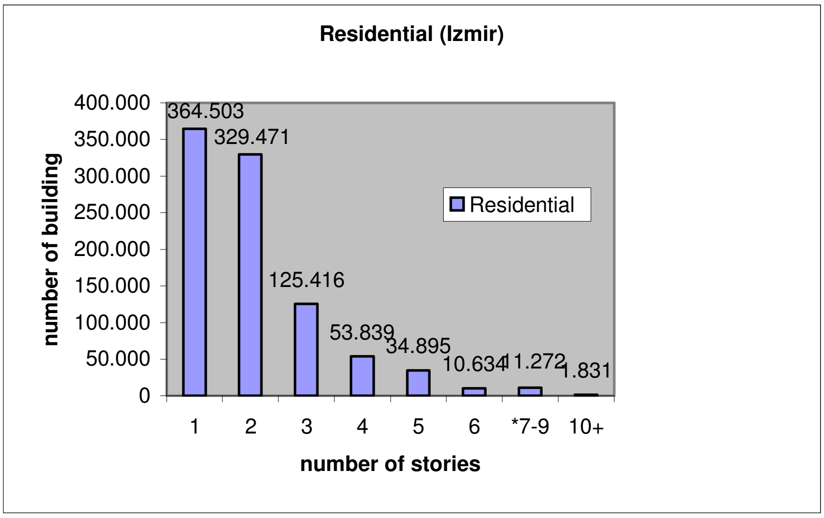


Figure 2.6. The information about number of stories in Izmir.
(Source: Building Census, 2000).

Residential waste water drainage system, there are two main methods. Sewerage system which is available in 358 587 residential units (77%) and the septic tanks, especially in summer houses, are used in 91 472 units.

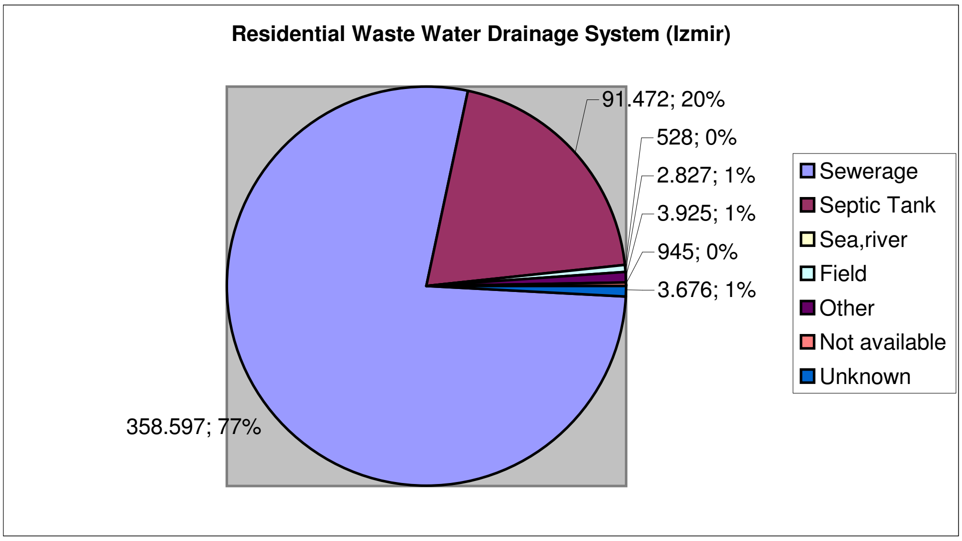


Figure 2.7. Waste Water Drainage Systems (Izmir).
(Source: Building Census 2000)

More than eighty six percent of the residential units use stoves for heating purposes. Second source is the single story heating with 23 025 residential units installed with this system. This value is high for Turkey's average because of the good climatic conditions in Izmir.

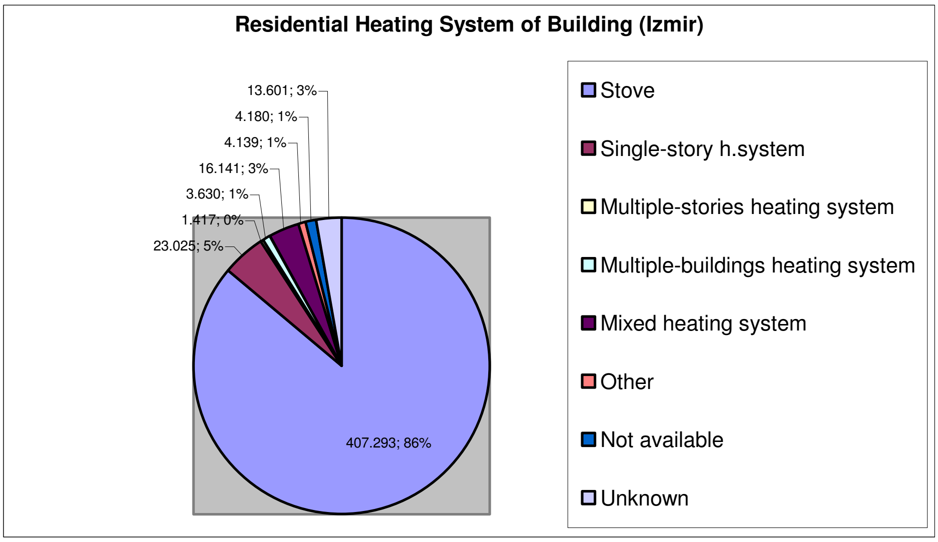


Figure 2.8. Heating Systems of Residential Buildings in Izmir.
(Source: Building Census 2000)

In the past, there were many earthquake, fire and war disasters in Izmir, for this reason the city's built environment were under major transformations. There is not a consistent architectural character for Izmir because of these disasters. However, the houses mainly constructed with timber frame, a precaution measure for earthquakes.

In Izmir, from beginning of civilisation, natural stones were used in the building constructions. All the monuments that stands still like Ephesus, Claros, Metropolis etc.,, stone was the main element for their construction. There is an ancient stone quarry near Claros, shows the evidence of the ancient construction techniques. Izmir's natural resources marble, granite, and basalt are located mainly in Tire, Torbali, Selçuk, Dikili, and Aliaga. Historical artefacts prove that the marble was used in many buildings.

Granite's main usage areas are interior decorations, exterior wall, kitchen and bathroom counter. Perlite is used in the plaster, light insulation concrete. Basalt is used as the filling material, plaster, tiling

Solid waste for person is increasing each day because of the population increases in the city. In Izmir, The Metropol Municipality is responsive for the safely discharge of the waste products inside city limits. All the local municipalities sent their waste to Harmandali Solid Waste Ground, and Uzundere Compost Facilities. Out of hundred percent collected waste 87,2% is in Harmandalı, and %12,8 is in Uzundere. The ratio of the solid waste in Harmandalı, according to 2004 figures, is 91,76% household waste, 7,85% industrial waste and 0,39 % medical waste (Figure 2.9.).

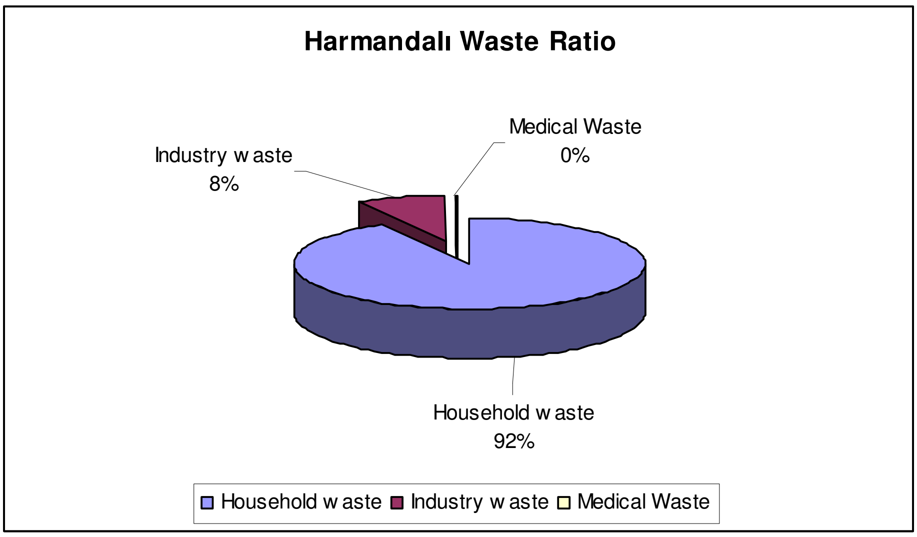


Figure 2.9. Harmandalı Waste Ratio
(Source: Izmir Metropolitan Municipality)

Hazardous wastes anywhere in Turkey are sent to IZAYDAS facilities in Izmit. There are temporary collection areas in the large municipalities like Izmir, located in Harmandali.

CHAPTER 3

BUILDING LIFE CYCLE ASSESSMENT (LCA) and the PERFORMANCE INDICATORS

In Chapter 2, the improvements taken towards the natural environment around the world were explained with examples. For instance, the new amendments on the building regulations for energy, water, transport, waste and ecology topics are key issues for the sustainable development. Then, Turkey's move towards sustainable nature was discussed with examples.

Chapter 2's main issue was, before achieving a sustainable home industry, there must be a sustainable natural environment. In Chapter 3, Life Cycle Assessment (LCA), an assessment method that mainly used for industrial processes and products, will be used to assess the residential units in this study. LCA has been accepted in the scientific community as the only legitimate and sustainable method to assessing and comparing materials, products and services from the environmental viewpoint. LCA will be explained with the international institutions contributions and the researches conducted by the scientists working in the field.

In the second part of Chapter 3, The Building LCA software tools will be described following Royal Melbourne Institute of Technology's LCA software categorisation system.

In the final part of Chapter 3, performance indicators, 5-point score system and existing rating models will be explained.

3.1. Life Cycle Assessment (LCA)

The generally recognised term for *environmental assessment of products* is *Life Cycle Assessment,* LCA in abbreviation. LCA is sometimes also read as life cycle *analysis*, but life cycle analysis is not a particularly correct description since an LCA always contains an element of *assessment*, namely the consideration and weighting of different resource and environmental problems required to make a decision (Wentzel 1997).

LCA has been accepted in the scientific community as the only legitimate method to assessing and comparing materials, products and services from the environmental viewpoint. LCA analyse the environmental aspects and potential impacts throughout a product's life cycle from raw material acquisition through production, use and disposal (cradle to grave) (Figure3.1.).

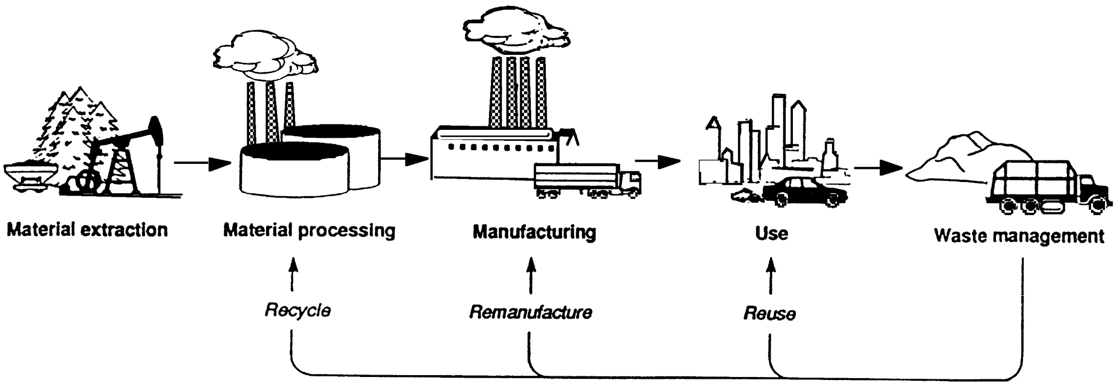


Figure 3.1. Cradle to Grave Approach
(Source: Hunt and Franklin 1996).

LCA was developed from the idea of comprehensive environmental assessments of products, which was conceived in Europe and in the USA in the late 1960s and early 1970s (Hunt and Franklin 1996).

The first studies of life cycle aspects of products and materials focuses on issues such as energy efficiency, the consumption of raw materials and waste disposal. In 1969, the Coca Cola Company funded a study to compare resource consumption and environmental releases associated with beverage containers. This LCA study was focused on energy, choice between glass and plastic for container. End of the study proved that the plastic bottle was best, contrary to expectations. The study was never fully published; however it led to calls by scientific community for a standardisation process.

In the 1970s, especially after the oil crisis, the LCA idea was used in projects, to analyze the life cycle of fuels and for tracking energy flows in industrial systems, and life cycle costs methods have been used for several years in economic studies. In 1972, in the UK, Ian Boustead calculated the total energy used in the production of various types of beverage containers including glass, plastic, steel, and aluminium. Later, Boustead and Hancock consolidated his methodology to make it applicable to a variety of materials, and in 1979, published the Handbook of Industrial Energy Analysis.

From 1975 through the early 1980s environmental concern shifted to issues of hazardous waste management. However, throughout this time, LCA continued to be conducted and the methodology improved through a slow stream, most of which focused on energy requirements. During this time, European interest grew with the establishment of an Environment Directorate (DG XI) by the European Commission. European LCA practitioners developed approaches parallel to those being used in the USA. Besides working to standardise pollution regulations throughout Europe, DG XI issued "the Liquid Food Container Directive" in 1985, which charged member companies with monitoring the energy and raw materials consumption and solid waste generation of liquid food containers. When solid waste became a worldwide issue in 1988, the LCA technique again emerged as a tool for analysing environmental problems. As interest in all areas affecting resources and the environment grows, the methodology of LCA is again being improved. Interest in moving beyond the inventory to analysing the impacts of environmental resource requirements and emissions brings LCA methods to another point of evolution. (Harrison and Vigon 1994)

The difficulties encountered in the development and standardization of LCA methodology inspired the interest of the academic world. A journal specifically dedicated to LCA research, The International Journal of Life Cycle Assessment, was started in 1996. In addition, scientific papers on LCA, have been published in other journals dedicated to environmental science, such as, Environmental Science and Technology and Resources, Conservation and Recycling, and in journals dedicated to specific sectors in society or specific types of products. The amount of LCA research has grown rapidly since the beginning of the 1990s.

Several international conferences on LCA, or with a significant LCA content, are held at a regular basis. The annual meetings of the European and North American branch of SETAC include several sessions on LCA methodology. In addition, SETAC-Europe organises an annual case study symposium. The Ecobalance conferences in Tsukuba, Japan focus on LCA and are held every other year. A newer series of conferences on life cycle management focus on the more practical aspects of LCA and life cycle thinking.

Historically, LCA has been used for benchmarking and making environmental comparisons based on the use of energy and raw materials, releases to air, water and land and associated environmental impacts potentials.

3.1.1. Institutions Working on Life Cycle Assessment (LCA)

The progress of LCA model seen in the product industry, lead a way to influence other sectors like construction industry. In the construction industry, there are three main institutions; Society of Environmental Toxicology and Chemistry (SETAC), United Nations Environment Development (UNEP), International Standards Organisation (ISO), promoting LCA model to the construction society. SETAC organises international meetings and training programs for LCA model, ISO uses its power to guide international standards, UNEP with the financial support of UN.

SETAC is a non-profit, worldwide professional society. SETAC's mission is to support the development of principles and practices for protection, enhancement and management of sustainable environmental quality and ecosystem integrity.

In 1990, in a SETAC) meeting, the general principles and guidelines for LCA started to be developed. The development process soon resulted with the "SETAC Code of Practice".

Table 3.1. SETAC Code of Practice.
(Source: SETAC 2003).

Subgroup 1	Driving forces for data exchange' reviewed the literature on drivers/impediments for free data flow, interviewed stakeholders, and organised workshops, resulting in an introduction to LCA novices and a guidance document On initiating and maintaining databases;
Subgroup 2	Recommended lists of exchanges' developed a nomenclature of LCI parameters, a recommended list of exchanges, and guidelines for the handling of sum parameters (hierarchies, overlaps);
Subgroup 3	Interfaces to existing software and implementations' designed methods to test the computerised data exchange and performed practical tests between LCA softwares;
Subgroup 4	Energy, transport, waste models' explained variability of databases for these modules and recommended criteria for the optimal goal-dependent choice and quality assessment of relevant background data in LCI
Subgroup 5	Data quality defined a framework, to handle different uncertainty types and clarify/facilitate their assessment in common LCI practice.

The SETAC working group "Data Availability and Quality" included members from Europe, USA, Asia, and Australia, representing academic, consultancy, government, and industry. Five subgroups were formed within this working group. The work of each subgroup is presented in separate chapters of the resulting book SETAC Code of Practice.

In the first phase of the working period from 1994 to 1996, two parallel working groups were active in this field: one in Europe, aiming to define a scientific basis for LCA, and one in North America, aiming to identify critical issues in this area. The second SETAC Europe working group was active in the period 1998 to 2000. The focus was on input from European members; however, the working group also involved members from other countries, the US and Japan, assuring that literature from countries outside Europe also considered. The total number of participants amounted to about 50, coming from fifteen countries (Helias and Udo de Haes 2002).

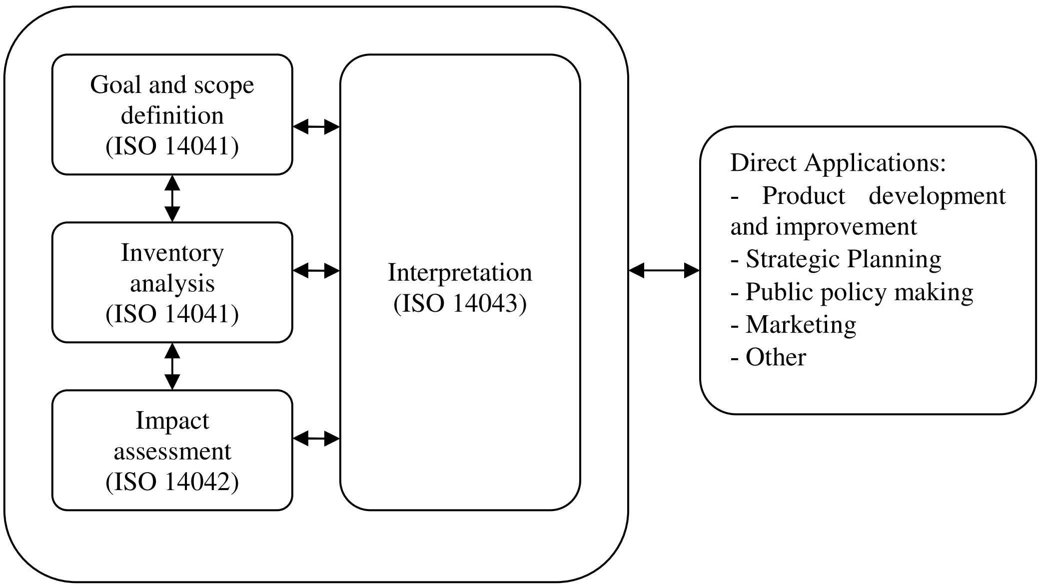


Figure 3.2. LCA (Source:ISO).

The objectives of the SETAC working group on LCA in the building and construction sector were to identify important characteristics of LCA and propose guidelines or options for methodological choices as well as to propose a set of recommendations for future work. The prevailing message from the working group is the need for harmonisation, allowing LCA results from different studies to be compared and to be used to make meaningful choices in the building and construction sector.

LCA has been the object of International Organisation for Standards (ISO 1997), another international institution to concentrate on LCA. According to ISO, the key phases of LCA are: goal/scope definition, inventory analysis, impact assessment and interpretation. In brief, the meanings of these stages are shown in Figure 3.2

Goal/scope definition (Figure 3.2) includes the definition of the purpose of the study, the functional unit (that is, the unit to which all data and calculations are referred), and of the system boundaries (e.g. which processes and operations would be included, and which ones would be excluded from the study).

Inventory (Figure 3.2.) includes data collection and calculation procedures to quantify relevant inputs and outputs of a product system. These inputs and outputs may include the use of resources and releases to air, water and land associated with the system. The main advantage of the LCA inventory process lies in being able to by-pointing the hottest portions of the systems where the largest reductions in environmental loadings can be made.

Interpretation is a systematic procedure to evaluate information from the conclusions of the previous phases, checking that the requirements of the application as described in the goal and scope of the study are met.

Once improvements have been suggested then the inventory stage is repeated to see if the expected improvements do in fact occur and also to identity any adverse side-effects resulting from the changes.

The 14000 series include the standard 14001 on environmental management systems, as well as a series of standards relating to LCA (the 14040 series). These ISO activities began in 1994 and aim to produce the first complete series of LCA standards.

Table 3.2. ISO 14000 series.

ISO 14040	A standard on principles and framework. 1st edition 1997
ISO 14041	A standard on goal and scope definition and inventory analysis. 1st edition 1998
ISO 14042	A standard on life cycle assessment. 1st edition 2000
ISO 14043	A standard on life cycle interpretation. 1st edition 2000
CD 14047	A draft technical report presenting examples for ISO 14042 on life cycle assessment (in preparation)
CD 14048	A draft standard on data format (in preparation)
TR 14049	A technical report presenting examples for ISO 14041 on the life cycle inventory phase. 1st edition 1999

The ISO 14042 standard on LCA defines relevant terminology, establishes a general technical framework, sets a number of important requirements on LCA application, and specifies technical requirements such as those for a critical review of the results. The ISO Technical Report TR 14047 contains examples, clarifying the different elements of the LCA process. The European Community (EC) requires companies to adhere to the ISO 14000 standards in order to market their goods within the EC member nations. In addition, eco-labels are having an impact on the evolution of LCA within Europe.

In 2000, one hundred environment ministers, meeting under the auspices of United Nations of Environmental Program (UNEP) declared,

> "Our efforts must be linked to the development of cleaner and more resource efficient technologies for a life-cycle economy" (Malmo Declaration, Global Ministerial Environment Forum 2000).

The Life Cycle Initiative is a response to the call from governments for a life cycle economy in the Malmo Declaration (2000). It contributes to the 10-year framework of programs to promote sustainable consumption and production patterns, as requested at the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg.

UNEP and SETAC worked together for the Life-Cycle Initiative. The goal of the UNEP/SETAC Life-Cycle Initiative is to develop and disseminate practical tools for evaluating the opportunities, risks, and trade-offs, associated with products and services over their whole life cycle

3.1.2. Product LCA Research

LCA first used in the product industry before construction industry. The idea of LCA emerged after the environmental impacts caused by the production of industrial products increased rapidly. The flexibility of the LCA model and its mapping system created an easy tool for monitoring the process.

An LCA practitioner tabulates the emissions and the consumption of resources, as well as other environmental exchanges at every relevant stage (phase) in a product's life cycle, from ''cradle to grave''—including raw material extractions, energy acquisition, materials production, manufacturing, use, recycling, ultimate disposal, etc. (Figure 3.3.). The complete life cycle, together with its associated material and energy flows, is called product system.

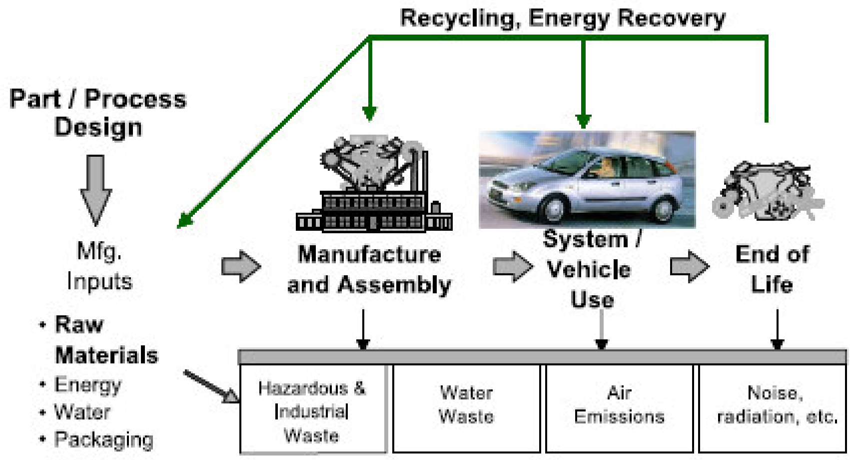


Figure 3.3. Life Cycle of a Car.
(Source: Adams and Smith 1998)

Different countries conduct many projects on the product LCA. The Nordic project on Environmentally Sound Product development (NEP) includes most Nordic countries (Sweeden, Norway) and consists of two parts, namely development of a common structure for a LCA database, and a number of case studies, primarily performed by Swedish and Norwegian companies. In the project, LCA was integrated with systematic product development tools like Quality Function Deployment (QFD) and Life Cycle Cost Analysis (LCCA) (Hanssen 1994, Hanssen 1995,).

The Dutch Milion programme has been somewhat similar in set-up and has been demonstrated for 6 products. It appears that substantial improvements have been implemented, but for reasons of confidentiality, no detailed reports have been published (Christiansen 1995). The Promise programme was formulated in the Netherlands with the experiences from the Eco-design and the Milion project as a background. The main results are a manual for environmental product development (Brezet 1994) and a report for the parliament on how to stimulate environmental product development and improvement. The manual is described as a framework for product development rather than an operational methodology (Christiansen 1995).

In the Danish Materials Technology Programme a methodology for screening potential life cycle impacts during the development of materials and products was developed (Schmidt 1994). The methodology and the accompanying paper database can be used for preliminary calculations of the contribution to global and environmental impacts as well as qualitative screening of potential health and ecological impacts and waste management options. The methodology pinpoints potential hot-spots in the life cycle and gives the basis for comparisons with existing technologies.

The Danish EDIP-project from 1991-1996 involved five Danish companies, in collaboration with the Institute for Product Development, at the Technical University of Denmark. The aim of the project was to give the design team at the companies' access to methods and tools supporting the introduction of environmental criteria in product development. The tools are based on the LCA methodology and supposed to be used interactively between a product developer and an environmental specialist. Detailed criteria and methods for assessment of environmental impacts have been extensively reported (Wenzel 1996 and 1997), and a supporting database has been released by the Danish Environmental Protection Agency.

The Danish QFD-project demonstrates how both customer and environmental requirements can be integrated in product development using the Quality Function Deployment methodology. Important quality and functional aspects are identified via interviews with stakeholders, while the most important environmental aspects are identified using LCA. All aspects are subsequently related to the technical properties of the components in the product, and options for improvements can be analysed taking both environmental and market considerations into account.

The Life Cycle Design Project in the USA resulted in a Life Cycle Design Guidance Manual (Keoleian and Menerey 1993). The core of the project is the framework of formulating five conceptual requirement matrices on environmental, performance, cost, legal and cultural aspects of the design process in relation to the whole life cycle. The formulation, identification and weighting of various design requirements are highlighted as crucial points in a successful project, in conjunction with a well organized environmental management system. The second phase of the project is a number of demonstration projects, the results of which are currently being reported. Further information can be obtained from the U.S. EPA.

As a part of the German research programme "Strategies for Industrial Production in the 21st Century" an iterative screening LCA methodology has been developed and used in product development (Fleischer and Schmidt 1997). The aim of the methodology is to produce results to be useful during product development and to facilitate the communication between the LCA practitioner and the product design team. The starting point is qualitative (or semi-quantitative) information on key issues and subsequent iterations may include selected data or even all data. The system boundaries are enlarged step by step in parallel with the product development, but the level of detail is only increased if it delivers valuable information for the decision making process.

A project in the Netherlands included an LCA for a man's shirt. The retailer who participated in this project was interested in developing an environmentally friendly range of shirts. The results showed that most of the environmental impact occurs during transportation to the retail outlet and during the use phase. For example, washing the shirts at 140°F (60°C) uses twice as energy as washing them at 104°F (40°C). Synthetic or mixed textile fibers are environmentally preferable because they are easier to dry and iron, which further reduces energy consumption.

3.1.3. Life Cycle Assessment in the Construction Industry

Environmental and energy problems have reached a state of significant global importance. These problems are no longer confined to local areas, and do extend across national boundaries. The world has seen the establishment of environmental industry bodies like the US Green Building Council, the UK's Association for Environmentally Conscious Builders, the Australian Building Energy Council and similar organisations in countries like Canada, the Netherlands, Japan and South Africa. Many levels of government now use the International Standard for Environmental Management Systems, ISO 14000, or a local equivalent as a prerequisite for eligibility to tender on building projects and have sponsored many energy efficiency and building-related greenhouse gas programmes. Global research organisations like the Civil Engineering Research Foundation, International Council for Research and Innovation in Building Construction (CIB) and the International Energy Agency have sponsored many research programmes and conferences aimed at creating knowledge that can be applied to mitigating building-related environmental damage. The development of life cycle assessment tools for the environmental assessment of buildings in design, and the availability of environmental performance rating schemes for completed buildings such as the UK Building Research Establishment's BREEAM programme. However, despite the volume of sustainable construction activity and the availability of tools, techniques, information and education, ecologically sustainable building remains far from mainstream practice.

Without considering a LCA model for any construction means not to take into account sustainable issues. Being aware of this fact, researches have initiated their projects based on LCA model. Home Michigan project conducted by Peter Rebbe and his team, was to determine the relationship between material production/construction (pre-use) phase energy, and use phase energy, as energy efficiency strategies are applied to various home systems. It is commonly believed that to achieve higher energy efficiency, more materials are needed in the initial construction. Thicker walls were needed obtain lower thermal conductance properties (i.e., higher R values). More windows of higher quality optimize solar heat gain. Additional internal thermal mass is required to allow for temporary storage of the increased solar heat for release at night. Standard home (SH) is an existing building in Michigan and Energy Efficient House (EEH) is on paper. Four energy scenarios are created for the both design (Table 3.3.).

Table 3.3. Energy Scenarios for home in Michigan.

Scenario	Description of Scenario	Source
1	Natural gas rates remain constant for 50 years Electricity rates remain constant for 50 years	Base Case
2	Natural gas rates decline 1.1 %/yr. from 1998 up to 2010, rises 0.03% /yr. up to 2020. Does not change from 2021 to 2048 Electricity rates decline 1 %/yr. From 1998 up to 2010, declines an additional 0.58%/yr. until 2020. Does not change from 2021 to 2048	EIA DOE70
3	Natural gas rates escalate 4.2 %/yr. from 1998 until 2010. This gives an increase of 63% at year 2010. Annual escalation between 2011 and 2048 assumed to be 1%. Electricity rates escalate 4.2 %/yr. from 1998 until 2010 This gives an increase of 63% at year 2010. Annual escalation between 2011 and 2048 assumed to be 1%.	Wefa Inc.71
4	Natural gas costs $0.721/therm in 1998 and increase annually 1% until 2048. Electricity costs $0.127 $/kWh in 1998 and increase annually 1% until 2048.	German72

The total life cycle energy consumption of SH is 15,455 GJ (equal to 2,525 barrels of crude oil). This figure takes into account the embodied energy of all construction and maintenance/improvement materials, all use phase energy, as well as demolition and transportation energy. SH raw material extraction / production and construction (pre-use phase) energy is 942 GJ or 6.1% of total life cycle energy use, while its use phase energy is 14,482 GJ (93.7%), and its end-of-life phase energy amounts to 31 MJ (0.2%).

The total life cycle energy of EEH in contrast is 5,653 GJ (equal to 927 barrels of oil). Raw material extraction/production and construction (pre-use) phase energy is 905 GJ (16.0%), use phase energy is 4,714 GJ (83.4%) and end-of-life phase energy is 34 GJ (0.6%). EEH life cycle energy consumption is 9,802 GJ less than the SH, which is a reduction of 63% (or 1,598 barrels of oil). Figure 3.4., graphically illustrates the percentage of pre-use, use, and end-of-life phase energy in both SH and EEH.

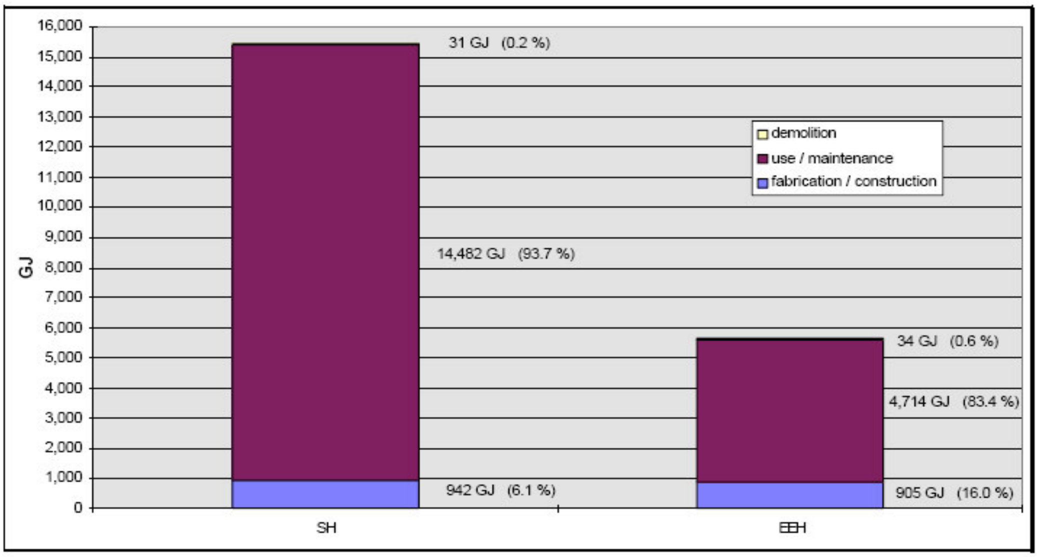


Figure 3.4. SH ad EEH Primary Energy, total life cycle.
(incl. All building materials, appliances, and utility energy consumption).

Another project done by Peter Reppe, a comprehensive case study LCA of a 7300m^2 , six-story building with a projected 75 year life span, located on the University of Michigan campus. An inventory of all installed materials and material replacements was conducted covering the building structure, envelope, interior structure and finishes, as well as the utility and sanitary systems. Computer modelling was used to determine primary energy consumption for heating, cooling, ventilation, lighting, hot water and sanitary water consumption. Demolition and other end-of-life burdens were also inventoried. The primary energy intensity over the building’s life cycle is estimated to be 2.3×106 GJ, or 316 GJ/m2. Production of building materials, their transportation to the site as well as the construction of the building accounts for 2.2% of life cycle primary energy consumption.

Table 3.4. Life span of materials for replacement calculations.
(Source: Scheuer and Reppe 2003)

Component	Years	Component	Years	Component	Years
Concrete foundation	75	Steel air ducts (sheet metal)	75	Wood panelling	75
Structural Steel	75	Duck liner, acoustic	75	Door frames	75
Fire proofing for structural steel	75	Pipe, copper	75	Interior column covers	75
Steel stairs	75	Sewer pipes	75	Stone, base material, interior	75
Face brick	75	Pipe, black steel	50	Drywall (gypsum board, steel studs)	75
Concrete masonry units (CMU)	75	Pipe, cast iron	50	Ceramic floor tile	75
Waterproofing, foundation walls	75	Pipe, PVC	50	Wooden doors	50
Thermal insulation	75	Restroom sinks	50	Metal doors	50
Floor slabs on steel deck	50	Urinals	50	Toilet compartments (stainless steel)	50
Hollow core plank, exterior wall	50	Toilet fixtures	50	Treatment of wood panelling	35
Hollow core plank, floors	50	Sprinkler system pipes	50	Joint sealer	25
Curtainwall, A1 panels	40	Elevators	40	Acoustical wall panels	20
Curtainwall, glazing	40	Radiators (base board)	40	Ceiling tiles	20
Operable A1 frame windows	40	Phone and data wiring (copper)	25	Raised rubber tile	18
Stone, exterior steps	40	Sprinkler heads	25	Sheet vinyl	18
Roofing insulation	40	Fan coils	20	Vinyl composition tile (VCT)	18
EPDM single ply roofing	35	Air-handling unit, roof	20	Carpet (tile and broadloom)	12
Exterior brick pavers	30	Shower tubs	20	Paint on drywall	5
Water proofing dock	20	Faucets, sink	20		
		Faucets, shower	20		
		Flush valves, urinal	20		
		Flush valves, toilet	20		

Peuportier from Ecole des Mines de Paris, developed a life cycle simulation tool and linked with thermal simulation. Inventories given in the Oekoinventare database or collected in the European REGENER project are considered to evaluate the environmental impacts of material production and other processes like energy, transport, etc. A typical house, corresponding to the present construction standard in France and named reference house, has been defined in the frame of a workshop organised by the French ministry of dwelling (Plan Construction et Architecture) and is considered here. Information from the national statistics institute (INSEE) has been used to identify the most common techniques. A typical plan has been defined by an architect, a single family house with 112 m2 living area. The walls are made of concrete blocks with an internal insulation layer (8 cm polystyrene) and 1 cm gypsum plastering. The 12 cm thick gravel concrete slab lays upon 6 cm polystyrene. The upper ceiling is covered with 20 cm mineral wool, under a clay tiles roof. The PVC frame windows are double glazed (overall K-value: 3 W/m2/K).

The house's ventilation is mechanical (0.6 air change/h) is heated by a gas boiler and the heating consumption is around 8000 kW h per year (i.e. 70 kW h/m2 per year). A comparison of houses designed according to the thermal regulation in different countries would be very interesting, but should take into account investment and functioning costs in various social and climatic contexts. The characteristics of the three houses are summarised in Table 3.5.

Table 3.5. Main characteristic of the three houses.

Main characteristic of the three houses			
Parameter	**Reference house**	**Observ'ER house**	**CNDB house**
Parameter	Concrete blocks and 8cm internal insulation (polystyrene)	Wooden frame above a Stone lower part with 12cm paper flocks insulation	Wooden frame with 20cm mineral wool insulation
Wall composition	Concrete blocks and 8cm internal insulation (polystyrene)	Wooden frame above a Stone lower part with 12 cm paper flocks insulation	Clat tiles and 20 cm mineral wool
Roof composition	Clay tiles and 20cm mineral wood	10cm polystyrene under a vegetal terrace roof	30 cm concrete slab upon 4 cm polystyrene
Slab composition	12cm gravel concrete slab upon 6 cm polystyrene	13 cm concrete slab upon 4 cm polystyrene	Standard double glazing
Glazing type	Standard double glazing	Standard double glazing	Standard double glazing

According to the purpose of the study, it may be more relevant to consider 1 m2 living area as the functional unit rather than the whole house. The following comparative ecoprofile is then obtained (Fig. 3.5).

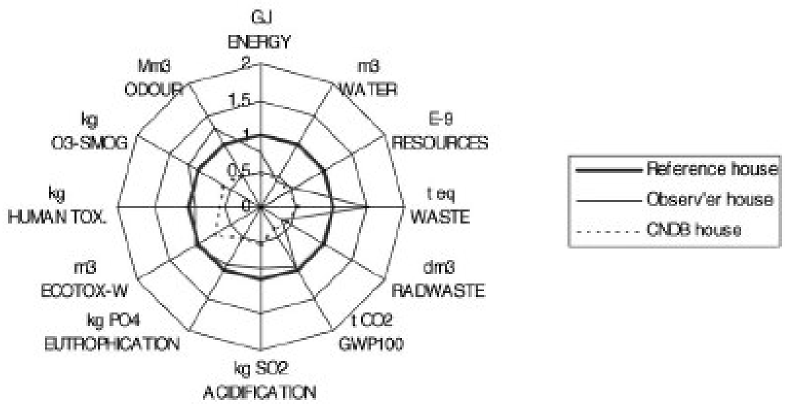


Figure 3.5. Comparative ecoprofile of 1m2 living area for the three houses.

The environmental impacts estimated for the standard wooden frame house are about half the reference values. It would have been rather easy to achieve equivalent thermal insulation in the solar house, leading to a much better environmental performance.

A sensitivity study has then been performed concerning the choice of materials (wood versus concrete blocks), the type of heating energy (gas versus electricity) and the transport distance of the wood (local production with 100 km transport by truck versus 5000 km transport by ship plus 500 km transport by truck). It is not possible to present detailed results here, and we just illustrate this comparison using the global warming indicator during construction and use phases. Assuming a 100 km transport by truck for all materials, transport-related equivalent CO2 emissions represent only 1.5% of the total. If the wood is transported over a longer distance (5000 km by ship and 500 km by truck) the total transport related contribution increases to 2.4% of the global life cycle CO2 emissions, which remains limited.

This project presents the results of a partial life cycle environmental assessment (LCA) of three alternative designs of a custom 2400 sq. ft. single-family home. The analysis was conducted using the Athena decision support software tool developed for architects and building designers.

The project addresses some of the practicalities and key data issues to be considered when applying LCA methods to whole buildings and building systems, and stresses the importance of ensuring comparability and equitable treatment of different materials and products through the use of accepted research protocols and transparent research processes.

Gong Xing Wu, Zhihui Zhang and Yongmei Chen from Tsinghua University's Department of construction Management conducted the study of the environmental impacts based on the 'green tax' – applied to several types of building materials. The study presents a method using building materials' environmental profiles to assess their environmental impacts based on the LCA framework. The 'green tax' including the pollutant tax and resource tax is the shadow price modified if the local special preference is considered. The final assessment result produced by this method represents the social willingness-to-pay for the environmental impacts of the building material.

The studies of Martin Erlandson from the IVL Swedish Environmental Research Institute proved that the environmental damage at the buildings and public housings can be reduced with by the help of LCA. The reasons for selecting the method of LCA are discovering the different possibilities that may be found in the scenario and proving that the construction is totally sensitive to the environment. As a result of the case studies, building's effect on the environment has reflected a benefit of 70 percent to the general heating system and 75 percent appraisal to the waste water.

The built environment affects human's body and mental health. The built environment occupies a particularly significant position in sustaining and improving the quality of life, by virtue of its role in producing the infrastructure (for example, roads, bridges, buildings) required for meeting growing human needs for food, transportation, energy and shelter. A great challenge for researchers and practitioners is the development of products, systems, methodologies and organisational arrangements that can be used to respond to the challenges of sustainability. Despite efforts made thus far to address sustainability-related issues in the built environment, there have been only limited achievements.

Thus, there is a need for more construction related research on environmental issues, especially as buildings become more efficient. It will beneficial for the society to use an observation method like LCA for the built environment. Such research should typically span the entire building life cycle.

A case study of a dwelling home in Scotland, a project provides a LCA of a three bed room semi-detached house in Scotland. Detailed LCA of a five main construction materials wood, aluminium, glass, concrete and ceramic tiles have been provided to determine their respective embodied energy and associated environmental impacts. Concrete, timber and ceramic tiles are the three energy expensive materials involved. Concrete alone consumes the total embodied energy, 147, 900 MJ that makes

65% of the home while its share of environmental impacts is even more crucial. The other two expensive materials are timber (30,000 MJ) and ceramic tiles (32 240 MJ). The results indicate that concrete and mortar are responsible for 99% of the total CO2 resulting from the home construction.

In previous researches conducted on residential units, it is necessary to consider indicators if it is wanted to assess the performance of the residential units. Indicators such as energy, material, management of waste, water use, transportation should be among the assessment and the order of them should be assessed based on LCA.

3.2. Building LCA Software Tools

If one to use *LCA* method in the built environment, it is certain that there are many data to classify thoroughly. The evaluation process should include nearly 60 years of forecasting for life span of the examined building and should involve acceptable solutions for environmental impacts, energy and resource depletion. In order to complete a productive inventory, the comprehensive software program is required, with valid databases. However, there are many software programs in the market, prepared by international research institutions with the support of government or private capitals.

Two categorisation systems for LCA softwares are created by ATHENA institution and Royal Melbourne Institute of Technology (RMIT). ATHENA developed a four category system; (1) Product comparison tools and information sources (2) Whole building decision support tool (3) Whole building assessment frameworks, (4) Supoort tools and techniques.

RMIT developed six category system which covers most of the softwares in the field. For this study, RMIT's classification method is used because of the comprehensive approach of the categorisation.

RMIT research centre in 2001, conducted a project title "Greening the Building Life Cycle: Life Cycle Assessment and Tools" is supported by Environment Australia. The project was to assess the status of LCA tools in the building and construction sector and to develop strategies to improve the uptake and use of these tools. This project aimed to improve of the environmental performance of the building and construction sector, by promoting LCA as a tool to assess the environmental impacts of building materials and building systems in Australia (WEB_9 2003). Instead of creating a new software categorization, LCA softwares will be evaluated using RMIT categorisation system.

Table 3.6. RMIT LCA Tool Categorisation.

RMIT LCA TOOL MATRIX	**1. Detailed LCA Modelling Tools**	SimaPRO, TEAM, GaBi, The Boustead Model, ATHENA,BEES)
	2. LCA Design Tools	EcoScan, Envest UK, ECOit, LCAit
	3. LCA CAD Tools	LCAid, Equer, PAPOOSE, EPCMB
	4. Green Product Guides and Checklist	EPM, BREEAM, LEED, BEPAL, Green Housing, Eco Specifier
	5. Building Assessment Schemes	GB Tool
	6. Embodied Energy- Input/Output	Carnegie Melon web based I/O model,

The Centre for Design at Royal Melbourne Institute of Technology (RMIT) decided to lead a project to assess the status of LCA software tools in the building and construction sector and to develop strategies to improve the uptake and use of these tools. It was commissioned by Environment Australia., aimed to improve of the environmental performance of the building and construction sector, by promoting LCA as a tool to assess the environmental impacts of building materials and building systems in Australia. The project is completed in 2001. According to RMIT, LCA Software programs can be classified in to six different categories (Table 3.6.).

3.2.1. Detailed LCA Modelling Tool

The importance of including environmental considerations when selecting building materials has lead to many initiatives to develop systems that support this need. A basic requirement is whether a system is capable of recommending one material alternative as better than another material. The comparisons are based on four aspects, environment, economy, building process, and user functionality.

In Burie Priemus' book published in 1978, a distinction is made between roles and participants in the building process. Burie Priemus distinguishes four roles; administrator, sees to regulations and planning at the higher levels of scale within environmental concern; builder, the responsibility after the initiation of the building work; the client and designer, involved in decisions that are taken in drawing up the plans.

Designer can assess and control overshadowing, shading device requirements, solar access, natural and artificial lighting levels, prevailing wind exposure, thermal comfort and the acoustic response of their building. In conjunction with this technical data, BREEAM (UK) The Building Research Establishment Environmental Assessment Method is a tool that allows the owners, users and designers of buildings to review and improve environmental performance throughout the life of a building. ATHENA (Canada), Sustainable Materials Institute world-leading source of data, expertise and tools for designing buildings with the environment in mind.

Detailed LCA Modelling Tools are SimaPRO (Netherlands), TEAM (France), GaBi, The Boustead Model (UK), ATHENA, BEES (USA).

SimaPro software, first released in 1990, stands for *"System for Integrated Environmental Assessment of Products"*. It is not only used for product assessment; its generic setup means use has expanded to analysis of processes and services. Currently, version seven is released (WEB_10 2004).

Table 3.7. Description of SimaPRO Software.

name	company / address	characteristics
SimaPro	Pré Consultants BV C/o Mr. Hes Plotterweg 12 NL-3821 BB Amersfoort, Netherlands +31-33-4555022 info@pre.nl http://www.pre.nl/simapro.html	**price:** 4800 NLG (single user), 9600 NLG (network version)
		structure: standalone, network version available
		functionality: standard; rigorous integration of impact assessment, only a few reports for the inventory available
		database: medium, data taken from Buwal 250, PWMI, ETH, Chalmers, TU Delft; lots of data is adapted to the Netherlands
		users: more than 300, e.g. Philips, Heineken, Unilever, Sony, Samsung, Motorola, ABB etc.

The SimaPro database is one of the more comprehensive ones. Compared with those supplied in other LCA software packages, the database on processes for production of commodity materials is more comprehensive and includes a greater variety of processes associated with non-packaging related materials. All of the embedded data are fully referenced as to their source and there are limited qualitative descriptions of data sets that are considered to be old or weak. No other formal data quality assessment procedures are used. All of the data (with a very few minor exceptions) are for European or more specifically Dutch conditions. The data are primarily secondary in nature, especially those for general European conditions, but there is a significant amount of data from specific LCA studies.

Table 3.8. Databases SimaPRO software uses.

Database	
EcoInvent	The ecoinvent database contains up-to-date and consistent life cycle inventory data for 2500+ processes. It is the only database that consistently includes uncertainty data. Ecoinvent is fully integrated in SimaPro, which has all the features to get the most out of this unique database.
ETH-ESU 96	Energy. Electricity generation and related processes like transport, processing, waste treatment. Includes 1200 unit processes and 1200 system (results) processes
Dutch Input Output database	Economic Input Output database, for us on it own or in hybrid LCA studies. Starting point was an overview of how the average consumer distributes its spending over 350 categories, such as buying tomatoes, driving to work and maintaining the garden. A link was made between these categories and the economic sectors. Introduced foreign input output tables for the OECD and non OECD regions. This allows the users to trace the impact of goods produced outside the Netherlands.
Danish Input Output database	The IO-database for Denmark 1999 is available as a part of the standard database that comes with the SimaPro software. The full documentation of this database can be found in B P Weidema, K Christiansen, A M Nielsen, G A Norris, P Notten, S Suh, J Madsen. (2005). Prioritisation within the integrated product policy. Environmental project no. 980. Copenhagen: Danish Environmental Protection Agency.
LCA food	The present site provides input/output data on processes in the food sector (process data) and environmental data on food products (product data). The site is linked with a database in the LCA software SimaPro
Industry Data	Inventory data provided by industry assocations. Mostly cradle to gate data.
IDEMAT 2001 database	Engineering materials (metals, alloys, plastics, wood), energy, transport.
FRANKLIN US LCI database	North American inventory data for energy, transport, steel, plastics, processing.
Data archive	Materials, energy, transport, processing, waste treatment.
Dutch Concrete database and wizards	Dutch data related to all aspects of concrete production and use. Can be used in combination with Wizards. Data and wizards are in Dutch.
IVAM 4.0 database	Materials, transport, energy and waste treatments. Mostly focused on Dutch data.
FEFCO database and wizards	European data on corrugated board production, partially based on BUWAL 250. Includes extensive wizards to model the production and life cycle of corrugated board.

Table 3.9. Benefits of SimaPRO Software.

BENEFITS	Hybrid LCA with input-output databases
	Monte Carlo Analysis: A calculation is repeated many times, each time choosing a different value for each parameter.
	Parameterized models can be analyzed with a scenario analysis.
	Analyze complex waste treatment and recycling scenarios.
	Full transparency: trace results back to their origins.

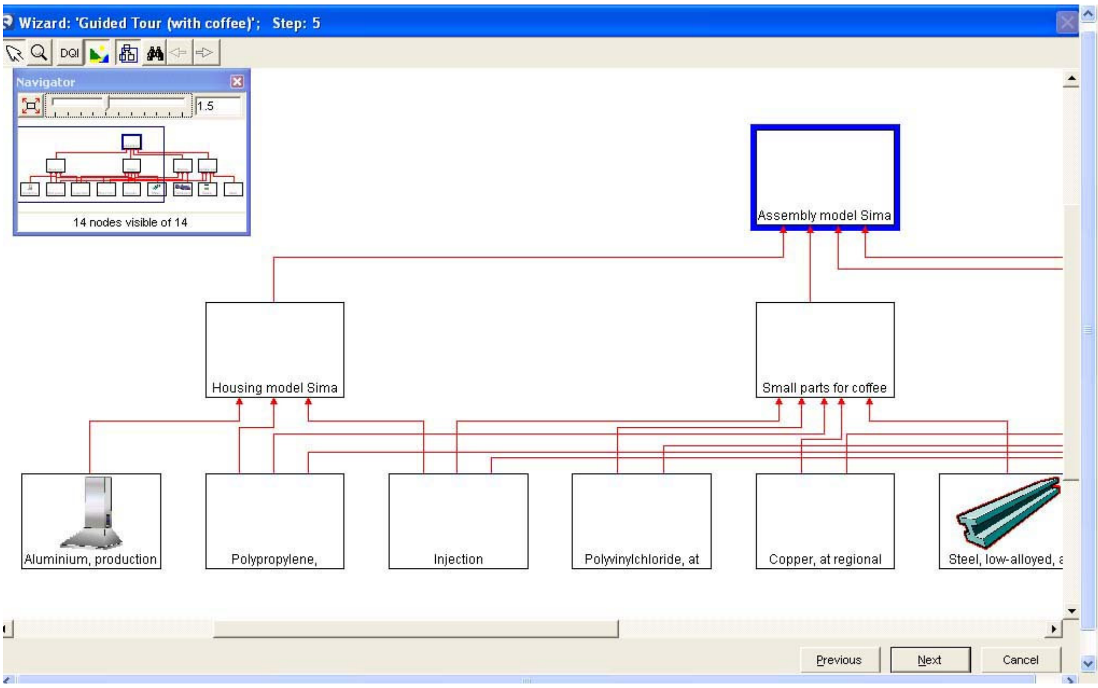


Figure 3.6. SimaPRO Interface example
(Source: SimaPRO Demo)

The second software in the list, The TEAM, consists of an integrated suite of software tools including modelling tools used to describe physical operations. It allows the use to build a large database and to calculate the Life Cycle inventories for complex systems. The main principles of this tool are flexibility, modularity, a high potential for evolution. The package includes database the DEAM (Data for Environmental Analysis and Management).

Table 3.10. Description of TEAM Software.

Name	company / address	Characteristics
TEAM	Ecobilan Group c/o Mr. Hockerts Immeuble Le Barjac - 1, Boulevard Victor F-75015 Paris, France +33-153-7823-47 kai.hockerts@ecobilan.com http://www.ecobalance.com	**price:** list prices between 50000 FF (annual license) and 100000 FF (indefinite license).
		structure: standalone, virtual client server installation using Objectstore
		functionality: sophisticated
		database: very large, additional data available, Ecobilan assists user by mediating between the user and third party data owners
		users: more than 100, e.g. BMW, Volkswagen, Xerox, Ford, Chrysler, General Motors etc

Model contains ten categories within which are contained 216 individual data files for product and material production, energy generation and transportation. The ten categories are as follows: 1) pulp and paper; 2) petrochemicals and plastics; 3) inorganic chemicals; 4) steel; 5) aluminium; 6) other metals; 7) glass; 8) energy conversion; 9) transportation; and 10) waste management. Within the full program the source of data is indicated; data quality indicators (i.e., geographical representation technology used and date of data) are available. Further data quality indicators are not discussed. User defined input data fields, as well as database editing, are fully supported by the system. Units are defined by the user and can be in any system.

Two levels are used in TEAM, the database level and the calculation level. Within the database level, information representing unit operations (processes, transport etc.) are stored in independent Modules. In the calculations level the system is developed into which flow the Modules data. Within the system, nodes represent process steps. Nodes can be linked and grouped to represent subsystems, and subsystems can be linked to create the total system. Closed loop and recycling inputs/outputs can be defined within a node by the user. Formulas from the package or created by the user can calculate various inputs and outputs within the system. This use of formulas and variables allows the development of a dynamic system which facilitates sensitivity analyst. There is no limit to the number of nodes and linkages possible within TEAM.

Table 3.11. Benefits of TEAM software.

BENEFITS	- Systems and sub-systems can be defined as modules, allowing highly detailed and complex systems to be simplified.
	- Inventory calculations can be propagated from anywhere within the system;
	- Allocation rules can be defined within the lowest process/unit level for any flow;
	- The various data protection and data access levels allow easy maintenance of data integrity;
	- A networking version of TEAM_ is also available which offers multiple remote access to a single system.

