KADİR HAS UNIVERSITY
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RENEWABLE ENERGY COOPERATION IN THE BRICS: A REALISTIC OPTION?

ELİF GÜNEY

MASTER’S THESIS

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This work entitled **RENEWABLE ENERGY COOPERATION IN THE BRICS: A REALISTIC OPTION?** prepared by **ELİF GÜNEY** has been judged to be successful at the defense exam held on **08/01/2020** and accepted by our jury as **MASTER'S THESIS**.

APPROVED BY:

Prof. Dr. Volkan Ş. EDİGER (Advisor)	Kadir Has University	
Assoc. Prof. Dr. H. Akın ÜNVER (Co-Advisor)	Kadir Has University	
Assoc. Prof. Dr. Gökhan KİRKİL	Kadir Has University	
Asst. Prof. Dr. İstemi BERK	Dokuz Eylül University.	

I certify that the above signatures belong to the faculty members named above.

Dean of School of Graduate Studies

Prof. Dr. Sinem AKGÜL AÇIKMEŞE

DATE OF APPROVAL:

08/01/2020

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RENEWABLE ENERGY COOPERATION IN THE BRICS: A REALISTIC OPTION?

ABSTRACT

The energy transition from coal to oil and natural gas was a requirement for a new energy system to improve efficiency and meet future energy demand. Therefore, the increase in natural gas and renewable energy resources is expected to lead to a new energy revolution to solve resource scarcity and the main challenges of global climate change. One of the most challenging questions for this transition: "Can countries with different energy profiles and strategies cooperate on the renewable energy transition?" To answer this question, the BRICS, defined as global cooperation made up of countries exhibiting tremendous heterogeneity in economic and political circumstances, is an appropriate case for understanding the energy transition. The analysis of BRICS as renewable energy cooperation also provides a further perspective to evaluate to what extent the BRICS still matter and to what extent these countries are approaching or moving away from each other. However, there is a deficiency in combining different parameters to understand the renewable energy transition in the BRICS. With this purpose, this thesis offers a comprehensive overview of the topic by comparing and applying two theoretical concepts – path dependence and leapfrogging – to analyze the possibility of BRICS cooperation. The study first reviews country-level variations through the theoretical concepts of path dependency and leapfrogging and then presents the BRICS countries regarding their country-level variations. It then elaborates on past energy cooperation among the BRICS and evaluates the possibility of future renewable energy cooperation. At the end of the study, it is argued that the BRICS can cooperate on the renewable energy transition, but this does not mean that the experience of each country will be similar. This study suggests that cooperation on the renewable energy transition among the BRICS is possible only under certain circumstances. To foster this process, BRICS members need to re-evaluate their energy policies, encourage renewable energy development with new policies and create a well-defined structure for economic diversification away from fossil fuel dependency.

Keywords: BRICS, Cooperation, Leapfrogging, Path Dependence, Renewable Energy Transition

BRICS ÜLKELERİNDE YENİLENEBİLİR İŞBİRLİĞİ:
GERÇEKÇİ BİR SEÇENEK Mİ?

ÖZET

Kömürden petrole ve doğal gaza olan enerji geçişi, enerji verimliliğini arttırmak ve gelecekteki enerji talebini karşılamak için yeni bir enerji sisteminin şartıdır. Bu nedenle, doğal gaz ve yenilenebilir enerji kaynaklarındaki artışın, kaynak kıtlığını ve küresel iklim değişikliğinin temel zorluklarını çözmek için yeni bir enerji devrimine yol açması beklenmektedir. Bu geçiş için en zorlu sorulardan biri: "Farklı enerji profillerine ve stratejilerine sahip ülkeler yenilenebilir enerji geçişinde işbirliği yapabilir mi?" Bu soruyu cevaplamak için, ekonomik ve politik koşullarda muazzam heterojenlik gösteren ülkelerden oluşan, küresel işbirliği olan BRICS uygun bir vakadır. Bununla birlikte, BRICS'deki yenilenebilir enerji geçişini anlamak için farklı parametrelerin birleştirilmesinde bir eksiklik vardır. Bu amaçla, bu tez, farklı ülke düzeyindeki farklılıkları ve BRICS işbirliğinin olasılığını analiz etmek için iki teorik kavramı - yol bağımlılığı ve sıçrama- karşılaştırarak ve uygulayarak konuyla ilgili kapsamlı bir genel bakış sunmaktadır. Çalışmada önce ülke düzeyindeki değişimler, yol bağımlılığı ve sıçrama ile ilgili teorik kavramlar incelenerek ardından BRICS ülkelerinde ülke düzeyindeki değişimler hakkında bilgi verilmektedir. Daha sonra, BRICS arasındaki geçmiş enerji işbirlikleri ele alınıp gelecekteki yenilenebilir enerji işbirliklerinin olasılığı değerlendirilmektedir. Çalışmanın sonunda, BRICS'in yenilenebilir enerji geçişi konusunda işbirliği yapabileceği, ancak bu her ülkenin deneyiminin benzer olacağı anlamına gelmediği iddia edilir. Bu çalışma, BRICS ülkeleri arasındaki yenilenebilir enerji geçişi konusunda işbirliğinin yalnızca belirli koşullar altında mümkün olduğunu göstermiştir. Bu süreci geliştirmek için BRICS üyelerinin, enerji politikalarını yeniden değerlendirmeleri ve yenilenebilir enerji gelişimini yeni politikalarla teşvik etmeleri gerektiği vurgulanmaktadır. Ayrıca, fosil yakıt bağımlılığından uzak ekonomik çeşitlilik için iyi tanımlanmış bir yapının gerekliliği vurgulanmaktadır.

Anahtar Sözcükler: BRICS, İşbirliği, Sıçrama, Yol Bağımlılığı, Yenilenebilir Enerji

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LIST OF ABBREVIATIONS

BIMSTEC	Multi-Sectoral Technical and Economic Cooperation
BN	Billion
BP	British Petroleum (Oil Company)
BRICS	Brazil, Russia, India, China and South Africa
EAEU	Eurasian Economic Union
EDI	Electoral Democracy Index
EIA	U.S. Energy Information Administration
EU	European Union
G20	Group of Twenty
GDP	Gross Domestic Product
iBRICS	BRICS Innovation Network
IMF	International Monetary Fund
IRENA	International Renewable Energy Agency
JNNSM	Jawaharlal Nehru National Solar Mission
KTOE	Thousand Tonnes of Oil Equivalent
LDI	Liberal Democracy Index
LTMS	Long-Term Mitigation Scenario
MDGs	Millennium Development Goals
MN	Million
MT	Million Tons
MW	Megawatt
MWT	Megawatt Hour
NDB	New Development Bank
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
R/P	Reserves-to-production Ratio
REN21	Renewable Energy Policy Network for the 21st Century
RES	Renewable Energy Resources
RFME	Ministry of Energy of the Russian Federation
SCO	Shanghai Cooperation Organization

TFC	Total Final Consumption
TPES	Total Primary Energy Supply
TWH	Terawatt Hours
US	The United States
V-DEM	Varieties of Democracy
WB	World Bank
WEF	World Economic Forum
WJP	World Justice Project

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1. INTRODUCTION

Energy is the primary source of human well-being and social welfare. Until about 200 years ago, the energy needed to sustain human existence came primarily from renewable sources (Seiferle, 2001). However, fossil fuels - coal, oil, and natural gas – began replacing these renewable sources in the 1800s and have dominated primary energy use ever since (Mitchell, 2009).

From coal to oil and natural gas, the energy transition was a necessity for a new energy system to maximize energy efficiency and adequately manage future energy demand (Sovacool, 2016). It is easy to discern that global energy utilization is trending towards the usage of clean, low-carbon energy with higher calorific value and greater practicality. Accordingly, the rise of natural gas and renewable energy resources (RES) in recent years is expected to lead to a new revolution in the energy sector (Wang et al., 2016). Since the essential problems of the existing energy system are related to resource scarcity and global climate change, the current transition aims to address them.

Centuries of burning fossil fuels have produced development in many parts of the world but have resulted in large-scale climate change at the same time (BNEF et al., 2018). Extensive research indicates that the possibility of quickly switching to clean and renewable energy systems that will mitigate the adverse effects of climate change is one of the world's most urgent crises. That switch is already happening in many parts of the developing world; global renewable energy investments rose 2% to $279.8 billion in 2017. In 2015, the developing world invested more in renewable energy than developed economies for the first time. Developing economies, such as like Brazil, India, and China, committed $177 billion to renewables in 2018.

The transition from fossil fuels to RES is accelerating. Governments and renowned international organizations have been taking increasingly more forceful action to foster it, while costs to generate solar and wind energy have fallen dramatically in recent years. Thus, global renewable energy consumption increased by more than 5% in 2017, and the share of renewable energy in worldwide energy consumption is forecast to increase from 2.9% in 2018 to 12.4% in 2023, which is a faster rate of progress than in the 2012-2017 period (IEA, 2018).

However, the renewable energy transition involves complex economic, social and technical dimensions. Multiple actors are involved, which necessitates successful coordination among them. This is why there are several discrepancies between what is technically feasible and what is socially desirable in the renewable energy transition (Sakellariou and Mulvaney, 2013). Hence, the pace and roadmap for each country are different. A recent report entitled "Climate Change and Renewable Energy" examined different ways for Group of Twenty (G20) countries to mobilize effective action on energy decarbonization and explored the critical role to combat climate change (IRENA, 2019a). The report gathers the existing portfolio of clean energy solutions to provide insights into the transition and shows individual roadmaps for the specific countries.

The transition's four main challenges are investment, intermittency and storage issues, available technologies, and resources (IRENA, 2019b). First of all, even though the cost of RES systems has declined unprecedentedly, financing and funding the new RES projects is still problematic, especially for developing countries. Since these countries are in the middle of their industrial development, they need to increase their energy supplies. Secondly, the intermittent of RES is another challenge. Renewable energy is only available when the wind blows or the sun shines. Although there are ongoing rigorous research and development efforts on new storage options, these are still not viable to-date. Thirdly, there are well-developed technologies in developed countries like China, Germany, and the United States, but these technologies are not always available in developing countries due to high costs and lack of know-how. Lastly, the availability of renewable resources is also a critical factor that directly affects the cost and available technologies. As a consequence of these challenges, the pace and depth of the energy transition vary considerably across different countries.

The pathways of fossil fuel-rich and poor countries are different. The fossil fuel-rich countries can be divided into two categories to understand the level of their transition.

The first group is not always enthusiastic about changing their current energy systems because they do not want to give up their power as a resource-rich country. Iran, which has the world's second-largest natural gas reserves and the fourth-largest crude oil reserves,[1] is a prime example. Iran’s strategic decisions are taken to build the wealth of its massive oil and gas resources and distribute their benefits by providing the low-cost energy to households and industrialists, even though Iran has substantial potential in the wind, solar, hydroelectric, and geothermal energy sources (Ghobadian et al., 2009).

The second group, which includes Nordic countries such as Norway and Denmark, is fossil fuel-rich and, at the same time, champions the renewable energy transition. Norway, for instance, is the third-leading exporter of oil and natural gas after Russia and Qatar (OECD, 2019c), but RES meet 68% of its domestic consumption (BP, 2019). Norway has always been one of the most significant contributors to sustainable development and fighting climate change. It uses the excess power generated by renewables as “a battery”; when the electricity is not needed, the stored energy is returned to the market (Karlstrøm and Ryghaug, 2014). Indeed, the pumped hydro storage has been using in Norway, which is the oldest way of large-scale energy storage and works on a simple principle. There are two reservoirs at different altitudes and, when the water is delivered from the upper reservoir to the lower reservoir, energy is created by the downflow, which is delivered through a turbine and generator to generate electricity. Moreover, Denmark is the European Union (EU)'s second-largest oil producer (OECD, 2019a), and generates 30% of its energy consumption from RES systems, mostly wind (BP, 2019). The Nordic countries intend to be “fossil-free” by 2050 (Sovacool, 2017).

Fossil fuel-poor countries can also be divided into two main categories. The first, headlined by Germany, promotes and invests in RES systems. The German economy is enormous—the fourth largest in the world by GDP—but its proven reserves of fossil fuels are modest. Herein, it is critical to mention that Germany used its coal reservoir for years to become an industrial power, but most of its coal mines were recently closed, and indigenous coal production meets only 51.4% of its consumption, 11.9% of its

[1] U.S. Energy Information Administration (EIA) (2019). Iran Analysis. Retrieved 2 February 2019 from https://www.eia.gov/beta/international/analysis.cfm?iso=IRN

natural gas consumption as of 2017 (OECD, 2019b). Germany has set ambitious policies to increase its share of renewable energy that was launched as part of *Energiewende*, the so-called German energy transition, in the early 2010s (Hansen et al., 2019).

Yet there are also fossil fuel-poor countries that are neither investing nor engaging in RES systems. Georgia is an example: it does not have a considerable amount of fossil fuel reserves but has renewable energy potential (BP, 2019). Although a clean energy revolution is urgently needed in Georgia to combat energy poverty and promote robust development, it has no standard portfolio of renewable energy transition or a voluntary target for renewable energy (World Energy Council, 2016).

Therefore, one of the most challenging questions is: "Can countries with different energy profiles and strategies cooperate on the renewable energy transition?" In order to answer this question, the BRICS, defined as a regional cooperative organization composed of countries that show considerable diversity in economic and political situations are an ideal rubric for understanding the past, present, and future of the energy transition. The BRICS include the Federative Republic of Brazil, the Russian Federation, the Republic of India, the People's Republic of China, and the Republic of South Africa. For years, these countries were accepted as newly emerging economies, but it is no longer reasonable to see them at the same level today. China's impact on international trade has been enormous, and its effects on the world economies have been studied extensively (Agarwal et al., 2019). These countries make significant contributions to the global economy: in 2019, the five BRICS constituted more than 3.2 billion people or about 42% of the world's population, and four out of five, excluding South Africa, are among the top ten countries in the world in population.[2] The BRICS are also the most comprehensive of the middle-income economies with US$18.6 trillion total nominal GDP, which means approximately 23% of the gross world product in 2018.[3]

[2] Worldometers (n.d). World Population. Retrieved 30 September 2019 from https://www.worldometers.info/world-populationsouth/population-by-country/

[3] The International Monetary Fund (IMF) (2013). Report for Selected Countries and Subjects. Retrieved 30 September 2019 from

This thesis, above all, will seek to answer whether the BRICS can cooperate on the renewable energy transition. It will also seek to answer the following sub-questions: what are the country-level variations among BRICS in the renewable energy transition?; what is the importance of BRICS cooperation on renewable energy?; and what is the future of BRICS cooperation?

