DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

FACTORS AFFECTING THE DEVELOPMENT OF R&D AND INNOVATION CAPACITY IN ECO-EFFICIENCY

by
Bengü GÜNGÖR

July, 2019
İZMİR

FACTORS AFFECTING THE DEVELOPMENT OF R&D AND INNOVATION CAPACITY IN ECO-EFFICIENCY

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M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"FACTORS AFFECTING THE DEVELOPMENT OF R&D AND INNOVATION CAPACITY IN ECO-EFFICIENCY"** completed by **BENGÜ GÜNGÖR** under supervision of **ASST.PROF.DR. BURCU FELEKOĞLU** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

Asst.Prof.Dr. Burcu FELEKOĞLU

Supervisor

Assoc.Prof.Dr. Ali Serdar TAŞAN

(Jury Member)

Assoc.Prof.Dr. Aslan Deniz KARAOĞLAN

(Jury Member)

Prof.Dr. Kadriye ERTEKİN

Director

Graduate School of Natural and Applied Sciences

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ABSTRACT

The principle of producing more goods using less resources and energy is called eco-efficiency. This concept has not only the objectives that take environmental concerns into consideration, but also has prominence in many other areas, such as the protection of industrial efficiency, conservation of natural resources and economic growth. In terms of companies, eco-efficiency concept has also the principles that lead to results such as increasing the process efficiency and reducing the consumption of natural resources and raw materials by taking into account the operational efficiency and profitability of a company. Thus, companies integrated with this concept increase their productivity and reduce their costs and become more competitive. In Turkey, many companies need to take consultancy services to increase their research and development efforts. Additionally, In Turkey, eco-efficiency principles other than environmental-focused perspective coming up with much of the unknown and insufficient innovation capacity in this field. In the context of this thesis, first of all, the concept of eco-efficiency has been tried to be defined, its definitions and purposes at international level have been mentioned. These objectives were grouped under categories that would be appropriate to a company process to constitute the parts and metrics of a performance evaluation tool which is a developed eco-efficiency maturity grid within this thesis. After, the grid was improved and verified with given feedbacks by experts. For understanding the grid is validated or not, the application part of the thesis was carried out in three different case companies from different sectors. The fact that this thesis provides an assessment tool guiding to companies in an existing field such as eco-efficiency constitutes the motivation of this study and reveals its importance in the literature.

Keywords: Eco-efficiency, R&D and innovation management, maturity grid

EKO-VERİMLİLİK ALANINDAKİ AR-GE VE YENİLİK KAPASİTESİNİN GELİŞTİRİLMESİNİ ETKİLEYEN FAKTÖRLER

ÖZ

Daha az kaynak ve enerji kullanarak daha fazla mal üretme ilkesine eko-verimlilik denir. Bu kavram, yalnızca çevresel kaygıları dikkate alan hedeflere sahip olmayarak, aynı zamanda endüstriyel verimliliğin korunması, doğal kaynakların korunması ve ekonomik büyüme gibi birçok alanda da ön plana çıkmaktadır. Şirketler açısından eko-verimlilik kavramı, aynı zamanda bir şirketin operasyonel verimliliğini ve karlılığını dikkate alarak proses verimliliğini artırmak, doğal kaynak ve hammadde tüketimini azaltmak gibi gelişmelere yol açan ilkelere sahiptir. Böylece, bu konsepte entegre olan şirketler verimliliklerini arttırmakta, maliyetlerini düşürmekte ve rakipleri arasında daha rekabetçi hale gelmektedir. Türkiye'de birçok şirket, ar-ge çalışmalarını arttırmak için danışmanlık hizmeti almaya ihtiyaç duymaktadır. Ayrıca, Türkiye'de bu kavramın yeterince bilinmemesi ve yetersiz inovasyon kapasitesi sonucu ortaya çıkan çevre odaklı bakış açısı dışındaki eko-verimlilik ilkeleri bu alanda yetersiz uygulama ile sonuçlanmaktadır. Bu tez kapsamında, öncelikle eko-verimlilik kavramı tanımlanmaya çalışılmış, uluslararası düzeyde tanımları ve amaçları belirtilmiştir. Bu hedefler, bu tez kapsamında geliştirilen bir performans ölçüm aracı olan eko-verimlilik olgunluk gridi'nin kısımlarını ve metriklerini oluşturmak için şirket sürecine uygun kategoriler altında gruplandırılmıştır. Geliştirilen araç, uzman kişilerden alınan geri bildirimler ile doğrulanmıştır. Tezin uygulama bölümünde ise, geliştirilen aracın geçerli olup olmadığının kontrolü için farklı sektörlerden üç ayrı firmada vaka analizi çalışması gerçekleştirilmiştir. Bu tezin, eko-verimlilik gibi mevcut bir alanda şirketlere rehberlik eden bir ölçüm aracı sağlıyor olması çalışmanın motivasyonunu oluşturmakta ve literatürdeki önemini ortaya koymaktadır.

Anahtar kelimeler: Eko-verimlilik, ar-ge ve inovasyon yönetimi, olgunluk gridi

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CHAPTER ONE

INTRODUCTION

The rapid decline of non-renewable resources and environmental values brought by technological and industrial developments, which have reached a dizzying pace in the last fifty years of the 20^{th} century, is accelerating today. Along with the permanently increasing amount of wastes and cost of treatment in parallel with the increasing environmental awareness of the public, the institutions and sectors that produce products and services have been directed to search for cheaper solutions to this problem. Additionally, while environmental awareness has been getting improvement in the last 20 years, particularly in developed countries, eco-efficiency principles prefer products and processes designed as less damaging to the environment in the course of production, use and post-use.

The studies that have been started after environmental based, more efficient use of the raw materials that have become waste without conversion into a useful product in the production process can prevent these losses and reduce waste production at the same time. Some intensive approaches to increase productivity in manufacturing and service sectors, replace raw materials used for production by less hazardous equivalents to the environment, and decrease water and energy requirements during production and use. The result is waste reduction, recycling, reuse, more responsive design of products and services, etc. The researches on the subjects have increased rapidly and the "eco-efficiency" approaches have begun to take the place of "pollution control" approaches (Demirer, 2003).

Within the studies carried out for the eco-efficiency approach at both national and international levels, it is said that the improvements to be made for more efficient use of input in production processes will both reduce raw material losses and minimize waste production (Kabongo & Boiral, 2017). Moreover, some eco-efficiency approaches have been emerging to increase productivity in service sector as well (Strasburg & Jahno, 2017). In 2004, current pollution control and eco-efficiency approaches in Organization of Economic Cooperation and Development (OECD) countries were compared within one of the studies of the European Economic Research Center (European Center for Economic Research) in Germany. As a result, it was understood that there are many studies in this field and strategies developed by the aim of spreading eco-efficiency applications in developed countries, especially in France and Japan (Frondel, 2007). In Turkey, while a pioneer project about establishment of a National Eco-efficiency Center is carrying by General Directorate of Productivity, the Project is also supported by both Scientific and Technological Research Council of Turkey (TÜBİTAK) and Technology Development Foundation of Turkey (TTGV) (İzmir Development Agency(İZKA), 2012).

All of the mentioned actions for eco-efficiency integration by the companies are directly linked to innovation management processes. Today, companies must be able to handle with competitive business environment to carry their profits one step ahead from their competitors and they can survive. This development can just be obvious with innovative actions. Trott (2005) defines innovation as a management process generating idea, developing technology, producing a new product, process or equipment and marketing. In this case, it is important that the scope of the innovation should be exactly defined due to companies' goals and business activities to integrate with eco-efficiency. Within this thesis, a maturity grid for eco-efficiency is proposed to assess current innovation performance and measure R&D and innovation capacity of different companies among all sectors at initial based. It is developed based on the descriptions of each type of innovation to make it applicable for each process.

Remainder of this thesis is organized as follows: problem definition and thesis structure, eco-efficiency, maturity grid/model, methodology, application and conclusion and discussion chapters. Scope and aim of the thesis are presented in Chapter 2. Literature review about eco-efficiency concept and its indicators are given in Chapter 3, and both literature review and development framework of maturity grid/model are presented in Chapter 4. Chapter 5 represents methodological framework and steps of the thesis and then, Chapter 6 performs application part. Finally, conclusion of this thesis and future directions are given in Chapter 7.

CHAPTER TWO
PROBLEM DEFINITION AND THESIS STRUCTURE

Industrial innovation covers both radical and incremental technological developments (Trott, 2005). Even if it is managed for a product or process, first of all, it must start with the innovative knowledge and making systematic improvements for its application in current system. Table 2.1 illustrates a typology of innovations which cites the scope of this thesis by innovation management aspect.

Table 2.1 A typology of innovation (Trott, 2005)

Type of Innovation	**Example**
Product innovation	The development of a new or improved product
Process innovation	The development of a new production process such as Pilkington's float glass process
Organizational innovation	A new venture division; a new internal communication system; introduction of a new accounting procedure
Management innovation	TQM (total quality management) systems; BPR (business process re-engineering); introduction to SAPR3
Production innovation	Quality circles; just-in-time (JIT) production system; new production planning software
Commercial/marketing innovation	New financing arrangements; new sales approach, e.g. direct marketing
Service innovation	Internet-based financial services

If this table match with the scope of this thesis, each type is already covered but examples are specified into common aspects as:

Table 2.2 Modified typology under the scope of the thesis

Type of Innovation	**Example**
Product innovation	Application of product life-cycle analysis, cost-effectiveness approaches to minimize environmental impact
Process innovation	Application of recyclability methods, designing overall process to optimize natural resources consumption
Organizational innovation	A new eco-efficient organizational system, collaboration of teams working on creating eco-efficient methods within the company

Table 2.2 continues

Management innovation	A new financial and managerial systems supporting to integrate with eco-efficiency, new marketing plans and a financial management system
Production innovation	A new production system based on eco-efficiency metrics
Commercial/marketing innovation	New financial monitoring and forecasting methods, comprehensive KPIs, benchmarking methods to understand cost drivers
Service innovation	Proactive customer interaction and stake-holder involvement system in decision-making

According to up-to-date studies, there is a strong relationship between innovation stimulus and innovation capacity which can be obviously shown as well as it is between innovation capacity and innovation performance (Prajogo & Ahmed, 2006). This result shows that there is a linkage between three innovation metrics which means that if a company desires to improve innovation performance, it should define factors such as R&D at first. Figure 2.1 illustrates this linkage below.

Figure 2.1 Innovation stimulus, capacity and performance (Prajogo & Ahmed, 2006)

Innovation process is divided into two different linear models which is shown in Figure 2.2 and Figure 2.3 as technology push and market pull systems. Technology push model encourages the production process developed by ideas of technologists, and then marketing will occur to promote product, process or service to customers.

Figure 2.2 Technology push innovation model

Moreover, if the innovation is represented as customer-driven due to the company's goals, marketing initiates innovation process to create ideas about new product, process or service development.

Figure 2.3 Market pull innovation model

For the purpose of this thesis which aims to measure R&D and innovation capacity in eco-efficiency, technology pull system is indicated as an innovation process model that aims to make actual processes capable for eco-efficiency. Marketing phase is evaluated not only based on customer, but also developing company's own innovation model enhancing other companies' models at the beginning of innovation process. This phase can also encourage collaboration between companies.

2.1 Problem Definition

An effective R&D process management has a direct relationship between product or services supplied by organization and organizational operations (Gann, 2000). New products, processes and services are created from production and service operations so, strong innovative developments can arise from understanding innovation capacity and measuring operations (Popadiuk & Choo, 2006).

Under the consideration of all of the eco-efficiency implementation reasons mentioned in Chapter 1, it is necessary to create awareness towards eco-efficiency concept for making sustainable applications of it. To fulfill this aim, process innovation should be implemented due to eco-efficiency metrics. Therefore, four main aspects were defined to properly group all of the business processes which are excepting sector-specific processes as follows: environmental, operational, financial and managerial. This thesis mainly aims to increase R&D and innovation capacity by managing process innovation under those defined aspects in eco-efficiency and create awareness about the importance of developing eco-efficient processes in both industrial and academic fields.

In literature, process innovation has gained less attention than product innovation on R&D based innovation management (Dziallas & Blind, 2018). Researchers commonly believe that it is caused from conceptualism of process innovations (Ringberg, Reihlen, & Rydén, 2018). While product innovation result in a visible and measurable product, process innovation results in re-designed operations or new technological integrations (Trott, 2005). Even if process innovations cannot be easily measured without creating a systematic approach or method covering overall production system, it increases productivity level of the companies in today's competitive advantage (Neely et al., 2000).

Additionally, the most important part of innovation management is designing operations and making them sustainable by considering customer satisfaction, business activities of competitors, new technologies and inventions in production processes. However, most of the companies still does not manage their processes eco-efficiently based on a continuous improvement framework. They need a systematic guide to achieve environmental goals and make sustainable developments in the environmental performance of their products and processes (Pigosso, Rozenfeld & McAloone, 2013). Litos, Gray, Johnston, Morgan, & Evans (2017) presents a study that develops a maturity-based improvement method for eco-efficiency in production system. Although the objective of both this study and this thesis is concurred at the same point, developing eco-efficiency maturity grid will provide an opportunity to assess not only production systems, but also other business processes such as operational, financial and managerial, and evaluate them holistically in a company. Hence, this thesis has a source of motivation to support eco-efficiency-based innovation management with process improvements and its adoption to business operations by redesigning current systems, implementing new methods under eco-efficiency objectives. The methodology is defined as developing a guidance tool which is an eco-efficiency maturity grid to assess process performance and benchmark current processes for understanding which is insufficient to achieve process innovation within whole system.

2.2 Thesis Structure

This thesis has seven main chapters which are illustrated in Figure 2.4. In Chapter 1, studied problem, scope of the thesis and methodology in this study are presented. Chapter 2 provides detailed problem definition which is related to R&D and innovation management for eco-efficiency in production systems and an organizational flow of the study as a thesis structure as well. In this section, types of innovation models are presented as a table and then each type is matched with the objectives of this study under general eco-efficiency metrics. On the basis of innovation models, application of process innovation is indicated as the core innovation strategy to develop R&D and innovation capacity in eco-efficiency within the study. Technology push innovation model is also represented as suitable model for process innovation management because, it is based on integrating with new eco-efficient methods and technologies which supports sustainability on production processes.

In Chapter 3, first of all, the concept of eco-efficiency is presented and its importance and objectives in both environment and production aspects are also given. Next, historical development of eco-efficiency concept according to global movements, organizations and studies are illustrated as a table by years within this section. Main definitions and objectives of eco-efficiency by some international, non-governmental organizations and government are also mentioned. Both national and company level examples of eco-efficiency implementation are examined and implementation steps are constructed in two separated flowcharts in this section.

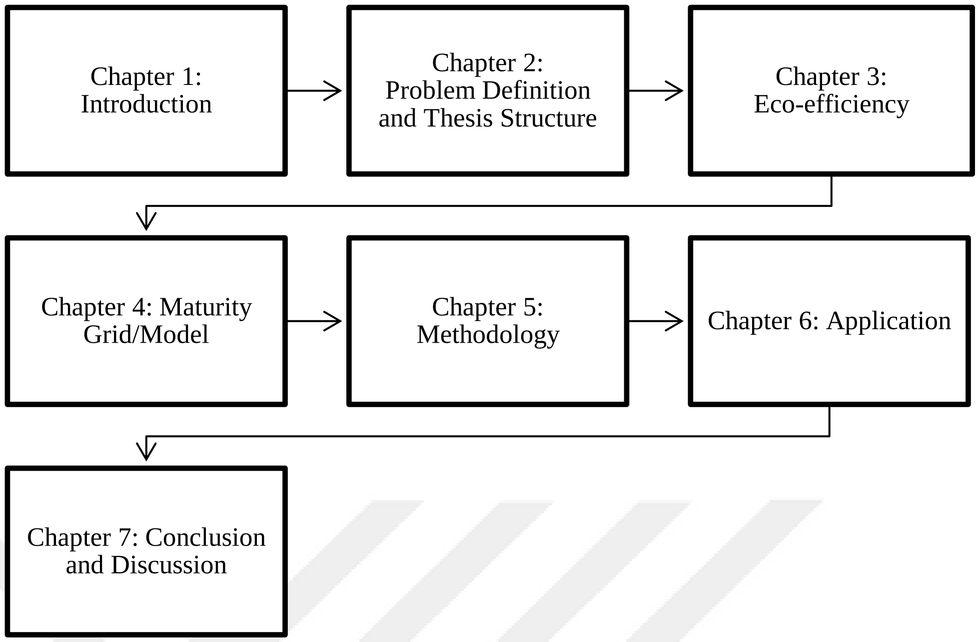

Figure 2.4 Structure of the thesis

Within the concept of eco-efficiency, indicators for measurement of eco-efficiency were selected as eco-efficiency metrics that are suitable for all sectors and business processes in literature. In this case, generic indicators to date defined by globally excepted organizations and studies were identified and illustrated in tables. Additionally, generic indicators from the most cited and core studies in literature were separated into tables under four main categories defined in previous section within the last part of Chapter 3.

In Chapter 4, maturity grids available in the literature are given. First, the maturity grid was defined and its objectives were specified. Then, it was aimed to give an idea about which types of models will be appropriate for the purpose of this study.

Chapter 5 includes the development of a maturity grid based on eco-efficiency objectives. At the end of this process, which is realized in three different steps as planning, development and evaluation, it is aimed to present a performance assessment tool that can be applied in every sector. In the planning phase of the model, a flow chart is presented first. Each development step is included in the flowchart which is formed after the decision on which type of maturity grid is to be developed with a comprehensive literature survey. After deciding on the purpose, scope and success criteria, main and sub-application areas of the grid, the levels of the grid were also defined. Descriptions were formulated for each level for each eco-efficiency metric so that the model development phase was completed. In the last step, verification of the grid was approved by experts' feedbacks and the grid was revised at the end.

In Chapter 6, case studies which are the validation phase of the developed eco-efficiency maturity grid are presented. According to the performed eco-efficiency metrics determined by the literature review, three different sectors which have priority in the implementation of eco-efficiency were selected as textile, packaging and wood industry. A pioneer company was selected for each sector and the grid was answered by process managers/engineers during face-to-face interviews. At the end of this case study design and application process, both the eco-efficiency maturity grid was assessed to understand its validation and the maturity level of each eco-efficiency metric was measured for each case company.

At last, Chapter 7 gives the conclusion of the overall results and discussion of them, and presents a future direction of this study.

CHAPTER THREE
LITERATURE REVIEW

3.1 The Concept of Eco-Efficiency

Eco-efficiency concept is represented as the provision of more products and services, or more economic and environmental efficiency with less energy and less natural resources. In this context, emphasis of this concept has been placed on productivity, profitability and competition to address the priorities of business circles. By the concept of eco-efficiency, productivity can be increased, environmental efficiency and economic returns can be obtained both in industry and services sectors in different size and activity areas.

Eco-efficiency refers to the prevention of environmental impacts in the source and requires that on contrary to pollution control approaches that try to avoid environmental problems after they occur, implement environmental issues such as industrial, urban, agricultural as a parameter in planning processes. Pollution control admits pollution as an inevitable consequence of design and production processes and it adds significant cost to organizations as pollution tries to solve this problem after it emerges. However, eco-efficiency provides decrease in production costs as well as increasing in environmental performance of companies with the approaches of resource efficiency, prevention of pollution sources, environmentally friendly products.

Nowadays, environmental issues for companies do not only come from environmental legislation pressures and additional costs for environmental protection, they also convert to reduction of raw materials, water and energy consumption, reduction of waste amount, recovery of waste including minimizing production and waste disposal costs, increasing workplace and worker safety etc.

One of the main objectives of eco-efficiency which is increasing process efficiency reduces energy, natural resource and raw material consumption and they are directly linked to operational efficiency for a company. Besides, producing of products with less energy, natural resources and raw materials consumption reduces product cost and increases profitability level in business area. Improvement of the production processes can supply the improvement of working environment to come up with the better quality and the consistency of the product.

3.1.1 Historical Development of Eco-Efficiency Concept

Since the beginning of the 20^{th} century, the concept of eco-efficiency has been reflected in the literature as “ecological efficiency”. In this period, the negative effects of industrialization have started to be felt and scientific findings have realized to reveal the important claims taking into account this problem (Zhelyazkova, 2016). Since the 1990s, the concept of eco-efficiency has been on the agenda of both developed and developing countries. However, this concept has been accepted by more enterprises in recent years, and more advanced application approaches to eco-efficiency have started to emerge.

Table 3.1 illustrates the historical process of the development of eco-efficiency concept according to global organizations, studies and movements. The definitions of eco-efficiency are given as titles in this section of the thesis.

Table 3.1 Distribution of eco-efficiency definitions by years

Global organizations, studies and movements that talk about the concept of eco-efficiency	**Date**	**Source**
Silent Spring	1962	(Carlson, 1962)
Limits to Growth	1972	(Meadows, 1972)
United Nations Conference on Human Environment	1972	(UNEP, 2002)
Pollution Prevention	1975	(Ochsner, Chess, & Greenberg, 1995)
Environmental Movement	1980-1990	(Carl, 1981)
Brundtland Commission Report	1987	(Bacher, 1987)
World Business Council of Sustainable Development	1992	(Schmiedheiny, 1992)
United Nations Conference on Environment and Development	1992	(UNEP, 2002)
Factor 10 Club	1994	(Srinivas, 2015)
Factor Four	1998	(Srinivas, 2015)
World Summit on Sustainable Development	2002	(UNEP, 2002)
1^{st}, 2^{nd} and 3^{rd} International Eco-efficiency Conference	2004/2010	(UN-TRUST IN, 2010)
UNIDO Eco-efficiency Program	2008-2011	(İZKA, 2012)
United Nations Environment Program Eco-Innovation Project	2012-2017	(UNEP, 2012)

Silent Spring (1962)

This book is written by American biologist Rachel Carson who researches the human-based impacts on environment. Silent Spring is an important book to create awareness of the negative consequences of using pesticides and support the environmental movement (Carlson, 1962).