Flows represent the elements (materials, emissions or energy) that enter or leave a system. They can be included in the inventory of a system. They correspond to the physical objects that are used as inputs or produced as outputs of industrial operations. To be included in a module as input, output or energy indicators, these flows must be present is the master flow list, with the following properties defined: name (e.g., CO2), unit (e.g., grams), visible/non visible, information fields and physical properties.

Table 3.12. Examples of flows.
(Source: http://www.ecobalance.com)

Flows
Raw materials: crude oil, coal, iron ore, bauxite, limestone, water, etc.
Indicators for energy consumption
Intermediate products: naphtha, ethylene, aluminium coil, etc.
Air emissions: CO2, CO, NOx, etc.
Water effluents: total dissolved solids, COD, nitrates, chlorides, etc.
Wastes: toxic, inert, etc.
Products and co-products
Financial flows: operating cost, capital equipment cost, etc.

Flows can be modified at any time and can also be deleted, provided that no module uses them as an input, output or energy indicator (Table 3.12.).

TEAM's graphical interface makes the creation of systems and sub-systems simple. An 'infinite' number of systems can be built, with the only limitation being the memory and speed of the computer. The hierarchical organization of the system and sub-systems is presented graphically in the form of a tree.

A decomposition approach is used to develop the skeleton of the model. This skeleton is filled out with modules that describe the operations occurring inside the system (e.g., a heating system needs a module for the transportation of the fuel and a module for the production of heat).

Limitations of TEAM include the lack of support for user-defined weighting factors for impact assessment and the limited (only one parameter between two Inventories) comparison of results capabilities as a feature within the software tool.

GaBi is a professional software system designed for life cycle engineering and life cycle assessment that was developed by IKP (University of Stuttgart) together with PE Europe GmbH since 1992.

The database includes eight hundred different energy and material flows. Ten generic process types which contain four hundred specific industrial processes are also included in the database. The 10 process types include industrial processes, transportation, mining, power plants, transformation processes, servicing, cleaning, repairing, wear, and processes of reduced consumption. Flows are contained within these process types. Multi-functional dialogue boxes allow user to input and edit data and comments as desired (not clearly demonstrated). Besides common process data from around the world, the database consists of special data from IKP research and cooperation with industrial companies from different sectors in Germany.

Table 3.13. Description of GaBi software.

name	company / address	Characteristics
GaBi 3.0	PE Product Engineering GmbH c/o Mr. Stichling Kirchheimer Str. 76 D-73265 Dettingen / Teck, Germany +49-7021-98001-13 j.stichling@pe-product.de http://www.pe-product.de	**price:** 3200 DM (lean), 12200 DM (professional)
		structure: standalone, developed with Delphi
		Functionality: highly sophisticated; very convincing Windows95-like user interface
		database: large, mainly manufacturing and car industry, - material inventories- manufacturing processes-transportation - impact categories – normalization and evaluation methods.
		users: more than 150, e.g. Alcan, Bayer, DaimlerChrysler, DuPont, EBARA, EMPA, Febe Ecologic, General Motors, GLOBAL & LOCAL Motorola, Nokia, Norwegian University of Science and Technology, Öko-Institut Freiburg, Rio Tinto Siemens, Solvay, Sydney Water, Timberland, Unilever, University of Tokyo, University Hamburg, Biozentrum Holzwirtschaft , IPL University Kassel Volkswagen, Wuppertal Institut

Table 3.14. The Benefits of the GaBi..

BENEFITS	Transparency and flexibility
	Up-to-date and extensive databases & data warehouse
	Scenario calculation and sensitivity analysis by parameter variation
	LCA includes ISO 14040 assistance

The *Boustead Model* is a computer modelling tool for *lifecycle inventory calculation*. The Boustead Model's database is divided into two parts as shown in Figure 3.10. The first of these called the Core Data, contains data for more than 33 300 unit operations, which include fuel production and processing operations for almost every country, as well as over 6000 materials processing operations. The second part of the database, called the Top Data, has space for 6000 unit operations. The *Boustead Model* is frequently updated and adequate customer support.

Table 3.15. The Description of the Boustead Model.

name	company / address	characteristics
The Boustead Model	2 Black Cottages, Worthing Road, West Grinstead, Horsham, West Sussex, Great Britain RH13 7BD	**price :** $24,000 initial lease; renewal negotiable. Expert users in general, although model are generally straight forward to operate; typically the model has been supported by a trained user within the leasing organization.
		structure: DOS prompt
		functionality: the printing of a proforma questionnaire for the data collection process
		database: Includes extensive data modules for energy carriers, fuels production and transportation. Unit operations data represent a mixture of U.K., general European, and U.S. conditions.
		users: unknown

ATHENA Sustainable Materials Institute[15], has developed a worldwide reputation in the field of sustainable building and life cycle assessment. It is non-profit organisation, offers a consulting services modified to meet a client's needs in a cost-effective manner. One of the Institute's main thrusts has been the development of comprehensive, comparable LCA databases for building materials and products. The ATHENA databases cover 90 -95% of the structural and envelope systems typically used in both residential and non-residential buildings. The Institute has also developed databases for energy use and related air emissions for on-site construction of a building's assemblies, for maintenance, repair and replacement effects through the operating life, and for demolition and disposal.

ATHENA software is a whole building, life cycle based environmental assessment tool, developed by the ATHENA Sustainable Materials Institute in Canada that assists architects, engineers, product specifiers and policy analysts to compare the relative environmental effects among alternative design solutions over the expected life of a building. The software enables users to describe a building in architectural terms, and then provides LCA-based environmental evaluations of alternative designs and material choices, tailored to the specific building design under consideration. Manufacturers can use the model to benchmark processes and assess the environmental effects of alternative technologies or production processes. ATHENA allows comparisons of conceptual building designs in a holistic, life cycle framework. The benefits of ATHENA software are given in Table 4.2.

[15] www.athenasmi.ca

Table 3.16. The benefits of ATHENA software.

	Comment
BENEFITS	the ability to model the building's complete structure and envelope (claddings, insulation, gypsum wall board, and roofing and window systems
	over 900 possible assembly combinations
	the ability to model maintenance and replacement life cycle effects based on building type, location and a user defined life for the building
	a calculator to convert operating energy to primary energy and emissions to allow users to compare embodied and operating energy environmental effects over the building's life (requires a separate estimate of operating energy as an input)
	an "end-of-life" module, which simulates demolition energy and final disposition of the materials incorporated in a building

Whole building LCA software tool ATHENA is chosen to assess the residential units in Izmir. During the selection process, there were issues like the cost of the software program, strong technical support, available assistance, and being suitable for the current study. ATHENA received positive points.

There are four stages for ATHENA software to work (Table 4.25.). All data should be collected before running the software program. For instance, in the first stage, the general description and operating energy use of the project are filled in the program. Then, all the building assemblies used during the construction can be added. In the third stage, the data tables can be produced for further evaluation. Finally, the forth stage where the absolute value tables are created with the comparison of different projects.

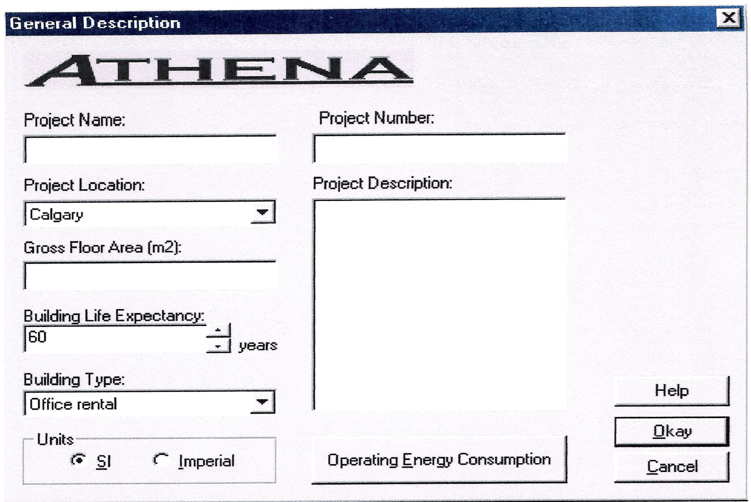


Figure 3.7. General description modify window
(ATHENA Original Version)

The Operating Energy Consumption button opens another window and allows the user to input annual operating energy for the building by fuel type (Figure 4.2.). The model takes this energy information and converts it to primary energy and calculates related emissions to air, water and land. Later the user may then compare and contrast embodied and operating energy and emissions within and between projects.

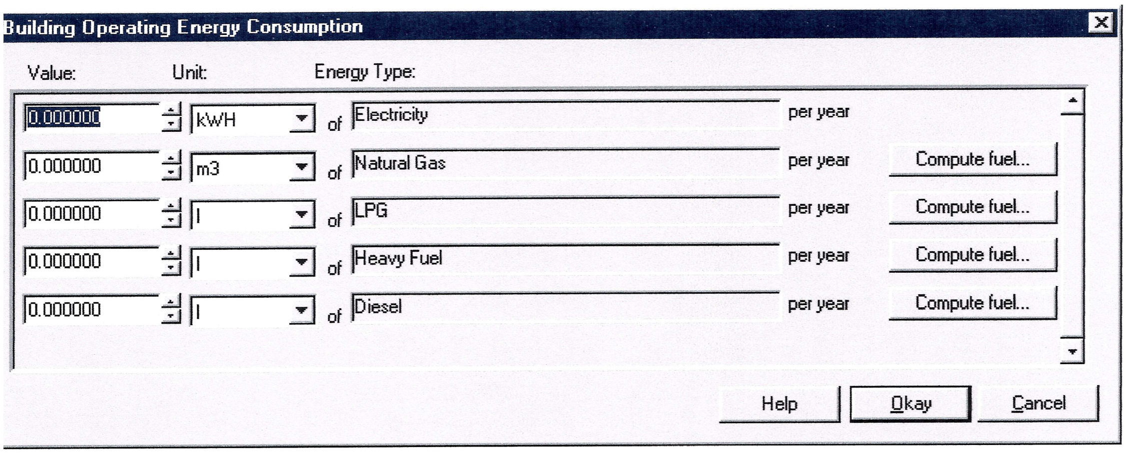


Figure 3.8. Building Operating Energy Consumption modify window
(ATHENA Original Version)

Modify window for wall assembly operates from Review /Modify button in the ATHENA main menu. The Add assembly item on the menu and a listing of various assembly types will appear to the right of the Insert menu item.

The model then opens the "Add Walls" dialogue box and by clicking on the pop-up menu you can scroll through the complete wall assembly menu until the user locates the wall assembly desired (Figure 3.9.).

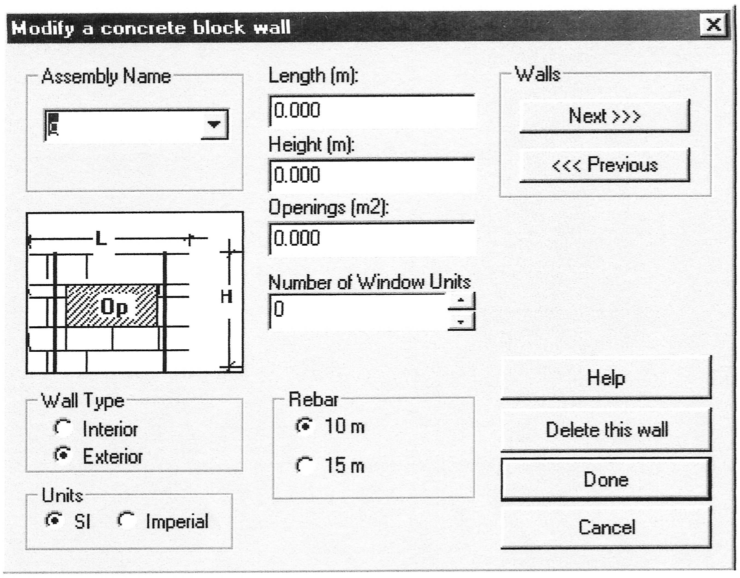


Figure 3.9. Modify window for a concrete block wall
(ATHENA Original Version)

Then a "Add a concrete wall" dialogue box opens and a descriptive schematic appears in the box showing all the input dimensions of interest for the wall (Figure 3.10.). The flashing cursor will automatically be placed in the "Assembly Name" box. Each assembly must be given a unique name, otherwise no data input is possible.

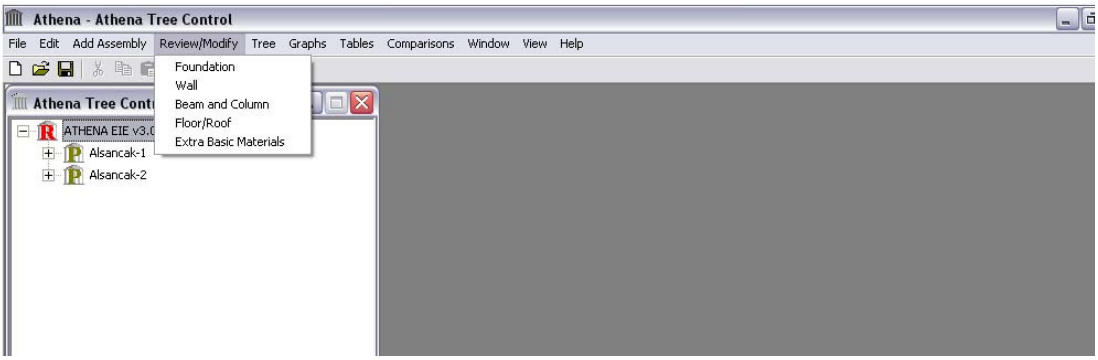


Figure 3.10. Review and Modify Assembly window
(ATHENA Original Version)

ATHENA is equipped with a separate utility for comparing the results of two or more project designs across the six summary measures. All ATHENA results are compiled and accessed at the project level. When the user click on "Compare Projects", a “Compare Summary Measures" dialogue box will appear as show as in Figure 3.11.).

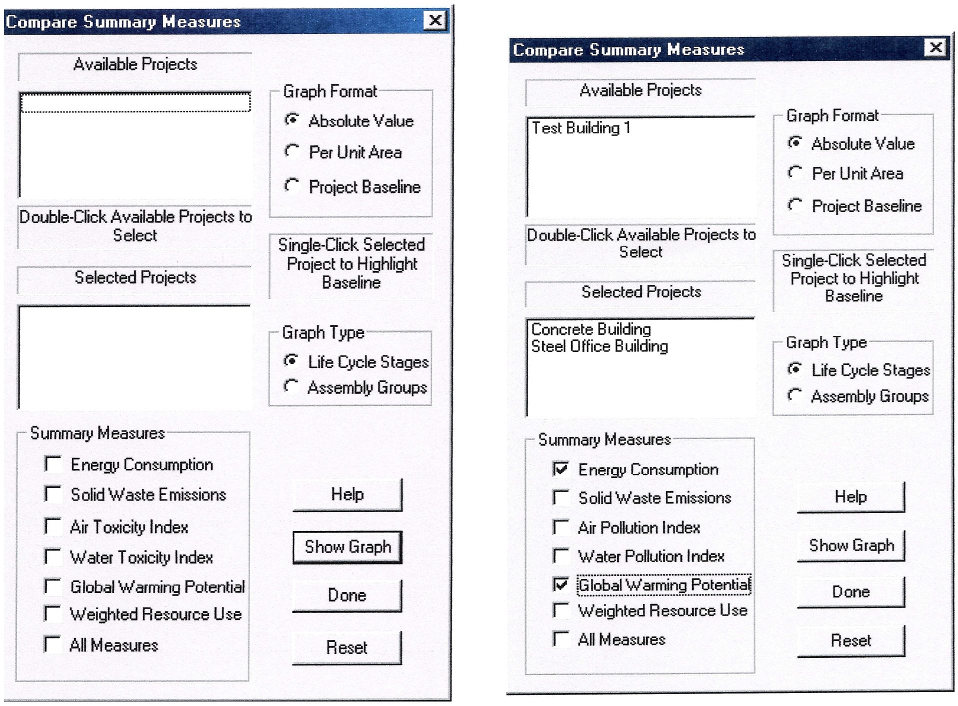


Figure 3.11. Comparing Summary Measures
(ATHENA Original Version)

The "Compare Summary Measures" dialogue displays all open project files in the "Available Projects" list box. When the user selects the "Graph Type" by clicking on the “Show Graph” button and choose a "Graph Format" (e.g., Absolute Value, Per Unit Area or Project Baseline), the absolute value graph compares the two designs by showing their respective actual summary measure results. The per unit comparison graph displays the results as a function of the design areas (in the units as entered for floor area within the General Description dialogue box, when the project was created). The Project Baseline displays results on a relative percent basis using one design as the reference case.

It is also possible to compare two or more projects across all six summary measures in a single graph. The "All Measures" box followed by the "Show Graph" button and a single graph will appear showing how each "Project" compares to the selected baseline project on a relative logarithmic scale basis (Figure 4.12.).

Fifth building software, The *Building for Environmental and Economic Sustainability* (BEES), is developed by the NIST (National Institute of Standards and Technology) in 1994 with support from the U.S. EPA Environmentally Preferable Purchasing Program.

Table 3.17. The description of BEES software.

name	company / address	Characteristics
BEES	Ecobilan Group c/o Mr. Hockerts Immeuble Le Barjac - 1, Boulevard Victor F-75015 Paris, France +33-153-7823-47 kai.hockerts@ecobilan.com http://www.ecobalance.com	**price:** list prices between 50000 FF (annual license) and 100000 FF (indefinite license).
		structure: standalone, virtual client server installation using Objectstore
		functionality: sophisticated
		database: very large, additional data available, Ecobilan assists user by mediating between the user and third party data owners
		users: more than 100, e.g. BMW, Volkswagen, Xerox, Ford, Chrysler, General Motors etc

The purpose of BEES is to develop and implement a systematic methodology for selecting building products that achieve the most appropriate balance between environmental and economic performance, developed by the NIST (National Institute of Standards and Technology) Green Buildings Program with support from the U.S. EPA Environmentally Preferable Purchasing Program.

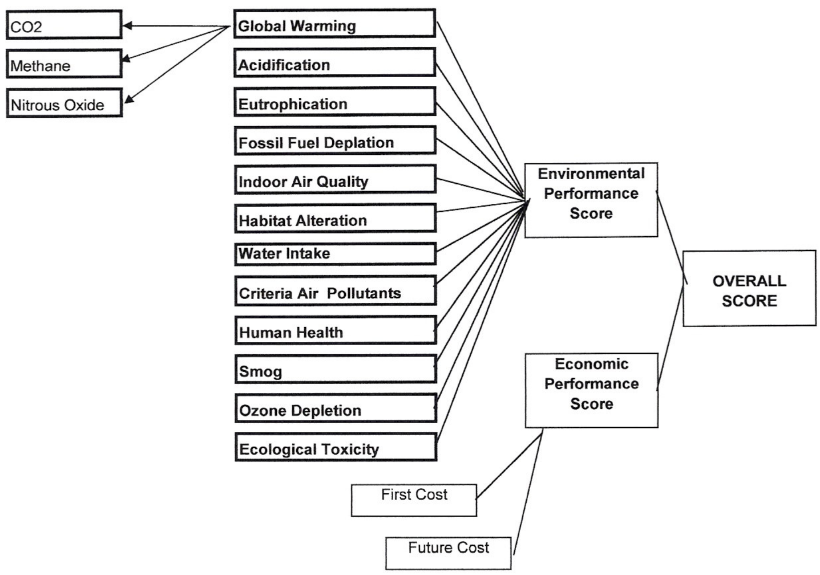


Figure 3.12. BEES 3.0 Model
(Source: BEES Demo Package)

The method was aimed at designers, builders, and product designers. The use of the *BEES* system requires no knowledge of environmental science or the different material properties. A user that is familiar with the terms of environmental effects, indoor air quality would find the method more useful. *BEES'* measures the environmental performance of building products by using the *life cycle assessment* approach specified in *ISO 14000 standards*.

3.2.2 LCA Design Tools

EcoScan is a software tool for analysis of the environmental impact of products or product concepts. All life cycle phases of a product (like production, usage and disposal) can be taken into account. Beside the environmental impact, EcoScan is able to take cost figures into account enabling the user to maximize the environmental profit per Euro.

Table 3.18. The benefits of EcoScan.

BENEFITS	Automatic disposal mode is available.
	Calculated components can be stored for instant re-use.
	Comparison of various products in a single graph.
	Functional unit can be used for automated calculations and graphs. Context sensitive help.
	Tool tips for providing background information. These can be defined by the user as well.

Envest UK, developed with support from DETR, has been designed to simplify the process of designing environmentally friendly buildings. Designers input their building designs (height, number of storeys, window area, etc) and choices of elements and then can calculate their impact and compare it to improvement options.

The environmental impacts of construction encompass a wide range of issues, including climate change, mineral extraction, ozone depletion and waste generation. Assessing such different issues in combination requires subjective judgements about their relative importance. For example, is a product with a high global warming impact that does not pollute water resources giving less overall environmental impact than a product that has a low global warming impact but produces significant water pollution? To enable such assessments, BRE have developed Ecopoints. Each environmental issue is measured using its own unit, for example BRE measure mineral extraction using tonnes of mineral extracted and climate change in mass of Carbon Dioxide equivalent. Using these impacts, it is hard to make any useful comparisons. However, by comparing each environmental impact to a "norm", each impact can be measured on the same scale. BRE have taken as their norm, the impacts of a typical UK citizen, calculated by dividing the impacts of the UK by its population.

Working closely with Bennetts, BRE used Envest to produce an environmental assessment of the building elements based on the initial design. The results were presented in terms of Ecopoints, a single composite rating which allows the designer to compare different designs and specifications directly.

Elements examined ranged from the frame to roof cladding. This allowed the design team to see which element of the building had the most adverse impact on the environmental performance. As the building design was firmed up, the focus turned to ECO-it is a tool for product and packaging designers. Designers often work under time pressure, and cannot be expected to be environmental experts. With ECO-it, the designers can work without detailed environmental knowledge.

ECO-it uses Eco-indicator scores to express the environmental performance of a product's life cycle as a single figure. These scores are calculated using the Eco-indicator methodology. This method is based on the principles of Life Cycle Assessment.

ECO-it comes with over 200 Eco-indicator 99 scores for commonly used materials such as metals, plastics, paper, board and glass as well as production, transport, energy and waste treatment processes. These scores are like predefined building blocks to model the life cycle of your products. 100 Eco-indicator 95 scores are also included.

ECO-it allows you to model a complex product and its life cycle in a few minutes. ECO-it immediately calculates the environmental load, and shows which parts of the product contribute most. Based on this information you can target your creativity to reduce the environmental load of the product.

Designers now have a yardstick to measure the environmental performance of a product. Most environmental information is confusing and often fragmented. With ECO-it designers have a tool to really measure and optimize the environmental performance of products in the design phase.

3.2.3. LCA CAD Tools

LCA CAD Tools provide environmental impact and embodied energy information through CAD design & documentation tools.

LCAid is computer software developed by DPWS Environmental Services with computer programming by Dr. Andrew Marsh of the University of Western Australia's, Department of Architectural Science and LCAid input from Murray Hall of Life Cycle Design. Essentially, LCAid takes LCA information, which until now has been limited to LCA specialists, and makes it more accessible to other practitioners (eg. architects, engineers, and portfolio managers) to make environmental assessments.

It is aimed at the building designer, LCA practitioner, LCA researcher or building rating practitioner (Green Building Challenge) as a user-friendly decision-making tool for evaluating the environmental performance and impacts of designs and options over the whole life cycle of a building/object/system.

LCAid arose from the need to provide a fast, comprehensive and scientifically based environmental assessment of buildings, which can also be used to assess any other system or object. This speed would overcome the cumbersome nature of using the specialist LCA Boustead model or similar LCA software.

LCAid is a decision making tool which uses the methodology of Life Cycle Assessment to evaluate the environmental performance and to identify the largest environmental impacts over the whole life cycle of a building, development, system or object. It is expected that LCA work that took 1-2 weeks can now be done in less than 15 mins (having a bill of quantities or 3-D CAD model).

LCAid assists environmental decision making in the initial phase of building design as well as providing a benchmark of building performance at the completion. It is also envisioned that LCAid will become a tool for international design/assessment frameworks such as the Green Building Challenge Tool 2000. The following diagram illustrates the environmental issues and scope considered by LCAid.

EQUER is a life cycle simulation tool providing quantitative indicators of environmental quality to various actors. The tool is primarily intended to work at the whole building level, in order to capture the trade offs between different systems. For example, a concrete slab may store the heat collected by a window and thus increase the environmental benefit of this window (and vice-versa). The system limits can be chosen according to the purpose of the study. For instance, work-at-home transportation can be included in the analysis when choosing the building site, but it may be excluded in the design steps. Finally, the tool allows for a comparison with a reference building, providing an evaluation of the improvement of environmental performance compared to a present construction standard.

This model EQUER (Evaluation de la Qualité Environnementale des bâtiments) is developed by Ecole des Mines de Paris, INERIS, DUMEZ-GTM, S'PACE and Pierre Diaz- Pedregal. It applies the LCA method to the building sector because it is adapted to the determination of the environmental impact of a system and its standardisation is in progress (ISO TC 207 SC 5). The project consists in developing a simulation tool which will allow the comparison of alternative designs.

EQUER considers for the environmental assessment of a building only its influence on the outside environment. The questions related to the inside comfort are supposed to be dealt with by other existing tools. Therefore the calculation of the inside air quality, illumination and noise level as well as the thermal comfort analysis are not dealt with.

The environmental impact of building components or processes (e.g. energy use, transport) can be evaluated on the basis of inventories, aggregated in a second step into environmental themes. An inventory is a table of impact factors, indicating the quantity of each emitted or used substance with regard to the unit of the component or process.

The used inventories contain impact factors on the following categories:

- the used resources (e.g. rare materials, energy)
- the emissions into air, water, ground (e.g. CO2 into air, ammonia into water, oil into ground)
- the created waste (e.g. inert, toxic, radioactive)

The overall input and output of a building system, occurring during its life cycle, can be calculated by the tool and constitute the inventory of the building, from which an eco profile is deduced.

Beyond the product definition, the LCA methods require the definition of the functional unit considered and the system boundaries. According to French AFNOR standard X30-300 (1994), they also recommend clearness about how energy, transport and recycling aspects are taken into account. The method used for aggregating the data of the building inventory, in order to get an environmental profile.

3.2.4. Green Product Guides and Checklist

Guides providing qualitative, subjective assessment of product environmental claims and possible benefits. For instance, the *Building Research Establishment Environmental Assessment Method* (BREEAM) is one of the earliest environmental labelling scheme that assesses the environmental quality of buildings. It considers design issues that affect the global environment, local environment and the health and well being of building occupants.

Table 3.19. Benefits of BREEAM.
(Source: http://www.ecde.demon.co.uk/breeam.htm).

BENEFITS	Identification of business bottom line benefits. For every 1 pound spent, the BREEAM process identifies up to 650 Pounds of operating cost savings
	Managers can reassure employees through credible communication of a buildings high environmental performance
	Improved sales for developers through credible communication of a buildings high environmental performance
	Designers are able to demonstrate their environmental achievements and low operating costs.
	Landlords and occupants can cost-effectively and continuously audit their property portfolio, set targets and gain variable targets.

BREEAM was co-developed by the Building Research Energy (BRE) consumed for building operation is not the only hazard a residential building creates to the environment. The construction materials and processes used during the building life span have to be considered as well. For instance, the processing of the refined ore into a construction material requires energy input and the process itself may have environmental side effects such as pollutant emissions or waste production. Since the 70s, several experts have analysed the environmental impacts of materials and services related to the building industry. The *BREEAM* scheme is currently used in UK, Canada and Hong Kong to meet international obligations on carbon dioxide emissions(WEB_11 2003).

The homes version of BREEAM is called EcoHomes. It provides an authoritative rating for new and converted or renovated homes, and covers houses, apartments and sheltered accommodation. EcoHomes considers the broad environmental concerns of climate change, resource use and impact on wildlife and balances these against the needs for a high quality, safe and healthy internal environment. EcoHomes can be used within design teams to consider some important sustainability functions in housing development at the planning and detailed design stages. For local authorities, EcoHomes uses various credits, which add up to a rating. Some of these credits are site- specific and will often be influenced by the developer, such as location with 0.5 km to 1km of public transport links and public amenities. The rating is expressed in terms of numbers of 'sunflowers'.

1 Sun Flower- Pass - 25-40%
2 Sun Flowers Good - 40-55%
3 Sun Flowers Very Good - 55-70%
4 Sun Flowers Excellent - 70-100%

For sustainable energy, credits are given for reductions in carbon dioxide (CO2) emissions below Building Regulations standards on estimated space and hot water heating and lighting requirements. Energy consumption and consequent CO2 emissions are calculated using the Standard Assessment Procedure for energy rating. This incorporates the Carbon Index Method, one of the three methods of compliance with the Building Regulations. The Carbon Index Method is a requirement for all English housing associations seeking Housing Corporation funding.

Carbon reduction credits are calculated from the annual carbon dioxide emissions rationalised for the floor area of the dwelling and are expressed in kg/m2/year. Maximum credits can be achieved for carbon neutral homes.

The LEED (Leadership in Energy and Environmental Design) Green Building Rating System is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. Members of the U.S. Green Building Council representing all segments of the building industry developed LEED and continue to contribute to its evolution.

LEED–Homes document is under pilot testing since August 5, 2006. USGBC has selected 12 LEED for Homes Providers to service some of the country's leading housing markets. These providers are local and regional organizations that have been chosen to provide technical, marketing and verification support to builders. They have a proven record of supporting builders in the construction of high performance, sustainable homes.

3.2.5. Building Assessment Schemes

The GB Tool software has been developed as part of the Green Building Challenge process, an international effort to establish a common language for describing green buildings, which now includes teams from 20 countries. The software has been developed by Natural Resources Canada on behalf of the GBC group of countries and may not be used for commercial purposes, except as per agreements that may be worked out between potential users, the relevant national team and NRCan.

Table 3.20. The benefits of the GBTool software.

BENEFITS	Allows third parties to establish parameter weights that reflect the varying importance of issues in the region, and to establish relevant benchmarks by occupancy type;
	Allows generic benchmarks to be replaced by local ones, in local languages;
	Allows assessments to be carried out at four distinct stages of the life-cycle and provides benchmarks suited to each phase;
	Handles up to three building types, separately or in a mixed-use project;
	Handles new and existing construction, or a mix of the two;
	Allows comparisons to be made with LEED and Green Globes.

The current version of the tool is being tested by the national teams on one or more case study buildings in each country. The system is used to assess predicted or "potential" performance of a building before occupancy. It is not intended to assess performance during operational conditions. The system is currently applicable to offices, multi-unit residential and school buildings only. The system is a framework, not a simulation model. Users are expected to use other software tools to simulate energy performance, estimate embodied energy and emissions, predict thermal comfort and air quality, etc. These values are hypothetical but realistic based on Canadian conditions. An important design feature of the system is that the characteristics of a design are compared to benchmark values and that the features of the design are then scored and weighted.

The GBC Assessment Framework and GBTool are designed to enable user-defined scoring scales and weights to replace the defaults provided in the start-up version.

The Environmental Preference Method is developed by Woon Energie in 1991. Experiences as a consultant with several experiments on sustainable building have shown that there was a great demand for easy accessible and up-to-date information on the environmental impact of building components and materials.

EPM can be considered as a combination of global and problem analysis. This means that all relevant aspects are taken into consideration, but based on available information. Aspects which are expected to have a large impact or a potential for improvement are more thoroughly investigated. With this approach all the relevant differences will quickly emerge. The procedure of Environmental Preference Method contains the same four steps as for a LCA: goal setting, inventory, classification, evaluation.

The method aims to compare available materials and products and rank them according to environmental preference. Other aspects or qualities like costs or aesthetics are not involved in this assessment. The result is not an absolute assessment but a relative ranking based on environmental impact: an environmental preference.

The Environmental Preference Method follows the same structure as LCA as formulated by CML (Leiden, The Netherlands) but in a simplified way. The entire life-cycle is considered, i.e. from extraction of the raw material through to processing the waste material at the end of the component's life.

The main issues included in the evaluation are shortage of raw materials, ecological damage caused by extraction of raw materials, energy consumption at all stages (including transport), water consumption, noise, odour pollution, harmful emissions, such as those leading to ozone depletion, global warming, acid rain, health aspects, risk of disasters, reparability, reusability, and waste.

3.2.6. Embodied Energy Input/Output

Carnegie Melon web based The Economic Input Output-Life Cycle Assessment software traces out the various economic transactions, resource requirements and environmental emissions require for a particular product or service. The model captures all the various manufacturing, transportation, mining and related requirements to produce a product or service. The current 1997 model is based upon the Department of Commerce's 491 sector industry input-output model of the US economy.

3.3. Performance Indicators

In general, an indicator is a sign or marker that points to a condition to be measured, in order to evaluate specific qualities and performances (Hasselaar 2003). Often indicators use quantification to make phenomena accessible that may well be perceptible in a qualitative way but that are difficult to manage without a way of accessing them through numeric figures. Commonly known examples of indicators are for example:

- in education: examination marks for the learning performance of pupils and students
- in the economic sphere: for example the prices of goods, the gross domestic product, percentage of economic growth, unemployment rates
- in medicine: for example the body temperature, the weight/height ratio.

By making things measurable it becomes possible to monitor changes and to judge the severity of a problem and the effectiveness of the measures taken to solve it. This normative power indicators gain from the fact that they usually refer to a reference-value that is commonly considered good or normal.

The quantitative element of the indicator is the measured deviation from this benchmark. The measured value can deviate from the benchmark either in space – if compared with a reference value measured at the same time at a different place (for example if the Gross Domestic Products and unemployment rates from different countries are compared as indicators for the state of national economies) - or in time – if compared with a reference value measured the same place at a different point in time. (for example the development of the GDP and the unemployment rate in one country through time).

The temperature as an indicator for the health of the human body can serve as another illustration for an indicator. The average temperature of 37 C serves as the reference value. Significant deviations from this average are considered to indicate a disease. A deviation is not a disease in itself as it may be the result of varying physiological processes. A complete understanding of each and every single link of the underlying causal chains is not even a precondition for the use of indicators: neither does one have to be able to name the physiological causes for the fever in order to speak of increased temperature of the body in a meaningful way, nor does the scientific debate on the processes and effects of global climate change have to have reached a consensus before the amount of CO2-emissions can be used as an indicator in environmental policy.

The housing performance can also be measured and compared by using performance indicators. A building evaluation model should reflect national, regional, and individual concerns if it is to be accepted and used (Todd and Geissler 1999)

For easy and clear presentation of the overall building performance score, it is useful to combine indicators and categories by weighting or crediting a numerical value which represents the partial contribution of indicators and categories to the overall performance score based on their relative importance to the decision-maker (Choo Schoner Wedley 1999).

3.3.1. Existing Home Performance Evaluation Models

For many years, a variety of building performance evaluation models for residential buildings have been developed internationally. In the early stages of development, there has been an increasing interest in building environmental performance assessments that met the needs of the time when there was emphasis on the impact of buildings on global environment and individual health. Such assessments focused on related tools, mainly on building energy use, indoor climate, and many other environmental issues (Forsberg and Malmborg 2004), considering that buildings present many qualities or performances which should be taken into account for a proper evaluation (Roulet 1999) several evaluation models that cover building performance more comprehensively have been introduced. Widely known evaluation models are shown in Table 3.21.

Table 3.21. Existing evaluation models.

Evaluation Model	**Country**	**Organization**
GBTool	International	Green Building Challange Team
BREEM	UK	Building Research Establishment
LEED	US	US Green Building
Housing Quality Indicator System	UK	Office of the Deputy Prime Minister
QUALITEL	France	QUALITEL
Housing performance indication system	Japan	Ministry of land, Infrastructure, Transport
QUARO	Portugal	National Laboratory of Civil Engineering

Green building assessment tool GBTool, BREEAM, and LEED are the most representative environmental performance assessment tools (Crawley 1999). They have made significant contribution to the field of building performance assessment. GBTool

(Cole 2002) is a building environmental performance assessment tool developed as part of the international Green Building Challenge Project. GBTool helps to assess and evaluate the energy and environmental performances of three building types: school, multi-family residence, and small-scale office building. It can be used internationally, while accounting for regional or national conditions. The scoring system that ranges from –2 to 5 was established, with level 0 being the benchmark level, set by regulations or industry norms. BREEAM (WEB_11 2003), developed in UK, is one of the most widely known means of reviewing and evaluating the environmental performance of buildings, and LEED green building rating system (WEB_12 2005), developed in US, is a national standard for developing high performance and sustainable buildings. All the three models provide a framework for evaluating building environmental performance and meeting sustainability goals, and provide an authoritative rating for new or renovated housings.

The rest of the models are performance evaluation tools mainly focusing on the housing quality of inside and outside the residential buildings.

LEED rating systems award points for meeting specific performance criteria defined in Prerequisites and Credits. Improved building performance is certified (based on the number of points earned by a project) with one of four ratings – Certified, Silver,

Gold, or Platinum. The LEED rating system, developed by the United Sates Green Building Council (USGBC), was first released in 1999. At that time, it was focused son new construction and major renovations.

The housing quality indicator (HQI) system (UK Office of the Deputy Prime Minister 2000), developed in 1998, is a measurement and assessment tool designed to allow all potential or existing housing schemes to be evaluated on the basis of quality rather than simply cost. The HQI allows an assessment of quality of key features of a housing project in three main categories, which are location, design, and performance. These three categories produce the 10 quality indicators that look not only at the housing unit and its design in detail, but also the context and surroundings, and aspects of performance in use. QUALITEL (Anon 1998) is a housing quality certification system of France and guarantees the performances of various technical equipment in the habitation based on the proprietary Qualitel method.

Housing Performance Indication System (WEB_13 2006) was developed by the Ministry of Land, Infrastructure and Transport of Japan based on the Housing Quality Assurance Act, enforced on April 1st, 2000. It is designed to help a homebuyer's housing selection and to promote improvements in the housing performance. The system is made up of nine parts and 28 performance evaluation items related to structural safety, fire safety, and housing performance and each item is graded into two or five levels. It can be applied to both detached housing and apartment housing. The introduction of the Housing Performance Indication System raised consumer interest toward housing quality related issues such as energy efficiency, durability, environmental friendliness and barrier-free access.

QUARQ (Pedro 2000) in Portugal is also an evaluation method which measures the degree of adequacy between the architectural characteristics of housings and occupants' needs and expectancies

Soebarto and Williamson pointed (Soebarto, and Williamson 2001) out that rating schemes adopted in most of the environmental performance evaluation models are generally of two sorts (Table 3.22.):

Table 3.22. Environmental performance evaluation models.
(Source: Soeborto and Williamson 2001)

certification	which means evaluating a building for good performance at the design stage, labelling, assessing the in use performance of a building compared with those of other similar buildings.
	models that are used for certification and indication of the building evaluate the superiority of a building's performance over a **reference building or other similar buildings**, and are usually developed by the national government authorities or public institutions. Many widespread and well-known environmental assessment tools and building performance indication systems operated by public institutions can be representative examples of this kind of an evaluation model.
labelling	models that are used for labelling the building performance level objectively and relatively compare a building to a reference building or other similar buildings. The performance of some evaluated buildings might be superior, but that of some buildings inferior to the reference building. This kind of model is usually developed for supporting users' comparison and decision-making on a purchase.

Housing performance may be difficult to evaluate quantitatively and performance indicators may change according to the evaluation purpose. In addition, an evaluator's own opinion may obstruct objective evaluation of housing performance. In this study, basic selection rules, which stipulate that a performance indicator should be objective, feasible, quantifiable, and appropriate, were used to sort the indicators.

CHAPTER 4

HOME RATING MODEL FOR IZMIR (HRM-Izmir)

In Chapter 3, The Building Life Cycle Assessment software tools were described following Royal Melbourne Institute of Technology's LCA software categorisation system. From these tools ATHENA software is the suitable tool for applying HRM-Izmir rating model.

In Chapter 4, HRM-Izmir's working principles and the forms will be explained. ATHENA software gives quantitative values for six performance indicators; energy consumption, solid waste emission, air pollution index, water pollution index, global warming potential, and weighted resource use. Six values will be filled in Form B, and each case will be compared with a reference case. These comparisons will help to classify the residential units with in five categories; Poor (1 point), Below Average (2 point), Average (3 points), Good (4 points), and Excellent (5 points).

Beside ATHENA indicators, selected thirty indicators that improve sustainable development in home industry, will be described under four life cycle stages; site selection, construction, operation, and demolition. The indicators will be rated under five categories; Poor (1 point), Below Average (2 point), Average (3 points), Good (4 points), and Excellent (5 points)., and Form C is designed to monitor the differences.

Form D's aim is to suggest further improvements for the residential units. The ratio of five categories will be given at end of Form D.

4.1. Home Rating Model for Izmir (HRM-Izmir)

Rating models allow the professionals to compare the environmental performance of similar products. This allows more informed choices for consumers and means to measure progress in reducing current environmental impacts.

Rating tools are used as part of rating schemes to establish the level of environmental performance. These range from single issue schemes, such as appliance energy ratings, to many building environmental assessments.

Many professionals that are familiar with the energy star and water efficiency ratings now found on many advantages. These allow a purchaser to choose the most efficient products. These are examples of rating tools that measure one aspect of environmental performance.

Currently most rating tools only focus on one aspect of environmental performance, but some do consider more than one and however there are intentions to find a rating model to consider the whole aspect.

Rating tools have an important role to achieve more sustainable buildings by providing assessments that can be used to set minimum standards required by regulations and to encourage best practice. For instance, the Building Code of Australia now requires a minimum energy star rating for new single dwellings of 3.5 or 4 stars dependent on the climate zone.

The proposed home rating for Izmir (HRM-Izmir) is developed with the implementation of LCA method, ATHENA software and the performance indicators (Figure 4.1.).

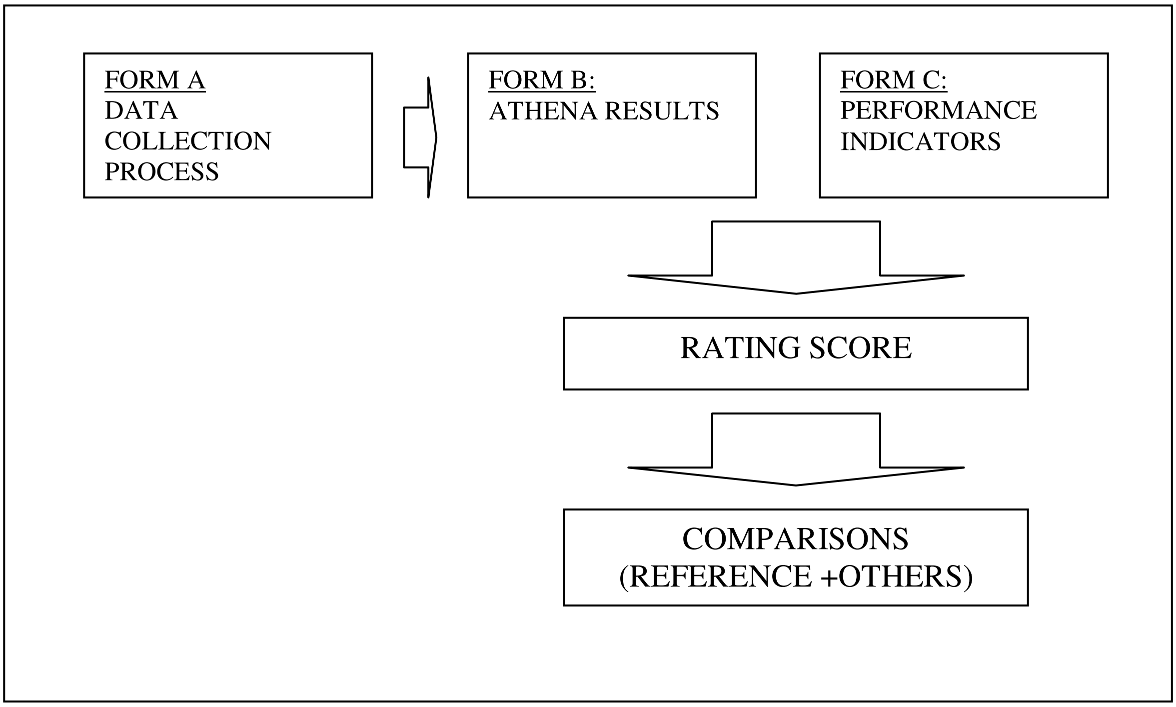


Figure 4.1. Proposed Home Rating Model for Izmir.

A rating model has to be designed in accordance with the features that will meet the local needs, in order to succeed in developing more sustainable society. Sustainability begins from the local environment which can cause effects on the global environment as well.

The proposed rating model is obtained by using LCA method. LCA as a method used for analysing and assessing the environmental impact of the building process, throughout its entire life cycle. The chain of Life Cycle Assessment (LCA) begins with site selection, construction, operation, and demolition.

With the help of the rating model for Izmir (HRM-Izmir), the occupants will be aware of whether their residential units are responsive to the natural environment. The local governments can plan their infrastructure according to these results. When the clients begin to see the benefits, they will demand better performances from their residential units.

This study analyses the computer programs that apply LCA and used the most convenient one, ATHENA. ATHENA software creates quantitive assessment system for building stock in Izmir, and with the help of this software, it targets to rate the residential units into 5 point category Rating Model (HRM-Izmir) regarding the sustainability aspect

The purpose of HRM-Izmir Rating Model is to rank buildings according to their performance with regard to several aspects. HRM-Izmir has four levels to achieve the final rating result:

1 - the data collection process which provides information about the studied unit, (Form A)

2 - use of the ATHENA software program,(Energy Consumption, Solid Waste, Air Index, Water Index, Global Warming Potential, Resource Use) (Form B)

3 - implying 30 indicators (1.Site Selection 2. Construction 3. Operation 4. Demolition) (Form C)

4 - final rating scores for the studied units. (Form D)

4.2. Data Collection Process (Collecting Data)

Data Collection Process (Form A) is designed to collect the necessary information (Table 4.1.). It provides accurate information about the studied residential unit. It has valuable data that can be implemented for ATHENA software and selected thirty performance indicators.

Table 4.1. Form A: Data Collection Process.

FORM A: DATA COLLECTION										
1	**Building Name**	Case no.			2	**Client**				
3	**Address**									
4	**Architect**									
5	**Consultants**									
6	**Year of construction**		7	**Year of completion**		8	**Year of occupation**			
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**		**House**		**Other**		
10	**Construction Type**	**R.C.**		**Masonry**		**Steel**		**Timber**		**Other… ………**

11	**Orientation**	**North**	**Nort-east**	**North-west**	**South**	**South-east**	**South-west**	**West**	**East**	12	**Energy Type**				
											Diesel	**Electricity**	**Natural Gas**	**Coal**	**Geothermal**

13	**Heating Type**	**Stove**		**Single Storey Heating**		**Central Heating**		**Other………**	
14	**Water heating**	**LPG**		**Single Storey Heating**		**Central Heating**		**Electricity**	
15	**Size (m2)**	**0- 100**		**100- 150**		**150-250**		**250-more**	
16	**Occupancy**	**1**		**2**		**2-4**		**4-more**	

Building name (1) (Table 4.1.) is the identity of the studied case, and the assessors must use a persistent numbering system if there is comparison between cases. Project no.1,2,etc or Case no.1,2, etc are examples of the method they can consider. If the location is important, they can use “Alsancak -1” or in short “AL-1” for describing the residential units. Client (2) is the owner of the property who has the authority to make necessary alterations in the residential units. The client’s vision and support is important for the success of the design. Address (3) section gives information about the location of the residential unit. Local conditions can affect the performance of the desired residential unit. Architect (4) is the professional who designs the residential unit. Architects responsibilities are given under contract documents. Consultants (5) are professionals in charge of the technical procedure of the residential unit. All the technical works consulted and applied by these professionals. Year of construction (6) is important for the evaluation for condition of the residential unit. The construction method for that time period and resource use can be predicted for the overall unit. For instance, the paint used in the past, had lead in its content causing lead poisoning. Year of completion (7) represents the occupation beginning process, and the completion period of the construction. This action will help the assessors to predict the energy, material, waste, and water use amounts during the construction. Year of occupation (8) indicates the time of occupancy in the residential unit and calculates the period between the completion and the occupation. Residential type (9) has thre main choices for Izmir's situation which are one Flat 2+1, Flat 3+1, and house. However, there are other situations which can be 4+1 or triplex house. Construction type (10) is the type of the main structure of the unit. The possibilities are reinforced concrete structure with bricks, masonry, steel, and timber construction. Orientation (11) considers the direction of the residential unit. The heating, cooling, and ventilation systems depend on the orientation of the unit. Energy type (12) indicates the energy heating system uses. Diesel, electricity, coal, and geothermal are main energy sources for the heating systems. Diesel energy is used for single storey heating systems, stoves work with the coal, and in some houses air-conditioning systems are used for heating as well. Central heating systems use natural gas, coal, diesel, and geothermal energy. Only geothermal energy is environmentally friendly source. Heating type (13) is the method of heating, the majority heating methods are fossil fuel based, and recently in Izmir, when the potential of geothermal energy recognised as a clean and efficient energy for heating purposes, many residential units began to use geothermal for heating and hot water purposes. Water heating (14) is mainly provided by the fossil fuel energies and electricity. Geothermal energy is added into this group. Size (15) of the residential unit is needed for the ATHENA software calculations. It will provide quantitive values for six ATHENA indicators; energy consumption, solid waste, air index, water index, global warming potential, resource use). Occupancy (16) value is necessary for the operation phase of the unit. The occupants' life pattern may affect the residential units' performance during operation phase of the life cycle.

4.3. ATHENA Six Quantitive Indicators (Form B)

The ATHENA model is able to generate an environmental profile based on environmental issues, such as: resource usage, energy used, global warming potential, solid waste, air and water pollution. The profiles are based on a series of investigations and product life cycle studies carried out over years, which formed an extensive database. ATHENA covers most building types, and has the ability to investigate the implications of design alternatives.

For instance, W. B. Trusty and J. K. Mei, investigated the results of a partial LCA of three alternative designs of a custom 2400 sq. ft. single-family home, commissioned by The Canadian Wood Council (CWC). While the three home designs are similar in outward appearance, size and divided living area, they are markedly different in terms of the types and quantities of materials used. One house is designed using softwood lumber and engineered wood I-joist framing, the second incorporates light frame steel for its structure, and the third design uses insulated concrete forms (ICF) for the basement and exterior walls as well as a HAMBRO floor system.

Table 4.2. Comparison of three alternative designs.
(Source: ATHENA Sustainable Materials Institute Canada)

	Wood Design	**Steel Design**	***Concrete Design***
Embodied Energy (GJ)	255	389	562
Global Warming Potential (kg CO2 equivalent	62,183	76,453	93,573
Air Toxicity (critical volume measure)	407,787	1,413,784	876,189
Water Toxicity (critical volume measure)	407,787	1,413,784	876,189
Weighted Resource Use (kg)	121,804	138,501	234,996
Solid Wasted (kg)	10,746	8,897	14,056

As a result of the investigation, the wood design has more benefits compare to the other designs. Explained in the example, ATHENA has six performance indicators that can be used to compare different processes or designs in quantitive values.

Table 4.3. Form B: ATHENA Software Results.

FORM B: ATHENA SOFTWARE RESULTS		CASE No.		
	All Measures	**Baseline (%)**	**Case No. (%)**	**Difference**
1	Energy Consumption	100		
2	Solid Waste Emission	100		
3	Air Pollution Index	100		
4	Water pollution Index	100		
5	Global Warming Potential	100		
6	Weighted Resource Use	100		

In Form B (Table 4.3.), the comparison results of two projects, one the reference, and the other is under assessment, is given under six ATHENA performance indicators; energy consumption, solid waste emission, air pollution index, water pollution index, global warming potential, and weighted resource use. These values are collected after implying the data from Form A to the ATHENA software program. The value difference will indicate the performance differences between the cases.

When more than one case under assessment, one case must be a baseline project, the other projects will receive values according to baseline (Figure 4.2.).

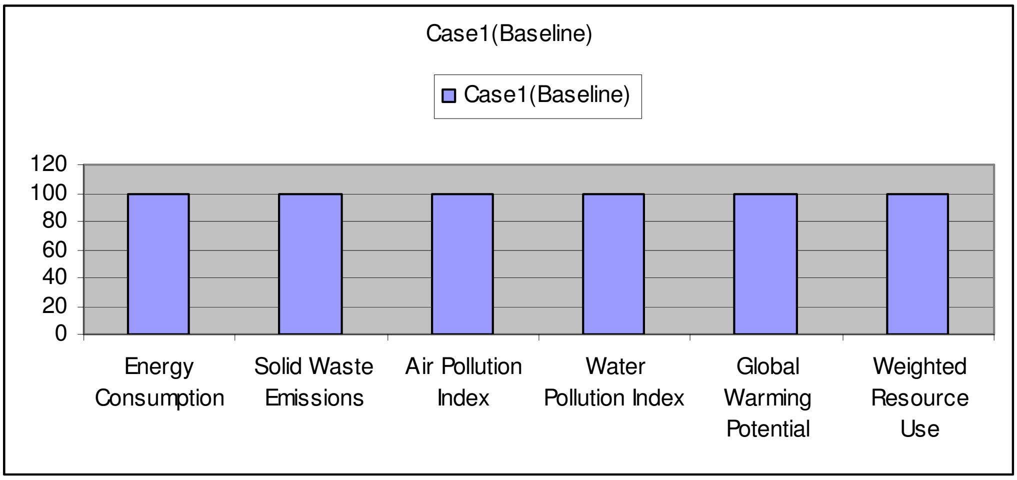


Figure 4.2. Case 1 (Baseline) Six ATHENA Indicators values 100%.

Case 1 as a reference project does not represent whether it's performance minimum or maximum. As shown in Figure 4.3., Case 1's water pollution index is higher than Case 2, but energy consumption, solid waste emission, global warming potential is lower than Case 2.

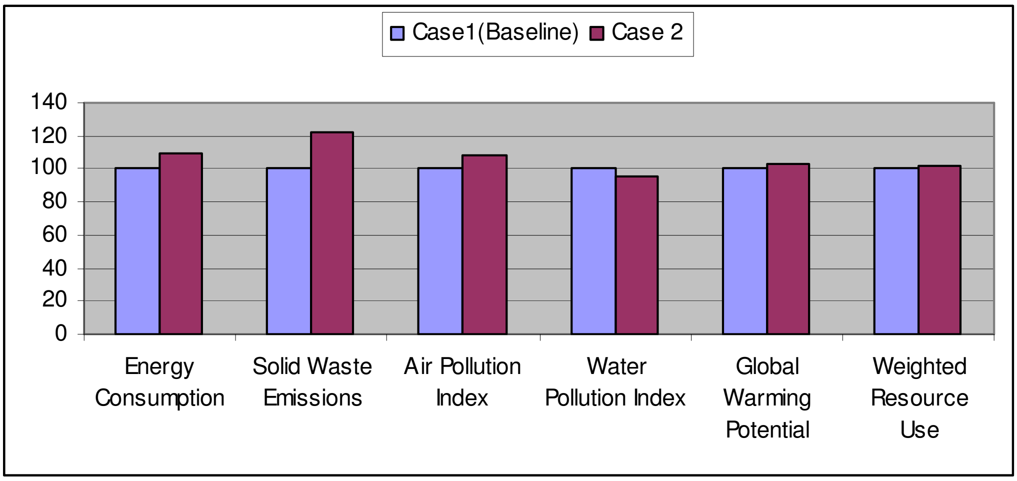


Figure 4.3. Case 1 and 2 Six ATHENA Indicators Comparison Chart.