Several authors have studied the renewable energy transition in the BRICS, but these studies have mostly focused on specific issues and do not examine the BRICS holistically. The existing literature can be grouped into four categories. The first pertains to the economic dimension of adopting renewable energy systems. While most authors explain the growing economic power of BRICS cooperation and its possible continuation within the renewable energy transition (e.g., Ahmed, 2017; Dudin et al., 2016; Rodionova et al., 2017; Sebri and Ben-Salha, 2014), some highlight that any possible shift will have direct adverse effects on their economies (e.g., Sasana and Imam, 2017; Zeng et al. 2017). For instance, Sebri and Ben-Salha (2014) argue that renewable energy sources have the potential to play a vital role in the expansion of domestic production by promoting the BRICS economic growth. However, according to Zeng et al. (2017), the financing models, which include institutional loans and funds, direct and international financing may be problematic for the BRICS in the long run because of investment shortages and the lack of financing channels. Bodas Freitas et al., (2012) also underline that BRICS economies have relied on fossil-based technologies and that, even if the financing issue is solved, the BRICS may face the risk of lagging far behind the developed countries.

The second group of literature analyzes the renewable energy transition in the BRICS with a particular emphasis on increasing climate problems. Many authors conclude that the efforts of BRICS nations to shift to renewable energy are prompted by the negative effects of climate change, which are severely felt in these countries (Kurtkoti, 2016; Maryam et al., 2017; Sharda, 2016). Sharda (2016), for instance, highlights that the BRICS are not only accelerating their transition because of climate change but also to

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https://www.imf.org/external/pubs/ft/weo/2013/01/weodata/weorept.aspx?pr.x=91&pr.y=5&sy=2011&ey=2018&scsm=1&ssd=1&sort=country&ds=.&br=1&c=223%2C924%2C922%2C199%2C534&s=NGDPD%2CNGDPDPC%2CPPPGDP%2CPPPPC&grp=0&a

start investing in the clean-energy technologies within and outside of BRICS members. Along these lines, the New Development Bank (NDB) of BRICS countries was established in 2014 to fund infrastructure projects supporting sustainable development and environmental solutions in developing countries. However, others argue that the practical policies to combat climate change are still missing due to the hyper-focus on economic development at the country level (Downie and Williams, 2018; Wentworth and Oji, 2013). According to Downie and Williams (2018), the BRICS' number one priority is national economic development, which explains why there is still no collective action to combat climate change.

The third group of literature covers the effect of fast-growing technologies on the renewable energy transition in the BRICS. It is posited that fast-growing technologies present opportunities for the BRICS to implement renewable energy systems and deal with limited resources (e.g., Araújo, 2014; Zhang et al. 2011). According to Araújo (2014), the adaptation of fast-growing renewable energy technologies would foster comparative advantages for BRICS and save them time and money during the transition.

The fourth and final group of literature illuminates the extent of renewable energy cooperation among BRICS members. This literature directly related with this thesis because cooperation is one of the main pillars of the study. To be sure, the multilateral energy cooperation between the BRICS remains mostly as initiatives with few significant acts (e.g., Downie, 2015; Eriksen et al., 2012; Jayan, 2012; Steblyanskaya et al., 2018; Sun, 2014). For Eriksen et al. (2012), all BRICS have high stakes in energy cooperation and have been able to agree on a comprehensive strategy. However, the eagerness to cooperate on renewable energy among members remains weak. According to Downie (2015), the BRICS consensus on this topic has significance on the international level because such countries are widely accepted as having the potential to reshape the global system.

These studies are the primary references used to evaluate the main literature on the renewable energy transition in the BRICS. Most of the studies cover the renewable energy transition by focusing on distinct economic, social and political factors. However, it is essential to apply an integrated approach. It is not possible to disconnect different economic, social and political dynamics, let alone different domestic and international structures. Thus, it is clear that there is a deficiency in combining different parameters to understand the renewable energy transition in the BRICS.

This thesis will offer a comprehensive overview of the topic by comparing and applying two theoretical concepts – path dependence and leapfrogging – to analyze the different country-level variations and the possibility of BRICS cooperation. Path dependence claims that energy systems are subject to long-term and robust path dependence due to institutional, infrastructural, behavioral and technological lock-ins (Fouquet, 2016). This concept is used in this thesis to understand the particular lock-ins for the BRICS and evaluate their potential to break out of these paths. Leapfrogging, on the other hand, assumes that developing countries can avoid fossil dependency by skipping or jumping to the adoption and encouragement of the new and advanced energy technologies (Gallagher, 2006). This concept helps evaluate fossil fuel dependency and the capacity of the BRICS to adapt to the requirements of the transition. These two particular concepts are applied in this thesis by collecting, comparing and contrasting different parameters of the renewable energy transition across the BRICS, namely main social and political variables, energy resources, energy production and consumption, and energy policies.

The thesis is organized into an introduction, four main parts and a conclusion. The second part reviews the literature on the theoretical concepts of path dependency and leapfrogging to understand the country-level variations. The features of the BRICS and their country-level variations, as well as their renewable energy systems, constitute the third part. It relies on the meeting reports of the BRICS; data from the international organizations like the World Bank (WB), the International Energy Agency (IEA), and the International Renewable Energy Agency (IRENA); and global indexes for their analyses. The fourth chapter then elaborates on past energy cooperation among the BRICS and evaluates the possibility of future renewable energy cooperation. In the fifth chapter, the different parameters of the renewable energy transition are assessed to understand the different dynamics of BRICS in the renewable energy transition by presenting the main findings of the thesis. The final part concludes with further recommendations.

2. THEORETICAL FRAMEWORK

Discussion of the renewable transition has emerged as a principal concern in both academic and societal discourses. The different approaches in the field of energy transitions prove that there are indeed country-level variations. This chapter examines the role of strict path dependency and the possibility of leapfrogging to explain these variations. The theoretical framework of this study, therefore, consists of the path-dependency concept of historical institutionalist theory and the leapfrogging concept of development theory.

2.1. The Concept of Path Dependency

The concept of path dependency is used here to explain whether a country can shift away from a dominant energy source on which the country's energy systems and hence economy have been based (Buhanist, 2015). Path dependency is part of the historical-institutionalist theory, and "history matters" could be the best-known short version for it. Paul A. David (1985), one of the pioneers of this approach, phrased path dependency as "one damn thing leads to another". The primary reason for this is that the decisions adopted in the past have critical effects on current choices, which, in turn, indicate that current decisions will influence the future choices (Arthur, 1990). In other words, contingency matters. Indeed, the concept of path dependency is from the fields of policy studies (Grube, 2016), the economy (Schienstock, 2007), and technological change (Bergek and Onufrey, 2014).

Energy systems are also subject to strong path dependency because of institutional, infrastructural, behavioral, and technological, lock-ins (Fouquet, 2016). The various energy sources initially compete with each other to be able to dominate markets, but only one can win in the long run due to higher rate of returns, which results from the repeated and mass production in different sectors by using that specific energy source. The early advantage of a particular source's hegemony allows large-scale production, through average cost of products, and eventually widespread adoption. Small historical events in the rivalry between sources can, therefore, drive a particular energy system towards a critical source, which increases its probability of growing as a dominant source. For instance, the U.S. Navy decided to practice with light water reactors in its submarines in the late 1940s, and then some European countries adopted the same method at the beginning of 1960s by considering the financial aid that they would receive from importing the U.S. technologies (Cowan, 1990). At this moment, it means that countries usually invest in subsidy policies and large projects intending to produce accessible, affordable energy to overcome poverty and stimulate economic improvement. On the one hand, these operations may support their aspirations, but they risk locking their economies onto energy-intensive pathways. Thus, their energy systems are transforming when their economies are industrializing. If these pathways are not yet fully locked-in, as is the case in developing countries, policymakers should prudently direct their systems towards energy-intensive pathways that are unlikely to damage their long-term critical prosperity (Fouquet, 2016).

Developing countries are not yet fully locked-in and often have fragile political and economic structures. In such countries, even though the dynamics of renewable transition are intensely discussed, the process itself is poorly understood (Meng, 2013). In this regard, the concept of path dependency presents a general outlook on why countries are not able to quickly switch their paths. Domestic and international politics, technological developments, and economic background can block countries from planning to create a new path. Once a path is chosen, capital is thoroughly invested, and institutions are built, shifting to alternatives results in irreversible charges (Goodstein, 1995). Thus, when the energy system becomes entrenched, there is no smooth corrective action.

Considering these realities, I have examined the approach of path dependency within three different categories for this particular study, namely domestic and international politics, technological developments, and economic background. The first category refers to the effects of different domestic and international political factors on the renewable energy transition. Considering the competing factions that undermine a coherent overall energy policy, political ideology has a significant impact on energy policy. Even the emergence of remarkable political parties seems to be marked by factors depending on the direction (Rosenbloom et al., 2019). This situation is a combination of an increase in political, cultural norms, and specific interests. The political decision to transform the existing energy system from fossil fuels to renewable energy leads to pervasive changes and shifts in the energy-supply overview. Furthermore, the role of interest groups, which are established both by civil- society and businesses groups, is critical. From the perspective of analyzing path dependencies, interest groups are significant; their interest is often linked to continuing existing business models. At this point, providing insights into how energy supply chains can be developed efficiently is essential only possible if the path dependence of several policy interventions and the effects of respective dominant policy tools on existing energy supply chains are understood (Moncada et al., 2017). The current discussion about U.S. President Donald Trump's claims that underestimate climate change’s effects on daily life can be seen as a specific example of political ideology (Dumas et al., 2014). It demonstrates that political dynamics can significantly affect, over time, the development of RES and carbon dioxide emissions.

Technological developments are the second key component of path dependency. It is well known that energy technology efficiencies have increased dramatically over the past few years. In each market, only a limited number of energy technologies are likely to dominate in the long run; so, countries that are dependent on particular technologies continue to stick with them by taking into account their long run benefits. Eventually, technologies for conventional fossil fuel systems oppose RES systems because the latter create "creative destruction," which highlights both sides of change; the arrival of the new and the termination of the old (Schumpeter, 2018). In principle, different renewable energy technologies are competing with each other, and each option will lead to new route dependencies (Clausen et al., 2017). Thus, the usage for one specific option also has potential to create new path dependencies that lock out other variants. According to the principle of a learning curve, the accumulated know-how leads to lower unit costs (Knauf and Göllinger, 2018). These effects are essential when old technologies have been generated for a long time. Knowledge leads to declining production costs. New technology becomes preferred due to economic and ecologic aspects; however, accumulation has not led to a decline in price due to low production quantity. The German government's subsidy for solar photovoltaic systems in the early 2000s is a suitable example of this phenomenon. Accordingly, countries still tend to prefer old technologies because of lower rates. The ongoing accumulation of know-how and investment into a particular technology diminishes the attractiveness to switch to an alternative (Unruh, 2002). Therefore, technology-related path dependencies can be one of the essential reasons why countries fail to transform, as changing a technological path can be a real, capital-intensive, long-term project.

Thirdly, the specific economic background of a country also affects path dependency (Bleakley and Lin, 2012). The transformation toward sustainability requires changing infrastructures and facilities that represent substantial value. Since countries tend to maintain their power, it also strengthens their dependence on abundant and traditional sources. Because of the connected economies of scale to path dependency, the new innovative systems have low production quantity at the beginning and then consequently cannot profit from economies of scale (Broadberry and Arthur, 2006). As a result of economies of scale, it is often possible to market established products produced in large quantities very efficiently and at low cost. Here, the long-lived capital investment and straightforward economic calculations of fixed versus marginal costs are the ways to evaluate the financial difficulty to retire the existing energy supply capital. For this reason, when new products are based on a fundamentally more practical or desirable concept, it is initially difficult, but not impossible, to enter the market (Wurzel, 2010). When new products are based on a fundamentally more effective or desirable concept, it is initially difficult, but not impossible, to enter the market. For example, Angela Merkel, Chancellor of Germany, seems to have been annoyed about the German automobile industry's slow progress in reducing carbon dioxide emissions from cars because this embarrassed Germany's image as an environmental state. However, she felt obliged to negotiate on behalf of the industry because of its economic significance to the domestic economy.

Hence, the literature on path dependency addresses different analytical dimensions (Table 1.1.). It has already been established that the path dependence theory describes how different mechanisms prevent the change of new trends in energy. Current studies primarily focus on path dependencies in domestic and international politics, technological developments, and economic background. However, none of the presented studies profoundly concentrate on how path dependency shapes how countries cooperate in the renewable energy transition. Thus, the following chapters evaluate the concept of path dependency in the BRICS, which have different political, economic and social backgrounds, and how path dependency affects cooperation.

Table 2.1. The Different Dimensions of Path Dependency

Dimensions of Path Dependency	**Dynamics**	**Literature**	**Hypothesis**
Domestic and International Politics	• Political decisions • Subsidies • Cultural norms	• Arthur (1990) • Buhanist (2015) • Dumas et al. (2014) • Moncada et al. (2017) • Rosenbloom, et al. (2019)	If there are domestic and international political interest groups, who are institutionalized and eager to keep the current energy system, there is strict path-dependency.
Technological Developments	• Higher returns from learning • Many networks are not compatible with existing infrastructure	• Clausen et al. (2017) • Cowan (1990) • David (1985) • Fouquet (2016) • Knauf and Göllinger (2018) • Schumpeter (2018) • Unruh (2002)	If a country is heavily dependent on a single technology, it is costly to break it down in the short term.
Economic Background	• nomies of scale and economies of spe • Efficiency • Switching costs	• Bleakley and Lin (2012) • Broadberry and Arthur (2006) • Wurzel (2010)	Countries tend to keep their economies of scale

2.2. The Concept of Leapfrogging

The concept of leapfrogging comes to the agenda of different countries related to the energy transition from fossil fuel to renewables. It is a rapidly revealing energy transition that is bypassing dominant fossil fuels and going straight to renewables. Developing countries seize this chance to “leapfrog” over fossil fuel-related energy system and increase their capacity of clean energy. It is argued that developing countries can avoid fossil fuel dependency by skipping or jumping to the adoption of new and advanced renewable energy technologies. In contrast, the highly industrialized nations followed a pattern of conventional energy-based development in their development journey (Gallagher, 2006). According to Gallagher, there are two patterns of leapfrogging that are most common: (1) skipping over generations of existing technologies and (2) not only jumping over technologies but also leaping further ahead to be a key leader. One may argue that due to the financial challenges, technology barriers, and policy inconsistencies mentioned in the previous section, not to mention other factors like skills and human resources, developing countries should follow the trend of the on-going renewable energy transition. However, some emerging global powers, like India and China, have demonstrated considerable advancement in fossil fuel technologies and renewables (Khaleel and Chakrabarti, 2018). They have acquired and installed these technologies recently based on the accumulated know-how.

Moreover, it has been argued in the transition debate that developing countries do not need to adopt the nasty technologies of the past (Goldemberg, 1998); instead, they might well be able to “leapfrog” over them. By doing this, developing countries can prevent duplicating the experience of developed countries and their path to industrialization with the continuation of environmental troubles. Also, they can bypass getting “locked” into hydrocarbon-intensive technologies (Unruh, 2000). Therefore, the possibility of leapfrogging to renewables is remarkable. Herein, the arguments for leapfrogging can be categorized according to domestic and international structures.