Limits to Growth (1972)

Donella H. Meadows (1972) presented a research which aims to show an intensive attention that natural resources are getting to be exhausted with attract pace because of the economic growth and within the next decade, the planet would be reached its growing limits. In other words, this growth would be coming up with an unpredictable and uncontrollable decrease in both population and industrial capacity (Meadows, 1972) .

United Nations Conference on Human Environment (1972)

During this conference in Stockholm, Sweden, required rights for a healthy and productive environment was discussed and importance of efficient use of resources to accelerate economic development was highlighted (United Nations Environment Programme[UNEP], 2012). In another conference in 1975, the significance of environmental protection was emphasized. On the other hand, negative sides of human impacts have begun to dramatically appeared and it has been becoming explicit that environmental-friendly technologies would provide much more benefits both for environment and producers instead of negative and costly consequences in the following years.

Pollution Prevention (1975)

This approach suggests that pollution prevention should has been taken into first place of priority rather than pollution control. In this case, the US manufacturer 3M presented its program called “Pollution Prevention Pays Program (3P)” to prevent pollution at source. In first year of the project, the company saved more than 800 million dollar (Ochsner et al., 1995).

Environmental Movement (1980s)

When there was an increasing awareness of the consumers against the negative effects of the products on the environment, this movement has started to gain momentum since the 1980s. As an example, “Union Carbide” pesticide factory in Bhopal, India, was faced with a poison gas leak in 1984. At that time, society questioned the roles and responsibilities of business by considering this tough break (Carl, 1981).

The Brundtland Commission Report (1987)

In 1987, Brundtland Commission published a report entitled “Our Common Future” which aims to review the existing perspectives based on humanity and to propose new solutions for the development of humanity. The commission also presented the formulation of sustainable development and represented as an important term. The term answers the needs of future generations and it is the most widely used term to date (United Nations[UN], 1987).

World Business Council for Sustainable Development (WBCSD, 1992)

The WBCSD firstly introduced the term of eco-efficiency in 1992. According to its definition, eco-efficiency is expressed on the basis of the relationship between environmental performance and economic benefit. In the same year, Stephen Schmidheiny, a Swiss businessman, published a book entitled “The Changing Course” in WBCSD which was explaining this concept in detail (Schmidheiny, 1992).

United Nations Conference on Environment and Development (UNEP, 1992)

At the 1st World Summit, major issues related to environmental protection and socio-economic development have been addressed. The agenda at this summit was designated by the presidents as the Sustainable Development Plan in the 21st century and named as the Agenda 21. The process of Sustainable Development was both on the agenda and the work of the World Environment and Development Commission (Luken & Navratil, 2004).

Factor 10 Club (1994)

In order to reduce natural resource consumption in the world within the scope of Factor 10 Club, international leaders from government, industry, academic and other sectors have proposed ten factors to increase resource and energy efficiency in developed countries. This statement aims to eliminate the marginal relationship policy that targets the use of natural resources while ensuring economic growth (Srinivas, 2015).

Factor Four (1998)

Factor four assumes four-fold increase in resource efficiency with the implementation of existing eco-efficiency methods while the importance of improving the overall quality of life. This concept was introduced in 1998 by the Rocky Mountain Institute in a book and declared as a fundamental economic thought (Srinivas, 2015).

World Summit on Sustainable Development (WSSD, 2002)

The World Summit on Sustainable Development held in Johannesburg, South Africa, emphasized that although globalization continues rapidly in the world, prosperity is not shared equally and that the perspectives of developed and developing countries differ. In addition, the agenda has been contributed to the introduction of the Agenda 21 Program and evaluations have been made regarding its implementation (UNEP, 2012).

1st International Eco-Efficiency Conference (2004)

This conference outlined the operational methods used by measurable eco-efficiency analysis as a measure of decision-making for social eco-efficiency analysis and focused on promoting sustainability (European Union[EU], 2010).

2nd and 3rd International Eco-efficiency Conference (2006/2010)

The theme of the conference, held in 2006, includes “Computational Eco-efficiency Analysis” and the development of the first conference in 2004. The aim of the conference is to better define the concept of eco-efficiency and to discuss the way in which eco-efficiency is implemented in the industry. Discussion of the most effective policies for eco-efficiency applications is another sub-topic of the conference. In 2010, a third conference on “Modeling and Evaluation for Sustainability: Eco-Innovation and Consumption Guidance” was held on the concept of eco-efficiency and its implementation (EU, 2010).

United Nations Eco-Efficiency Program (UNIDO, 2008-2011)

As the most important step taken by the United Nations Industrial Development Organization (UNIDO) at national level and maintaining under the "Emerging Climate Change Adaptation Strategy of Turkey" called "UNIDO Eco-Efficiency Program" was held. Within the program, many achievements have been triggered to raise the awareness, disseminate and implement eco-efficiency, build capacity and make pilot applications (İzmir Development Agency[İZKA], 2012).

The United Nations Environment Program Eco-Innovation Project (UNEP, 2012-2017)

This project is funded by the European Commission to promote eco-innovation with the support of the Technical University of Denmark and to encourage eco-innovation in developing countries. By using the eco-innovation handbook on a database created for the project, companies can gain insight into how to start eco-innovation and review success stories from around the world and eco-innovation case studies (UNEP, 2012).

3.1.2 The Definitions and Goals of Eco-Efficiency Concept

Since the 1970s, the concept of eco-efficiency has been developed by some international organizations, non-governmental organizations and governments. In this section, the main definitions and objectives of eco-efficiency are presented.

World Business Council for Sustainable Development (WBCSD)

In 1992, The World Business Council of Sustainable Development (WBCSD) presented the concept of eco-efficiency with its publication entitled by “Changing Course”. According to this definition, eco-efficiency can be achieved by offering competitive-priced goods and services that meet human needs and increase quality.

The World Business Council for Sustainable Development states that eco-efficiency will gradually reduce ecological impacts and resource density throughout the lifecycle, bringing it to a level appropriate to the world's estimated carrying capacity (Stigson, Madden, Young, Brady & Hall, 2006). In short, the concept of eco-efficiency focuses on producing more goods and services with less waste and pollution, and less resource consumption.

The World Business Council for Sustainable Development defines the main objectives of eco-efficiency as follows:

- Reducing the amount of material and energy used to create products or services,
- Increasing product and service efficiency,
- Reducing the concentration and effects of toxic substances on the environment,
- Improving recyclability,
- Reducing consumption of non-renewable resources,
- Improving product durability and product-life cycle.

Organization for Economic Co-operation and Development (OECD)

The Organization for Economic Co-operation and Development argues that the volume of production/consumption and the environmental impact per unit produced/consumed have an impact on environmental human factors. In this context, various initiatives have been taken at the enterprise, local government and community level to reduce pollution, increase recyclability, get benefit from renewable energy resources, provide efficient resource utilization in product or service production and minimize wastes. The Organization for Economic Cooperation and Development expresses the concept of eco-efficiency as an ecological concept that targets increasing productivity while meeting human needs (Anon, 1996). According to this definition, eco-efficiency is a rate in which the output (the total value of the products or services) is expressed as the share and the input (the sum of the environmental impacts created by the company) as the denominator.

Global Development Research Center (GDRC)

According to the Global Development Research Center, businesses can create more goods and services for technological and process changes. At the same time, with eco-efficiency studies involving environmental-oriented technological innovations and process changes, it can create more value both in the production process and throughout the life cycle of the product or service by reducing resource consumption and environmental impacts (Srinivas, 2015).

The concept of eco-efficiency defined by the Global Development Research Center highlights the following main objectives:

- Reducing raw material, water and energy consumption,
- Reducing environmental wastes and pollution levels,
- Improving product or service life by taking into account life cycle principles,
- Improving the recyclability levels of products or services,
- Improving service efficiency.

European Environment Agency (EEA)

The European Environment Agency defines eco-efficiency as a strategy that aims to create an environment of greater prosperity while at the same time preserving the natural environment and establishing an adequate link between economic activities and benefiting from nature for the fulfillment of human needs by considering the accessibility of the environment for both present and future generations. . The main eco-efficiency indicators identified by the European Environment Agency are: observing air and water quality, preserving nature and living diversity, natural resource and energy consumption, soil and chemical use (European Environment Agency[EEA], 1999).

ISO/DIS 14045 Environmental Management Standards

ISO/DIS 14045 is a tool to manage eco-efficiency through product systems that quantitatively address the environmental impacts of the product-life cycle and offers it as a measure of operational value, as well as through the product systems that begin with raw material supply and result in waste disposal at the end of product life (EU, 2010). Therefore, it evaluates both product and production processes together during eco-efficiency assessment.

The main objectives of eco-efficiency as determined by all these globally recognized organizations are summarized in Table 3.2.

Table 3.2 Summary table of eco-efficiency objectives defined by global organizations

	WBCSD	**OECD**	**GDRC**	**EEA**	**ISO/DIS 14045**
Reduction of natural resource consumption and land use	+	+	+	+	+
Reduction of the amount of material, water and energy used	+	+	+	+	+
Reduction of waste, pollution and greenhouse effect	+	+	+	+	+
Reducing human impact on the environment				+	
Increasing service efficiency	+	+	+		+
Decreasing the amount and density of toxic substances	+	+		+	+
Improvement of recyclability	+	+	+		
Tending to use of renewable energy resources	+	+			
Increasing product durability	+				+
Extending the product/service life and improving its features			+		+
Reduction of using coal, oil, gas and mineral		+		+	

According to the table, it is seen that the most frequently referred objectives in the scope of eco-efficiency are the reduction of natural resource consumption and land use, the amount of material, water and energy used, and the reduction of waste, pollution and greenhouse effect. As a result, it is understood that the primary purpose of the eco-efficiency application is to reduce the environmental impacts.

3.1.3 Implementation Steps of Eco-efficiency

It is possible to investigate the level of production and service processes on the environment and to evaluate the process-based activities by means of eco-efficient applications. In addition, organizational, financial and environmental profiles can be developed by evaluating the outputs of the eco-efficiency implementation process. The main steps in the implementation of eco-efficiency in this part of the thesis are presented at both national and company levels.

3.1.3.1 Implementation Steps of Eco-efficiency at National Level

When the examples of various countries are examined (Luken & Navratil, 2004; UNEP, 2012; Verfaillie & Bidwell, 2000), the steps of implementation of eco-efficiency in a country have generally started with the formation of concept consciousness: to provide awareness about eco-efficiency and to build capacity for implementation, to determine the interactions between stakeholders and stakeholders, to establish information sharing networks and to establish necessary collaborations (Yedla & Park, 2017), to support the implementation it continued with the creation of financial mechanisms (Kosonen & Nicodeme, 2009) and transformation into political reforms (Sakai et al., 2011). In Figure 3.1, these steps are given as a flow diagram.

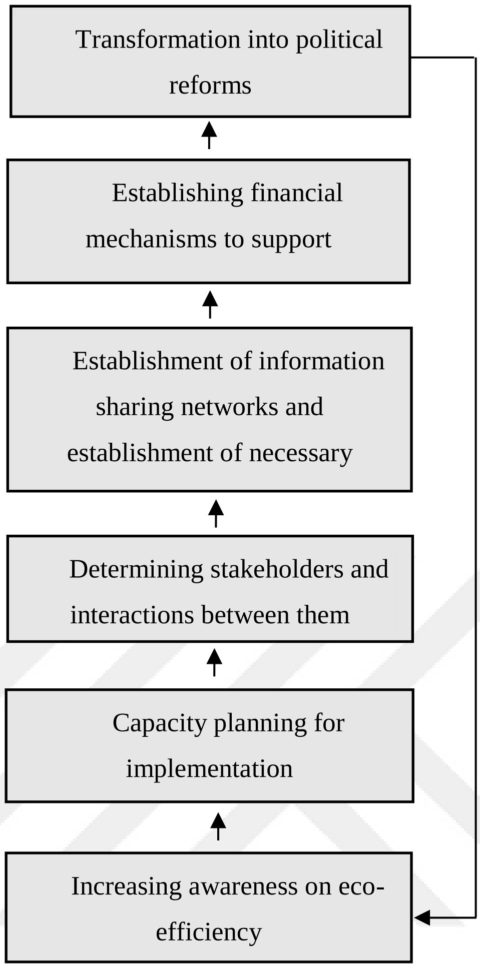

Figure 3.1 Implementation steps of eco-efficiency at national level

It can be understood from the figure above, when the process is developed as a natural process and the highest level of participation and support is achieved at the national level, while the eco-efficiency practices are carried out, the process firstly starts from the bottom upwards with the formation of social awareness. However, this process can sometimes develop from top to bottom, instead of flowing from bottom to top because of local, cultural reasons (Ghisellini, Cialani & Ulgiati, 2016).

Since the countries will adopt the eco-efficiency approach in the most appropriate way to their local structures, the implementation steps of the eco-efficiency approach at the national level and the flow direction of the process may vary from country to country. In countries such as European Union countries, America, Korea, Japan, China and Vietnam, there are studies on the development process of national policies on resource wasting, reuse, recycling and waste management, which underlie eco-efficiency studies (Sakai et al., 2011).

3.1.3.2 Implementation Steps of Eco-efficiency at Company Level

While eco-efficiency practices for industrialists are generally due to increased environmental legislation pressures and additional costs for environmental protection, this concept includes reducing raw material, water and energy consumption, reducing waste, recovering waste and minimizing production and waste disposal costs. It provides important contributions to enterprises by gaining an identity which covers various possibilities (Atalay, 2012).

Increasing process efficiency, which is one of the main targets of eco-efficiency, decrease energy, natural resources and raw material usage, increases the operational efficiency directly and adds value to the operation. By improving the production processes, both the working environment efficiency and the product quality can be improved. In this context, the eco-efficiency implementation process should be planned taking into account the main objectives of the enterprise. This process starts with the identification of eco-efficiency objectives on the basis of the company (EEA, 1999) and respectively: determination of system boundaries and indicators for the implementation of eco-efficiency (Ferrer, Negny, Cortes, Lann & Marc, 2012), identification of strategies for implementation process and assignment of targets, integration and tracking of defined indicators in the process (EU, 2010), follow-up and evaluation of the outputs Revision of defined indicators, decisions taken and targets. In Figure 3.2, the eco-efficiency implementation steps at the business level are given as a flow diagram. As seen, unlike the implementation of the eco-efficiency implementation which moves from the bottom up at the national level, the implementation process at the enterprise level starts with the adoption of the senior management at the strategy level and moves towards the operational level.

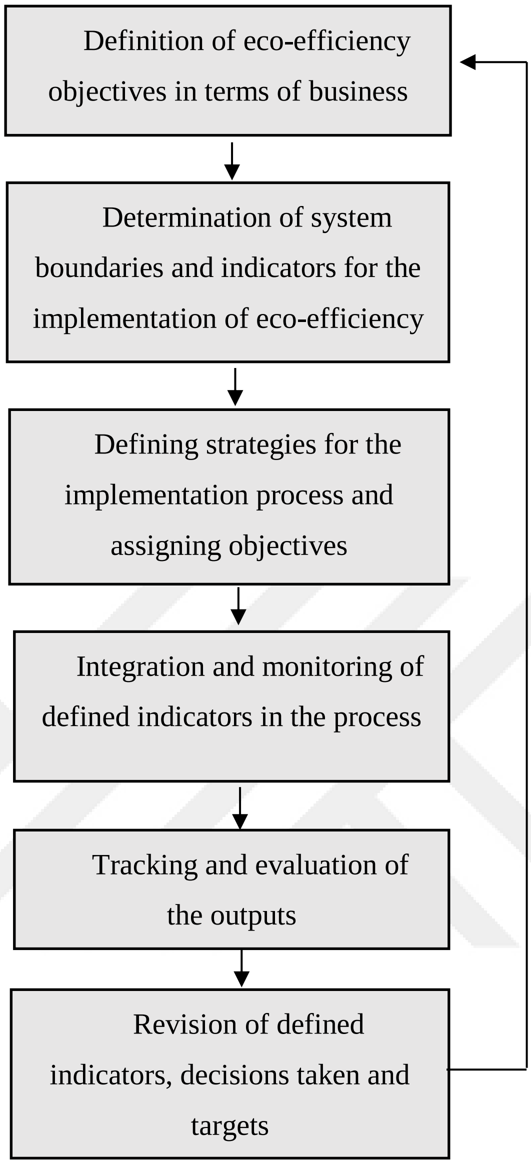

Figure 3.2 Implementation steps of eco-efficiency at company level

The eco-efficiency studies in the world have been implemented under different names for nearly 20 years. In this period, significant gains have been made in many industrial sectors by using different tools. These studies were conducted in cooperation with universities and relevant international institutions. However, sectoral distribution of the eco-efficiency studies have made significant contributions to the literature. In Table 3.3, sectoral distribution of eco-efficiency is given and total number of studies for each sector in literature is presented.

Table 3.3 Distribution of eco-efficiency applications based on sectors around the world (İZKA, 2012)

Sector	Number of applications
Food and beverage products production	50
Metalsmith industry (without machine and equipment)	50
Chemical materials and products production	42
Furniture production	32
Electrical machine and devices production	28
Coach, trailer and semi-trailer production	18
Textile production	14
Non-metallic mineral products	8
Wood industry	5
Tannery industry	4
Base metal industry	4
Printing and publishing	3
Plastics-rubber products production	3
Paper and paper products production	2
Machine and equipment production	2
Other transportation vehicles production	2

Some examples that reflect the results from the eco-efficiency application are given below (Stigson et al., 2006):

1. With eco-efficiency applications, STMicroelectronics is projected to save $ 38 million per year from energy costs and $ 8 million a year from water costs, and the company's total savings are estimated to reach $ 900 million in a decade.
2. United Technologies Corporation saves $ 50,000 per year by managing test cells, waste streams and underground storage tanks.
3. Dupont saves 17 million dollars a year by reducing energy consumption to one third. At the same time, greenhouse gas pollution was reduced by 50% per product cost. Business, resource and productivity growth has led to a savings of $ 400 million in 2000.
4. SC Johnson reduced production waste by 50% in five years and increased production by the same amount. The company's annual cost savings is more than $ 125 million.

Businesses that develop and implement eco-efficiency strategies not only gain the advantage of being in compliance with today's regulations, but also prepare themselves for legal regulations and environmental management standards that will increase the future sanctions. Thus, eco-efficiency practices enable enterprises to make their image stronger, enabling them to capture new market opportunities with products that meet higher standards.

3.1.3.3 Measurement of Eco-efficiency by Using Indicators

Eco-efficiency combines two dimensions of environment and economy to measure the environmental influence of a product or service. This measurement is referred by a ratio both for evaluation of their value and environmental impact created by operational processes (Hahn, Figge, Liesen, & Barkemeyer, 2010). In this case, monetary value is represented as value added or profit, and environmental impacts as wastes, resource/energy consumption and emissions (Burritt & Saka, 2006).

$$\text{Eco-efficiency} = \frac{\text{Value of a product}}{\text{Environmental impact of a product}} \tag{3.1}$$

The ratio of eco-efficiency (Ichimura et al., 2009)

Even if eco-efficiency ratios are useful to implement in different processes like production, product development, marketing and customer; however, they may need to be specifically constructed for each different process. When the relevant studies are examined, it is suggested that the starting points in the selection of indicators should be formed from long-term goals, principles, strategic and tactical plans (Uçmuş, 2004). For example, even a producer may identify an eco-efficiency indicator for a product as kilogram per kilojoule of energy used, it may not be fit for a product manager and he/she could calculate an indicator based on monetary value such as total sales per kilojoule of energy used.

The calculations given as examples of eco-efficiency ratios result in impact intensity ratios which mean positive performance improvement is affected by declining intensity ratio. However, accepted information from the literature contains both efficiency and intensity ratios as the same. GRI, WBCSD, UN-ISAR and the other international groups working on eco-efficiency indicators calculate similar ratios by using a similar methodology. Although energy consumption, amount of raw material and wastes are the most common environmental items, sales rate and value-added costs are the most commonly presented economic item referred as an environmental item based on production.

Even many studies suggest generic indicators and measurement metrics, most of them are basic components used in the eco-efficiency ratios like such kind of indicators mentioned above. This perspective limits the different approaches to measure eco-efficiency level of a process (Zhang, Bi, Fan, Yuan, & Ge, 2008). Therefore, there is a need for measuring eco-efficiency based on business-specific indicators at company level. This study aims to meet this need via developing a performance assessment tool which is eco-efficiency maturity grid and contribute the literature.

3.2 Eco-efficiency Indicators

To measure eco-efficiency, indicators are essential tools for monitoring and improving performance of businesses. In business environment, companies need to trace and document their performance, set targets to make necessary improvements on their processes, identify financial situation such as profit, net savings for measuring eco-efficiency performance. In this case, indicators may be helpful to meet companies' need and understand environmental performance of products for both producers and customers at the same time. They can also provide managers the ideas about the ways of creating more eco-efficient and sustainable business processes.

According to literature review, generic indicators are presented across every kind of businesses. However, many of them cannot be implemented to all business processes because of different operations and products. Therefore, all business can use the defined indicators but indicators may not have equal importance for all businesses (Verfaillie et al., 2000).

Additionally, ecological footprint and sustainability measurement become easier by using indicators. As another point, customers can also understand the environmental performance of the products by using eco-efficiency indicators. Eco-efficiency ratios can be helpful to show product performance for single products or market segments to their users.

3.2.1 Generic Indicators at Company Level to Date

Globally applicable indicators among all businesses are many in literature. It is predicted that operational and product differences are separated as the value-based and environmental-based aspects that do not allow to be figured out with common indicators. In addition, inadequate methods for eco-efficiency measurement create also the same problem about defining generic indicators or prioritizing specific environmental issues (Verfaillie et al., 2000). Due to this reason, globally accepted studies of the top international organizations and a pioneer article focusing on the determining generic indicators are presented as tables in this part.

UN Economic and Social Commission for Asia and the Pacific (UNESCAP)

Due to UNESCAP, while eco-efficiency indicators consider both economic and ecological goals, they also satisfy to the different environmental problems and sustainability. This global institution divides eco-efficiency indicators into two groups as scope-wide indicators which are covering both economic and sectoral issues, and subject-wise indicators to measure other relevant issues identified by policymakers in UNESCAP (Ichimura et al., 2009). Below table was created based on the two group of indicators which are calculated as intensity indices.