In overall comparison between twenty cases (Figure 4.4.), Case 1's performance is twelfth in twenty cases.

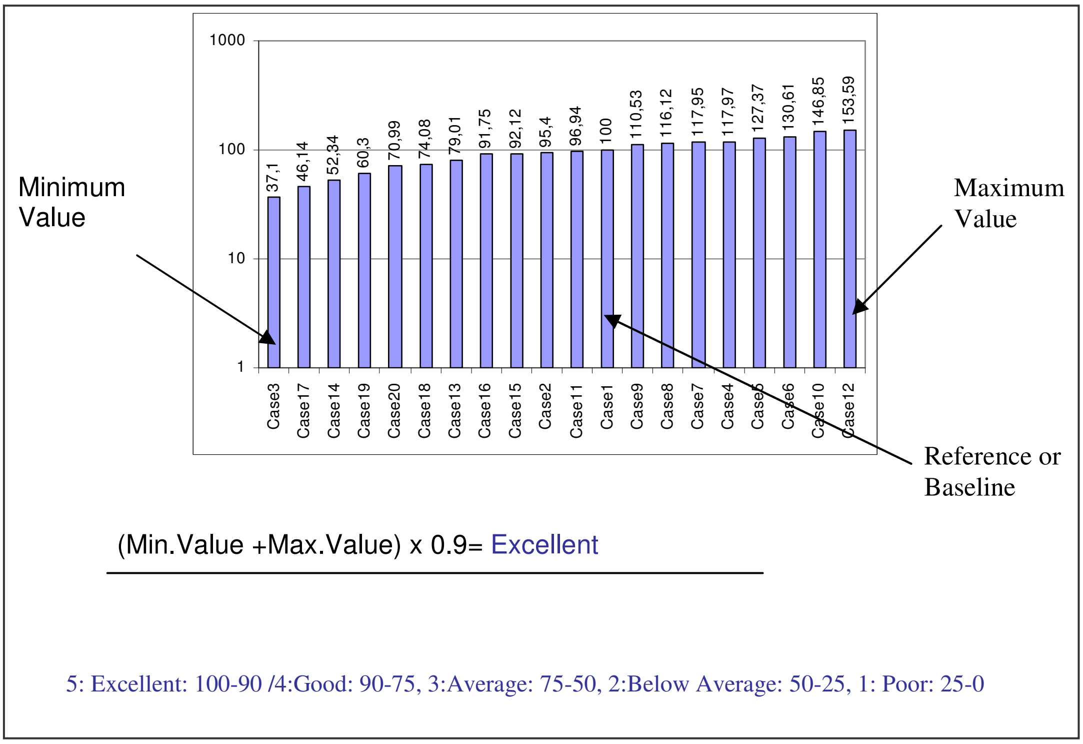


Figure 4.4. Performance comparisons example.

These comparisons will help to classify the residential units with in five categories; Poor (1 point), Below Average (2 point), Average (3 points), Good (4 points), and Excellent (5 points). Case with minimum performance will receive Poor (1 point) rating. The rating method is explained in Figure 4.5.

Min +(max - min) x (percentage value for Excellent: 0.9,
Good: 0.75,Average:0.5, Below
Average:0.25, Poor: 0)

Example:

37.1 +(153.59 – 37.1) x 0.9 = 141.9- (between141.9 and 153.59) Excellent
37.1 +(153.59 – 37.1) x 0.75 = 124.46 – (between 124.46 and 141.9) Good
37.1 + (153.59 – 37.1) x 0.50= 95.35 – (between 95.35 and 124.46) Average
37.1 + (153.59 -37.1) x 0.25 = 66.22 – (between 66.22 and 95.35) Below Average
37.1 + (153.59 – 37.1) x 0 = 37.1 – (between 37.1 and 66.22) Poor

Figure 4.5. ATHENA Indicators performance rating formula.

This study will evaluate the performance of twenty cases from the city of Izmir. If the number of cases increased to twenty-one, the value for rating categories will only change when Case 21 has minimum or maximum value (Figure 4.6.). If Case 21's value is in between, then it's performance will be evaluated according to existing situation.

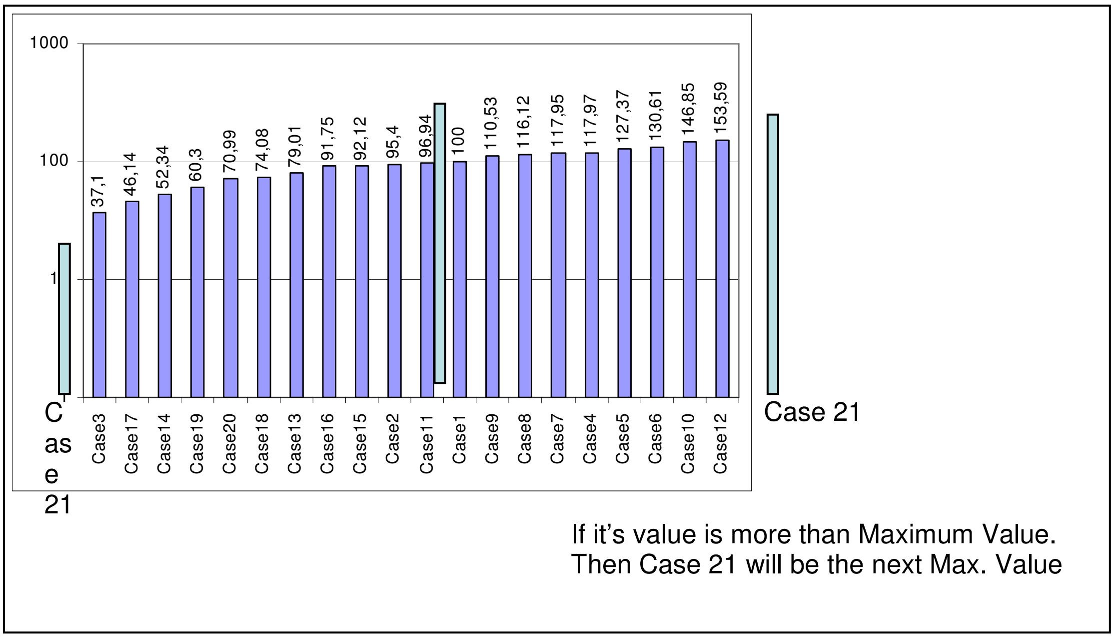


Figure 4.6. Adding a case into the system.

At this stage, Case 21 can be a project outside Izmir or a project from another country. The method will provide the necessary results for further comparisons.

4.4. Selected Thirty Performance Indicators in Four Life Cycle Stages: Site Selection, Construction, Operation, and Demolition

ATHENA Indicators give quantitive comparisons between cases. After this stage, selected thirty performance indicators provide rating scores for the performance of the residential units. These thirty indicators evaluate the residential units performance under four life cycle stages as shown in Table 4.4.

Table 4.4. Performance Indicators in Life Cycle Stages.

PERFORMANCE INDICATORS

A. SITE SELECTION	B. CONSTRUCTION	C. OPERATION	D. DEMOLITION
1. Location	5 Building envelope	16. Materials Maintenance	29. Recycling plan
2. Ecology	6. Material selection	17. Energy Use	30. Solid Waste handling plan
3. Existing B/Environment	7. Material transportation	18. Cooling	
4. Orientation	8. Material Conservation	19. Heating	
	9. Energy Conservation	20. Ventilation	
	10. Renewable Energy Use	21.Indoor Air Quality	
	11. Waste Strategy	22. Lighting	
	12. Water strategy	23. Noise	
	13. Unit components	24. Acoustic	
	14. Insulation	25. Waste handling	
	15. Glazing	26. Water use	
		27. Transport	
		28. Refurbishment	

Selected Performance Indicators based on six physical issues; material, energy, water, waste, transport, and ecology that affect building performance and nature. Some indicators were excluded such as indicators which were difficult to apply to the home construction cases, indicators of which the evaluation result may be varied dependent on occupants' management, indicators which did not have any standardized criteria, and indicators which were likely to be evaluated depending on each evaluator's own opinion.

During its life cycle, a residential unit consumes energy sources, materials, and water. Transport is necessary to carry energy, materials, water, and occupants. During these activities, ecology is under threat causing degradation in air, water, soil, and natural habitat. Waste produced from energy sources, materials and transport activities increasing so much that nature's life cycle can not handle them any more.

The rating model should consider these six main subjects; material, energy, water, waste, transport and ecology that effect building performance in life cycle stages.

Form C is developed to record the performance of a studied case (Table 4.5.). There are five categories to evaluate the performance of the indicators. One can increase the number of performance indicators and the number of categories. Important issue here is to rate the performance in a simplified system.

Table 4.5. Selected Performance Indicators Form C.

	FORM C							
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**							
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora						
		b. Fauna						
		c. Water quality						
		d. Soil contamination						
		e. Electro Magnetic Fields (EMF)						
		f. Wetlands or flood plain						
		g. Wind conditions						
		h. Sun conditions						
		i. Temperature						
		j. Noise Resources						
		k. Air Quality Index						

Table 4.5. Selected Performance Indicators Form C. (Cont.)

3	Existing B/Environment	Sub-indicator	(5)	(4)	(3)	(2)	(1)	
		a. Car parking						
		b. Green Area						
		c. Medical Centre						
		d. School						
		e. Place of Worship						
		f. Surrounding buildings						
		g. Public Transport						
		h. Retail						
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation						
		b. Wind Orientation						
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate						
		b. Adjacent Structure(s)						
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location						
		b. Material LCA						
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials						
		b. Powdered materials						
		c. Liquid materials						
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity						
		b. Heating						
		c. Machinery use						
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use						
		b. Wind power						
11	**Waste Strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials						
		b. Powdered Materials						
		c. Liquid Materials						
		d. Packages						
		e. Spare Parts						
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use						
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors						
		b. Windows						
		c. Ceiling						
		d. Floor						
		e. Walls						
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound						
		b.Heat						

Table 4.5. Selected Performance Indicators Form C. (Cont.)

15	Glazing		(5)	(4)	(3)	(2)	(1)	
		a.Glazing						
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance						
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Electricity use						
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System						
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System						
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents						
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air						
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight						
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level						
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time						
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling						
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use						
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) ‘Transport						
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment						
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan						
		b.Recycle Plan						
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		Solid Waste Handling						
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Site selection considers location (1), ecology conditions (2) and existing built environment (3). The design can influence the use of the energy and material resources to minimise waste products. Orientation indicator (4) may affect the energy use, ventilation, day lighting, and indoor air quality inside the building. Correct orientation helps to reduce energy use, waste production and even material use.

Construction stage has fifteen main indicators. These indicators based on energy, material, water, waste, and transportation. Building envelope (5) indicator covers the issues for noise, acoustic, daylight, ventilation, cooling, heating. These issues are effective during the operation stage of the building, but if they are considered during design and construction stage, they will work properly during operation.

Material selection (6) is also important for acoustic, noise, heating and cooling, and plus transport, waste, energy, water use can be effected from the end result. Material conservation (9) is directly related to material resources, also energy, waste, water use, and transport has a link. Unit components (13), insulation (14), glazing (15) indicators considers material resources in design process. The decision taken about these indicators will affect operation stage (between 16-28 indicators).

Energy Conservation (9) and Renewable Energy Use (10) indicators are two different indicators. Energy conservation (9) covers issues about fossil fuel energies efficient use. Renewable energy use is designed to influence users to develop new strategies.

Waste strategy (11) indicator considers material resources, energy, water, transport and ecology. Efficient waste strategy will help reduce the amounts that nature can recycle by itself.

Water strategy indicator (12) at this stage covers water use during construction. Water uses during construction and operation stages have different patterns. During operation stage, water use depends on occupants use performance. However, the design should assist the occupants for efficient consumption of water.

Operation stage is the third stage in LCA, there are thirteen indicators that consider energy, material, water, waste, transportation, and ecology. Heating(19), cooling (18), ventilation (20), day lighting (22), noise(23), acoustic(24), waste handling(25), material maintenance (16), and water use (26) indicators has influence on the ecology.

Performance scores will be given to selected indicators and sub-indicators. Some indicators are valid in international regulations for instance the air quality index. New performance evaluation methods are considered for some indicators and sub-indicators.

Each indicator has performance score between 1 to 5. These scores represent the condition of the indicator. If the performance score received Poor (1 point) in the overall performance mean energy, water, material, ecology, transport subjects need further considerations and amendments. Individual performance indicators help the assessors to identify the problems in the residential unit.

There are four life cycle stages; site selection, construction, operation, and demolition. However, some indicators have sub-indicators; each main indicator can receive maximum five points or excellent category.

4.4.1. Site Selection

Site selection is critical to the success of a residential project. An ideal site should have clean air, water and soil, solar access, public transportation nearby, to be close to existing workplaces, schools, libraries, shopping centres and other communities.

Site selection is divided into four main indicators; location, ecology, existing built environment, and orientation. Existing built environment gives information about the existing infrastructure, facilities and the buildings that can be shared to reduce the construction activities.

Ecology indicator, with sub-indicators; flora conditions, fauna conditions, water quality, air quality, soil contamination, and wetlands, assesses the existing conditions on the selected site.

Building orientation indicator helps to reduce the future energy consumption especially during the third stage, operation stage. Sun and wind orientation as a design tool has been used since the ancient times to improve the thermal comfort in the building without using air conditioning or any heating systems.

4.4.1.1. Site Selection: Location (1)

Reducing distances reduce people’s need to drive and thereby reduces air pollution, preserves open space and habitat, and reduces the need for government to spend taxpayers’ money on infrastructure expansion. Suburban sprawl also saps the economic vitality of urban centres.

Residential unit near the city centre means that the occupants can reach the public services in short distances. The level of transport is low and the resources available in short time. It will get 5 points (Excellent) value. Outside the city centre, occupants’ travel distances from the public services increase, but it is still part of the city’s main infrastructure, so it will get 4 points (Good). Average score is given to residential units outside the city's main infrastructure that a local area provides basic supplies. Transport connections are still available in standard. Below Average (2 points) rating is given if the road standards become low, and the travelling distances increases to provide even basic supplies. Poor (1 point) is given to the residential unit where there is not any other unit near by. It is away from public facilities like medical centre, school and etc.

4.4.1.2. Site Selection: Site Ecology (2)

The environmental burden resulting from a building can be classified into two parts, inside and outside the region. Most of the concrete measures to preserve the regional environmental are planned and taken by local governments. Thus, the building's LCA should also clarify the local environmental burden, and not only the total EB.

The processes producing a local EB are considered to include transportation of materials, production of building materials in the region, operation of construction machines, fossil fuels consumption during the building's operation phase, collection and treatment of solid wastes and sewage, and consumption of exhaustible resource acquired from region. The resource input and pollutant output in these processes will result in a local EB. To estimate the pollutant output directly released to the region, a database of local emission intensity is necessary for production of various building materials, vehicle travelling, waste disposal, and consumption of fossil fuels. Energy input and consumption of purchased electricity are not considered to result in a local EB because energy sources such as oil and coal are not obtained from urban areas, although they are exhaustible ones, and purchased electricity is generally generated away from urban areas. If the home is located within or near a mine site or power plant, the local EB caused by the energy input and consumption of electricity should be considered. (Li, 2006)[16]

The protection of biodiversity and other key ecological features is an important part of sustainable development. As pressure on land use becomes greater, it is

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[16] Li, Z., 2006. A new life cycle impact assessment approach for buildings, Building and Environment Vol. 41 p.1414–1422.

important to protect and enhance existing plant and wildlife habitats. This should ensure the preservation of the natural species, many of which are already in decline. The reuse of existing sites will help to preserve remaining wildlife habitats and other areas of high ecological value, as well as reducing the current pressure to build in high-risk areas such as floodplains or areas of potential water shortage. Wherever houses are constructed there is always the risk that, no matter how environmentally responsive the building or development itself, it may present a threat to local ecology or areas of natural beauty.

Table 4.6. Site ecology sub-indicators.

2 Ecology	Sub-indicator	(5)	(4)	(3)	(2)	(1)	
	a.Flora						
	b. Fauna						
	c. Water quality						
	d. Soil contamination						
	e. Electro Magnetic Fields (EMF)						
	f. Wetlands or flood plain						
	g. Wind conditions						
	h. Sun conditions						
	i. Temperature						
	j. Noise Resources						
	k. Air Quality Index						
		Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

Damage can be minimised either by selecting a site with low ecological value or by developing a site in such a way as to protect the most important ecological attributes. There will always be some temporary disturbance to the local ecology, but wildlife will return once the construction is complete provided that there is the right habitat available for it to do so.

Flora means all the plant life in particular region or country. Sub-indicator flora (Table 4.6.) has five scores. Excellent (5 points) is given to residential unit with clean natural environment. There is a minimum threat from the existing built environment. Good (4 points) is given to residential unit that causing less than 10% of degradation in the flora conditions. Average (3 points) is given to the residential unit that causing less than 50% of degradation. Below Average (2 points) is the score that causing degradation less than 75 %. Poor (1 point) is given to the residential unit that causing more than 75% damage for the existing flora. Information about the flora conditions can be provided by the local monitoring program.

Fauna means all the plant life in particular region or country. Sub-indicator fauna (Table 4.6.) has five scores. Excellent (5 points) is given to residential unit with clean natural environment. There is a minimum threat from the existing built environment. Good (4 points) is given to residential unit that causing less than 10% of degradation in the fauna conditions. Average (3 points) is given to the residential unit that causing less than 50% of degradation. Below Average (2 points) is the score that causing degradation less than 75 %. Poor (1 point) is given to the residential unit that causing more than 75% damage for the existing fauna. Information about the fauna conditions can be provided by the local monitoring program.

Water quality sub-indicator has five rating categories, valid internationally. Excellent (5 points) is given to e.coli bacteria value (0-2), pH value (7 and 7.5), temperature value (0.0), dissolved oxygen value (90-120%), nitrate oxygen value (0-5), phosphate phosphorus value (0.5 mg LP), turbidity value (0 NTU). The residential unit that has E.coli bacteria value (5-50), pH value (8), temperature value (between -5 and 5), dissolved oxygen value (70-80%), nitrate oxygen value (0.75-1), phosphate phosphorus value (1mg LP), turbidity value (10 NTU) will be rated Good (4 points). Average (3 points) is given to the residential unit that has e.coli bacteria value (50-100), pH value (9), temperature vakue (between -7.5 and 5), dissolved oxygen value (70%), nitrate oxygen value (1-4), phosphate phosphorus value (1.5mg LP), turbidity value (15 NTU). Below Average (2 point) score for e.coli bacteria value (100-500), pH value (9 and 10), temperature value (-10,-7.5), dissolved oxygen value (140%), nitrate oxygen value (15-4), phosphate phosphorus value (2 mg LP), turbidity value (20-30 NTU). Finally, Poor(1 point) for the residential unit that has e.coli bacteria value (600-2000), pH value (2-5 and 11-12), temperature value (10-30), dissolved oxygen value (0-50%), nitrate oxygen value (3-20), phosphate phosphorus value (2.5-3 mg LP), turbidity value (40-100 NTU).

Pollution in the form of contaminated land is a potential risk to human health and wildlife. The use of previously built on and contaminated sites is to be encouraged where appropriate in order to relieve the pressure on undeveloped land. But it is important that contaminated sites are decontaminated in line with statutory regulations to ensure that any health risks are either removed or reduced to within acceptable limits.

Soil contamination sub-indicator is measured under five categories. Excellent (5 points) is given to cases with no significant negative effects to human health or the environment. Good (4 points) is the value for the case that has contamination level between 10 and 25% effect. Average (3 points) is given to the case that has between 25% and 50% of negative effects to human health or the environment. Below Average (2 points) is the score for 50 and 75% contamination level. Finally, more than 75% soil contamination will receive Poor (1 point).

Man has evolved in an environment with extremely low exposure to time-varying extremely low-frequency electromagnetic fields (EMF) from natural sources, resulting from the activity of the sun, fields from the earth, and fields emitted by the human body. The advent of residential and industrial use of electricity for power, heating, and lighting, however, has brought about far greater and increasing exposures over the last 120 years, from the generation, transmission, and use of electricity. These exposures are now a ubiquitous part of modern life, and there has been concern in some quarters that they might have adverse health effects.[17]

If the residential area's exposure frequency range between 0.1-20 Hz, the performance score for the case is Excellent (5 points). When frequency range between 20-60 Hz, the residential rating score is Good (4 points). Frequency range between 60-180 Hz. results Average (3 points), frequency range between 180-1500 Hz scores Below Average (2 points), and finally frequency range between 1500-3000 Hz receives Poor (1 point) performance.

Wetlands and floodplains (Table 4.6.) serve vital ecological functions as water treatment and water overflow zones. Building in these zones can endanger not only people and property on-site but also those downstream. Flooding can not only lead to a loss of life, but can impose a massive economic cost on government and indirectly, to the public at large for disaster relief.

Minimizing paving or using permeable paving, and preserving existing mature trees and groundcover will prevent soil erosion and run off, will prevent flooding and help conserve and protect groundwater. Minimizing paving has the added benefit of reducing the "heat island" effect around buildings and cities. Using climate-appropriate landscaping and irrigation methods will also help conserve water.

[17] Anders Ahlbom, Elisabeth Cardis, Adele Green, Martha Linet, David Savitz, and Anthony Swerdlow Review of the Epidemiologic Literature on EMF and Health *Environmental Health Perspectives Supplements* Volume 109, Number S6, December 2001.

Excellent (5points) wetlands less than 10% impact on the land, Good (4 points) between 10%-25% impact on the land. Average (3 points) between 25%-50%. Below Average (2 points) between 50%-75% impact on the land. Poor (1 point) more than 75% impact on the land.

The release of carbon dioxide (CO_2) and other gases into the atmosphere is contributing to the greenhouse effect, leading to climate change. The release of nitrous oxides (NOX) from the combustion of fossil fuels also contributes to climate change and, on a more local level, to the production of acid rain. The effects of climate change, ozone depletion and acid rain can be reduced by the introduction of low NOX boilers, reduction in energy consumption (occupational and transport) and the specification of CFC- and HCFC-free construction products. Waterborne pollution due to pollutant run-off into watercourses and oceans can be reduced by the introduction of interception measures such as separators or oil interceptors within building and infrastructure drainage systems and the use of sustainable urban drainage.

Excellent (5 points), the AQI value for your community is between 0 and 50. Air quality is considered satisfactory, and air pollution poses little or no risk. Good (4 points), the Air Quality Index (AQI) for a community is between 51 and 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms. Average (3 points) when AQI values are between 101 and 150, members of sensitive groups may experience health effects. This means they are likely to be affected at lower levels than the general public. For example, people with lung disease are at greater risk from exposure to ozone, while people with either lung disease or heart disease are at greater risk from exposure to particle pollution. The general public is not likely to be affected when the AQI is in this range. Below Average (2 points), everyone may begin to experience health effects when AQI values are between 151 and 200. Members of sensitive groups may experience more serious health effects. Poor (1 point), AQI values between 201 and 300 trigger a health alert, meaning everyone may experience more serious health effects.

4.4.1.3. Site Selection: Existing Built Environment (3)

Before any design activity, the architects should investigate the existing built environment conditions that may affect their designs. Surrounding facilities may support the future design's development. Car parking, green areas, medical centre, store, school, and public transport should be considered before any design action.

Table 4.7. Existing built environment sub-indicators.

3	Existing B/Environment	Sub-indicator	(5)	(4)	(3)	(2)	(1)	
		a. Car parking						
		b. Green Area						
		c. Medical Centre						
		d. School						
		e. Place of Worship						
		f. Surrounding buildings						
		g. Public Transport						
		h. Retail						

Location and Linkages for Community resources intent is to minimise dependency on personal car and associated environmental impacts by encouraging development patterns that allow for walking, biking, or transit as alternative means of transportation to necessary services.

In the requirements, there is not any mandatory measure; however optional measures are taken into consideration. Walkable access to four basic activity resources within 500 metre or seven activity within or proximity to transit service within 500 m for bus; 1000 metres for train or ferry.

Community open spaces are defined as publicly accessible land that consists predominantly of unsealed, permeable surfaces such as soil, grass, shrubs, and trees. These include natural open spaces, parks, play areas, and other community open spaces specifically intended for recreational use.

As a sub-indicator, car parking conditions has five performance input. In Izmir, there are few enclosed and secure areas for cars. Excellent (5points), the cars are parked in a close environment, maintaining the safety of roads and pavements by reducing parking on pavements and verges. Above (4points), the cars are parked outside marked spaces near the residential unit. Standard (3 points) , cars can find a suitable, marked places near the residential unit. Below standard: (2points), the car owners need to walk long distances to park their cars. Poor (1 point): cars are parked on narrow streets, causing traffic problems and low living standards.

Green condition represents the quality of the nature in an existing environment. Excellent (5 points) is given to the case with highly dense plantation. Medium plantation encourages for the cases Good (4 points) score. Average (3 points) is awarded to the cases with standard plantation. Below Average is the degreasing amount of the plantation, especially the trees. Finally, Poor (1 point) is given to areas where there is few trees and low plantation ratio.

Medical centre's distance from the residential unit needs consideration because it's hard to assume the health problems. In another point of view, if there is a health problem, the occupants' transportation increases and causes more energy consumption. According to LEED assessment, the preferred distance for a medical centre is less than 500 meters, either hundred meters to a public transport or walking distance. Excellent (5 points) is given to residential units 500m away. If the unit is away between 500 m and 1 km, then it deserves Good (4 points). Average score is for the units that has a distance up to 2 km After 2 km the distance is rising and up to 5 km, it is Below Average (2 points). 5 km and more distances will cause the units to get Poor(1 point) score.

School distance creates energy consumption, and may increase the dependency on fossil fuels. Excellent (5 points) is given to residential units 500m away. If the unit is away between 500m and 1 km, then it deserves Good (4 points). Average score is for the units that have a distance up to 2 km. After 2 km the distance up to 5 km, it is Below Average (2 points). 5 km and more distances will cause the units to get Poor (1 point) score.

Place of worship is not very critical indicator, but it may increase the dependency on fossil fuels. Place of worship is the place where religion practiced. The building type can range from a small room to a big mosque. Excellent (5 points) is given to residential units 500 m away from a religious building. If the unit is away between 500 m and 1 km, then it deserves Good (4 points). Average score is for the units that have a distance up to 2km. After 2km the distance is rising and up to 5 km, it is Below Average (2 points). 5 km and more distances will cause the units to get Poor(1 point) score.

The local municipality should influence the public to use public transport to reduce dependency on fossil fuels. The distance of the public transport persuades occupants to consider using the service. Excellent (5 points) is given to residential units 100 m away from a religious building. If the unit is away between 100 m and 200 m, then it deserves Good (4 points). Average score is for the units that have a distance up to 500 m. After 500 m the distance is rising and up to 1 km, it is Below Average (2 points). 1 km and more distances will cause the units to get Poor(1 point) score.

Retail shop is a place where the occupants can provide their basic living supplies. The distance of a retail shop may increase dependency on fossil fuels Excellent (5 points) is given to residential units 100 m away from a religious building. If the unit is away between 100 m and 500 m, then it deserves Good (4 points). Average score is for the units that have a distance up to 1 km. After 1km the distance up to 2 km, the rating score is Below Average (2 points). Finally, 2 km and more distances will cause the units to get Poor (1 point) score.

Surrounding buildings may affect the building performance. For instance, a near by building may block sunlight to penetrate or effect the wind. The ratio of surrounding building may affect the rating score.

4.4.1.4. Site Selection: Orientation (4)

Parts of the site development two primary environmental and energy considerations in the sitting of a building are orientation to the sun, and orientation to the wind.

The building should be sited away from any potentially contaminated areas, away from sensitive habitat areas, away from floodplains and wetlands on the site, and close to infrastructure and transit stops. Architect should consider layout and orientation of building groups in relation to insolation and over shadowing. Size and location of hard surfaces, in relation to desired sunlight and shelter need considerations as well. Using shelter planting can create protected and sheltered areas.

If the efficiency measures are between 100-90 %, it is Excellent (5 points), 90-75 % Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 point), and less than 25% Poor performance (1 point).

4.4.2. Construction Stage

Buildings have a major impact on the environment, not just in terms of materials used in construction, but also due to the amount of energy used during their lifetime. Construction, running and using buildings contributes to greenhouse gas emissions, the prime influence on climate change.

At construction stage, architects check the general conformity with the designs of works being executed. They provide any instructions needed for the contractors to co-ordinate and correctly execute the works. The documents and services to be provided include preparation of contract documents, including the contract, drawings, specifications and any guaranties; monitoring the construction work in accordance with the project timetable, applicable rules and standards, and the contract documents with regard to building dimensions, quality standards and appearance; issuing instructions for executing the works; arranging and recording of site and progress meetings; making periodic valuations of the works (ACE 1999).

4.4.2.1 Construction: Building Envelope (5)

A better envelope may sometimes be more expensive to build, but it improves the balance between heat gain and heat loss, reduces the size of conventional heating system (ACE 1999). Building envelopes need to be durable, aesthetically pleasing, weather tight, structurally sound and secure. Building envelopes need to respond solar radiation both for the sun's heat and light, design systems to be introduced to allow natural ventilation with minimised heat loss, noise and dust (Thomson 1996).

Table 4.8. Building envelope indicator.

5	Building envelope	Sub-indicator	(5)	(4)	(3)	(2)	(1)	
		a. Climate						
		b. Adjacent Structure(s)						

Shading is needed to control overheating in the summer. Shading control at the building envelope must be related to the activities in the building, its mass and ventilation system. A historical example, illustrating the need for shading devices, is Le Corbusier’s Salvation Army Hotel in Paris. The original design included a way of removing heat from in front of an inner skin of unopenable south-facing glazing. However, for the cost reasons the design was altered leaving only the fixed glazing which almost roasted the occupants. Later, sun screen was added to reduce overheating (Thomas 1996).

If the efficiency measures are between 100-90 % Excellent (5 points), 90-75 % Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 point), and less than 25% Poor performance (1 point).

4.4.2.2. Construction: Material Selection (6)

First call must be to select materials that their manufactures use little energy. These are either materials that can be used close to their raw state such as stone, timber and compacted earth or recycled manufactured materials such as crushed brick and concrete, hardcore and used steel joists or waste materials from other processes.

The manufacture and use of building materials has a significant impact on the environment as well as project costs. Conventional building materials often use large amounts of energy in their manufacture and some are not healthy to live with and use. Many products are difficult to dispose of safely and, when they are disposed of, have adverse effects on the environment.

The appropriate selection of more sustainable building materials is critical if these impacts are to be minimised. A key part of the selection of the materials is the use of life cycle assessment to establish the overall impact of the material "from cradle to grave".

Table 4.9. Material Selection.

6	Material selection		(5)	(4)	(3)	(2)	(1)	
		a. Country location						
		b. Material LCA						

If the efficiency measures are between 100-90 % Excellent (5 points), 90-75 % Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 point), and less than 25% Poor performance (1 point).

4.4.2.3. Construction: Material Transportation (7)

Using pre-existing aerial photography in the (GIS) of Google Earth, specific locations can be pinpointed and overlays containing any type of information can be created. For Google Earth to be used as an ecological navigational tool for manufacture's and consumers, a comprehensive overlay that maps the location of raw materials and products needs to be developed. Closer manufacturers would receive the highest ratings.

The embodied energy for transportation tool would also be useful to architects. Currently, an enormous interest is being taken in Leadership in Energy and Environmental Design (LEED) ratings for buildings.

Table 4.10. Transport sub-indicators.

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Transport						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

All phases of construction would benefit from having good real time data of resources and recycling sites. For example, aggregate is used in building construction to provide bulk, strength, support and wear resistance. Robinson and Kapo completed a geographic information systems analysis for determining construction aggregate recycling sites using existing transportation networks and population (2004).

If the efficiency measures are between 100-90 % Excellent (5 points), 90-75 % Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 point), and less than 25% Poor performance (1 point).

4.4.2.4. Construction: Material Conservation (8)

Designers who specify environmental materials must know that production and consumption of building materials has diverse implications on the environment. Extraction, processing, manufacturing, and transporting building materials can all cause ecological damage to some extent. There are input and output reduction methods for materials conservation. Accommodate existing buildings to new users; one of the most effective methods for material conservation is to make use of the resources that already exist in the form of buildings. Most buildings outlive the purpose for which they were designed. Many, if not all, of these buildings can be converted to new uses at a lower cost than brand-new construction. Combining the reclaimed or recycled materials together; buildings that have to be demolished should become the resources for new buildings. The reinforced concrete can be separated from reinforcing bars and cement, sand and gravel mixture. For instance, the construction of an apartment building with 14 flats with 120m2 floor area each, needs 24 m3 gravel, 10m3 sand. Total amount is 476m3, and for every m3, the building requires 6 sags of cement weighting 50 kg. Total cement is approximately 143 tons which is equal to 95m3 cement. Total mixture is 571m3 after demolition. This amount can be used again as gravel and sand portion with addition of new cement for a new 16 flat apartment building.

Table 4.11. Material Conservation

8	Material Conservation		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials						
		b. Powdered materials						
		c. Liquid materials						

Wood, steel, and glass can easily recycled into new materials as well. Architects should use recycled materials; during the process of designing the building and selecting the building materials, look for ways to use materials that can themselves be recycled. This preserves embodied energy during their manufacturing. When a building is too large or small for the number of occupants, it must contain its heating, cooling, and ventilation systems, typically sized by square meter, will be inadequate or inefficient. Architects are encouraged to design around standardized building material sizes as much as possible.

If the efficiency measures are between 100-90 % Excellent (5 points), 90-75 % Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 point), and less than 25% Poor performance (1 point).

4.4.2.5. Construction: Energy Conservation (9)

All buildings use energy in their construction due to the extraction of raw materials, manufacture and transport of materials and components and assembly on site. In their life cycle, buildings use energy in a number of different ways:

- in construction;
- in operation, for lighting, heating and power;
- for demolition, recycling and disposal.

Energy is found in a variety of forms, some of which are immediately usable by human like fossil fuels, others require transformations. There are two categories of energy sources which are renewable and non-renewable energies.

All conventional types of buildings consume energy in a number of ways; in the manufacture of a building materials, components and systems; in the distribution and transportations of building materials and components to the construction site. Grey energy is expended in transporting materials and components from places of extraction and manufacture to the construction site can be minimised by support of local industries and the use of local materials. Where there are no suitable local resources available, careful account needs to be taken of delivery distances and the mode of the transport employed.

Induced energy, the energy used in the construction itself, is normally modest in comparison to embodied and grey energy, and for this reason is not usually given much attention. On-site construction activity requires electricity for tools, lighting, hoists and other electrical items. Cranes and mixers use fossil fuels which cause atmospheric pollution The architect should ensure, at tender stage, that the builder has a comprehensive energy policy for site operations, including waste avoidance (5 to 10 percent of building materials are thrown away unused), economic use of water and eco-friendly disposal of demolished materials, and that this policy is acted upon during construction (Jones 1997).

Table 4.12. Energy Conservation sub-indicators

9	Energy Conservation	Sub-indicator	(5)	(4)	(3)	(2)	(1)	
		a. Electricity						
		b. Heating						
		c. Machinery use						

Energy conservation has three sub-indicators (Table 4.12.); electricity use, heating, and machinery use. Excellent (5 points) score is given to the residential unit with full energy conservation. Poor (1 point) score is given to no energy conservation.

4.4.2.6. Construction: Renewable Energy Use (10)

During the construction, many appliances need electricity for them to work. Some appliances works only with high voltage transferred from the main system. However, there can be some occasions that the renewable energy sources can be used and help the reduce energy demand.

Table 4.13. Renewable Energy Use sub-indicators.

10	Renewable Energy Use		(5)	(4)	(3)	(2)	(1)	
		a. Solar use						
		b. Wind power						

Advantage of solar or wind use, helps charging the hand-drills and etc., provides ot water for the showers, night lighting for the construction site, and cooking purposes.

Excellent (5 points) score is given to the residential unit with full solar and wind power use. Poor (1 point) score is given to no use of solar or wind power.

4.4.2.7. Construction: Waste Strategy (11)

At the end of its life, a building also generates waste like sheet materials, powdered materials, liquid materials, packages and spare parts from the machinery , which must be included in the assessment of a building. These wastes also generate environmental impacts during transport.

Table 4.14. Waste Strategy sub-indicators.

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials						
		b. Powdered Materials						
		c. Liquid Materials						
		d. Packages						
		e. Spare Parts						

Excellent (5 points) score is given to sub-indicators full measures on sheet materials, powdered materials, liquid materials, packages, and spare parts. Good (4 points) is given to the residential unit more than 75% consideration for waste plan. Poor (1 point) performance is equal to the residential unit with no waste strategy plan.

4.4.2.8. Construction: Water Strategy (12)

Water use strategy can save valuable water resources, and the architect needs to imply the method into the design. Occupants have the main role during the operation stage of the home unit, but architects need to adapt suitable methods that the occupants can follow through the operation stage.

Table 4.15. Water strategy indicator

12	Water strategy		(5)	(4)	(3)	(2)	(1)	
		a.Water use						

If the efficiency measures are between 100-90 % Excellent (5 points), 90-75 % Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 point), and less than 25% Poor performance (1 point).

4.4.2.9. Construction: Unit (13)

Five components; door, window, ceiling, floor, and wall create the living space. Their quality affects the living environment inside the residential unit. Correct detailing of these components will provide energy efficiency, material efficiency, and comfortable physical environment.

Materials and craftsmanship are main issues for the assessment of the components. Another issue is the correct method of production that lowers energy, water, material use and reduces waste production, air pollution.

Table 4.16. Unit components

13	Unit components		(5)	(4)	(3)	(2)	(1)	
		a.Doors						
		b. Windows						
		c. Ceiling						
		d. Floor						
		e. Walls						

If the efficiency measures are between 100-90 % Excellent (5 points), 90-75 % Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 point), and less than 25% Poor performance (1 point).

4.4.2.10. Construction: Insulation (14)

The age of the building and its heating installations is also a determinant factor on building's heating energy consumption, since it is directly related to the type of materials used for construction and the efficiency of the installations. The average heating energy consumption was calculated for different age intervals (0–15 years, 16–30 years, 31–45 years, and 46–60 years.

Table 4.17. Insulation indicatior

14	Insulation		(5)	(4)	(3)	(2)	(1)	
		a.Sound						
		b.Heat						

If the efficiency measures are between 100-90 % Excellent (5 points), 90-75 % Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 point), and less than 25% Poor performance (1 point).

4.4.2.11. Construction: Glazing (15)

Windows and other glazed external surfaces have a major impact on the energy efficiency of the building envelope. If not designed correctly they can allow substantial unwanted heat transfer between the interior and the outdoors. There are literally thousands of glass types to choose from. Choosing the right glass is a major factor in determining the energy efficiency of a window and will determine many other desirable properties such as light transmittance, noise control and security.

Table 4.18. Glazing system

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Glazing system						
	Excellent (5)	Good (4)	Average (3)	Below (2)	Poor (1)	

If the efficiency measures are between 100-90 % Excellent (5 points), 90-75 % Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 point), and less than 25% Poor performance (1 point).

4.4.3. Operation

This is the phase where the client is using the building. The most important impacts here are the use of energy and possibly water. Waste generation is also important. In this phase, general guidelines on maintenance and operational building management should be followed.

People spend on average around 90 percent of their time in buildings, or within the built environment. Buildings make a major contribution to the quality of life because of the environment they provide for work, leisure and home. They should provide a healthy and comfortable environment and provide appropriate amenities for the activities carried out. The availability of external space around, or close to, the home is one key aspect affecting the quality of life of the occupiers. Indoors, the key issues are air quality, daylight and transmission of noise (one of the most common causes for disputes between neighbours is noise).

If the efficiency measures are between 100-90 % Excellent (5 points), 90-75 % Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 point), and less than 25% Poor performance (1 point).

4.4.3.1. Operation: Materials Maintenance (16)

After the completion of the residential unit, the architect inspects the building for final acceptance for the client, in accordance with the construction drawings and specifications. Architects should prepare maintenance folder to guide the clients during their occupation in the buildings. The folder should include documents about the manuals for passive systems and performance of service installations, component maintenance and repair, a safety file with advice on safe maintenance and repair. Whether the design features are passive or active, the client will best optimise building performance by having the working of the building explained and illustrated (ACE 1999).

During the operation stage, the building materials need maintenance until refurbishment decision. Except walls and ceilings, the materials used for the windows, doors, floor, ceramic tiles, bathroom facilities, furniture, kitchen counter etc. should be cleaned to prevent dust and decay in the living environment. Any areas with paint should be maintained every five years.

Correct building maintenance:

- Maintaining and renewing floor and wall finishes selected for health and environmental performance
- Regular cleaning of windows and luminaries
- Maintaining internal and external planting
- Use of sustainable, non-toxic, biodegradable cleaning agents
- Application of paint and thin film coatings in properly ventilated spaces.

Annual inspection of active systems to check continued efficiency of boilers, cooling equipment, radiator valves, infrared switching, heating and cooling controls

Table 4.19. Materials maintenance.

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Materials Maintenance						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

Material maintenance indicator (16) gives performance score to the residential unit (Table 4.19.). The cleaning activity divided into five periods. Daily or weekly maintenance, monthly maintenance, every three months, every six months, and yearly or no maintenance are five periods that represent the performance of the indicator. These conditions are only valid for existing residential units. If the residential unit is under construction then it will get the minimum score assuming that the design will follow the desired performance in time.

The residential unit that has daily or weekly maintenance will receive five points (Excellent), monthly four points (Good), every three months (Average) every six months (Below Average), and if no maintenance (Poor).

4.4.3.2. Operation: Energy Use (17)

Operation energy is the energy used in running a building. This kind of consumption will continue as long as the building stands and is occupied which could be more than hundred years (Jarmal 1992).

The largest proportion of energy used is for the operation of the residential unit. Energy efficiency measures are most cost-effective when installed in new homes (or those being renovated) and when existing equipment that has reached the end of its useful life is being replaced. Particular attention should be given to reducing heating, hot water and artificial lighting loads as well as ensuring that these services are maintained to ensure energy efficiency.

In order to promote energy conservation and to provide consumers with information about energy efficiency, energy labels have been proposed. There are two main types: endorsement labels, which simply identify appliances that are particularly energy efficient (e.g. ‘Energy Star’), and comparison labels, which provide information that enables consumers to compare the energy efficiency of a specific product with the rest of appliances within the same category. Some examples of comparison labels are the Australian ‘Energy Rating’, the US ‘Energy Guide’ and the European ‘Energy label’. ‘Energy label’ is conceived for a variety of electrical appliances, like refrigerators/freezers, washing machines, dish washers and lamps.

Investigate energy consumption through an entire heating and cooling season, by reference to utilities invoices or electricity gas, other. These can be totalled over a year and consumption in kWh/m2 readily derived. This can be compared with reference figures for an assessment of the overall performance of the building users' comfort, particularly in relation to overheating in the cooling season, where air conditioning is not provided and natural cooling methods are employed and user satisfaction in relation to daylight availability.

Table 4.20. Electricity use

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Electricity use						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

Using electricity efficiently reduces the structures for more facilities. Electricity efficiency measures like sensors etc., will help save energy. If the efficiency measures are between 100-90 % Excellent (5 points), 90-75 % Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 point), and less than 25% Poor performance (1 point).

4.4.3.3. Operation: Cooling (18)

Design strategies for passive cooling, Solar control; to prevent the sun's rays from reaching and entering the building. External gains; to prevent increases in heat due to conduction through the building skin or by the infiltration of external hot air. Internal gains to prevent unwanted heat from occupants and equipment raising the internal temperatures.

Ventilation; unwanted hot air may be expelled and replaced by fresh external air at a suitable temperature. Good ventilation will reduce the risk to human health of emissions of toxic chemicals from furniture, construction materials and paints (Goulding, 1992).

Natural cooling; internal air speeds can be increased to maximise perceived cooling. Air adjacent to the building can be cooled by evaporation.

Radiant cooling, transferring into the building cold energy generated during the night hours by radiant heat loss from the roof, or using a special radiator on the roof, with or without cold storage for daytime (Yeang 1999). Increasing the building's contact with the ground can provide additional cooling. Underground structures provide various advantages, protection from noise, dust and solar radiation. One example project for ground cooling is the Holy Island Buddhist

Retreat Project by Andrew Right. The living areas of the Buddhist are earth sheltered. However, when using ground cooling, architects need consider strategies to prevent future problems like damp penetration, condensation and daylight (Goulding 1994). Thermal mass and ventilation to promote passive cooling measures (ACE 1999) Modelling of temperature changes to predict internal in relation to ambient temperatures, advice on facade design, and modelling of shading and daylight solar gain. Cooling can be provided in two methods one is the natural cooling provided by ventilation and the other is the mechanical cooling. If the cooling is provided 100-90% by natural ventilation, the residential unit will get Excellent score (5 Points). Between 90-75 % Good (4 points), 75-50% Average (3 points), 50-25% Below average, and less than 25% is poor score (1 point).

Table 4.21. Cooling.

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Cooling						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

4.4.3.4. Operation: Heating (19)

During the operation stage, the heating indicator represents the heating efficiency of the residential unit. The use of heating system depends on the climatic zone, and location of the unit.

When designing a heating system, architects should find methods for promoting passive heating techniques and maximising the efficiency of active heating measures. Selection of heating method and fuel, combined heat and power, high efficiency heat emitters for the smaller quantities of heat involved, air and water plant size optimisation, optimisation of controls including Building Energy Management systems, air heating systems and fully ducted systems- with optional free cooling. Input on life cycle costing calculations.

Table 4.22. Heating system.

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Heating efficiency						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

If the heating efficiency is between 100-90%, the residential unit will receive Excellent (5 points) score, 90-75% Good (4 points), 75-50% Average (3 points), 50-25% Below average, and Poor score for efficiency less than 25%.

4.4.3.5. Operation: Ventilation (20)

Building modelling to maximise through ventilation and stack effect ventilation for cooling (ACE 1999). Important issues are decision on whether the occupant will operate manually operated trickle vents in windows (ACE 1999), deciding on which areas required mechanically assisted ventilation, and identify the possibilities of heat exchangers, discuss capital against life cycle costs (ACE 1999).

Table 4.23. Control of ventilation.

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Control of Ventilation						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

If control of ventilation strategy is between 100-90%, the residential unit will receive Excellent (5 points) score. 90-75% ventilation strategy is equal to Good (4 points), 75-50% is equal to Average (3 points), 50-25% is equal to Below average (2 points), and Poor (1 point) score for efficiency less than 25%.

4.4.3.6. Operation: Indoor Air Quality (21)

Indoor air quality is important to human health and well being, since a great deal of time is spent indoors, at work, home, or school. Unhealthy buildings contain volatile organic compounds which can be found in paint, carpet, fabric, cabinets, etc. The smell of newly constructed places is often actually toxic outgasing that is detrimental to the human health (Jones 1999). The effects of unhealthy buildings cause illnesses ranging from headaches, sinus and lung irritation to long term damage to the immune system. There are products available with reduced levels of volatile organic compounds that can be chosen to improve indoor air quality (Edwards 1999).

The term *sick building syndrome* is defined to describe the condition where people became ill from the inside environment because of poor thermal visual and aural comfort conditions, the gaseous pollutants, dust and fibres and tobacco smoke. In addition, external pollutants like traffic fumes, radon and landfill gases can affect the quality of the inside environment. Symptoms are headache, nausea, stress, sore throats, asthma attacks and similar illnesses. These can effect the performance of the individual while working. The functions that cause the sick building syndrome are air conditioning, sealed windows, recirculated air, high-density occupation, smoking, air borne micro organisms, dust and dust-mite excrement (Edwards 1999).

Plants can absorb the toxins, formaldehyde, benzol, and trichloroethylene. Certain plants are well suited to elimination of contaminants. For example, an ivy plant is able to eliminate 90 percent of the benzol contained in and released through tobacco smoke, artificial fibres, dyes and plastics. Aloe, bananas, spider plants and philodendron are effective agents against formaldehyde which may seep from insulating foam and particleboard. Trichloroethylene from lacquers and glues is best eliminated with the help of chrysanthemums and gerbera (Yeang 1999).

With regard to humidification, plants are better agents than electrically powered air humidifiers or even humidifiers combined with air-conditioning systems because they don't provide favourable breeding ground for bacteria.

Designing with passive systems will improve the indoor air quality performance of the building. The choice of materials and efficient ventilation can provide desired conditions inside the building.

Poor (1 point) indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have not been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins may be used.

Below average (2points) More than 50% of indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used.

Table 4.24. Indoor Air Quality.

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Indoor Air Quality						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

Average (3points) More than 75% of indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used.

Good (4 points) All indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used.

Excellent (5 points) All indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for zero rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used.

4.4.3.7 Operation: Lighting (22)

Commission Internationale de l'Eclairage (CIE) is an organization devoted to international cooperation and exchange of information among its member countries on all matters relating to the science and art of lighting[18].

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[18] http://www.cie.co.at/cie/

The level and distribution of daylight factors (ratio between internal and external illuminance) can be used as an indicator of the impact of daylighting inside the building.[19] For this purpose daylighting studies including daylight factor studies, daylighting simulations should be done. Lighting management should be done to control and integrate natural and artificial light

Table 4.25. Daylight Indicator

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Daylight conditions						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

If the daylight ratio is between 100-90 %, the performance score will be excellent (5 points), 90-75 % good (4 points), 75-50 % average (3 points), 50-25% below average (2 points) and less than 25% poor performance (1 point).

4.4.3.8. Operation: Noise (23)

Hearing loss from noise exposure is one of the top occupational hazards. In addition to hearing loss, noise can cause headaches, tinnitus20, high blood pressure, heart problems, respiratory ailments, and negative fetal development (WEB_14)[21]. Noise can cause irritation, annoyance, anxiety, anti-social behaviour, hostility, violence.

The operation of the facility should not pollute the environment. Although the LEED program takes into account water, air, land, and light pollution, it does not include noise pollution.

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19 Citherlet, S, J. Hand, J. Assessing energy, lighting, room acoustics, occupant comfort and environmental impacts performance of building with a single simulation program. Building and Environment Vol..37

20 Tinnitus is characterized by a constant ringing, hissing, or other sound in the ears or head when no external sound is present.

21 http://acoustics.com/ceu02/slide20.html

Sound Pressure Level (SPL) is a logarithmic measure of the pressure of a particular noise relative to a reference noise source[22]. Sound intensity is measured in decibels (dB). The range of hearing starts at 0 dB and is considered safe up to 70 dB. Over and above that level is hazardous and can result in permanent hearing damage. Auditory nerves can be permanently damaged from prolonged exposure at 90 dB. 120 dB can cause pain and ringing in the ear. Sharp pain and extensive destruction of the auditory nerves occurs at 140 dB[23].

Table 4.26. Noise Indicator

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Sound pressure level						
	0-30 dB Excellent	30-60 dB Good	60-70 dB Standard	70-110 dB Below Standard	110-140 dB Poor	

Sound pressure level (Table 4.26.), excellent is given to between 0-30 decibels(5 points), 30-60 decibels (4 points), 60-70 decibels (3 points), 70-110 decibels (2 points) and 110-140 (1 point) poor performance.

4.4.3.9. Operation: Acoustic (24)

Acoustic is the study of sound waves distribution in variously shaped enclosed or partly enclosed spaces with effects of sound waves on objects of different shapes which are in their way. Mostly concentrated on how sound and buildings interact, including the behavior of sound in concert halls and auditoriums but also in office buildings, factories and homes.

Acoustic science analyzes noise transmission from building exterior envelope to interior and vice versa. The main noise paths are roofs, eaves, walls, windows, door and penetrations. Sufficient control ensures space functionality and is often required based on building use and local municipal codes. An example would be providing a suitable design for a home which is to be constructed close to a high volume roadway, or under the flight path of a major airport, or of the airport itself.

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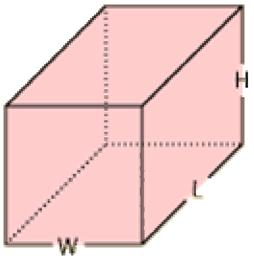
22 http://personal.cityu.edu.hk/~bsapplec/sound.htm
23 http://www.acousticalsolutions.com/education/pdfs/Sound_Pressure_Level.pdf

The reverberation time has been retained to demonstrate the feasibility of the integrated approach as it is a well known metric to assess the room acoustics (Citherlet and Hand 2002)[24].

Sabine is credited with modeling the reverberation time with the simple relationship which is called the Sabine formula (Sabine 1993)[25]:

$$\text{Reverberation Time} = RT_{60} = (0.16 s/m)\ \frac{V}{S_e}$$



Modeling a room of

Height H = m

Length L = m

Width W = m

With absorption coefficients:

a_{walls}= , a_{floor} = , $a_{ceiling}$ = for average of a_{avg} =

gives an effective absorbing area of S_e = m^2

or a room of volume V = m^3

The corresponding reverberation time is RT_{60} = seconds

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[24] Citherlet, S, J. Hand, J. (2002) Assessing energy, lighting, room acoustics, occupant comfort and environmental impacts performance of building with a single simulation program. Building and Environment Vol..37 p.845 – 856.

[25] Sabine W.,C.(1993) Collected papers on acoustics (Originally 1921). Los Altos, CA: Peninsula Publishing.

The reverberation time is perceived as the time for the sound to die away after the sound source ceases. The optimum reverberation time for a room depend upon its intended use. Around one second is desirable for a normal room, and two seconds for a medium-sized general purpose auditorium (WEB_15).[26]

Table 4.27. Acoustic Indicator (24)

Sub-indicator	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
a. Reverberation time						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

For the rating purposes, if the reverberation time is between 1 and 2 seconds it is an average value. If it is between one and 0.5 seconds, good (4 points). If it is less than 0.5, then the space has an excellent (5 points) acoustical environment. If the residential unit under construction means the operation score for acoustic indicator will receive one point until it improves to the desired performance.

4.4.3.10. Operation: Waste Handling (25)

Waste handling strategy creates valuable savings from used materials, and reduces energy use. Every residential should have waste handling strategy to minimise the impact of waste. However, currently this is not possible and there is an urgent need to find a method to influence the public.

Table 4.28. Waste Handling Indicator

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Waste handling						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

[26] http://hyperphysics.phy-astr.gsu.edu/Hbase/acoustic/revtim.html

If the waste handling amount during operation stage is between 100-90 %, the performance score for the residential unit will be excellent (5 points), 90-75 % good (4 points), 75-50 % average (3 points), 50-25% below average (2 points) and less than 25% poor performance (1 point).

4.4.3.11. Operation: Water Use Strategy (26)

Water is a high consumed natural resource and current state forces society to preserve and protect the clean water resources. During the operation phase of the home construction, water consumption rate needs to be kept at certain level. For this reason, the architect should develop water use strategy during each life cycle stage of the home unit. In the past, there are many examples of water use strategy, for instance, the foot operated sink models. This method prevents water to flush away without any purpose.

First rule for the water use strategy is to check the conditions of the fittings and pipes. Any leakage, in these items increase the water consumption, and creates undesirable damages in the building itself. Many clients consider poor quality, low cost fittings and pipes. But at later stage, operation life cycle stage, the damage will cost higher than the expected.

Another important strategy is to create a checklist for water consumption areas. Washing machine, dishwashers, baths, showers, toilets, and sinks need to be evaluated in a chart to follow their performances (Table 4.26.).

Table 4.29. Water Consumption Checklist.