The literature on leapfrogging has argued that governments tend to be less stable in late-industrializing countries than in developed countries (Berkhout and Raven, 2011). Since the institutional and governance capacities of late-industrializing countries have yet to be settled, leapfrogging attempts have more potential to be successful. Thus, the renewable transition by leapfrogging is more likely to occur in countries identified with strong niche development in the late-industrializing period due to their domestic structures (Yu and Gibbs, 2018). In these countries, the lock-in effect is weak because this effect results from increasing adoption return enjoyed by technologies that include cost savings, market share, and learning effects (Connor, 1996). For this reason, developing countries are expected to invest in clean energy systems at an early stage of their industrialization path (Grubb, 1997). However, this actuality is only reasonable if the country's domestic dynamics recognize specific kinds of incentives (Anantharaman and Schroeder, 2016). Emerging economies usually lack many of the ingredients needed to initiate and maintain leapfrog-type development strategies by nature (Perkins, 2003). Herein, the incentives have a critical position to accelerate the potential for leapfrogging (Murphy, 2001). Therefore, leapfrogging is only possible if domestic dynamics allow for specific kinds of incentives.

Apart from domestic factors, international structures also affect the renewable transition because the international supports in the form of encouragement, partnership or investment will speed up the likelihood of leapfrogging (Noordeh, 2017). The developed world has been investing gradually in advancing RES technologies that the developing world can take advantage of without contribution to concrete research and development (R&D) costs. Late adopters, including developing countries, generally rely on the developed countries for new energy solutions before internal capacities are sufficient for the development and implementation of advanced energy technologies (Tukker, 2005). Thus, the success of leapfrogging could appeal globally by decreasing emissions and inducing pressure from socio-technical developments. It can also be argued that leapfrogging will entail large-scale North-South transfers, since most of the new technologies have been developed and are owned by companies in developed economies (Rajagopal, 1992), primarily to support the financing of clean and renewable technologies, for which high capital costs still intimidate for adoption and implementation (Dasgupta, 2000). More broadly, assistance is needed to overcome a lack of information on the availability of competing technologies, performance and cost (Worrell et al., 2000). This can go beyond technology transfer to promote the development of a technology-friendly macro-environment through joint organizational capacity-building and R&D programs, for example (Fukuda-Parr, 2014). This cooperation is a vital tool to bypass technological and economic shortcomings in developing countries.

Consequently, the literature on leapfrogging refers to several domestic and international structures that facilitate or complicate the renewable energy transition (Table 1.2.). The possibility of leapfrogging is an accelerating phenomenon; however, none of the presented studies focuses on leapfrogging in the context of institutionalized cooperation on the renewable energy transition. Thus, the following chapters evaluate leapfrogging in the BRICS to understand the level of cooperation on the renewable energy transition.

Table 2.2. The Different Dimensions of Leapfrogging

Dimensions of Leapfrogging	Dynamics	Literature	Hypothesis
Domestic Structures	• Less ordered and stable regime • Weak lock-in effects (behavioral changes, social innovation and cultural transformation of consumption systems, etc.)	• Berkhout and Raven (2011) • Yu and Gibbs (2018) • Connor (1996) • Grubb (1997) • Anantharaman and Schroeder (2016) • Perkins (2003) • Murphy (2001)	If there is a less ordered and stable domestic structure, it is comparatively easy to bypass dominant fossil fuels and go straight to low-cost renewables.
International Structures	• Relationship between developed and developing countries (North-South transfers) • Deadlocks related to economy and technology • Global interest	• Noordeh (2017) • Tukker (2005) • Rajagopal (1992) • Dasgupta (2000) • Worrell et al. (2000) • Fukuda-Parr (2014)	The international cooperation between developed and developing countries can accelerate the leapfrogging

3. THE BRICS

The BRICS are an informal group of states that include the Federative Republic of Brazil, the Russian Federation, the Republic of India, the People's Republic of China, and the Republic of South Africa.[4] The first use of "BRIC" as an acronym was in 2001 by economist Jim O'Neill in his paper entitled "The World Needs Better Economic BRIC" (O'Neill, 2002). The phrase was associated with emerging economies with great significance to the world's economy. It was the Russian side that initiated the creation of the BRIC countries, excluding South Africa. In 2009, the first BRIC Summit was held in Russia and set goals for the countries to promote dialogue and cooperation. In 2010, South Africa was included and became a strategic member from the African continent (Thiébaut, 2013).

Since there are no official rules of entry to the BRICS, there are different scenarios regarding possible members. Turkey is one of the highly discussed options. Although there is no standardized strategy yet, Turkey is interested in developing a formal relationship with the BRICS (Bacik, 2013). It is a middle-income country and a member of NATO. In 2018, the Turkish President joined the BRICS at the Johannesburg Summit by the South African President's invitation. Both the BRICS members and Turkey have challenged the supremacy of the European countries and the United States in the world financial system. If Turkey is admitted into the grouping, the BRICS will be BRICST.

Indeed, these five nations have different social, political and economic realities. The five BRICS countries contain more than 3 billion people, about 40% of the world's population, with about 27% of the world's land surface (Table 2.1). Among them, China has the most significant population and the largest total area.

[4] BRICS Information Portal (n.d). History of BRICS. Retrieved 30 September 2019 from https://infobrics.org/page/history-of-brics/

Table 3.1. Main Social, Political and Economic Variables in the BRICS

Factors	Brazil	Russia	India	China	South Africa
Population (2018)[5]	209,469,333	144,478,050	1,353,000,000	1,393,000,000	57,779,622
Population Change in Last 5 Years	3.29%	1.18%	11.08%	2.12%	14.40%
Population Change in Last 10 Years	8.00%	0.45%	4.39%	4.65%	5.90%
Total Area[6]	8,515,767 km2	171,098,242 km2	3,287,590 km2	9, 760,960 km2	1,221,037 km2
Regime	Electoral Democracy	Electoral Autocracy	Electoral Democracy	Closed Autocracy	Electoral Democracy
Governance[7]	Strong	Weak	Strong	Comparatively Strong	Weak
Rule of Law Index[8]	58/126	148/179	68/126	82/126	47/126
GDP (in U.S. dollars, 2018)[9]	1,869B	1,658B	2,726B	1,3608B	368,288M
GDP per Capita (in U.S. dollars, 2018)	8,920.76	11,288.87	2,015.59	9,770.85	6,374.02
GDP per Capita Growth in Last 5 Years (%)	-7,7%	1.35%	28,2%	27,2%	-1,96%
GDP per Capita Growth in Last 10 Years (%)	4,07%	14,8%	65,9%	87,6%	3.01%

[5] WB (2019). World Development Indicators. Retrieved 30 September 2019 from https://data.worldbank.org/indicator/sp.pop.totl
[6] WB (2019). World Development Indicators. Retrieved 30 September 2019 from https://data.worldbank.org/indicator/AG.SRF.TOTL.K2
[7] Varieties of Democracy (V-DEM) (n.d) Variable Graph. Retrieved 12 November 2019 from https://www.v-dem.net/en/analysis/VariableGraph/
[8] The World Justice Project (WJP) is the world's leading source for original data on the rule of law. The 2019 edition covers 126 countries and jurisdictions. WJP (2019). Rule of Law Index. Retrieved 30 September 2019 from http://data.worldjusticeproject.org/
[9] WB (2019). GDP per capita. Retrieved 30 September 2019 fromhttps://data.worldbank.org/indicator/NY.GDP.PCAP.CD

The regime system also varies in the BRICS nations. Brazil, India and South Africa are electoral democracies, Russia is an electoral autocracy, and China is a closed autocracy (V-Dem Institute, 2019). These different regimes affect how the rule of law is applied in their countries (Table 2.1.). This ranking is critical to mention because different legal actions and governance have been affecting the order and stability, which are directly related to the different level of experiences of the energy transition. According to the Rule of Law Index, the BRICS rank in between 47th and 88th although Denmark rank 1st, Germany 6th, the U.S. 20th.

When it comes to economic realities, the BRICS are the largest of the middle-income economies. These five nations had a total nominal GDP of US$18.6 trillion as of 2018, around 23.2 percent of the world's gross product,[10] and together accounted for over a fifth of the global economy. The BRICS countries have been experiencing an economic boom over the past several years. China's GDP has shown a significant upward trend and has been steadily increasing (Table 2.1). While the GDP of India has risen, it is still far behind China (Figure 2.1). The GDP of the other BRICS countries has grown but at a slower pace. However, it is expected that the BRICS are likely to continue to expand their economies in the long run (Morazán et al., 2012).

[10] The International Monetary Fund (IMF) (2013). Report for Selected Countries and Subjects. Retrieved 30 September 2019 from https://www.imf.org/external/pubs/ft/weo/2013/01/weodata/weorept.aspx?pr.x=91&pr.y=5&sy=2011&ey=2018&scsm=1&ssd=1&sort=country&ds=.&br=1&c=223%2C924%2C922%2C199%2C534&s=NGDPD%2CNGDPDPC%2CPPPGDP%2CPPPPC&grp=0&a

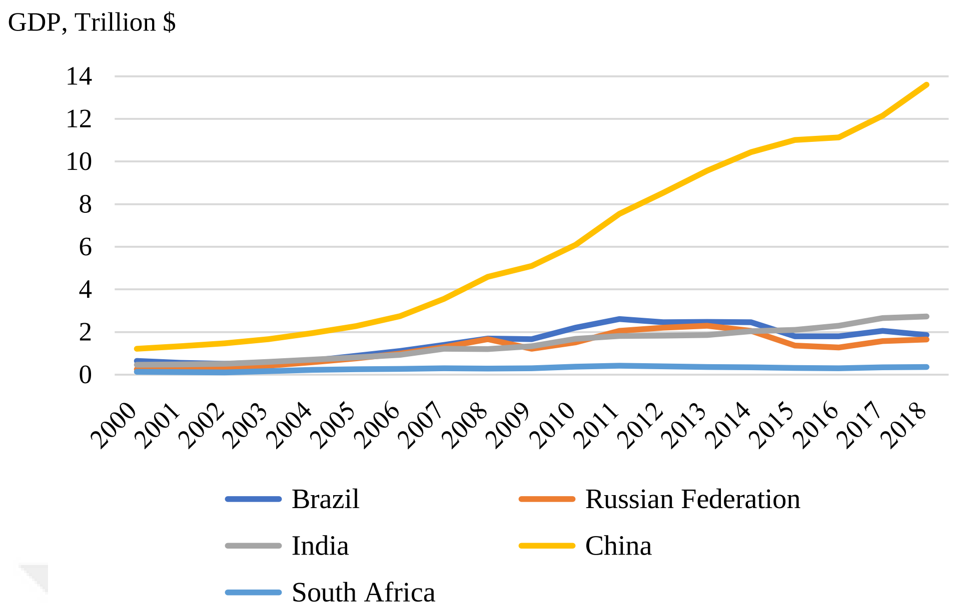

Figure 3.1. GDP (in US$) in the BRICS from 2000 to 2018[11]

For all BRICS economies, industry was the second largest sector (Figure 2.2). The service sector estimated to two-thirds of each country's economy in 2017. The service sector's impact on national growth for the BRICS was the highest, except for Brazil (Figure 2.3). While the share of agriculture in the GDP accounted in between 8 and 15 percent in China and India, it is less than 5 percent in Brazil, Russia, and South Africa. The impact of the service sector on national growth was the most powerful in 2017 for other BRICS countries, except for Brazil. The service and industry sectors were virtually stagnant in Brazil, which was the only BRICS country where agriculture contributed the most to GDP growth.

[11] WB (n.d). GDP (current in US$). Retrieved 18 August 2019 from https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?end=2018&locations=CN-BR-RU-IN-ZA&start=2002

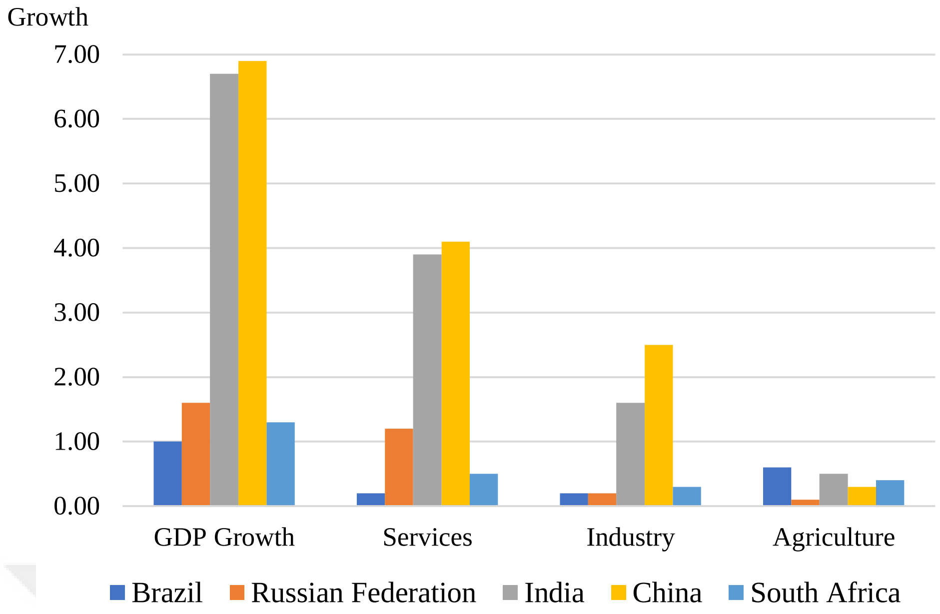

Figure 3.2. Sector-wise value added (% of GDP), 2017 in the BRICS[12]

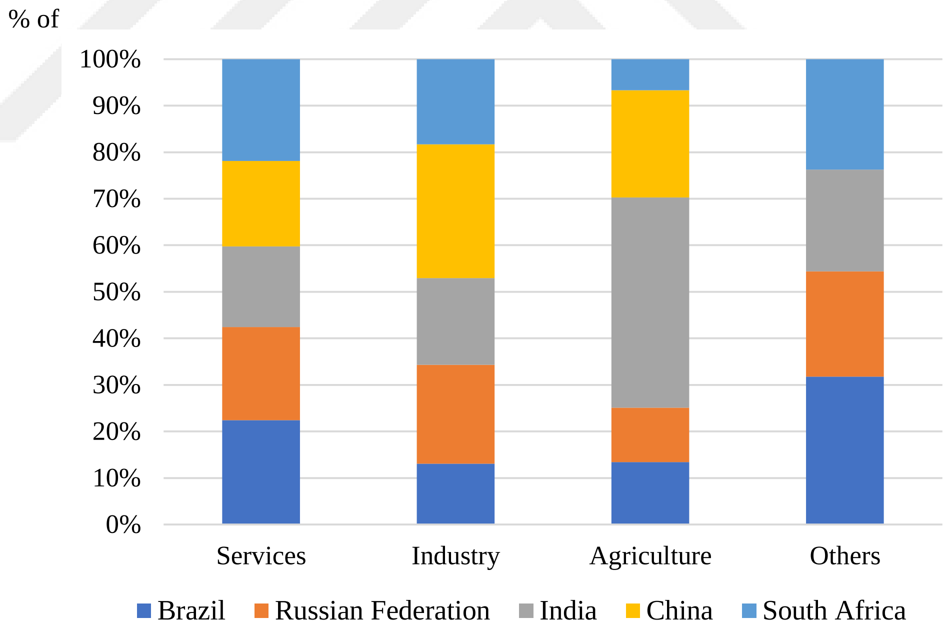

Figure 3.3. Annual GDP Growth (%) and Sector Contribution to Growth (%), 2017 in the BRICS[13]

[12] WB (2019). World Development Indicators. Retrieved 30 September 2019 from http://datatopics.worldbank.org/world-development-indicators/stories/services-drive-economic-growth.html

The BRICS countries also have different available resources (Table 2.2.), which determines the source of energy supply. In fossil fuel-rich countries, the fossil fuel rents of GDP are high. Fossil fuel rents indicate the measure of total fossil fuel rents as a share of a country's GDP. This accounting for the contribution of fossil fuels to the economic output is essential to formulate a systematic structure for sustainable development. Thus, high fossil fuel rents make it difficult to implement sustainable energy solutions.