Table 3.4 Table of indicators calculating intensity as value-added divided by cost of environmental impact in eco-efficiency (Ichimura et al., 2009)

		Resource-use intensity	**Environmental impact intensity**
Scope-wise indicators	**Economy-wide indicators**	Water intensity Energy intensity Land use intensity Material intensity	Emission to water intensities Emissions to air intensities Ozone depleting gases emissions intensities
	Sectoral indicators	Water intensity Energy intensity Land use intensity Material intensity Fuel intensity	CO_2 intensity CH_4 intensity (agriculture) Solid waste intensity BOD intensity Wastewater intensity

World Business Council for Sustainable Development (WBCSD)

World Business Council for Sustainable Development (WBCSD) divides eco-efficiency indicators into two groups: generally applicable and business specific (Passetti & Tenucci, 2016). Business specific indicators are more suitable to be defined specifically by different businesses.

In the following Table 3.5, indicators which are related with value creation process based on the company are represented as business specific indicators, and the others are generally applicable according to WBCSD.

Table 3.5 Table of eco-efficiency indicators defined by WBCSD

Product or service value	**Environmental influence in product or service creation**	**Environmental influence in product or service use**
Volume/mass Monetary Function	Energy consumption Materials consumption Natural resources consumption Unintended events Non-product output	Product/service characteristics Packaging waste Energy consumption Emissions during use

Standardized Eco-Efficiency Indicators by K. Müller and A. Sturm

This thesis generates the eco-efficiency indicators by considering to be able to save itself over time, measure the change within company, and comparable between times, companies and sectors. As similar to WBCSD categorization of eco-efficiency indicators, Müller and Sturm (2001) also defines generic indicators as globally applicable indicators by all businesses across all sectors (see Table 3.6). Within this thesis, standardized generic indicators were selected to be sensitive to global environmental problems, a link between environmental problems at the macro level and activities of businesses at the micro level, and directly effective on the environment to measure financial performance after evaluating global studies in literature.

Table 3.6 Table of eco-efficiency indicators defined by Müller and Sturm (2001)

Two-item indicators	Generic indicators
Waste produced/resources used CO_2 emissions/unit of sales Energy purchased/energy costs	Non-renewable primary energy input/value added Water use/value added Global warming contribution/value added Contribution to ozone depletion/value added Waste disposed/value added

3.2.2 Categorization of Eco-efficiency Indicators

By reviewing previous section about eco-efficiency concept, it is clearly shown that environmental efficiency and improving environmental performance are promoted with eco-efficiency applications (Alrazi, De Villiers, & Van Staden, 2015). Besides, eco-efficiency indicators are useful tools to measure the level of eco-efficiency proficiency at processes. Within this chapter, gathered eco-efficiency indicators from literature review are categorized based on some reference articles and studies.

Litos, Gray, Johnston, Morgan, & Evans (2017) states that operational practices, environmental planning and performance assessment, environmental management systems and business strategy are strategic factors of eco-efficiency measurement (Epstein & Roy, 2003). To start from this point, environmental category is firstly defined and generated by identifying global environmental problems from global organizations' published papers such as WBCSD, EEA, OECD etc. Then, identified problems are matched with companies' activities which are common through all sectors such as contribution to ozone depletion, water usage etc. Finally, to assess financial category, generic financial items (sales, value-added etc.) are defined.

By considering both environmental and business specific dimensions, four categories were identified as; environmental, operational, financial and managerial.

All indicators separated into four different categories were indicated after nine most cited studies about generic indicators to date. As seen in Table 3.7, all of the reviewing studies have consensus on defined the most important environmental indicator as energy consumption effect within environmental category. Table 3.8 indicates that the most important indicator in operational category is solid and liquid wastes. In Table 3.9, number of employees, business segments, system boundaries and company size are equally important indicators for companies within managerial category. Table 3.10 shows that net sales and openness to stake-holder involvement in decision making are equally important for companies within financial category.

Table 3.7 Set of environmental indicators

Environmental					References				
Indicators	WBCSD	EEA	OECD	UNESCAP	Litos et al. (2017)	Muller and Strum (2001)	Veleva and Ellenbecker (2001)	Maxime, Marcotte and Arcand (2006)	Passetti and Tenucci (2016)
Energy consumption	+	+	+	+	+	+	+	+	+
Material consumption	+	+	+	+	+		+	+	+
Water consumption	+		+		+	+	+	+	+
Greenhouse gas emission	+	+				+	+	+	+
Ozon depleting substance emissions	+	+				+	+	+	+
Natural resource consumption	+			+	+			+	
Toxic chemicals consumption	+	+		+			+		
Material and product recyclability	+						+		
Heavy metal and eutrophication emissions				+					+
Photochemical Oxidant Creation (POC)				+					
Chemical Oxygen Demand to surface water (COD)		+	+	+					
Land use		+		+					
Product durability	+	+	+	+		+			
Non-renewable energy consumption	+	+							+
Service intensity	+								+
Using biodegradable packaging							+		

Table 3.8 Set of operational indicators

Operational Indicators	References							
	WBCSD	OECD	UNESCAP	Litos et al. (2017)	Muller and Strum (2001)	Veleva and Ellenbecker (2001)	Maxime, Marcotte and Arcand (2006)	E. Passetti and A. Tenucci (2016)
Non-product output	+		+	+		+	+	+
Packaging waste	+		+	+		+	+	+
Solid and liquid wastes	+	+	+		+	+	+	+
Unintended events	+							
Equipment performance				+				
Percent of workers who complete job satisfaction		+		+		+		
Lost time as a result of injuries and illnesses		+				+		
Turnover rate		+		+		+		
Average number of hours of employee training/year	+			+		+		+
Number of collaborated and information sharing networks	+					+		
Number of active methods for process improvement	+							
Rate of satisfied workers for their jobs						+		

Table 3.9 Set of financial indicators

Financial	References				
Indicators	WBCSD	OECD	Muller and Strum (2001)	Veleva and Ellenbecker (2001)	E. Passetti and A. Tenucci (2016)
Net sales	+		+		+
Cost of goods and services			+		+
Energy cost			+		
Value-added	+		+		
Volume/mass			+		
Gross margin	+				
EBIT (Earnings before interest taxes)			+		
Quantity of products or services	+			+	
Rate of customer complaints or returns				+	
EHS compliance costs				+	
Employment opportunities for the local community		+		+	
Number of community-company partnerships	+			+	
Community spending and charitable contributions as percent of revenues		+		+	

Table 3.10 Set of managerial indicators

Managerial	**References**			
Indicators	WBCSD	Litos et al. (2017)	Veleva and Ellenbecker (2001)	E. Passetti and A. Tenucci (2016)
Number of employees	+		+	
Business segments	+			+
Primary products	+			
Major changes in the structure of the company	+			
System boundaries	+			+
Sector environmental sensitivity				+
Company size		+		+

There is an exact difference between an issue/a goal and an indicator. Whether both of them are identified as specifically, indicators must have some dimensions to represent the issue quantitatively. For developing an indicator, four key dimensions must be defined to distinguish it from an issue, goal or parameter. The paper of Veleva & Ellenbecker (2001) presents actual dimensions of the indicators created by Lowell Center for Sustainable Production (see Table 3.11).

Table 3.11 Indicator dimensions defined by Lowell Center for Sustainable Production (Veleva and Ellenbecker, 2001)

Unit of Measurement (Metrics)	Liters, kilograms, kWh, percent, tons, currency, rate, number, hours etc.
Unit of Analysis	Product line, company, supply-chain distribution, life cycle of products/materials etc.
Type of Measurement	Absolute: Total amount of consumption Adjusted: Intensity calculation as total amount/unit of product or services/year, month etc.
Period of Measurement	Fiscal year, calendar year, six months, quarter etc.

In this thesis, the unit of analysis is defined as company through all sectors, type of measurement is selected as absolute, period of measurement is a calendar year but it might be change for gathering sufficient data in additional period.

CHAPTER FOUR
MATURITY GRID/MODEL

Maturity grid provides a flexible assessment way for companies and organizations to measure their current states and define insufficient processes which have to be improved for reaching the industrial goals. Furthermore, it is suitable to determine necessary actions to make an improvement on a specific process or simplify unnecessary actions within the overall system of the company (Rose, 2013). In this chapter, definition of the maturity grid, its literature survey and types are presented respectively.

4.1 Definition and Main Purposes of The Maturity Grid/Model

Maturity grid/model based on capability levels may provide a framework to evaluate current state of systems, predict the future to define improvement actions to implement eco-efficiency as an assessment tool. This tool is constructed as a matrix or a grid covering cells in each level of performance or key activities indicating the extent of capability or maturity and most of the studies state that they are considered not only as an assessment tool, but also as a tool for improvement on systems applied by industrial experts, consultants and academics (Moultrie, Sutcliffe, & Maier, 2016).

There are many maturity models in the literature than the maturity grid. The difference between these two types is that the maturity grid offers a more general methodology than a maturity model because, maturity models are basically designed for a specific purpose. Maturity model is constructed based on the scope and features of defined process to assess its performance. On the other hand, maturity grids aim to be applicable for every sector, to be suitable for evaluating different business processes and to be presented to top performance segments as performance measurement. Therefore, this thesis provides a maturity grid tool to understand how the capabilities of each business process in a production company, to evaluate and to develop an easy-to-use tool for assessing eco-efficiency performance of a process. For this purpose, systematic methodologies for developing capability maturity grid tool was investigated and the capabilities affecting the eco-efficiency performance were identified. In this thesis, measurement of the validity of the model is given in the application part. In addition, it was decided to present the model aiming to improve the R&D and innovation capacity of all sectors and all processes and to develop maturity group.

Maturity grids should be fit for defined goals and implemented due to systematic facilities. To analyze a process, this assessment tool gives a warranty to provide adequate controlling because, it evaluates a specific level of subjectivity. Models may be used to describe the "as is" state of the process, provide prescriptive guidelines on improvement, or compare one process implementation to another (Pöppelbuß & Röglinger, 2011).

When compare the use of a maturity grid with an audit technique, both should reflect the actual proficiency level of a process. Although it should not be implemented as a checklist, it replaces the responsibility for independently and objectively identifying unmitigated risk by auditor or expert, and makes up the potential inadequacy of control. The grid should provide a framework and guide for discussion of governance, risk, and control maturity.

4.2 Types of Maturity Grid/Model in Literature

Maturity grid/model, which is a performance measurement tool, differs according to organizational processes. The most important and first step of an evaluation with maturity grid is to select and integrate the model type that is suitable for the purpose and process. Within the scope of this thesis, the varieties of the maturity model to be applied in the production sector are given in this section.

Quality Management Maturity Grid (QMMG)

Crosby (1979) presented QMMG as an organizational maturity matrix that aims to support businesses for increasing their competitiveness level due to awareness of process capability, measure current maturity of their systems and benchmark with other processes in the same sector. The scope of this type of grid is based on managing quality and providing an individually applicable assessment tool. Levels of the grid are uncertainty, awakening, enlightenment, wisdom and certainty in order.

Safety Management Maturity Grid

It is specifically designed for safety management to understand organization status and take correct actions for improving safety and health conditions within company. On the other hand, it provides better working place to workers due to ergonomic design principles. This type of maturity grid is applied by both individually rating and paper-based at least three people per department. Levels are ordered as uncertainty, awakening, enlightenment, wisdom and certainty (Maier, Moultrie, & Clarkson, 2012).

Process Grid

This grid is specialized for software evaluation and designed applicable for assessment through interviews of product group members. It aims to raise awareness and benchmark an organization's processes relative to each other. For the developing a generic software assessment tool, levels are designed as traditional, awareness, knowledge, skill and wisdom and integrated management system (Rus & Lindvall, 2002).

Project Management Maturity Model (PMMM)

The Project Management Maturity Model creates the opportunity to see the relationship between project management practices and creates an opportunity to measure project performance related to project management. It evaluates as an enterprise-wide project management approach and especially useful in decision-making process (Grant & Pennypacker, 2006). Basically, this maturity model makes progress with steps leading to the desired improvement in order to level at initial process, structured process and standards (level 2), organizational standards and institutionalized process (level 3), managed process (level 4), optimizing process (level 5) (Tahri & Drissi-Kaitouni, 2015).

Berkeley PM Process Maturity Model

With this model that provides a systematic project management process to institutions and organizations, maturity assessment in processes can also be carried out. For example, measuring the current level of maturity for adaptation to a new system that a company wants to integrate into its processes and comparing processes with each other is the advantage of this model. Its primary objective is to implement this methodology among industries with many other mature models, such as new product development or software development (Kwak & William, 2015).

The Information Process Maturity Model (IPMM)

It is very difficult to register data on customers, products, inventory and financial issues, especially for multi-customer corporate companies. As data availability became more difficult to maintain in time, the Information Maturity Grid and data development techniques began to be developed by companies. Although it provides a general model, its main purpose is to increase awareness and compare processes within the company (Mettler, 2009).

The Business Process Maturity Model (BPMM)

The business process maturity model, which helps to achieve mature business processes, is also a measurement tool designed to systematically evaluate and develop the capabilities of an enterprise to achieve perfection. An evaluation of how well an enterprise or process can operate flawlessly, and improving the process can be achieved with the performance measurement tool features of this model (Looy, Backer, Poels, & Snoeck, 2013). Since all these features will meet the objectives mentioned in the problem definition of this thesis, this type of maturity model's feature is adopted to design stages of maturity grid within methodology section of this thesis.

4.3 Generic Purposes of Using Maturity Grid/Model

The main purpose of maturity models is to measure maturity of processes in terms of performance evaluation and to define maturation pathways. In the implementation phase of this model, it is aimed to determine the strategies to discover and eliminate the deficiencies (Pöppelbuß & Röglinger, 2011). The generic purposes of maturity grids are following:

- **Descriptive:** Based on the existing characteristics of a company, the maturity model serves as a descriptive use when evaluated according to the given criteria (Becker, Knackstedt, & Pöppelbuß, 2009).
- **Prescriptive:** If there is a maturity model that shows how to define the level of maturity targeted by a company and what the improvement measures will be, this descriptor says that there is a prescriptive purpose of use.
- **Comparative:** If a maturity model aims to make a comparison between the processes within the enterprise or between different businesses, it serves a comparative purpose.

In this thesis, it is aimed to evaluate how mature an enterprise is in eco-efficiency area with the maturity model to be developed. In addition, performance is evaluated in terms of eco-efficiency integration of internal processes and it is aimed to provide a guiding tool in taking necessary actions.

4.4 Literature Survey about Maturity Grid/Model Applications

The number of maturity model studies in the literature has increased significantly in the last 10 years (Tarhan & Turetken, 2016). It is noteworthy that the business process maturity model practices are becoming more popular than the other types of maturity models.

In this part of the thesis, a systematic literature review based on the maturity model studies between 2000-2017 is presented in Table 4.1. The selected 34 number of studies, which are scanned through Google academic and ScienceDirect, is reviewed based on citation numbers respectively.

Table 4.1 Literature survey about process management maturity grid/model

Year	Author	Objective	Technique	Field
2000	Neely et al.	Provide a guideline to develop performance measurement system design	Process-based approach	Implementation in three action research projects evolving automotive and aerospace companies
2002	Gallagher	Present how operational organizations can get benefit from Capability Maturity Model Integration (CMMI)	Systematic literature review	Implementation of CMMI in operational organizations
2004	Berg et al.	Present a quality and maturity method (QMM)	Systematic literature review, case studies	Evaluating the quality and maturity of R&D in continuous improvement process
2005	Rosemann and Bruin	Develop of a holistic business process maturity model (BPMM)	Delphi studies	Separate studies focusing on further defining and expanding the six core factors within the model
2005	Bruin et al.	Propose basic phases of developing a generic model	Systematic literature review	Evolution of a maturity model in various domains
2006	Strutt et al.	Develop a safety design capability maturity model	Systematic literature review, scoring method	Risk-based decision making in environmental risk management
2006	Grant and Pennypacker	Provide a review of present level of project management maturity	Systematic literature review, benchmarking	Supporting organizational assessment of project management maturity
2005	Adesola and Baines	Describe a research to support the implementation of business process improvement (BPI)	Systematic literature review, Delphi technique and case studies	Development of a generic model-based methodology and integrated process improvement (BPI)
2009	Becker et al.	Develop and propose criteria for development of maturity models	Systematic literature review, case studies	Development and comparison of maturity approaches
2009	Mettler	Argue the typical phases of maturity model development and application	Design science research	Development of a maturity model in organizational engineering domain
2010	Dong-Young and Grant	Recommend a framework for assessing the maturity level of electronic government (e-government)	Systematic literature review	Providing process-based assessments conducted by governments
2011	Pöppelbuss and Röglinger	Recommend a pragmatic framework of general design principles of maturity model	Systematic literature review	Demonstration of various business process management maturity models

Table 4.1 continues

2012	García-Mireles et al.	Investigate and analyze the existing methods and practices for developing maturity models	Systematic literature review	Development of a maturity model for software process management
2012	Moultrie et al.	Present a roadmap for developing maturity grids	Systematic literature review	Managing and improving organizational capabilities
2013	Rose	Provide a guideline on the uses of maturity models, selection and development.	Systematic literature review, case studies	Application of maturity models in assurance or consulting engagements
2013	Looy et al.	Build a decision tool to support Business Process Maturity Model (BPMM) selection process of organizations	Delphi study, Analytical Hierarchy Process, case studies	Development of a decision support tool in business process management
2013	Pigosso et al.	Propose a framework to support eco-design implementation process	Hypothetical-deductive approach, empirical testing	Adaptation of a continuous improvement approach for process improvement
2014	Looy et al.	Present a conceptual framework respecting the traditional business process lifecycle	Cluster analysis, discriminant analysis	Contributing to the grounding of business process literature
2014	Albrecht and Spang	Identify potential effects on an organizational level of project management maturity	Qualitative/exploratory approach, multiple-case studies	Proposing a roadmap for developers of Project Management Maturity Models (PMMM)
2014	Hynds et al.	Develop a maturity model focused on environmental sustainability	Research-on-research, comparison of sustainability ranking systems	Creating an assessment tool to organizations to implement sustainability into New Product Development (NPD)
2015	Kwak and William	Evaluate replicability of project success in Berkeley Project Management Process Maturity Model	Benchmarking project management practices	Accomplishing a higher and more advanced project management maturity
2015	Tahri and Drissi-Kaitouni	Propose a framework for analyzing the project management maturity level in organizations	Systematic literature review	Assessing both dimension or entire organization by a mixed maturity model

Table 4.1 continues

2016	Schumacher et al.	Evaluate the industry 4.0 maturity of industrial enterprises in discrete manufacturing	Becker’s step-by-step process, multi-methodological development approach	Proposing an empirically grounded novel model and implementation
2016	Tarhan et al.	Understand the state of research on business process maturity models	Systematic literature review	Proposing generic models for business process maturity
2016	Moultrie et al.	Report on the development of a Maturity Grid	Systematic literature review, case studies	Improvement on the eco-design of medical devices
2017	Correira et al.	Give insights into methodological issues related to maturity models	Systematic literature review, case studies	Presenting supply-chain maturity models with sustainability concerns
2017	Ormazabal et al.	Provide a model to assess maturity stages on ecological advancement	Integrative multimethod research	Help companies to understand the need for nontechnical elements in the process in environmental management
2017	Allais et al.	Provide a grid enabling the assessment and the improvement of current strategic and operational practices regarding sustainability	Principle back-casting approach	Presenting a tool to support organizational innovation for system sustainability
2018	Kaassis and Badri	Develop indicators suitable for evaluating OHS risk management maturity in industrial SMEs	Systematic literature review	Improve the OHS performance of businesses

As understood after the literature review, despite the increase in the number of maturity model studies focusing on process and performance management over the last decade, the number of process management studies in the field of environmental issues is quite low. For this reason, the main contribution of this study is developing maturity model for process management in the field of eco-efficiency will be developed. This study will both contribute to the environmental study gap in the literature and will support the process innovation studies in the literature since the resulting tool helps identifying necessary process improvement actions or inform new process designs.

CHAPTER FIVE
METHODOLOGY

In previous chapter, maturity grid was interpreted based on literature and it is especially indicated that it is an assessment tool to measure performance of current business processes. Hence, this chapter of the thesis is constructed for development of a maturity grid for implementing eco-efficiency among different production sectors to increase R&D and innovation capacity covering their whole processes.

5.1 Methodological Framework of The Thesis

Maturity grid development process of this thesis was managed under a methodological framework which is presented in Figure 5.1. At the beginning, the problem definition of the thesis was reviewed (see Chapter 2), and then linked with the research objectives in this thesis which are to empirically understand how can both organizational and production systems' maturity be used to increase eco-efficiency awareness, utilizes the development of long-term eco-efficiency implementation methods, and create the sustainability of this concept on the processes. Additionally, a prescriptive guideline is provided by maturity grid tool and internal or external processes within company is benchmarked from immature to mature process.

In development stage 2, suitable maturity grid type was detected due to literature review on maturity grid given in Chapter 4. In this case, business process maturity grid was selected because, it presents a common evaluation framework among any processes such as managerial, financial or production. In stage 3, a proposed framework was created that includes four main phases as: planning, development, evaluation and maintenance. This thesis covers mainly first three phases for grid development process; however, maintenance phase will be evaluated in details to present future directions of the thesis in results and discussion chapter. Within the stage 3, first of all, the specific audience was defined as the user group of the maturity grid, for what purpose it is developed, its scope and success criteria are involved, and then, process areas such as organizational, financial or managerial were indicated and maturity levels were defined for each cell. Cell descriptions in each level of maturity were also formulated. In evaluation phase, validation of the grid was done by considering experts' feedbacks and grid was revised due to gathered opinions. At last phase, conclusions were reported and maturity grid was revisited regularly (Moultrie et al., 2016).