ITEM	Standard Water Consumption Rate	Current Water Consumption Rate
Washing Machine		
Dishwasher		
Bath		
Shower		
Toilet		
Sink		
Garden		
Other		

The result of the research conducted in USA by American Water Works Association[27] (AWWA), illustrated in Figure 4.7., gives the ratio of water use of one person. The greatest amount is used by toilets with 20 gallons (28 percent of total use), closely followed by clothes washers with 15 gallons (21 percent), and showers with 13 gallons (17 percent). Although these numbers are national averages, studies show wide variations in water usage between households. In general, urban households use more than rural households, with people in western states using more than in the eastern U.S. or Midwest. Less water is used in the early morning hours of the day and during the winter months. Peak consumption takes place in the summer, when lawns are often watered, and families return home in the late afternoon.[28]

Table 4.30. Water use strategy indicator.

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Water use efficiency						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

Figure 4.7. Typical water use (per person) in an American single family home.
(Source: AWWA Residential End Use Study, 1999)

[27] AWWA: International nonprofit scientific and educational society dedicated to the improvement of drinking water quality and supply. www.awwa.org

[28] http://www.ces.purdue.edu/extmedia/WQ/WQ-34.pdf

The water use efficiency (Table 4.30.) is necessary during the operation life cycle stage of the home unit. Between 100-90% water efficiency, the performance score is excellent (5 points), 90-75% good (4 points), 75-50% average (3 points),

4.4.3.12. Operation: Transport (27)

The transport of people between buildings accounts for 22 per cent of UK energy use (based on 1996 figures), while freight transport, about half of which is building materials, is responsible for 10 per cent of UK energy use. Energy use for transport is growing by approximately 4 per cent a year, mostly owing to the increase in personal transport.

Energy use and CO2 emissions from transport largely depend on the relative location of home, workplace and general amenities such as shops and schools, as well car parking availability. Consequently, transport energy use is markedly lower in areas well served by public transport. Transport has other detrimental impacts on the public. In areas of high transport usage there is likely to be a corresponding increase in congestion, noise and air pollution which may have an adverse effect on the health of local inhabitants. There is also an increased risk of road accidents, especially in residential areas.

House builders should aim to encourage greater use of public transport and other alternatives to the private car, such as walking and cycling. This can be best achieved by providing nearby local amenities, sitting buildings near to public transport and providing facilities for cyclists.

Table 4.31. Transport Indicator (27)

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Occupant(s)' Transport						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

Working from home also reduces transport demand, and providing adequate space and infrastructure for a home office should help to encourage this.

Transport indicator (Table 4.29.) gives the ratio of the transportation of the occupants. If the occupants only use walk, cycle and public transport (in summary basic transport) for 100-90% of their transportation, it will receive 5 points credit. The residential unit will receive four points (Good) if the occupants use basic transport for their 90-75% of their journeys. Average score will be given to 75-50%, below average to 50-25%, and finally poor score for 25-0%. The fuel consumption begins to increase more for average, below average and poor.

It's difficult to forecast car dependency without knowing details about the occupants in the residential unit. Transport indicator is only valid for existing residential units. If the residential unit is under construction or under design stage, it will receive one point.

4.4.3.13. Operation: Refurbishment (28)

When the architects are working on existing building, they need to adapt the structure for new uses and solve the existing environmental problems which are the air quality and movement, condensation, toxins from existing construction materials, noise pollution caused by traffic and neighbours. For the life cycle management, they should reuse existing building components and materials. This way, less energy and materials will be used in the construction. Conservation of resources and energy can be accomplished by the use of recycled materials as well as from agriculture and industrial by-products.

Identify the building's potential for environmental improvement (ACE 1999),

- Increasing day lighting through roof lighting.
- Reducing overheating through the use of external louvers or blinds.
- Reducing heating demand through installation of draught lobbies and by adding insulation to external walls and roof.
- Envelope performance by better windows and doors
- Natural ventilation by adding opening sections to windows and roof lights
- Controlling ventilation and casual infiltration
- Performance of active systems through better controls, time clocks, thermostats, building energy management systems, and more efficient fittings like lights, heat emitters.

• Indoor air quality by substituting natural for synthetic finishes, linoleum, water based paints.

Considerations during refurbishment (ACE 1999),

• Improve controls on active systems.

• Improve thermal insulation.

• Passive climate control devices fixed or movable shading.

• Retrofitting sustainable components such as solar water heaters and photovoltaic cells.

• Use of renewable and recycled sources of materials

• Durability and flexibility of the proposed building

Table 4.32. Refurbishment Indicator

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Refurbishment						
	Excellent (5)	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	

If the environmental performance of the residential unit increased 100-90% after refurbishment, it will receive Excellent (5 points) credit. The residential unit will receive four points (Good) if the occupants use basic transport for their 90-75% of their journeys. Average score will be given to 75-50%, below average to 50-25%, and finally poor score for 25-0%.

4.4.4. Demolition

Demolition life cycle stage is the end life of any building construction. When buildings are demolished, some materials may be reused or recycled, but the remain goes to landfill sites or incineration causing more pressure on land and pollution.

The demolition decision for a residential unit is given under certain circumstances:

1. area redevelopment
2. changing land values

3.building’s physical condition

- outdated appearance

-lack of maintenance

-specific problem with structural or other material or system

4. building’s maintenance is expensive

5. socially undesirable use

6. improvements needed to bring the building to code is too expensive, and not suitable for anticipated use’ or because of ‘Fire damage’.

In most cases over 85% of demolition materials can be reduced, reused, reclaimed or recycled. The world's natural resources are gradually running out, at the current rate, future generations won't be able to use some of the natural resources.

Architects need to carry out material survey of the building, and look for any materials that can be reused in the present state, recycled after processing or recycled//reused through conservation (Table 4.33.).

Table 4.33. Materials to recycle and reusable.

Easy to recycle	**Reusable materials**	
- concrete (often recycled and reused at the site) - steel and other metals - pallets - packaging and paper products fluorescent tubes	- wood beams, joists, studs, baseboards - cabinets and cupboards - railings - brick - doors and casings	- interior windows - bathroom fixtures - light fixtures - ceiling grid and tile - furnishings - replant trees, shrubs

Architects should ask the local authority to find out where to send materials, such as your nearest crushing plant and recycling centre or find methods to make process them on site. They should plan the demolition to keep reusable materials in good condition. For instance, they should select reusable bricks and masonry and take them down by hand. Where possible, and when the site conditions allow, crush hardcore on site to save on transport needs. The waste handling plan should reduce as much as possible the need for landfill.

4.4.4.1. Demolition: Reuse and Recycle Plan (29)

Recycling is the process of reprocessing materials. The benefit of recycling is to lower demand for raw materials and energy required in the manufacturing process and reduction of waste to landfill. Recycling is a process that helps to solve environmental problems. It can save some finite natural resources, in particular non-renewable sources like iron ore and bauxite ore that are used to manufacture steel and aluminium cans. Recycled materials are becoming supplementary materials in the manufacturing process to ease off the ever increasing demand for natural raw materials and energy consumption. To justify the recycling of a material, the architects should assure that the energy and resources saved are greater than those needed to make a new product. For instance, composite materials make recycling difficult.

Materials that can be recycled are aluminium, concrete aggregates, plastics, steel, stone and timber. Strategies for recycling (Yeang 1999):

- Making the components easy to disassemble for instance using mechanical methods of fixing.
- Reduce the number of different types of materials used.
- Avoid using combinations of materials that are not mutually compatible.
- Considering how materials can be identified.
- Ensuring that it is possible to remove easily any components which would contaminate the recycling process.

A long-life product which is easy to reuse or to repair means less overall waste. Designing products which last longer than their predecessors is one way to reduce waste through reuse. Sometimes this can be done by employing a new technology, as in energy-efficient compact fluorescent light bulbs, which last much longer than traditional incandescent bulbs. Another approach is to fabricate products using more durable materials (Yeang 1999). Materials that can be used are ceramics, glass, lighting fixtures, and steel.

Minimising waste will require skilful knowledge of the life cycle of the product and enough information about the performance of different materials within the reuse or recycling chain. It also raises fundamental questions about the wisdom of designing products that have a life expectancy far shorter than that of the materials of which they are made (Yeang 1999).

Table 4.34. Recycling plan

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Reuse and recycling plan						
	Excellent (5)	Good (4)	Average (3)	Below (2)	Poor (1)	

Strategies for reuse involve (Yeang 1999):

• Ensuring that parts are interchangeable between items.

• Making components repairable or easily replaced.

• Allowing for technological components to be replaced without affecting the overall frame of the product.

• Choosing a design aesthetic that allows for the easy update of that part of the building through the replacement of key components such as panels.

4.4.4.1. Demolition: Solid Waste Handling Plan (30)

At the end of demolition stage, there are solid wastes created that need handling. After removing reusable and recyclable materials, left over material should be disposed with environmentally friendly methods. Each residential unit should have previous plan to tackle with the waste problem.

Table 4.35. Solid Waste Handling Plan

Sub-indicator	(5)	(4)	(3)	(2)	(1)	
a. Solid waste plan						
	Excellent (5)	Good (4)	Average (3)	Below (2)	Poor (1)	

If the waste handling plan tackles the problem 100-90%, the performance score for the residential unit will be Excellent (5 points), 90-75% Good (4 points), 75-50 % Average (3 points), 50-25% Below Average (2 points) and less than 25% or no existence of a plan Poor (1 point).

4.5. Final Performance Score

The next step in the development of the model is the stage for defining the evaluation criteria and performance grade for measuring the degree or level in which the performance indicators are met. Performance grades were established to measure the degree, and the evaluation criteria were defined by relating the characteristics of the performance indicators with the degrees in the performance grade.

Each evaluation criterion consists of the evaluation factor which is the assessable characteristics of the indicator considered significant to determine performance and the expected performance levels for the performance grades.

To exactly compare alternative residential buildings, it would be helpful to represent performance as a single score based on indicators credits and performance grades. Because the housing performance evaluation is carried out by evaluating each related performance indicator, it is necessary to aggregate their respective performance scores calculated from the credits, evaluation criteria, and performance grades. That is, the overall score of housing performance for residential buildings depends on the aggregate of indicators' respective performance scores which result from multiplying the numerical values (1–5) of the evaluated performance grades by the credits, respectively, allocated for the indicators. For comparing alternative buildings, users can get an overall housing performance score.

For easy and clear presentation of the overall building performance score, it is useful to combine indicators and categories by weighting or crediting a numerical value which represents the partial contribution of indicators and categories to the overall performance score based on their relative importance to the decision-maker (Choo 1999).

The earlier version of building evaluation models adopted the form of simple checklists with the indicators of equal importance. Recently, the derivation of credits and weights based on each indicator's relative importance to other indicators within the overall performance score is becoming more accepted (Lee 2002). Weights of the performance features are often influenced by ethical or social value judgment based on national, regional, and individual concerns (Todd and Geissler 1999) rather than scientific and technical information only. They might also change with the evaluation purpose.

To make a practical evaluation process using the proposed model, a preliminary case study for Izmir is carried out by evaluating 10 apartments and 10 houses. The residential buildings evaluated by reviewing related drawings obtained from the owners and building inspectors and the field surveys. The features of the evaluation factors were examined and the results were reflected in the performance score calculation.

Setting all criteria and credits to their initial values, the overall housing performance score will be evaluated. This case study played a role in finding the aspects in real application which should be modified by identifying the problems which evaluators may have in application, and in supplying the ground data for developing performance evaluation guiding principles.

CHAPTER 5

HOME RATING MODEL CASE STUDY

In the previous chapter, LCA Based Home Rating Model for Izmir (HRM-Izmir) was introduced as a rating method for the home construction industry. The purpose of Chapter 5 is to implement proposed HRM-Izmir on twenty residential units collected from the architectural offices and building inspection office, located at different areas of Izmir. For the case study, a total of twenty residential building audits were performed in the different residential areas in Izmir. The buildings cover typical architectural typologies, size and constructions, and installations, at different states of deterioration. The data used were collected from site visits, personal interviews with the residential owners, architects and building inspection companies.

The current case study was performed to imply the Home Rating Model-IZMIR (HRM-Izmir), a proposed rating method to assess the performance of the residential buildings in Izmir.

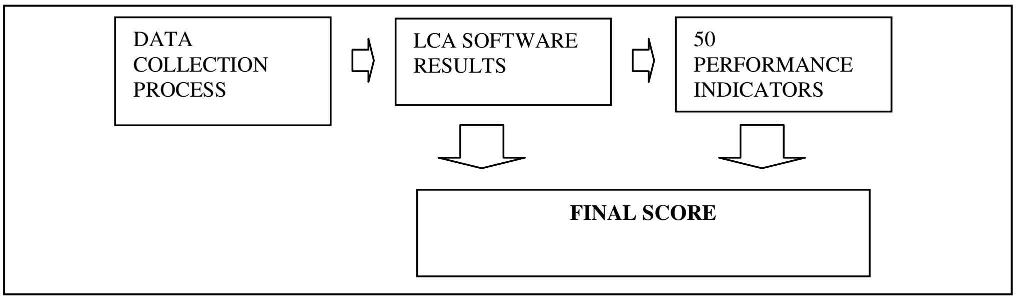


Figure 5.1. HRM-Izmir Model flow chart

HRM-Izmir has four levels to achieve the final rating result, as explained in previous chapter. First level is the data collection process which provides information about the studied unit, second level is the use of the ATHENA software program, third level consists of the implying thirty indicators and the forth level is to give a final rating score for the studied unit.

In the second part of the chapter, ATHENA computer software's results will be aggregated in data charts. Case 1 is chosen as the baseline or reference project. The energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential and weighted resource use are accepted as 100% and the comparison charts for each case will be provided.

In the third part of the chapter, implementing thirty performance indicators, and finally the chosen cases will be categorised according to the Home rating model.

Case study will only cover the legal buildings that comply with the building regulations. It will consider the methods of similar researches; however it aims to reach innovative and simple solutions. There is no intention to discuss the architectural qualities of the selected projects or the occupants' behaviours inside these units. The aim here is to evaluate the residential units impacts on the environment.

5.1. Case Study: Twenty Residential Units in Izmir

HRM-Izmir Rating Model is prepared for Izmir, however the findings and results may provide valuable data for research in this subject. Case study is organised from various residential areas in Izmir.The data collection process begins with the site visits to the ten areas in the urban city. Twenty cases, ten flats and ten houses, determined in the case study, gathered from different residential development zones, in areas named Alsancak (AL), Bornova (BOR), Balçova(BAL), Uckuyular(UC), Karsiyaka(KAR), Mavisehir (MAV), Narlidere (NAR), Seferihisar(SEF), Ceşme (CES).

Research on the case study began in September 2005. The first site visit completed in Alsancak, the size of the residential unit is 145 m^2. The flat (Case1) has three bedrooms, a living room, and a kitchen. The projects are provided from local architects, building inspection companies, and occupants of the residential units.

The selection process began by defining conditions for the residential units. First of all, they are all in the Izmir Municipality Territory, and built according to Izmir's building regulations. In Izmir, there are four types of energy sources in use; coal, fuel-oil, electricity and geothermal. Geothermal is available in Balçova District, and five cases selected for comparisons. Seven houses, and four flats selected are fuel-oil, so their performance can be compared with in each energy source or between energy sources.

Table 5.1. Location of cases in ten areas in Izmir.

CASE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Alsancak (AL)	*	*																			2
Balcova(BAL)			*				*										*	*	*		5
Mavisehir (MAV)				*										*							2
Uckuyular (UC)					*	*															2
Bornova (BOR)								*	*											*	3
Karsiyaka(KAR)										*					*	*					3
Narlidere(NAR)											*										1
Seferihisar(SEF)												*									1
Cesme(CES)													*								1

From twenty projects, ten consists of flats and the other ten are two or three storey houses. Table 5.1 indicates the locations of the twenty project, two from Alsancak(10%), five from Balcova(25%), two from Mavisehir(10%), , two from Uckuyular(10%), three from Bornova(15%), three from Karsiyaka(15%), one from Narlidere(5%), one from Seferihisar(5%), and one from Cesme(5%) area (Figure 5.2).

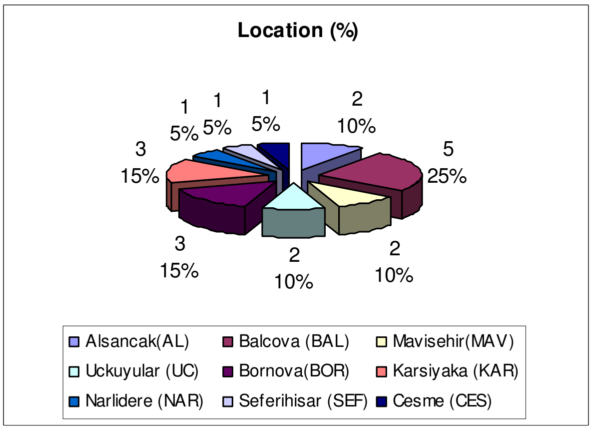


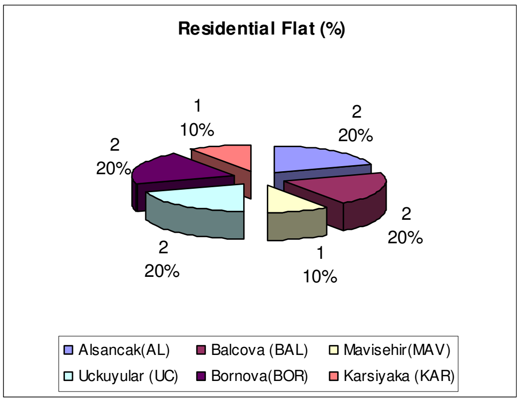
Figure 5.2. The ratio of the location of the cases.

Table 5.2 illustrates the deviation of the flats and houses, two flats in Alsancak no house (10%), two flats and three houses in Balcova (20%, 30%), one flat and one house in Mavisehir (10%, 10%), two flats in Uckuyular (10%), two flat and one house in Bornova(20%,10%), one flat and two houses in Karsiyaka (10%,20%), one house in Narlidere (10%, Seferihisar(10%) and Cesme (10%).

Table 5.2. The locations of two residential types.

CASE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Alsancak (AL)	F	F																			2F
Balcova(BAL)			F				F										H	H	H		2F,3H
Mavisehir (MAV)				F										H							1F,1H
Uckuyular (UC)					F	F															2F
Bornova (BOR)								F	F											H	2F,1H
Karsiyaka(KAR)										F					H	H					1F,2H
Narlidere(NAR)											H										1H
Seferihisar(SEF)												H									1H
Cesme(CES)													H								1H

F: Flat, H:House



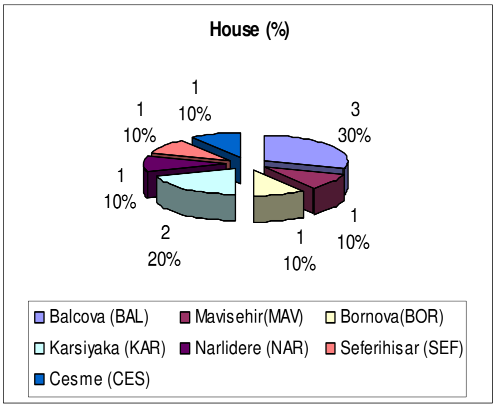


Figure 5.3. The ratio of the residential flats and the houses.

For space heating, there are four energy sources- geothermal, fuel-oil, coal, and electricity - only the geothermal energy is produced with in Izmir's boundaries (Table 5.3). In the casestudy, 55%-11 residential units use diesel energy for the space heating, 25%- 5 units use geothermal energy, 10%- 2 units use coal, and 5% -1 use electricity for heating purposes.

Table 5.3. The energy use for the space heating.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Geothermal			*				*										*	*	*		5
Fuel oil	*			*		*			*		*	*	*	*	*	*				*	11
Coal		*								*											2
Electricity								*													1

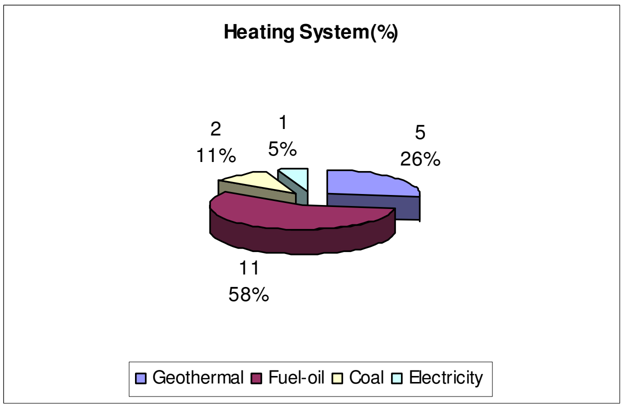


Figure 5.4. The ratio of the energy use type.

Table 5.4. The size of the units.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Less than 100					*	*				*											3
100-160m2	*	*					*	*													4
Between 160-240				*					*		*	*	*		*	*		*		*	9
240 and more														*			*		*		3

Among the cases, there are seven out of twenty units are below 160 m^2. Thirteen cases ,in majority, are residential house. Out of thirteen units, three of them are above 240 m^2, and Case 19 is heated with the geothermal energy.

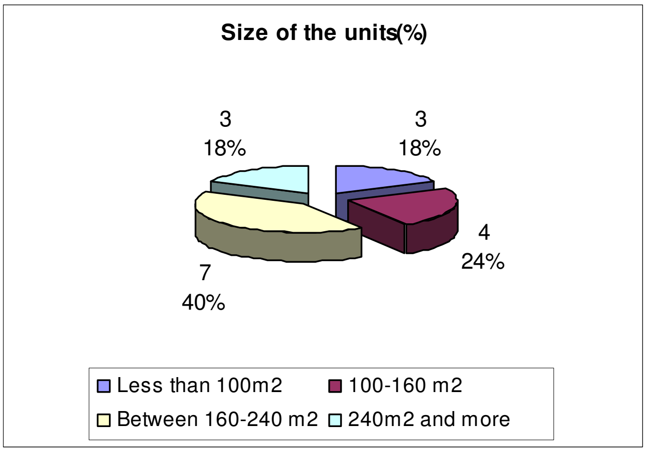


Figure 5.5. The ratio of the size of the units.

Table 5.5. The year of completion of the construction.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1980-1990	*	*								*					*						4
1990-2000			*	*			*				*	*		*					*	*	8
2000-2006					*	*		*	*				*			*	*	*			8

Eight recent projects between 2000 and 2006 are places from the increasing home construction areas like Balçova, Karşıyaka and Bornova. During this period, In Alsancak, the home construction ratio has decreased.

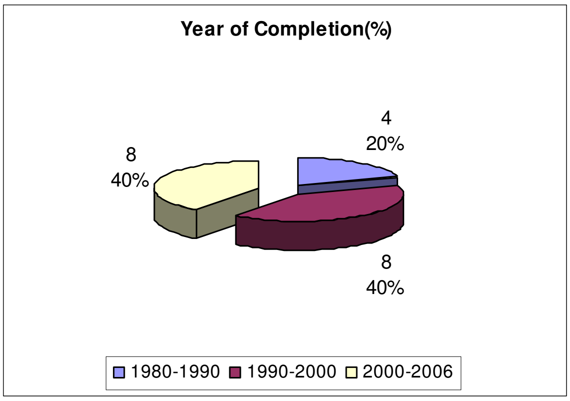


Figure 5.6. The year of completion of the construction.

Another eight cases built between year 1990 and 2000, consist of 40% of the whole case study.

Table 5.6. The number of rooms.

Case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
2 rooms	*		*		*	*															4
3 rooms		*		*			*	*		*	*	*		*				*			9
4 rooms									*				*		*					*	4
5 rooms and more																*	*		*		3

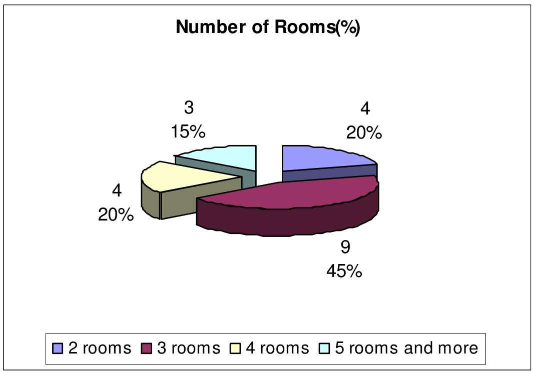


Figure 5.7. The ratio of rooms.

Four flats have two bedrooms; consist of 20% percent of the whole study. Five flats and four houses have three bedrooms. One flat and three houses have four bedrooms and a large living room. Three houses located in Karşıyaka and Balçova, have five to six bedrooms.

5.2. Case Study: Appling HRM-Izmir Model

HRM-Izmir Rating Model was applied to each case. First stage was to fill Form A which is the "Data Collection Process". Second stage began after entering all the information to ATHENA- LCA software. All the findings recorded and placed in Form B "ATHENA Software Results". Case 1 is selected as a baseline project, and all the other cases values placed in Form B. At the third stage, Form C "Performance Indicators" was completed for each project, giving performance scores of the selected thirty indicators in four life cycle stages. The results were categorised under five scores; Excellent (5 points), Good (4 points), Average (3 points), Below Average (2points), and Poor (1 point).

5.2.1. Case One: Alsancak-1 Flat

Case 1 is an apartment flat, located in Alsancak District near Izmir Fair (Figure 5.8). It's at the third floor of four floor apartment building. The size of the flat is 145 m^2 with three rooms, kitchen, living room, WC and bathroom. Water heating is created by the electrical boiler. For space heating, single storey heating system is used and it consumes approximately 1210 litre diesel fuel annually.

Bathroom, WC and Room 3 (Figure 5.8) have only artificial lighting. Small vents are used to ventilate these areas. A long balcony connects kitchen, living room, and room 2 from outside provides sunlight and natural ventilation. Inside corridor solves the circulation inside the flat.

Case 1 LOCATION AND PLAN

Figure 5.8. Location and Floor Plan of Case 1.

Form A (Table 5.7) gives information about the residential unit’s local conditions like orientation, construction history and materials, energy use and unit size of the residential unit. Form A provides valuable information for Form B and C.

Table 5.7. Form A: Data Collection Process for Case 1.

FORM A: DATA COLLECTION (Flat)										Case No. 1 ALSANCAK-1
1	Building Name	Case 1 Flat 1		2	Client	First owner				
3	Address	Alsancak (AL)								
4	Architect	-								
5	Consultants	-								
6	Year of construction	1985	7	Year of completion	1988	8	Year of occupation	1989		
9	Residential Type	Flat 2+1		Flat 3+1	X	House		Other		
10	Construction Type	R.C.	X	Masonry		Steel		Timber		Other………….

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East	12	Energy Type: Diesel	Electricity	Natural Gas	Coal	Geothermal
				X								X		X	

13	Heating Type	Stove		Single Storey Heating		Central Heating	X	Other…………
14	Water heating	LPG		Single Storey Heating		Central Heating	X	Electricity	X
15	Size (m2)	0- 100		100- 150	X	150-250		250-more	
16	Occupancy	1		2	X	2-4		4-more	

After completing Form A, Case 1 is evaluated with six ATHENA indicators (Table 5.8) which are, energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential, and weighted resource use.

Case 1 is a baseline or a reference project and another case will be compared and the difference will give information about the performance of the cases between each other. For Case 1 six ATHENA indicators, each indicator is accepted as 100%, for the comparison purposes of the other projects.

All the cases will be evaluated among each other, and the baseline case does not mean that it is the best residential unit. As the results of the comparisons show that Case 1 can be poor in one indicator or average in another. The unique issue about Case 1 is to be the first residential unit visited.

Table 5.8. ATHENA Software Results for Case 1.

FORM B: ATHENA SOFTWARE RESULTS		CASE 1 (Flat)	ALSANCAK-1	
	All Measures	**Baseline (%)**	**Case No. (%)**	**Difference**
1	Energy Consumption	100		
2	Solid Waste Emission	100		
3	Air Pollution Index	100		
4	Water pollution Index	100		
5	Global Warming Potential	100		
6	Weighted Resource Use	100		

Form B measures (Table 5.7) the quantitive amounts of the material, energy, solid waste, pollution, water use and air. Form C comes into action after Form B and measures performance values for selected thirty indicators under four life cycle stages; site selection, construction, operation, and demolition. These indicators based on energy, material, water, waste and environment issues. Some issues may repeat itself in other stages, but the assessor should keep in mind that the performance of the issue may be evaluated differently in each stage. For instance, energy use in construction stage may differ in operation stage.

Form C is the third form of the HRM-Izmir Model. Selected indicators will categorise the studied case under five performance score; excellent (5point), good (4 point), average (3point), below average (2 point) and poor (1 point).

Case 1 is located in the city centre immediately receives five points from the location indicator (1) (Table 5.9). However, the ecology indicator (2) scores are good for noise resources sub-indicator, average for 3 sub-indicators; water quality, soil contamination, electro magnetic field, and below average for seven sub-indicators; flora fauna, wetlands, wind condition, sun condition, air quality index. Out of fifty five points, Case 1 scored twenty seven points, meaning Average Category (3 points) in overall ecology indicator (1).

Table 5.9. Form C Performance Indicators for Case 1.

FORM C: PERFORMANCE INDICATORS			CASE No. 1 ALSANCAK -1 (Flat)					
Indicator			Excellent (5)	Good (4)	Average (3)	Below (2)	Poor (1)	
	A. SITE SELECTION							
1	**Location**		X					5
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora				X		2
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)			X			3
		f. Wetlands or flood plain				X		2
		g. Wind conditions				X		2
		h. Sun conditions				X		2
		i. Temperature				X		2
		j. Noise Resources		X				4
		k. Air Quality Index				X		2
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking			X			3
		b. Green Area			X			3
		c. Medical Centre		X				4
		d. School		X				4
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport		X				4
		h. Retail		X				4
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation					X	1
		b. Wind Orientation					X	1
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate				X		2
		b. Adjacent Structure(s)				X		2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity				X		2
		b. Heating				X		2
		c. Vehicle use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.9. Form C Performance Indicators for Case 1. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors			X			3
		b. Windows			X			3
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					**X**	1
		b.Heat				**X**		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing					X	1
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance					X	1
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use					**X**	
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System					X	1
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System					X	1
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents					X	1
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air					X	1
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight				X		2
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level					X	1
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling				X		2
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use				X		2
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport					X	1
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment			X			3
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 1 has four good, three average scores, one below average score for its sub-indicators. Case 1 scores twenty seven out of forty, receives average score in overall existing built environment indicator (3).

At construction stage, there are seven performance indicators to evaluate the conditions of construction till completion date. Building envelope indicator (5) evaluates the physical volume of the studied unit. Building envelope improves energy use, indoor air quality, ventilation and heating consumption. Building envelope is dependant on two sub-indicators; one local climate conditions, and the other is adjacent structures. Total score for building envelope indicator (5) is four out of ten points, meaning below average performance for Case 1.

Material selection has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. If 100-90% of the materials supplied from inside Turkey, the case will be in Excellent category. However, for Case 1, 67% of the materials are made in Turkey, that means Case 1 performance category for material selection is average.

Material LCA sub-indicator records the amount of LCA applied materials. For Case 1, LCA is applied to less than 25% of the materials during construction, so the final score for Case 1 is poor. The sum of two sub-indicators are material selection indicator (6)'s category, scores below average (3 points).

During the material transportation, fossil fuels are used to run the vehicles that carry materials from one distance to another distance. Material transportation indicator (7) considers the method and distance of the transportation. For Case 1, 64% percent of materials are transported from local warehouses, means the performance score is average.

Material conservation indicator (8) considers the efficient use of construction materials. The material consultants must provide necessary management documents and manuals to minimise misuse of materials. This indicator is valid for new residential constructions, so Case 1 as an existing building has not have any material conservation plan. The performance score for Case 1 is assumed in Poor category (1 point).

During construction, there are many activities that consume fossil fuel and electricity energy. Energy efficiency is important because energy needs energy to carry the source. Minimised energy use means more savings for producing and carrying the source. Energy conservation indicator (9) influences the building site to use energy efficiently. For Case 1, during construction, it is assumed that there were not any methods to safe energy use. Performance score is Poor Category for Case 1.

Renewable energies are promoted as clean sources. However, the installation of solar panels initial costs can be expensive for the construction site. The construction process may take more than one year and can save considerable amount of fossil and hydro energy. After the completion of the construction, either the panels can be also used during operation stage of the residential unit or the building contractor can transport the solar panels to new construction site.

Renewable energy use indicator (10) for Case 1 is Poor performance because it is assumed that there was not any use of renewable energy source during construction.

Waste problem is increasing each day because of improper use of energy, material and water. Waste strategy must begin from construction stage and must continue during operation and demolition stages. In construction stage, the waste products are the packages, spare parts and left over of the materials after their application. All these waste must be collected separately and stored in containers. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 1 has not have any plan for waste strategy. During new constructions, this indicator will have important role to reduce waste during construction. Water is a scarce source on earth, so any construction site should use water efficiently, otherwise it is stated in many literature that water will not be available for future generations. Water strategy indicator (12) helps the construction site to minimise water consumption. Case 1 is assumed Poor Category.

A residential unit has five main components; door, window, ceiling, floor, and wall. Each component has different design potentials. For instance, the colour or the material type of the walls may vary depending on architects' visions. However, final product should be efficient and environmentally responsive. During their production and application processes, LCA Evaluation must be conducted to achieve sustainable environment. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels.

Insulation is the blanket of the residential unit. Correct application of insulation, can minimise heating and cooling loads. Sound insulation reduces outside noise sources and creates comfortable living environment inside the unit for the occupants. Insulation indicator (14) assesses the standard of insulation in five categories. Case 1 has scored poor in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average category.

Materials Maintenance indicator (16) follows the maintenance progress for the residential unit. Case 1 is in poor condition compare to other units. The Poor performance result means that the unit needs refurbishment. Energy use indicator (17) monitors the energy use efficiency for electricity. Saving electricity will reduce the overall national energy cost for the country. Case receives poor performance because there are not any measures or methods to reduce electricity use. Cooling indicator (18) is valid during hot seasons. Materials, building envelope design, and ventilation are partially related with cooling indicator. There is not any specific natural cooling strategy for Case 1. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor performance for Case 1. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a poor performance for Case 1. Indoor air quality indicator (21) for Case1 is poor performance. Indoor materials including paints, sealants, adhesives, carpets and composite wood products, have not been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins are used. The level and distribution of daylight factor is 45% for Case 1. Day lighting indicator (22) is below average (2 points) performance. Sound pressure level is more than 70 decibels (dB). Noise indicator (23) performance for Case1 is Poor(1 point). For acoustic indicator (24) the reverberation time is poor for Case 1. Waste handling indicator (25) assesses the level of waste collection process in the residential units. The local government should provide necessary rules to persuade the occupants to separate their garbage at home. For instance in Switzerland, the government charges every black bin bag, and adjusted collection periods for different wastes. Charging bin bags persuades occupants to separate glass, metal cans, and paper to save space in the black bin bag. For Case 1, waste handling indicator (25)'s performance is below average because they only separate the paper products. Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is below average (2 points) for Case 1. The flat needs to reduce water consumption in the toilet flushing and shower use. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 52% of their travelling on private car. Transport indicator performance receives average score. Refurbishment indicator (28) checks the environmental improvements of an existing dwelling or whether future refurbishment plan is considered. For Case 1, refurbishment indicator is average because only some parts of the residential unit were improved.

Table 5.10. Form D score sheet for Case 1.

FORM D: SCORE SHEET Indicator	Category	Case 1 Alsancak-1 (Flat) Comment
1.Location	EXCELLENT	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	POOR	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	BELOW AVERAGE	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	POOR	More environmentally responsive glazing techniques
16. Materials Maintenance	POOR	Improve the maintenance program of the unit.
17. Energy Use	POOR	Reduce energy consumption.
18. Cooling	POOR	Imply natural cooling techniques
19. Heating	POOR	Improve energy source
20. Ventilation	POOR	Increase number of vents
21. Indoor Air Quality	POOR	Choose materials with low VOC emissions.
22. Daylighting	BELOW AVERAGE	Improve existing windows. Prevent glare with shutters.
23. Noise	BELOW AVERAGE	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	BELOW AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	BELOW AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	AVERAGE	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1 (1 out of 30)	- (0 out of 30)	2-3-7-13-27-28(6 out of 30)	5-6-9-22-25-26(6 out of 30)	4-8-10-11-12-14-15-16-17-18-19-20-21-23-24-29-30 (17 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 1 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 1 does not have a plan; the solid waste handling plan will be Poor (1 point).

Form D (Table 5.10), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent Category: Indicator1, Good: no Indicator, Average: Indicator 2-3-7-13-27-28 (6 Indicators; 20%) Below Average: Indicator 5-6-9-22-25-26 (6 Indicators; 20%) Poor: Indicator 4-8-10-11-12-14-15-16-17-18-19-20-21-23-24-29-30 (17 Indicators; 57%)

5.2.2. Case Two: Alsancak-2 Flat

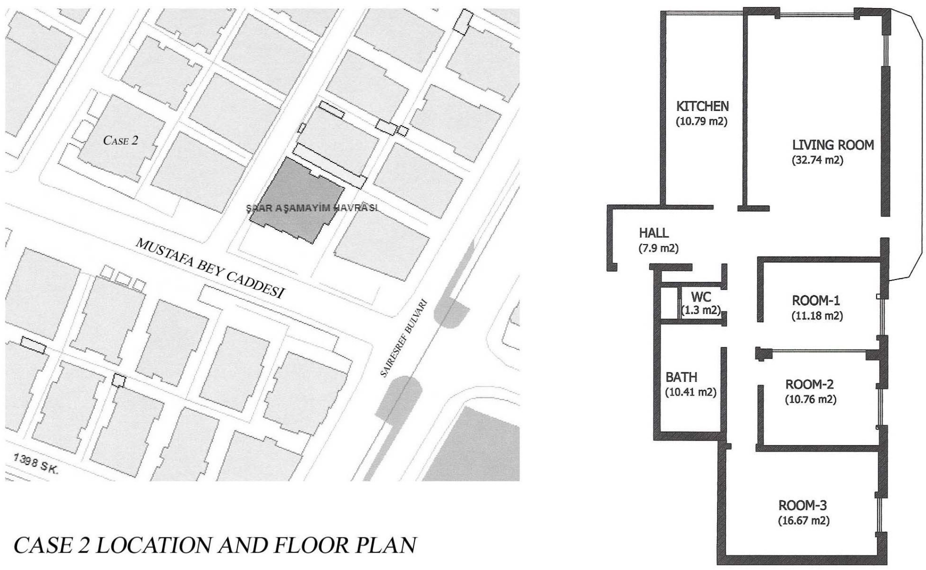


Figure 5.9. Location and floor plan for Case 2.

Case 2 is an apartment flat, located in Alsancak District (Figure 5.9). It's at the forth floor of six floor apartment. Case 2 is completed in 1985 and the size of the flat is 152 m^2 with three rooms, kitchen, living room, WC, and a bathroom. Central heating system operates the space heating and water heating.

Bathroom and WC have artificial lighting and other areas have a clear access to natural lighting. Small vents in the bathroom and WC are used to ventilate these areas. Living room has a long balcony, and kitchen has a normal size balcony, later refurbished and added to the existing kitchen.

Form A (Table 5.11) gives conditions about Case 2 like orientation of the flat, construction history, energy use and unit size.

Table 5.11. Form A: Data Collection Process for Case 2

FORM A: DATA COLLECTION								**Case No. 2 ALSANCAK-2 (Flat)**
1	**Building Name**	Case 2 Flat 2	**2**	**Client**	-			
3	**Address**	**Alsancak (AL)**						
4	**Architect**	-						
5	**Consultants**	-						
6	**Year of construction**	**1983**	**7**	**Year of completion**	**1985**	**8**	**Year of occupation**	**1986**
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**	**X**	**House**		**Other**

10	Construction Type	R.C.	X	Masonry		Steel		Timber		Other…….....	

11	**Orientation**	**North**	**Nort-east**	**North-west**	**South**	**South-east**	**South-west**	**West**	**East**	**12**	**Energy Type: Diesel**	**Electricity**	**Natural Gas**	**Coal**	**Geothermal**
			X											**X**	

13	**Heating Type**	**Stove**		**Single Storey Heating**		**Central Heating**	**X**	**Other…………**	
14	**Water heating**	**LPG**		**Single Storey Heating**		**Central Heating**		**Electricity**	**X**
15	**Size (m2)**	**0- 100**		**100- 150**	**152**	**150-250**		**250-more**	
16	**Occupancy**	**1**		**2**	**X**	**2-4**		**4-more**	

After completing Form A, Case 2 is evaluated with six ATHENA indicators (Table 5.12). Energy consumption for Case 2 is higher than Case 1. Solid waste emission is 122.56 for Case 2, the difference is 22.56 compared with Case 1. Air pollution index, global warming potential and weighted resource use indicators are slightly higher than Case 1. Water pollution index performance is better than Case 1.

Table 5.12. Form B: ATHENA Software Comparison Chart for Case 1 and Case 2

FORM B: ATHENA SOFTWARE RESULTS		CASE 2		ALSANCAK-2 (Flat)
	Indicator	**Baseline (%)**	**Case 2 (%)**	**Difference**
1	Energy Consumption	100	109.55	9.55
2	Solid Waste Emission	100	122,56	22.56
3	Air Pollution Index	100	108,46	8.46
4	Water pollution Index	100	95.40	-4.6
5	Global Warming Potential	100	103.65	3.65
6	Weighted Resource Use	100	101.34	1.34

The ATHENA six performance comparisons indicate that Case 2 is better than Case 1 in only water pollution index indicator. However Case 1 is only a baseline project, it's not the excellent project. Case 2's overall performance can be better than other cases in this study.

Form C comes into action after Form B and measures performance values for selected thirty indicators under four life cycle stages; site selection, construction, operation, and demolition. These indicators based on energy, material, water, waste and environment issues.

Selected indicators will rate Case 2 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point). First stage begins with site conditions and Case 2 is located in the city centre immediately receives five points from the location indicator (1). However, the ecology indicator (2) has eleven sub-indicators (Table 5.13). Noise resources sub-indicator scores good (4 points), three sub-indicators; water quality, soil contamination and EMF score average (3 points), six sub-indicators; flora, fauna, wetlands, wind, sun, temperature, and air quality index receive below average (2 points) score for its sub-indicators. Case 2 scores twenty seven out of fifty-five, receives average (3 points) score in overall existing built environment indicator (3).

Table 5.13. Form C Performance Indicators for Case 2.

FORM C: PERFORMANCE INDICATORS			CASE No. 2 ALSANCAK -2 (Flat)					
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**		X					5
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora				X		2
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)			X			3
		f. Wetlands or flood plain		X				4
		g. Wind conditions				X		2
		h. Sun conditions				X		2
		i. Temperature				X		2
		j. Noise Resources		X				4
		k. Air Quality Index				X		2
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking			X			3
		b. Green Area			X			3
		c. Medical Centre		X				4
		d. School		X				4
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport		X				4
		h. Retail		X				4
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation					X	1
		b. Wind Orientation					X	1
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate				X		2
		b. Adjacent Structure(s)				X		2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity				X		2
		b. Heating				X		2
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1

Table 5.13. Form C Performance Indicators for Case 2. (cont.)

		b. Wind power					**X**	**1**
11	**Waste Strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors			X			3
		b. Windows			X			3
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					X	1
		b.Heat				X		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing					X	1
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Materials maintenance			X			3
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use				X		2
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Heating System				X		2
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Control of vents					X	1
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air					X	1
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b. Level of Daylight					X	1
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level				X		2
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling				X		2
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use				X		2
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport			X			3
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Refurbishment			X			3
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reuse Plan					X	1
		b. Recycle Plan					X	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) has eight sub-indicators. Four sub-indicators; medical centre distance, school distance, public transport, and retail score good (4 points), three sub-indicators; car parking, green area, place of worship have average (3 points) performance, one sub-indicator; surrounding buildings is below average score (2 points). Case 2 scores twenty seven out of forty, receives average score (3 points) in overall existing built environment indicator (3)

Final indicator for site selection is orientation indicator (4) with two sub-indicators sun and wind. Case 2's existing conditions are poor (1 point) performance for sun and wind conditions.

At construction stage, building envelope indicator (5) evaluates the physical volume of the studied unit. Total score for building envelope indicator (5) for Case 2 is four out of ten points, meaning below average (2 points) performance for Case 2. Material selection has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. 62% the materials used in Case 2 produced in Turkey, that means Case 2 performance category for material selection (6) is average (3 points). LCA is applied to less than 25% of the materials during construction, material LCA sub-indicator performance for Case 2 is poor (1 point). Material selection indicator (6)' total performance score is below average (Table 5.13). Material transportation indicator (7) considers the method and distance of the transportation. For Case 2, 67% percent of materials are transported from local warehouses, means the performance score is average (3 points). Material conservation indicator (8) for Case 2 is an existing building has not have any material conservation plan. The performance score for Case 2 is assumed Poor (1 point) category. Energy conservation indicator (9) influences the building site to use energy efficiently. For Case 2, during construction, it is assumed that there were not any methods to safe energy use. Performance score is poor (1 point) Category for Case 2.

Renewable energy use indicator (10) for Case 2 is poor (1 point) performance because it is assumed that there was not any use of renewable energy source during construction.

In construction stage, the waste products are the packages, spare parts and left over of the materials after their application. All these waste must be collected separately and stored in containers. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 2 has not have any plan for waste strategy. During new constructions, this indicator will have important role to reduce waste during construction. Water strategy indicator (12) helps the construction site to minimise water consumption. It is assumed that Case 2 has not have any plan for water strategy. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels. Door components score below average (2 points), windows score below average (2 points), ceiling score below average (2 points), floor score below average (2 points), and walls score below average (2 points). Total performance category for Case 2 is below average (2 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 2 has scored poor in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in below average (2 points) Category.

Materials Maintenance indicator (16) follows the maintenance progress for the residential unit. Case 2 is in poor condition compare to other units. Poor (1 point) performance result means that the unit needs refurbishment. Energy use indicator (17) monitors the energy use efficiency for electricity. Case 2 receives poor (1 point) performance because there are not any measures or methods to reduce electricity use. Cooling indicator (18) is valid during hot seasons. There is not any specific natural cooling strategy for Case 2. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 2. There is a basic ventilation method; opening windows to circulate air, ventilation indicator (20) is poor(1 point) performance for Case 2. Indoor air quality indicator (21) for Case 2 is Poor (1 point) performance. Indoor materials including paints, sealants, adhesives, carpets and composite wood products, have not been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins are used. The level and distribution of daylight factor is less than 25% for Case 2. Day lighting indicator (22) is Poor (1 point) performance. Sound pressure level is more than 70 decibels (dB). Noise indicator (23) performance for Case 2 is Poor (1 point). Acoustic indicator (24) measures the reverberation time, poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. Waste handling indicator (25)'s performance is below average because they only separate the paper products. Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is below average. The flat needs to reduce water consumption in the toilet flushing and shower use. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 65% of their travelling on private car.

Transport indicator performance receives Average (3 points) score. Refurbishment indicator (28) checks the environmental improvements of an existing dwelling or whether future refurbishment plan is considered. For Case 2, refurbishment indicator is Average (3 points) because there is not any refurbishment plan prepared.

Table 5.14. Form D score sheet for Case 2.

FORM D: SCORE SHEET		Case 2 Alsancak-2 (Flat)
Indicator	Category	Comment
1.Location	EXCELLENT	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	POOR	Existing residential unit is difficult to improve. However, building envelope can increase the performance.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	BELOW AVERAGE	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	POOR	More environmentally responsive glazing techniques
16. Materials Maintenance	AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	POOR	Reduce energy consumption.
18. Cooling	BELOW AVERAGE	Imply natural cooling techniques
19. Heating	BELOW AVERAGE	Improve energy source
20. Ventilation	POOR	Increase number of vents
21. Indoor Air Quality	POOR	Choose materials with low VOC emissions.
22. Daylighting	POOR	Improve existing windows. Prevent glare with shutters.
23. Noise	BELOW AVERAGE	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	BELOW AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	BELOW AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	AVERAGE	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1 (1 out of 30)	- (0 out of 30)	2-3-7-13-16-27-28 (7 out of 30)	5-6-9-18-19-23-25-26 (8 out of 30)	4-8-10-11-12-14-15-17-20-21-22-24-29-30 (14 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 2 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 2 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.14), provides comments to improve the residential unit's conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent Category: Indicator1 (3%), Good: no Indicator, Average: Indicator 2-3-7-13-16-27-28 (7Indicators; 23%) Below Average: Indicator 5-6-9-18-19-23-25-26 (8 Indicators; 27%) Poor: Indicator 4-8-10-11-12-14-15-17-20-21-22-24-29-30 (14 Indicators; 47%).

5.2.3. Case Three: Balçova-1 Flat

Case3 (BAL), residential flat is completed in 2000 and occupied by the owner since then. The size of the flat is 72 m^2 with two rooms, kitchen, living room, and a bathroom. Central heating system operates the space heating and water heating with the

Figure 5.10. Location and Floor Plan for Case 3.

help of the geothermal energy. The total annual electricity use is 2560 kWh and 100 litre of LPG is used for cooking purposes. Each room in Case 3 daylight penetrates inside the space, and has basic ventilation.

Table 5.15. Form A Data Collection Process for Case 3.

FORM A: DATA COLLECTION (Flat)								Case No. 3 BALÇOVA-1
1	Building Name	Case 3 Flat 3		2	Client			
3	Address	Balcova (BAL)						
4	Architect							
5	Consultants							
6	Year of construction	1998	7	Year of completion	2000	8	Year of occupation	2000
9	Residential Type	Flat 2+1	X	Flat 3+1		House		Other
10	Construction Type	R.C.	X	Masonry		Steel		Timber

10 (cont.)	Other……...	

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East

12	Energy Type	Diesel	Electricity	Natural Gas	Coal	Geothermal
						X

13	Heating Type	Stove		Single Storey Heating		Central Heating	X	Other……	
14	Water heating	LPG		Single Storey Heating		Central Heating	X	Electricity	X
15	Size (m2)	0- 100	72	100- 150		150-250		250-more	
16	Occupancy	1		2	X	2-4		4-more	

After completing Form A, Case 3 is evaluated with six ATHENA indicators; Case 3 and Case 1 (baseline project) were compared in Form B (Table 5.16). Energy consumption, solid waste emission, air pollution index, and global warming potential for Case 3 are lower than Case 1. Solid waste emission is 63.89 for Case 3; the difference is 36.11 compared with Case 1.

ATHENA six performance comparisons indicate that Case 3 is better than Case 1 in energy consumption, solid waste emission, air pollution index, global warming potential and weighted resource use indicators. Case 3 water pollution rate is extremely high compared to Case 1.

Table 5.16. Form B: ATHENA Software Comparison Chart for Case 1 and Case 3.

FORM B: ATHENA SOFTWARE RESULTS		CASE 3		BALÇOVA-1 (Flat)
	Indicator	**Baseline (%)**	**Case 3 (%)**	**Difference**
1	Energy Consumption	100	42,60	- 57,40
2	Solid Waste Emission	100	63,89	- 36,11
3	Air Pollution Index	100	37,10	-62,90
4	Water pollution Index	100	181,78	81,78
5	Global Warming Potential	100	37,73	- 62.27
6	Weighted Resource Use	100	23,63	-76.37

Form C comes into action after Form B and measures performance values for selected thirty indicators under four life cycle stages; site selection, construction, operation, and demolition. These indicators based on energy, material, water, waste and environment issues.

Selected indicators will rate Case 3 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point). The conditions of the categories are defined in Chapter 4.

First stage begins with site conditions stage and Case 3 is located away from the city centre, but it is part of the city's main infrastructure, receives Good (4 points) from the location indicator (1).

Ecology indicator (2) has eleven sub-indicators (Table 5.17). The flat is located in a quiet neighbourhood, noise resources sub-indicator scores Excellent (5 points). Four sub-indicators; water quality, wind conditions, sun conditions, and air quality index score Good (4 points). The buildings are very close to each other, so lowers sun and wind conditions, but the three facades are open in this flat. Three sub-indicators; soil contamination, EMF, and temperature score Average (3 points). Three sub-indicators; flora, fauna and wetlands score Below Average (2 points). It is hardly any green area near the area. Case 3 scores thirty-six out of fifty-five points, and receives Average score (3 points) in overall for existing built environment indicator (3).

Table 5.17. Form C Performance Indicators for Case 3.

FORM C: PERFORMANCE INDICATORS			CASE No. 3 BALÇOVA -1 (Flat)					
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora				X		2
		b. Fauna				X		2
		c. Water quality		X				4
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)			X			3
		f. Wetlands or flood plain				X		2
		g. Wind conditions		X				4
		h. Sun conditions		X				4
		i. Temperature		X				4
		j. Noise Resources	X					5
		k. Air Quality Index		X				4
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking		X				4
		b. Green Area			X			3
		c. Medical Centre		X				4
		d. School		X				4
		e. Place of Worship		X				4
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail		X				4
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation					X	1
		b. Wind Orientation					X	1
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate				X		2
		b. Adjacent Structure(s)			X			3
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location		X				4
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.17. Form C Performance Indicators for Case 3. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors			X			3
		b. Windows			X			3
		c. Ceiling				X		2
		d. Floor			X			3
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound				**X**		2
		b.Heat				**X**		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing		X				4
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance	X					5
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use		X				4
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System		X				4
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System	X					5
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air			X			3
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight		X				4
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level	X					5
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time				X		2
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling			X			3
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use			X			3
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport			X			3
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment		X				4
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Five categories defined in Chapter 4. Case 3 has five Good (4 points); car parking, medical centre, school, plan of worship, and retail sub-indicators, two Average scores (3 points); green area and public transport, one Below Average (2 points) for its sub-indicators. Case 3 scores twenty eight out of forty, receives Average (3 points) in overall existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Building envelope indicator (5) evaluates the physical volume of the studied unit. Building envelope improves energy use, indoor air quality, ventilation and heating consumption. Total score for building envelope indicator (5) is five out of ten points, meaning Average (3 points) performance for Case 3. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 3, 87% of the materials are made in Turkey that means Case 3 performance category for material selection is Good (4 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 3, LCA is applied to less than 25% of the materials during construction, so the final score for Case 3 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, final score is Average (3 points). Material transportation indicator (7) is average score for Case 3, 69% percent of materials are transported from local warehouses. Material conservation indicator (8) is valid for new residential constructions, so Case 3 as an existing building has not have any material conservation plan. The performance score for Case 3 is Poor category. Energy conservation indicator (9) influences the building site to use energy efficiently. For Case 3, during construction, it is assumed that there were not any methods to safe energy use. Performance score is Poor Category for Case 3. Renewable energy use indicator (10) for Case 3 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 3 has not have any plan for waste strategy during construction.

For Case 3, water strategy indicator (12) has not have any plan. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 3 is average (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 3 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Materials Maintenance indicator (16) for Case 3 is in Excellent (5 point) score. Energy use indicator (17) monitors the energy use efficiency for electricity. It is Good (4 points) for 78% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Average (3 points). There is not any specific natural cooling strategy for Case 3. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor performance for Case 3. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a Below Average (2 points) performance for Case 3. Indoor air quality indicator (21) for Case 3 is Average (3 points) performance. More than 75% of indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used. Indoor materials including paints, sealants, adhesives, carpets and composite wood products, have not been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins are used. The level and distribution of daylight factor is 85% for Case 3. Day lighting indicator (22) is Good (4 points) performance. Sound pressure level is less than 30 decibels (dB). Noise indicator (23) performance for Case 3 is Excellent (5 points). Acoustic indicator (24) for Case 3 is Below Average (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 3, waste handling indicator (25)'s performance is Average (3 points). Water use indicator (26) performance for water use is Average (3 points) for Case 3. The occupants spent 52% of their travelling on private car. Transport indicator (27) performance receives average score. Refurbishment indicator (28) for Case 3 is Average (3 points).