On the other hand, the reserves-to-production ratio (R/P) is an essential factor in evaluating the transition in the country (Figure 2.4.). It is the estimated roughly remaining number, measured in a year, of a non-renewable resource. Among the BRICS countries, Russia seems to have the highest R/P ratio for coal, oil and natural gas, while South Africa has the lowest ratio.

Fuel Type	**Brazil**	**Russia**	**India**	**China**	**South Africa**
Coal	-	364	132	38	39
Oil	13,7	25,4	14,1	18,7	-
Natural Gas	15,1	58,2	46,9	37,6	-

Figure 3.4. R/P, 2018 in the BRICS[14]

[13] WB (2019). World Development Indicators. Retrieved 30 September 2019 from http://datatopics.worldbank.org/world-development-indicators/stories/services-drive-economic-growth.html

[14] BP (2019). BP Statistical Review of World Energy. Retrieved 12 July 2019 from https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf

Table 3.2. Energy Resources in the BRICS in 2019

Factors	Brazil	Russia	India	China	South Africa
Available Resources[15]	Water dams and oil	Natural gas	Coal and oil	Coal and oil	Coal
Exploited Resources	Hydropower, biofuels	Natural gas, oil, nuclear energy	Coal, oil and renewable resources	Coal, oil, nuclear, and renewable resources	Coal and oil
Coal Rents % of GDP in Last 5 Years	0.02%	1.10%	2.57%	1.36%	5.61%
Coal Rents % of GDP in Last 10 Years	0.06%	3.48%	9.84%	10.83%	21.72%
Oil Rents % of GDP in Last 5 Years	3.19%	18.56%	0.91%	0.93%	0.02%
Oil Rents % of GDP in Last 10 Years	13.02%	90.76%	6.60%	7.25%	0.26%
Natural Gas Rents % of GDP in Last 5 Years	0.11%	7.49%	0.17%	0.33%	0.08%
Natural Gas Rents % of GDP in Last 10 Years	0.35%	27.01%	0.87%	0.90%	0.34%

[15] BP (2019). BP Statistical Review of World Energy. Retrieved 12 July 2019 from https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf

Since higher economic development requires more energy consumption, the energy overview is the most vital determinant for the development of BRICS. While the total primary energy consumption in the BRICS is gradually increasing, China has the highest consumption (Figure 2.5). Apart from this, while Russia, India and China are increasing its coal, oil and natural gas consumption, which has a direct effect on the carbon emissions, all BRICS nations have shown remarkable effort regarding the renewable energy consumption (Table 2.3).

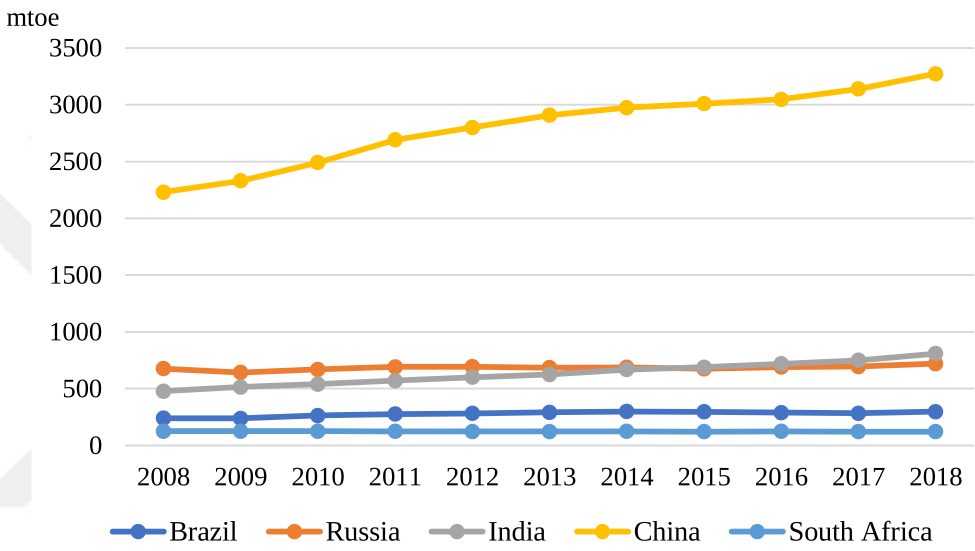

Figure 3.5. Total Primary Energy Consumption in the BRICS from 2008 to 2018[16]

[16] BP (2019). BP Statistical Review of World Energy. Retrieved 12 July 2019 from https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf

Table 3.3. Energy Overview in the BRICS in 2019

Factors	Brazil	Russia	India	China	South Africa
Fossil Fuel Energy Consumption in Last 10 Years (% of total)[17]	833.78%	2428.00%	1415.45%	2267.00%	2186.95%
Renewable Energy Consumption in Last 10 Years (% of total final energy consumption)	792.31%	423.00%	587.16%	98.70%	153.30%
Increase in Coal Production in Last 10 Years	-53.80%	55.30%	25.50%	18.90%	2.50%
Increase in Coal Consumption in Last 10 Years	43.20%	-4.50%	61.03%	13.06%	-8.30%
Increase in Oil Production in Last 10 Years	32.70%	12.30%	3.90%	-0.20%	-
Increase in Oil Consumption in Last 10 Years	20.30%	14.90%	52.20%	60.05%	5.20%
Increase in Natural Gas Production in Last 10 Years	103.70%	24.80%	-24.10%	87.90%	-
Increase in Natural Gas Consumption in Last 10 Years	73.50%	14.20%	18.20%	213.50%	27.50%
Increase in Renewable Energy Generation in Last 10 Years	59.70%	29.36%	144.10%	239.04%	522.05%
Increase in Renewable Energy Consumption in Last 10 Years	337.03%	200.00%	328.50%	1204.50%	2700.00%
CO2 Emissions (Mt, 2017)[18]	476	1693	2467	9836	456
CO2 Emissions (change in last 5 years)	-8.40%	1.50%	11.70%	0.10%	-8.90%
CO2 Emissions (change in last 10 years)	32.20%	7.60%	43.40%	26.80%	6.50%

[17] BP (2019). BP Statistical Review of World Energy. Retrieved 12 July 2019 from https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf
[18] Global Carbon Atlas (n.d). Co2 Emissions. Retrieved 30 September 2019 from http://www.globalcarbonatlas.org/en/CO2-emissions

The energy policies adopted by the BRICS from various renewable sources are listed below (Table 2.4). Brazil has well-built energy policies for biofuel, solar and wind power. Russia is necessitating improvement in its legal and regulatory framework with more incentives in renewable energy policies. China is improving upon wind and hydropower, but it requires effective renewable energy policy measures to deal with its increased carbon emissions. India needs to improve its energy policy and add more incentives and policies for new technologies. South Africa requires models to increase renewable energy and reduce coal mining. In general, all BRICS countries need to redefine their energy policies based upon their existing economic, social, geographical and environmental conditions.

Table 3.4. Energy Policies in the BRICS in 2019

Factors	Brazil	Russia	India	China	South Africa
Tax Exemptions[19]	Tax exemptions for imported wind and solar energy equipment; tax reduction for flex-fuel vehicle industrial products.	Income tax exemption for the individuals who are earning from the sale of electricity produced by micro-generation facilities, including renewable; Tax exemption for high efficiency equipment in buildings	Depreciation tax benefit for renewable energy plant developers; duty-free import; capital subsidy for the wind and biomass energy.	Tax exemption for all projects in their first three years; lower tax rates for projects involving methane gas, small hydro and wind; tax incentives for environmentally friendly commercial vehicles.	Tax exemptions to encourage clean and renewable development mechanism for the emissions reduction.
Subsidies and Incentives on Renewable Energy Resources	Funding for R&D initiatives related to renewable energy, energy efficiency, hybrid vehicles, and smart grids.	Compensation for the cost to connect renewable energy facilities; subsidies to save regional energy and energy efficient improvement programs.	Reduced VAT and financial incentives.	Infrastructure subsidy for wind and solar power; ethanol production subsidies and tax reductions.	Grants for long- and short-term funding, feasibility studies, export credits and soft loans, and purchase of wind, solar, gravitational water and biomass carbon reduction credits.
Subsidies and Incentives on Research and Development	Incentive for infrastructure development of electricity and	Energy efficiency and energy efficiency initiatives to encourage R&D.	R&D funds for wind, solar, and hydropower projects.	R&D funds for wind, solar, geothermal and biomass projects.	Deduction of expenditures of eligible R&D projects.

[19] Pathak, L. & Shah, K. Front. Energy (2019) 13: 506. https://doi.org/10.1007/s11708-018-0601-z

	cogeneration renewable energy projects.				
Renewable Energy Feed-in-Tariffs (REFIT)	Actually, there is no feed in wind, hydro and biomass tariff policy.	Tariff schemes for the electricity generated from renewable and high-efficiency co-generation facilities.	Generation-based grid, windmill, biomass, and solar opportunities.	Specific feed-in tariffs for projects involving solar, wind and biomass; tariffs for hydropower prices and market demand.	Actually, there is no feed in wind, hydro and biomass tariff policy.
Paris Climate Agreement (year of entry into force)	2016	2019	2016	2016	2016
Major Energy Policies	PROINFA (Brazilian Program of Incentives for Alternative Electricity Sources) (2002) for wind, hydropower, biomass-fueled plants; Act No. 10, 848-Auctions (2004) to determine operating rules for the regulated market; Act No.11,448-Auctions (2007) to produce tax exemptions for infrastructure projects; ANEEL's normative resolution No. 482	2008 Electricity Premium Price Scheme for the electricity generated by accredited renewable energy facilities; Decree No1715-r (2009) on Russia's power policy for the period up to 2030; new 2010 capacity-based scheme for renewable energy production.	Electricity Act (2003) for generation, transmission, distribution of energy with new environmental policies; The National Tariff Policy (2006) for electricity at competitive rates; National Rural Electrification Policy (2006) for electricity at all households; Jawaharlal Nehru National Solar Mission (JNNSM)	China's 12th Five Year Plan (2010–2015) to promote use of small hydro and wind projects; China's 13th Five Year Plan (2016–2020) for feed-in tariffs to solar and wind power; Transport sector-related policies to boost the renewable energy usage for automobiles; Solar water installation policy for constructions (2000–	White Paper on Energy Policy (1998) to improve energy governance; Renewable Energy White Paper (2003) for sustainability vision; National Climate Change Response Policy White Paper (2011) for the Long-Term Mitigation Scenario (LTMS) to overcome climate change; An Integrated Resource Plan 2010–2030 to

	(2012) to defines the requirements for the small scale power generators; Executive Decree 656 (2014) for wind turbine component tax exemption; Ministerial Decree 538 ProGD program (2015) for tax incentives.		(2008) to increase solar capacity; New Hydropower Policy (2008) for hydropower generations; National Policy on Biofuels for the mixing of biofuels; MNRE Strategic Plan (2011–2017) to support renewable energy for the energy mix.	2012); Industrial policies for renewable energy (2013) for R&D strategies for infrastructure development primarily for wind turbine; Carbon policy (2011) to regulate the trading scheme.	promote use of renewable sources.

The level of cooperation among the BRICS countries has evolved over time. With the official establishment of BRICS cooperation, the countries were recognized as a powerful emerging block of economies. However, the development level among them has varied over time, and the concept of BRICS is different today than it was ten years ago. The given data evaluates and presents the different parameters of the renewable energy transition across the BRICS. It is evident that China has materially grown its economy and caught up to the United States amid a trade war, while Russia is still a giant economy that depends on fossil fuels revenues. Brazil, India and South Africa are somewhere in between China and Russia. Herein, the vital question is how and to what extent the BRICS will act to further shape the future of the block. In order to find a concrete answer for these questions, the following section thoroughly delves into the energy outlook in the BRICS, which have serious potential to introduce new cooperation in the renewable energy transition.

3.1. Federative Republic of Brazil

According to land area, Brazil is the fifth largest country in the world, with about 5.6% of world landmass, and has a relatively modest population size, as the fourth largest country in the BRICS. The total primary energy supply in Brazil is around 287,022 ktoe in 2017 (Figure 2.6.). While the share of fossil energy is approximately 55%, the share renewables are around 43%. Nuclear energy represents a modest share of total primary energy supply. Compared to the 1990s, the share of coal and oil remained have slightly increased, and natural gas has grown dramatically. In 2019, Brazil was the 46th country in the World Economic Forum's (WEF) Energy Transition Index with 45% transition readiness (WEF, 2019).

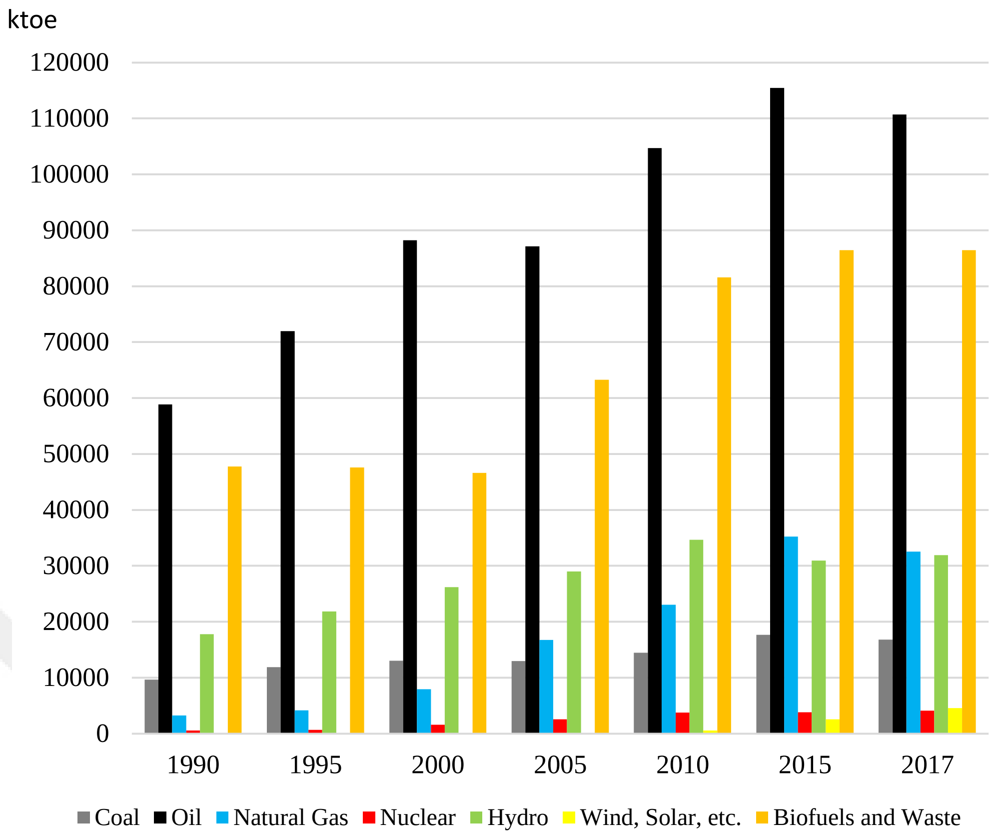

Figure 3.6. Total Primary Energy Supply (TPES) by Source in Brazil from 1990 to 2017[20]

Brazil is the world's fourth largest shareholder of total renewable energy capacity, around 104.5 TWh in 2018, excluding hydroelectric power. The nation has plenty of energy resources and is well known for its impressive portfolio of clean and renewable energy. The renewable sector is expected to keep rising and play a vital role in Brazil's energy mix (Swedish Agency for Growth Policy Analysis, 2014). Even though Brazil has produced high shares of renewable energy, the majority is coming from hydropower, which accounts for the majority of electricity generation (Figure 2.5). The Itaipu Dam is the second-largest hydroelectric facility worldwide, which has been producing more than 2.6 billion MWh since its first day in 1984. Brazil shares Itaipu with its neighbor Paraguay.