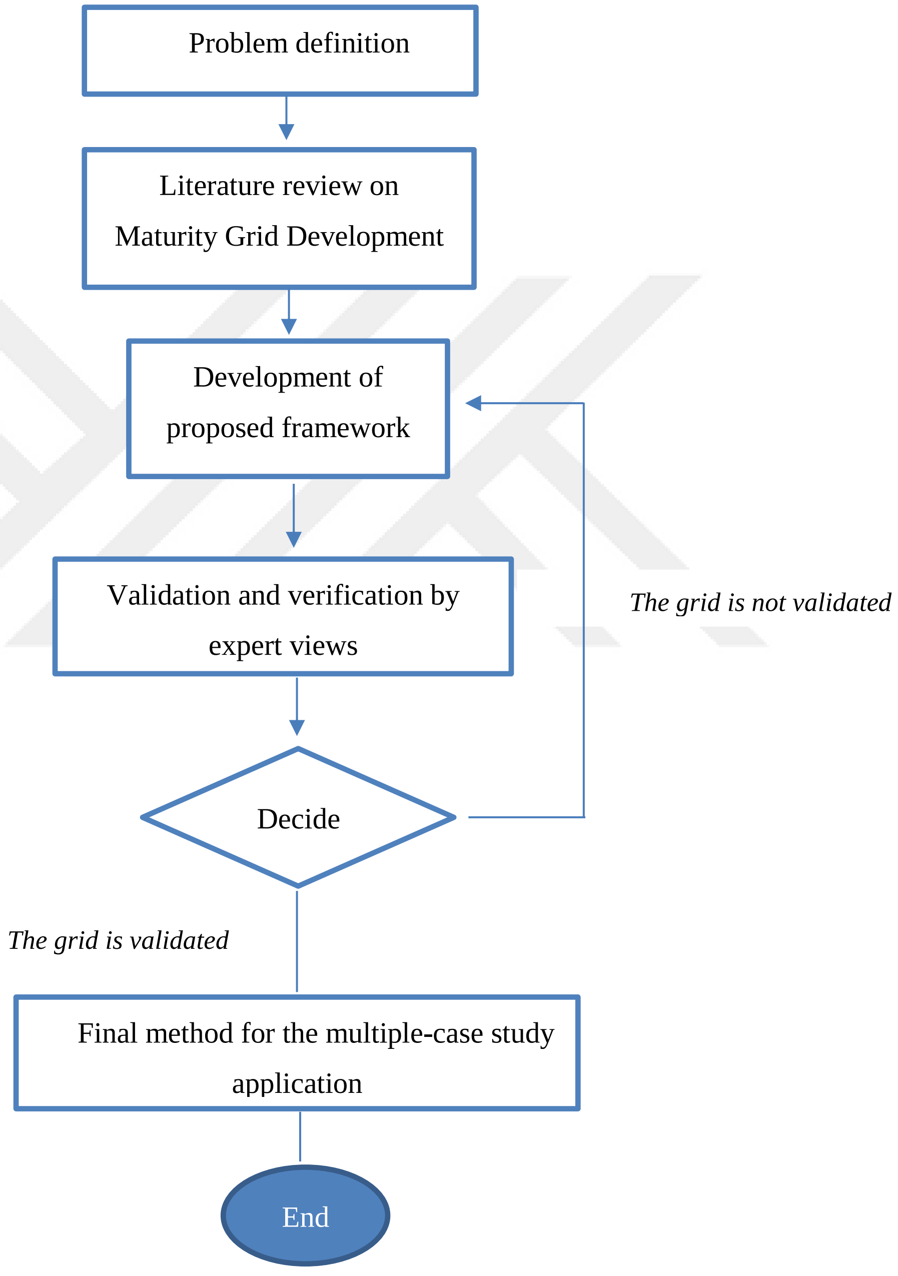

Figure 5.1 Research methodology for development of a maturity grid

After the grid evaluation phase by expert views, the validation of the grid was assessed. If developed grid is accepted as validate by experts, then it can be applicable for application stage of the method. Otherwise, the grid is rechecked and the stage is going back to development stage to revise the proposed framework of eco-efficiency maturity grid development. At the final stage of the method, multiple-case study application was selected within the descriptive study in maturity grid development (Litos et al., 2017).

5.2 Development Framework for Eco-efficiency Maturity Grid

The maturity grid was developed following a development framework (see Figure 5.2) proposed by Moultrie et al. (2016) including four main phases: planning, development, evaluation and maintenance. According to this framework, even if the order of each step is constant, it is possible to repeat and reverse between the steps. In addition, at the final step which is maintenance was supported with case studies within this thesis under application section. For this reason, instead of developing the maturity grid development step, it was considered as a step of verification and validation under this section. Decision points and decision options are defined for each step. In this section, each of them will be mentioned in detail and each will be given a description for the development of eco-efficiency maturity grid.

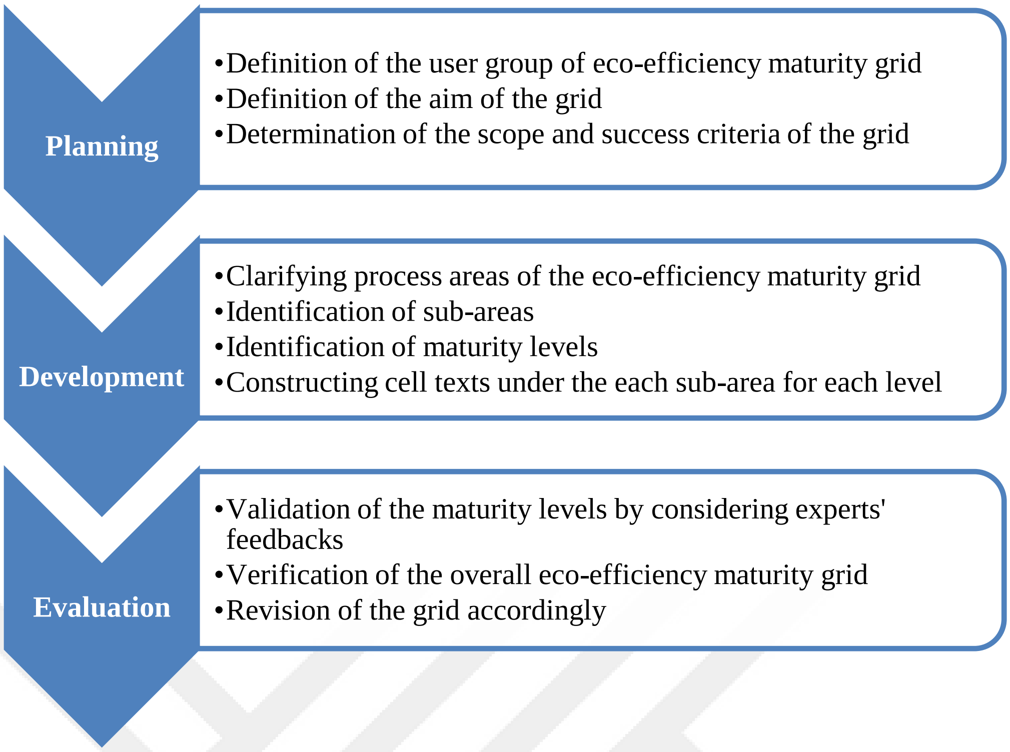

Figure 5.2 Proposed development framework of eco-efficiency maturity grid

5.2.1 Planning of The Eco-efficiency Maturity Grid

User Group

When planning a maturity grid, it must be defined that what are the specified users of the grid. Users are covered by whole stakeholders who participate to performance assessment or implement the grid. Besides, multiple users can be participated at the same time, for example, a process manager may be information supplier for capability assessment as target user; whereas, an R&D engineer provides improvement exercises and recommendations for the managerial process of the maturity grid such as corporate planning (Maier et al., 2012). Hence, the main decision point in planning stage of the grid, it is important to interpret the target users and improvement entities to understand the supplied information can be generalized for overall company's processes. In this thesis, the target user is defined as process managers/engineers who decide on maturity level evaluation and improvement entities are both R&D engineers and experts on innovation management who have knowledge about eco-efficiency to validate the developed eco-efficiency maturity grid.

Aim

According to literature review, maturity grids have two main aims which are raising awareness and benchmarking between companies or sectors. Within this thesis, both aims are emphasized for performance evaluation of whole processes in a production company. Even benchmarking can be inferred an assessment about performance of a whole sector rather than a specific process or capability, it is indicated comparison between process performances in a production company and understanding which is more mature or immature to implement eco-efficiency metrics on system due to this thesis. Eco-efficiency awareness is pointed out as an eco-efficiency aspect on maturity grid because, one of the designed propositions in multiple-case study application is defined to investigate that higher level of awareness provides self-improvement on other processes or not.

Scope and Success Criteria

Another important point is to determine the scope of the maturity grid which means that the grid is generic or domain-specific. Generic grids assess and improve a specific process such as material consumption during production. On the other hand, domain-specific grids collect information about whole production system from the users within the context. Therefore, designed eco-efficiency maturity grid is a domain-specific because, it aims to propose a generic framework for a company at the beginning of its eco-efficiency implementation process except the sector-specific conditions. The grid desires to be applicable among all sectors and processes under four general categories: environmental, operational, financial and managerial processes in this thesis.

As recognized in literature review, eco-efficiency applications in production industries has insufficient number of systematic practices and there is any intensive implementation tool for process management without considering sectoral features (Pigosso et al., 2013). In other words, companies need to benefit from a roadmap on process improvement methods of eco-efficiency implementation which can provide a sustainable development for production systems. Hence, success criteria have to be defined at the beginning and figure out within the context of specific requirements. In this case, assessment methods are developed to focus on high-level requirements such as feasibility, usability and usefulness (Maier et al., 2012). In this case, Adesola and Baines (2005) states that an assessment procedure has three subsequent categories of measurement question for defining success criteria as following:

1. *Feasibility:* can the eco-efficiency maturity grid methodology be applied?
2. *Usability:* is the eco-efficiency maturity grid usable for different processes in a production company and has easy-to-use steps?
3. *Usefulness:* does the candidate companies which are willing to apply eco-efficiency maturity grid methodology get useful results and find it helpful for their system?

Specific requirements are defined by the designer of a maturity grid and affected from the designer’s objectives. For this thesis, specific requirements of the study cover all of three success criteria given above to add a multi-functional roadmap to literature which can be applicable for four different categorizations of the processes as environmental, operational, financial and managerial in production companies from different sectors.

5.2.2 Development of The Eco-efficiency Maturity Grid

Process Areas

Within the context of this thesis, process areas indicate where a company should focus to improve its production processes. By this aim, they clarify the milestones to achieve each maturity level. Process areas identify a group of related activities to achieve defined goals for enhancing process capability (Paulk & Curtis, 1993). The steps to achieve these goals must be separately assigned to each process depending on the application area of the eco-efficiency. According to this perspective, process areas can be referred as a set of requirements for achieving a maturity level and each area must be identified for that specific level. Level 1 has no process areas due to this term.

Gallagher (2002) presents a group of process areas under four categories which are a collection of specific practices to reflect the characteristics of effective processes (see Table 5.1).

Table 5.1 Process categories and process areas (Gallagher, 2002)

Category	Process Areas
Project Management	Project planning Project monitoring and control Supplier agreement management Integrated project management Risk management Quantitative project management
Support	Configuration management Process and product quality assurance Measurement and analysis Causal analysis and resolution Decision analysis and resolution
Process Management	Organizational process focusses Organizational process definition Organizational training Organizational process performance Organizational innovation and deployment
Engineering	Requirement management Requirements development Technical solution Product integration Verification Validation

This study basically aims to raise awareness on the eco-efficiency implementation in production processes and increase innovativeness level of business processes in production companies. Then, it can be said that process management should be the core objective for this study. The measurement of the process capability for eco-efficiency implementation can be evaluated under organizational process performance in process management category due to Table 5.1.

The process areas of developed eco-efficiency maturity grid in this study are divided into three main aspects as: performance enablers, structural enablers and awareness and its levels are ordered as shown in Figure 5.2. Developed maturity grid in this process category provides guidance to help companies through an approach to carry on process development stages including sub-areas.

Figure 5.2 A framework for assessing eco-efficiency maturity grid level adopted from Kim & Gerald (2010)

Sub-areas

To achieve the objectives of eco-efficiency maturity grid in this study, process area manages a descriptive evaluation perspective to sustain future systematic of a company in eco-efficiency and process performance management. Companies should adopt their processes to eco-efficiency concept and make innovative changes in the system for increasing its competitiveness level. In the eco-efficiency maturity grid development stages, possible outcomes are a list of process areas, indicators and sub-areas. Key evaluators and users of the grid are process and R&D engineers, and managers. Defining goals should be related with eco-efficiency implementation goals and strategies using resources efficiently and examining the progress of activities periodically (Kim & Gerald, 2010). Key users of this grid can offer a feedback for selecting core indicators that are associated to eco-efficiency goals and strategies to grid developer. In this case, the grid is revised according to given feedback and maintaining in process area.

In the developed grid within this study, process area is divided into 16 sub-areas which are encompassed generic eco-efficiency indicators after a literature review grouped under four main categories only based on common focusing objectives among the indicators: environmental, operational, financial and managerial (see Chapter 3). Each category is illustrated with the number of citations of indicators detected from the core studies and presented in a table. However, within the scope of the study, since these indicators will be integrated to business processes, they should be grouped based on the relationship between an eco-efficiency indicator and an eco-efficiency objective for a specific process of a production company. According to this procedure, three different categories were identified which are includes process-related indicators:

performance enablers, structural enablers and awareness. In Chapter 4, developed eco-efficiency maturity grid is illustrated under these three categories.

As a first and major request to implement eco-efficiency to production processes, companies has to be sensitive environmental aspect of eco-efficiency concept. When going back to Chapter 3, eco-efficiency objectives mainly indicate that companies should aim to create less damaging on environment while increasing value and profit to become eco-efficient. Therefore, performance enablers should cover all of the environmental indicators kept under specific sub-areas which are shown in Table 5.2 as a main process area for eco-efficiency maturity grid.

Table 5.2 Process areas, indicators and sub-areas of developed eco-efficiency maturity grid

Process areas	Indicators	Sub-areas
Performance enablers	Non-renewable energy consumption	Energy consumption
	Material and product recyclability	Material consumption
	Natural resource consumption	Water consumption
	Ozone depleting substance	Emissions
	POC	
	COD	
	Greenhouse gas	
	Heavy metal and eutrophication	
	Toxic chemicals	Toxic chemicals consumption
	Material and product durability	Product life-cycle
	Amount of inner and outer dispensable area	Land use
	Non-product output	Wastes
	Non-biodegradable packaging	
	Solid and liquid wastes	
	Lost time as a result of injuries and illnesses	
	Equipment performance on employee	
	Average number of hours of employee training/year	
	Percent of workers who complete job satisfaction	
	Number of employees	Company structure
	System boundaries	
	Turnover rate	
	Company size	
	Service intensity	Business activities
	Business segments	

Table 5.2 continues

Structural enablers	Primary products	
	Number of active methods for cross-functional team management	Collaboration
	Number of collaborated and information sharing networks	
	Gross margin	Financial monitoring and forecasting
	Energy cost	
	Quantity of products/services	
	Volume/mass	
	Value-added	
	Net sales	
	Community spending and charitable contributions as a percent of revenues	Financial planning for community-based activities
	Employment opportunities for the local community	
	Number of community-company partnerships	
	Openness to stakeholder involvement in decision-making	Finance for decision-making
	Rate of customer complaints and returns	
	Cost of goods and services	
	Energy cost	
Awareness	Company norms and values	Eco-efficiency awareness

As another process area, structural enablers deal with the remaining defined categories: operational, financial and managerial. They are directly related with companies' own production and business processes that are also included in the scope of eco-efficiency concept. The indicators of the structural enablers and sub-areas are also given in above table for providing a preview of eco-efficiency maturity grid aspects.

The last process area which is awareness means that the capability of gaining eco-efficiency knowledge within the company and willing to take actions for implementing it. However, it is indicated that company norms and values described by top management should be defined as main indicator of this process area because, they can be insistent to push the employees gaining eco-efficiency knowledge and transform it to awareness.

Maturity Levels

Maturity levels depend on the level of eco-efficiency integration in company's processes. In this regard, generic metrics of eco-efficiency are not only evaluation criteria to decide a specific process is mature or not within the company. The aim of developed maturity grid is not put a prescriptive tool, it works like a roadmap for eco-efficiency implementation by considering current situation and capability of a company.

Each maturity grid level was taken a scale of 1 to 5 and key users select one of them to score of maturity for a specific process. This scale shows that level 1 represents the worst situation and getting better up to level 5 indicating the best case. For developed eco-efficiency maturity grid, level 1 represents initial situation like no data monitoring or any actions taken to make the process mature. For this study, defined maturity levels are detailedly explained in Table 5.3 below.

Table 5.3 Determined scale of eco-efficiency maturity grid level referenced by Rose (2013)

Level 5- Optimized	Processes are designed to optimize weaknesses to overall system become eco-efficient. Eco-efficiency concept is sustained in each process.
Level 4- Managed	Defined actions are started to apply and system is started to manage for adaptation of eco-efficiency metrics.
Level 3- Defined	Recorded data are analyzed and compared with the goals. Necessary actions are planned to develop eco-efficient process.
Level 2- Infrastructure	Periodical data tracking and some special methods are defined for eco-efficiency implementation.
Level 1- Initial	No data record used for defining eco-efficiency implementation steps on the system.

Formulate Cell-texts

Cell texts are intersection of process areas and maturity levels which are the descriptions of capabilities or processes. To start to formulate cell texts, first of all, the grid developer should decide on whether the cell text is "prescriptive" or "descriptive" (Maier et al., 2012). For each maturity level of process area, prescriptive approach suggests that specific and detailed description of action. As another approach, descriptive, it creates less concerns about comparison of results between application cases and notices about a detailed explanation of an individual case. For this study, cell texts are constructed as prescriptive to evaluate a process existing in every production sector. Therefore, information source is synthesized based on sustainable development goals around the world and improved by key users' feedbacks. Formulation mechanism includes some eco-efficiency implementation practices on production companies compared for understanding the maturity levels represent the same scale. Each cell text focuses on the process maturity assessment. Therefore, face-to-face interviews drive a role of administration mechanism in this case.

In this study, each cell text was constructed based on the "Sustainable Development Goals of Turkey". This formulation awareness was provided by expert's feedbacks and some academic papers which are emphasized the importance of sustainability in innovation management. Sustainable Development Model satisfies the needs of population in today without according the meeting the demands of future generations. Towards the end of 20^{th} century, this development model has started to being mentioned in the world agenda and signed with the international plan in the 1990s as a global implementation plan. Within sustainability perspective, sustainable development concept presents a common denominator in the economic and social development goals of the countries which encourages future to meet everyone's basic needs and expectations for a better life. In this sense, the basic philosophy of sustainable development holistically evaluates both economic and social structure and environmental interaction, and ensures the generations getting benefit from the its opportunities.

Environmental and economic problems such as climate change, recent economic crises have revealed the framework of sustainable development under the concept of green growth like green economy, low-carbon economy, sustainable production and consumption. International organizations such as OECD, UNEP prioritize investment and consumption of goods and services contributing to environmental improvements within green concept. According to The European Union, green economy increases human welfare through the use of sustainable technologies and the creation of new jobs. However, there is no common definition because of not clearly defined concept.

For this reason, countries create their own framework of original conditions and states their specific definitions.

At initial step of cell text formulation, sustainable development goals were identified with the eco-efficiency concept and its objectives, and then separated due to process areas which are linked to process areas, indicators and sub-areas of developed eco-efficiency maturity grid. Table 5.4 gives all goals published by United Nations Development Programme and identified process areas within the study.

Table 5.4 Table of Sustainable Development Goals of Turkey and their process areas

Sustainable Development Goals of Turkey	Process Areas
1. Eradicating the poverty	Social
2. Eradicating the starvation	Social and economic
3. Health and welfare	Social and economic
4. Education with quality	Social
5. Gender equality	Social
6. Access to healthy water	Social and environmental
7. Accessible and clean energy	Environmental
8. Decent work and economic growth	Social and economic
9. Industry, innovation and infrastructure	Economic
10. Reduction of inequalities	Social
11. Sustainable cities and living quarters	Social, economic and environmental
12. Conscious production and consumption	Economic and environmental
13. Fight against climate change	Environmental
14. Life under water	Environmental
15. Life on land	Environmental
16. Peace and justice	Social
17. Collaboration for the goals	Social and economic

Caetano, de Araújo, & Amaral (2012) states that eco-efficiency indicators are in the intersection between economic and environmental indicators within the scheme of sustainability indicators (see Figure 5.3). Within the scope of this study, although the sustainable development goals are taken into consideration according to the eco-efficiency objectives, there is also an aim of developing a maturity grid among the objectives of sustainable assessment tool creation. Thus, all three dimensions were adapted to sustainable development goals by taking into account eco-efficiency objectives during the cell text formulation.

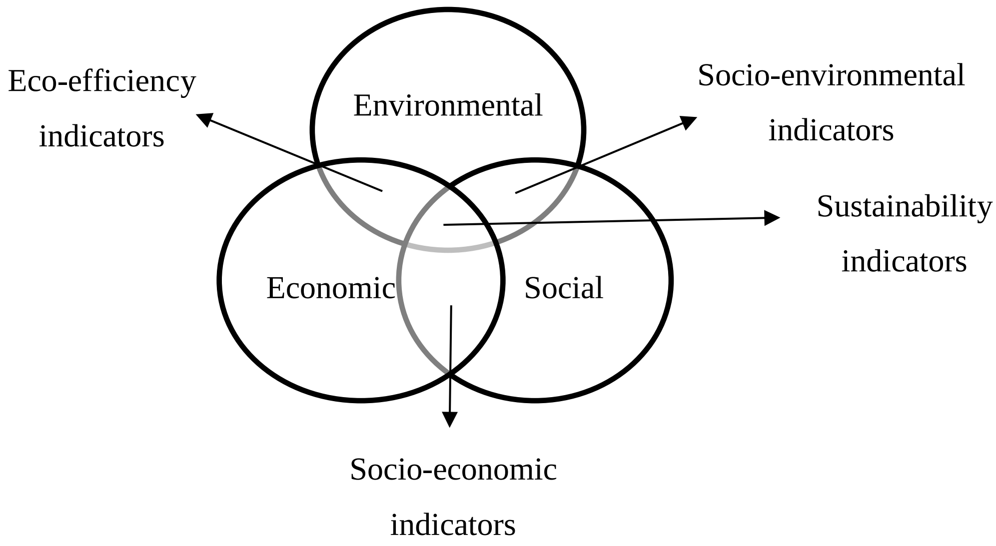

Figure 5.3 A different dimensions of sustainability indicators adopted from (Caetano et al., 2012)

By adhering to this scheme, each cell description is designed in accordance with the sustainable development goals in terms of indicators corresponding to each goal. In this case, first of all, sustainable development goals and the reasons of why they are important are presented below (United Nations Development Program[UNDP] n.d.).