Table 5.18. Form D score sheet for Case 3.

FORM D: SCORE SHEET		Case 3 Balçova-1(Flat)
Indicator	Category	Comment
1.Location	GOOD	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	AVERAGE	
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	AVERAGE	Increase use of material LCA
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	BELOW AVERAGE	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	BELOW AVERAGE	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	GOOD	
16. Materials Maintenance	EXCELLENT	Excellent condition
17. Energy Use	GOOD	Reduce energy consumption.
18. Cooling	GOOD	Imply natural cooling techniques
19. Heating	EXCELLENT	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	AVERAGE	Choose materials with low VOC emissions.
22. Day lighting	GOOD	Improve existing windows. Prevent glare with shutters.
23. Noise	EXCELLENT	Use sound insulation to reduce the outside noise impact
24. Acoustic	BELOW AVERAGE	Improve sound transmission inside the space with special panels and components.
25. Waste handling	AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	GOOD	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
15-19-23(3 out of 30)	1-15-17-18-22-28 (6 out of 30)	2-3-4-6-7-13-21-25-26-27(10 out of 30	5-9- 14-20-24 (5 out of 30)	8-10-11-12-29-30 (six out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. Case 3 does not have a reuse and recycle plan previously, receives Poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 1 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.18), provides comments to improve the residential unit's conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent Category: Indicator 15-19-23 (3 Indicators; 10%), Good: Indicator 1-15-17-18-22-28 (6 Indicators; 20), Average: Indicator 2-3-4-6-7-13-21-25-26-27 (10 Indicators; 33%) Below Average: Indicator 5-9-14-20-24 (5 Indicators; 17%) Poor: Indicator 8-10-11-12-29-30 (6 Indicators; 20%).

5.2.4. Case Four: Mavişehir-1 Flat

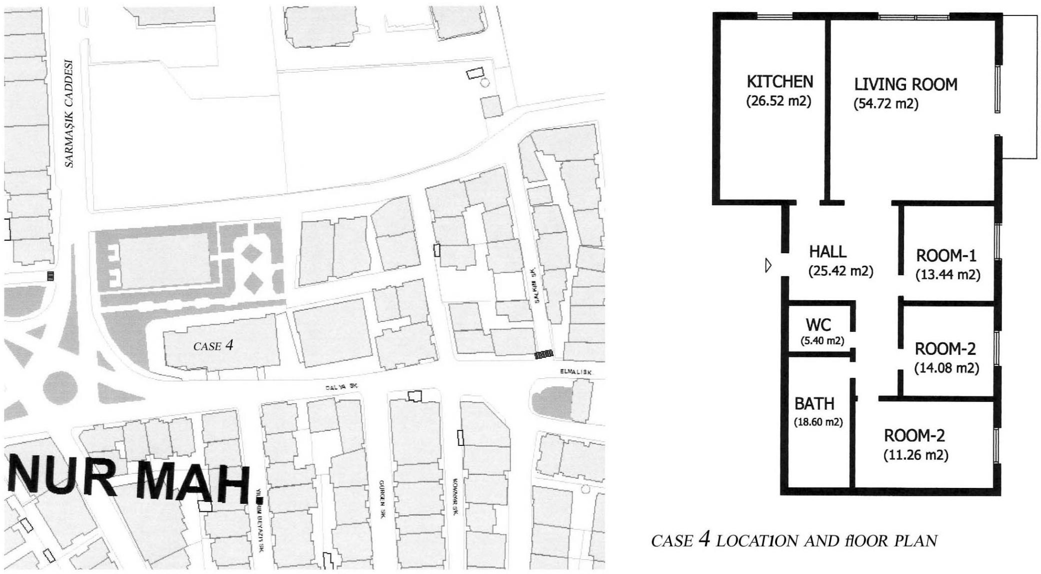


Figure 5.11. Location and Floor Plan for Case 4.

Case 4 (MAV), residential flat is completed in 2000 and occupied by the first owner since then. The size of the flat is 170 m^2 with three rooms, kitchen, living room, WC, and a bathroom. Single storey heating with diesel, operates the space heating and the electrical water boiler provides the hot water.

Form A (Table 5.19) developed for the HRM-Izmir home rating model, gives accurate information about Case 4's conditions like orientation of the flat, construction history, energy use and unit size.

Table 5.19. Form A: Data Collection Process for Case 4.

FORM A: DATA COLLECTION										**Case No. 4 MAVİŞEHİR-1 (Flat)**	
1	**Building Name**	Case 4 Flat 4	**2**	**Client**	-						
3	**Address**	**Mavisehir (MAV)**									
4	**Architect**	**-**									
5	**Consultants**	**-**									
6	**Year of construction**	**1998**	**7**	**Year of completion**	**2000**	**8**	**Year of occupation**	**2000**			
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**	**X**	**House**		**Other**			
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**		**Other………..**	

11	**Orientation**	**North**	**Nort-east**	**North-west**	**South**	**South-east**	**South-west**	**West**	**East**	**12**	**Energy Type:** **Diesel**	**Electricity**	**Natural Gas**	**Coal**	**Geothermal**
					X						**X**				

13	**Heating Type**	**Stove**		**Single Storey Heating**	**X**	**Central Heating**		**Other………** **…**	
14	**Water heating**	**LPG**		**Single Storey Heating**	**X**	**Central Heating**		**Electricity**	**X**
15	**Size (m2)**	**0- 100**		**100- 150**		**150-250**	**170**	**250-more**	
16	**Occupancy**	**1**		**2**	**X**	**2-4**		**4-more**	

After completing Form A, Case 4 is evaluated with six ATHENA indicators and Case 4 and Case 1 (baseline project) were compared in Form B (Table 5.19). Case 4's air pollution index indicator is lower than Case1, the difference is -2.29. Energy consumption, solid waste emission, water pollution index, global warming potential, and weighted resource use indicators are higher than Case 1.

Table 5.20. Form B ATHENA Software Comparison Chart for Case 1 and Case 4.

FORM B: ATHENA SOFTWARE RESULTS		CASE 4		MAVİŞEHİR-1 (Flat)
	Indicator	**Baseline (%)**	**Case 4 (%)**	**Difference**
1	Energy Consumption	100	101,32	1,32
2	Solid Waste Emission	100	116,75	16,75
3	Air Pollution Index	100	97,71	- 2,29
4	Water pollution Index	100	117,87	17,87
5	Global Warming Potential	100	108,64	8,64
6	Weighted Resource Use	100	125,42	25,42

Form C measures performance values for selected thirty indicators under four life cycle stages; site selection, construction, operation, and demolition. These indicators based on energy, material, water, waste and environment issues.

Selected indicators will rate Case 4 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point). Chapter 4 describes the rating method for the indicators.

First stage begins with site conditions and Case 4 is located away from the city centre, receives four points from the location indicator (1). Ecology indicator (2) has eleven sub-indicators, in total fifty-five points (Table 5.20). One sub-indicator; noise resource scores Excellent (5 points). The flat is located in a quiet neighbourhood. Five sub-indicators; water quality, soil contamination, wetlands, wind conditions, and temperature scores Average (3 points). Five sub-indicators; flora, fauna, EMF, sun conditions and air quality index scores Average (3 points). Case 4 scores thirty out of fifty-five points, and receives Average score (3 points) in overall for existing built environment indicator (3).

Table 5.21. Form C. Performance Indicators for Case 4.

FORM C: PERFORMANCE INDICATORS			CASE No. 4 MAVİŞEHİR -1 (Flat)					
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				4
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Flora		X				4
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)			X			3
		f. Wetlands or flood plain			X			3
		g. Wind conditions			X			3
		h. Sun conditions				X		2
		i. Temperature			X			3
		j. Noise Resources	X					5
		k. Air Quality Index			X			3
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking			X			3
		b. Green Area			X			3
		c. Medical Centre				X		2
		d. School		X				4
		e. Place of Worship		X				4
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail		X				4
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation				X		2
		b. Wind Orientation				X		2
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate				X		2
		b. Adjacent Structure(s)				X		2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location		X				4
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.21. Form C. Performance Indicators for Case 4. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors			X			3
		b. Windows			X			3
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					**X**	1
		b.Heat			**X**			3
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Glazing			X			3
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Materials maintenance			X			3
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use			X			3
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Heating System			X			3
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Control of vents			X			3
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air			X			3
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight		X				4
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level		X				4
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling			X			3
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use			X			3
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport		X				4
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment		X				4
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 4 has four Good (4 points) scores; car parking, school, place of worship, , and retail sub- indicators, two Average (3 points) scores; green area, public transport, two Below average (2 points) score for medical centre, and surrounding buildings' sub-indicators. Case 4 scores twenty-six out of forty, receives Average score in overall for existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Total score for building envelope indicator (5) is four out of ten points, meaning Below Average (2 points) performance for Case 4. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 4, 43% of the materials are made in Turkey that means Case 4 performance category for material selection is Below Average (4 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 4, LCA is applied to less than 25% of the materials during construction, so the final score for Case 4 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Below Average (2 points). For Case 4, 52% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7). Material conservation indicator (8) for Case 4 as an existing building has not have any material conservation plan. The performance score for Case 4 is Poor category. Energy conservation indicator (9) for Case 4, is assumed that there were not any methods to safe energy use. Performance score is Poor Category. Renewable energy use indicator (10) for Case 4 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 4 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12) is assumed that Case 4 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 4 is average score (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 4 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Materials Maintenance indicator (16) for Case 4 is in Excellent (5 point) score. Energy use indicator (17) is Good (4 points) for 76% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Average (3 points). There is not any specific natural cooling strategy for Case 4. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 4. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a below average (2 points) performance for Case 4. Indoor air quality indicator (21) for Case 4 is Average (3 points) performance. More than 75% of indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used. Indoor materials including paints, sealants, adhesives, carpets and composite wood products, have not been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins are used. The level and distribution of daylight factor is 85% for Case 4. Day lighting indicator (22) is Good (4 points) performance. Sound pressure level is less than 30 decibels (dB). Noise indicator (23) performance for Case 4 is Good (4 points). Acoustic indicator (24) for Case 4 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 4, waste handling indicator (25)'s performance is Average (3 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is below average for Case 4. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 22 % of their travelling on private car. Transport indicator performance receives Good. Refurbishment indicator (28) for Case 4 is Good (4 points).

Table 5.22. Form D score sheet for Case 4.

FORM D: SCORE SHEET Indicator	Category	Case 4 Mavişehir (Flat) Comment
1.Location	GOOD	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	BELOW AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	BELOW AVERAGE	Use environmentally responsive components.
14. Insulation	BELOW AVERAGE	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	AVERAGE	More environmentally responsive glazing techniques
16. Materials Maintenance	AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	AVERAGE	Reduce energy consumption.
18. Cooling	BELOW AVERAGE	Imply natural cooling techniques
19. Heating	AVERAGE	Improve energy source
20. Ventilation	AVERAGE	Increase number of vents
21. Indoor Air Quality	AVERAGE	Choose materials with low VOC emissions.
22. Daylighting	GOOD	Improve existing windows. Prevent glare with shutters.
23. Noise	GOOD	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	GOOD	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	GOOD	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

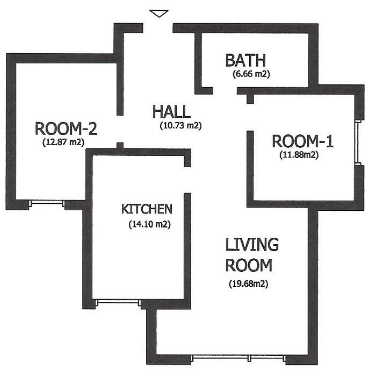
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
-	1-22-23-27-28	2-3-7-15-16-17-19-20-25-26	4-5-6-13-18	8-9-10-11-12-21-24-29-30

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. Case 4 does not have a reuse and recycle plan previously, receives Poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 1 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.22), provides comments to improve the residential unit's conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent Category: no indicator, Good: Indicator 1-22-23-27-28 (5 Indicators; 20), Average: Indicator 2-3-7-15-16-17-19-20-25-26 (10 Indicators; 33%) Below Average: Indicator 4-5-6-13-18 (5 Indicators; 17%) Poor: Indicator 8-9-10-11-12-21-24-29-30 (9 Indicators; 30%).

5.2.5. Case Five: Üçkuyular-1 Flat

Case 5 is located in Üçkuyular district, completed in 2005. The are of the flat is is 76m^2 with two rooms, kitchen, living room, WC, and a bathroom. Single storey heating operates the space heating and water heating. Case 5 is a concrete frame with not insulated brick walls, located at the forth floor of five storey apartment.



CASE 5 LOCATION AND FLOOR PLAN

Figure 5.12. Location and Floor Plan for Case 5.

Form A (Table 5.23) developed for the HRM-Izmir home rating model, gives accurate information about Case 5's conditions like orientation of the flat, construction history, energy use and unit size.

Table 5.23 Form A: Data Collection Process for Case 5.

FORM A: DATA COLLECTION											**Case No. 5 ÜÇKUYULAR-1 (Flat)**
1	**Building Name**	Case 5 Flat 5			2	**Client**					
3	**Address**	**Uckuyular**									
4	**Architect**										
5	**Consultants**										
6	**Year of construction**		7	**Year of completion**	**2005**	8	**Year of occupation**	**2005**			
9	**Residential Type**	**Flat 2+1**	**X**	**Flat 3+1**		**House**		**Other**			
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**		**Other...........**	

11	**Orientation**	**North**	**Nort-east**	**North-west**	**South**	**South-east**	**South-west**	**West**	**East**	12	**Energy Type:** **Diesel**	**Electricity**	**Natural Gas**	**Coal**	**Geothermal**
			X								**X**				

13	**Heating Type**	**Stove**		**Single Storey Heating**	**X**	**Central Heating**		**Other......... ...**	
14	**Water heating**	**LPG**		**Single Storey Heating**		**Central Heating**		**Electricity**	**X**
15	**Size (m2)**	**0- 100**	**76**	**100- 150**		**150-250**		**250-more**	
16	**Occupancy**	**1**		**2**	**X**	**2-4**		**4-more**	

After completing Form A, Case 5 is evaluated with six ATHENA indicators. All the necessary information about Case 5, entered into the ATHENA software. Later, Case 5 and Case 1 (baseline project) were compared in Form B (Table 5.24). Energy consumption, solid waste emission, air pollution index is, global warming potential weighted resource use, and Water pollution index performance is lower than Case 1. Weighted Resource Use difference between Case 5 and 1 is 33.11. Case 1 performance is better than Case 5.

Table 5.24. Form B: ATHENA Software Comparison Chart for Case 1 and Case 5.

FORM B: ATHENA SOFTWARE RESULTS		CASE 5	ÜÇKUYULAR-1 (Flat)	
	Indicator	**Baseline (%)**	**Case 5 (%)**	**Difference**
1	Energy Consumption	100	109,48	9,48
2	Solid Waste Emission	100	126,41	26,41
3	Air Pollution Index	100	105,49	5,49
4	Water pollution Index	100	127,37	27,37
5	Global Warming Potential	100	117,13	17,13
6	Weighted Resource Use	100	133,11	33,11

Form C comes into action after Form B and measures performance values for selected thirty indicators under four life cycle stages; site selection, construction, operation, and demolition. These indicators based on energy, material, water, waste and environment issues.

Case 5's location indicator (1) receives four points. Ecology indicator (2) has eleven sub-indicators (Table 5.25). The definitions of the indicators are given in Chapter 4. Flora, fauna, wind, sun indicators are Poor (1 point) performance for Case 5. Electromagnetic field, wetlands, and soil contamination receives Below Average (2 points) score. Water quality, temperature, noise resources, and air quality index indicators performance are average(3 points). Ecology indicator's overall performance is Below Average (2 points).

Table 5.25. Form C. Performance Indicators for Case 5.

FORM C: PERFORMANCE INDICATORS			CASE No. 5 ÜÇKUYULAR-1 (Flat)					
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				4
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora					X	1
		b. Fauna					X	1
		c. Water quality			X			3
		d. Soil contamination				X		2
		e. Electro Magnetic Fields (EMF)				X		2
		f. Wetlands or flood plain				X		2
		g. Wind conditions					X	1
		h. Sun conditions					X	1
		i. Temperature			X			3
		j. Noise Resources			X			3
		k. Air Quality Index			X			3
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking				X		2
		b. Green Area				X		2
		c. Medical Centre				X		2
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail			X			3
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation					X	1
		b. Wind Orientation					X	1
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate				X		2
		b. Adjacent Structure(s)				X		2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location				X		2
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.25. Form C. Performance Indicators for Case 5 (Cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors					X	1
		b. Windows				X		2
		c. Ceiling					X	1
		d. Floor				X		2
		e. Walls				X		2
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					**X**	1
		b.Heat				**X**		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing					X	1
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance				X		2
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Electricity use				X		2
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System					X	1
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air					X	1
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight				X		2
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level				X		2
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time				X		2
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling				X		2
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use					X	1
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport				X		2
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment					X	1
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan				X	1	
		b.Recycle Plan				**X**	**1**	
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling				X	1	
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 5 has four Below Average (2 points) scores; car parking, green area, medical centre, and surrounding buildings sub- indicators, and has four Average (3 points) scores; school, place of worship, public transport, and retail. Case 5's existing built environment overall rating score is twenty out of forty, receives Average (3 points).

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Total score for building envelope indicator (5) is four out of ten points, meaning Below Average (2 points) performance for Case 5. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 5, less than 41% of the materials are made in Turkey that means Case 5's performance for material selection is Below Average (4 points). For Case 5, LCA is applied to less than 25% of the materials during construction, so the final score for Case 5 is Poor (1 point). The sum of two sub-indicators is Below Average (2 points), final rating score for Material Selection Indicator. For Case 5, 59% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7).

Indicator no.8, 9, 10,11,12 will be assumed Poor(1 point) rating score, because there is not any plan record about them. For instance, material conservation indicator (8) has not have any material conservation plan, so the performance score for Case 5 is Poor (1 point) rating score. Energy conservation indicator (9) for Case 5, is assumed that there were not any methods to safe energy use. Performance score is Poor (1 point). Renewable energy use indicator (10) for Case 5 is Poor (1 point) performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 5 has not have any plan for waste strategy during construction; final rating score is Poor (1 point). Water strategy indicator (12) is assumed that Case 5 has not have any plan for water strategy, final score is Poor (1 point).

Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component Poor (1 points), windows Below Average (2 points), ceilings Poor (1 point), floors below average (2 points), walls below average (2 points). Total performance category for Case 4 is Average (3 points).

Insulation indicator (14) assesses the standard of insulation in five categories. Case 5 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Glazing standard is Poor (1 point) performance. Materials Maintenance indicator (16) for Case 5 is Below Average (2 point) score. Energy use indicator (17) is Below Average for 42 % of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Below Average (2 points). There is not any specific natural cooling strategy for Case 5. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 5. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives Below Average (2 points) performance for Case 5. Indoor air quality indicator (21) for Case 5 is Poor (1 point). Indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have not been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins may be used. The level and distribution of daylight factor is 42% for Case 5. Day lighting indicator (22) is Below Average (2 points). Sound pressure level is higher than 70 decibels (dB). Noise indicator (23) performance for Case 5 is Below Average (2 points). Acoustic indicator (24) for Case 5 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 5, waste handling indicator's (25) performance is Below Average (2 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is Poor (1 point) for Case 5. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 74% of their travelling on private car. Transport indicator performance receives below average (2 points). Refurbishment indicator (28) is Poor (1 points) rating score for Case 5.

Table 5.26. Form D score sheet for Case 5.

FORM D: SCORE SHEET Indicator	 Category	Case 5 Üçkuyular-1 (Flat) Comment
1.Location	GOOD	Has some advantages of the city
2. Ecology	BELOW AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	BELOW AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	POOR	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	BELOW AVERAGE	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	POOR	More environmentally responsive glazing techniques
16. Materials Maintenance	POOR	Improve the maintenance program of the unit.
17. Energy Use	BELOW AVERAGE	Reduce energy consumption.
18. Cooling	POOR	Imply natural cooling techniques
19. Heating	POOR	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	POOR	Choose materials with low VOC emissions.
22. Daylighting	BELOW AVERAGE	Improve existing windows. Prevent glare with shutters.
23. Noise	BELOW AVERAGE	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	BELOW AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	POOR	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	BELOW AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	POOR	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
-	1	7-13	2-3-5-6-9-17-20-22-23-25-27	4-8-10-11-12-14-15-16-18-19-21-26-28-29-30

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 5 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 5 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan. Form D (Table 5.26), provides comments to improve the residential unit's conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent Category: (0 Indicator;), Good: Indicator 1 (1 Indicator;), Average: Indicator 7-13 (Indicator;) Below Average: Indicator 2-3-5-6-9-17-20-22-23-25-27 (11 Indicators; 17%) Poor: Indicator 4-8-10-11-12-14-15-16-18-19-21-26-28-29-30 (15 Indicators; %).

5.2.6. Case Six: Üçkuyular-2 Flat

Case six is an apartment flat, located in Üçkuyular District (Figure 5.13). It's at the third floor of five storey apartment. Residential apartments around Case 6, block the sun and the natural air flow. The are of the flat is 100 m^2 with two rooms, kitchen, living room, WC, and a bathroom. The sun orientation is east and completed in 2005

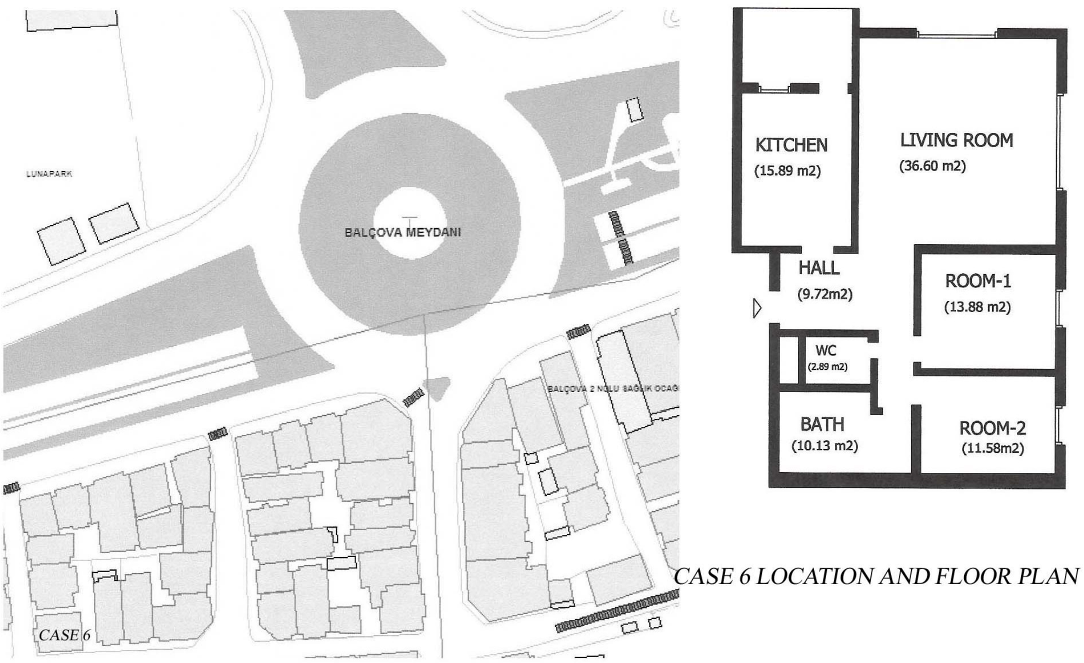


Figure 5.13. The location and floor plan for Case 6.

Form A (Table 5.26) developed for the HRM-Izmir home rating model, gives accurate information about Case 6's conditions like orientation of the flat, construction history, energy use and unit size.

Table 5.27. Form A: Data Collection Process for Case 6.

FORM A: DATA COLLECTION									**Case No. 6 ÜÇKUYULAR-2 (Flat)**
1	**Building Name**	Case 6 Flat 6	**2**	**Client**					
3	**Address**	**Uckuyular**							
4	**Architect**								
5	**Consultants**								
6	**Year of construction**		**7**	**Year of completion**	**2005**	**8**	**Year of occupation**	**2005**	
9	Residential Type	Flat 2+1	X	Flat 3+1		House		Other	
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**	
		Other..........							

11	**Orientation**	**North**	**Nort-east**	**North-west**	**South**	**South-east**	**South-west**	**West**	**East**
			X						

12	**Energy Type**	**Diesel**	**Electricity**	**Natural Gas**	**Coal**	**Geothermal**
		X				

13	**Heating Type**	**Stove**		**Single Storey Heating**	**X**	**Central Heating**		**Other.........**	
14	**Water heating**	**LPG**		**Single Storey Heating**		**Central Heating**		**Electricity**	**X**
15	**Size (m2)**	**0- 100**	**100**	**100- 150**		**150-250**		**250-more**	
16	**Occupancy**	**1**		**2**	**X**	**2-4**		**4-more**	

After completing Form A, Case 6 is evaluated with six ATHENA indicators (Table 5.28). All the necessary information about Case 6, entered into the ATHENA software. Later, Case 6 and Case 1 (baseline project) were compared in Form B (Table 5.28). Energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential, and weighted resource use indicators are lower than Case 1. Case 1's performance is better than Case 6.

Table 5.28. Form B: ATHENA Software Comparison Chart for Case 1 and Case 6

FORM B: ATHENA SOFTWARE RESULTS		CASE 6	ÜÇKUYULAR-1 (Flat)	
	Indicator	**Baseline (%)**	**Case 6 (%)**	**Difference**
1	Energy Consumption	100	111,89	11,89
2	Solid Waste Emission	100	128,01	28,01
3	Air Pollution Index	100	107,93	7,93
4	Water pollution Index	100	130,61	30,61
5	Global Warming Potential	100	120,15	20,15
6	Weighted Resource Use	100	139,83	39,83

Form C comes into action after Form B and measures performance values for selected thirty indicators under four life cycle stages; site selection, construction, operation, and demolition. These indicators based on energy, material, water, waste and environment issues.

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 6 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point).

Table 5.29. Form C. Performance Indicators for Case 6.

FORM C: PERFORMANCE INDICATORS			CASE No. 6 ÜÇKUYULAR-2 (Flat)					
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**		X					5
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora				X		2
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination				X		2
		e. Electro Magnetic Fields (EMF)				X		2
		f. Wetlands or flood plain				X		2
		g. Wind conditions					X	1
		h. Sun conditions					X	1
		i. Temperature			X			3
		j. Noise Resources			X			3
		k. Air Quality Index			X			3
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking				X		2
		b. Green Area				X		2
		c. Medical Centre				X		2
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail			X			3
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation					X	1
		b. Wind Orientation					X	1
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate				X		2
		b. Adjacent Structure(s)				X		2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity						1
		b. Heating						1
		c. Machinery use						1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use						1
		b. Wind power						1

Table 5.29. Form C. Performance Indicators for Case 6. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use						1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors					X	1
		b. Windows				X		2
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls				X		2
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					**X**	1
		b.Heat				**X**		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing					X	1
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Materials maintenance				X		2
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use				X		2
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Heating System					X	1
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air					X	1
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight				X		2
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level				X		2
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling				X		2
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use					X	1
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport				X		2
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment					X	1
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reuse Plan					X	1
		b. Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

First stage begins with site conditions and Case 6 is located in the city centre immediately receives five points from the location indicator (1). Ecology indicator (2) has eleven sub-indicators (Table 5.29). Two sub-indicators; wetlands and noise resources sub-indicators score good (4 points), three sub-indicators; water quality, soil contamination and EMF score average (3 points), five sub-indicators; flora, fauna, wetlands, wind, sun, temperature, and air quality index. one below average score for its sub-indicators. Case 6 scores twenty seven out of fifty-five, receives average score (3 points) in overall existing built environment indicator (3).

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 6 has four Good (4 points) scores; car parking, school, place of worship, , and retail sub- indicators, two Average (3 points) scores; green area, public transport, two Below average (2 points) score for medical centre, and surrounding buildings' sub-indicators. Case 6 scores twenty-six out of forty, receives Average score in overall for existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Total score for building envelope indicator (5) is four out of ten points, meaning Below Average (2 points) performance for Case 6. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 6, 43% of the materials are made in Turkey that means Case 6 performance category for material selection is Below Average (4 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 6, LCA is applied to less than 25% of the materials during construction, so the final score for Case 6 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Below Average (2 points). For Case 6, 52% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7). Material conservation indicator (8) for Case 6 as an existing building has not have any material conservation plan. The performance score for Case 6 is Poor category. Energy conservation indicator (9) for Case 6, is assumed that there were not any methods to safe energy use. Performance score is Poor Category. Renewable energy use indicator (10) for Case 6 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 6 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12) is assumed that Case 6 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 6 is average score (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 6 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Glazing indicator(15) scores Poor (1 point). Materials Maintenance indicator (16) for Case 6 is Below Average (2 points). Energy use indicator (17) is Below Average(2 points) for 32% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but poor insulation provides Poor(1 point). There is not any specific natural cooling strategy for Case 6. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 6. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a below average (2 points) performance for Case 6. Indoor air quality indicator (21) for Case 6 is Poor (1 point) performance. Indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have not been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins may be used. The level and distribution of daylight factor is 56% for Case 6. Day lighting indicator (22) is Below Average (2 points). Sound pressure level is more than 70 decibels (dB). Noise indicator (23) performance for Case 5 is Below Average (2 points). Acoustic indicator (24) for Case 6 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 6, waste handling indicator (25)'s performance is Below Average (2 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is Poor (1 point) for Case 6. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 58% of their travelling on private car. Transport indicator performance receives average score. Refurbishment indicator (28) for Case 6 is Poor (1 point).

Table 5.30. Form D score sheet for Case 6.

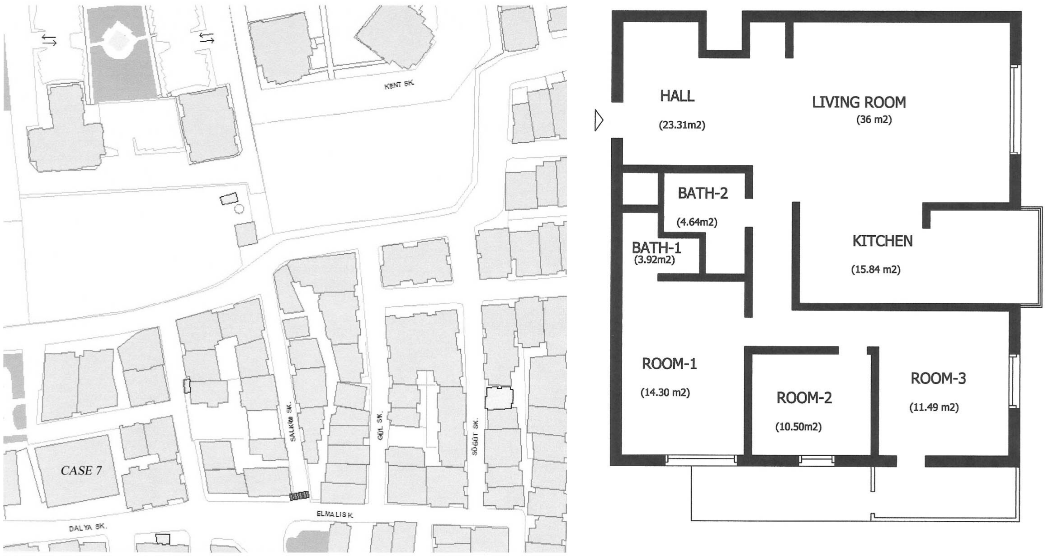
FORM D: SCORE SHEET		Case 6 Üçkuyular-2 (Flat)
Indicator	Category	Comment
1.Location	EXCELLENT	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	BELOW AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	POOR	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	BELOW AVERAGE	Use environmentally responsive components.
14. Insulation	BELOW AVERAGE	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	POOR	More environmentally responsive glazing techniques
16. Materials Maintenance	BELOW AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	BELOW AVERAGE	Reduce energy consumption.
18. Cooling	POOR	Imply natural cooling techniques
19. Heating	POOR	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	POOR	Choose materials with low VOC emissions.
22. Daylighting	BELOW AVERAGE	Improve existing windows. Prevent glare with shutters.
23. Noise	BELOW AVERAGE	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	BELOW AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	POOR	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	BELOW AVERAGE	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1 (1 out of 30)	- (0 out of 30)	2-7-27 (3 out of 30)	3-5-6-13-14-16-17-20-22-23-25-28 (12 out of 30)	4-8-9-10-11-12-15-18-19-21-24-26-29-30 (14 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 6 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 6 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.30), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, Good, Average, Below Average and poor). Excellent Category: Indicator 1 (1 Indicator;3%), Good: no Indicator. Average: Indicator 2-7-27 (3 Indicators; 10%), Below Average: Indicator 3-5-6-13-14-16-17-20-22-25-28 (12 Indicators; 40%), Poor: Indicator 4-8-9-10-11-12-15-18-19-21-24-26-29-30 (14 Indicators; 47%)

5.2.7. Case Seven: Balçova-2 Flat



CASE 7 LOCATION AND FLOOR PLAN

Figure 5.14. The location and floor plan for Case 7

Case7, is a flat, located in Balçova District. It is completed in 1999 and occupied by the owner since then. The size of the flat is 120 m^2 with three rooms, kitchen, living room, bathroom and WC.

Bathroom, WC 3 have only artificial lighting. Small vents are used to ventilate these areas. A long balcony connects bedrooms from outside. Two facades are open, provide sunlight and natural ventilation. Inside corridor solves the circulation inside the flat.

Form A (Table 5.31) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.31. Form A: Data Collection Process for Case 7.

FORM A: DATA COLLECTION (Flat)												**Case No. 7 BALÇOVA-2**
1	**Building Name**	Case 7 Flat 7					**2**	**Client**				
3	**Address**	**Balcova (BAL)**										
4	**Architect**											
5	**Consultants**											
6	**Year of construction**		**7**	**Year of completion**	**2005**	**8**	**Year of occupation**	**2005**				
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**	**X**	**House**		**Other**				
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**		**Other……....**		
11	**Orientation**	**North**	**Nort-east**	**North-west**	**South**	**South-east**	**South-west**	**West**	**East**			
			X									
12	**Energy Type**	**Diesel**	**Electricity**	**Natural Gas**	**Coal**	**Geothermal**						
						X						
13	**Heating Type**	**Stove**		**Single Storey Heating**		**Central Heating**	**X**	**Other………**				
14	**Water heating**	**LPG**		**Single Storey Heating**		**Central Heating**	**X**	**Electricity**	**X**			
15	**Size (m2)**	**0- 100**		**100- 150**	**120**	**150-250**		**250-more**				
16	**Occupancy**	**1**		**2**	**X**	**2-4**		**4-more**				

Heating type (12) is a central heating system using coal as an energy source. Use of coal creates air pollution. Electrical boiler is used only one month in whole year.

After completing Form A, Case 7 is evaluated with six ATHENA indicators. Case 7 and Case 1 (baseline project) were compared in Form B (Table 5.32). Energy consumption for Case 7 is lower than Case 1.Air pollution index is 92.76 for Case 7, the difference is -7.24 compared with Case 1. Solid waste emission, water pollution, global warming potential and weighted resource use indicators are higher than Case 1.

Form C comes into action after Form B and measures performance values for selected thirty indicators under four life cycle stages; site selection, construction, operation, and demolition. These indicators based on energy, material, water, waste and environment issues. Some issues may repeat itself in other stages, but the assessor should keep in mind that the performance of the issue may be evaluated differently in each stage. For instance, energy use in construction stage may differ in operation stage.

Table 5.32. Form B: ATHENA Software Comparison Chart for Case 1 and Case 7.

FORM B: ATHENA SOFTWARE RESULTS		CASE 7		BALÇOVA-2 (Flat)
	Indicator	**Baseline (%)**	**Case 7 (%)**	**Difference**
1	Energy Consumption	100	96,21	-3,79
2	Solid Waste Emission	100	105,99	5,99
3	Air Pollution Index	100	92,76	-7,24
4	Water pollution Index	100	117,95	17,95
5	Global Warming Potential	100	104,51	4,51
6	Weighted Resource Use	100	128,24	28,24

Form C is the third form of the HRM-Izmir Model. Selected indicators will categorise the studied case under five performance score; excellent (5point), good (4 point), average (3point), below average (2 point) and poor (1 point).

Case 7 is located in the city centre immediately receives four points Good from the location indicator (1) (Table 5.33). However, the ecology indicator (2) scores are good for noise resources sub-indicator, average for 3 sub-indicators; water quality, soil contamination, electro magnetic field, and below average for seven sub-indicators; flora fauna, wetlands, wind condition, sun condition, air quality index. Out of fifty five points, Case 7 scored twenty seven points, meaning Average Category (3 points) in overall ecology indicator (1).

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 7 has four Good (4 points) scores; car parking, school, place of worship, , and retail sub- indicators, two Average (3 points) scores; green area, public transport, two Below average (2 points) score for medical centre, and surrounding buildings' sub-indicators. Case 7 scores twenty-six out of forty, receives Average score in overall for existing built environment indicator.

Table 5.33. Form C Performance Indicators for Case 7.

FORM C: PERFORMANCE INDICATORS			CASE No. 7 BALÇOVA-2 (Flat)					
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				4
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora			X			3
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)		X				4
		f. Wetlands or flood plain				X		2
		g. Wind conditions				X		2
		h. Sun conditions				X		2
		i. Temperature			X			3
		j. Noise Resources			X			3
		k. Air Quality Index			X			3
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking				X		2
		b. Green Area				X		2
		c. Medical Centre				X		2
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail			X			3
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation				X		2
		b. Wind Orientation				X		2
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate				X		2
		b. Adjacent Structure(s)				X		2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location		X				4
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
					X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.33. Form C Performance Indicators for Case 7. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors					X	1
		b. Windows				X		2
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					**X**	1
		b.Heat				**X**		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing					X	1
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance				X		2
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use				X		2
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System					X	1
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air					X	1
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight				X		2
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level				X		2
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling				X		2
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use					X	1
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport		X				4
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment					X	1
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

At construction stage, there are seven performance indicators to evaluate the conditions till completion date, defined in Chapter 4. Total score for building envelope indicator (5) is four out of ten points, meaning Below Average (2 points) performance for Case 6. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 7, 65% of the materials are made in Turkey that means Case 7 performance category for material selection is Average (3 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 7, LCA is applied to less than 25% of the materials during construction, so the final score for Case 7 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Average (3 points). For Case 7, 52% percent of materials are transported from local warehouses, means the performance score is Average for material transportation indicator (7). Material conservation indicator (8) for Case 7 as an existing building has not have any material conservation plan. The performance score for Case 7 is Poor (1 point) category. Energy conservation indicator (9) for Case 7, is assumed that there were not any methods to safe energy use. Performance score is Poor (1 point) Category. Renewable energy use indicator (10) for Case 7 is Poor (1 point) performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 7 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12), it is assumed that Case 7 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component Poor (1 point), window Below Average (2 points), ceiling is Below Average, floor Below Average(2 point), and wall sub-indicator is average (3 points). Total performance category for unit components indicator (13) is Below Average (2 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 7 has scored Poor (1 point) in sound insulation and Below Average (2 points) in heating insulation. Overall, insulation indicator (14) is in Poor (1 point) Category. Materials Maintenance indicator (16) for Case 7 is in Below Average (2 points) score. Energy use indicator (17) is Below Average (2 points) for 40% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Below Average (2 points). There is not any specific natural cooling strategy for Case 7.

Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is Below Average (2 points) performance for Case 7. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, performs Below Average (2 points) performance for Case 7. Indoor air quality indicator (21) for Case 7 is Poor (1 point) performance. Indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have not been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins may been used. The level and distribution of daylight factor is 45% for Case 7. Day lighting indicator (22) is Good (4 points) performance. Sound pressure level is more than 70 decibels (dB). Noise indicator (23) performance is Below Average (2 points). Acoustic indicator (24) for Case7 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 7, waste handling indicator (25)'s performance is Below Average (2 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is Poor (1 point) for Case 7. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 11% of their travelling on private car. Transport indicator performance receives Good (4 points) score. Refurbishment indicator (28) for Case 7 is Poor (1 point) condition.

Table 5.34. Form D score sheet for Case 7.

FORM D: SCORE SHEET Indicator	Category	Case 7 Balçova-2 (Flat) Comment
1.Location	GOOD	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	BELOW AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	BELOW AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	POOR	More environmentally responsive glazing techniques
16. Materials Maintenance	BELOW AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	BELOW AVERAGE	Reduce energy consumption.
18. Cooling	BELOW AVERAGE	Imply natural cooling techniques
19. Heating	BELOW AVERAGE	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	POOR	Choose materials with low VOC emissions.
22. Daylighting	BELOW AVERAGE	Improve existing windows. Prevent glare with shutters.
23. Noise	BELOW AVERAGE	Use sound insulation to reduce the outside noise impact
24. Acoustic	**POOR**	**Improve sound transmission inside the space with special panels and components.**
25. Waste handling	BELOW AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	POOR	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	GOOD	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	POOR	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
-	1-27(2 out of 30)	2-3-6-7 (4 out of 30)	4-5-13-16-17-18-19-20-22-23-25 (11 out of 30)	8-9-10-11-12-14-15-21-24-26-28-29-30 (13 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 7 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 7 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.34), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: (0 Indicator), Good: Indicator 1-27 (2 Indicator;7%), Average: Indicator 2-3-6-7 (4 Indicators; 13%) Below Average: Indicator 4-5-13-16-17-18-19-20-22-23-25 (11 Indicators; 37%) Poor: Indicator 8-9-10-11-12-14-15-21-24-26-28-29-30 (11 Indicators; 43%).

5.2.8. Case Eight: Bornova -1 Flat

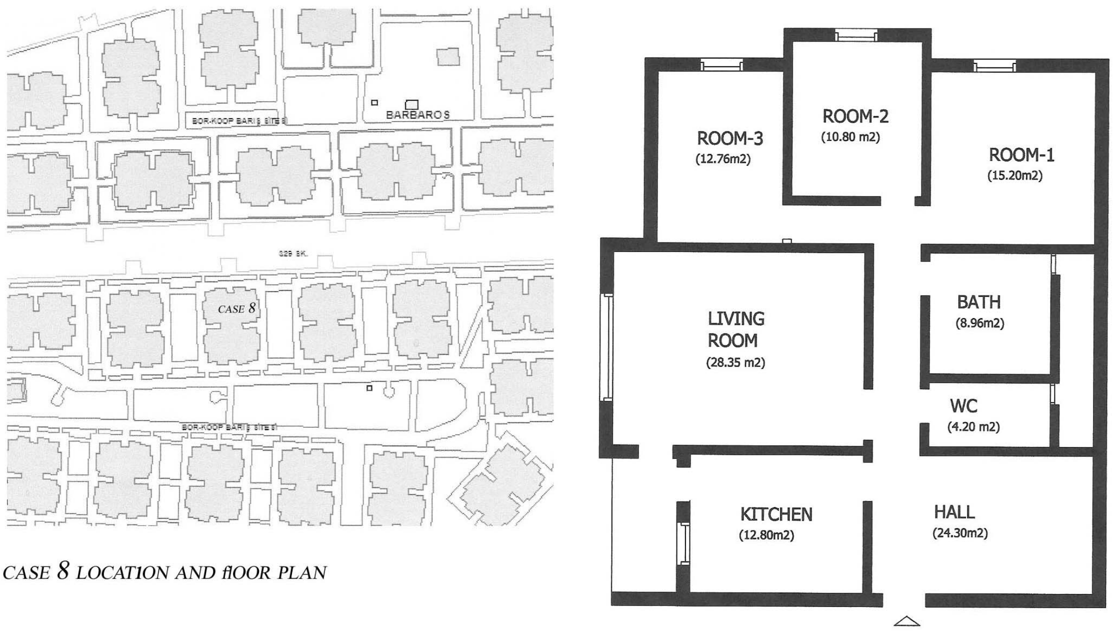


Figure 5.15. The location and floor plan for Case 8.

Case 8 is an apartment flat, located in Bornova District (Figure 5.15). The size of the flat is 118 m^2 with three rooms, kitchen, living room, WC and bathroom. Water heating is done by the electrical boiler. For space heating, air conditioning system is used.

Form A (Table 5.35) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.35. Form A: Data Collection Process for Case 8.

FORM A: DATA COLLECTION								**Case No. 8 BORNOVA-1 (Flat)**		
1	**Building Name**	Case 8 Flat 8		2	**Client**					
3	**Address**	**Bornova (BOR)**								
4	**Architect**									
5	**Consultants**									
6	**Year of construction**	**2000**	7	**Year of completion**	**2002**	8	**Year of occupation**	**2003**		
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**	**X**	**House**		**Other**		
10	Construction Type	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**		**Other……....**

11	**Orientation**	**North**	**Nort-east**	**North-west**	**South**	**South-east**	**South-west**	**West**	**East**	12	**Energy Type**				
											Diesel	**Electricity**	**Natural Gas**	**Coal**	**Geothermal**
		X										**X**			

13	**Heating Type**	**Stove**		**Single Storey Heating**		**Central Heating**		**Other………** **…**	**X**
14	**Water heating**	**LPG**		**Single Storey Heating**		**Central Heating**		**Electricity**	**X**
15	**Size (m2)**	**0- 100**		**100- 150**	**118**	**150-250**		**250-more**	
16	**Occupancy**	**1**		**2**	**X**	**2-4**		**4-more**	

Heating type (12) is a central heating system using coal as an energy source. Use of coal creates air pollution. Electrical boiler is used only one month in whole year.

After completing Form A, Case 8 is evaluated with six ATHENA indicators. All the necessary information about Case 8, entered into the ATHENA software. Later, Case 8 and Case 1 (baseline project) were compared in Form B (Table 5.36). Energy consumption for Case 8 is higher than Case 1. Solid waste emission is 122.56 for Case 8, the difference is 22.56 compared with Case 1. Air pollution index is 96.30 that is lower than Case 1. Solid Waste Emission, Water Pollution Index, Global warming potential and weighted resource use indicators are lower than Case 1.

Table 5.36. Form B: ATHENA Software Comparison Chart for Case 1 and Case 8.

FORM B: ATHENA SOFTWARE RESULTS		CASE 8		BORNOVA-1 (Flat)
	Indicator	**Baseline (%)**	**Case 8 (%)**	**Difference**
1	Energy Consumption	100	100,19	0,19
2	Solid Waste Emission	100	118,57	18,57
3	Air Pollution Index	100	96,30	96,30
4	Water pollution Index	100	116,12	16,12
5	Global Warming Potential	100	106,65	6,65
6	Weighted Resource Use	100	120,60	20,60

Form C is the third form of the HRM-Izmir Model. Selected indicators will categorise the studied case under five performance score; excellent (5point), good (4 point), average (3point), below average (2 point) and poor (1 point).

Case 8 is located in the city centre immediately receives five points from the location indicator (1) (Table 5.36). However, the ecology indicator out of fifty five points, Case 8 scored thirty points, meaning Average Category (3 points).

Table 5.37. Form C. Performance Indicators for Case 8.

FORM C: PERFORMANCE INDICATORS			CASE No. 8 BORNOVA-1 (Flat)					
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora			X			3
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)		X				4
		f. Wetlands or flood plain				X		2
		g. Wind conditions				X		2
		h. Sun conditions				X		2
		i. Temperature			X			3
		j. Noise Resources			X			3
		k. Air Quality Index			X			3
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking				X		2
		b. Green Area				X		2
		c. Medical Centre				X		2
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail			X			3
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation				X		
		b. Wind Orientation				X		
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate			X			3
		b. Adjacent Structure(s)				X		2
6	Material selection		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.37. Form C. Performance Indicators for Case 8 (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors		X				4
		b. Windows			X			3
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					X	1
		b.Heat				X		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing			X			3
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance				X		2
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use				X		2
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System					X	1
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air			X			3
22	Daylighting		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight			X			3
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level			X			3
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling				X		2
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use			X			3
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport		X				4
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment					X	1
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 8 scores twenty out of forty, receives Below Average score in overall for existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Total score for building envelope indicator (5) is four out of ten points, meaning Below Average (2 points) performance for Case 8. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 8, 43% of the materials are made in Turkey that means, performance category for material selection is Below Average (2 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 6, LCA is applied to less than 25% of the materials during construction, so the final score for Case 8 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Below Average (2 points). For Case 8, 52% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7). Material conservation indicator (8) for Case 8 as an existing building has not have any material conservation plan. The performance score for Case 8 is Poor category. Energy conservation indicator (9) for Case 6, is assumed that there were not any methods to safe energy use. Performance score is Poor Category. Renewable energy use indicator (10) for Case 8 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 8 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12) is assumed that Case 8 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 8 is average score (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 8 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Materials Maintenance indicator (16) for Case 8 is in Excellent (5 point) score. Energy use indicator (17) is Good (4 points) for 76% of energy efficiency.

Cooling indicator (18) is valid during hot seasons, but good insulation provides Average (3 points). There is not any specific natural cooling strategy for Case 8. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 8. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a below average (2 points) performance for Case 8. Indoor air quality indicator (21) for Case 8 is Poor (1 point) performance. More than 75% indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used. The level and distribution of daylight factor is 58% for Case 8. Day lighting indicator (22) is Average (3 points) performance. Sound pressure level is more than 30 decibels (dB). Noise indicator (23) performance for Case 8 is Average (5 points). Acoustic indicator (24) for Case 8 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 8, waste handling indicator (25)'s performance is Average (3 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is Average for Case 8. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 90% of their travelling on private car. Transport indicator performance receives Good (4 points). Refurbishment indicator (28) for Case 8 is Poor (1 point).

Table 5.38. Form D score sheet for Case 8.

FORM D: SCORE SHEET Indicator	Category	Case 8 Bornova-1(Flat) Comment
1.Location	GOOD	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	BELOW AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	AVERAGE	More environmentally responsive glazing techniques
16. Materials Maintenance	BELOW AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	BELOW AVERAGE	Reduce energy consumption.
18. Cooling	BELOW AVERAGE	Imply natural cooling techniques
19. Heating	POOR	Improve energy source
20. Ventilation	**BELOW AVERAGE**	**Increase number of vents**
21. Indoor Air Quality	POOR	Choose materials with low VOC emissions.
22. Daylighting	BELOW AVERAGE	Improve existing windows. Prevent glare with shutters.
23. Noise	POOR	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	BELOW AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	BELOW AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	AVERAGE	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1 (1out of 30)	2-3-7-13-15-27-28 (7out of 30)	4-5-6-16-17-18-20-22-25-26 (10 out of 30)	8-9-10-11-12-14-19-21-23-24-29-30 (12 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 8 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 8 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.38), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: (0 Indicator), Good: Indicator 1 (1 Indicator;3%), Average: Indicator 2-3-7-13-15-27-28 (7 Indicators; 23%) Below Average: Indicator 4-5-6-16-17-18-20-22-25-26 (10 Indicators; 33%) Poor: Indicator 4-8-9-10-11-12-14-21-23-24-29-30 (12 Indicators; 41%).

5.2.9. Case Nine: Bornova-2 Flat

Case 9 is an apartment flat, located in Bornova District. It's at the third floor of four floor apartment, living room and one bedroom face to the street side. Residential apartments around the studied unit, block the sun and the natural air flow.

The size of the flat is 240 m^2 with four rooms, kitchen, living room, WC and two bathrooms. Water heating is created by the electrical boiler. For space heating, single storey heating system is used

Form A (Table 5.39) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.39. Form A: Data Collection Process for Case 9.

FORM A: DATA COLLECTION								Case No. 9 BORNOVA-2 (Flat)		
1	Building Name	Case 9 Flat 9		2	Client					
3	Address	Bornova (BOR)								
4	Architect									
5	Consultants									
6	Year of construction	2004	7	Year of completion	2006	8	Year of occupation	?		
9	Residential Type	Flat 2+1		Flat 3+1		House		Other: Flat 4+1		
10	Construction Type	R.C.	X	Masonry		Steel		Timber		Other……...

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East	12	Energy Type				
											Diesel	Electricity	Natural Gas	Coal	Geothermal

13	Heating Type	Stove		Single Storey Heating		Central Heating		Other………	
14	Water heating	LPG		Single Storey Heating		Central Heating		Electricity	
15	Size (m2)	0- 100		100- 150		150-250	240	250-more	
16	Occupancy	1		2		2-4		4-more	

After completing Form A, Case 9 is evaluated with six ATHENA indicators. Later, Case 9 and Case 1 (baseline project) were compared in Form B (Table 5.40) . Energy consumption, air pollution index, and global warming potential for Case 9 is lower than Case 1. Solid waste emission is 101.43 for Case 9, the difference is 1.53 compared with Case 1. Solid waste emission, water pollution index potential and weighted resource use indicators are higher than Case 1.

Table 5.40. Form B: ATHENA Software Comparison Chart for Case 1 and Case 9.

FORM B: ATHENA SOFTWARE RESULTS		CASE 9		BORNOVA-2 (Flat)
	Indicator	**Baseline (%)**	**Case 9 (%)**	**Difference**
1	Energy Consumption	100	90,37	9.63
2	Solid Waste Emission	100	**101,43**	1,53
3	Air Pollution Index	100	87,38	- 12,62
4	Water pollution Index	100	110,53	10,53
5	Global Warming Potential	100	98,05	- 1,95
6	Weighted Resource Use	100	118,18	18,18

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 6 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point).

Table 5.41. Form C. Performance Indicators for Case 9.

FORM C: PERFORMANCE INDICATORS			CASE No. 9 BORNOVA -2 (Flat)					
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				4
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora			X			3
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination			X			3
		Sub-indicator	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		e. Electro Magnetic Fields (EMF)		X				4
		f. Wetlands or flood plain				X		2
		g. Wind conditions				X		2
		h. Sun conditions				X		2
		i. Temperature			X			3
		j. Noise Resources			X			3
		k. Air Quality Index			X			3
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking				X		2
		b. Green Area				X		2
		c. Medical Centre				X		2
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail			X			3
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation				X		2
		b. Wind Orientation				X		2
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate				X		2
		b. Adjacent Structure(s)				X		2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.41. Form C. Performance Indicators for Case 9. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors			X			3
		b. Windows			X			3
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound						1
		b.Heat						2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing					X	1
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance				X		2
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use				X		2
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System					X	1
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air					X	1
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight				X		2
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level				X		2
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling				X		2
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use					X	1
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) ‘Transport		X				4
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment					X	1
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					X	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

First stage begins with site conditions and Case 9's location indicator (1) performance receives Good (4 points) described in Chapter 4. However, the ecology indicator out of fifty five points, Case 9 scored thirty points, meaning Average Category (3 points).