[20] IEA (n.d). TPES by Source in Brazil. Retrieved 18 September 2019 from https://www.iea.org/statistics/?country=BRAZIL&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES

Brazil also has installed wind farms, and the share of non-hydro-renewable energy has risen by almost 10% (REN21, 2019). According to the Brazilian Ministry of Mines and Energy's 10-year energy sector plan released in September 2015, solar photovoltaic (PV) generation capacity would rise to seven gigawatts (GW) by 2024.[21] It can be seen as a modest amount when the country's potential is taken into consideration. For example, Brazil receives much more solar energy per square meter than Germany, the world's leader in photovoltaics, and its wind conditions are among the world's most favorable and prodigious.

Most research on the evolution of Brazilian renewable energy policy is also related to the evolution of the country's biofuel (Zhang et al., 2011). The country has a vast potential of biofuel energy generation.

On the other hand, Brazil's energy sector's carbon emissions have more than tripled from 1990 to 2018 (Figure 2.7), making Brazil one of the top-ten greenhouse gas emitters worldwide and one of the top seven if consideration is given to the impact of deforestation and carbon-intensive agriculture (Greenpeace, 2015). Brazil's carbon emissions have been nearly doubled in between 2006 and 2015 due to growing reliance on the maintain high levels of water storage in dams and the risk of prolonged drought conditions (WEF, 2019). It also continues to build high-capacity hydropower plants; since 2000, the total capacity produced by large hydropower has increased from 304 TWh to 387 TWh by approximately 27% (Eriksen et al., 2012). However, it can still be argued that Brazil has started to reduce its emissions within the last four years. It is also relevant to mention that Brazilian hydro-dams induce severe social and environmental repercussions. Unfortunately, most of the dams are located in the middle of the Amazon Rainforest, which affects indigenous communities directly. In addition, changes in weather patterns associated with climate change pose significant risks to hydropower, which relies on total water in reservoirs.

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[21] The Brazilian Ministry of Mines and Energy (2015). Electricity in the 2024 Brazilian Energy Plan. Retrieved 18 September 2019 from http://www.mme.gov.br/documents/10584/3642013/02+-+Electricity+in+the+2024+Brazilian+Energy+Plan+(PDF)/96be552a-4a2c-4a32-839a-f51299c911fb;version=1.1

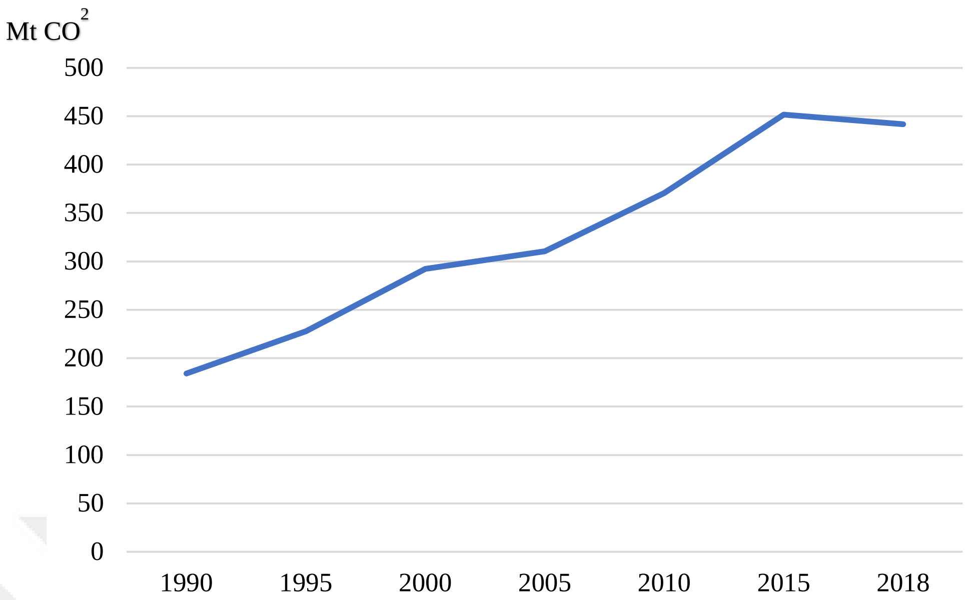

Figure 3.7. CO^2 Emissions in Brazil from 1990 to 2018[22]

3.2. Russian Federation

Russia is the world's largest country by land area, about 11% of world landmass, and is endowed with mineral resources and a relatively modest population size, as the third largest nation in the BRICS. Russia is mostly dependent on fossil fuel energy sources and is a major global coal, oil, and gas exporter. Russia provides 19% of the world's coal assets, 23% of the world's entire natural gas reserves, and 8% of the global production of natural uranium (RFME), 2010). The total primary energy supply in Russia is around 733,071 ktoe in 2017 (Figure 2.8). The share of fossil energy is approximately 90%. Compared to the 1990s, the share of coal has stabilized, while oil and natural gas have been slightly increased. Natural gas is the bedrock of power generation in Russia. Up to 2017, non-renewable sources provided 80%-85% of total energy generation, with less than 6% coming from renewable energy. In 2019, Russia was the 79th country in the World Economic Forum's (WEF) Energy Transition Index with 39% transition readiness (WEF, 2019).

[22] IEA (n.d). CO2 Emissions in Brazil. Retrieved 18 September 2019 from https://www.iea.org/statistics/?country=BRAZIL&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES

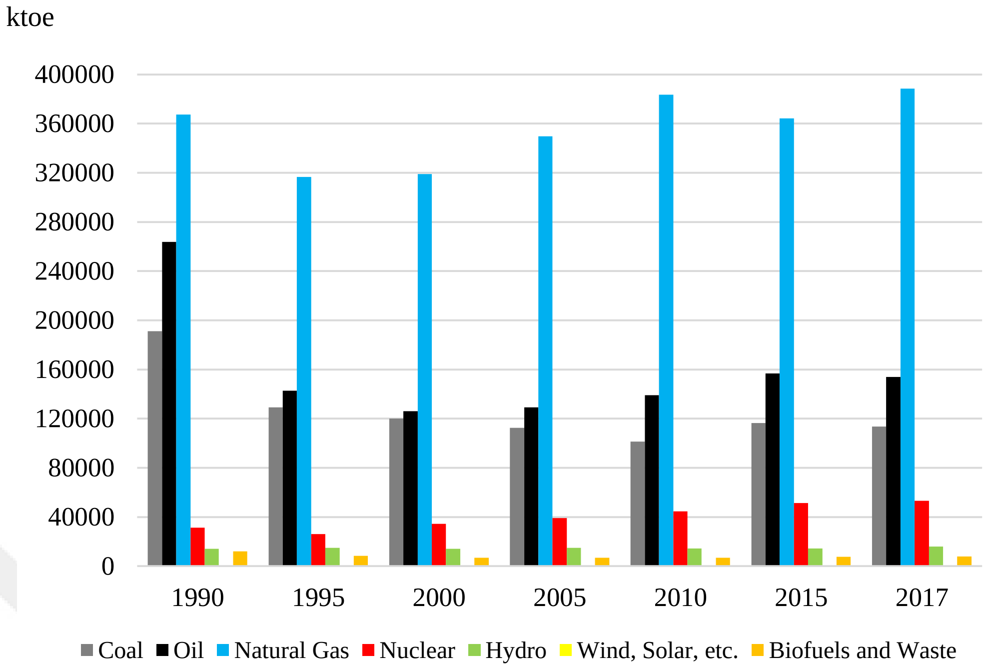

Figure 3.8. Total Primary Energy Supply (TPES) by Source in Russia from 1990 to 2017[23]

In addition to Russia's reliance on fossil fuels, the nation has a small share of massive hydropower, and hydropower has the most significant share of electricity generation among other renewable energy sources (Figure 2.9.). It is projected that Russia's renewable energy capacity is 189-224 Mtoe per year. Nevertheless, no significant changes in renewable energy generation in Russia were observed in 2017.

In its Energy (R)evolution report, Greenpeace highlighted Russia's vast renewable resources (SolarPowerEurope et al., 2015). Russia has the potential to benefit in many ways from the green transition. The country will produce domestic added value and be less dependent on fluctuating prices of fossil fuels, which has hurt the country for the past year and at other periods in history. Furthermore, there are numerous co-benefits. The country would save a considerable amount of the national budget, which is spent on

[23] IEA (n.d). Total Primary Energy Supply (TPES) by Source in Russian Federation. Retrieved 10 August 2019 from https://www.iea.org/statistics/?country=RUSSIA&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES

the so-called "Northern Supply", where hundreds of billions of rubles go to supply crude, heavy oil and coal the northern regions. Moreover, through distributed projects, the country would strengthen its rural communities, mitigate the impact of fossil fuel extraction, and clean up the environment. Herein, Russia must reconsider and develop ambitious targets for renewable energy by removing barriers to implementing energy efficiency systems. One of the most implementable ways is to reorient state subsidies for energy conservation from oil and gas extraction and renewable energy as well as from the nuclear industry. Therefore, speeding up the development of a domestic greenhouse gas accounting system is a win-win solution for Russia, as is the further development of a greenhouse gas regulatory mechanism. It should then launch global RES projects with neighboring countries such as China, Kazakhstan, and Mongolia.

Russia still emits a high amount of carbon, but these emissions have declined in the last 25 years (Figure 2.9.). On the one hand, it is significant that, due to the huge amount of fossil fuel exports, Russia's actual impact on the global climate is more significant than its domestic emissions indicate. On the other hand, carbon emissions have plummeted primarily as a result of two economic events. The first is related to the Russian financial collapse of the 1990s following the Soviet Union's dissolution, which led to a considerable drop in carbon emissions because the resulting economic crisis meant many people stopped eating meat. Meat from domestic livestock farming was the main food staple during communist rule in the region. In 1990, Soviet citizens each consumed an average of 32 kilograms of beef a year, which is 27% more than Western Europeans and four times more than the global average at the time. Nevertheless, the emissions have risen again with the effects of industrial developments since the late 1990s, except for a significant decline because of the 2008 financial crisis. Since there are no policy guidelines for reducing oil, gas and coal dependency, it is business as usual (Greenpeace, 2015).

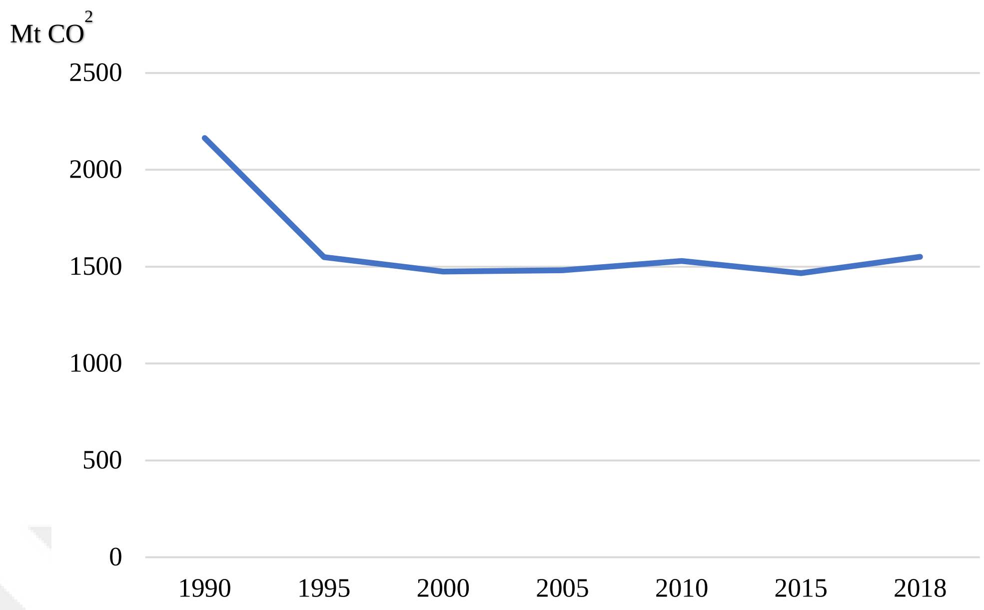

Figure 3.9. CO^2 Emissions (Mt of CO^2) in Russia from 1990 to 2018[24]

3.3. Republic of India

India is the seventh largest country in the world according to the land area, with approximately 2% of the world's landmass, and is enriched with a vast population size, the second largest in the BRICS. India has been known for its significant renewable energy potential since the 1990s. The total primary energy supply in India is around 882,082 ktoe in 2017 (Figure 2.10.). The share of fossil energy is approximately 74%. The proportion of coal, oil and natural gas has increased tremendously compared to the 1990s. More recently, renewable energy generation has gained more attention due to high domestic coal prices, heavy dependence on petroleum imports, volatility on the oil market, increasing population in the country and, at the same time, increasing demand for energy. In 2019, India was the 76th country in the World Economic Forum's (WEF) Energy Transition Index with 49% transition readiness (WEF, 2019).