Eradicating the Poverty

Today, more than 800 million people worldwide cannot enable to sufficient food, clean water and sanitary conditions. Even the economic growth progress has not been balanced yet, countries like China and India has saved millions of people from poverty. Because of unfairness in education and access to property, women need to get a salary and to be employed more than men.

This advancement has been limited in extreme regions such as South Asia and Sub-Saharan Africa with the percent of 80% in poverty. New threats from conflicts, climate change and food insecurity suggest that the government need to work harder to protect people from poverty. Hence, Sustainable Development Goals are a dramatic loyalty to end what the government have started and eliminate all forms and dimensions of poverty. Targeting those who are most vulnerable include arising access to key resources and services, and supporting societies affected by climate-based disasters.

Eradicating the Starvation

The immediate economic growth and increasing agricultural productivity more than last 20 years have resulted in more than half the number of malnourished people. Most of the developing countries, which suffered from famine and starvation, can now satisfy the nutrition of the most precise masses. Unfortunately, excessive starvation and malnutrition are a core difficulty to development in many countries.

By 2030, the Sustainable Development Goals targets to fight with every type of hunger and malnutrition, and to ensure that it supplies adequate nutrients throughout the year around the world. The objectives include the promotion of sustainable farming practices that support small farmers and support their fairness on accessing to land, technology and markets. They also request international cooperation in investing in infrastructure and technology for increasing productivity in agriculture.

Health and Welfare

Since 1990, there have been more than 50% globally reduction in avoidable child mortality. In each year, more than 6 million children die and 16,000 children die because of measles and tuberculosis. Additionally, a huge number of women are faced with pregnancy or birth complications and lose their lives every day. These deaths can be prevented through education, sexual and reproductive health services, vaccination campaigns, in this case, Sustainable Development Goals fight with AIDS, tuberculosis, malaria and other infectious disease and outbreak until 2030 to eliminate them. The aim is to ensure accessing to general health care, safe and accessible medicines, and vaccines for everyone.

Education with Quality

There has been a large increasing in literacy rates, and also the number of girls attending due to Sustainable Development Goals. The children of families whose economic situation is inadequate due to financial difficulties leave school four times more than wealthiest families. This gap is also actual between rural and urban sectors and increases.

According to Sustainable Development Goals, education is one of the most powerful and testable tools for sustainable development. It will provide free primary and secondary education by 2030. In addition, it focuses on providing cost-effective vocational training in equality, eliminate gender and asset inequalities, and ensure that everyone is accessing qualified tertiary education.

Gender Equality

Eliminating of every types of discrimination against women and girls is critical to speeding up sustainable development. From this point of view, it has been shown that the multiplier effect has an effect on the empowerment of women and girls and accelerates economic growth and development in all areas.

The Sustainable Development Goals aim to eliminate discrimination against women and girls; however, there are still inequalities about insufficient accessing of women in labor market. Since 2000, gender equality is taken as the core point of governmental work of Turkey collaborated with other UN partners and the international community. Today, more girls have education opportunity than 15 years ago. To succeed this goal, it is necessary to ensure that women have equal rights over economic resources. In this case, women leaders are encouraged under the strengthening policies and legislation that will further gender equality.

Access to Healthy Water

Today, lack of water affects more than 40% of people around the world. Climate change will increase this ratio further as it is estimated. Due to records in 2011, 41 countries experienced water shortages and 10 of them running out of renewable fresh water to find alternative sources. By 2050, it is estimated that at least one in four people will be affected by water shortages.

Until 2030, it is crucial to invest in infrastructure, build sanitary facilities and promote hygiene at all levels; therefore, Turkish Government must protect water-related eco-systems such as forests, wetlands and rivers to alleviate water shortages. International cooperation must also promote water efficiency and support purification technologies in developing countries.

Accessible Clean Energy

Accessible electricity increased by 1.7 billion between 1990 and 2010. Demand for cheap energy is also increasing with the growing population. The increase in global economy and greenhouse gas emissions based on fossil fuels result in huge effects in our climate system and these changes affect all continents.

By 2030, it is necessary to invest in clean energy sources such as solar, wind and thermal energy to supply accessible energy. Cost-effective standards can also decrease electricity consumption in buildings and industry by 14% worldwide. The infrastructure of expanding clean energy and upgrading the technology in all developing countries is a critical target that can both encourage growth and contribute to the environment.

Employment and Economic Growth

In the last 25 years, the number of workers in extreme poverty has fallen due to the lasting effects of the 2008 economic crisis and the global depression. The global economy continues to evolve, but growth slows down, inequalities go up, and job opportunities decrease at the same rate as the growing workforce.

Sustainable Development Goals support higher productivity levels, technological innovations and sustainable economic growth. To encourage entrepreneurship and business opportunities, productive and full employment is aimed of ensuring to satisfy proper work for all men and women until 2030.

Industry, Innovation and Infrastructure

Infrastructure innovation and investment are critical forces for economic growth and enlargement. The cities where over than 50% of the world’s population, public transport and renewable energy have become more crucial. Technological process finds sustainable solving to economic and environmental issues.

Internet cannot be accessed by more than 4 billion people worldwide and developing countries include 90% of world's population. It is critical to address digital inequality in terms of innovation and entrepreneurship development. The ways which build up a sustainable development are to support investing in scientific research and innovation and sustainable industries.

Reduction of Inequalities

The richest 10% population, with income inequality increasing, has achieved 40% of the total global income. The poorest 10% is only 2% to 7% of global income. When it is taken care of population growth, inequality in developing countries grew by 11%.

In order to overcome growing inequalities, it is imperative to adopt sound policies that support the economic participation of all, regardless of gender, race and ethnic origin, which reinforce 10% of the lowest income.

Income inequality brings global solvings which involve developing the regulation and screening of institutions and financial markets, and development guidance giving direction to foreign investments to the region's most in need. Ensuring people to migrate and move safely is also important in reducing growing inequality.

Sustainable Cities and Communities

Increasing in the migration from rural to inner-city cause to uncontrollable population growth in mega-cities, in the developing countries. Although the crowd of mega-cities include 10 million people in 1990, there are now 28 mega-cities with 453 million people.

To provide the population growth inner-city, national and local governments are making an effort because of extreme poverty that creates secure and sustainable city. Sustainable Development Goals also define this aim by public transportation investment, creation of green places, management of urban areas.

Conscious Production and Consumption

A successful economic growth and sustainable development, ecological footprint has to be directly reduced to produce and consume goods and resources. Agriculture is at the first position of consuming water and the fresh water used by nearly 70% of people is consumed to irrigate agricultural areas.

Protecting natural resources and eliminating toxic wastes and pollutants are major for encouraging industries, businesses and consumers. In developing countries, recycling and reducing waste is to sustain consumption model by 2030.

Most of the world's population still has low consumption, not enough to satisfy their primary requirements. In creating effective and better production and supply chains, reducing food waste at the seller and consumer level by half is very significant. Doing so can improve food security and ensure the transition to a more efficient economy.

Fight Against Climate Change

According to the amount of greenhouse gas emission in 1990, it takes 50% more and pursue to go up. In Eastern Europe and Central Asia, large number of producers suffering from the results of climate change contribute negatively on greenhouse gas emissions. The floods in the Western Balkans have destroyed thousands of houses. Diminishing glaciers and decreasing water resources in Central Asia can dramatically affect irrigation and hydropower production.

Throughout the region, people are mobilized to reduce greenhouse gas emissions, save lives and support societies to get back to the ground. Unique actions are managed to store carbon safely in underground peatlands of Belarus. Georgia has already developed advanced warning systems and better protection against floods.

Life Under Water

The oceans in the world lead to globally applied methods for becoming Earth available for humans. Resource management is vital to make equal the impacts of climate change as well as for humanity as a whole. People who wants to keep under guarantee their lives has to rely on biodiversity in the seas and coasts and this population covers more than three billion people. On the other hand, fish stocks are consumed over the regular level by 30% around the world; while, sustainability level is under the product. Ocean acidification is increased by 26% because of human-created carbon dioxide with 30%. Besides, about 13 thousand pieces of plastic waste per square of oceans.

The Sustainable Development Goals sustain marine and coastal eco-systems to preserve them from pollution and reduce the effects of ocean acidification. Protection and sustaining the use of ocean-based resources through international regulation will provide to handle with the basic challenges in oceans.

Life on Land

Human life is dependent on land as well as on oceans in terms of food and livelihoods. Plants provide 80% of human resources, and government lead to agriculture as a vital resource of economic resources and enlargement. Forests cover 30% of the Earth's surface, provide importance for millions of species and significant fresh air and water resources, and at the same time, it is critical to combat climate change.

Nowadays, soil degradation is witnessed on an unprecedented scale to date. The loss of cultivable area has reached 30 to 35 times the historical rates. Drought and desertification are getting increased every year, causing a loss of 12 million hectares worldwide and affecting poor communities. 8,800 of the 8,300 animal breeds are vanished and 22% are in danger of disappearance.

By 2020, the Sustainable Development Goals target to protect forests, wetlands, arid areas and mountains. Stopping deforestation is crucial in reducing the effect of climate change. Immediate action should be managed to reduce the loss of natural habitats and biodiversity.

Peace and Justice

Sustainable development cannot be expected without effective management taking into account peace, durability, human rights and the rule of law. While peace, security and prosperity are constant in some regions, in some other regions there is a spiral of unending disagreement and violence. High levels of armed causes confliction and insecurity which have a devastating effect on the development of countries. It affects economic growth and creates injustices that can last for generations. Sexual violence, crime, abuse and torture are common where there is no regulation and countries must take measures to protect those most at risk.

The Sustainable Development Goals collaborate with governments and communities to drastically decrease each type of violence and to find sustainable solutions to disagreement and distrust. To make strong the rule of law, it is the key to this process and also very important to prevent illegal arms trade and to strengthen the participation of developing countries in global governance institutions.

Collaboration for The Goals

Sustainable Development Goals can carried out with strong obligation to global partnership and cooperation. The demands for financial resources assisting to keep on increasing due to the humanitarian crisis caused by natural disasters. Today's world has been becoming more interrelated than previous times. Increasing connection with to technology and knowledge renders possible to share knowledge and promote innovation. Coordinating policies enable to manage the debts and support investments in the developing countries and are significant for success in sustainable growth and development.

Increasing number of cooperation between North-South and South-South due to created national plans for achieving all targets. The development of international trade and the support of developing countries to rise their exports are the elements of creating a fair and open trade system based on universal rules that are in the best interests of everyone.

In the context of the study, when the relationship between both eco-efficiency and sustainability-oriented indicators and sustainable development goals are established, the matches shown in the Table 5.5 are obtained.

Table 5.5 Relationship table between sustainable development goals and indicators of eco-efficiency maturity grid

Sustainable Development Goals of Turkey	**Related indicator(s) on Eco-efficiency Maturity Grid**
1. Eradicating the poverty	Company structure, financial planning for community-based activities
2. Eradicating the starvation	Company structure, financial planning for community-based activities
3. Health and welfare	Human factors, company structure, financial planning for community-based activities
4. Education with quality	Human factors, company structure, financial planning for community-based activities
5. Gender equality	Human factors, company structure
6. Access to healthy water	Water consumption, emissions, toxic chemicals consumption, wastes
7. Accessible and clean energy	Energy consumption
8. Decent work and economic growth	Company structure, business activities, financial planning for community-based activities, finance for decision-making
9. Industry, innovation and infrastructure	All indicators
10. Reduction of inequalities	Company structure
11. Sustainable cities and living quarters	All indicators
12. Conscious production and consumption	All indicators
13. Fight against climate change	Energy consumption, material consumption, water consumption, emissions, toxic chemicals consumption, product life-cycle, land use, wastes, eco-efficiency awareness
14. Life under water	Energy consumption, material consumption, water consumption, emissions, toxic chemicals consumption, product life-cycle, land use, wastes, eco-efficiency awareness
15. Life on land	Energy consumption, material consumption, water consumption, emissions, toxic chemicals consumption, product life-cycle, land use, wastes, eco-efficiency awareness
16. Peace and justice	Human factors, company structure, business activities, collaboration, financial planning for community-based activities
17. Collaboration for the goals	Collaboration, eco-efficiency awareness

Each indicator handles with presented sustainable development goals to formulate cell texts. Although there is not a corresponding description of mentioned sustainable development goals for some situations in terms of eco-efficiency objectives, it has been tried to be considered them according to the eco-efficiency perspective in cell text formulation process. The cell text descriptions of eco-efficiency maturity grid developed with this point of view and the purpose for which they were developed are given below.

Energy Consumption

In order to meet the increasing demand for cheap energy and to expand the use of renewable resources, the processes in the companies should be designed with the focus on energy saving, methods to optimize energy consumption should be used and integrated with renewable energy sources. In this way, clean energy awareness is created from sustainable development goals and the fight against climate change is provided on the basis of a company. In addition, environmental support is provided for the sustainability of life on land and water without deformation and for the achievement of sustainable cities and society. In terms of the company, all these innovations provide the infrastructure to become an eco-efficient company and provide opportunities in the competitive environment.

Material Consumption

From this sustainable development point of view, companies should focus on consuming less amount of raw material in production process and should integrate with methods to optimize material consumption. Thus, fighting against climate change, sustainability of life on land and water, sustainable cities and society are provided on the basis of a company which support increasing innovation capacity to become competitive.

Water Consumption

The idea that water scarcity across the world will be confronted by global warming is a concern for the future of safe drinking water resources. Therefore, sustainable actions should be taken regarding the consumption of clean water resources. Through the development of sustainable systems for reducing and preventing unnecessary water losses in production processes, resource consumption will be taken into consideration. Access to healthy water resources can be achieved basically by this attention.

Emissions

Pollutants, which are used in production processes and which may have serious damages on the environment, have effects that limit access to healthy water in terms of sustainability, adversely affect the fight against climate change and lead to negative effects on land and water. Therefore, it is important to use these pollutants in production directly or indirectly. Developing sustainable systems by knowing these environmental effects in production processes also provides process innovation in the sense of eco-efficiency.

Toxic Chemicals Consumption

Toxic chemicals are evaluated as the same level of effective as pollutants on environment. In this case, chemical risk assessment is necessary action in production processes and companies should search a way to use less toxic chemical which are equivalent for the same operations. Furthermore, they should be faced with minimum number of uncertainties regarding toxic effects of chemicals under the objectives of eco-efficiency.

Product Life-cycle

To ensure a sustainable environment and economy, minimizing product effects and environmental impacts is crucial to sustainable development and eco-efficiency. In the production process, the material consumption and the use of environmental-friendly materials, which have already been emphasized, are factors that will contribute to the future image of the company. For this reason, functional, user-friendly and technical durability of a product should be considered within the scope of product life-cycle. Both product and process design should be designed according to these priorities and should be integrated under eco-efficiency objectives.

Land Use

Although land use in sustainable development targets depends on the increasing population, it addresses the spread of squatter, the use of land in terms of eco-efficiency and production processes can become an indirectly negative factor to this objective. While there is already a shortage of land use, the companies designing the processes that occupy unnecessary land by acting unconsciously on this issue increase the resource consumption and emissions. In this sense, starting from the planning stage of the production area, the companies should continue their production by evaluating their physical structure, especially on the basis of complying with the legal laws. Impacts on the environmental, economic and social environment should be investigated and companies should be treated according to the its decision-making mechanism.

Wastes

Deficiencies in the management of wastes due to increasing consumption with increasing population lead to the implementation of enforcements at national level for many countries. In particular, the disposal and recycling of waste from production-related wastes is an eco-efficiency objective, which is considered at first in companies. Both environmental and urban returns bring that this awareness will be a step at national level to ensure sustainability. At the same time, sustainable development goals will be provided, such as reducing emissions, protecting natural resources from pollution. Therefore, in order to reduce the total amount of waste in the production systems, it is necessary to integrate the waste management methods according to the type of waste into the processes. If a recyclable waste type exists, it should be evaluated for re-use in production, otherwise it should be disposed at the end of the process.

Human Factors

Despite continued global growth, higher productivity levels across the world on behalf of the context of sustainable development goals to overcome the growing inequalities and unemployment in the labor force in many countries, including Turkey. and technological innovation are encouraged by the goals. In this respect, it is important that employers make their policies on this issue as mission and vision. Designing trainings to improve the quality of education will increase the number of qualified staffs throughout the country and support the applicability of technological developments. In this way, both employees will be provided peace of mind at the workplace and employers will be satisfied to close the labor shortage. In addition, gender equality will be ensured in a company where job assignment is made according to abilities and capabilities. The fact that the job assignment is done in this way will decrease the employee-related loss times and equipment deformation so, it increases efficiency and profitability. As a result, peace and justice will be indirectly ensured throughout the world with this awareness acquired by countries.

Company Structure

Technological progress can be achieved through objectives that support the concept of eco-efficiency, such as creating new jobs and increasing energy efficiency. In particular, it has been emphasized under the sustainable development goals where increasing employment in the fight against poverty and starvation is important. In this way, peace and justice will be ensured and support will be given to the creation of a healthy and welfare society. The creation of a qualified workforce, which is also referred to as human factors and the appointment of a job in line with the capabilities, will positively affect the attitude of the employees towards the work and the company. When considering the weaknesses and strengths of the companies, it will enable them to gain an opportunity in the sector.

Business Activities

One of the important ways that enable sustainable development is to support sustainable industries and invest in scientific research and innovation. It is important that the financial mechanisms within the companies planning the investments in order to realize this goal, which will support employment and economic growth, are functioning effectively. One of the main steps is to create an accounting plan in which the labor and production costs will be managed professionally. In particular, the marketing and sales plans developed upon the marketing of the innovation created and the satisfaction of staying in touch with the customers after the sale, help to make the best use of the service efficiency. Before carrying out all this, qualified personnel and workers should be employed and should be involved in planning the process.

Collaboration

Increasing access to technology and knowledge plays a key role in sharing ideas and promoting innovation. Supporting such shares within the company is an important element of innovation at the micro level, but at the macro level it is important to achieve economic and political growth and development. In this respect, first of all, providing trust among employees supports exchange of ideas and the emergence of more innovative thinking. The participation of different departments in team work should be encouraged to ensure full participation and the idea of each team member should be felt as important for the success of the team.

Financial Monitoring and Forecasting

As mentioned in business activities, financial management is the most important management process of a company in the emergence of innovative thoughts which are important in achieving economic and political growth and development. Performing financial performance evaluation periodically and performing professionally with key performance indicators will make a difference to the company. Although this seems to be effective primarily at the company level, it will form the basis of economic development with the value and profitability to be created.

Financial Planning for Community-based Activities

The fact that many of the strategies put forward in the sense of sustainable society, economy and technology are observed on a single process and this process is generally on internal production and management strategies restricts the efforts to increase the peace and welfare of the society within the scope of eco-efficiency concept. Providing the job opportunities to the local people in the process of making the decisions given by the top management and the support on the basis of the association will be a big step in achieving this goal.

Finance for Decision-making

It is important for the sustainable environment and the community as a similar to the formulation of community-based activities. At the point where they differ, cost factors that play an important role in the decision-making mechanism of the company should be determined. All costs incurred during the production process, the rate of customer complaints etc. It is important to know the cost analysis by top management in the evaluation of such criteria. Developing and integrating an appropriate cost model will support the realization of this sustainability development objective.

Eco-efficiency Awareness

The eco-efficiency awareness aspect covers all the mentioned aspects previously and it should start with the formation of this awareness among the company employees in terms of the standardization and sustainability of the processes. Employees should take trainings on this issue and know how to implement this concept. Managers should begin to support eco-friendly technologies after gaining this awareness and should direct the teams to produce less waste. Follow-up of resource efficiency should be done by these trained teams as well.

As a result of all this planning and evaluation steps of maturity grid development process, the developed eco-efficiency maturity grid within the methodology of this thesis is given below.