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 9 scores eighteen out of forty, receives Average (3 points) score in overall for existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date, defined in Chapter 4. Total score for building envelope indicator (5) is four out of ten points, meaning Below Average (2 points) performance for Case 9. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 9, 43% of the materials are made in Turkey that means Case 9 performance category for material selection is Below Average (4 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 9, LCA is applied to less than 25% of the materials during construction, so the final score for Case 9 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Below Average (2 points). For Case 9, 52% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7). Material conservation indicator (8) for Case 9 as an existing building has not have any material conservation plan. The performance score for Case 9 is Poor category. Energy conservation indicator (9) for Case 9, is assumed that there were not any methods to safe energy use. Performance score is Poor Category. Renewable energy use indicator (10) for Case 9 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 9 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12) is assumed that Case 6 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 9 is average score (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 9 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Materials Maintenance indicator (16) for Case 9 is in Excellent (5 point) score. Energy use indicator (17) is Good (4 points) for 76% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Average (3 points). There is not any specific natural cooling strategy for Case 9. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 9. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a below average (2 points) performance for Case 9. Indoor air quality indicator (21) for Case 9 is Poor (1 point) performance. Indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have not been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins may be used. The level and distribution of daylight factor is 65% for Case 9. Day lighting indicator (22) is Below Average (3 points) performance. Sound pressure level is more than 70 decibels (dB). Noise indicator (23) performance for Case 9 is Below Average (2 points). Acoustic indicator (24) for Case 9 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 9, waste handling indicator (25)'s performance is Below Average (2 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is Poor (1 point) for Case 9. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent less than 12% of their travelling on private car. Transport indicator performance receives Good (4 points) score. Refurbishment indicator (28) for Case 9 is Poor (1 point) condition.

Table 5.42. Form D score sheet for Case 9.

FORM D: SCORE SHEET Indicator	Category	Case 9 Bornova-2 (Flat) Comment
1.Location	GOOD	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	BELOW AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	BELOW AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	POOR	More environmentally responsive glazing techniques
16. Materials Maintenance	BELOW AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	BELOW AVERAGE	Reduce energy consumption.
18. Cooling	BELOW AVERAGE	Imply natural cooling techniques
19. Heating	POOR	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	POOR	Choose materials with low VOC emissions.
22. Daylighting	BELOW AVERAGE	Improve existing windows. Prevent glare with shutters.
23. Noise	BELOW AVERAGE	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	BELOW AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	POOR	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	GOOD	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	POOR	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1-27 (2 out of 30)	2-3-7 (3 out of 30)	4-5-6-13-16-17-18-20-22-23-25 (11 out of 30)	8-9-10-11-12-14-15-19-21-24-26-28-29-30 (14 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 9 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 9 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.42), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: (0 Indicator), Good: Indicator 1-27 (2 Indicator;7%), Average: Indicator 2-3-7 (3 Indicators; 10%) Below Average: Indicator 4-5-6-13-16-17-18-20-22-23-25 (11 Indicators; 37%) Poor: Indicator 8-9-10-11-12-14-15-19-21-24-26-28-29-30 (14 Indicators; 46%).

5.2.10. Case Ten: Karşıyaka-1 Flat

Case 10 is an apartment flat, located in Karşıyaka District. It's at the first floor of four floor apartment. The size of the flat is 100 m^2 with three rooms, kitchen, living room, WC and bathroom. Hot water is provided from the central heating system. For space heating, central heating system is used that consumes coal as energy source.

Form A (Table 5.43) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.43. Form A: Data Collection Process for Case 10.

FORM A: DATA COLLECTION											Case No. 10 KARŞIYAKA-1 (Flat)
1	Building Name	Case 10 Flat 10	2	Client							
3	Address	Karsiyaka (KAR)									
4	Architect										
5	Consultants										
6	Year of construction	1983	7	Year of completion	1985	8	Year of occupation	1985			
9	Residential Type	Flat 2+1		Flat 3+1	X	House		Other			
10	Construction Type	R.C.	X	Masonry		Steel		Timber		Other..........	

Table 5.43. Form A: Data Collection Process for Case 10. (cont.)

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East	12	Energy Type: Diesel	Electricity	Natural Gas	Coal	Geothermal
						X								X	

13	Heating Type	Stove		Single Storey Heating		Central Heating	X	Other......... ...	
14	Water heating	LPG		Single Storey Heating		Central Heating	X	Electricity	
15	Size (m2)	0- 100		100- 150	100	150-250		250-more	
16	Occupancy	1		2		2-4	X	4-more	

After completing Form A, Case 10 is evaluated with six ATHENA indicators. Case 10 and Case 1 (baseline project) were compared in Form B (Table 5.44).Case 1's overall performance is better than Case 10. Energy consumption, solid waste emission, air pollution index, global warming potential and weighted resource use indicators are lower than Case 1.

Table 5.44. Form B: ATHENA Software Comparison Chart for Case 1 and Case 10.

FORM B: ATHENA SOFTWARE RESULTS		CASE 10	KARŞIYAKA-1 (Flat)	
	Indicator	**Baseline (%)**	**Case 10(%)**	**Difference**
1	Energy Consumption	100	125,44	9.63
2	Solid Waste Emission	100	142,13	1,53
	Indicator	**Baseline (%)**	**Case 10(%)**	**Difference**
3	Air Pollution Index	100	120,86	- 12,62
4	Water pollution Index	100	146,85	10,53
5	Global Warming Potential	100	134,28	- 1,95
6	Weighted Resource Use	100	151,47	18,18

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 10 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point).

First stage begins with site conditions and Case 10's location indicator (1) performance receives Good (4 points) described in Chapter 4. However, the ecology indicator out of fifty five points, Case 10 scored thirty points, meaning Average Category (3 points).

Table 5.45. Form C performance indicators for Case 10.

FORM C: PERFORMANCE INDICATORS		CASE No. 10 KARŞIYAKA-1 (Flat)						
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				4
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora			X			3
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination						3
		e. Electro Magnetic Fields (EMF)		X				4
		f. Wetlands or flood plain				X		2
		g. Wind conditions				X		2
		h. Sun conditions				X		2
		i. Temperature			X			3
		j. Noise Resources			X			3
		k. Air Quality Index			X			3
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking				X		2
		b. Green Area				X		2
		c. Medical Centre				X		2
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail			X			3
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation				X		2
		b. Wind Orientation				X		2
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate				X		2
		b. Adjacent Structure(s)				X		2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location				X		2
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.45. Form C performance indicators for Case 10. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors					X	1
		b. Windows					X	1
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					**X**	1
		b.Heat					**X**	1
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing				X		2
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance			X			3
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use			X			3
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System					X	1
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System				X		2
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air			X			3
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight			X			3
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level		X				4
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling				X		2
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use		X				4
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport			X			3
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment					X	1
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling						1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 10 scores eighteen out of forty, receives Average (3 points) score in overall for existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Total score for building envelope indicator (5) is four out of ten points, meaning Below Average (2 points) performance for Case 10. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 10, 43% of the materials are made in Turkey that means Case 10 performance category for material selection is Below Average (4 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 10, LCA is applied to less than 25% of the materials during construction, so the final score for Case 10 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Below Average (2 points). For Case 10, 52% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7). Material conservation indicator (8) for Case 6 as an existing building has not have any material conservation plan. The performance score for Case 6 is Poor category. Energy conservation indicator (9) for Case 6, is assumed that there were not any methods to safe energy use. Performance score is Poor Category. Renewable energy use indicator (10) for Case 10 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 10 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12) is assumed that Case 10 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 6 is average score (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 10 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Materials Maintenance indicator (16) for Case 10 is in Excellent (5 point) score. Energy use indicator (17) is

Good (4 points) for 76% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Average (3 points). There is not any specific natural cooling strategy for Case 6. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 10. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a below average (2 points) performance for Case 6. Indoor air quality indicator (21) for Case 10 is Average (3 points) performance. More than 75% of indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used. The level and distribution of daylight factor is 85% for Case 10. Day lighting indicator (22) is Average (3 points) performance. Sound pressure level is less than 30 decibels (dB). Noise indicator (23) performance for Case 5 is Excellent (5 points). Acoustic indicator (24) for Case 10 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 10, waste handling indicator (25)'s performance is Below Average (3 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is Good for Case 10. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 51% of their travelling on private car. Transport indicator performance receives average score. Refurbishment indicator (28) for Case 10 is Poor (1 point).

Table 5.46. Form D score sheet for Case 10.

FORM D: SCORE SHEET Indicator	Category	Case 10 Karşiyaka-1 (Flat) Comment
1.Location	GOOD	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	BELOW AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	BELOW AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	BELOW AVERAGE	More environmentally responsive glazing techniques
16. Materials Maintenance	AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	AVERAGE	Reduce energy consumption.
18. Cooling	POOR	Imply natural cooling techniques
19. Heating	BELOW AVERAGE	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	AVERAGE	Choose materials with low VOC emissions.
22. Daylighting	AVERAGE	Improve existing windows. Prevent glare with shutters
23. Noise	GOOD	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	BELOW AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	GOOD	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	POOR	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1-23-26 (3 out of 30)	2-3-7-13-16-17-21-22-27 (9 out of 30)	5-6-9-22-25-26 (6 out of 30)	4-8-9-10-11-12-14-18-24-28-29-30 (12 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 10 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 10 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.46), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: (0 Indicator), Good: Indicator 1-23-26 (3 Indicators;10%), Average: Indicator 2-3-7-13-16-17-21-22-27 (9 Indicators; 30%) Below Average: Indicator 5-6-9-22-25-26 (6 Indicators; 20%) Poor: Indicator 4-8-9-10-11-12-14-18-24-29-30 (12 Indicators; 40%).

5.2.11. Case Eleven: Narlıdere House

Case 11 is a house, located in Narlıdere District. The size of the house is 189 m^2 with three rooms, kitchen, living room, WC and bathroom. Hot water is provided from the central heating system. For space heating, single heating system is used that consumes fuel-oil as energy source.

Form A (Table 5.47) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.47. Form A: Data Collection Process for Case 11.

FORM A: DATA COLLECTION							**Case No. 11 NARLIDERE (House)**				
1	**Building Name**	Case 11 House 1	**2**	**Client**							
3	**Address**	**Narlıdere (NAR)**									
4	**Architect**										
5	**Consultants**										
6	**Year of construction**	**1996**	**7**	**Year of completion**	**1999**	**8**	**Year of occupation**	**1999**			
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**		**House**	**X**	**Other**			
10	Construction Type	R.C.	**X**	Masonry		Steel		Timber		Other…….....	

Table 5.47. Form A: Data Collection Process for Case 11(cont.)

<table>
<tr><td rowspan="3">11</td><td rowspan="3">Orientation</td><td>North</td><td>Nort-east</td><td>North-west</td><td>South</td><td>South-east</td><td>South-west</td><td>West</td><td>East</td><td rowspan="3">12</td><td colspan="5">Energy Type</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Diesel</td><td>Electricity</td><td>Natural Gas</td><td>Coal</td><td>Geothermal</td></tr>
<tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>13</td><td>Heating Type</td><td colspan="2">Stove</td><td></td><td colspan="3">Single Storey Heating</td><td>X</td><td colspan="2">Central Heating</td><td></td><td colspan="3">Other………
…</td><td></td></tr>
<tr><td>14</td><td>Water heating</td><td colspan="2">LPG</td><td></td><td colspan="3">Single Storey Heating</td><td>X</td><td colspan="2">Central Heating</td><td></td><td colspan="3">Electricity</td><td>X</td></tr>
<tr><td>15</td><td>Size (m2)</td><td colspan="2">0- 100</td><td></td><td colspan="3">100- 150</td><td></td><td colspan="2">150-250</td><td>X</td><td colspan="3">250-more</td><td></td></tr>
<tr><td>16</td><td>Occupancy</td><td colspan="2">1</td><td></td><td colspan="3">2</td><td></td><td colspan="2">2-4</td><td>X</td><td colspan="3">4-more</td><td></td></tr>
</table>

After completing Form A, Case 11 is evaluated with six ATHENA indicators Case 11 and Case 1 (baseline project) were compared in Form B (Table 5.48). Energy consumption, air pollution index, water pollution index, global warming potential indicators performance is better than Case 1. Solid waste emission , weighted resource use indicators performance slightly lower than Case 1.

Table 5.48. Form B: ATHENA Software Comparison Chart for Case 1 and Case 11.

FORM B: ATHENA SOFTWARE RESULTS		CASE 11	NARLIDERE (House)	
	Indicator	**Baseline (%)**	**Case 11(%)**	**Difference**
1	Energy Consumption	100	85,07	-14,93
2	Solid Waste Emission	100	105,29	5,29
3	Air Pollution Index	100	81,52	1,52
4	Water pollution Index	100	96,94	6,94
5	Global Warming Potential	100	89,78	9,78
6	Weighted Resource Use	100	100,61	0,61

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 11 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and Poor (1 point).

First stage begins with site conditions and Case 11's location indicator (1) performance receives Good (4 points) described in Chapter 4. However, the ecology indicator out of fifty five points, Case 11 scored twenty seven points, meaning Average Category (3 points).

Table 5.49. Form C performance indicators for Case 11.

FORM C: PERFORMANCE INDICATORS		CASE No. 11 NARLIDERE (House)						
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				4
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora				X		2
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)						3
		f. Wetlands or flood plain				X		2
		g. Wind conditions				X		2
		h. Sun conditions				X		2
		i. Temperature				X		2
		j. Noise Resources		X				4
		k. Air Quality Index				X		2
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking				X		2
		b. Green Area				X		2
		c. Medical Centre				X		2
		d. School				X		2
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail			X			3
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation					X	1
		b. Wind Orientation					X	1
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate			X			3
		b. Adjacent Structure(s)				X		2
6	Material selection		(5)	(4)	(3)	(2)	(1)	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.49. Form C performance indicators for Case 11. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors				X		2
		b. Windows				X		2
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls				X		2
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					X	1
		b.Heat				X		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing					X	1
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance				X		2
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Electricity use			X			3
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System				X		2
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air					X	1
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight			X			3
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level		X				4
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling			X			3
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use				X		2
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport			X			3
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment					X	1
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 11 scores nineteen out of forty, receives Average score in overall for existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Total score for building envelope indicator (5) is six out of ten points, meaning Average (3 points) performance for Case 11. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 11, 43% of the materials are made in Turkey that means Case 11 performance category for material selection is Below Average (4 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 11, LCA is applied to less than 25% of the materials during construction, so the final score for Case 11 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Below Average (2 points). For Case 11, 52% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7). Material conservation indicator (8) for Case 11 as an existing building has not have any material conservation plan. The performance score for Case 11 is Poor category. Energy conservation indicator (9) for Case 11, is assumed that there were not any methods to safe energy use. Performance score is Poor Category. Renewable energy use indicator (10) for Case 11 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 11 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12) is assumed that Case 11 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 11 is average score (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 11 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Materials Maintenance indicator (16) for Case 11 is in Excellent (5 point) score. Energy use indicator (17) is

Good (4 points) for 76% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Average (3 points). There is not any specific natural cooling strategy for Case 11. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 11. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a below average (2 points) performance for Case 11. Indoor air quality indicator (21) for Case 11 is Poor (1 point) performance. Indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have not been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins may be used. The level and distribution of daylight factor is 85% for Case 11. Day lighting indicator (22) is Average (3 points) performance. Sound pressure level is less than 30 decibels (dB). Noise indicator (23) performance for Case 11 is Good (4 points). Acoustic indicator (24) for Case 11 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 11, waste handling indicator (25)'s performance is Average (3 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is below average for Case 11. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 52% of their travelling on private car. Transport indicator performance receives average score. Refurbishment indicator (28) for Case 11 is Poor (1 point).

Table 5.50. Form D score sheet for Case 11.

FORM D: SCORE SHEET Indicator	Category	Case 11 Narlıdere (House) Comment
1.Location	GOOD	Has all the advantages of the city
2. Ecology	BELOW AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	BELOW AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	POOR	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	POOR	More environmentally responsive glazing techniques
16. Materials Maintenance	POOR	Improve the maintenance program of the unit.
17. Energy Use	POOR	Reduce energy consumption.
18. Cooling	POOR	Imply natural cooling techniques
19. Heating	POOR	Improve energy source
20. Ventilation	POOR	Increase number of vents
21. Indoor Air Quality	POOR	Choose materials with low VOC emissions.
22. Daylighting	BELOW AVERAGE	Improve existing windows. Prevent glare with shutters.
23. Noise	POOR	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	BELOW AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	BELOW AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	AVERAGE	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1 (1 out of 30)	5-7-13-27-28 (5 out of 30)	2-3-6-22-25-26 (6 out of 30)	4-8-9-10-11-12-14-15-16-17-18-19-20-21-23-24-29-30 (18 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 11 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 11 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.50), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: (0 Indicator), Good: Indicator 1 (1 Indicator;), Average: Indicator 5-7-13-27-28 (5 Indicators; %) Below Average: Indicator 2-3-6-22-25-26 (6 Indicators; %) Poor: Indicator 4-8-9-10-11-12-14-15-16-17-18-19-20-21-23-24-29-30 (18 Indicators; 40%).

5.2.12. Case Twelve: Seferihisar House

Case 12 is a house, located in Seferihisar District. The size of the house is 210 m^2 with three rooms, kitchen, living room, WC and bathroom. Hot water is provided from the central heating system. For space heating, single storey system is used that consumes fuel-oil as energy source.

Form A (Table 5.51) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.51. Form A: Data Collection Process for Case 12.

FORM A: DATA COLLECTION							Case No. 12 SEFERİHİSAR (House)				
1	**Building Name**	Case 12 House 2	**2**	**Client**							
3	**Address**	**Seferihisar (SEF)**									
4	**Architect**										
5	**Consultants**										
6	**Year of construction**		**7**	**Year of completion**		**8**	**Year of occupation**				
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**		**House**	**X**	**Other**			
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**		**Other……....**	

Table 5.51. Form A: Data Collection Process for Case 12. (Cont.)

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East	12	Energy Type				
											Diesel	Electricity	Natural Gas	Coal	Geothermal

13	Heating Type	Stove		Single Storey Heating	X	Central Heating		Other……… …	
14	Water heating	LPG		Single Storey Heating	X	Central Heating		Electricity	X
15	Size (m2)	0- 100		100- 150		150-250	X	250-more	
16	Occupancy	1		2		2-4		4-more	

Table 5.52. Form B: ATHENA Software Comparison Chart for Case 1 and Case 12.

FORM B: ATHENA SOFTWARE RESULTS		CASE 12	SEFERİHİSAR (House)	
	Indicator	**Baseline (%)**	**Case 12(%)**	**Difference**
1	Energy Consumption	100	123,06	23,06
2	Solid Waste Emission	100	124,55	24,55
3	Air Pollution Index	100	119,25	19,25
4	Water pollution Index	100	153,59	53,59
5	Global Warming Potential	100	135,38	35,38
6	Weighted Resource Use	100	169,10	69,10

After completing Form A, Case 12 is evaluated with six ATHENA indicators Case 12 and Case 1 (baseline project) were compared in Form B (Table 5.53). Case 12's energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential, and weighted resource use indicators are lower than Case 1.

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 12 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and Poor (1 point).

First stage begins with site conditions and Case 12's location indicator (1) performance receives Average (3 points) described in Chapter 4. The ecology indicator out of fifty five points, Case 12 scored twenty five points, Below Average Category (3 points).

Table 5.53. Form C. Performance Indicators for Case 12.

FORM C: PERFORMANCE INDICATORS		CASE No. 12 SEFERİHİSAR (House)						
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**				X			3
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora				X		2
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)			X			3
		f. Wetlands or flood plain				X		2
		g. Wind conditions				X		2
		h. Sun conditions				X		2
		i. Temperature				X		2
		j. Noise Resources		X				4
		k. Air Quality Index				X		2
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking				X		2
		b. Green Area				X		2
		c. Medical Centre				X		2
		d. School				X		2
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail			X			3
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation					X	1
		b. Wind Orientation					X	1
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate				X		2
		b. Adjacent Structure(s)				X		2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.53. Form C. Performance Indicators for Case 12. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	Unit components		(5)	(4)	(3)	(2)	(1)	
		a.Doors				X		2
		b. Windows				X		2
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls				X		2
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					**X**	1
		b.Heat				**X**		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing					X	1
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance					X	1
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use			X			3
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System					X	1
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System					X	1
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air					X	1
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight					X	1
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level		X				4
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling					X	1
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use				X		2
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport				X		2
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment					X	1
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 12 scores nineteen out of forty, receives Below Average (2 points) score in overall for existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Total score for building envelope indicator (5) is four out of ten points, meaning Below Average (2 points) performance for Case 12. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 12, 43% of the materials are made in Turkey that means Case 12 performance category for material selection is Below Average (4 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 12, LCA is applied to less than 25% of the materials during construction, so the final score for Case 12 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Below Average (2 points). For Case 12, 52% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7). Material conservation indicator (8) for Case 12 as an existing building has not have any material conservation plan. The performance score for Case 12 is Poor category. Energy conservation indicator (9) for Case 12, is assumed that there were not any methods to safe energy use. Performance score is Poor Category. Renewable energy use indicator (10) for Case 12 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 12 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12) is assumed that Case 12 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 12 is average score (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 12 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Materials Maintenance indicator (16) for Case 12 is in Excellent (5 point) score. Energy use indicator (17) is

Good (4 points) for 76% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Average (3 points). There is not any specific natural cooling strategy for Case 12. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 12. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a below average (2 points) performance for Case 12. Indoor air quality indicator (21) for Case 12 is Poor (1 point) performance. Indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have not been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used. The level and distribution of daylight factor is 24% for Case 12. Day lighting indicator (22) is Poor (1 point) performance. Sound pressure level is less than 30 decibels (dB). Noise indicator (23) performance for Case 12 is Good (4 points). Acoustic indicator (24) for Case 12 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 12, waste handling indicator (25)'s performance is Poor (1 point). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is below average for Case 12. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 78% of their travelling on private car. Transport indicator performance receives Below Average score. Refurbishment indicator (28) for Case 12 is Poor (1 point).

Table 5.54. Form D score sheet for Case 12.

FORM D: SCORE SHEET		Case 12 Seferihisar (Houae)
Indicator	Category	Comment
1.Location	AVERAGE	Has all the advantages of the city
2. Ecology	BELOW AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	BELOW AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	POOR	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	POOR	More environmentally responsive glazing techniques
16. Materials Maintenance	POOR	Improve the maintenance program of the unit.
17. Energy Use	AVERAGE	Reduce energy consumption.
18. Cooling	POOR	Imply natural cooling techniques
19. Heating	POOR	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	POOR	Choose materials with low VOC emissions.
22. Daylighting	POOR	Improve existing windows. Prevent glare with shutters.
23. Noise	GOOD	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	POOR	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	BELOW AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	BELOW AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	POOR	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	23 (1 out of 30)	1-7-13-17 (4 out of 30)	2-3-5-6-20-26-27 (7 out of 30)	4-8-9-10-11-12-14-15-16-18-19-21-22-24-25-28-29-30 (18 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 12 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 12 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.54), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: (0 Indicator), Good: Indicator 23 (1 Indicator; 3 %), Average: Indicator 1-7-13-17 (4 Indicators; 13%) Below Average: Indicator 2-3-5-6-20-26-27 (7 Indicators; 23%) Poor: Indicator 4-8-9-10-11-12-14-15-16-18-19-21-22-24-25-28-29-30 (18 Indicators; 61%).

5.2.13. Case Thirteen: Çeşme House

Case 13 is a house, located in Çeşme District. The size of the house is 224m^2 with four rooms, kitchen, living room, WC and bathroom. Hot water is provided from the central heating system. For space heating, single storey system is used that consumes fuel-oil as energy source.

Form A (Table 5.55) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.55. Form A: Data Collection Process for Case 13.

FORM A: DATA COLLECTION													**Case No. 13 ÇEŞME (House)**
1	**Building Name**	Case 13 House 3				2	**Client**						
3	**Address**	**Cesme (CES)**											
4	**Architect**												
5	**Consultants**												
6	**Year of construction**		7	**Year of completion**		8	**Year of occupation**						
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**		**House**	**X**	**Other**					
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**		**Other……....**			

Table 5.55. Form A: Data Collection Process for Case 13 (cont.)

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East	12	Energy Type				
											Diesel	Electricity	Natural Gas	Coal	Geothermal
				X							X				

13	**Heating Type**	**Stove**		**Single Storey Heating**	X	**Central Heating**		**Other……… …**	
14	**Water heating**	**LPG**		**Single Storey Heating**	X	**Central Heating**		**Electricity**	X
15	**Size (m2)**	**0- 100**		**100- 150**		**150-250**	X	**250-more**	
16	**Occupancy**	**1**		**2**		**2-4**		**4-more**	X

After completing Form A, Case 13 is evaluated with six ATHENA indicators Case 13 and Case 1 (baseline project) were compared in Form B (Table 5.56). Energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential, and weighted resource use indicators are better than Case 1.

Table 5.56. Form B: ATHENA Software Comparison Chart for Case 1 and Case 13

FORM B: ATHENA SOFTWARE RESULTS		CASE 13		ÇEŞME (House)
	Indicator	**Baseline (%)**	**Case 13(%)**	**Difference**
1	Energy Consumption	100	69.74	-30.26
2	Solid Waste Emission	100	88.88	-11.12
3	Air Pollution Index	100	66.56	-33.44
4	Water pollution Index	100	79.01	-20.99
5	Global Warming Potential	100	73.09	-26.91
6	Weighted Resource Use	100	82.30	-17.7

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 13 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point)

First stage begins with site conditions and Case 13's location indicator (1) performance receives Average (3 points) described in Chapter 4. The ecology indicator out of fifty five points, Case 13 scored thirty four points, Average Category (3 points).

Table 5.57. Form C performance indicators for Case 13.

FORM C: PERFORMANCE INDICATORS			CASE No. 13 ÇEŞME (House)					
Indicator			Excellent (5)	Good (4)	Average (3)	Below (2)	Poor (1)	
	A. SITE SELECTION							
1	**Location**				X			3
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora		X				4
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)		X				4
		f. Wetlands or flood plain		X				4
		g. Wind conditions			X			3
		h. Sun conditions				X		2
		i. Temperature				X		2
		j. Noise Resources		X				4
		k. Air Quality Index			X			3
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking	X					5
		b. Green Area		X				4
		c. Medical Centre			X			3
		d. School		X				4
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail			X			3
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation					X	1
		b. Wind Orientation					X	1
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate		X				4
		b. Adjacent Structure(s)			X			3
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		A. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.57. Form C performance indicators for Case 13. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors		X				4
		b. Windows			X			3
		c. Ceiling			X			3
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					X	1
		b.Heat				X		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing		X				4
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance			X			3
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use			X			3
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System			X			3
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System			X			3
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents			X			3
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air				X		2
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight		X				4
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level	X					5
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling			X			3
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use			X			3
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport		X				4
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment		X				4
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 13 scores twenty seven out of forty, receives Average score in overall for existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Total score for building envelope indicator (5) is seven out of ten points, meaning Below Average (2 points) performance for Case 13. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 13, 43% of the materials are made in Turkey that means Case 13 performance category for material selection is Below Average (4 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 13, LCA is applied to less than 25% of the materials during construction, so the final score for Case 13 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Below Average (2 points). For Case 13, 52% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7). Material conservation indicator (8) for Case 6 as an existing building has not have any material conservation plan. The performance score for Case 13 is Poor category. Energy conservation indicator (9) for Case 13, is assumed that there were not any methods to safe energy use. Performance score is Poor Category. Renewable energy use indicator (10) for Case 13 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case13 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12) is assumed that Case 13 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 13 is average score (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 13 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Materials Maintenance indicator (16) for Case 13 is in Average (3 point) score. Energy use indicator (17) is

Average (3 points) for 54% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Average (3 points). There is not any specific natural cooling strategy for Case 6. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 13. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a below average (2 points) performance for Case 6. Indoor air quality indicator (21) for Case 13 is Below Average (2 points) performance. More than 50 % of indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used. The level and distribution of daylight factor is 84% for Case 13. Day lighting indicator (22) is Good (4 points) performance. Sound pressure level is less than 30 decibels (dB). Noise indicator (23) performance for Case 13 is Good (4 points). Acoustic indicator (24) for Case 13 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 13, waste handling indicator (25)'s performance is Average (3 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is average for Case 13. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent less than 25% of their travelling on private car. Transport indicator performance receives Good (4 points) score. Refurbishment indicator (28) for Case 13 is Good (4 points).

Table 5.58. Form D score sheet for Case 13.

FORM D: SCORE SHEET		Case 13 Çeşme (House)
Indicator	Category	Comment
1.Location	AVERAGE	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	GOOD	More environmentally responsive glazing techniques
16. Materials Maintenance	AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	AVERAGE	Reduce energy consumption.
18. Cooling	AVERAGE	Imply natural cooling techniques
19. Heating	AVERAGE	Improve energy source
20. Ventilation	AVERAGE	Increase number of vents
21. Indoor Air Quality	BELOW AVERAGE	Choose materials with low VOC emissions.
22. Daylighting	GOOD	Improve existing windows. Prevent glare with shutters.
23. Noise	EXCELLENT	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	GOOD	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	GOOD	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
23 (1 out of 30)	15-22-27-28 (3 out of 30)	1-2-3-45-7-13-16-17-18-19-20-25-26 (13 out of 30)	6-21 (2 out of 30)	8-9-10-11-12-14-24-29-30 (10 out 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 13 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 13 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.58), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: Indicator 23(1 Indicator; 3%), Good: Indicator 15-22-27-28 (4 Indicators; 13%), Average: Indicator 2-3-4-7-13-16-17-21-22-27 (10 Indicators; 31%) Below Average: Indicator 5-6-9-22-25-26 (6 Indicators; 19%) Poor: Indicator 8-9-10-11-12-14-18-24-29-30 (11 Indicators; 34%).

5.2.14. Case Fourteen: Mavişehir-2 House

Case 14 is a house, located in Mavişehir District. The size of the house is 285m^2 with three rooms, kitchen, living room, WC and bathroom. Hot water is provided from the central heating system. For space heating, single storey system is used that consumes fuel-oil as energy source.

Form A (Table 5.59) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.59. Form A: Data Collection Process for Case 14.

FORM A: DATA COLLECTION							**Case No. 14 MAVİŞEHİR-2 (House)**				
1	**Building Name**	Case 14 House4			**2**	**Client**					
3	**Address**	**Mavisehir (MAV)**									
4	**Architect**										
5	**Consultants**										
6	**Year of construction**	**1996**	**7**	**Year of completion**	**1999**	**8**	**Year of occupation**	**1999**			
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**		**House**	**X**	**Other**			
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**		**Other………..**	

Table 5.59. Form A: Data Collection Process for Case 14. (cont.)

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East	12	Energy Type: Diesel	Electricity	Natural Gas	Coal	Geothermal
			X								X				
13	Heating Type	Stove			Single Storey Heating			X	Central Heating			Other………			
14	Water heating	LPG			Single Storey Heating			X	Central Heating			Electricity			X
15	Size (m2)	0- 100			100- 150				150-250		285	250-more			
16	Occupancy	1			2			X	2-4			4-more			

After completing Form A, Case 14 is evaluated with six ATHENA indicators. Case 14 and Case 1 (baseline project) were compared in Form B (Table 5.59). The ATHENA six performance comparisons indicate that Case 14 is better than Case 1. Energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential, and weighted resource use indicators are better than Case 1.

Table 5.60. Form B: ATHENA Software Comparison Chart for Case 1 and Case 14.

FORM B: ATHENA SOFTWARE RESULTS		CASE 14	MAVİŞEHİR-2 (House)	
	Indicator	**Baseline (%)**	**Case 14(%)**	**Difference**
1	Energy Consumption	100	48,83	-51.17
2	Solid Waste Emission	100	70,29	-29.71
3	Air Pollution Index	100	46,23	-53,77
4	Water pollution Index	100	52,34	-47,66
5	Global Warming Potential	100	49,85	-50,15
6	Weighted Resource Use	100	53,78	-46,22

Form C comes into action after Form B and measures performance values for selected thirty indicators under four life cycle stages; site selection, construction, operation, and demolition. These indicators based on energy, material, water, waste and environment issues.

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 14 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point).

First stage begins with site conditions and Case 14's location indicator (1) performance receives Good (4 points) described in Chapter 4. The ecology indicator out of fifty five points, Case 14 scored thirty seven points, Average Category (3 points).

Table 5.61. Form C. Performance Indicators for Case 14.

FORM C: PERFORMANCE INDICATORS		CASE No. 14 MAVİŞEHİR-2 (House)						
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**		X					
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora			X			3
		b. Fauna				X		2
		c. Water quality		X				4
		d. Soil contamination				X		2
		e. Electro Magnetic Fields (EMF)			X			3
		f. Wetlands or flood plain				X		2
		g. Wind conditions		X				4
		h. Sun conditions		X				4
		i. Temperature			X			3
		j. Noise Resources	X					5
		k. Air Quality Index		X				4
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking		X				4
		b. Green Area	X					5
		c. Medical Centre			X			3
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport		X				4
		h. Retail		X				4
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation			X			3
		b. Wind Orientation			X			3
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate			X			3
		b. Adjacent Structure(s)		X				4
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.61. Form C. Performance Indicators for Case 14. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors		X				4
		b. Windows			X			3
		c. Ceiling			X			3
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					**X**	1
		b.Heat				**X**		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing			X			3
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance			X			3
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Electricity use		X				4
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System					X	1
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System					X	1
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents			X			3
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air				X		2
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight		X				4
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level		X				4
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling		X				4
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use			X			3
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) ‘Transport			X			3
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment		X				4
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 14 scores thirty six out of forty, receives Good (4 points) score in overall existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. Building envelope indicator (5) evaluates the physical volume of the studied unit. Building envelope improves energy use, indoor air quality, ventilation and heating consumption. Building envelope is dependant on two sub-indicators; one local climate conditions, and the other is adjacent structures. Total score for building envelope indicator (5) is Average (3 points) performance for Case 14.

Material selection has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. Case 14, 67% of the materials are made in Turkey, that means Case 14 performance category for material selection is Average.

Material LCA sub-indicator records the amount of LCA applied materials. For Case 14, LCA is applied to less than 25% of the materials during construction, so the final score for Case 14 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, below average (Table 5.60).

During the material transportation, fossil fuels are used to run the vehicles that carry materials from distances. Material transportation indicator (7) considers the method and distance of the transportation. For Case 14, 67% percent of materials are transported from local warehouses, means the performance score is average.

Material conservation indicator (8) considers the efficient use of construction materials. The material consultants must provide necessary management documents and manuals to minimise misuse of materials. This indicator is valid for new residential constructions, so Case 14 as an existing building has not have any material conservation plan. The performance score for Case 2 is Poor category.

During construction, there are many activities that consume fossil fuel and electricity energy. Energy efficiency is important because energy needs energy to carry the source. Minimised energy use means more savings for producing and carrying the source. Energy conservation indicator (9) influences the building site to use energy efficiently. For Case 14, during construction, it is assumed that there were not any methods to safe energy use. Performance score is Poor Category for Case 14.

Renewable energies are promoted as clean sources. However, the installation of solar panels initial costs can be expensive for the construction site. The construction process may take more than one year and can save considerable amount of fossil and hydro energy. After the completion of the construction, either the panels can be also used during operation stage of the residential unit or the building contractor can transport the solar panels to new construction site.

Renewable energy use indicator (10) for Case 14 is Poor performance because it is assumed that there was not any use of renewable energy source during construction.

Waste problem is increasing each day because of improper use of energy, material and water. Waste strategy must begin from construction stage and must continue during operation and demolition stages. In construction stage, the waste products are the packages, spare parts and left over of the materials after their application. All these waste must be collected separately and stored in containers. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 14 has not have any plan for waste strategy. During new constructions, this indicator will have important role to reduce waste during construction.

Water is a scarce source on earth, so any construction site should use water efficiently, otherwise it is stated in many literature that water will not be available for future generations. Water strategy indicator (12) helps the construction site to minimise water consumption.

A residential unit has five main components; door, window, ceiling, floor, and wall. Each component has different design potentials. For instance, the colour or the material type of the walls may vary depending on architects' visions. However, final product should be efficient and environmentally responsive. During their production and application processes, LCA Evaluation must be conducted to achieve sustainable environment. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels.

Insulation is the blanket of the residential unit. Correct application of insulation, can minimise heating and cooling loads. Sound insulation reduces outside noise sources and creates comfortable living environment inside the unit for the occupants. Insulation indicator (14) assesses the standard of insulation in five categories. Case 14 has scored poor in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average Category.

Materials Maintenance indicator (16) follows the maintenance progress for the residential unit. Case 14 is in poor condition compare to other units. The Poor performance result means that the unit needs refurbishment. Energy use indicator (17) monitors the energy use efficiency for electricity. Saving electricity will reduce the overall national energy cost for the country. Case receives poor performance because there are not any measures or methods to reduce electricity use. Cooling indicator (18) is valid during hot seasons. Materials, building envelope design, and ventilation are partially related with cooling indicator. There is not any specific natural cooling strategy for Case 2. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor performance for Case 14. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a poor performance for Case 14. Indoor air quality indicator (21) for Case14 is Below Average (2 points) performance. More than 50% of indoor materials including paints, sealants, adhesives, carpets and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins may be used. The level and distribution of daylight factor is 90% for Case 14. Day lighting indicator (22) is Good (4 points) performance. Sound pressure level is more than 70 decibels (dB). Noise indicator (23) performance for Case 14 is Good (4 points). Acoustic indicator (24). The reverberation time is poor for Case 14. Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 14, waste handling indicator (25)'s performance is Good (4 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is Average for Case 14. The flat needs to reduce water consumption in the toilet flushing and shower use. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 58% of their travelling on private car. Transport indicator performance receives average score. Refurbishment indicator (28) checks the environmental improvements of an existing dwelling or whether future refurbishment plan is considered. For Case 14, refurbishment indicator is Good (4 points) because only some parts of the residential unit were improved.

Table 5.62. Form D score sheet for Case 14.

FORM D: SCORE SHEET		Case 14 Mavişehir-2(House)
Indicator	Category	Comment
1.Location	EXCELLENT	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	GOOD	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	GOOD	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	BELOW AVERAGE	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	AVERAGE	More environmentally responsive glazing techniques
16. Materials Maintenance	AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	AVERAGE	Reduce energy consumption.
18. Cooling	POOR	Imply natural cooling techniques
19. Heating	POOR	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	BELOW AVERAGE	Choose materials with low VOC emissions.
22. Daylighting	GOOD	Improve existing windows. Prevent glare with shutters.
23. Noise	GOOD	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	GOOD	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	GOOD	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1(1 out of 30)	3-5-22-23-25-28(6 out of 30)	2-4-7-13-15-16-17-26-27 (9 out of 30)	6-14-20-21 (4 out of 30)	8-9-10-11-12-18-19-24-29-30 (11 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 14 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 14 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.62), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: Indicator 1 (1 Indicator; 3%), Good: Indicator 3-5-22-23-25-28 (6 Indicators; 20%), Average: Indicator 2-4-7-13-15-17-26-27 (9 Indicators; 30%) Below Average: Indicator 6-14-20-21 (4 Indicators; 13%) Poor: Indicator 8-9-10-11-12-18-19-24-29-30 (10 Indicators; 34%).

5.2.15. Case Fifth-teen: Karşıyaka-2 House

Case 15 is a house, located in Karşıyaka District. The size of the house is $175m^2$ with four rooms, kitchen, living room, WC and bathroom. Hot water is provided from the central heating system. For space heating, single storey system is used that consumes fuel-oil as energy source.

Form A (Table 5.63) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.63. Form A: Data Collection Process for Case 15.

FORM A: DATA COLLECTION							**Case No.15 KARŞIYAKA-1 (House)**				
1	**Building Name**	Case 15 House5				2	**Client**				
3	**Address**	**Karşıyaka (KAR)**									
4	**Architect**										
5	**Consultants**										
6	**Year of construction**	**1987**	**7**	**Year of completion**	**1989**	**8**	**Year of occupation**	**1990**			
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**		**House**	**X**	**Other**			
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**		**Other...........**	

Table 5.63. Form A: Data Collection Process for Case 15 (Cont.)

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East	12	Energy Type: Diesel	Electricity	Natural Gas	Coal	Geothermal
						X					X				

13	**Heating Type**	**Stove**		**Single Storey Heating**	X	**Central Heating**		**Other………** **…**	
14	**Water heating**	**LPG**		**Single Storey Heating**	X	**Central Heating**		**Electricity**	X
15	**Size (m2)**	**0- 100**		**100- 150**		**150-250**	175	**250-more**	
16	**Occupancy**	**1**		**2**		**2-4**	X	**4-more**	

After completing Form A, Case 15 is evaluated with six ATHENA indicators. Case 15 and Case 1 (baseline project) were compared in Form B (Table 5.64). The ATHENA six performance comparisons indicate that Case 15 is better than Case 1 Energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential, and weighted resource use indicators are better than Case 1.

Table 5.64. Form B: ATHENA Software Comparison Chart for Case 1 and Case 15.

FORM B: ATHENA SOFTWARE RESULTS		CASE 15		KARŞIYAKA-1 (House)
	Indicator	**Baseline (%)**	**Case 15(%)**	**Difference**
1	Energy Consumption	100	79,90	-20,1
2	Solid Waste Emission	100	98,00	-2
3	Air Pollution Index	100	76,67	-23,33
4	Water pollution Index	100	92,12	-7,88
5	Global Warming Potential	100	84,82	15,18
6	Weighted Resource Use	100	97,91	-2,09

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 15 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point).

First stage begins with site conditions and Case 15's location indicator (1) performance receives Excellent (5 points) described in Chapter 4. The ecology indicator out of fifty five points, Case 15 scored thirty eight points, Average Category (3 points).

Table 5.65. Form C Performance Indicators for Case 15.

FORM C: PERFORMANCE INDICATORS		CASE No. 15 KARŞIYAKA-1 (House)						
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**		X					5
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora			X			3
		b. Fauna			X			3
		c. Water quality		X				4
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)			X			3
		f. Wetlands or flood plain				X		2
		g. Wind conditions		X				4
		h. Sun conditions		X				4
		i. Temperature			X			3
		j. Noise Resources	X					5
		k. Air Quality Index		X				4
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking			X			3
		b. Green Area		X				4
		c. Medical Centre			X			3
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport		X				4
		h. Retail		X				4
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation				X		2
		b. Wind Orientation				X		2
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate						2
		b. Adjacent Structure(s)						2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.65. Form C Performance Indicators for Case 15. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors			X			3
		b. Windows			X			3
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					X	1
		b.Heat				X		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing					X	1
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance			X			3
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use				X		2
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System					X	1
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air				X		2
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight			X			3
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level		X				4
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling			X			3
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use			X			3
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport		X				4
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment				X		2
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 15 receives Average score in overall for existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Total score for building envelope indicator (5) is four out of ten points, meaning Below Average (2 points) performance for Case 15. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 15, 43% of the materials are made in Turkey that means Case 15 performance category for material selection is Below Average (4 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 15, LCA is applied to less than 25% of the materials during construction, so the final score for Case 15 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Below Average (2 points). For Case 6, 52% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7). Material conservation indicator (8) for Case 6 as an existing building has not have any material conservation plan. The performance score for Case 15 is Poor category. Energy conservation indicator (9) for Case 15, is assumed that there were not any methods to safe energy use. Performance score is Poor Category. Renewable energy use indicator (10) for Case 15 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 15 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12) is assumed that Case 15 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 15 is average score (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 15 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Materials Maintenance indicator (16) for Case 15 is in Excellent (5 point) score. Energy use indicator (17) is

Good (4 points) for 76% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Average (3 points). There is not any specific natural cooling strategy for Case 15. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 15. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a below average (2 points) performance for Case 15. Indoor air quality indicator (21) for Case 15 is Below Average (2 points) performance. More than 50% of indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used. The level and distribution of daylight factor is 85% for Case 15. Day lighting indicator (22) is Average (3 points) performance. Sound pressure level is less than 30 decibels (dB). Noise indicator (23) performance for Case 15 is Good (4 points). Acoustic indicator (24) for Case 15 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 15, waste handling indicator (25)'s performance is Average (3 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is average for Case 15. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent less than 25% of their travelling on private car. Transport indicator performance receives Good (4 points) score. Refurbishment indicator (28) for Case 15 is Below Average (2 points).

Table 5.66. Form D score sheet for Case 15.

FORM D: SCORE SHEET Indicator	Category	Case 15 Karşıyaka-1(House) Comment
1.Location	EXCELLENT	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	BELOW AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	BELOW AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	BELOW AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	POOR	More environmentally responsive glazing techniques
16. Materials Maintenance	AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	BELOW AVERAGE	Reduce energy consumption.
18. Cooling	BELOW AVERAGE	Imply natural cooling techniques
19. Heating	POOR	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	BELOW AVERAGE	Choose materials with low VOC emissions.
22. Daylighting	AVERAGE	Improve existing windows. Prevent glare with shutters.
23. Noise	GOOD	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	GOOD	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	BELOW AVERAGE	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1 (1 out of 30)	23-27 (2 out of 30)	2-7-16-22-25-26 (6out of 30)	3-4-5-6-13-17-18-20-21-28 (10 out of 30)	8-9-10-11-12-14-15-19-24-29-30 (11 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 15 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 15 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.66), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: Indicator 1(1 Indicator; 3%), Good: Indicator 23-27 (2 Indicators; 7%), Average: Indicator 2-7-16-22-25-26 (6 Indicators; 20%) Below Average: Indicator 3-4-5-6-13-17-18-20-21-28 (10 Indicators; 33%) Poor: Indicator 8-9-10-11-12-14-15-19-20-24-29-30 (11 Indicators; 37%).

5.2.16. Case Six-teen: Karşıyaka-3 House

Case 16 is a house, located in Karşıyaka District. The size of the house is 200m^2 with five rooms, kitchen, living room, WC and bathroom. Hot water is provided from the central heating system. For space heating, single storey system is used that consumes fuel-oil as energy source.

Form A (Table 5.67) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.67. Form A: Data Collection Process for Case 16.

FORM A: DATA COLLECTION												**Case No. 16 KARŞIYAKA-3 (House)**	
1	**Building Name**	Case 16 House 6					**2**	**Client**					
3	**Address**	**Karşıyaka (KAR)**											
4	**Architect**												
5	**Consultants**												
6	**Year of construction**	**2001**		**7**	**Year of completion**		**2004**		**8**	**Year of occupation**		**2004**	
9	**Residential Type**	**Flat 2+1**			**Flat 3+1**			**House**	**X**	**Other**			
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**			**Timber**		**Other……....**		

Table 5.67. Form A: Data Collection Process for Case 16. (Cont.)

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East	12	Energy Type				
											Diesel	Electricity	Natural Gas	Coal	Geothermal
					X						X				
13	Heating Type	Stove			Single Storey Heating			X	Central Heating			Other…………			
14	Water heating	LPG			Single Storey Heating			X	Central Heating			Electricity			X
15	Size (m2)	0- 100			100- 150				150-250		200	250-more			
16	Occupancy	1			2				2-4			4-more			

After completing Form A, Case 16 is evaluated with six ATHENA indicators. Case 16 and Case 1 (baseline project) were compared in Form B (Table 5.68). ATHENA six performance comparisons indicates that energy consumption, air pollution index, water pollution index, global warming potential, and weighted resource use indicators are better than Case 1. Case 1's solid waste emission is better than Case 16.

Table 5.68. Form B: ATHENA Software Comparison Chart for Case 1 and Case 16.

FORM B: ATHENA SOFTWARE RESULTS		CASE 16	KARŞIYAKA-3 (House)	
	Indicator	**Baseline (%)**	**Case 16(%)**	**Difference**
1	Energy Consumption	100	81,28	-18,72
2	Solid Waste Emission	100	106,37	6,37
3	Air Pollution Index	100	77,50	-22,5
4	Water pollution Index	100	91,75	-8,25
5	Global Warming Potential	100	85,02	-14,98
6	Weighted Resource Use	100	97,20	-2,8

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 16 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point).

First stage begins with site conditions and Case 16's location indicator (1) performance receives Good (4 points) described in Chapter 4. The ecology indicator out of fifty five points, Case 16 scored Goof Category (4 points).

Table 5.69. Form C. Performance Indicators for Case 16.

FORM C: PERFORMANCE INDICATORS		CASE No. 16 KARŞIYAKA-3 (House)						
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				4
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora			X			3
		b. Fauna			X			3
		c. Water quality		X				4
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)			X			3
		f. Wetlands or flood plain		X				4
		g. Wind conditions		X				4
		h. Sun conditions		X				4
		i. Temperature			X			3
		j. Noise Resources		X				4
		k. Air Quality Index			X			3
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking		X				4
		b. Green Area		X				4
		c. Medical Centre		X				4
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail		X				4
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation		X				4
		b. Wind Orientation			X			3
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate		X				4
		b. Adjacent Structure(s)				X		2
6	Material selection		(5)	(4)	(3)	(2)	(1)	
		a. Country location		X				4
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.69. Form C. Performance Indicators for Case 16. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors			X			3
		b. Windows		X				4
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					X	1
		b.Heat				X		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing			X			3
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance			X			3
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Electircity use			X			3
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System					X	1
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air				X		2
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight			X			3
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level		X				4
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling			X			3
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use			X			3
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport			X			3
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment				X		2
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 16 scores Good (4 points) performance in overall existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. Building envelope indicator (5) evaluates the physical volume of the studied unit. Total score for building envelope indicator (5) is four out of ten points, meaning below average performance for Case 16.

Material selection has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. In Case 16, 67% of the materials are made in Turkey, that means Case 16 performance category for material selection is average.

Material LCA sub-indicator records the amount of LCA applied materials. For Case 16, LCA is applied to less than 25% of the materials during construction, so the final score for Case 16 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, below average (Table 5.69).

During the material transportation, fossil fuels are used to run the vehicles that carry materials from distances. Material transportation indicator (7) considers the method and distance of the transportation. For Case 16, 67% percent of materials are transported from local warehouses, means the performance score is average.

Material conservation indicator (8) considers the efficient use of construction materials. The material consultants must provide necessary management documents and manuals to minimise misuse of materials. This indicator is valid for new residential constructions, so Case 16 as an existing building has not have any material conservation plan. The performance score for Case 16 is Poor category.

During construction, there are many activities that consume fossil fuel and electricity energy. Energy efficiency is important because energy needs energy to carry the source. Minimised energy use means more savings for producing and carrying the source. Energy conservation indicator (9) influences the building site to use energy efficiently. For Case 16, during construction, it is assumed that there were not any methods to safe energy use. Performance score is Poor Category for Case 16.

Renewable energies are promoted as clean sources. However, the installation of solar panels initial costs can be expensive for the construction site. The construction process may take more than one year and can save considerable amount of fossil and hydro energy. After the completion of the construction, either the panels can be also used during operation stage of the residential unit or the building contractor can transport the solar panels to new construction site.

Renewable energy use indicator (10) for Case 16 is Poor performance because it is assumed that there was not any use of renewable energy source during construction.

Waste problem is increasing each day because of improper use of energy, material and water. Waste strategy must begin from construction stage and must continue during operation and demolition stages. In construction stage, the waste products are the packages, spare parts and left over of the materials after their application. All these waste must be collected separately and stored in containers. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 16 has not have any plan for waste strategy. During new constructions, this indicator will have important role to reduce waste during construction.

Water is a scarce source on earth, so any construction site should use water efficiently, otherwise it is stated in many literature that water will not be available for future generations. Water strategy indicator (12) helps the construction site to minimise water consumption.

A residential unit has five main components; door, window, ceiling, floor, and wall. Each component has different design potentials. For instance, the colour or the material type of the walls may vary depending on architects' visions. However, final product should be efficient and environmentally responsive. During their production and application processes, LCA Evaluation must be conducted to achieve sustainable environment. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels.

Insulation is the blanket of the residential unit. Correct application of insulation, can minimise heating and cooling loads. Sound insulation reduces outside noise sources and creates comfortable living environment inside the unit for the occupants. Insulation indicator (14) assesses the standard of insulation in five categories. Case 2 has scored poor in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average Category.

Materials Maintenance indicator (16) follows the maintenance progress for the residential unit. Case 16 is in poor condition compare to other units. The Poor performance result means that the unit needs refurbishment. Energy use indicator (17) monitors the energy use efficiency for electricity. Saving electricity will reduce the overall national energy cost for the country. Case receives poor performance because there are not any measures or methods to reduce electricity use. Cooling indicator (18) is valid during hot seasons. Materials, building envelope design, and ventilation are partially related with cooling indicator. There is not any specific natural cooling strategy for Case 16. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor performance for Case 15. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a poor performance for Case 16. Indoor air quality indicator (21) for Case16 is Below Average (2 points) performance. More than 50% of indoor materials including paints, sealants, adhesives, carpets and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used. The level and distribution of daylight factor is 45% for Case 16. Day lighting indicator (22) is average (3 points) performance. Sound pressure level is more than 70 decibels (dB). Noise indicator (23) performance for Case 16 is Good (4 points). Acoustic indicator (24). The reverberation time is poor for Case 16. Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 16, waste handling indicator (25)'s performance is Average (3 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is average for Case 16. The flat needs to reduce water consumption in the toilet flushing and shower use. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 50% of their travelling on private car. Transport indicator performance receives average score. Refurbishment indicator (28) checks the environmental improvements of an existing dwelling or whether future refurbishment plan is considered. For Case 16, refurbishment indicator is Below Average (2 points) because many parts of the residential unit need improvement.

Table 5.70. Form D score sheet for Case 16.

FORM D: SCORE SHEET		Case 16 Karşıyaka-3 (House)
Indicator	Category	Comment
1.Location	GOOD	Has all the advantages of the city
2. Ecology	GOOD	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	AVERAGE	More environmentally responsive glazing techniques
16. Materials Maintenance	AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	AVERAGE	Reduce energy consumption.
18. Cooling	BELOW AVERAGE	Imply natural cooling techniques
19. Heating	POOR	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	BELOW AVERAGE	Choose materials with low VOC emissions.
22. Daylighting	AVERAGE	Improve existing windows. Prevent glare with shutters.
23. Noise	GOOD	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	BELOW AVERAGE	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out 30)	1-2-23 (3 out of 30)	3-4-5-6-7-13-15-16-17-22-25-26-27 (13 out of 30)	18-20-21-28 (4 out of 30)	8-9-10-11-12-14-24-29-30 (7 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 16 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 16 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.70), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: Indicator 1(1 Indicator; 3%), Good: Indicator 1-2-23 (3 Indicators; 10%), Average: Indicator 3-4-5-6-7-13-15-16-17-22-25-26-27 (13 Indicators; 44%) Below Average: Indicator 18-20-21-28 (4 Indicators; 13%) Poor: Indicator 8-9-10-11-12-14-24-29-30 (9 Indicators; 30%).

5.2.17. Case Seventeen: Balçova-3 House

Case 17 is a house, located in Balçova District. The size of the house is 320 m^2 with five rooms, kitchen, living room, WC and bathroom. Hot water is provided from the central heating system. For space heating, central heating is used that uses geothermal as energy source.

Form A (Table 5.71) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.71. Form A: Data Collection Process for Case 17.

FORM A: DATA COLLECTION								**Case No. 17 BALÇOVA-3 (House)**			
1	**Building Name**	Case 17 House 7			**2**	**Client**					
3	**Address**	**Balcova (BAL)**									
4	**Architect**										
5	**Consultants**										
6	**Year of construction**	**2002**	**7**	**Year of completion**	**2004**	**8**	**Year of occupation**	**2005**			
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**		**House**	**X**	**Other**			
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**		**Other……....**	

Table 5.71. Form A: Data Collection Process for Case 17 (Cont.)