[24] IEA (n.d). CO2 Emissions (Mt of CO2) in Russia Federation. Retrieved 10 August 2019 from https://www.iea.org/statistics/?country=RUSSIA&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES

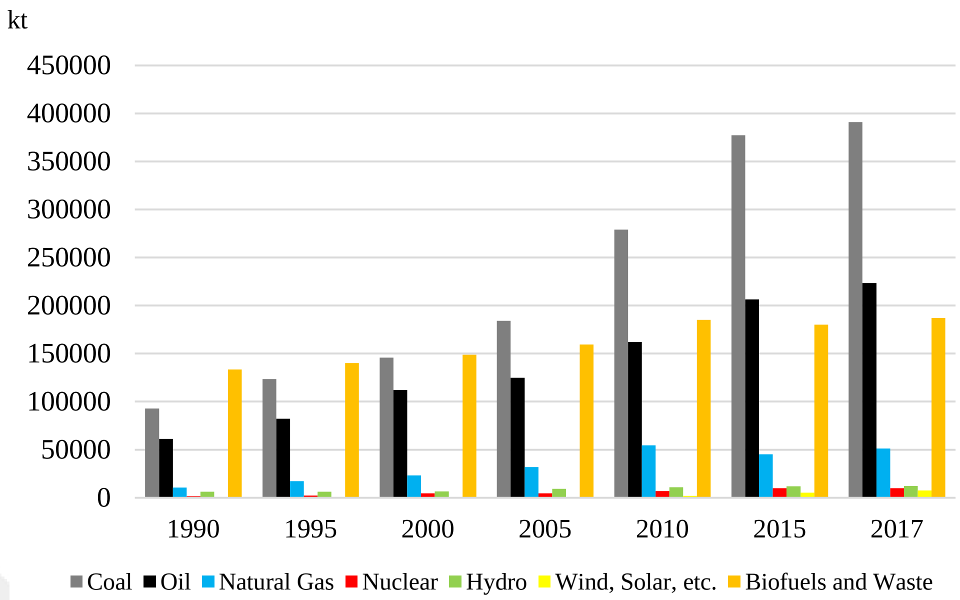

Figure 3.10. Total Primary Energy Supply (TPES) by Source in India from 1990 to 2017[25]

Coal provides about half of India's primary energy and is the dominant fuel for power production. Since consumption is increasing more rapidly than domestic production, it is also problematic in India. The main challenges are related to the over-building of coal-fired capacity, increasing competition from low-cost renewable and hydro energy sources, and, more seriously, declining water supplies (Woods and Schlissel, 2019). As the Indian economy continues to grow and remains dependent on coal, India for the foreseeable future could be the primary driver of thermal coal on global markets. The Supreme Court recently ordered that all the 2006-2010 coal allocations were illegal, and the Ministry of the Environment is serving to reduce the number of coal mines (Greenpeace, 2015).

Renewables have seen substantial growth in recent years (Figure 2.11.). By the end of 2014, India had the fifth largest wind sector of the world with an installed capacity of 22.5 GW and solar energy of just over 3 GW. Through 2022, the government has a

[25] IEA (n.d). TPES by Source in India. Retrieved 10 August 2019 from https://www.iea.org/statistics/?country=INDIA&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES

target of 100 GW for solar power plants; 40 GW will be allocated for the solar panels on the roof. (Greenpeace, 2015). On the other hand, Indian biomass policy is based totally at non-food feedstock produced in degraded areas or wastelands not suitable for agriculture. The overall goal for 2022 is 175 GW of renewable energy (REN21, 2019). Worldwide, there are still 1.2 billion people lacking primary access to primary energy, and a fourth of them are living in India. The Indian government promised to provide all households with "24/7 power by 2019".[26] Renewable energy distribution is an effective way to ensure access to energy for all.

Unfortunately, India has more than tripled its CO2 emissions since the 1990s (Figure 2.11), much of which resulted from the country's tremendous economic growth over the past 25 years (REN21, 2019). India is expected to add nearly 273 million people between now and 2050; so, Indian population will surpass that of China and remain the most populated country through the end of the current century. This projection has the potential to change emissions levels drastically.

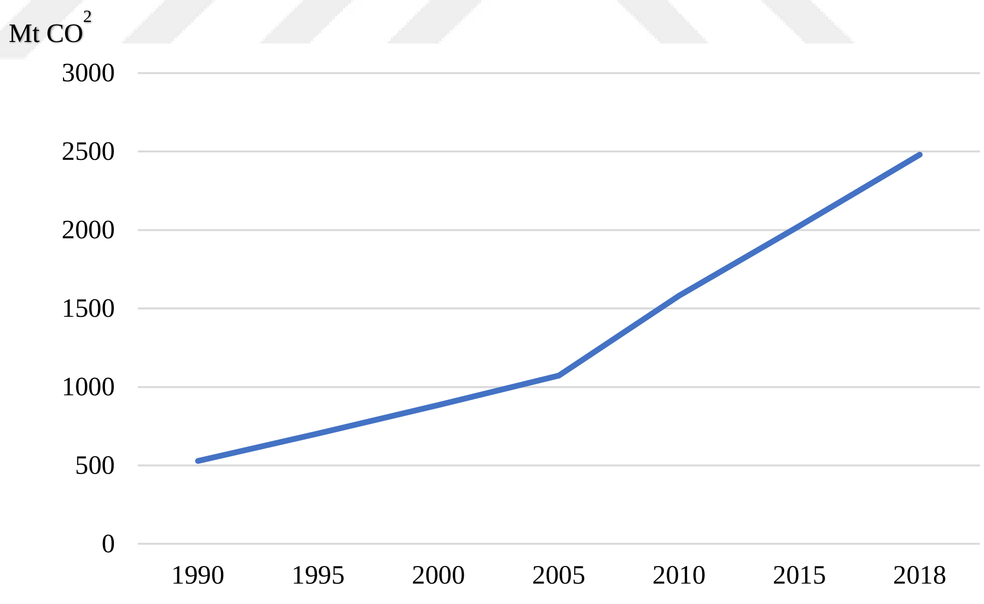

Figure 3.11. CO^2 Emissions (Mt of CO^2) in India from 1990 to 2018[27]

[26] The Indian Press Information Bureau (2015). Affordable Power for all by 2019. Retrieved 10 August 2019 https://pib.gov.in/newsite/PrintRelease.aspx?relid=118109

[27] IEA (n.d). CO2 Emissions (Mt of CO2) in India. Retrieved 10 August 2019 from https://www.iea.org/statistics/?country=RUSSIA&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES

3.4. People's Republic of China

According to the land area, China is the third largest country in the world-roughly 6.3% of world landmass. With a population of over 1.3 billion, the largest in the BRICS, China is one of the most severely affected countries by the adverse effects of global climate change. The total primary energy supply in India is around 3,064,557 ktoe in 2017 (Figure 3.13.). The share of fossil energy is approximately 89%. Compared to 1990s, the share of oil and natural gas has been slightly increased, while the share of coal has been substantial. The country has vast reserves of coal and oil; it relies mostly on thermal power to meet the demand for electricity (Figure 2.12). China's primary energy demand is expected to reach 4.2 billion tons by 2020, and only 70% of increased energy demand will be generated by fossil fuels (Lam and Shiu, 2004). In 2019, China was the 82nd country in the World Economic Forum's (WEF) Energy Transition Index with 51% transition readiness (WEF, 2019).

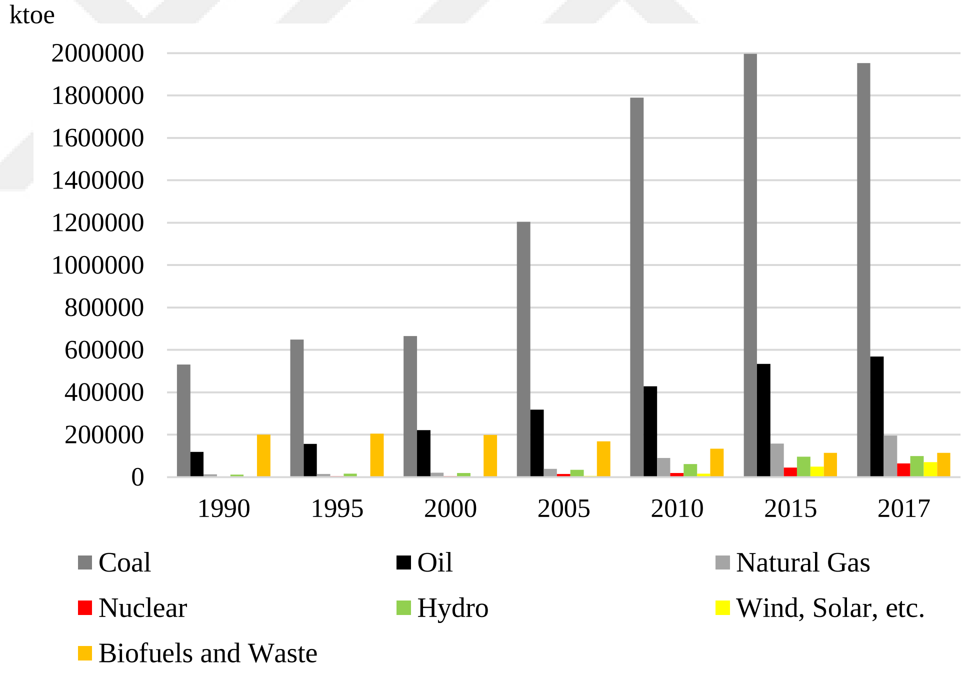

Figure 3.12. Total Primary Energy Supply (TPES) by Source in China from 1990 to 2017[28]

[28] IEA (n.d). TPES by Source in China. Retrieved 10 August 2019 from https://www.iea.org/statistics/?country=CHINA&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES

On the other hand, the growing Chinese electricity consumption from solar and wind is remarkable. New annual solar photovoltaic systems may cross 80 GW-160 GW and 70 GW-140 GW of wind annually. Approximately one-third of global wind power is now deployed in China (SolarPowerEurope et al., 2015).

China has been the world's most populous country for a long time. With increasing population, China is also in rapid industrialization and urbanization at the moment. In the context of the renewable energy transition, its impact on climate change has become a much-debated topic. China is now the largest carbon dioxide emitter (Figure 2.13) and per capita has reached the EU level (Greenpeace, 2015).

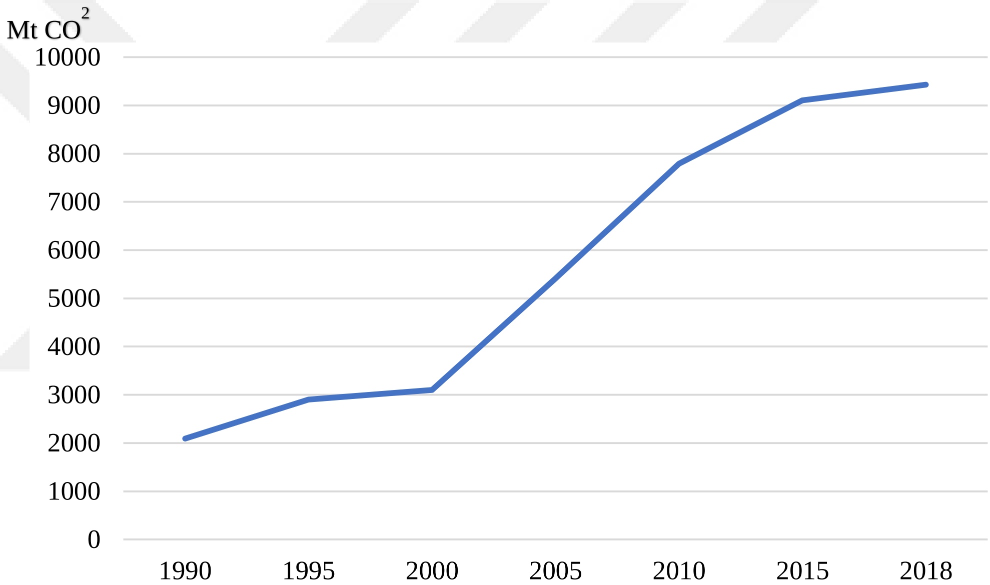

Figure 3.13. CO^2 Emissions (Mt of CO^2) in China from 1990 to 2018[29]

Furthermore, other governments like the United States are getting support and creating an excuse for their polluting industries, by pointing to China's skyrocketing emissions. Chinese officials are now investigating possible solutions. The share of coal in power generation does, however, have a diminished trend. Due to low energy demand and the growth of RES systems, coal-fired power plants in China had significantly fewer operating hours in 2017 than in 1978 (Linster M. and Yang, 2018). China is also

[29] IEA (n.d). CO2 Emissions (Mt of CO2) in China. Retrieved 10 August 2019 from https://www.iea.org/statistics/?country=CHINA&year=2016&category=Emissions&indicator=TotCO2&mode=chart&dataTable=INDICATORS

speeding up the implementation of the National Climate Adaptation Strategy (Chinese Ministry of Ecology and Environment, 2018) to respond to extreme climatic events and make positive progress in critical areas of adaptation to climate change. Capacity building to combat climate change was also further enhanced by endorsing the implementation of China's Science and Technology Actions on Climate Change in terms of science and technology.

3.5. Republic of South Africa

South Africa has the smallest land area, population, and economy among the BRICS, but it is the largest economy in Africa. The total primary energy supply in South Africa is around 132,756 ktoe in 2017 (Figure 2.14.). The share of fossil energy is approximately 90%. Compared to 1990s, the share of coal, oil and natural gas has been considerably increased. However, the share of renewable energy is comparatively miniscule because renewable energy systems and the notion of transition have only gained importance since 2014. South Africa is enriched not only with conventional resources like coal and natural gas, but also mineral reserves like diamonds, gold, and platinum. Over the past 15 years, traditional assets have exceeded 92 percent of South Africa's power supply (Greenpeace, 2015). South Africa used coal to generate energy, mostly in 2014 and 2016. In 2019, South Africa was the 114th country in the World Economic Forum’s (WEF) Energy Transition Index with 37% transition readiness (WEF, 2019).

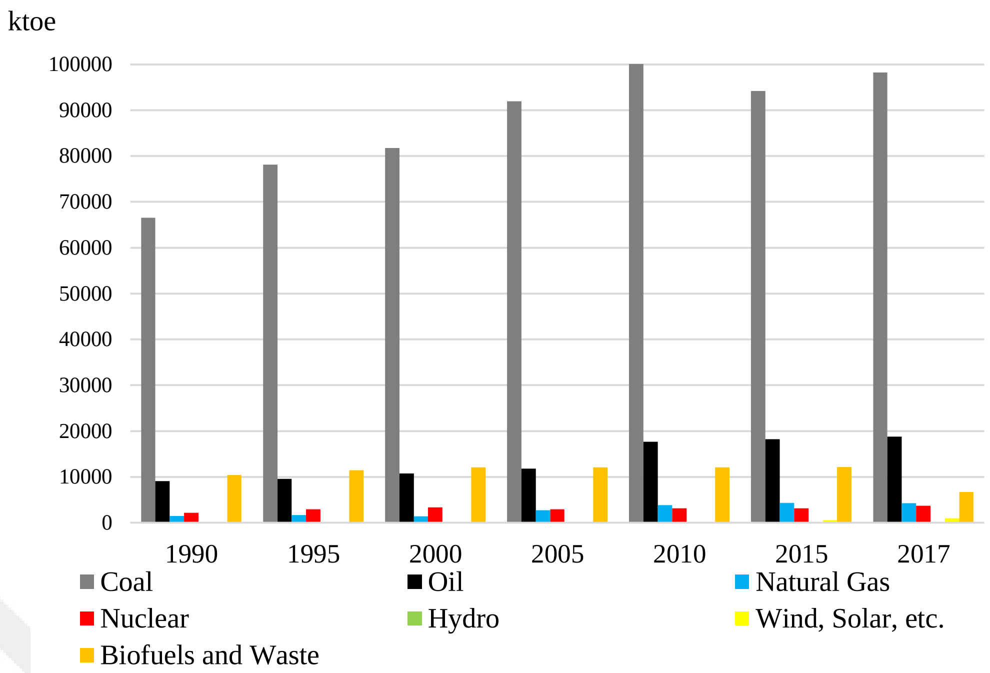

Figure 3.14. Total Primary Energy Supply (TPES) by Source in South Africa from 1990 to 2017[30]

Among the BRICS, South Africa is the most dependent on carbon, and its capacity to produce coal is foreseen to grow at a rate comparable to renewable energy. It is also expanding two of its largest coal-fired power plants, Medupi and Kusile, while also seeking approval from individual coal-fired plants (Scholvin, 2014).