Table 5.6 Eco-efficiency Maturity Grid

ECO-EFFICIENCY MATURITY GRID						
Eco-efficiency Aspects		Maturity Levels				
		1	2	3	4	5
Performance Enablers	**Energy Consumption**	No tracking on energy consumption levels and any data gathering about periodical consumption amount.	Energy consumption amount is periodically tracked by some special methods within the company.	The amount of energy consumption is compared with the defined levels under energy regulations. Process is monitored and root causes of unidentifiable energy leaks are indicated.	Company starts to take actions for energy savings on processes. Sustainable technologies are started to implement for reducing energy consumption.	Company designs overall process to optimize energy consumption. It tends to integrate with new technologies and equipment to decrease the use of non-renewable energy resources.
	Material Consumption	No records on the amount of input and output materials, stocks and material costs.	Stocks are tracked and recorded on warehouse management system. Materials having less volume in production are identified from the past data.	Employees understand the impacts of materials on environment. Process engineers evaluate each impact of the materials against environmental restrictions.	Recyclable materials are preferred to use in manufacturing systems. Waste tracking system is started to develop for reducing amount of wastes at the end of the process. Cost calculation system is also designed to understand savings after taking actions for eco-efficiency.	Production system is re-designed by considering eco-efficiency principles. Some recyclability methods are implemented. Process is improved to maximize resource efficiency.
	Water Consumption	No tracking on water consumption levels and any data gathering about periodical consumption amount.	Water consumption amount is periodically tracked by some special methods within the company.	The amount of water consumption is compared with the regulated levels. Process is monitored and root causes of unidentifiable water flows are detected.	Company starts to take actions for water savings on processes. Sustainable technologies are searched to implement for reducing water consumption.	Company designs overall process to optimize water consumption. It tends to integrate with new technologies and equipment to reduce the use of water resources.
	Emissions	No monitoring the emission levels of pollutants.	Pollution levels of wastes and gases produced by processes are tracked and categorized into direct or indirect effective groups on environment.	Pollutants are separated based on different processes. Process engineers understand which one is released during which operation in the system. Environmental effects are emphasized on planning process.	Company starts to take actions for reducing the emissions of pollutants. Sustainable technologies are searched and top management collaborates with external networks such as local authorities to develop pilot applications.	Process managers set periodical impact assessments for new developments on the processes. Company designs more efficient exhaust gas management system.
	Toxic Chemicals Consumption	No data collection for chemical risk assessment.	Chemical risk data are monitored to reduce the hazardous impacts on humans and environment.	Collected data are analyzed to provide a better risk control of chemicals' concern.	Specific actions and process-based restrictions are set. Less toxic chemicals which are equivalent for the same operations are indicated.	Company is faced with minimum number of uncertainties regarding toxic effects of chemicals. Toxic chemicals are replaced with less hazardous types in the process.
	Product Life-Cycle	No data for life-cycle analysis of products.	Collected data are stored to monitor reliability and environmental effects of a product. Various methods that facilitate a systematic approach to material choice are evaluated.	Preliminary life-cycle analysis is evaluated. Life-time limiting mechanisms or failure modes of the studied materials and components are identified and characterized.	Detailed life-cycle analysis is interpreted by considering functionality, user reliability and technical durability. Cost-effectiveness approaches are implemented to minimize environmental impact.	Product-tracking combines both product and process design by using life-cycle analysis outputs. New product development process is integrated with more eco-efficient methods.

Table 5.6 continues

Performance enablers	**Land Use**	No land use objectives and data of company to plan the goals to be worked for.	Data are collected and reserved due to identified objectives by the company.	Team members dealing with land use planning issues are assigned. Selected methods are compared with alternative land use methods. Land use problems and opportunities of the planning area are identified by considering legal regulations.	The team evaluates land suitability for each type of plans. Land requirements are matched with physical suitability. The impacts of land planning alternatives are assessed on environment, economic and social areas.	A land use strategy is created and taken into action by decisionmakers of the company. Top management monitors this progress toward identified the goals.
	Wastes	No periodical data about the total amount of disposal units/materials.	Data are collected and recorded. Wastes are separated such as material, packaging or solid/liquid.	Recycled wastes are re-used in the manufacturing process. Company developed a waste management system to recycle as much as possible amount of wastes.	Disposal methods are integrated to create less amount of wastes which cannot be recycled at the end of the process.	Company designs recycle and disposal processes to minimize process-based wastes and maintains continuous improvement on the manufacturing process.
Structural enablers	**Human Factors**	No information about the lost times because of unintended events, injuries and illnesses of employees.	Root causes of lost times are identified and categorized as equipment-based, process-based and human-based. Important actions are defined to optimize operational performance.	Employees are trained to improve equipment performance. Jobs are assigned to employees based on their qualifications and job satisfactions.	Total lost time is reduced and percent of employees' complaints about unsatisfied job is decreased.	Cross-functional teams are created to support employees' skills. Continuous improvements are ongoing on the equipment and process design to provide more ergonomic conditions.
	Company Structure	Internal impacts of the company such as company size, number of employees are not figured out and not grouped into strengths and weaknesses.	Periodical performance evaluation is applied on the employees to understand their level of practical skills and attitudes through their works.	Company is aware of how efficient the structure applied. Department heads make sure that the information flow is widely accessed by all customers.	Suitable rules and regulations are applied to verify the benefits of employees and businesses.	Top management makes sure that infrastructure of the company is sufficient for all functions of the company. Well-motivated and well-trained employees are supported by high quality facilities.
	Business Activities	There is no policies and programs to maintain business activities effectively.	Basic business activities are identified and comprehensive guidelines to make a business plan are defined.	Periodical accounting data is reported to monitor financial situation for taking actions and crafting budget for new strategies.	Marketing plans are developed that use sales projections to help determining the most efficient way for service intensity. Sales group compares data from previous year with actual year to create a plan to expand the customer base. It matches company solutions with customer needs to forecast product demand.	Qualified candidates whose qualifications match with current positions are hired. Proactive customer interaction is sustained to expand the company's revenues and provide solutions to customers.
	Collaboration	No active methods which support collaborated working environment. Lack of information sharing and trust between employees.	Team works are supported within company but members are commonly working alone and giving more importance on their own concerns rather than overall team idea.	Team is aware of the importance of each idea comes from each member, evaluates them and tries to create solutions from all its members.	All members contribute created solutions and work for improving them. Team combines suggestions from different ideas from the members.	Each team member attends with full participation honesty and ambition for working together within the team. Number of active cross-functional projects are getting increase.

Table 5.6 continues

Structural enablers	**Financial Monitoring and Forecasting**	There are any adequate financial management practices. Very limited financial performance information is produced.	Basic financial management practices are applied but do not support managers for financial monitoring. Some financial performance information is reported to top management; however, it is not integrated.	Financial management practices are adequate but will not be sufficient in challenging times. Even reports to top management contain information of financial management performance, they are produced on consistent bases.	Professional financial management practices can cope with in challenging times and will identify some key performance indicators (KPIs) to improve its performance.	Financial management practices optimize both challenging and enabler performance indicators. Comprehensive metrics (KPIs) are set for each business segment and reported with financial information.
	Financial Planning for Community-based Activities	Strategic, corporate and financial planning processes are not coordinated.	There is a weak linkage between planning processes and community-based activities. Company does not separate some amount of financial resources from its revenues to support community spending and charitable contributions.	There is some integration actions with community for the most open to improvement business area. Some strategic plans are started to develop for supplying employment opportunities to local community.	Top management makes sure about the importance of strategic plans to engage with community and aims to sustain them in long term. Strategic plans are set and supported by finance team.	Top management gives direction to organization in the short, medium and long term. They aim to get into mush more partnerships with community. In this case, financial plans are integrated to all levels of the developed strategies.
	Finance for Decision-making	No awareness of the drivers of cost and the operational changes in cost on company's activities.	There is awareness about some cost drivers but there is little understanding of the operational changes on cost.	Managers know that the costs of activities, outcomes and drivers. They benchmark methods of other organizations performed to understand cost drivers.	Managers and employees can understand cost analysis. They can demonstrate the impact of changes in the rate of customer complaints, cost of goods/services and energy.	Managers and employees are willing to apply different cost methods to maximize demand volumes, new services and products. They create future plans by their openness to stake-holder involvement in decision-making.
Awareness	**Eco-efficiency Awareness**	There is no awareness of top management and employees on eco-efficiency.	Employees are trained to being environmental sensitive and gained knowledge about environmental regulations.	Managers support eco-friendly technologies and adopt their teams to idea of creating less waste in the workplace.	Resource efficiency is maintained by cross-functional teams and projects.	Budgets for eco-efficiency plans are crafted and managerial accounting principles are used by top management to develop the plans.

5.2.3 Verification of The Eco-efficiency Maturity Grid

The evaluation step, which is the last step of the development of maturity model in this study, serves many purposes within the scope of the study. Tests for the validity of the model are generally carried out by companies. At this stage, a decision must be taken on which test to perform and the results obtained will provide information on the accuracy of the model. In this thesis, case study was preferred as part of the application. Therefore, the validity of maturity grid will be tested in this section. In addition, improvements have been made on the fiction of the model with the feedbacks received from five different experts from academical, industrial and activist fields, and its accuracy has been confirmed before going into implementation.

The selection of these people, each of whom has knowledge and experience on eco-efficiency and sustainability, has been provided by accessing biographies from the internet and some work platforms. In this process, where the established model is intended for purpose and is a model that can be applied in every sector, the proposed points are compiled to be changed or added on the model and presented in the table.

Table 5.7 Compiled table of experts' feedbacks

Water consumption	Designing a rainwater collection system in level 5.
Financial planning for community-based activities	Making periodical interviews and taking proposed solutions from experts in civil society organizations in level 4.
Eco-efficiency awareness	Participating to related meetings about eco-efficiency and proposing periodical summits with experts from different industries in level 5.
Emissions	Aiming to integrate with zero carbon policy rather than reducing carbon emission in level 5.
Wastes	Detection of different waste types from Turkish Materials Marketplace in level 2.

Table 5.7 continues

Finance for decision-making	Managing cash flow for sustainability in level 5.
Company structure	Maintaining corporate social responsibility projects for being a preferable company in level 5.

After obtaining all these feedbacks, the maturity model was revised and the revised version was applied to three different production companies from three different sectors. The revised version of the model is in Appendix-1.

CHAPTER SIX
APPLICATION

In literature, two different research methods are specialized in qualitative and quantitative problems. Quantitative methods solve numerical models like mathematical, experimental and formal; however, qualitative methods are applicable in social and cultural models like case studies, grounded theory and action research. To enhance application chapter of this thesis, case study research method is selected because, maturity grid is a qualitative assessment tool and it gives non-numerical output as well.

6.1 Case Study Research Method for Validation of Eco-efficiency Maturity Grid

Case study research method makes possible to focus on individuals, groups and organizations and other social phenomena as well (Yin, 2003). As its common feature, a systematic analysis of both qualitative and quantitative data is constructed by case study to understand given context about a specific issue and components in that context. Therefore, this research method applies multi-source approach to data collection and becomes advantageous for a researcher due to its wider, in-depth assessment benefits.

Case study research can be covered by several modalities such as single case or multiple cases. Even single case studies investigate one case, multiple case studies drive many of them at the same time (Yin, 2003). After the first step which is determination of quantity of cases, research questions are defined to point the way the study towards an explanatory, exploratory or descriptive design as next step.

An explanatory case study carries on cause-effect relationships which contend how or why something happen (Gangeness & Yurkovich, 2006). The other design, exploratory case study, defines the questions for giving a direction to future studies based on its context. Descriptive case study provides an overall description of a phenomenon within its context (Yin, 2003). All of explanatory, exploratory or descriptive studies can adopt itself to single-case or multiple-case approach.

6.2 Designing Case Studies

Case study approach motivates itself to gather more explanatory questions on "how", "what" and "why" to give direction to events that cannot be totally controlled by researchers (Yin, 2003). Additionally, it can supply more exact reasons on why one implementation strategy might be selected over another or what gaps exist in its delivery. In this case, detecting the suitable type of case study to implement this thesis is a significant part of at the beginning of application.

Case study can be mixed by both qualitative and quantitative methods so, which type of it is useful for the study should be initially identified. Each type of research study asks some questions and expects to get the best answers. To success this aim, it is very important to clearly define boundaries between phenomenon and context. When there is an unsuitable condition, case study provides a contemporary phenomenon as real-life problem and an empirical inquiry (Crowe, Cresswell, Robertson, & Huby, 1993).

According to two pioneer study about case study research design, Table 6.1 is presented by covering both authors. Yin (2003) categorizes case studies as explanatory, exploratory, or descriptive and also divides them into single, holistic case studies and multiple-case studies. Another author, Stake (1995) identifies case studies as intrinsic, instrumental, or collective.

Table 6.1 Different types of case studies presented by Yin's and Stake's

Yin (2003)	Stake (1995)
Explanatory: For complex real-life interventions for the survey or experimental strategies	**Intrinsic:** For illustrating a particular trait or problem and becoming applicable when a case represents other cases
Exploratory: For situations in no clear interventions and single set of outcomes	**Instrumental:** For providing an insight into an issue or helps to refine a theory
Descriptive: For describing an intervention or phenomenon and real-life context	**Collective:** Similar to multiple-case studies description

In every research design logic, collected data should be represented by initial questions of the study. This logic covers four conditions to expand design study for cases which are construct validity, internal validity for only explanatory or causal case studies, external validity and reliability. Matrix shown in Figure 6.1 gives four major types of case studies among current case study designs in literature.

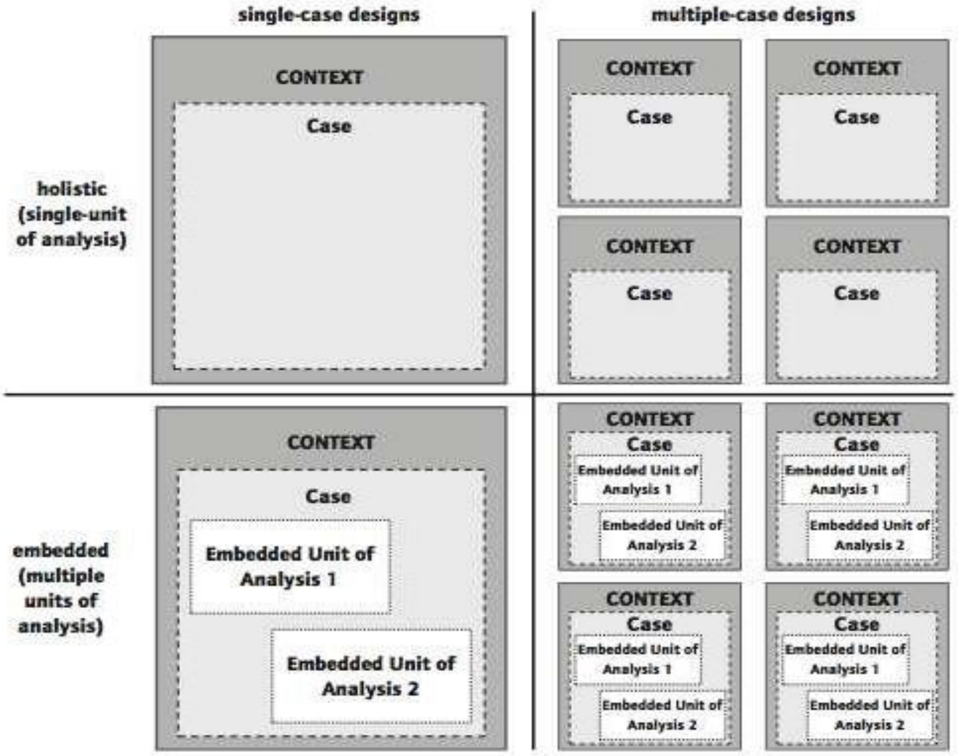

Figure 6.1 Basic types of design for case studies (Yin, 2003)

Above matrix shows that each design type includes a context to analyze case conditions and the dotted lines states that there are no strict boundaries between the context and the case. Within the matrix, it is also shown that a single-case and multiple-cases studies convey different design situations like a unitary unit or multiple units of analysis. As a result, four types of designs for case studies come to exist as single-case (holistic) designs, single-case embedded designs, multiple-case (holistic) designs and multiple-case (embedded) designs.

In develop theory step for application within this thesis, multiple-case study method was adopted to perform eco-efficiency maturity grid among different sectors and it was applied as a descriptive method in order to exercise on real-life examples.

6.2.1 Potential of Multiple-Case Designs

Multiple-case designs are used in the case of a study investigating more than a single case. Actually, multiple-case studies have increased number in literature (Yin, 2003); therefore, this thesis is motivated to contribute this trend and presumes a dynamic study itself.

The replication approach to multiple-case studies is illustrated in Figure 6.2 as a framework for understanding case study application steps developed by Yin (2003). As it is shown in figure, designing the study has to start with theory development at initial, then continues with case selection. Specific measures are defined and it is important step in both design and data collection process.

Each selected case study presents a complete study as regards the facts and conclusions for the case and results for each case are evaluated as the information needing replication by other individual cases. After, each individual case is concluded with individual case reports covered by multiple case results as well. Each report should present how and why questions on a specific proposition was demonstrated or not (Yin, 2003). Cross case conclusions indicate the analyzing of the replication logic and the reasons of contrasting results coming up with certain cases.

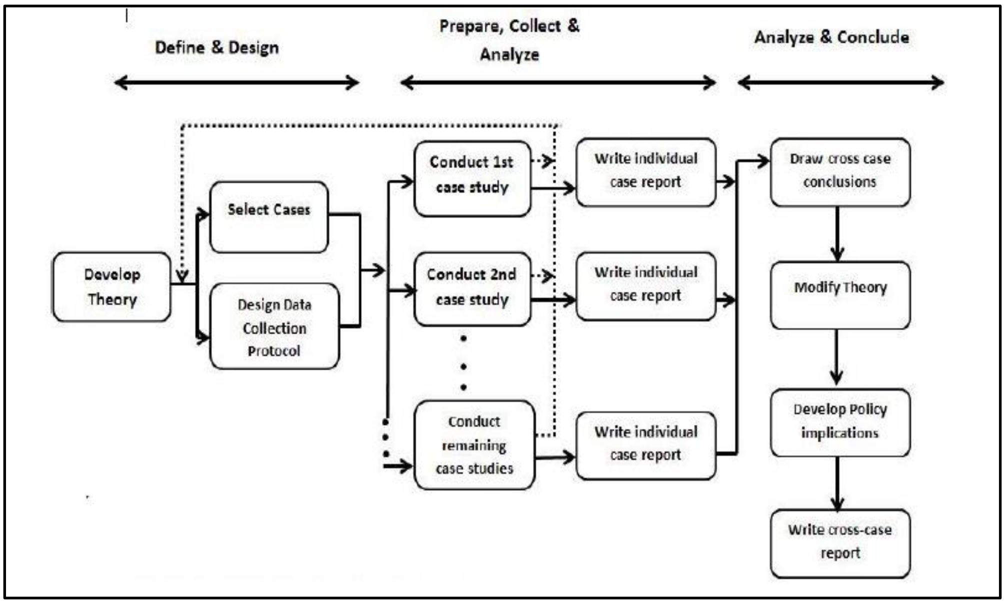

Figure 6.2 Application framework of case study adopted from Yin (2003)

Another important output of this figure above, dotted line is represented as a feedback loop. The loop manages the one of the individual case studies to conduct its appropriateness to original design. If there is an unsuitable situation, redesigning take place rather than proceeding analyzing and concluding steps. Redesigning is important because, it provides to decide on adding alternative cases to study or making changes in the theory.

Within the context of this thesis, the eco-efficiency studies in the world have been implemented under different names for nearly 20 years. In this period, significant gains have been made in many industrial sectors by using different tools. These studies were conducted in cooperation with universities and relevant international institutions. However, the eco-efficiency studies carried out so far and the sectoral distribution of these studies have made significant contributions to the literature. This section is also gained significant information about which sectors should be selected for case studies in eco-efficiency from literature review.

In case selection step, three different production companies from textile, packaging and wood industries were selected and selection reasons of each sector will be given in Section 6.3 in details. As a method of application in this thesis, maturity grid is assigned a basic tool for data gathering step but, interviews are initial step in this process. For each company, a standardized interview was carried out which means some predetermined questions represents each description of the maturity grid about special topic, eco-efficiency. Which maturity level is fit to your current process question was asked to interviewees who are process or R&D managers systematically (Berg, Pihlajamaa, Nummi, Leinonen, & Leivo, 2004). Questions and other components of designed cases will be given in Section 6.2.2.

6.2.2 Components of Case Study Design

For designing a case study, five main components are important: questions of a study, propositions (if any), units of analysis, logic (linking data to propositions) and the criteria for interpreting the findings which are given in Table 6.2.

Table 6.2 Components of case study design (Yin, 2003)

	Explanatory	Exploratory	Descriptive
Study questions	+	+	+
Propositions (if any)	+		
Purpose	+	+	+
Units of analysis	+	+	+
Logic (linking data to propositions)	+		
Criteria for interpreting findings	+		

In this thesis, multiple-case study method containing three different companies and descriptive approach are selected. Therefore, study questions, purpose and units of analysis components are existing for the case study design. Each component is indicated in this chapter.

Study Questions

Researchers need to get information and collect sufficient data from the individual case. Each question should be designed to create a source including the names of individual interviewees, documents or observations. An investigator should review the designed questions before starting a particular interview to get valid information. In this case, case study theory is important for highlighting research questions suitability due to the literature discipline. Additionally, investigators can construct questions which cover general interests and contextual within the proposed case study. Hence, the purpose of the research has to be defined for utilizing this feature of designing questions (Rowley, 2002).

For data collection purposes, these two question levels defined by Yin (2003) are very important within the aim of this thesis:

Level 1: Questions for specific interviewees

Level 2: Questions for the individual cases

Within the aim of this thesis, both level of questions is covered in research questions design step and questions are designed based on the metrics of maturity grid. The grid-based questions are firstly answered by interviewees related to process management, and then a general idea about company's maturity in eco-efficiency are detected to provide a foresight about innovativeness of eco-efficiency company's sector as well. In this context, a sample of created questions due to maturity grid are below. The same questions are defined for each metric and directly asking to each R&D or process engineer/manager for each company. They evaluate their specific process under a Likert scale-based evaluation which defines the levels of maturity between 1 to 5. Level 1 means that the company has no action about eco-efficiency in the specific process, whereas level 5 is optimized the process and maintained a sustainable system in eco-efficiency.

- **Energy consumption:** At which level does your company sensible to properly consume energy, use of renewable energy resources and take proactive actions against to more than adequate consumption of energy? (Level 1: No action, Level 5: Optimized)

- **Material consumption:** At which level does your company sensible to properly consume materials, their impacts on environment and prefer recyclable materials in production system? (Level 1: No action, Level 5: Optimized)

- **Water consumption:** At which level does your company sensible to properly consume water, take actions for water savings and able to identify root causes of water leaks in production system? (Level 1: No action, Level 5: Optimized)

- **Emissions:** At which level does company's production system track pollutant levels, aware of their environmental effects to separate them based on different processes? (Level 1: No action, Level 5: Optimized)

Propositions

During analysis, descriptive and explanatory studies need propositions which focus on the case study process (Rowley, 2002). These research propositions support the data collection and structured for analysis data. In this case, research questions should be transformed into propositions that are defined specifically within the scope of the study and are not primarily expressed in research questions. This type of component represents expected outcomes like a hypothesis (Gangeness & Yurkovich, 2006). Therefore, investigator should generate propositions basically for collecting data. This helps to investigator to maintain the study accepting any bias.