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East	12	Energy Type: Diesel	Electricity	Natural Gas	Coal	Geothermal
						X									X

13	Heating Type	Stove		Single Storey Heating	X	Central Heating		Other............	
14	Water heating	LPG		Single Storey Heating	X	Central Heating		Electricity	X
15	Size (m2)	0- 100		100- 150		150-250		250-more	320
16	Occupancy	1		2		2-4	X	4-more	

Table 5.72. Form B: ATHENA Software Comparison Chart for Case 1 and Case 17.

FORM B: ATHENA SOFTWARE RESULTS		CASE 17	BALÇOVA-3 (House)	
	Indicator	**Baseline (%)**	**Case 17(%)**	**Difference**
1	Energy Consumption	100	41,60	-58,4
2	Solid Waste Emission	100	55,98	-44,02
3	Air Pollution Index	100	39,60	-60,4
4	Water pollution Index	100	46,14	-53,86
5	Global Warming Potential	100	43,19	- 56,81
6	Weighted Resource Use	100	48,12	- 51,88

After completing Form A, Case 17 is evaluated with six ATHENA indicators Case 17 and Case 1 (baseline project) were compared in Form B (Table 5.72). Energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential, and weighted resource use indicators are better than Case 1.

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 17 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point).

First stage begins with site conditions and Case 17's location indicator (1) performance receives Good (4 points) described in Chapter 4. The ecology indicator is Good Category (4 points).

Table 5.73. Form C Performance Indicators for Case 17.

FORM C: PERFORMANCE INDICATORS		CASE No.17 BALÇOVA-3 (House)						
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				4
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora		X				4
		b. Fauna			X			3
		c. Water quality		X				4
		d. Soil contamination		X				4
		e. Electro Magnetic Fields (EMF)		X				4
		f. Wetlands or flood plain				X		2
		g. Wind conditions		X				4
		h. Sun conditions		X				4
		i. Temperature			X			3
		j. Noise Resources	X					5
		k. Air Quality Index		X				4
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking			X			3
		b. Green Area			X			3
		c. Medical Centre			X			3
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings		X				4
		g. Public Transport			X			3
		h. Retail		X				4
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation		X				4
		b. Wind Orientation			X			3
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate			X			3
		b. Adjacent Structure(s)		X				4
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.73. Form C Performance Indicators for Case 17. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors		X				4
		b. Windows			X			3
		c. Ceiling		X				4
		d. Floor		X				4
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound						1
		b.Heat						2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing			X			3
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance		X				4
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use			X			3
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System			X			3
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System		X				4
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents			X			3
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air				X		2
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight		X				4
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level			X			3
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling			X			3
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use			X			3
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport					X	1
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment			X			3
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					X	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 17 receives Average (3 points) score in overall existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. Building envelope indicator (5) evaluates the physical volume of the studied unit. Building envelope improves energy use, indoor air quality, ventilation and heating consumption. Building envelope is dependant on two sub-indicators; one local climate conditions, and the other is adjacent structures. Total score for building envelope indicator (5) is four out of ten points, meaning below average performance for Case 17.

Material selection has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 1, 67% of the materials are made in Turkey, that means Case 17 performance category for material selection is average.

Material LCA sub-indicator records the amount of LCA applied materials. For Case 17, LCA is applied to less than 25% of the materials during construction, so the final score for Case 17 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, below average (Table 5.73).

During the material transportation, fossil fuels are used to run the vehicles that carry materials from distances. Material transportation indicator (7) considers the method and distance of the transportation. For Case 17, 67% percent of materials are transported from local warehouses, means the performance score is average.

Material conservation indicator (8) considers the efficient use of construction materials. The material consultants must provide necessary management documents and manuals to minimise misuse of materials. This indicator is valid for new residential constructions, so Case 17 as an existing building has not have any material conservation plan. The performance score for Case 17 is Poor category.

During construction, there are many activities that consume fossil fuel and electricity energy. Energy efficiency is important because energy needs energy to carry the source. Minimised energy use means more savings for producing and carrying the source. Energy conservation indicator (9) influences the building site to use energy efficiently. For Case 17, during construction, it is assumed that there were not any methods to safe energy use. Performance score is Poor Category for Case 17.

Renewable energies are promoted as clean sources. However, the installation of solar panels initial costs can be expensive for the construction site. The construction process may take more than one year and can save considerable amount of fossil and hydro energy. After the completion of the construction, either the panels can be also used during operation stage of the residential unit or the building contractor can transport the solar panels to new construction site.

Renewable energy use indicator (10) for Case 17 is Poor performance because it is assumed that there was not any use of renewable energy source during construction.

Waste problem is increasing each day because of improper use of energy, material and water. Waste strategy must begin from construction stage and must continue during operation and demolition stages. In construction stage, the waste products are the packages, spare parts and left over of the materials after their application. All these waste must be collected separately and stored in containers. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 17 has not have any plan for waste strategy. During new constructions, this indicator will have important role to reduce waste during construction.

Water strategy indicator (12) helps the construction site to minimise water consumption. It is Poor (1 point) for Case 17.

A residential unit has five main components; door, window, ceiling, floor, and wall. Each component has different design potentials. For instance, the colour or the material type of the walls may vary depending on architects' visions. However, final product should be efficient and environmentally responsive. During their production and application processes, LCA Evaluation must be conducted to achieve sustainable environment. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels.

Insulation is the blanket of the residential unit. Correct application of insulation, can minimise heating and cooling loads. Sound insulation reduces outside noise sources and creates comfortable living environment inside the unit for the occupants. Insulation indicator (14) assesses the standard of insulation in five categories. Case 17 has scored poor in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average Category.

Materials Maintenance indicator (16) follows the maintenance progress for the residential unit. Case 17 is in poor condition compare to other units. The Poor performance result means that the unit needs refurbishment. Energy use indicator (17) monitors the energy use efficiency for electricity. Saving electricity will reduce the overall national energy cost for the country. Case receives poor performance because there are not any measures or methods to reduce electricity use. Cooling indicator (18) is valid during hot seasons. Materials, building envelope design, and ventilation are partially related with cooling indicator. There is not any specific natural cooling strategy for Case 17. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor performance for Case 17. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a poor performance for Case 17. Indoor air quality indicator (21) for Case17 is Below Average (2 points) performance. More than 50% of indoor materials including paints, sealants, adhesives, carpets and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used. The level and distribution of daylight factor is 91% for Case 17. Day lighting indicator (22) is Good (4 points) performance. Sound pressure level is more than 70 decibels (dB). Noise indicator (23) performance for Case 17 is below average. Acoustic indicator (24). The reverberation time is poor for Case 17. Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 17, waste handling indicator (25)'s performance is Average (3 points) because they only separate the paper products. Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is Average (3 points) for Case 17. The flat needs to reduce water consumption in the toilet flushing and shower use. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 92% of their travelling on private car. Transport indicator performance receives Poor(1 point) score. Refurbishment indicator (28) checks the environmental improvements of an existing dwelling or whether future refurbishment plan is considered. For Case 17, refurbishment indicator is Average (3 points) because only some parts of the residential unit were improved.

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 17 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 1 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Table 5.74. Form D score sheet for Case 17.

FORM D: SCORE SHEET		Case 17 Balçova-3 (House)
Indicator	Category	Comment
1.Location	GOOD	Has all the advantages of the city
2. Ecology	GOOD	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	GOOD	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	GOOD	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	GOOD	More environmentally responsive glazing techniques
16. Materials Maintenance	GOOD	Improve the maintenance program of the unit.
17. Energy Use	GOOD	Reduce energy consumption.
18. Cooling	GOOD	Imply natural cooling techniques
19. Heating	GOOD	Improve energy source
20. Ventilation	AVERAGE	Increase number of vents
21. Indoor Air Quality	BELOW AVERAGE	Choose materials with low VOC emissions.
22. Daylighting	GOOD	Improve existing windows. Prevent glare with shutters.
23. Noise	AVERAGE	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	POOR	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	AVERAGE	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1-2-4-5-15-16-17-18-19-22 (10 out of 30)	3-7-13-23-25-26-28 (7 out of 30)	6-21 (2 out of 30)	8-9-10-11-12-14-24-27-29-30 (11 out of 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 17 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 17 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.66), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: no case, Good: Case 1-2-4-5-15-16-17-18-19-22 (10 cases; 34%), Average: Case 3-7-13-23-25-26-28 (7 cases; 23%) Below Average: Case 6-21 (2 cases; 7%) Poor: Case 8-9-10-11-12-14-24-27-29-30 (10 cases; 33%).

5.2.18. Case Eight-teen: Balçova-4 House

Case 18 is a house, located in Balçova District. The size of the house is 230 m^2 with three rooms, kitchen, living room, WC and bathroom. Hot water is provided from the central heating system. For space heating, central heating is used that uses geothermal as energy source.

Form A (Table 5.75) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.75. Form A: Data Collection Process for Case 18.

FORM A: DATA COLLECTION													**Case No. 18 BALÇOVA-4 (House)**
1	**Building Name**	Case 18 House 8				**2**	**Client**						
3	**Address**												
4	**Architect**												
5	**Consultants**												
6	**Year of construction**			**7**	**Year of completion**			**8**	**Year of occupation**				
9	**Residential Type**	**Flat 2+1**			**Flat 3+1**			**House**	X	**Other**			
10	**Construction Type**	**R.C.**	X	**Masonry**		**Steel**		**Timber**		**Other……....**			

Table 5.75. Form A: Data Collection Process for Case 18. (Cont.)

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East	12	Energy Type: Diesel	Electricity	Natural Gas	Coal	Geothermal
											X				
13	Heating Type	Stove			Single Storey Heating			X	Central Heating			Other……… …			
14	Water heating	LPG			Single Storey Heating			X	Central Heating			Electricity			X
15	Size (m2)	0- 100			100- 150				150-250		230	250-more			
16	Occupancy	1			2				2-4			4-more			

After completing Form A, Case 18 is evaluated with six ATHENA indicators Case 17 and Case 1 (baseline project) were compared in Form B (Table 5.76). Energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential, and weighted resource use indicators are better than Case 1.

Table 5.76. Form B: ATHENA Software Comparison Chart for Case 1 and Case 18.

FORM B: ATHENA SOFTWARE RESULTS		CASE 18	BALÇOVA-4 (House)	
	Indicator	**Baseline (%)**	**Case 18(%)**	**Difference**
1	Energy Consumption	100	64,04	-35,96
2	Solid Waste Emission	100	80,16	-19,84
3	Air Pollution Index	100	61,22	-38,78
4	Water pollution Index	100	74,08	-25,92
5	Global Warming Potential	100	67,69	-32,31
6	Weighted Resource Use	100	79,60	-20,4

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 18 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point).

First stage begins with site conditions and Case 18's location indicator (1) performance receives Good (4 points) described in Chapter 4. The ecology indicator is Average Category (3 points).

Table 5.27. Form C Performance Indicators for Case 18.

FORM C: PERFORMANCE INDICATORS		CASE No.18 BALÇOVA-4 (House)						
Indicator			Excellent (5)	Good (4)	Average (3)	Below (2)	Poor (1)	
	A. SITE SELECTION							
1	**Location**							4
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora		X				4
		b. Fauna			X			3
		c. Water quality			X			3
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)			X			3
		f. Wetlands or flood plain		X				4
		g. Wind conditions		X				4
		h. Sun conditions		X				4
		i. Temperature			X			3
		j. Noise Resources	X					5
		k. Air Quality Index		X				4
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking			X			3
		b. Green Area		X				4
		c. Medical Centre			X			3
		d. School		X				4
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail		X				4
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation			X			3
		b. Wind Orientation			X			3
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate				X		2
		b. Adjacent Structure(s)				X		2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.77. Form C Performance Indicators for Case 18. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors			X			3
		b. Windows			X			3
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					X	1
		b.Heat				X		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing					X	1
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance			X			3
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use			X			3
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System		X				4
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air				X		2
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight			X			3
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level		X				4
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling			X			3
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use			X			3
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport			X			3
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment			X			3
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					X	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 18 scores Average (3 points) in overall existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. Building envelope indicator (5) evaluates the physical volume of the studied unit. Building envelope improves energy use, indoor air quality, ventilation and heating consumption. Building envelope is dependant on two sub-indicators; one local climate conditions, and the other is adjacent structures. Total score for building envelope indicator (5) is four out of ten points, meaning below average performance for Case 18.

Material selection has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 18, 53% of the materials are made in Turkey, that means Case 18 performance category for material selection is Average.

Material LCA sub-indicator records the amount of LCA applied materials. For Case 18, LCA is applied to less than 25% of the materials during construction, so the final score for Case 18 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, below average (Table 5.77).

During the material transportation, fossil fuels are used to run the vehicles that carry materials from distances. Material transportation indicator (7) considers the method and distance of the transportation. For Case 18, 72% percent of materials are transported from local warehouses, means the performance score is Average (3 points).

Material conservation indicator (8) considers the efficient use of construction materials. The material consultants must provide necessary management documents and manuals to minimise misuse of materials. This indicator is valid for new residential constructions, so Case 18 as an existing building has not have any material conservation plan. The performance score for Case 18 is Poor category.

During construction, there are many activities that consume fossil fuel and electricity energy. Energy efficiency is important because energy needs energy to carry the source. Minimised energy use means more savings for producing and carrying the source. Energy conservation indicator (9) influences the building site to use energy efficiently. For Case 18, during construction, it is assumed that there were not any methods to safe energy use. Performance score is Poor Category for Case 18.

Renewable energies are promoted as clean sources. However, the installation of solar panels initial costs can be expensive for the construction site. The construction process may take more than one year and can save considerable amount of fossil and hydro energy. After the completion of the construction, either the panels can be also used during operation stage of the residential unit or the building contractor can transport the solar panels to new construction site.

Renewable energy use indicator (10) for Case 18 is Poor performance because it is assumed that there was not any use of renewable energy source during construction.

Waste problem is increasing each day because of improper use of energy, material and water. Waste strategy must begin from construction stage and must continue during operation and demolition stages. In construction stage, the waste products are the packages, spare parts and left over of the materials after their application. All these waste must be collected separately and stored in containers. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 18 has not have any plan for waste strategy. During new constructions, this indicator will have important role to reduce waste during construction.

Water is a scarce source on earth, so any construction site should use water efficiently, otherwise it is stated in many literature that water will not be available for future generations. Water strategy indicator (12) helps the construction site to minimise water consumption.

A residential unit has five main components; door, window, ceiling, floor, and wall. Each component has different design potentials. For instance, the colour or the material type of the walls may vary depending on architects' visions. However, final product should be efficient and environmentally responsive. During their production and application processes, LCA Evaluation must be conducted to achieve sustainable environment. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels.

Insulation is the blanket of the residential unit. Correct application of insulation, can minimise heating and cooling loads. Sound insulation reduces outside noise sources and creates comfortable living environment inside the unit for the occupants. Insulation indicator (14) assesses the standard of insulation in five categories. Case 2 has scored poor in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average Category.

Materials Maintenance indicator (16) follows the maintenance progress for the residential unit. Case 18 is in poor condition compare to other units. The Poor performance result means that the unit needs refurbishment. Energy use indicator (17) monitors the energy use efficiency for electricity. Saving electricity will reduce the overall national energy cost for the country. Case receives poor performance because there are not any measures or methods to reduce electricity use. Cooling indicator (18) is valid during hot seasons. Materials, building envelope design, and ventilation are partially related with cooling indicator. There is not any specific natural cooling strategy for Case 18. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor performance for Case 18. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a poor performance for Case 18. Indoor air quality indicator (21) for Case18 is Below Average (2 points) performance. More than 50% of indoor materials including paints, sealants, adhesives, carpets and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins are used. The level and distribution of daylight factor is 52% for Case 18. Day lighting indicator (22) is Average (3 points) performance. Sound pressure level is more than 70 decibels (dB). Noise indicator (23) performance for Case 18 is Excellent. Acoustic indicator (24),the reverberation time is poor (1 point) for Case 18. Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 18, waste handling indicator (25)'s performance is Average (3 points) because they only separate the paper products. Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is Average (3 points) for Case 18. The flat needs to reduce water consumption in the toilet flushing and shower use. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 59% of their travelling on private car. Transport indicator performance receives average score. Refurbishment indicator (28) checks the environmental improvements of an existing dwelling or whether future refurbishment plan is considered. For Case 18, refurbishment indicator is average because only some parts of the residential unit were improved.

Table 5.78. Form D score sheet for Case 18.

FORM D: SCORE SHEET		Case 18 Balçova-4 (House)
Indicator	Category	Comment
1.Location	GOOD	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	BELOW AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	POOR	More environmentally responsive glazing techniques
16. Materials Maintenance	AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	AVERAGE	Reduce energy consumption.
18. Cooling	BELOW AVERAGE	Imply natural cooling techniques
19. Heating	POOR	Improve energy source
20. Ventilation	POOR	Increase number of vents
21. Indoor Air Quality	POOR	Choose materials with low VOC emissions.
22. Daylighting	BELOW AVERAGE	Improve existing windows. Prevent glare with shutters.
23. Noise	GOOD	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	AVERAGE	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
-(0 out of 30)	1-23 (2 out of 30)	2-3-4-7-13-16-17-25-26-27-28(11 out of 30)	5-6-13-18-22 (5 out of 30)	8-9-10-11-12-14-15-19-20-21-24-29-30 (13 out 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 18 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 18 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.78), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: no Indicator, Good: Indicator 1-23 (2 Indicators; 7%), Average: Indicator 2-3-4-7-13-16-17-25-26-27 (10 Indicators; 33%) Below Average: Indicator 5-6-13-18-22 (5 Indicators; 17%) Poor: Indicator 8-9-10-11-12-14-15-19-20-21-24-29-30 (13 Indicators; 43%).

5.2.19. Case Nineteen: Balçova-5 House

Case 19 is a house, located in Balçova District. The size of the house is 280 m^2 with five rooms, kitchen, living room, WC and bathroom. Hot water is provided from the single storey heating system. For space heating, single storey heating is used that uses geothermal as energy source.

Form A (Table 5.79) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.79. Form A: Data Collection Process for Case 19

FORM A: DATA COLLECTION								**Case No. 19 BALÇOVA-5 (House)**			
1	**Building Name**	Case 19 House 9				**2**	**Client**				
3	**Address**										
4	**Architect**										
5	**Consultants**										
6	**Year of construction**	**1995**	**7**	**Year of completion**	**1997**	**8**	**Year of occupation**	**1998**			
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**		**House**	**X**	**Other**			
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**		**Other..........**	

Table 5.79. Form A: Data Collection Process for Case 19 (Cont.)

11	Orientation	North	Nort-east	North-west	South	South-east	South-west	West	East	12	Energy Type: Diesel	Electricity	Natural Gas	Coal	Geothermal
					X										X

13	Heating Type	Stove		Single Storey Heating	X	Central Heating		Other…………	
14	Water heating	LPG		Single Storey Heating	X	Central Heating		Electricity	X
15	Size (m2)	0- 100		100- 150		150-250		250-more	280
16	Occupancy	1		2		2-4		4-more	X

After completing Form A, Case 19 is evaluated with six ATHENA indicators Case 19 and Case 1 (baseline project) were compared in Form B (Table 5.80). Energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential, and weighted resource use indicators are better than Case 1.

Table 5.80. Form B: ATHENA Software Comparison Chart for Case 1 and Case 19.

FORM B: ATHENA SOFTWARE RESULTS		CASE 19	BALÇOVA-5 (House)	
	Indicator	**Baseline (%)**	**Case 19(%)**	**Difference**
1	Energy Consumption	100	53,80	-46,20
2	Solid Waste Emission	100	71,15	-28.85
3	Air Pollution Index	100	51,28	-48,72
4	Water pollution Index	100	60,30	-39,7
5	Global Warming Potential	100	56,13	-43,87
6	Weighted Resource Use	100	63,59	-36,41

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 19 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point).

First stage begins with site conditions and Case 19's location indicator (1) performance receives Good (4 points) described in Chapter 4. The ecology indicator is Average Category (3 points).

Table 5.81. Form C. Performance Indicators for Case 19.

FORM C: PERFORMANCE INDICATORS		CASE No.19 BALÇOVA-5 (House)						
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				4
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora			X			3
		b. Fauna				X		2
		c. Water quality		X				4
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)			X			3
		f. Wetlands or flood plain		X				4
		g. Wind conditions		X				4
		h. Sun conditions		X				4
		i. Temperature		X				4
		j. Noise Resources	X					5
		k. Air Quality Index		X				4
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking		X				4
		b. Green Area			X			3
		c. Medical Centre			X			3
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings			X			3
		g. Public Transport		X				4
		h. Retail		X				4
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation			X			3
		b. Wind Orientation			X			3
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate			X			3
		b. Adjacent Structure(s)				X		2
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.81. Form C. Performance Indicators for Case 19. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors			X			3
		b. Windows			X			3
		c. Ceiling				X		2
		d. Floor				X		2
		e. Walls			X			3
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Sound					**X**	1
		b.Heat				**X**		2
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Glazing			X			3
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Materials maintenance			X			3
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use		X				4
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Cooling System			X			3
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Heating System			X			3
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Control of vents			X			3
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air				X		2
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight			X			3
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level	X					5
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling			X			3
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use			X			3
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport			X			3
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment			X			3
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 19 scores Average (3 points) score in overall for existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Total score for building envelope indicator (5) is Average (3 points) performance for Case 19. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 19, 43% of the materials are made in Turkey that means Case 19 performance category for material selection is Below Average (2 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 19, LCA is applied to less than 25% of the materials during construction, so the final score for Case 19 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Below Average (2 points). For Case 18, 52% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7). Material conservation indicator (8) for Case 19 as an existing building has not have any material conservation plan. The performance score for Case 19 is Poor category. Energy conservation indicator (9) for Case 6, is assumed that there were not any methods to safe energy use. Performance score is Poor Category. Renewable energy use indicator (10) for Case 19 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 19 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12) is assumed that Case 19 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 19 is average score (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 19 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Materials Maintenance indicator (16) for Case 19 is in Excellent (5 point) score. Energy use indicator (17) is Good (4 points) for 76% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Average (3 points). There is not any specific natural cooling strategy for Case 19. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 19. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a below average (2 points) performance for Case 19. Indoor air quality indicator (21) for Case 19 is Below Average (2 points) performance. More than 50% of indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used. The level and distribution of daylight factor is 42% for Case 19. Day lighting indicator (22) is Below Average (3 points) performance. Sound pressure level is more than 30 decibels (dB). Noise indicator (23) performance for Case 19 is Excellent (5 points). Acoustic indicator (24) for Case 19 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 19, waste handling indicator (25)'s performance is Average (3 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is Average for Case 19. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 62% of their travelling on private car. Transport indicator performance receives Average (3 points) score. Refurbishment indicator (28) for Case 19 is Average (3 points).

Table 5.82. Form D score sheet for Case 19.

FORM D: SCORE SHEET		Case 19 Balçova-5 (House)
Indicator	Category	Comment
1.Location	GOOD	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	BELOW AVERAGE	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	AVERAGE	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	POOR	More environmentally responsive glazing techniques
16. Materials Maintenance	AVERAGE	Improve the maintenance program of the unit.
17. Energy Use	AVERAGE	Reduce energy consumption.
18. Cooling	BELOW AVERAGE	Imply natural cooling techniques
19. Heating	GOOD	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	BELOW AVERAGE	Choose materials with low VOC emissions.
22. Daylighting	AVERAGE	Improve existing windows. Prevent glare with shutters.
23. Noise	GOOD	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	AVERAGE	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	AVERAGE	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1-19-23 (3 out of 30)	2-3-4-7-13-16-17-22-25-26-27-28 (12 out of 30)	5-6-18-20-21 (5 out of 30)	8-9-10-11-12-14-15-24-29-30 (10 out 30)

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 19 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 19 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.82), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: no Indicator, Good: Indicator 1-19-23 (3 Indicators; 10%), Average: Indicator 2-3-4-7-13-16-17-22-25-26-27-28 (12 Indicators; 40%) Below Average: Indicator 5-6-18-20-21 (5 Indicators; 17%) Poor: Indicator 8-9-10-11-12-14-15-24-29-30 (10 Indicators; 33%).

5.2.20. Case Twenty: Bornova-3 House

Case 20 is a house, located in Bornova District. The size of the house is 206 m^2 with four rooms, kitchen, living room, WC and bathroom. Hot water is provided from the single heating system. For space heating, central heating is used that uses fuel-oil as energy source.

Form A (Table 5.83) gives accurate information about the residential unit's local conditions like orientation, construction history and materials, energy use and unit size of the residential unit.

Table 5.83. Form A: Data Collection Process for Case 20.

FORM A: DATA COLLECTION											**Case No. 20 BORNOVA-3 (House)**	
1	**Building Name**	Case 20 House 10				**2**	**Client**					
3	**Address**	**Bornova (BOR)**										
4	**Architect**											
5	**Consultants**											
6	**Year of construction**	**1998**	**7**	**Year of completion**			**8**	**Year of occupation**				
9	**Residential Type**	**Flat 2+1**		**Flat 3+1**		**House**	**X**	**Other**				
10	**Construction Type**	**R.C.**	**X**	**Masonry**		**Steel**		**Timber**		**Other……....**		

Table 5.83. Form A: Data Collection Process for Case 20. (cont.)

11	**Orientation**	**North**	**Nort-east**	**North-west**	**South**	**South-east**	**South-west**	**West**	**East**	**12**	**Energy Type** **Diesel**	**Electricity**	**Natural Gas**	**Coal**	**Geothermal**
											X				
13	**Heating Type**	**Stove**			**Single Storey Heating**			X	**Central Heating**			**Other…………**			
14	**Water heating**	**LPG**			**Single Storey Heating**			X	**Central Heating**			**Electricity**			X
15	**Size (m2)**	**0- 100**			**100- 150**				**150-250**		**206**	**250-more**			
16	**Occupancy**	**1**			**2**				**2-4**			**4-more**			

After completing Form A, Case 20 is evaluated with six ATHENA indicators Case 20 and Case 1 (baseline project) were compared in Form B (Table 5.84). Energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential, and weighted resource use indicators are better than Case 1.

Table 5.84. Form B: ATHENA Software Comparison Chart for Case 1 and Case 20.

FORM B: ATHENA SOFTWARE RESULTS		CASE 20		BORNOVA-3 (House)
	Indicator	**Baseline (%)**	**Case 20(%)**	**Difference**
1	Energy Consumption	100	57,78	-42,22
2	Solid Waste Emission	100	63,73	-36,27
3	Air Pollution Index	100	55,68	-44,32
4	Water pollution Index	100	70,99	-29,01
5	Global Warming Potential	100	62,73	-37,27
6	Weighted Resource Use	100	76,97	-23.03

Form C is the third form of the HRM-Izmir Model. Selected indicators will rate Case 20 under five performance category; excellent (5point), good (4 point), average (3 point), below average (2 point) and poor (1 point).

First stage begins with site conditions and Case 20’s location indicator (1) performance receives Excellent (5points) described in Chapter 4. The ecology indicator is Average Category (3 points).

Table 5.85. Form C. Performance Indicators for Case 20.

FORM C: PERFORMANCE INDICATORS		CASE No. 20 BORNOVA-3 (House)						
Indicator			**Excellent (5)**	**Good (4)**	**Average (3)**	**Below (2)**	**Poor (1)**	
	A. SITE SELECTION							
1	**Location**			X				4
2	**Ecology**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Flora			X			3
		b. Fauna				X		2
		c. Water quality			X			3
		d. Soil contamination			X			3
		e. Electro Magnetic Fields (EMF)		X				4
		f. Wetlands or flood plain		X				4
		g. Wind conditions			X			3
		h. Sun conditions			X			3
		i. Temperature			X			3
		j. Noise Resources	X					5
		k. Air Quality Index		X				4
3	**Existing B/Environment**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Car parking		X				4
		b. Green Area			X			3
		c. Medical Centre			X			3
		d. School			X			3
		e. Place of Worship			X			3
		f. Surrounding buildings				X		2
		g. Public Transport			X			3
		h. Retail				X		2
4	**Orientation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sun Orientation			X			3
		b. Wind Orientation			X			3
	B. CONSTRUCTION							
5	**Building envelope**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Climate			X			3
		b. Adjacent Structure(s)		X				4
6	**Material selection**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Country location			X			3
		b. Material LCA					X	1
7	**Material transportation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Transport			X			3
8	**Material Conservation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sheet materials					X	1
		b. Powdered materials					X	1
		c. Liquid materials					X	1
9	**Energy Conservation**	**Sub-indicator**	**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity					X	1
		b. Heating					X	1
		c. Machinery use					X	1
10	**Renewable Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Solar use					X	1
		b. Wind power					X	1

Table 5.85. Form C. Performance Indicators for Case 20. (cont.)

11	Waste Strategy		(5)	(4)	(3)	(2)	(1)	
		a. Sheet materials					X	1
		b. Powdered Materials					X	1
		c. Liquid Materials					X	1
		d. Packages					X	1
		e. Spare Parts					X	1
12	**Water strategy**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Water use					X	1
13	**Unit components**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Doors		X				4
		b. Windows		X				4
		c. Ceiling		X				4
		d. Floor		X				4
		e. Walls		X				4
14	**Insulation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound					X	1
		b. Heat			X			3
15	**Glazing**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Glazing		X				4
	C. OPERATION							
16	**Materials Maintenance**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Materials maintenance		X				4
17	**Energy Use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Electricity use		X				4
18	**Cooling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Cooling System				X		2
19	**Heating**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Heating System				X		2
20	**Ventilation**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Control of vents				X		2
21	**Indoor Air Quality**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Indoor Air				X		2
22	**Daylighting**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		b.Level of Daylight		X				4
23	**Noise**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Sound pressure level	X					5
24	**Acoustic**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Reverberation time					X	1
25	**Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Waste handling		X				4
26	**Water use**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Water use			X			3
27	**Transport**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a. Occupant(s) 'Transport			X			3
28	**Refurbishment**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Refurbishment		X				4
	D. DEMOLITION							
29	**Reuse and Recycle plan**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Reuse Plan					X	1
		b.Recycle Plan					**X**	1
30	**Solid Waste handling**		**(5)**	**(4)**	**(3)**	**(2)**	**(1)**	
		a.Solid Waste Handling					X	1
(5) Excellent, (4) Good, (3) Average, (2) Below Average, (1) Poor								

Existing built environment indicator (3) evaluates the activities around the site before construction. Case 20 scores Average (3 points) score in overall for existing built environment indicator.

At construction stage, there are seven performance indicators to evaluate the conditions till completion date. The conditions are defined in Chapter 4. Total score for building envelope indicator (5) is Average (4 points) performance for Case 20. Material selection indicator (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. For Case 20, 43% of the materials are made in Turkey that means Case 20 performance category for material selection is Below Average (2 points). Material LCA sub-indicator records the amount of LCA applied materials. For Case 20, LCA is applied to less than 25% of the materials during construction, so the final score for Case 6 is poor. The sum of two sub-indicators is material selection indicator (6)'s category, Below Average (2 points). For Case 20, 52% percent of materials are transported from local warehouses, means the performance score is average for material transportation indicator (7). Material conservation indicator (8) for Case 20 as an existing building has not have any material conservation plan. The performance score for Case 20 is Poor category. Energy conservation indicator (9) for Case 20, is assumed that there were not any methods to safe energy use. Performance score is Poor Category. Renewable energy use indicator (10) for Case 20 is Poor performance because it is assumed that there was not any use of renewable energy source during construction. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that Case 20 has not have any plan for waste strategy during construction, Poor (1 point) Category. For water strategy indicator (12) is assumed that Case 20 has not have any plan for water strategy, Poor (1 point) Category. Unit components indicator (13) checks the components environmental responsive issues, and divides the result in five category levels defined in Chapter 4. Door component average (3 points), window average (3 points), ceiling below average, floor below average, walls average. Total performance category for Case 6 is average score (3 points). Insulation indicator (14) assesses the standard of insulation in five categories. Case 20 has scored Below Average (2 points) in sound insulation and below average in heating insulation. Overall, insulation indicator (14) is in Below Average (2 points) Category. Materials Maintenance indicator (16) for Case 20 is in Excellent (5 point) score. Energy use indicator (17) is Good (4 points) for 76% of energy efficiency. Cooling indicator (18) is valid during hot seasons, but good insulation provides Average (3 points). There is not any specific natural cooling strategy for Case 20. Heating indicator (19) checks the efficiency of the heating system in the residential unit. It is poor (1 point) performance for Case 20. Ventilation indicator (20) measures the ventilation provided by vents and louvers. There is a basic ventilation method; opening windows to circulate air, gives a below average (2 points) performance for Case 20. Indoor air quality indicator (21) for Case 20 is Below Average (2 points) performance. More than 50% of indoor materials, including paints, sealants, adhesives, carpets, and composite wood products, have been selected for low rates of VOC emissions and composite wood products that contain urea-formaldehyde resins have not been used. The level and distribution of daylight factor is 85% for Case 20. Day lighting indicator (22) is Good (4 points) performance. Sound pressure level is less than 30 decibels (dB). Noise indicator (23) performance for Case 20 is Excellent (5 points). Acoustic indicator (24) for Case 20 is Poor (1 point). Waste handling indicator (25) assesses the level of waste collection process in the residential units. For Case 20, waste handling indicator (25)'s performance is Good (4 points). Water use indicator (26) aim is to reduce water consumption in the residential unit. The performance for water use is Average for Case 20. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. The occupants spent 69% of their travelling on private car. Transport indicator performance receives average score. Refurbishment indicator (28) for Case 20 is Good (4 points).

Table 5.86. Form D score sheet for Case 20.

FORM D: SCORE SHEET		Case 20 Bornova-3 (House)
Indicator	Category	Comment
1.Location	EXCELLENT	Has all the advantages of the city
2. Ecology	AVERAGE	Existing flora and fauna conditions need improvements.
3. Existing B/Environment	AVERAGE	Reduce concrete use and increase green landscaping. Influence secure car parking areas.
4. Orientation	AVERAGE	Existing residential unit is difficult to improve. However, building envelope can increase the performance. This indicator is important for new developments.
5.Building envelope	GOOD	Unit should improve the building envelope considering local climate conditions.
6.Material selection	BELOW AVERAGE	For new developments, increase the use of environmentally responsive materials.
7.Material transportation	AVERAGE	To reduce the damage of transport, increase the use of local materials.
8.Material Conservation	POOR	Introduce material saving methods.
9.Energy Conservation	POOR	Energy conscious methods should be reduced.
10. Renewable Energy Use	POOR	Increase renewable energy use
11.Waste Strategy	POOR	Introduce waste separation methods
12. Water strategy	POOR	Water is valuable source and need to introduce methods to decrease its consumption
13. Unit components	GOOD	Use environmentally responsive components.
14. Insulation	POOR	Less than 25% insulation material. For better building performance increase the insulation.
15. Glazing	GOOD	More environmentally responsive glazing techniques
16. Materials Maintenance	GOOD	Improve the maintenance program of the unit.
17. Energy Use	GOOD	Reduce energy consumption.
18. Cooling	BELOW AVERAGE	Imply natural cooling techniques
19. Heating	BELOW AVERAGE	Improve energy source
20. Ventilation	BELOW AVERAGE	Increase number of vents
21. Indoor Air Quality	BELOW AVERAGE	Choose materials with low VOC emissions.
22. Daylighting	GOOD	Improve existing windows. Prevent glare with shutters.
23. Noise	EXCELLENT	Use sound insulation to reduce the outside noise impact
24. Acoustic	POOR	Improve sound transmission inside the space with special panels and components.
25. Waste handling	GOOD	Improve the waste handling strategy. Introduce efficient methods to tackle with waste.
26. Water use	AVERAGE	Apply water saving methods. Improve systems for toilets, showers and washing machine, main water consumers at home.
27. Transport	AVERAGE	Increase public transport use. Plan each journey, and decrease fossil fuel uses.
28. Refurbishment	GOOD	Improve the current conditions for better space use
29. Reuse and Recycle plan	POOR	There was no previous plan, so it is accepted Poor
30. Solid Waste handling	POOR	There was no previous plan, so it is accepted Poor.

EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1-23	5-13-15-16-17-22-25-28	6-7-26-27	5-6-18-19-20-21	8-9-10-11-12-14-24-29-30

Reuse and Recycle plan (29) should be done during the design period. The architect should prepare a manual for the demolition process. For instance, the architect should prepare a list of materials that can be re-used like ceramics, glass, lighting fixtures, and steel. Case 20 does not have a reuse and recycle plan, receives poor (1 point) score. Solid Waste Handling plan (30) suggests methods to reduce and dispose solid waste after demolition. Case 15 does not have a plan, so it deserves Poor (1 point) for solid waste handling plan.

Form D (Table 5.86), provides comments to improve the residential unit's current conditions. Same form gives the comparison chart of five categories (Excellent, good, Average, Below Average and poor). Excellent: Indicator 1-23(2 Indicator; 7%), Good: Indicator 5-13-15-16-17-22-25-28 (8 Indicators; 28%), Average: Indicator 6-7-26-27 (4 Indicators; 14%) Below Average: Indicator 5-6-18-19-20-21 (6 Indicators; 21%) Poor: Indicator 8-9-10-11-12-14-24-29-30 (9 Indicators; 30%).

5.3. Final Rating Scores

After applying HRM-Izmir model to each twenty cases, there are final results to be evaluated according to five point category system. There are two sets of results, one ATHENA Software Results on six indicators and other thirty performance indicators

ATHENA Software is an existing software developed by ATHENA Sustainable Materials Institute. It was previously tested in other projects, and accepted as a performance comparison tool as defined in Chapter 3. However, thirty performance indicators is newly developed method to support HRM-Izmir model. These indicators are chosen from many possible indicators, but limited to thirty for possible comparisons over Izmir's built environment.

By introducing a case study, this thesis creates a testing ground for HRM-Izmir Model. The out coming results will guide the further studies in the field.

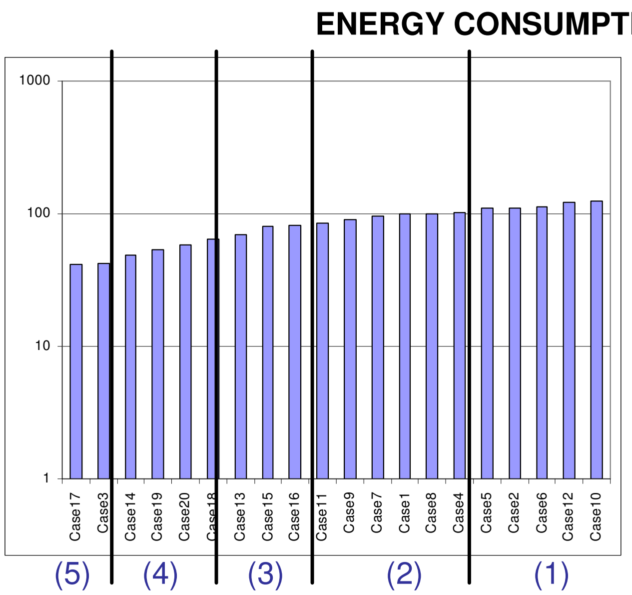
5.3.1 ATHENA Performance Indicators Final Results

ATHENA Software has six performance indicator; energy consumption, solid waste emission, air pollution index, water pollution index, global warming potential and weighted resource use, introduced in Chapter 4. The values of the twenty cases entered to ATHENA software and generated final performance results for each case. Then , a comparison chart is prepared for final rating score. The method for the five point system is explained in Chapter 4, p.89.

Table 5.87. Energy consumption indicator performance values for twenty cases.

Energy				
Case17	41,6		Excellent(5)	5
Case3	42,15			5
Case14	48,83			4
Case19	53,8			4
Case20	57,78			4
Case18	64,04	62.64	Good(4)	4
Case13	69,74			3
Case15	79,9			3
Case16	81,28	83.52	Average (3)	3
Case11	85,07			2
Case9	90,87			2
Case7	96,21			2
Case1	100			2
Case8	100,19			2
Case4	101,32	104.48	Below average (2)	2
Case5	109,48			1
Case2	109,55			1
Case6	111,89			1
Case12	123,06			1
Case10	125,44		Poor (1)	1

In Table 5.87, the comparison chart for energy consumption indicator is given. Case 10 has the highest value, and Case 17 has the minimum value. Case 17'th energy conservation is Excellent compare to other cases. Average value for energy consumption is 83.52%, and Case 16, 15,11's performances are at this category.



EXCELLENT (5)	CASE 17-3
GOOD (4)	CASE 14 19-20-18
AVERAGE (3)	CASE 13-15-16
BELOW AVERAGE (2)	CASE 11-9-7-1-8-4
POOR (1)	CASE 5-2-6-12-10

,

Figure 5.297. Energy consumption indicator final score.

Two cases, Case 17, and 3, both uses the geothermal energy, have received Excellent (5 points) score (Figure 5.16). Other two cases that use the geothermal energy, Case 19 and 20, have performed Good (4 points). However, Case 7 has scored below average because the insulation standard is low, so energy consumption is higher.

Table 5.88. Energy consumption indicator five point system results.

Category	Location	Type	Energy Source	Size (m^2)	Year of completion
EXCELLENT (5)	CASE 17: BALÇOVA CASE 3: BALÇOVA	HOUSE FLAT	GEOTHERMAL GEOTHERMAL	320 72	2004 2004
GOOD (4)	CASE 14: MAVİŞEHİR CASE 19:BALÇOVA CASE 20: BORNOVA CASE 18: BALÇOVA	HOUSE HOUSE HOUSE HOUSE	FUEL-OIL GEOTHERMAL FUEL-OIL GEOTHERMAL	285 280 206 230	1999 1997 1999 2002
AVERAGE (3)	CASE 13: CESME CASE 15 KARŞIYAKA CASE 16: KARŞIYAKA	HOUSE HOUSE HOUSE	FUEL-OIL FUEL-OIL FUEL-OIL	224 175 200	2003 1989 2004
BELOW AVERAGE (2)	CASE 11: NARLIDERE CASE 9: BORNOVA CASE 7: BALÇOVA CASE 1: ALSANCAK CASE 8: BORNOVA CASE 7: BALÇOVA CASE 4: MAVİŞEHİR	HOUSE FLAT FLAT FLAT FLAT FLAT FLAT	FUEL-OIL FUEL-OIL GEOTHERMAL FUEL-OIL ELECTRICITY GEOTHERMAL FUEL-OIL	189 240 120 145 118 120 170	1999 2006 2005 1989 2002 2005 2000
POOR (1)	CASE 5: ÜÇKUYULAR CASE 2: ALSANCAK CASE 6: ÜÇKUYULAR CASE 12: SEFERİHİSAR CASE 10: KARŞIYAKA	FLAT FLAT FLAT HOUSE FLAT	COAL COAL FUEL-OIL FUEL-OIL COAL	76 152 100 210 100	2005 1985 2005 1998 1985

The results of energy consumption indicator show that energy consumption is not only dependant on the type of the energy source, material use, glazing type, and insulation standards may affect as well (Table 5.88). However, the energy source is an advantage.

In overall twenty cases, 10 % of cases have scored Excellent (5 points), 20% Good (4 points), 15 % Average (3 points), 30% Below Average (2 points), and finally 25% Poor (1 point) (Figure 5.17).

At this stage, it is local authorities decision to accept a certain standard, like Average score for the energy consumption in Izmir. Then, 45% of the residential unit out of twenty cases, may pass the standard.

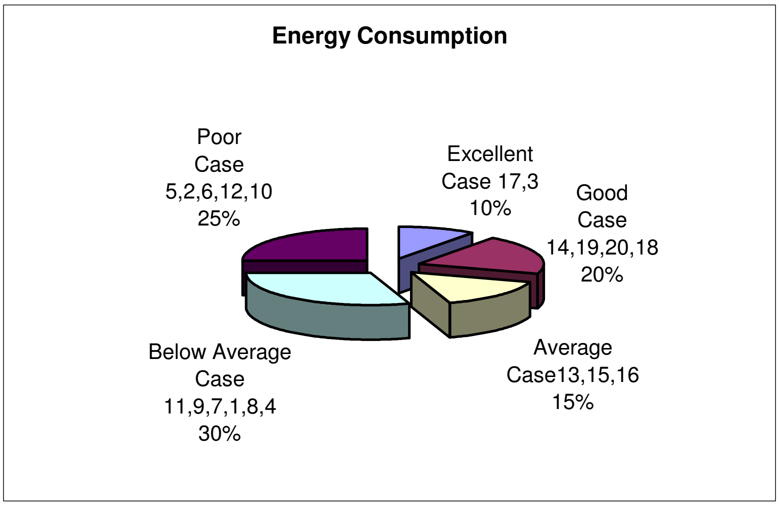


Figure 5.17. The ratio of energy consumption.

In Table 5.89, the comparison chart for solid waste emission indicator is given. Case 10 has the highest value, and Case 3 has the minimum value. Case 3's solid waste emission is Excellent (5 points) compare to other cases. Average value for energy consumption is 92.36%, and Case 14,19,18,13's performances are at this category.

Table 5.89. Solid waste emission indicator performance values for twenty cases.

Solid Waste				
Case3	42,6		**Excellent(5)**	5
Case17	55,98			4
Case20	63,73			4
Case14	70,29	67.4	**Good(4)**	3
Case19	71,15			3
Case18	80,16			3
Case13	88,88	92.36	**Average (3)**	3
Case15	98			2
Case1	100			2
Case9	101,43			2
Case11	105,29			2
Case7	105,99			2
Case16	106,37			2
Case4	116,75	117.24	**Below average (2)**	2
Case8	118,57			1
Case2	122,66			1
Case12	124,55			1
Case5	126,41			1
Case6	128,01			1
Case10	142,13		**Poor (1)**	1

One reason for Case 3 has received Excellent (5 points) score (Figure 5.18) is the size of the unit which is 76 m^2. Case 17 and 20 have scored Good (4 points), although their size is more than 200 m^2. They have many materials that can be reused in another construction or recycled and can send back to the system. Solid waste is not just dependant on the size of the unit.

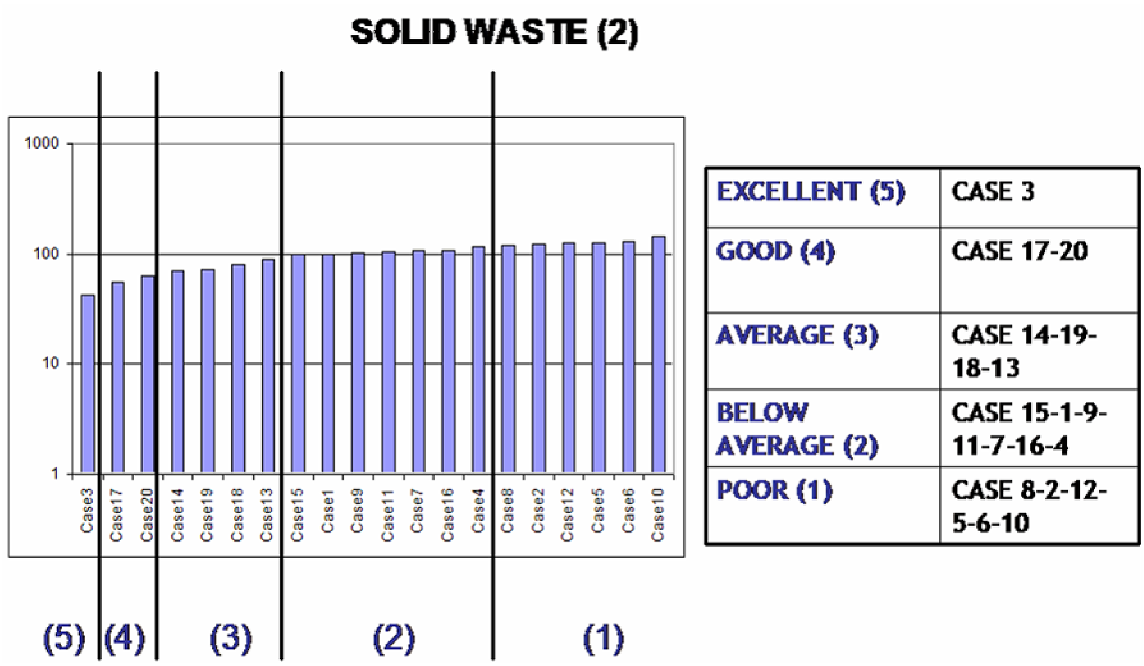


Figure 5.18. Solid waste indicator final score.

The results of solid waste indicator show that solid waste is not only dependant on material use, building's design and performance may affect as well (Table 5.90). However, the energy source is an advantage.

Table 5.90. Solid waste emission indicator five point system results.

Category	Location	Type	Energy Source	Size (m^2)	Year of completion
EXCELLENT (5)	CASE 3: BALÇOVA	FLAT	GEOTHERMAL	72	2004
GOOD (4)	CASE 17: BALÇOVA CASE 20: BORNOVA	HOUSE HOUSE	GEOTHERMAL	320 206	2004 1999
AVERAGE (3)	CASE 14: MAVİŞEHİR CASE 19: BALÇOVA CASE 18: BALÇOVA CASE 13: CESME	HOUSE HOUSE HOUSE HOUSE	FUEL-OIL GEOTHERMAL GEOTHERMAL FUEL –OIL	285 280 230 224	1999 1997 2002 2003
BELOW AVERAGE (2)	CASE 15: KARŞIYAKA CASE 1: ALSANCAK CASE 9: BORNOVA CASE 11: NARLIDERE CASE 7: BALÇOVA CASE 16: KARŞIYAKA CASE 4: MAVİŞEHİR	HOUSE FLAT FLAT HOUSE FLAT HOUSE FLAT	FUEL-OIL FUEL-OIL FUEL-OIL FUEL-OIL GEOTHERMAL FUEL-OIL FUEL-OIL	175 145 240 189 120 200 170	1989 1989 2006 1999 2005 2004 2000
POOR (1)	CASE 8: BORNOVA CASE 2: ALSANCAK CASE 12: SEFERİHİSAR CASE 5: ÜÇKUYULAR CASE 6: ÜÇKUYULAR CASE 10: KARŞIYAKA	FLAT FLAT HOUSE FLAT FLAT FLAT	ELECTRİCITY COAL SEFERİHİSAR COAL FUEL-OIL COAL	118 152 210 76 100 100	2002 1985 1998 2005 2005 1985

In overall twenty cases, 5 % of cases have scored Excellent (5 points), 5% Good (4 points), 20 % Average (3 points), 35% Below Average (2 points), and finally 30% Poor (1 point) (Figure 5.19).

At this stage, it is local authorities decision to accept a certain standard, like Average score for the energy consumption in Izmir. Then, 35% of the residential unit out of twenty cases, may pass the standard.

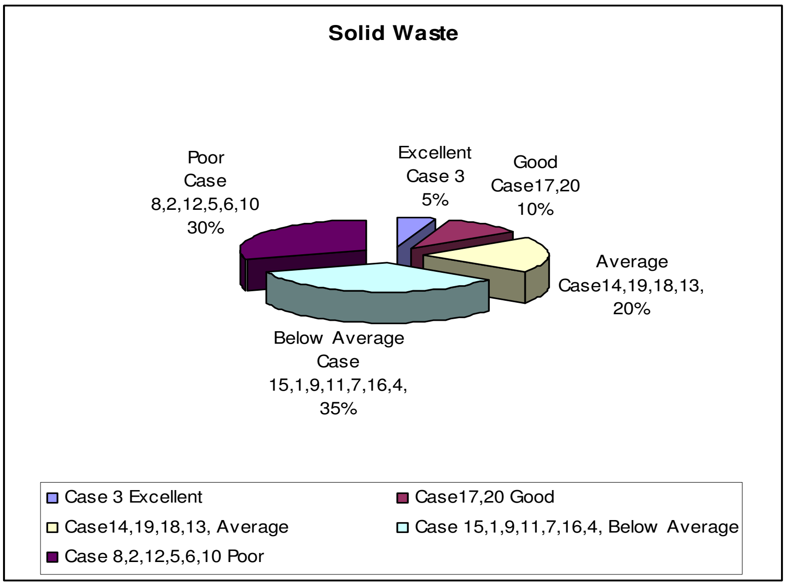


Figure 5.19. The ratio of solid waste emissions.

In Table 5.91, the comparison chart for air pollution index indicator is given. Case 10 has the highest value, and Case 17 has the minimum value. Case 17's air pollution index is Excellent (5 points) compare to other cases. Average (3 points)value for energy consumption is 80.23%, and Case 18, 3, 13, 15, and 16's performances are at this category.

Table 5.91. Air pollution index indicator performance values for twenty cases.

Air Index				
Case17	39,6		Excellent	5
Case14	46,23			5
Case19	51,28	47,78		4
Case20	55,68			4
Case18	61,22	59,92	Good	3
Case3	63,89			3
Case13	66,56			3
Case15	76,67			3
Case16	77,5			3
Case11	81,52	80,23	Average	2
Case9	87,38			2
Case7	92,76			2
Case8	96,3			2
Case4	97,71			2
Case1	100	100,54	Below average	2
Case5	105,49			1
Case6	107,93			1
Case2	108,46			1
Case12	119,25			1
Case10	120,86		Poor	1

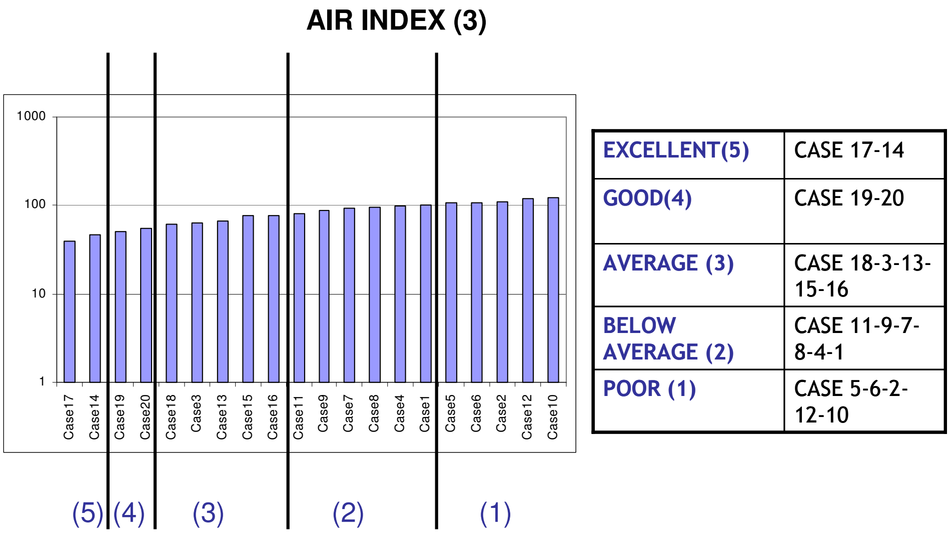


Figure 5.20. Air Index Pollution Index indicator final score.

One reason for Case 3 has received Excellent (5 points) score is the quality of the materials and construction technique. Case 19,20 have scored Good (4 points), although the size of the unit is more than 200 m^2.

The results of air pollution index indicator show that air pollution is dependant on the type of the energy source and material use.

Table 5.92. Air pollution index indicator five point system results.