On the other hand, South Africa has tremendous renewable energy potential (REN21, 2019). The government should include renewables distributed, not just projects on a utility scale. Small projects will support electrification and rural development, and the elimination of barriers to solar rooftops offers notable opportunities. Such obstacles include the absence of a regulatory framework for solar rooftops, funding mechanisms, aggressive renewable sector goals and a stable grid. The government's strategy for 2010-2020 was to provide a more inclusive and greener economy by expanding the production of technologies for solar, wind, and biofuels. South Africa became the

[30] IEA (n.d). TPES by Source in South Africa. Retrieved 10 August 2019 from https://www.iea.org/statistics/?country=SOUTHAFRICA&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES

fastest growing renewable energy market in the G20 in 2012, after some delays in implementation (OECD, 2013).

However, carbon emissions have been rapidly increasing in South Africa. During the 1990s, its carbon emissions climbed steadily, but the increase was more considerable in the 2000s. Emissions were mostly flat during the economic crisis (Figure 2.15.). South African greenhouse gas emissions per capita are high compared to China or Brazil but below the OECD average.

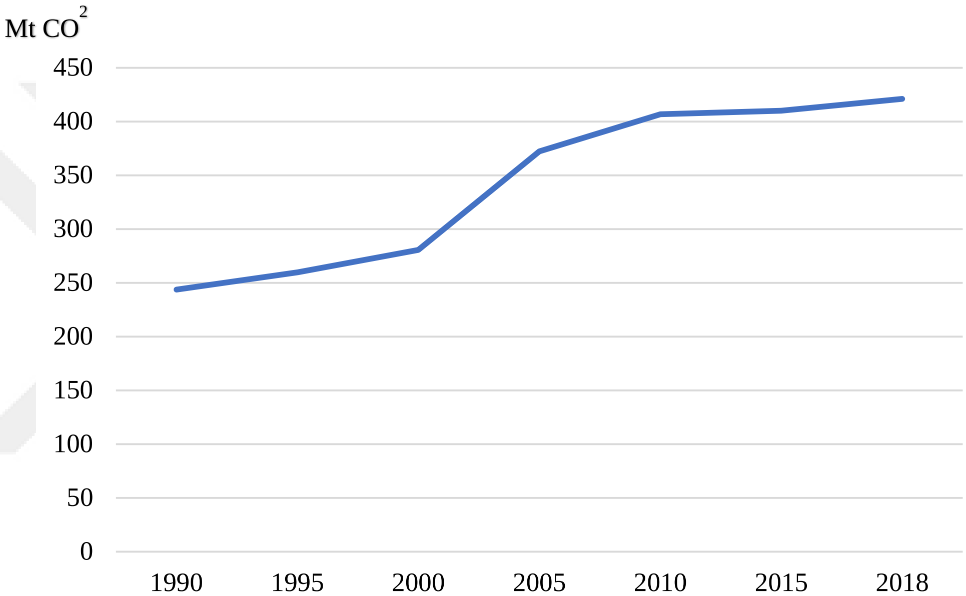

Figure 3.15. CO^2 Emissions (Mt of CO^2) in South Africa from 1990 to 2018[31]

[31] IEA (n.d). CO2 Emissions (Mt of CO2) in South Africa. Retrieved 10 August 2019 from https://www.iea.org/data-and-statistics?country=SOUTHAFRIC&fuel=CO2%20emissions&indicator=Total%20CO2%20emissions

4. THE ENERGY DIMENSION OF BRICS COOPERATION

Energy cooperation is always acknowledged as one of the leading factors behind the development of BRICS nations (Sun, 2014). Correspondingly, energy concerns will undoubtedly remain an indispensable and influential drive for the BRICS to shape their domestic structures and influence the global energy system, even if asymmetries in consumption and production of different energy sources exist between them.

Indeed, the first BRIC summit in 2009 highlighted the strengthening of cooperation among the member states in the field of energy:[32]

> "We stand for strengthening coordination and cooperation among states in the energy field, including amongst energy producers and consumers and transit states, in an effort to decrease uncertainty and ensure stability and sustainability. We support diversification of energy resources and supply, including renewable energy, security of energy transit routes and creation of new energy investments and infrastructure."

The main energy-related goals of the BRICS include the development of traditional energy sources such as fossil fuels and nuclear, energy efficiency, new technologies for renewable energy, and energy distribution and storage (Steblyanskaya et al., 2018). Furthermore, in 2017 the BRICS adopted "the Memorandum of Mutual Understanding in Energy Saving and Governmental Agencies of BRICS Responsible for Energy and Energy Efficiency," which aims to improve energy efficiency, preserve and extend existing resources, tackle climate change, and strengthen energy efficiency cooperation among the BRICS based on the principle of mutual benefit.

In terms of energy security, the BRICS have different profiles as energy producers and consumers (Pedro et al., 2018). While consumers are interested in the security of supply, producers are more concentrated about the security of demand for their exports. China, India, and South Africa are the consumers-importers; Russia and Brazil are primarily producers-exporters. Additionally, Russia is looking to diversify its consumer

[32] BRICS Information Centre (n.d). Joint Statement of the BRIC Countries' Leaders. Retrieved 12 April 2019 from http://www.brics.utoronto.ca/docs/090616-leaders.html

base for its natural gas exports away from Europe and is looking towards BRICS markets. All the BRICS nations are investing in developing renewable energy systems to satisfy their growing energy demands and re-consider their reliance on fossil fuels due to climate change concerns.

The BRICS share common concerns about dependence on non-renewable energy sources, the unpredictability of fossil fuel prices, and the effects of climate change (Wilson, 2015). There have been efforts to build bilateral energy cooperation between the BRICS members, but this has, thus far, only occurred through bilateral agreements for specific energy projects and investments (Taylor, 2018). At present, there is no multi-level energy cooperation among them and, even if it came to exist, the question remains whether it would address issues about energy governance or shape energy policies and reform agendas towards the transition. For now, it is merely coming from the BRICS cooperative approach to ensuring national autonomies and energy independence.

The BRICS certainly have the potential to develop multilateral energy cooperation based on their meetings and agreed outcomes from 2009 to 2018 (Table 3.1.). Members have been agreed on various topics from financing energy and infrastructure projects to building a low emissions economy and encouraging sustainable development. Unfortunately, none of these agreed outcomes could turn into a successful and institutionalized outcome except for the establishment of the NDB. Herein, it is self-evident that the BRICS are quite successful in setting the agenda, but there is still a need to develop a well-established mechanism to implement agreed outcomes.

Regardless of these initiatives, the BRICS are re-shaping global energy markets due to their increasing energy demands and nationalistic energy policies. Henceforward, if intra-BRICS cooperation can be institutionalized in the area of the renewable energy transition, it will have an impact at the global level. Nonetheless, energy security issues hinder energy cooperation among the energy-producing countries and energy-consuming countries, while the international energy system discourages the BRICS from taking concerted action to ensure their energy security. Herein, multilateral cooperation on energy can only be accomplished by addressing the energy resource competition. Even though the BRICS have increased their cooperation on energy-related issues over the years, there remains considerable distance between agreed goals and reforms pertaining to the renewable energy transition. This gap is coming from the role of communication between states (Majeski and Fricks, 1995). A prosperous BRICS cooperation on the renewable transition faces challenges because there are controversial and competitive areas between the BRICS members. However, a standardized and binding cooperation model between them could create a formal communication between countries that would decrease competition and conflict. Herein, bureaucratic level agreements and consensus among interest groups are essential. When the bilateral relations between countries turn competitive, the existing structure could reduce tension. For instance, the reciprocal relationship between India-China and China-Russia over the Central Asian energy overview could be solved with a well-defined BRICS cooperation. Thus, clear communication among BRICS could be a beneficial factor and account for higher levels of cooperation in international relations than would be predicted.

Table 4.1. The BRICS Summits and Agreed Outcomes[33]

Year	Country	Meeting	Agreed outcomes
2009	Russia	Yekaterinburg Summit	The first BRICS Summit, attended by Brazil, Russia, India and China. The summit initiated the cooperation at the level of heads of state. It aimed to enhance cooperation among countries on issues related to global governance, especially in the economic sector, by claiming the participation of emerging economies in the international financial institutions through a transparent and merit-based system.
2010	Brazil	Brasilia Summit	The second summit included new cooperative concepts; leaders signed a cooperation agreement to facilitate the funding of electricity and infrastructure projects.
2011	China	Sanya Summit	The first South Africa summit to be included as a participant. The BRICS reaffirmed the need for global governance reform, with particular emphasis on issues such as economics, encouragement of the use of renewable energy, commitment to the Millennium Development Goals (MDGs), promotion of the peaceful use of nuclear energy, and eradication of hunger and poverty. Renewable energy came to the agenda of the BRICS with this meeting and became an area of cooperation.
2012	India	New Delhi Summit	The focus of the fourth meeting was global peace, security and prosperity partnership. The development of the “New Development Bank (NDB)” was also discussed. Multilateral cooperation on energy within the framework of the BRICS was a "new area of cooperation." They pointed out that for the foreseeable future, fossil fuels would continue to dominate the energy mix of the countries. Nevertheless, it agreed to commit to raising investment in renewable energy by promising to share expertise, know-how, innovation and best practices in energy-efficient and environmentally friendly systems. In the BRICS system, the establishment of the New Development Bank has strengthened multilateral energy cooperation.
2013	South Africa	Durban Summit	The theme was Africa's growth, integration, and industrialization, culminating in the “BRICS Multilateral Infrastructure Co-Financing Agreement for Africa” to facilitate co-financing arrangements across the continent for infrastructure projects. This summit marked the beginning of broader membership dialogue.

[33] The BRIC S Brazil 2019 (n.d). Previous Summits. Retrieved 12 April 2019 http://brics2019.itamaraty.gov.br/en/about-brics/previous-summits

2014	Brazil	Fortaleza Summit	The theme was sustainable development and permanent solutions. Agreements have been signed between the NDB and BRICS Contingent Reserve Arrangement to allocate resources to finance the sustainable development projects in developing countries.
2015	Russia	Ufa Summit	This was a joint meeting with the Eurasian Economic Union (EAEU) and the Shanghai Cooperation Organization (SCO) to identify key areas of cooperation. Also discussed was the NDB's potential to fund environmental projects and the possibility of setting up a collaborative platform for the BRICS to exchange best environmental practices and facilitate know-how exchange with the participation of public and private stakeholders. Also approved was the BRICS Economic Partnership Plan, a roadmap for member countries to diversify trade and investment. The sharing of know-how was addressed with the involvement of public and private investors, which could break down strict path dependence directly.
2016	India	Goa Summit	This summit addressed global economic recovery, addressing issues related to the social responsibility, institutionalization of the NDB, and economic growth. BRICS cooperation is always focused on improving economic situations.
2017	China	Xiamen Summit	This was another joint meeting with the Multi-Sectoral Technical and Economic Cooperation Initiative (BIMSTEC) of the Bay of Bengal. The action plans for “the 2017-2020 BRICS Technology Cooperation Action Plan” and “The Customs Cooperation Policy and Memorandum of Understanding” between the NDB and the BRICS Business Council have been signed. Also, discussed was the establishment of the BRICS Tuberculosis Research Network. Members decided to encourage the most effective use of fossil fuels and the broader use of coal, hydroelectric power and nuclear power to reduce emissions and support sustainable development. It was a pledge to promote sustainable growth and low-carbon economies to strengthen BRICS climate change cooperation and increase green funding.
2018	South Africa	Johannesburg Summit	The theme was collaboration in the 4th industrial revolution for inclusive growth. Agreements on the establishment of the NDB's Regional Office for the Americas and “the Regional Aviation Partnership Memorandum of Understanding” have been signed. Also approved was the creation of “the BRICS Innovation Network (iBRICS)”.
2019	Brazil	2019 Summit	For an optimistic future, the most recent summit focused on economic growth. New areas with enhancing cooperation have been identified as research, technology and innovation; digital economy; combating transnational crime; and reconciliation between the NDB and the BRICS

			Business Council.
2020	Russia	2020 Summit	It is going to be a joint Shanghai Cooperation Organization (SCO) summit.

5. GENERAL DISCUSSION AND MAIN FINDINGS

Since the BRICS have developed at different paces and levels since 2009, cooperation among them has also evolved to reflect new realities (Bauman and Klein, 2014). There are different parameters of the renewable energy transition that also help determine how the BRICS can manage leapfrogging or path-dependence in a unique and collective way. When the country-level tendency to leapfrog or path-dependence is clear, it is much more valid to estimate the scope of cooperation on the renewable energy transition among BRICS members. For this purpose, the parameters and tendencies are discussed below.

5.1. Population and Total Area

Energy requirements are directly related to the population of a particular country. Since India and China are densely populated, their energy demands are comparably high (Table 4). Population directly affects the GDP, the energy consumption per capita and also the urbanization level in these countries; the increasing population is a lock-in factor for these countries (Rosenbloom et al., 2019).

5.2. Economy

The BRICS have been considered emerging economies for years. However, their divergent development levels have created asymmetries between them. The fundamental assumption behind all the discourse surrounding the BRICS is that India and China have risen as the world's principal suppliers of manufactured goods and services, while Brazil and Russia are becoming equally dominant as suppliers of raw materials (Thiébaut, 2013). Herein, the problem is that all these countries have experienced profoundly different levels of GDP and GDP per capita growth in the last five and ten years (Table 2.1). Since Russia and India are continually growing, the level of growth for Brazil and South Africa is comparatively moderate. Furthermore, China is in a class of its own, having experienced 87.6% GDP per capita growth only in the last ten years. Thus, as economist Jim O'Neill said, calling China an emerging market is "ridiculous" (Sprague, 2019). However, China's view of itself as a developing country featured prominently. A white paper, entitled "China and the World in the New Era" published on September 27, 2019 (The State Council Information Office of the People’s Republic of China, 2019), highlighted the opportunities that the rise of China has brought by "fundamentally altering the international structures of power." The main message is that South-South cooperation and assistance without conditions provide a win-win. A mechanism for this collaboration is the Chinese Belt and Road Initiative, a global development plan that involves infrastructure, R&D, and investment in 152 countries and international organizations. Herein, emerging countries are overpowered by China’s importance and influence. At this point, a transition from an abundant energy source to another means changing the overall structure of the economy for China, and even Russia and India. For these reasons, it can be argued that these countries have strong lock-ins to create path dependence.