Designed maturity grid includes several eco-efficiency metrics and provides an inference to investigator about which metric effects on each other and which one can be evaluated as the most effective on innovation capacity of company in eco-efficiency. Within this scope, validation of applicability is evaluated by following example propositions for the planned case study:

- **Proposition 1:** Applicable to companies from different sectors.
- **Proposition 2:** Easy to understand on use.
- **Proposition 3:** Easy to interpret findings.

Unit of Analysis

A comprehensive case study design needs to be generated by the research purpose, questions, propositions and context of the study. All of the components supply quality of data for both individual and multiple-cases. Data collection process should also consider data gathering resources, data type and period of study in this case. It can be inferred from Figure 6.3 presented by Yin (2003), collected data within this thesis is about an organization from an individual because, study conclusion is completed by an organization. On the other hand, questions and propositions defined in context of the thesis evaluates investigate how organization works for eco-efficiency implementation to processes and why organization works for increasing awareness about eco-efficiency and developing its R&D and innovation capacity in this field.

		From an individual	From an organization	Study conclusions
Design	About an individual	Individual behavior Individual attitudes Individual perceptions	Archival records Other reported behavior, attitudes and perceptions	If case study is an individual
	About an organization	How organization works Why organization works	Personnel policies Organization outcomes	If case study is an organization

Figure 6.3 Design of data collection process in a case study (Yin, 2003)

The unit of analysis is the major component for a case. This component may cover an individual, a process, an organization, team or department within the organization. Even in some situations, identifying the boundaries of the unit of analysis is difficult but core issue is that the case study should just ask questions about the unit of analysis, and any sub-units (Rowley, 2002). In addition, unit of measurement metrics, type of measurement and period of measurement are another important component in data collection process under the case study design (see Table 6.3).

Table 6.3 The base components of data collection process in case study design

Unit of measurement (metrics)	Liters, kilograms, kWh, percent, tons, currency, rate, number, hours etc.
Unit of analysis	Product line, company, supply-chain distribution, life cycle of products/materials etc.
Type of measurement	**Absolute:** Total amount of consumption **Adjusted:** Intensity calculation as total amount/unit of product or services/year, month etc.
Period of measurement	Fiscal year, calendar year, six months, quarter etc.

In this study, unit of measurement covers whole metrics based on the qualitative type of eco-efficiency metrics; for example, company actions to increase eco-efficiency awareness is scaled between no action to optimized level evaluated by R&D or process engineer/manager. Unit of analysis is defined as company through all sectors, type of measurement is both absolute and adjusted according to indicator's metric, period of measurement is a calendar year but it might be change for gathering sufficient data in additional period.

6.3 Case Selection

This thesis designed a multiple-case study that allows more controlled observations and results, comparison between cases, better validity and generalizability when compared to single case studies (Darke, Shanks, & Broadbent, 1998). To maximize vision from the application, multiple-case designs require careful case selection. By this aim, theoretical sampling of extreme situations or reverse types for best insights on the process under investigation and recommends (Bärenfänger & Otto, 2014). In this case, three research cases selected from three different sectors which are textile, packaging and wood industries. All case companies have some regulations under eco-efficiency concept and R&D process to design their systems more technologically. Therefore, pilot implementations of this thesis have been giving significance information about innovation capacity in eco-efficiency based on both company-specific and sectoral conditions.

Data were collected by interviews based on eco-efficiency maturity grid. Interviews were negotiated with a process manager/supervisor who has a strong qualification about the whole processes in production system and R&D activities within the company. Extensive notes and voice records (if interviewee accept) during the interviews and each interview completed nearly one hour. To ensure case study validity and reliability, the study was designed due to the data collection principles mentioned in previous chapter (Yin, 2003). Even the design of data collection process by Yin (2003) (see Figure 6.2) presents organization-based collection; however, some process development reports and documents were supplied by company. All given answers which evaluate the levels of maturity for each eco-efficiency metric were marked on the grid. Then, the interactions among the metrics were investigated and the impact of a specific metric on eco-efficiency maturity level of the company was identified. Next three sections are about case companies to give selection reasons of the sector, information about the company and application results by case study research process.

6.3.1 Case Company Selection in Textile Industry

In textile production, there are huge amount of water, energy and toxic chemicals consumption in processes. Especially dyeing and printing processes are required large amount of water in textile processing. Kant (2012) states that an average sized textile mill consumes 1.6 million liters water about 8000 kg of fabric per day during production. In this case, the World Bank estimates that 17 to 20 percent of industrial water pollution was emerged because of textile dyeing and finishing treatment given to fabric (Kant, 2012).

Kant (2012) also says more than 8000 chemicals in varied processes are used for dyeing and printing and they may be damaging on human health directly or indirectly. In fact, 30 of 72 toxic chemicals from textile dyeing have been identified in water and they cannot be removed unfortunately. Textile production also creates solid, hazardous and air pollutant wastes, wastewater (Ozturk, Yetis, Dilek, & Demirer, 2009). In addition, production system includes few number of textile machines which consume electricity and fuel (Parisi, Fatarella, Spinelli, Pogni, & Basosi, 2015). Energy and water consumption promote fossil fuel exhausting, climate change, ozone depletion is at the high level along with the value chain of textile products especially in washing, tumble drying and ironing processes. The detergent and the energy used during the washing process have provided significant contribution particularly to the toxicity indicators related to human beings and water ecosystems (Alay, Duran, & Korlu, 2016).

The mentioned issues from literature about textile production indicates properly solving them with eco-efficient actions and many studies call to produce more efficient solutions contributing to increase number of eco-efficient textile companies. Therefore, a case company from textile sector was selected for application and this thesis motivates itself to add a new study on textile production based on eco-efficiency within this section.

6.3.1.1 Information About the Selected Textile Company

The selected company is one of the largest knitting fabric manufacturer and exporter of both Turkey and Europe. It is highly motivated company to engage with innovative technologies and R&D activities with more than 450 personnel. Company has a high capacity of straight dyed products and digital printed products. During production, jet dyeing machines and pad batch dyeing machines are managed by an online accessible centralized dyeing and chemical distribution automation system. Additionally, there is another central computer system developed for storing 10,000 different fabrics (Ekoten Fabrics Company, n.d.).

Besides, the company's production system is carried by environmental-friendly and naturally sensitive methods considering to develop technologies under customer-oriented vision, swift and high-quality service. In this case, the company has developed an android application and IOS systems which are providing to track orders, quick access to price data and all test results over smartphones and tablets and other information for all base codes. All of the company's R&D and innovation centered activities are guided by The Turkish Ministry of Science, Industry and Technology related with customer demands, current fashion trends and global technological developments affecting on customer's satisfaction, quality of products and company image.

Human resources are contributing new product development, quality and productivity within the company because, it is aware of the importance of self-development of its employees in regard of training and safety. Especially, solution groups established by green belt employees focus on finding the most suitable solutions for problems under Six Sigma projects.

Its environmental-friendly production including waste management system makes the company a pioneer in its sector supported by certifications of ISO 9001 Quality Certificate, ISO 14001 Environmental Certificate, OHSAS 18001 Occupational Health and Safety Management Systems Certificate, GOTS Organic cotton certificate, OCS 100, OCS Blended and Oekotex. Moreover, the company has successfully gained ISO 50001 Energy Management System Certificate which aims to help businesses continuously evolve their energy performance, to track their energy consumption more effective, to decrease their energy costs and to reduce greenhouse gas emissions even if indirectly.

6.3.1.2 Interview Outputs and Application Results of the Textile Company

The application in the company was carried out with the interview conducted with the potential team about eco-efficiency activities, who are machinery energy manager, production systems chief executive and production management systems engineer within the company. In the maturity grid, it is possible to measure the levels corresponding to different processes, and questions are asked to the team worker who is more dominant in a certain process. First of all, the concept of eco-efficiency was introduced in order to inform the team about the study, the objectives and metrics of the eco-efficiency maturity grid in the performance measurement were mentioned. Then, the question of the level of specific process in the company for each eco-efficiency metric has been addressed and the results in the Table 6.4 are obtained.

Table 6.4 Eco-efficiency maturity grid application results of the textile company

Eco-efficiency Aspects		**Maturity Levels**				
		1	**2**	**3**	**4**	**5**
Performance Enablers	Energy Consumption					X
	Material Consumption				X	
	Water Consumption				X	
	Emissions					X
	Toxic Chemicals Consumption					X
	Product Life-Cycle					X
	Land Use				X	
	Wastes				X	
Structural Enablers	Human Factors					X
	Company Structure					X

Table 6.4 continues

Structural enablers	Business Activities					X
	Collaboration				X	
	Financial Monitoring and Forecasting					X
	Financial Planning for Community-based Activities					X
	Finance for Decision-making				X	
Awareness	Eco-efficiency Awareness				X	

According to results in the table, the lack of levels other than 4 and 5 for each metric created the impression that this company is a mature company in the field of eco-efficiency. The fact that eco-efficiency pilot projects such as the use of cogeneration hot water in different areas, the use of rain water and re-processed wastewater in the production process support the performance indicators to be mature. In addition, it is another mature process that the interviewed team gives feedback on energy saving, reduction in CO_2 emissions, solid waste reduction and water saving results as a result of other environmental-oriented projects.

Furthermore, according to the feedback received, it has been said that adaptation to the environmental legislation for reducing the pollution level is strongly sustained within the plant. Moreover, it is thought that there is a serious chemical saving in the company due to the fact that water and chemicals are inseparable pairs of production in textile processes. Air emissions were decreased due to lower fuel consumption at the same time. The decrease in water consumption and treatment sludge with pilot eco-efficiency projects have also contributed to the savings in wastewater treatment costs.

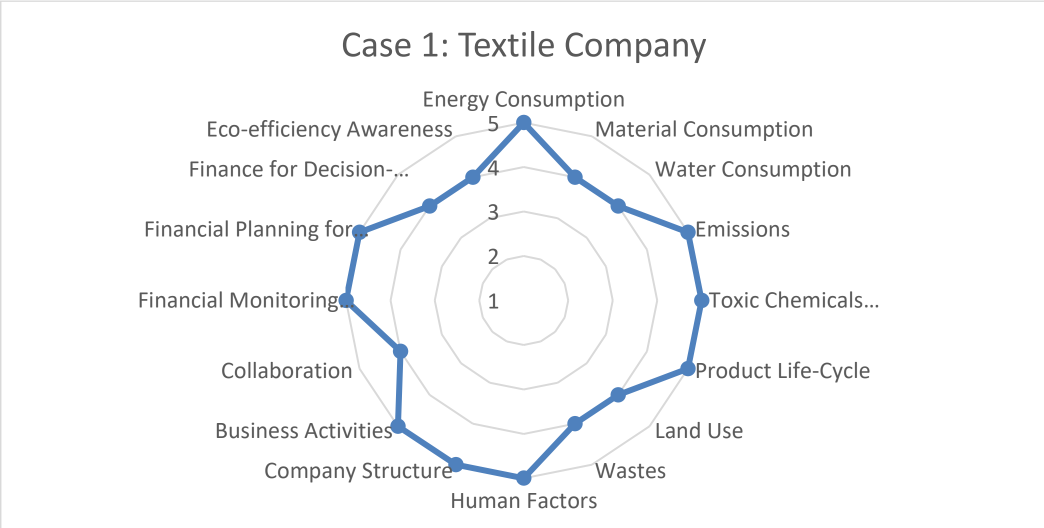

Figure 6.4 Radar chart of the textile company

In order to see the relationship between the level of maturity between metrics more clearly, a radar graph is drawn. According to the graph in Figure 6.4, it is seen that the metrics in the performance enablers aspect for this textile company are at the most mature level which can be understood from smoother graphical pattern among them. This shows the contribution of the pilot projects carried out by the company in the name of eco-efficiency studies with a focus on savings and sustainability.

6.3.2 Case Company Selection in Packaging Industry

Globalization of economies cause high level of competition in both production and services sectors (Affuso, Capello, & Fratesi, 2010). Nevertheless, growing population consumes natural resources and creates more wastes each day. Therefore, supply chain operations for producing sustainable products ensure a very high importance (Ravi, 2015). To develop durable, reusable and upgradable products are helpful to reduce energy, material and natural resource consumption in production system (Bocken, de Pauw, Bakker, & van der Grinten, 2016). Under these circumstances, a package must protect items from contact with the surrounding, keeping a product away from alterations and maintain the purity and freshness of its ingredients (Avella, Bonadies, Martuscelli, & Rimedio, 2001).

In today's competitive environment, packaging can be represented as a strong source to social prestige and public good. It provides functionality to a product and add innovativeness in a competitive market. As more important advantage, it reduces product's environmental impact which also increases competitiveness level of a company. Moreover, there is an increasing awareness among consumers toward environmental-friendly, easy-to-use packaging by considering ecological and social effects of the products they use. Under the view of packaging sector, this situation means that packaging companies should be engaged with resource minimization methods, taking actions to reduce hazards caused from chemicals and emissions, increasing recycled wastes and waste reduction (Holdway, Walker, & Hilton, 2002).

At both national and international level of packaging, it has been one of the most focused problems in environmental politics because of creating the highest percent of wastes on environment. In this case, the EU Packaging Directive has been an important basis to support recycling of packaging materials and packaging waste reduction at the same time (Avella et al., 2001). Therefore, companies are controlled by strong regulations about packaging wastes so, they have to implement environmental-friendly concepts to their business dynamics such as eco-efficiency (Hanssen, Olsen, Møller, & Rubach, 2003).

From all reasons above, packaging sector has a potential for studying on eco-efficiency concept because, it needs designing with ecological design, especially for decreasing packaging wastes, and maintaining more eco-effective production system. However, eco-efficiency studies in this sector are few in literature unfortunately. With the opinion of insufficient eco-efficiency awareness in this sector, this thesis motivates itself to apply a case study from packaging sector for both supporting the gap in literature and make significance observation of maturity level in eco-efficiency.

6.3.2.1 Information About the Selected Packaging Company

The case company operates in the sectors of industrial packaging which is one of the first synthetic weaving companies in Turkey and one of the biggest exporters with 70 percent of Turkey's market. Its structure allows to produce tape, continuous filament, packaging materials from polypropylene raw material, all within an integrated system. Its products are garnet Big Bag, jade/opal Big Bag, conductive Big Bag, UN certified Big Bag and jumbo Bag (FIBC's) (İşbir Sentetik, n.d.).

The company is the only representative at national level and has the largest Bag production facility in the world operating with a yearly production of 2,100,000 quantity of Big Bags. It has also full of awareness on effective hygiene policy and the requirements of companies involved in the food, chemical and pharmaceutical sectors. They produce their food grade Big Bags with both 100 percent of polypropylene and LDPE/LLDPE inner liners which are accepted by both food and pharmaceutical industries.

To satisfy customer's highest demands, the high-tech equipments are installed for producing jumbo Bags and ultrasonic cutting equipment, sewing machines, vacuum systems and metal detection equipments are used to maintain production process with a minimum amount of loses. The raw materials are approved by authorities. Company's quality process includes material inspection and testing, process inspection and testing, and final quality control. For doing each operation effectively, employees and suppliers have been trained to satisfy operation-specific qualifications. Moreover, all employees are also trained on hygienic standards of processing. As another important point, the chemical industry is one of the most technology-based industry including a lot of processes which raw materials are converted to pure form around the world. Designed Big Bags for chemical industry protects the products from unsafe chemical reactions.

To manage risks, TS EN ISO 27001:2013 information security management system is adopted by the company. This system enables to measure the process performance and the relations with the third person about information security. The company believes that information assets are under protection and closed to all threats from both inner and external areas. This shows that company is taking innovative action for data protection so, it can be evaluated as a highly motivated competitor in sectoral environment.

The company has several certificates which verify mentioned sensitivities in business case such as Cleanroom Validation Certificate, Eco Vadis-Corporate Social Responsibility, ISO 9001 Quality Management System Certificate, ISO 22000 Food Safety Management System Certificate, ISO 14001Environmental Management Systems Certificate, BRC Global Standard for Packaging and Packaging Materials, ISO 27001 Information Security Management System Certificate. Additionally, it has BAM Recognition and Turkish Standards Institution Laboratory Accreditation Certificates.

6.3.2.2 Interview Outputs and Application Results of the Packaging Company

Within the scope of the interview carried out in this packaging company, two people were interviewed who are R&D manager and the environment and Occupational Health and Safety engineer with the assumption that both interviewees could give more accurate answers with an authority in the R&D and innovation processes. Eco-efficiency maturity grid application results are given in Table 6.5 below.

At the first point, the most energy leakage process is defined at air pressure point. For this reason, since 2017, production managers and technical teams have received intensive training against air leaks. In the factory, the systematic systems of compressed air producing units were examined and they were installed with a motor driver and they were allowed to operate without any fluctuations. This has resulted in a large amount of electricity gain. However, although it is not possible to convert some systems to electricity saving systems, it is possible to integrate with natural gas and to improve consumption.

There is an ERP system for material consumption within the company. The relationship between the production lot of a material from any company and a Big Bag sold to the world can be established by this system. This ensures traceability. However, due to increasing competition from countries such as China and India, the focus has been on creating value-added production with decreasing the need for less recyclable raw materials such as flame-retardant fabrics, water vapor and oxygen-proof applications. The wastes of these fabrics cannot be recycled as standard fabrics. Although there is an awareness within the company, no method has yet been developed on how to recycle it due to insufficient technological resources. However, there are studies on the bio-degradable fabrics currently available.

Table 6.5 Eco-efficiency maturity grid application results of the packaging company

Eco-efficiency Aspects		Maturity Levels				
		1	**2**	**3**	**4**	**5**
Performance Enablers	Energy Consumption				X	
	Material Consumption				X	
	Water Consumption				X	
	Emissions			X		
	Toxic Chemicals Consumption					X
	Product Life-Cycle		X			
	Land Use			X		
	Wastes					X
Structural Enablers	Human Factors				X	
	Company Structure					X
	Business Activities			X		
	Collaboration			X		
	Financial Monitoring and Forecasting				X	
	Financial Planning for Community-based Activities		X			
	Finance for Decision-making			X		
Awareness	Eco-efficiency Awareness			X		

Training is given to the operators through materials safety data sheets for each chemical usage within the scope of toxic chemical consumption. There is always a risk management system within the company. Shelf life of the product varies according to customer demand. However, the product life-cycle process, which may change depending on the customer's usage conditions, is evaluated on a more marketing basis.

The product life-cycle is insufficient due to the difficulty of accessing information from the customer as to how many degrees the product is stored and which product is stored in it. In addition, in terms of land use, the company is very vulnerable because it rented an area. For this reason, plant layout has been optimized and university support has been taken for this issue.

Although the company tries to pursue strategies for teamwork, they want to work individually because a cooperative climate has not been established in the company in the past. This has to the failure of collaboration within the company. Besides, even though there is a very good ERP system and KPI's software in the company, only managers know about the cost drivers due to the hesitation to give clues about the price to the competitors, this issue is not transferred to the workers. All of these reasons caused by inadequate conditions are represented by the financial planning for community-based activities, finance for decision-making and collaboration metrics (see Figure 6.5).

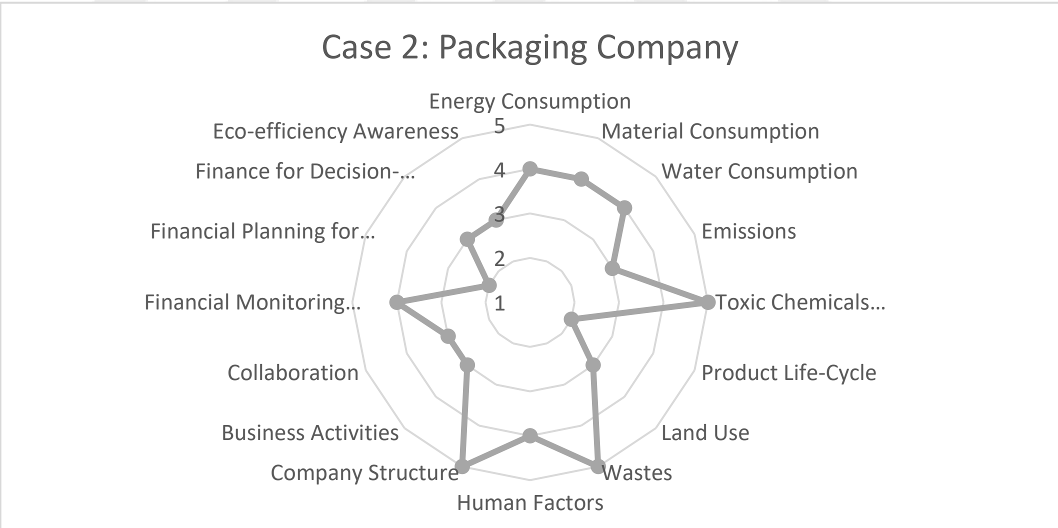

Figure 6.5 Radar chart of the packaging company

6.3.3 Case Company Selection in Wood Industry

Wood is one of the most renewable material that is processed to transform a variety of products and its wastes can be reused as thinning, bark, sawdust, shavings, chips and fibers, side-cuts based on wood industries (Jungmeier, Werner, Jarnehammar, Hohenthal, & Richter, 2002). Different forms of wood are mainly used in construction and in furniture. However, especially in paper industry, wood is also a main resource and it is also the most important fuel in many countries (Lafleur & Fraanje, 1997). In regard to reuse, recycling and energizing use of wood, the material characteristics of it allows for a variety of options.

In many areas around the world, wood consumption amount is getting higher which leads to deterioration of forests. When a wood company wants to utilize wood as raw material, it needs a management system to optimize the use of resources and to reduce the environmental impact (Rivela, Moreira, Muñoz, Rieradevall, & Feijoo, 2006). To sustain natural resources and protect environment, wood products should be produced more effective and efficient by optimized processes using technology and create more durable and recyclable products with longer service life, recyclable and less energy consumption (Lafleur & Fraanje, 1997).