Category	Location	Type	Energy Source	Size (m^2)	Year of completion
EXCELLENT (5)	CASE 17: BALÇOVA CASE 14: MAVİŞEHİR	HOUSE HOUSE	GEOTHERMAL FUEL-OIL	320 285	2004 1999
GOOD (4)	CASE 19:BALÇOVA CASE 20: BORNOVA	HOUSE HOUSE	GEOTHERMAL FUEL-OIL	280 206	1997 1999
AVERAGE (3)	CASE 18:BALÇOVA CASE 3: BALÇOVA CASE 13: CESME CASE 15 KARŞIYAKA CASE 16: KARŞIYAKA	HOUSE FLAT HOUSE HOUSE HOUSE	GEOTHERMAL GEOTHERMAL FUEL-OIL FUEL-OIL FUEL-OIL	230 72 224 175 200	2002 2004 2003 1989 2004
BELOW AVERAGE (2)	CASE 11: NARLIDERE CASE 9: BORNOVA CASE 7: BALÇOVA CASE 8: BORNOVA CASE 7: BALÇOVA CASE 4: MAVİŞEHİR CASE 1: ALSANCAK	HOUSE FLAT FLAT FLAT FLAT FLAT FLAT	FUEL-OIL FUEL-OIL GEOTHERMAL ELECTRICITY GEOTHERMAL FUEL-OIL FUEL-OIL	189 240 120 118 120 170 145	1999 2006 2005 2002 2005 2000 1989
POOR (1)	CASE 5: ÜÇKUYULAR CASE 6: ÜÇKUYULAR CASE 2: ALSANCAK CASE 12: SEFERİHİSAR CASE 10: KARŞIYAKA	FLAT FLAT FLAT HOUSE FLAT	COAL FUEL-OIL COAL FUEL-OIL COAL	76 100 152 210 100	2005 2005 1985 1998 1985

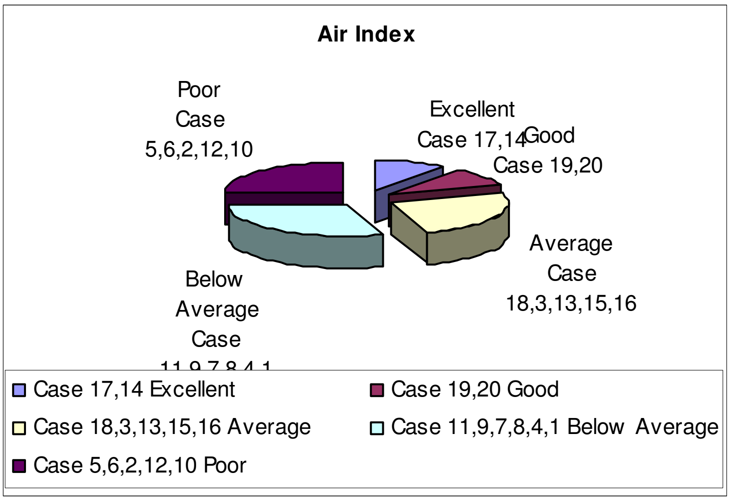


Figure 5.21. The ratio of air pollution index

In overall twenty cases, 5 % of cases have scored Excellent (5 points), 10% Good (4 points), 20 % Average (3 points), 35% Below Average (2 points), and finally 30% Poor (1 point) (Figure 5.17).

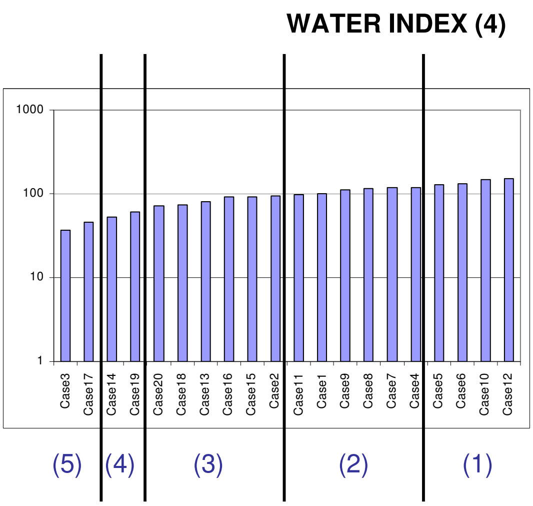
At this stage, it is local authorities decision to accept a certain standard, like Average score for the energy consumption in Izmir. Then, 35% of the residential unit out of twenty cases, may pass the standard.

Table 5.93. Water pollution index indicator performance values for twenty cases.

Water Index				
Case3	37,1		Excellent	5
Case17	46,14	48,75		5
Case14	52,34			4
Case19	60,3			4
Case20	70,99	66,23	Good	3
Case18	74,08			3
Case13	79,01			3
Case16	91,75			3
Case15	92,12			3
Case2	95,4	95,35	Average	2
Case11	96,94			2
Case1	100			2
Case9	110,53			2
Case8	116,12			2
Case7	117,95			2
Case4	117,97	124,47	Below Average	2
Case5	127,37			1
Case6	130,61			1
Case10	146,85			1
Case12	153,59			1

Case 3 and Case 17 have received Excellent (5 points) score (Figure 5.22). Case 14 and Case 19 has scored Good 4 points. Poor performance is given to Case 5, 6,2,10, and 12.,

The results of water pollution index indicator show that uncontrolled use of water may affect the performance (Table 5.94). However, the correct use strategy can protect the water source.



EXCELLENT (5)	CASE 3-17
GOOD (4)	CASE 14-19
AVERAGE (3)	CASE 20-18-13-16-15-2
BELOW AVERAGE (2)	CASE 11-1-9-8-7-4
POOR (1)	CASE 5-6-2-10-12

Figure 5.22 Water pollution index indicator final score.

In overall twenty cases, 5 % of cases have scored Excellent (5 points), 10% Good (4 points), 20 % Average (3 points), 35% Below Average (2 points), and finally 30% Poor (1 point) (Figure 5.23.).

Table 5.94. Water pollution index indicator five point system results.

Category	Location	Type	Energy Source	Size (m^2)	Year of completion
EXCELLENT (5)	CASE 3: BALÇOVA CASE 17: BALÇOVA	FLAT HOUSE	GEOTHERMAL GEOTHERMAL	72 320	2000 2004
GOOD (4)	CASE 14: MAVİŞEHİR CASE 19:BALÇOVA	HOUSE HOUSE	FUEL-OIL GEOTHERMAL	285 280	1999 1997
AVERAGE (3)	CASE 20: BORNOVA CASE 18:BALÇOVA CASE 13: CESME CASE 16: KARŞIYAKA CASE 15 KARŞIYAKA CASE 2: ALSANCAK	HOUSE HOUSE HOUSE HOUSE HOUSE FLAT	FUEL-OIL GEOTHERMAL FUEL-OIL FUEL-OIL FUEL-OIL COAL	206 230 224 200 175 152	1999 2002 2003 2004 1989 1985
BELOW AVERAGE (2)	CASE 11: NARLIDERE CASE 1: ALSANCAK CASE 9: BORNOVA CASE 8: BORNOVA CASE 7: BALÇOVA CASE 4: MAVİŞEHİR	HOUSE FLAT FLAT FLAT FLAT FLAT	FUEL-OIL FUEL-OIL FUEL-OIL ELECTRICITY GEOTHERMAL FUEL-OIL	189 145 240 118 120 170	1999 1989 2006 2002 2005 2000
POOR (1)	CASE 5: ÜÇKUYULAR CASE 6: ÜÇKUYULAR CASE 10: KARŞIYAKA CASE 12: SEFERİHİSAR	FLAT FLAT FLAT HOUSE	COAL FUEL-OIL COAL FUEL-OIL	76 100 100 210	2005 2005 1985 1998

At this stage, it is local authorities decision to accept a certain standard, like Average score for the energy consumption in Izmir. Then, 45% of the residential unit out of twenty cases, may pass the standard.

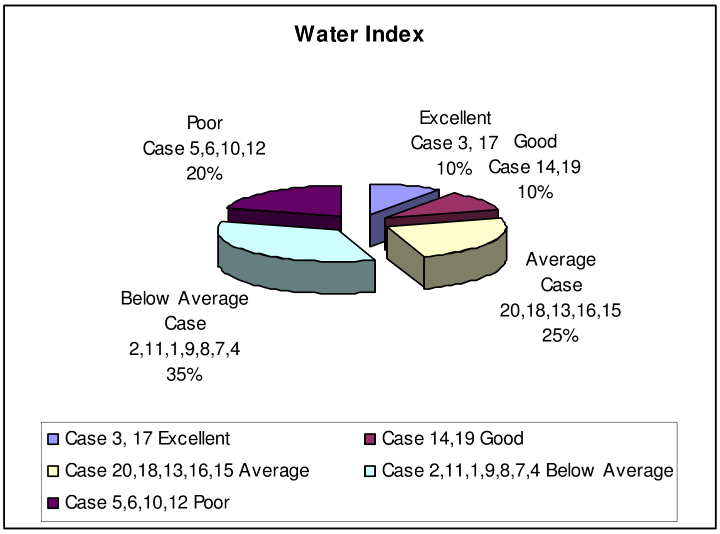


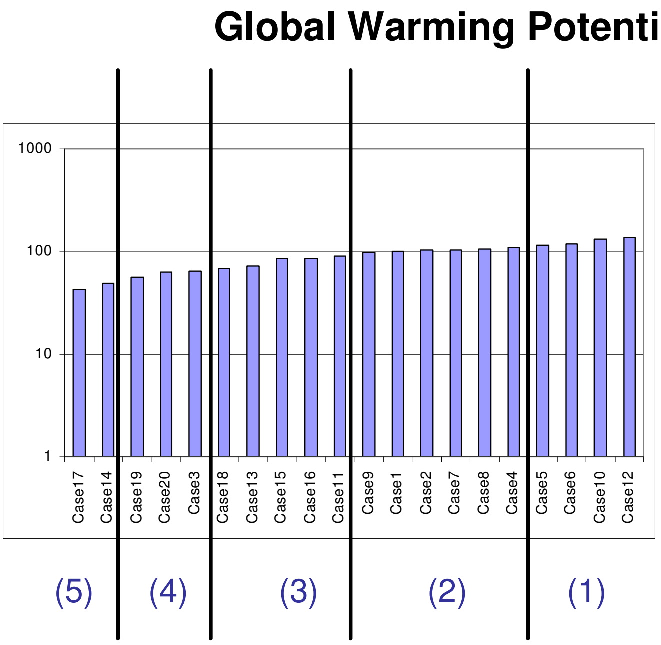
Figure 5.23. The ratio of water pollution index.

In Table 5.95, the comparison chart for global warming potential indicator indicator of twenty cases is given. Case 10 has the highest value, and Case 17 has the minimum value. Case 17's global warming potential is Excellent (5 points) compare to other cases. Average (3 points)value for global warming potential is 112.48%, and Case 15,16, 11, 9,1,2,7,8, and 4's performances are at this category.

Table 5.95.. Global warming potential indicator performance values for twenty cases

Global Warming Potential				
Case17	43,19		Excellent	5
Case14	49,85			5
Case19	56,13	57,05		5
Case20	62,73			4
Case18	67,69			4
Case13	73,09			4
Case15	84,82	77,84	Good	3
Case16	85,02			3
Case11	89,78			3
Case9	98,05			3
Case1	100			3
Case2	103,65			3
Case7	104,51			3
Case8	106,65			3
Case4	108,64	112,48	Average	3
Case5	117,126			2
Case6	120,15			2
Case10	134,28			2
Case12	135,38	147,13	Below Average	2
Case3	181,78		Poor	1

Case 17, 14, 19 have received Excellent (5 points) score (Figure 5.24). Case 19,20, and 3 have scored Good (4 points). Global warming potential indicator is not only dependant on energy use, all the material selection and building performance may affect the conditions.



EXCELLENT (5)	CASE 17-14-19
GOOD (4)	CASE 19-20-3
AVERAGE (3)	CASE 18-13-15-16-11
BELOW AVERAGE (2)	CASE 9-1-2-7-8-4
POOR (1)	CASE 5-6-10-12

Figure 5.24 Global warming potential indicator final score

The results of global warming potential indicator have proved that the global warming potential is not only dependant energy (Table 5.96). House units have more advantages than flats. However, only one flat, Case 3 with geothermal energy source has scored average.

Table 5.96. Global warming potential indicator five point system results.

Category	Location	Type	Energy Source	Size (m^2)	Year of completion
EXCELLENT (5)	CASE 17: BALÇOVA CASE 14: MAVİŞEHİR	HOUSE HOUSE	GEOTHERMAL FUEL-OIL	320 285	2004 1999
GOOD (4)	CASE 19:BALÇOVA CASE 20: BORNOVA CASE 3: BALÇOVA	HOUSE HOUSE FLAT	GEOTHERMAL FUEL-OIL GEOTHERMAL	280 206 72	1997 1999 2000
AVERAGE (3)	CASE 18:BALÇOVA CASE 13: CESME CASE 15 KARŞIYAKA CASE 16:KARŞIYAKA CASE 11: NARLIDERE	HOUSE HOUSE HOUSE HOUSE HOUSE	GEOTHERMAL FUEL-OIL FUEL-OIL FUEL-OIL FUEL-OIL	230 224 175 200 189	2002 2003 1989 2004 1999
BELOW AVERAGE (2)	CASE 9: BORNOVA CASE 1: ALSANCAK CASE 2: ALSANCAK CASE 7: BALÇOVA CASE 8: BORNOVA CASE 4: MAVİŞEHİR	FLAT FLAT FLAT FLAT FLAT FLAT	FUEL-OIL FUEL-OIL COAL GEOTHERMAL ELECTRİCITY FUEL-OIL	240 145 152 120 118 170	2006 1989 1985 2005 2002 2000
POOR (1)	CASE 5: ÜÇKUYULAR CASE 6: ÜÇKUYULAR CASE 10: KARŞIYAKA CASE 12: SEFERİHİSAR	FLAT FLAT FLAT HOUSE	COAL FUEL-OIL COAL FUEL-OIL	76 100 100 210	2005 2005 1985 1998

In overall twenty cases, 15 % of cases have scored Excellent (5 points), 15% Good (4 points), 45 % Average (3 points), 20% Below Average (2 points), and finally 5% Poor (1 point) (Figure 5.25).

At this stage, it is local authorities decision to accept a certain standard, like Average score for the energy consumption in Izmir. Then, 75% of the residential unit out of twenty cases, may pass the standard.

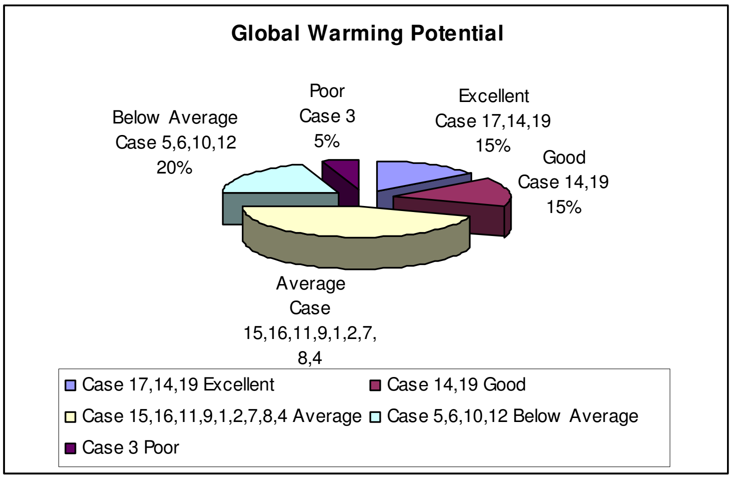


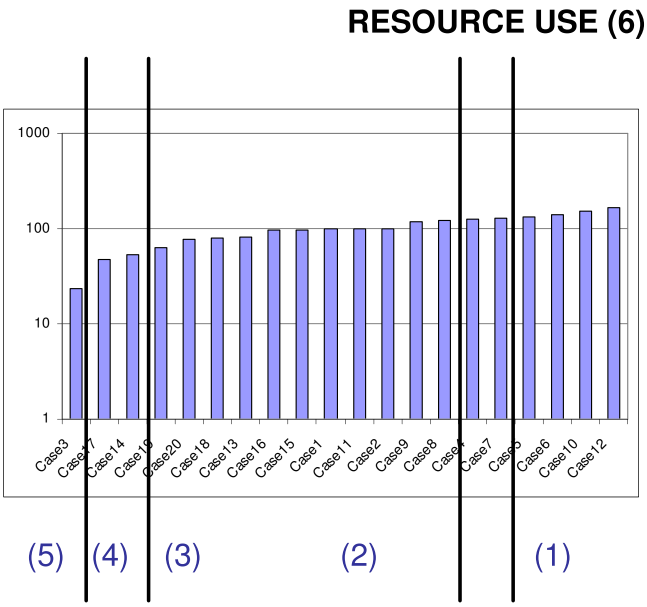
Figure 5.25. The ratio of global warming potential.

In Table 5.97, the comparison chart for global warming potential indicator indicator of twenty cases is given. Case 12 has the highest value, and Case 3 has the minimum value. Case 3's global warming potential is Excellent (5 points) compare to other cases. Average (3 points)value for global warming potential is 96.36%, and Case 19,20,18 and 13's performances are at this category.

Table 5.97. Resource use index indicator performance values for twenty cases.

		Resource Use		
Case3	23,63		Excellent	5
Case17	48,12	38,17		4
Case14	53,78			4
Case19	63,59	60	Good	3
Case20	76,97			3
Case18	79,6			3
Case13	82,3			3
Case16	97,2	96,36	Average	2
Case15	97,91			2
Case1	100			2
Case11	100,61			2
Case2	101,34			2
Case9	118,18			2
Case8	120,6			2
Case4	125,42			2
Case7	128,24			2
Case5	133,11	132,73	Below Average	1
Case6	139,83			1
Case10	151,47			1
Case12	169,1		Poor	1

Case 3 has received Excellent (5 points) score (Figure 5.26). Case 17,14 have scored Good (4 points).



EXCELLENT (5)	CASE 3
GOOD (4)	CASE 17-14
AVERAGE (3)	CASE 19-20-18-13-16-15-1-11-2-9-8
BELOW AVERAGE (2)	CASE 4-7
POOR (1)	CASE 5-6-10-12

Figure 5.26. Weighted resource use indicator final score

The results of resource use indicator show that resource use is not only dependant material use and selection., also the building's performance may affect the resource use(Table 5.98).

Table 5.98. Resource use indicator five point system results

Category	Location	Type	Energy Source	Size(m^2)	Year of completion
EXCELLENT (5)	CASE 3: BALÇOVA-	FLAT	GEOTHERMAL	72	2000
GOOD (4)	CASE 17: BALÇOVA-	HOUSE	GEOTHERMAL	320	2004
	CASE 14: MAVİŞEHİR-	HOUSE	FUEL-OIL	285	1999
AVERAGE (3)	CASE 19: BALÇOVA –	HOUSE	GEOTHERMAL	280	1997
	CASE 20: BORNOVA	HOUSE	FUEL-OIL	206	1999
	CASE 18:BALÇOVA	HOUSE	GEOTHERMAL	230	2002
	CASE 13: CESME	HOUSE	FUEL-OIL	224	2003
	CASE 16:KARŞIYAKA	HOUSE	FUEL-OIL	200	2004
	CASE 15: KARŞIYAKA	HOUSE	FUEL-OIL	175	1989
	CASE 1: ALSANCAK	FLAT	FUEL-OIL	145	1989
	CASE 11: NARLIDERE	HOUSE	FUEL-OIL	189	1999
	CASE 2: ALSANCAK	FLAT	COAL	152	1985
	CASE 9: BORNOVA	FLAT	FUEL-OIL	240	2006
	CASE 8: BORNOVA	FLAT	ELECTRICITY	118	2002
BELOW AVERAGE (2)	CASE 4: MAVİŞEHİR	FLAT	FUEL-OIL	170	2000
	CASE 7: BALÇOVA	FLAT	GEOTHERMAL	120	2005
POOR (1)	CASE 5: ÜÇKUYULAR	FLAT	COAL	76	2005
	CASE 6: ÜÇKUYULAR	FLAT	FUEL-OIL	100	2005
	CASE 10: KARŞIYAKA	FLAT	COAL	100	1985
	CASE 12: SEFERİHİSAR	HOUSE	FUEL-OIL	210	1998

In overall twenty cases, 5 % of cases have scored Excellent (5 points), 10% Good (4 points), 20 % Average (3 points), 35% Below Average (2 points), and finally 30% Poor (1 point) (Figure 5.17).

At this stage, it is local authorities decision to accept a certain standard, like Average score for the resource use in Izmir. Then, 35% of the residential unit out of twenty cases, may pass the standard.

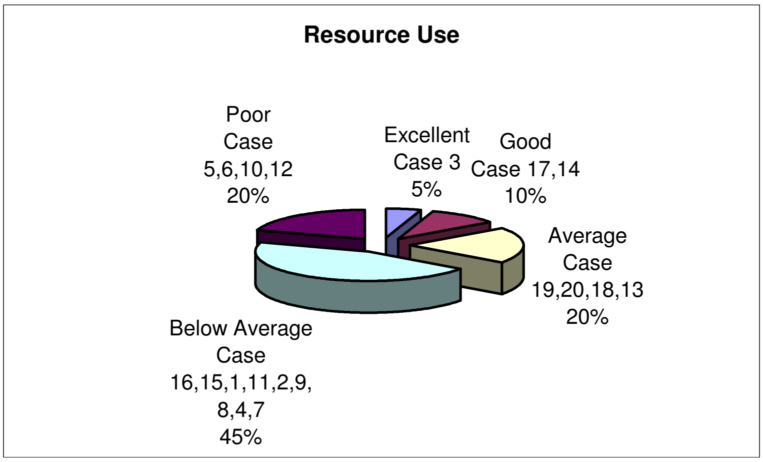


Figure 5.27. The ratio of weighted resource use.

5.3.2. Selected Thirty Indicators Final Results

Thirty indicators selection process is explained in Chapter 4, between p.76 and 78. Selected thirty indicators have been considered under four life cycle stages; 1. site selection, 2. construction, 3. operation and 4. demolition. Site selection stage provides information before construction. Construction stage is the period between beginning of the construction and completion. Operation stage is the use period of the unit.

Table 5.99. Thirty performance indicators five points categorisation.

Case 1				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1 (1 out of 30) 3%	- (0 out of 30)	2-3-7-13-27-28(6 out of 30) 20%	5-6-9-22-25-26(6 out of 30) 20%	4-8-10-11-12-14-15-16-17-18-19-20-21-23-24-29-30 (17 out of 30) 57%
Case 2				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1 (1 out of 30) 3%	- (0 out of 30)	2-3-7-13-16-27-28 (7 out of 30)23%	5-6-9-18-19-23-25-26 (8 out of 30) 27%	4-8-10-11-12-14-15-17-20-21-22-24-29-30 (14 out of 30) 47%
Case 3				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
15-19-23(3 out of 30) 10%	1-15-17-18-22-28 (6 out of 30) 20%	2-3-4-6-7-13-21-25-26-27(10 out of 30)33%	5-9- 14-20-24 (5 out of 30) 17%	8-10-11-12-29-30 (six out of 30) 20%
Case 4				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1-22-23-27-28 (5 out 30) 17%	2-3-7-15-16-17-19-20-25-26 (10 out of 30) 33%	4-5-6-13-14-18 (6 out of 30) 20%	8-9-10-11-12-21-24-29-30 (9 out of 30) 30%
Case 5				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1 (1 out of 30)3%	7-13 (2 out of 30) 6%	2-3-5-6-9-17-20-22-23-25-27 (11 out of 30) 36%	4-8-10-11-12-14-15-16-18-19-21-26-28-29-30 (15 out of 30)50%
Case 6				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1 (1 out of 30) 3%	- (0 out of 30)	2-7-27 (3 out of 30) 10%	3-5-6-13-14-16-17-20-22-23-25-28 (12 out of 30)40%	4-8-9-10-11-12-15-18-19-21-24-26-29-30 (14 out of 30) 46%
Case 7				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
-	1-27(2 out of 30) 7%	2-3-6-7 (4 out of 30) 13%	4-5-13-16-17-18-19-20-22-23-25 (11 out of 30) 37%	8-9-10-11-12-14-15-21-24-26-28-29-30 (13 out of 30) 43%
Case 8				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1 (1out of 30) 3%	2-3-7-13-15-27-28 (7out of 30) 23%	4-5-6-16-17-18-20-22-25-26 (10 out of 30)33%	8-9-10-11-12-14-19-21-23-24-29-30 (12 out of 30)40%
Case 9				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1-27 (2 out of 30) 7%	2-3-7 (3 out of 30) 10%	4-5-6-13-16-17-18-20-22-23-25 (11 out of 30) 37%	8-9-10-11-12-14-15-19-21-24-26-28-29-30 (14 out of 30) 46%
Case 10				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1-23-26 (3 out of 30) 30%	2-3-7-13-16-17-21-22-27 (9 out of 30) 30%	5-6-9-22-25-26 (6 out of 30) 20%	4-8-9-10-11-12-14-18-24-28-29-30 (12 out of 30) 40%
Case 11				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1 (1 out of 30) 3%	5-7-13-27-28 (5 out of 30)16%	2-3-6-22-25-26 (6 out of 30) 20%	4-8-9-10-11-12-14-15-16-17-18-19-20-21-23-24-29-30 (18 out of 30) 60%

Table 5.99. Thirty performance indicators five points categorisation. (cont.)

Case 12				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	23 (1 out of 30) 3%	1-7-13-17 (4 out of 30)13%	2-3-5-6-20-26-27 (7 out of 30) 23%	4-8-9-10-11-12-14-15-16-18-19-21-22-24-25-28-29-30 (18 out of 30) 60%
Case 13				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
23 (1 out of 30)	15-22-27-28 (4 out of 30) 13%	1-2-3-4-5-7-13-16-17-18-19-20-25-26 (13 out of 30) 43%	6-21 (2 out of 30) 6%	8-9-10-11-12-14-24-29-30 (10 out 30) 33%
Case 14				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1(1 out of 30)3%	3-5-22-23-25-28(6 out of 30) 20%	2-4-7-13-15-16-17-26-27 (9 out of 30) 30%	6-14-20-21 (4 out of 30) 13%	8-9-10-11-12-18-19-24-29-30 (11 out of 30) 37%
Case 15				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1 (1 out of 30)3%	23-27 (2 out of 30) 7%	2-7-16-22-25-26 (6out of 30)20%	3-4-5-6-13-17-18-20-21-28 (10 out of 30) 33%	8-9-10-11-12-14-15-19-24-29-30 (11 out of 30) 37%
Case 16				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out 30)	1-2-23 (3 out of 30) 10%	3-4-5-6-7-13-15-16-17-22-25-26-27 (13 out of 30) 43%	18-20-21-28 (4 out of 30) 13%	8-9-10-11-12-14-24-29-30 (7 out of 30) 23%
Case 17				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1-2-4-5-15-16-17-18-19-22 (10 out of 30) 33%	3-7-13-20-23-25-26-28 (8 out of 30) 27%	6-21 (2 out of 30) 7%	8-9-10-11-12-14-24-27-29-30 (10 out of 30) 33%
Case 18				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
-(0 out of 30)	1-23 (2 out of 30) 7%	2-3-4-7-13-16-17-25-26-27-28(11 out of 30) 37%	5-6-13-18-22 (5 out of 30) 17%	8-9-10-11-12-14-15-19-20-21-24-29-30 (13 out 30) 43%
Case 19				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
- (0 out of 30)	1-19-23 (3 out of 30) 10%	2-3-4-7-13-16-17-22-25-26-27-28 (12 out of 30) 40%	5-6-18-20-21 (5 out of 30) 17%	8-9-10-11-12-14-15-24-29-30 (10 out 30)33%
Case 20				
EXCELLENT	GOOD	AVERAGE	BELOW AVERAGE	POOR
1-23(2 out of 30) 7%	5-13-15-16-17-22-25-28 (8 out of 30) 27%	6-7-26-27 (4 out of 30) 13%	5-6-18-19-20-21 (6 out of 30) 20%	8-9-10-11-12-14-24-29-30 (9 out of 30) 30%

Table 5.100. Thirty Performance Rating Calculation Method

Min +(max - min) x (percentage value for Excellent: 0.9, Good: 0.75,Average:0.5, Below Average:0.25, Poor: 0)
Example:
46 + (85 – 46) x 0.9 = 81.6- (between 81.6 and 85) Excellent
46 + (85- 46) x 0.75 = 75.25 – (between 75.25 and 81.6) Good
46 + (85-46) x 0.50= 65.5 – (between 65.5 and 75.25) Average
46 + (85-46) x 0.25 = 55.75– (between 55.75and 65.5) Below Average
46 + (85-46) x 0 = 46 – (between 46 and 55.75) Poor

Finally, the demolition stage is the end life of the residential unit. More than seventy years of process and performance is hard to monitor by anybody. Many professionals have given assumptions about the building process or imply tests for certain period to find results. The performance indicators developed for HRM-Izmir, will provide flexibility for any research and analyse the building process in life cycle stages.

The results gathered from thirty performance indicators, have been rated under five point system.

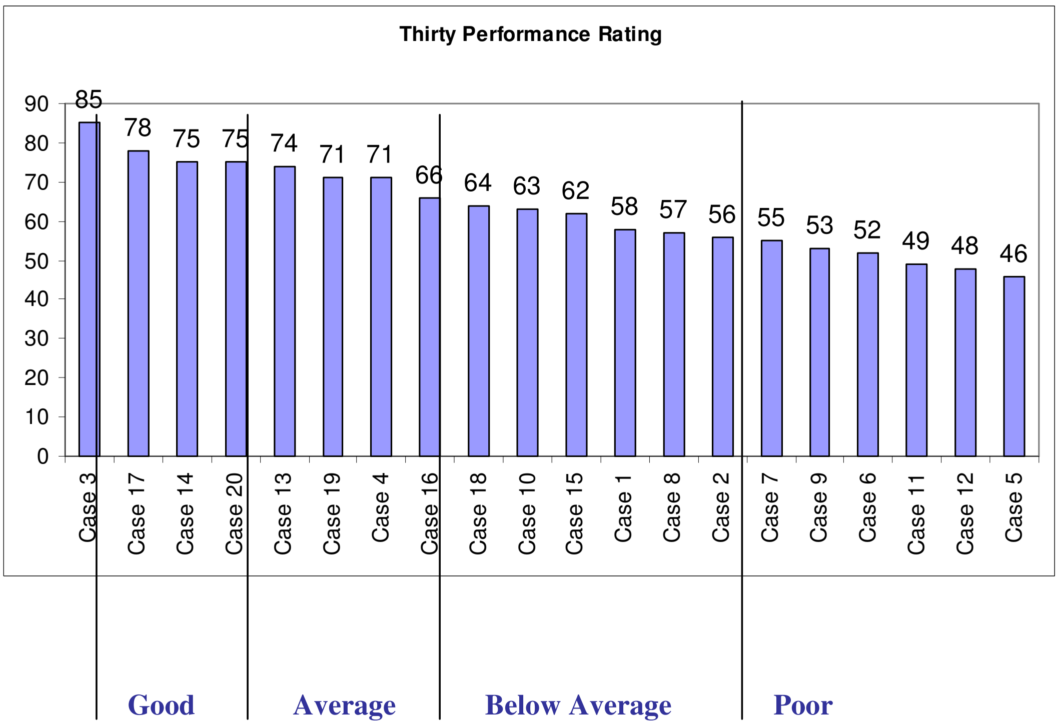


Figure 5.28. Selected Performance Rating Final Score.

After completion of rating, the results will provide solutions to improve the conditions in the studied units. Case 3 in Balçova is an Excellent (5 points) project when compared between twenty cases. However, Case 7 in Balçova has performed Poor (1 point). Local authority may set a benchmark for the residential units in that area. For instance, the Building Code of Australia now requires a minimum energy star rating for new single dwellings of 3.5 or 4 stars dependent on the climate zone.

For instance, Balçova Municipality will require at least Average score from the residential units in Balçova. There are five Balçova projects, Case 3, Case 17 and Case 19 will pass the Balçova Municipality's standard. Case 7 and Case 17 will need further improvements to pass the benchmark. If the minimum standard is Good (4 points), then Case 3 and Case 17 will get pass certificate.

CHAPTER 6

CONCLUSION

A building should have good performance to support the activities of its occupants. Among the various types of buildings, the residential building should perform especially well because occupants spend most of their time inside it. Therefore, the performance of residential buildings should be evaluated continually and managed accordingly to provide sustainable built environment.

For more objective and consistent evaluation, a comprehensive performance evaluation model for residential units that can encompass various building performance features needs to be developed. In the pursuit of a sustainable society, improvements in the environmental performance of buildings have a critical effect. It is essential to have suitable tools available at the conceptual design stage that can assist designers in finding better design alternatives efficiently.

This study proposed HRM-Izmir model for rating the performance of the residential buildings. Moreover, as a case study for HRM-Izmir Model, twenty residential units have been assessed, and their effects of the site selection, construction, operation, and demolition stages of the residential units discussed. The main factors of local environmental burden, heating, cooling, transport, and disposal of wastes are also evaluated with the proposed model as well.

The purpose of HRM-Izmir Rating Model is to rank buildings according to their performance. HRM-Izmir has four levels to achieve the final rating result:

1 - the data collection process which provides information about the studied unit, (Form A)

2 - use of the ATHENA software program,(Energy Consumption, Solid Waste, Air Index, Water Index, Global Warming Potential, Resource Use) (Form B)

3 - implying 30 indicators (1.Site Selection 2. Construction 3. Operation 4. Demolition) (Form C)

4 - Final rating scores for the studied units. (Form D)

More than seventy years of building life cycle is hard to monitor by any human being, however suitable tools can be developed to prevent future problems and evaluate the process in quantitive values. The idea of HRM-Izmir triggered after the search to find a correct tool to evaluate more than seventy years of building's life cycle. In a building construction, there are many issues that need special attention, unfortunately in today's world, some architects neglect to consider them. For instance, ventilation, indoor air quality, ecology, existing built environment, natural cooling strategy and lighting, acoustic issues are ignored by large number of architects. As a result of this ignorance, occupants we live in a chaotic, not sustainable environment. If our way of life continues we will have more troubles day by day.

Any research that turns the direction of the current path, will be acknowledged by many authorities. However, any model or tool in theory does not mean it's the perfect solution for the current situation. Many pilot tests may be applied before accepting that the model is the right solution.

In theory, the model implies six ATHENA indicators and thirty selected indicators that evaluate the performance of the residential unit during its life cycle. A valuable use of HRM-Izmir Model is to persuade architects to consider neglected issues like ventilation, natural lighting, indoor air quality, ecology etc., during design stage before any construction works. Another good advantage of HRM-Izmir is to influence existing buildings to improve their conditions for better environment.

One other advantage of the model is to place a benchmark to improve sustainable environment. Local authorities may use the model to understand and improve the conditions in their cities. For instance, in five points system, a municipality may demand overall "Average" score for the city. If the residential unit fail to reach this standard may pay more tax than others.

A model developed in theory, needs a testing ground like the City of Izmir to observe performance. The cases have been collected from ten main residential areas of Izmir, consists of ten flats and ten houses. The different cases with different conditions have been chosen to increase the variety; however it has been limited to twenty cases to keep the situation under control. During the comparisons between these cases, the property value, desirable area issue or the occupants' living standards have not been considered. Only the buildings' performances have been evaluated and rated according to HRM-Izmir's theory.

Desirable area does not represent the real value for a property. Currently, the estate values change depending on the view, location, and use of popular, fashionable materials. First statement of HRM-Izmir is to avoid following the current situation based on purchasing residential units depending on desirability. There is a location indicator in the model; however it considers the surrounding infrastructure for basic services. For instance, Alsancak is currently desirable area to live, but it may receive poor performance from the location of the residential unit.

Thirty performance indicators have been applied to the twenty residential units , and their performance scores have been filled in Form C and D. After the evaluation process, the ratio of Excellent (5 points), Good (4 points), Average (3 points), Below Average (2 points) and Poor (1 point) has given for each indicator.

Ecology indicator (2) evaluates the natural environment around the site with eleven sub-indicators. As a result of this indicator, there is not any construction site out of twenty that has received excellent score. Out of twenty cases, most of the cases are average or below average category.

Existing built environment indicator (3) assesses the previous construction activity on site. Efficient use of existing infrastructure creates valuable savings for the planned construction. 40% of the cases scored excellent. At this stage, the size of the residential unit is not considered, however the conditions may affect the performance of the future occupants.

Final indicator for site selection is orientation indicator (4) with two sub-indicators sun and wind. Correct sun and wind orientation will reduce energy consumption cooling load for the building. Out of twenty cases, only Case 17 has Good (4 points) score. Six cases have scored Average (3 points). Out of six cases only one case is a flat located in Balçova.

At construction stage, building envelope indicator (5) evaluates the physical volume. The size of residential units should consider local climate conditions. Window sizes should be adjusted according to the local climate. Out of twenty cases, there have not been any cases that scored Excellent (5 points) and Good (4 points).

Material selection (6) has two parts; the first one is the country of the materials made, and the second is whether LCA applied during the production of the selected materials. Twenty cases have rated Average (3 points), Below Average (2 points), and Poor (1 point).

Material transportation indicator (7) considers the method and distance of the transportation. Overall performance for the cases has been Average (3 points), considering the road conditions.

Material conservation indicator (8) for all cases are existing buildings, have not prepared any material conservation plan. The performance score for all cases is assumed Poor category.

Energy conservation indicator (9) influences the building site to use energy efficiently. For all cases, during construction, it is assumed that there have not any methods to save energy. Performance score is Poor Category for all twenty cases.

Renewable energy use indicator (10) performances for all cases are Poor (1 point) because it is assumed that there was not any use of renewable energy source during construction.

In construction stage, the waste products are the packages, spare parts and left over of the materials after their application. All these waste must be collected separately and stored in containers. Waste strategy indicator (11) assesses the plan for the waste collection process during construction. It is assumed that all twenty cases did not have any plan for waste strategy. For new constructions, this indicator has important role to reduce waste during construction. Water strategy indicator (12) helps the construction site to minimise water consumption. It is assumed that all twenty cases have not considered any plan for water strategy. Unit components indicator (13) checks the components environmental responsive issues. Only one case, Case 20 has Good (4 points) performance and the rest are Average or Below Average. Insulation indicator (14) assesses the standard of insulation in five categories. All the cases have scored under average. Materials Maintenance indicator (16) follows the maintenance progress for the residential unit. Case 17 has Good (4 points) performance compared to other twenty cases. Energy use indicator (17) monitors the energy use efficiency for electricity. Each twenty cases receive poor performance because there are not any measures or methods to reduce electricity use. Cooling indicator (18) is valid during hot seasons. There is not any specific natural cooling strategy for all cases. Heating indicator (19) checks the efficiency of the heating system in the residential unit. The units with the geothermal energy source have scored high performance. Ventilation indicator (20) is a poor performance for over all cases. When considering indoor air quality indicator (21) Eight out of twenty have rated Poor (1 point), mainly apartment flats.

Day lighting indicator (22) performance for the twenty cases has mostly rated below average performance. Noise indicator (23) performance for the twenty cases has mainly been rated below average. Acoustic indicator (24) has the lowest performance, Poor (1 point) for most of the twenty cases.

Waste handling indicator (25) assesses the level of waste collection process in the residential units. The local government should provide necessary rules to persuade the occupants to separate their garbage at home. For instance in Switzerland, the government charges every black bin bag, and adjusted collection periods for different wastes. Charging bin bags persuades occupants to separate glass, metal cans, and paper to save space in the black bin bag. For Case 2, waste handling indicator (25)'s performance is below average because they only separate the paper products.

The aim of water use indicator (26) is to reduce water consumption in the residential unit. Transport indicator (27) judges the amount of private car transport for the occupants during operation stage. Refurbishment indicator (28) checks the environmental improvements of an existing dwelling or whether future refurbishment plan is considered. For many cases, refurbishment indicator is average because only some parts of the residential unit were improved. Reuse and Recycle plan (29) should be done during the design period. All twenty cases do not have a reuse and recycle plan, receives poor (1 point) score.

Table 6.1. Selected thirty performance five point system results.

	Location	**Type**	**Energy Source**	**Size (m^2)**	**Year of completion**
EXCELLENT (5)	CASE 3: BALÇOVA-	FLAT	GEOTHERMAL	72	2000
GOOD (4)	CASE 17: BALÇOVA-	HOUSE	GEOTHERMAL	320	2004
	CASE 14: MAVİŞEHİR-	HOUSE	FUEL-OIL	285	1999
	CASE 20: BORNOVA	HOUSE	FUEL-OIL	206	1999
AVERAGE (3)	CASE 13: CESME –	HOUSE	FUELOIL	224	2003
	CASE 19: BALÇOVA –	HOUSE	GEOTHERMAL	280	1997
	CASE 4: MAVİŞEHİR-	FLAT	FUEL-OIL	170	2000
	CASE 16:KARŞIYAKA	HOUSE	FUEL-OIL	200	2004
BELOW AVERAGE (2)	CASE 18:BALÇOVA –	HOUSE	GEOTHERMAL	230	2002
	CASE 10: KARŞIYAKA-	FLAT	COAL	100	1985
	CASE 15:KARŞIYAKA –	HOUSE	FUEL-OIL	175	1989
	CASE 1: ALSANCAK –	FLAT	FUEL-OIL	145	1989
	CASE 8: BORNOVA-	FLAT	ELECTRICITY	118	2002
	CASE 2:ALSANCAK	FLAT	COAL	152	1985
POOR (1)	CASE 7:BALÇOVA –	FLAT	GEOTHERMAL	120	2005
	CASE 9: BORNOVA –	FLAT	FUEL-OIL	240	2006
	CASE 6: ÜÇKUYULAR	FLAT	FUEL-OIL	100	2005
	CASE11:NARLIDERE	HOUSE	FUEL-OIL	189	1999
	CASE 12: SEFERİHİSAR	HOUSE	FUEL-OIL	210	1998
	CASE 5: UÇKUYULAR	FLAT	COAL	76	2005

There are ten apartment units among twenty cases. Two flats are from Alsancak, two flats from Balçova, one from Mavisehir, two from Uçkuyular, two from Bornova and one from Karsiyaka district. According to ATHENA, Case 3's comparison between ten flats prove that it has performed Excellent (5 points). However, other case in Balçova, Case 7, has scored Below Average (2 points). For heating purposes, the both flats use geothermal, but Case 7 has single glazing that effects the energy consumption performance. Case 1, 2, 3,4,5,6,9, and 10 use fossil fuels, either coal or fuel-oil for heating, have been graded Below Average (2 points). Finally, Case 8, located in Bornova, uses electricity for heating, has performed Below Average score as well. Energy source may affect the performance, but insulation and glazing type need right considerations.

ATHENA's energy consumption indicator comparison between flats and houses indicate that most of the houses performances have been below average. Insulation and glazing performance in the houses can be better than flats. Another reason is houses can control their own heating system, so they can adjust the use conditions of the heating system and save energy.

The size of the residential unit may be an important factor for energy consumption performance; however use of efficient heating system, right energy source and insulation materials can increase the performance. For instance Case 5, located in Uçkuyular with 100 m^2 area has performed Poor (1 point) score because the design has avoid considering efficient heating and insulation materials.

Solid waste emission indicator of ATHENA considers the solid waste amount that after removing recyclable and reusable materials of the residential unit. As the evaluation proves that old dated constructions have B.Average (2 point) performance for instance Case 1 and Case 2 in Alsancak, Case 10 and 15 in Karşıyaka. For the solid waste emission performance, material selection and construction method have direct influence. The cases from Balçova; Case 3, 17, 20, 18, and 19, Mavisehir; Case 14, and Çeşme; Case 13 have improved construction quality with new methods.

Air pollution index indicator proves that air pollution value may change according to the type of energy source and material use. The residential units with geothermal energy perform better than other types. Another result is house performance is far better than flats because they create green areas around them and the occupant's use energy sources when they need them. Case 17 from Balçova and Case 14 Mavişehir have scored Excellent (5 points). They have open green areas around them that create clean environment. Case 10 from and Case 2 from Alsancak, are located in a dense built environment that prevents clean environment.

Water pollution index indicator proves that water consumption strategy will persuade users to efficiently consume water. Case 3 and Case 17 in Balçova have received Excellent (5 points), however the result does not prove that the residential units in Balçova is the best in Izmir. The aim of the case study is to observe the individual performance of the residential units. For instance, Case 7 located also in Balçova has performed Below Average (2 points). Desirable area issue has not been a dominant criteria for the performance evaluation of the cases.

When global warming potential is considered, houses have achieved better performance than flats. Global warming potential indicator is not only dependant on energy use, also the material selection, building services' performance, ratio of green areas, and waste potential may affect the conditions. Case 17 in Balçova and Case 14 in Mavisehir have rated Excellent (5 points).

The performance concept in buildings has been gradually extended to diverse aspects and there has been a demand for the pre-organized systems which help the user's to understand the performance of an issue in comparison to other issues. Accordingly, various performance evaluation models for certification have been introduced for residential buildings in the past, but some of the existing performance evaluation models have focused only on a specific performance and sometimes appeared to be difficult and complicated to use because users are required to answer too many questions or to submit many related documents.

The HRM-Izmir model is aimed to provide users more substantial and practical information about in-use housing performance, which is more closely related with their position, compared to those of other residential units. The presented results allow prospective occupants to rate and compare the residential buildings, according to their overall housing performance scores as well as partial scores of concerning lower-level performance features. This ability is considered to be significant since it helps them estimate the strengths and the weaknesses of alternative residential buildings which they would like to purchase or lease. The HRM-Izmir model is expected to be able to stimulate building owners or managers to maintain high housing performance. The most desirable and anticipated role of the model would be to offer occupants more objective evaluation. The performance evaluation is also necessary to minimize the demands for rebuilding or remodelling as well as to serve as a fundamental measure for ensuring the longevity of buildings that offer good environment.

For instance, construction waste is one of the major problems faced by contractors; it leads to loss of profits and is a prime contributor to the total waste stream. Construction industry does not give due attention to waste related issues. It is important to cultivate a waste minimisation culture among the industry professionals and clients. The HRM-Izmir model can help to remind these to the professionals. The HRM-Izmir model can assess the building waste score which may represent the construction waste generation potential of a particular building design. Its main significance is to help designers to deliver the most viable design in terms of minimum waste generation on site. The LCA can influence the industry's progress towards waste awareness and minimisation by publicising the HRM-Izmir model and using it to educate clients and designers. Having in place benchmarks for the HRM-Izmir score will help to cultivate a waste minimisation culture in the industry.

In summary, modelling HRM-Izmir Model is a robust approach to evaluating, the overall performance of the residential unit, together with the LCA phase, —as required by sustainable development. However, there remain many open questions to be solved, and dissemination strategies to be elaborated. These include education, awareness rising, and mutual learning as well as suitable and easily accessible tools and appropriate international databases, which are needed for a global spread of this relatively new methodology.

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APPENDIX A

INSTITUTIONS WORKING ON LIFE CYCLE ASSESSMENT

Table A.1. Institutions working on Life Cycle Assessment.

Name of the Institution	**Web Location**
Product Ecology Consultants (www.pre.nl)	www.pre.nl
Centre for Sustainable Construction	
Danish Building Research Institute (SBI) www.dbri.dk	www.dbri.dk
Danish Environmental Protection Agency (www.mst.dk)	www.mst.dk
The Stockholm Environment Institute (SEI) –	www.york.ac.uk/inst/sei/is/overview.html
The Environmental Change Institute	
The International Design Centre for the Environment **–EPA**	**www.idce.org**
ASMI- Athena Sustainable Materials Institute	(www.athenasmi.ca)
BRE – Building Research Establishment (	www.bre.co.uk/sustainable)
CSTP – Centre Scientifique et Technique du Batiment: Escale –	www.cstp.fr
IKP Stuttgart University- Stuttgart.de	www.ikpz.uni
SUREAC – Green	www.dgmr.nl
KTH Infrastructure and Planning:	www.infra.kth.se
The University of Hong Kong –	www.arch.hku.hk/research/BEER/sustain.htm
RMIT –Royal Melbourne Institute of Technology	http://buildlca.rmit.edu.au
Association for Environment Conscious Building –	www.aecb.net/linkf.htm
The Centre for Sustainable Design –	www.cfsd.org.uk
Sapling –	www.sapling.org.uk
BSRIA – Building Services and Research and Information Association –	www.bsria.co.uk
European Environment Agency –	www.eea.eu.int

APPENDIX B

INTERNATIONAL CODES AND STANDARDS

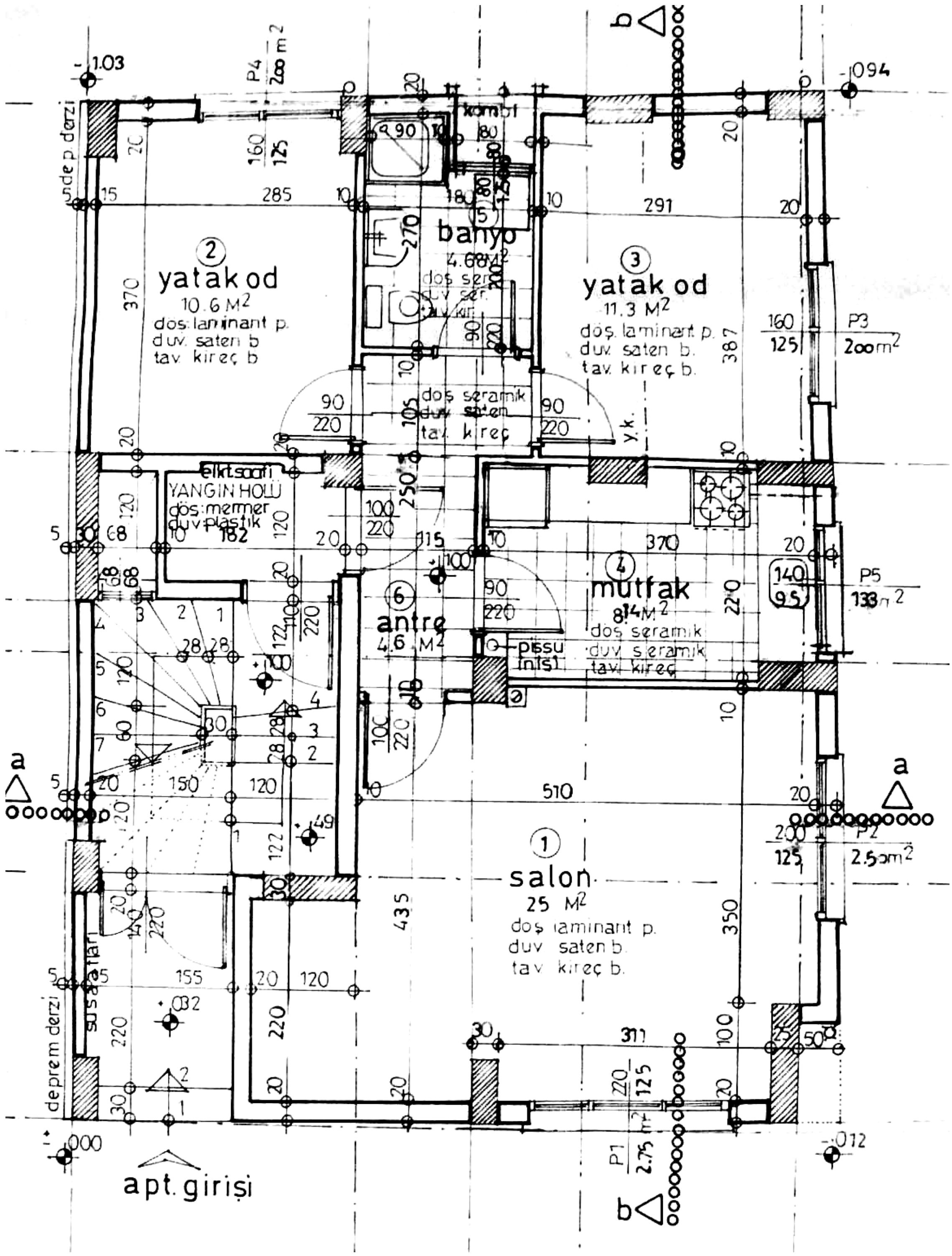
Table B.1. Internatıonal Codes And Standards

International Codes and Standards	Web Address
Australia - ABCB Australian Building Codes Board	http://www.abcb.gov.au
Australia - CSIRO The Commonwealth Scientific & Industrial Research Organization	http://www.dbce.csiro.au
Belgium - BBRI The Belgian Building Research Institute	http://www.bbri.be
Canada - CIPH Canadian Institute of Plumbing and Heating	http://www.ciph.com
Canada - CSA Canadian Standards Association	http://www.csa.ca
Canada - IRC The Institute for Research in Construction	http://www.nrc.ca/irc/irccontents
Canada - OBOA Ontario Building Officials Association	http://www.oboa.on.ca
Canada - RAIC Royal Architectural Institute of Canada	http://www.raic.org
Canada - SCC Standards Council of Canada	http://www.scc.ca
Chile - INN Chile	http://www.inn.cl
Finland - SFS Finnish Standards Association	http://www.sfs.fi
France - AFNOR Association Franuaise de Normalisation	
Germany - DIN Deutsches Institut fur Normung	
ISO International Organization for Standardization	http://www.iso.ch
Malaysia - SIRIM Standards and Industrial Research of Malaysia	http://www.sirim.my
Netherlands - TNO Building and Construction Research	http://www.bouw.tno.nl/homepage
Norway - NBI The Norwegian Building Research Institute	http://www.byggforsk.no
Norway - NSA Norwegian Standards Association	http://www.standard.no
Solvenia - SMIS Standards and Metrology Institute	
South Africa - CSIR Council for Scientific & Industrial Research	http://www.csir.co.za
Turkey- Turkish Standards Institute	http://www.tse.gov.tr
USA - ANSI American National Standards Institute	http://www.ansi.org
USA - ICC International Code Council	http://www.iccsafe.org
USA - NSSN National Standards System Network	http://www.nssn.org

APPENDIX C

EXAMPLE OF A DRAWING FROM THE CASE STUDY

Table C.1. Example Of A Drawıng From The Case Study



VITA

Eray Bozkurt is born in Uşak, on June 1, 1975. He received his B.Sc.(Hons) Degree from University of East London in July 1997. Then, he worked for Ken Yeang in Malaysia, as a design architect. He completed his M. Arch Degree from Middle East Technology University between 1998 and 2000. During the master degree, he worked for Yuksel Proje Inc. in Ankara. Since December 2001, he has been teaching in Izmir Institute of Technology, Department of Architecture, as a research assistant.

His publications include:

International	Bozkurt, Eray and Erkarslan, Özlem.“ Life Cycle Assessment (LCA) Based Home Rating Model for Izmir”, XXXIV IAHS World Congress on Housing Sustainable Housing Design Emphasizing Urban Housing September 20-23, 2006, Naples, Italy.
National	Erkarslan, Özlem, Bozkurt, Eray. “Sürdürülebilir Yapi Tasarımı İçin Yaşam Döngü Değerlendirme Yöntemine Ait Yazilim Programlari”, Yapı ve Kentte Bilişim 04-05 December 2004.
	Bozkurt, Eray. “ Dialogue with Ken Yeang about Bio-Climatic Architecture”. Ege Mimarlık Vol.50
	Altınışık, Burak and Bozkurt, Eray. “ Interview with Ken Yeang”. Ege Mimarlık Vol. 50
Exhibitions	“UIA Architects and Disasters Summer School 2004, in Izmir”, exhibited in UIA 2005 Istanbul Congress.