In wood industry, operational effectiveness which can be represented as process innovation has been pursued through computer-aided production, customized machinery, and improved quality control, among other methods (Wagner & Hansen, 2005). In this case, managers in wood industry honestly justify process innovation when they compare their product or business systems (Hansen, 2010). As it is highlighted in Chapter 2, innovative companies improve their operational effectiveness and gain competitive advantage both in the market and sector especially with imported wood products (Wagner & Hansen, 2005). Furthermore, engineered wood products are an example of product innovation and its other products are evaluated as product or business systems innovation for the companies.

In this thesis, wood industry was selected for case study because, it is suitable for the application within the context of this thesis covering process innovation under eco-efficiency. Moreover, there is a lack of eco-efficiency application at national level in this sector and many of wood companies need to take consultancy services especially for waste management and disposal. Therefore, this thesis provides a comprehensive example of performance evaluation for wood industry related with eco-efficiency.

6.3.3.1 Information About the Selected Wood Company

The case company produces the raw and melamine coated particle boards, glossy panels, MDF, laminate flooring, tops, door panels and value-added products for the needs of the furniture, decoration and construction sectors as the top company in its sector at national level (Kastamonu Entegre Company, n.d.). It operates with 6000 employees and exports to 100 countries from Middle America to India. The company has its own system created for the after sales services to answer the customers' requests in shortest lead time and efficiently.

The company has high quality standards for each manufactured product and it takes operational actions to rise the quality level and reduce the costs by efficiently applied methods on the quality system at each stage of production. There are 26 laboratory and quality control points installed in the factory which are fully approved by EN "European Norms" standards to ensure the product quality. Moreover, several product tests and controls are performed in order to customer's satisfactions. In panel production operation, pressing and painting tests are implemented, while laminate flooring production is maintained by fixing production implementations.

There is an innovative and pioneer point of this company based on its certifications. In addition to standard quality certificates such as ISO 9001 Quality Management System, OHSAS 18001 Work Health and Safety management System, ISO 50001 Energy Management System, the company has obtained the ISO 27001 Information Security Management System Certificate as well. Furthermore, it runs the production system more eco-efficiently and design more environmental-sensitive processes so, it has also obtained FSC Forest Stewardship Council Certificate that is documenting the raw materials amount from the industrial forests approved by independent committee. Besides, the company creates very less amount of deterioration on natural forests and environment.

On the other hand, the company is sensitive to human health and aims to meet necessary criteria of global market over the human health. To fulfill this aim, the CARB2 Certificate has been obtained by the company which is becoming more and more noteworthy and demanded in the whole world. Two of the TSE Turkish Standards Certificate of Conformity (E1, E0, FR etc.)

6.3.3.2 Interview Outputs and Application Results of The Wood Company

According to interview outputs carried out with process and logistics operations manager of the company, it was seen that the company uses wood more effective for contributing to the environmental protection. Thirty percent of the waste is collected and used in the production process again. Since reducing the emission of chemicals during production, the gases coming out of the chimney are kept by a filtration system. Detectors located at certain points of the company are trying to prevent the mixing of formaldehyde gas into the air. If a product can be reworked, it is reused in production. Additionally, consumed water are available for reuse as well.

E0 certificate is taken and production is realized by considering zero carbon emission. In addition, due to the carbon emission from the forklifts, it has been transformed from diesel to electric, thereby eliminating the carbon emission of 14 forklifts. It is intended to be used as a minimum level of melamine chemical substance on the furniture surface. Urea material is stored in closed and concrete silos and the chemical effect is minimized. It is aimed to reduce the consumption of raw materials with the works carried out in order to benefit from the end user's wastes.

The company wants to reduce the cost of waste as much as possible. In the whole company, wood, wedge parts and chips are purchased from the other close-ranged wood companies, and then wood shells are provided as fuel to these companies. In this way, inter-company cooperation is achieved through the exchange of waste materials. At the same time, non-destructible wastes such as oil waste are sold to external waste management companies. Due to all these initiatives, the company's consumption and waste metrics are at the 4th and 5th maturity levels (see Table 6.6).

Since 2010, the recruitment of employees in line with the requirements of the position has supported the improvement of the quality of work and the increase of employee satisfaction. The impact of this criterion is low during the evaluation of the lost times. Furthermore, it is aimed to ensure easy and effective communication between teams in new investments thanks to the policy of structuring as inter-location support teams.

After the 2018, despite the increase in the capacity of the market in terms of sales strategies, production started according to customer demand and sales started to be customer focused. Gradually, because all customers put certain criteria into the product, the actions taken have started to increase. This allows the company to retain its customer portfolio for the next year on a customer basis and to more easily estimate demand. The sales-marketing department constantly visits the customers and conducts them in person with the customer. Additionally, once the annual targets are determined, it is divided into monthly targets and followed every month. In the production program, certain data are determined immediately after the customer order is displayed and assignment is made to the lines. The system is designed by a company that estimates the inventory during the missing production.

Table 6.6 Eco-efficiency maturity grid application results of the wood company

Eco-efficiency Aspects		**Maturity Levels**				
		1	**2**	**3**	**4**	**5**
Performance Enablers	Energy Consumption					X
	Material Consumption					X
	Water Consumption				X	
	Emissions					X
	Toxic Chemicals Consumption				X	
	Product Life-Cycle			X		
	Land Use				X	
	Wastes				X	
Structural Enablers	Human Factors			X		
	Company Structure				X	
	Business Activities					X

Table 6.6 continues

Structural Enablers	Collaboration					X
	Financial Monitoring and Forecasting					X
	Financial Planning for Community-based Activities					X
	Finance for Decision-making					X
Awareness	Eco-efficiency Awareness				X	

The innovation team within the company is gathering in a certain period of the year and forming an idea platform. In this platform, budgets are planned by evaluating investment plans and project teams are created and the project is carried out. Moreover, company's mission is to be a pioneer in the sector and it has obtained ISO and Turquality certificates showing that they have initiatives on environmental impact and eco-efficiency.

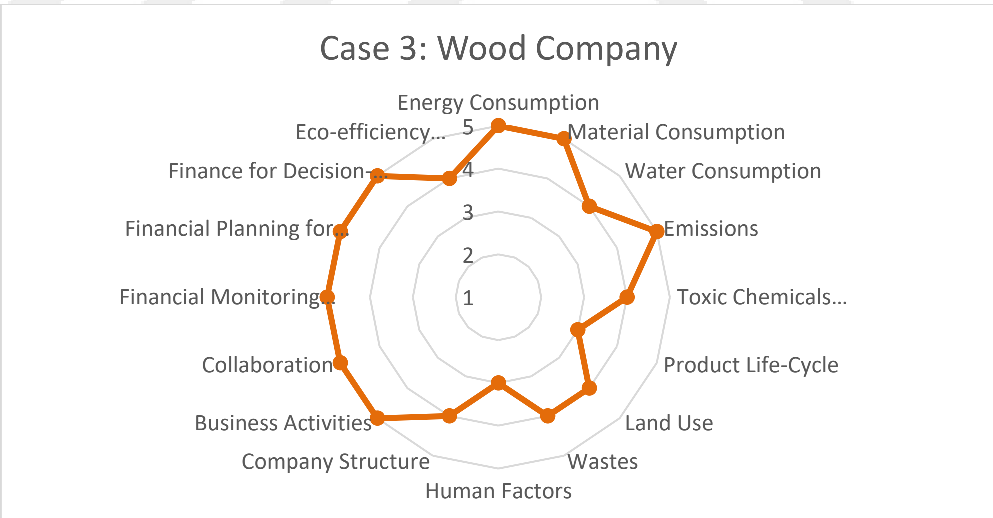

Figure 6.6 Radar chart of the wood company

It is observed that the most dominant metrics detected during the interview were consumption, waste management, investment and environment-oriented financial resource planning. This awareness on the basis of the company has enabled the finance-based metrics to be included in the 5^{th} level maturity on the radar diagram (see Figure 6.6).

CHAPTER SEVEN
CONCLUSION AND DISCUSSION

Eco-efficiency is the technological and managerial practices that are carried out in order to reduce the raw material resources by using inputs more efficiently and to prevent or reduce the source of pollution in the processes of product and service. Especially, the effects of the recent changes in the climate change, the scarcity of water resources, the destruction of the nature riches, the decrease in the share of the agricultural production in the economy and the rapid development of the industry in the regions have started to be the causes that triggered attention.

Nowadays, due to the increasingly competitive environment in the business world, companies need to integrate innovative ideas to add value to their processes. In addition to designing a new system, innovation is also possible by making changes or making improvements in existing processes. This type of innovation, which is evaluated in the context of process innovation, generally targets sustainability. The fact that sustainability is an important criterion in terms of eco-efficiency concept indicates that this concept can be applied in the field of process innovation management. In this context, adapting the eco-efficiency concept that has just begun to be formed in the process, the adapted companies make a difference against their competitors.

In this thesis which includes the integration of the concept of eco-efficiency at company level, production and management processes were examined together. According to its' implementation process at company level presented in Figure 3.2, the objectives of eco-efficiency in a company should be identified at first. Although this thesis basically focuses on increasing awareness on eco-efficiency, capacity building at the beginning of the implementation process is a major step in a production company. Thus, system boundaries should be defined by applying case studies and eco-efficiency capacity should be measured by identified indicators to detect open-to-improvement processes within a system. In accordance with this purpose, a comprehensive systematic literature review was conducted to determine an effective method. It was decided to develop a maturity grid that enables current situation analysis and performance management in both production and management processes in line with eco-efficiency objectives and metrics.

In the planning step of the maturity grid developed in three separate steps, the purpose, scope and application area of the model were defined. In the second step of the development step, the model's levels and cell descriptions were defined in accordance with the performance and structural promoters and eco-efficiency awareness perspectives. In the last stage of evaluation, verification of the developed model was conducted due to expert feedbacks. The case study methodology was selected to measure the validation of the grid and this step was presented in the application part of the thesis.

The developed maturity grid, which was designed to be applied to different sectors, shows its specificity in terms of not having a sector-specific study as well as its contribution to the literature due to the lack of a study that uses maturity grid methodology in eco-efficiency. Furthermore, this developed performance assessment tool was especially designed for senior managers to utilize it in companies' business activities within the company such as in decision-making process of top management. In this respect, this thesis can be evaluated as an original study which provides an easy-to-use guidance for both academic and technical experts for eco-efficiency implementation to different processes. At the same time, measuring the R&D and innovation capacity can be recognized by maturity grid to manage performances of processes. Thus, the gap of maturity grid application in the field of process innovation management is contributed in literature.

As a result of the practices carried out in three different sectors: textile, packaging and wood industry, this thesis concludes that performance-enabling eco-efficiency metrics (especially energy, material, water consumption and wastes) are getting attraction by companies aiming to be an eco-efficient company and sustained their processes to cover these metrics. The metrics grouped under structural enablers are developed according to the vision and mission of the companies. Therefore, their levels among the case companies are shown as less common in given radar chart in Figure 7.1.

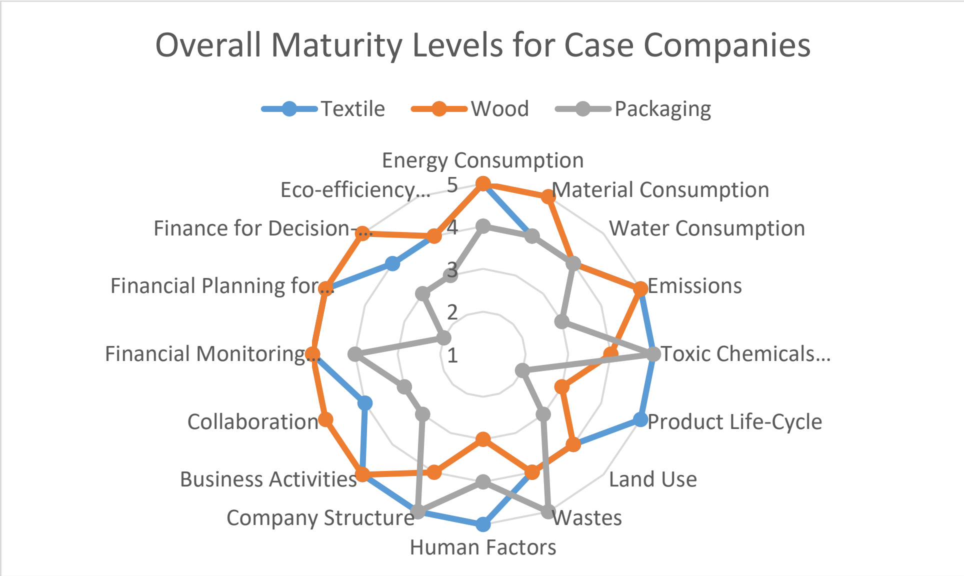

Figure 7.1 Radar chart covering whole case companies

In the future research, the consistency of the developed eco-efficiency model can be achieved via more applications in more companies among different sectors. To measure the consistency of the eco-efficiency maturity grid, selection of case companies which have the common maturity levels based on the same metrics may provide better result for application of this study. In addition, gathered data via eco-efficiency maturity grid is subjective and differ from each other due to evaluators. This may be considered as a weak point of the grid and this issue can be solved by the larger data collection from an additional number of applications for each selected sector in future. The collected data can be analyzed by applying multi-criteria decision-making methods and used for prioritizing eco-efficiency metrics on a sectoral basis.

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APPENDIX-1: Revised Eco-efficiency Maturity Grid with experts' feedbacks

ECO-EFFICIENCY MATURITY GRID

Eco-efficiency Aspects		Maturity Levels				
		1	**2**	**3**	**4**	**5**
Performance Enablers	**Energy Consumption**	No tracking on energy consumption levels and any data gathering about periodical consumption amount.	Energy consumption amount is periodically tracked by some special methods within the company.	The amount of energy consumption is compared with the defined levels under energy regulations. Process is monitored and root causes of unidentifiable energy leaks are indicated.	Company starts to take actions for energy savings on processes. Sustainable technologies are started to implement for reducing energy consumption.	Company designs overall process to optimize energy consumption. It tends to integrate with new technologies and equipment to reduce the use of non-renewable energy resources.
	Material Consumption	No records on the amount of input and output materials, stocks and material costs.	Stocks are tracked and recorded on warehouse management system. Materials having less volume in production are identified from the past data.	Employees understand the impacts of materials on environment. Process engineers evaluate each impact of the materials against environmental restrictions.	Recyclable materials are preferred to use in production systems. Waste tracking system is started to develop for reducing amount of wastes at the end of the process. Cost calculation system is also designed to understand savings after taking actions for eco-efficiency.	Production system is re-designed by considering eco-efficiency principles. Some recyclability methods are implemented. Process is improved to maximize resource efficiency.
	Water Consumption	No tracking on water consumption levels and any data gathering about periodical consumption amount.	Water consumption amount is periodically tracked by some special methods within the company.	The amount of water consumption is compared with the regulated levels. Process is monitored and root causes of unidentifiable water flows are detected.	Company starts to take actions for water savings on processes. Sustainable technologies are searched to implement for reducing water consumption.	Company designs overall process to optimize water consumption. It tends to integrate with new technologies and equipment to reduce the use of water resources. It also creates a system for rainwater collection for use in production.
	Emissions	No monitoring the emission levels of pollutants.	Pollution levels of wastes and gases produced by processes are tracked and categorized into direct or indirect effective groups on environment.	Pollutants are separated based on different processes. Process engineers understand which one is released during which operation in the system. Environmental effects are emphasized on planning process.	Company starts to take actions for reducing the emissions of pollutants. Sustainable technologies are searched and top management collaborates with external networks such as local authorities to develop pilot applications.	Process managers set periodical impact assessments for new developments on the processes. Company designs more efficient exhaust gas management system. It aims to integrate with zero carbon policy rather than reducing carbon emission.
	Toxic Chemicals Consumption	No data collection for chemical risk assessment.	Chemical risk data are monitored to reduce the hazardous impacts on humans and environment.	Collected data are analyzed to provide a better risk control of chemicals' concern.	Specific actions and process-based restrictions are set. Less toxic chemicals which are equivalent for the same operations are indicated.	Company is faced with minimum number of uncertainties regarding toxic effects of chemicals. Toxic chemicals are replaced with less hazardous types in the process.
	Product Life-Cycle	No data for life-cycle analysis of products.	Collected data are stored to monitor reliability and environmental effects of a product. Various methods that facilitate a systematic approach to material choice are evaluated.	Preliminary life-cycle analysis is evaluated. Life-time limiting mechanisms or failure modes of the studied materials and components are identified and characterized.	Detailed life-cycle analysis is interpreted by considering functionality, user reliability and technical durability. Cost-effectiveness approaches are implemented to minimize environmental impact.	Product-tracking combines both product and process design by using life-cycle analysis outputs. New product development process is integrated with more eco-efficient methods.

APPENDIX-1 continues

Performance enablers	**Land Use**	No land use objectives and data of company to plan the goals to be worked for.	Data are collected and reserved due to identified objectives by the company.	Team members dealing with land use planning issues are assigned. Selected methods are compared with alternative land use methods. Land use problems and opportunities of the planning area are identified by considering legal regulations.	The team evaluates land suitability for each type of plans. Land requirements are matched with physical suitability. The impacts of land planning alternatives are assessed on environment, economic and social areas.	A land use strategy is created and taken into action by decisionmakers of the company. Top management monitors this progress toward identified the goals.
	Wastes	No periodical data about the total amount of disposal units/materials.	Data are collected and recorded. Wastes are separated such as material, packaging or solid/liquid.	Recycled wastes are re-used in the production process. Company developed a waste management system to recycle as much as possible amount of wastes.	Disposal methods are integrated to create less amount of wastes which cannot be recycled at the end of the process.	Company designs recycle and disposal processes to minimize process-based wastes and maintains continuous improvement on the production process.
Structural Enablers	**Human Factors**	No information about the lost times because of unintended events, injuries and illnesses of employees.	Root causes of lost times are identified and categorized as equipment-based, process-based and human-based. Important actions are defined to optimize operational performance.	Employees are trained to improve equipment performance. Jobs are assigned to employees based on their qualifications and job satisfactions.	Total lost time is reduced and percent of employees' complaints about unsatisfied job is decreased.	Cross-functional teams are created to support employees' skills. Continuous improvements are ongoing on the equipment and process design to provide more ergonomic conditions.
	Company Structure	Internal impacts of the company such as company size, number of employees are not figured out and not grouped into strengths and weaknesses.	Periodical performance evaluation is applied on the employees to understand their level of practical skills and attitudes toward their works.	Company is aware of how effective the structure is when applied. Department heads make sure that the information flow is widely conveyed to all customers.	Suitable rules and regulations are applied to ensure the benefits of employees and businesses.	Top management makes sure that infrastructure of the company is good enough for all functions of the company. Well-motivated and well-trained employees are supported by high quality facilities. It organizes corporate social responsibility projects for being a preferable company.
	Business Activities	There is no policies and programs to maintain business activities effectively.	Basic business activities are identified and comprehensive guidelines to make a business plan are defined.	Periodical accounting data is reported to monitor financial situation for taking actions and crafting budget for new strategies.	Marketing plans are developed that use sales projections to help determining the most efficient way for service intensity. Sales group compares data from previous year with actual year to create a plan to expand the customer base. It matches company solutions with customer needs to forecast product demand.	Qualified candidates whose qualifications match with current positions are hired. Proactive customer interaction is sustained to expand the company's revenues and provide solutions to customers.
	Collaboration	No active methods which support collaborated working environment. Lack of information sharing and trust between employees.	Team works are supported within company but members are commonly working alone and giving more importance on their own concerns rather than overall team idea.	Team is aware of the importance of each idea comes from each member, evaluates them and tries to create solutions from all its members.	All members contribute created solutions and work for improving them. Team combines suggestions from different ideas from the members.	Each team member attends with full participation honesty and ambition for working together within the team. Number of active cross-functional projects are getting increase.

APPENDIX-1 continues

Structural enablers	**Financial Monitoring and Forecasting**	There are any adequate financial management practices. Very limited financial performance information is produced.	Basic financial management practices are applied but do not support managers for financial monitoring. Some financial performance information is reported to top management; however, it is not integrated.	Financial management practices are adequate but will not be sufficient in challenging times. Even reports to top management contain information of financial management performance, they are produced on consistent bases.	Professional financial management practices can cope with in challenging times and will identify some key performance indicators (KPIs) to improve its performance.	Financial management practices optimize both challenging and enabler performance indicators. Comprehensive metrics (KPIs) are set for each business segment and reported with financial information.
	Financial Planning for Community-based Activities	Strategic, corporate and financial planning processes are not coordinated.	There is a weak linkage between planning processes and community-based activities. Company does not separate some amount of financial resources from its revenues to support community spending and charitable contributions.	There are some integration actions with community for the most open to improvement business area. Some strategic plans are started to develop for supplying employment opportunities to local community.	Top management makes sure about the importance of strategic plans to engage with community and aims to sustain them in long term. Strategic plans are set and supported by finance team. They make periodical interviews and taking proposed solutions from experts in civil society organizations	Top management gives direction to organization in the short, medium and long term. They aim to get into mush more partnerships with community. In this case, financial plans are integrated to all levels of the developed strategies.
	Finance for Decision-making	No awareness of the drivers of cost and the operational changes in cost on company's activities.	There is awareness about some cost drivers but there is little understanding of the operational changes on cost.	Managers know that the costs of activities, outcomes and drivers. They benchmark methods of other organizations performed to understand cost drivers.	Managers and employees can understand cost analysis. They can demonstrate the impact of changes in the rate of customer complaints, cost of goods/services and energy.	Managers and employees are willing to apply different cost methods to maximize demand volumes, new services and products. They create future plans by their openness to stake-holder involvement in decision-making and manage cash flow for sustainability
Awareness	**Eco-efficiency Awareness**	There is no awareness of top management and employees on eco-efficiency.	Employees are trained to being environmental sensitive and gained knowledge about environmental regulations.	Managers support eco-friendly technologies and adopt their teams to idea of creating less waste in the workplace.	Resource efficiency is maintained by cross-functional teams and projects.	Budgets for eco-efficiency plans are crafted and managerial accounting principles are used by top management to develop the plans. Company participates related meetings about eco-efficiency and proposing periodical summits with experts from different industries.