5.3. Variables of Democracy

Regimes in late-industrializing countries tend to be less orderly and stable than in developed countries, as the governance and institutional capacities of late-industrializing countries are still to be settled (Berkhout and Raven 2011). These countries have accordingly realized greater success in leapfrogging. Herein, South Africa is a critical case because it is comparatively late in its industrialization among BRICS members. Since the initial aim is cheap energy generation in South Africa, but the country has weak legal actions and governance and no meaningful amount of natural reserves, leapfrogging is a suitable strategy. However, leapfrogging in the energy sector depends upon massive amounts of investment and modernization of existing infrastructure. At this point, an international partnership between developed and developing countries can accelerate leapfrogging.

5.4. Energy Resources

On the other hand, the availability of natural reserves and resources is a critical factor. If an economy is heavily dependent on a single resource, it is costly to transition away from it in the short term (Knauf and Göllinger, 2018). When coal, oil and natural gas rents as a percentage of GDP in last five and ten years are considered (Table 2.1), Russia's heavy dependence on oil and natural gas, and South Africa and China's quiet dependence on coal, are evident. These values show the difference between the value of production of coal, oil and natural gas at world prices and total production costs. Estimating the contribution of natural resources to financial output is essential to understanding the potential of the renewable energy transition. In countries like Russia, earnings from fossil fuels indicate the liquidation of the country's capital stock (Bleakley and Lin, 2012; Schumpeter, 2018). This blocks a direct shift to renewable energy systems.

For the countries that have tremendous renewable energy potential, the situation is the opposite. These countries have real potential for leapfrogging. Brazil, for instance, is a leading country among the BRICS in hydropower generation, generating an energy mix with low lock-in effects (Grubb, 1997; Perkins, 2003). Thus, leapfrogging seems a much more suitable option for Brazil.

5.5. Energy Production and Consumption

Energy production and consumption are also important indicators. Among BRICS countries, Russia and China have significantly increased their fossil fuel consumption in the last ten years and, when it comes to renewable energy consumption, Brazil has realized a significant increase (Table 2.3). The data is vital to understand country-level dependence on fossil fuels. Herein, the existing parameters are Brazil’s dependence on natural gas and renewables; Russia’s dependence on natural gas; India’s dependence on coal, oil and renewables; China’s dependence on oil, natural gas and renewables; and South Africa’s eagerness on renewables. It can be argued that the energy mix allows countries to avoid path dependence, but the dependence on a single energy source is problematic.

Carbon emissions are another critical component of the energy overview. A country’s dependence on fossil fuels has a direct impact on its emissions. In countries like China, it would create interest groups, who are institutionalized and eager to change the current system (Engels, 2018).

5.6. Energy Policies

Although increasing energy demand among the BRICS leads to increased use of fossil fuels, policies are being introduced to boost the use of renewable sources (Table 2.4). China offers most of the BRICS's subsidies and opportunities for solar, wind and biomass energy generation. Brazil provides mainly subsidies and tax exemptions for the production of biofuels. All BRICS countries are providing R&D funding to produce renewable energy. Such developments resulted from global interest in reducing emissions and rising socio-technical pressure (Batinge et al., 2017).

Many different policies have been adopted by the BRICS on energy generation from various renewable sources (Table 4). Brazil has a number of policies to produce biomass, hydro, photovoltaic solar and wind turbines. The country also taxes exemptions on technical pieces of equipment. Russia has set its goal for solar and wind power plants as part of its "Energy Efficiency and Energy Growth" program. India is encouraging both private and public sectors in energy from hydropower, solar and wind generations. India also regulates the promotion and establishment of biomass to meet industrial electricity demand. China has policies, incentives, and subsidies for flex-fuel vehicles. It also encourages hydropower and solar water-heating projects with a special feed-in-tariff. South Africa has also initiated an independent procurement system for renewable energy and has special incentives and subsidies for projects related to solar photovoltaics, wind turbine construction and biomass.

Renewable energy support programs and subsidies are turning renewable energy production into a profitable business (Table 2.4), and more intensively the BRICS are exploring this region. Brazil generates a considerable amount of biofuels and hydropower to meet its energy demand. Since Russia has plenty of natural gas and oil reserves, and South Africa has vast coal reserves that are cost-effective for an economically feasible generation of energy, both countries pay less attention to renewable energy policies. The barrier to the implementation of renewable energy systems is the lack of coherent policies and regulations. China is attentive to the growth of research infrastructure and the provision of funding for renewable energy production.

Given the abundance of coal reserves in India, renewable energy is crucial for the country to satisfy its ever-growing demand for energy.

When the parameters of RES development and transition across the BRICS are analyzed, the possibility for each country regarding specific parameters was presented in the second chapter. While leapfrogging is only a possible scenario for Brazil and South Africa as far as economy concerned, Russia, India and China tend towards strict path dependence. Nevertheless, China and India still have a broad vision for the renewable energy transition, and Brazil and South Africa need a considerable amount of investment to facilitate the necessary technical base for leapfrogging. Herein, it can be argued that such leapfrogging is only possible if the countries cooperate to obtain necessary technical and financial infrastructures. Thus, it can be argued that the BRICS could be more dependent on each other. However, it is not peculiar to consolidation among the members; rather, countries can also cooperate with other countries, which can, in turn, foster the process like it does in the OECD countries. In the context of the BRICS, it is much more straightforward to create this group dynamic since there are already shared energy interests and strategies among members. The BRICS can be seen as a puzzle to many because members have limited commonalities, but they certainly have the potential to create collective leverage and hasten the renewable energy transition.

Table 5.1: Leapfrogging and Path-Dependence Possibilities in the BRICS

Parameters	**Leapfrogging**	**Path-Dependence**
Population and Total Area	-	India, China
Economy and Resources	Brazil, South Africa	Russia, India, China
Variables of Democracy	South Africa	
Energy Overview	South Africa	Russia, China
Legal Actions and Governance	Brazil, China, South Africa	-

While considering the collective leverage that the BRICS can bring to bear on what is still a relatively "new" phenomenon, the renewable energy transition, the positioning of these countries should be carefully monitored. China's prodigious investments all over the world, its serious policies for the renewable energy transition, and its advocacy for emerging markets demonstrate that China is pursuing a different strategy as "a big brother" for BRICS and non-BRICS alike. There is no doubt that China is expanding its ties with several countries apart from the BRICS; these ties could be analyzed in various circles, including political, economic, and cultural. China is in the process of launching its ambitious multi-billion transcontinental infrastructure projects.

On the other hand, the competition will be fostered in the future with Russia's taking over the one-year chairmanship of BRICS. Russia is also interested in increasing financial and economic cooperation. Apart from the joint projects, Russia also favors promoting bilateral relations in the area of energy via the implemented and planned pipelines in the Asia region with the support of Russia. Herein, Russia's plan to redirect an enormous amount of natural gas from Europe to Asia has the potential to foster the relations. However, its effects on possible renewable energy cooperation are ambiguous. Russia could push BRICS cooperation to focus on the transition; however, there is a need to re-evaluate their government subsidies to fossil fuels and encourage renewable energy development with new policies among the BRICS. Besides, a well-defined structure for the economic diversification away from fossil fuel dependency will be essential.

States are trying to maximize their absolute gains for the absolute level of economic welfare. However, states are also trying to maximize their economic welfare within the constraints imposed by the international system (Powell, 1991). When the cost of using force is sufficiently low, cooperative outcomes cannot be supported even though the states' preferences are defined only over their absolute level of economic welfare. For instance, for countries like China and Russia, the cost of transition is relatively high. It decreases the possibility of cooperation even there is a relative gain in the long run. For countries like Brazil and South Africa, the transition has the potential to create an absolute gain. However, if Russia and Brazil may use the BRICS as cooperation to control the other countries, it produces also absolute gains for them. For this reason, cooperation is only possible under certain circumstances.

Sovereign governments do not recognize a universal authority and therefore may engage in limited cooperation (Keohane, 1986). The BRICS somehow challenge the authority of the so-called Western powers, namely Europe and the United States. Therefore, they are not eager to interfere or limit each other's sovereignty and are willing to cooperate in areas that create win-win scenarios for both sides. While the five members have successfully focused on different topics from global governance to financing models, they are also currently stimulating investment among the members. Thus, it means there is rooted reciprocity among them. If they can also create beneficiary impacts of catching up with the RES transition, cooperation would be possible. It does not mean that every country will transition, but some can help others to foster the overall process, which may create win-win scenarios. Herein, the BRICS need to redefine their energy policies based upon their existing geographical, economic, societal and environmental conditions, which will help in shaping global energy policies and more financial stability.

Furthermore, a sustainable and institutionalized funding mechanism across the BRICS countries to foster the renewable energy transition is necessary. To canalize the direction of the change to renewable energy in countries like Brazil and South Africa, the investment models are the prerequisite. That is why renewable energy is a key focus area for the NDB for a while; however, the institutionalized agenda for the transition investments is still missing.

However, there is a risk of freeriding among the BRICS during the RES transition, since not all of them are leapfrogging. If the framework of cooperation would be defined clearly, there will be no free-rider problem among the members. However, there is nothing special to the BRICS here; such conditions can be possible for any cooperation. Thus, the BRICS can cooperate on the RES transition, but there is nothing special about the BRICS to foster this cooperation.

6. CONCLUSIONS

The renewable energy transition is a pathway toward a long-term structural change of the global energy sector from fossil fuel-based sources to ones that can deliver zero carbon emissions. This transition requires substantial efforts, supportive market tools, innovative technologies, and constructive policy frameworks. Accordingly, cooperation among countries that have different energy profiles is a critical factor to foster the transition. From this point of view, I chose the BRICS countries, a regional cooperative organization composed of noteworthy variety in economic and politic structures and experiences to try to understand the possibility of cooperation on the transition. Since these countries have a great significance to the world's economy and already cooperate on various topics, their cooperation on this topic is also significant to evaluate the future of the transition. In this thesis, I aimed to show how different BRICS members are hastening or forestalling the transition and to analyze the possibility of cooperation among members.

Even though there is extensive literature on the renewable energy transition, most studies focus on separate economic, social and political factors. Cooperation among countries that have a different background, like the BRICS, is clearly missing. In order to fill this gap, this thesis has sought to present a comprehensive overview of the country-level variations among the BRICS by applying two theoretical concepts: path dependence and leapfrogging. Path dependence argues that due to infrastructural, operational, behavioral, and technological lock-ins, energy systems are subject to continuous path dependence. This concept has been used to understand the particular lock-ins of the BRICS. The concept of leapfrogging, on the other hand, assumes that developing countries have the potential to avoid fossil fuel dependency by adopting the most advanced energy technologies. As a result of evaluating different parameters in the BRICS, it finds that Brazil and South Africa have the potential to eliminate their moderate lock-ins, but Russia, India and China have strict lock-ins considering their economic and infrastructural backgrounds. The domestic and international structures of Russia, India, and China make these countries eager to extend the current energy system, which creates strict path-dependency. Also, these countries are heavily dependent on a single abundant resource, which increases the cost of breaking that dependence in the near term. For this reason, they tend to keep their economies of scale. The potential of Brazil and South Africa to leapfrog, however, depends on various additional factors, the most important of which is adequate investment through international partnership.

The country-level variations among the BRICS members highlight that the countries' different needs define their form of cooperation on the renewable energy transition. Herein, it can be argued that the BRICS can cooperate on the renewable energy transition and this cooperation can foster the renewable energy transition, but this does not mean that the experience of each country will be similar. While Russia, India, and China are likely to continue to invest in renewable energy technologies at home and abroad in the long run, a real and quick transition only seems possible in Brazil and South Africa.

It could be argued that BRICS cooperation has lost its relevance because of different economic development experiences since 2009. While the share of Russia, India, China are growing in the global economy, the share Brazil and South Africa have shrunk. Even though the last BRICS meeting emphasized cooperation, how and to what extent the BRICS take the next step in renewable energy cooperation remains an open question. However, it is evident that due to interwoven needs, they have a tremendous potential to become a force of considerable leverage and power. If the BRICS formalize a practical strategy, there is no significant barrier to the transition for these countries in the long term. They also have the potential to become a knowledge hub of the renewable energy transition for other developing countries. However, states are the major actors in world affairs. Thus, if the framework of renewable energy cooperation fails to create profitable results for all members, it will not be durable. The BRICS countries could agree on possible cooperation because of joint advantages; each country will have a different national-level interest. That is why cooperation between leapfrogged countries and path-dependent countries can cooperate on the transition.

At this stage, China and the role of its supply chain for solar panels batteries, fuel cells, and so forth are critical. It is the fact that not just the BRICS are buying these materials from China; also, the United States, Europe, and most every other country are trading with China. It seems that China is going to take the initiative to lead not only the BRICS but also the developing countries. Currently, China is pushing for influence across the developing world via its investments in developing countries, which is critical to have a clear understanding of China. While its approach is less aggressive, it is still frequently undermining financial and political independence. It also interferes with developing countries' political systems by moving towards politics and policies that are China-friendly.

Like the American Marshall Plan in 1948, China is using the Belt and Road Initiative to mobilize its investments in developing countries with a focus on Chinese economic progress. China is trying to modernize the countries which were not mainly targeted by the Marshall Plan. These neglected countries are getting infrastructural investments from China on the areas like railways, telecommunications, and harbors. Then, China has been constructing a large unified market with mutual dependence. The Chinese mindset could undermine existing cooperation among BRICS members because Russia and India also have strong national agendas. Thus, cooperation on the RES transition among BRICS members would only be possible if Russia, India and China find a win-win mechanism to invest in the renewable energy systems at home and abroad. Nonetheless, it must be acknowledged that this sort of model of cooperation would take years to reach maturity and make a real difference. Currently, the BRICS do meet often enough at a high level; even defining the frameworks of the transition will take years.

This study has shown that cooperation on the RES transition among the BRICS is possible only under certain circumstances. To foster this process, BRICS members need to re-evaluate their government subsidies to fossil fuels and encourage renewable energy development with new policies. In addition, a well-defined structure for the economic diversification away from fossil fuel dependency will be essential. Furthermore, the countries are moving away from earlier similarities as cooperation. The BRICS is not a substantial consolidation anymore, like in the past; China's position has an incredible effect in there. However, a new model of the BRICS, which is under the guidance of China with the new structures, could draw an innovative framework for the renewable energy transition and then foster the process in the member countries. The success of this leverage depends on the country level variances, namely Brazil and South Africa's potential for leapfrogging and the others' different path dependencies.

This study is essential to understand the country-level variations among the BRICS members, which affect the cooperation on renewable energy transition on a global level. However, the study falls short on some issues due to the limitations of time. Its findings could be improved by well-analyzed detailed economic, political and social parameters. It also would be more fruitful by physically participating in ongoing BRICS meetings and in-depth interviews with the energy stakeholders in the different BRICS countries. For future studies, it would be useful to focus on the leadership of China within the BRICS cooperation and how other countries react to this development.

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CURRICULUM VITAE

Personal Information

Name Surname Elif Güney
Date of Place and Birth Istanbul, January 1, 1994

Education

09/2017 - 12/2019 Postgraduate with dissertation, Energy and Sustainable Development, Faculty of Engineering, Kadir Has University, Istanbul, Turkey (GPA: 4.00)

09/2011 - 01/2017 Undergraduate, Political Science & International Relations, Faculty of Economics and Administrative Sciences, Boğaziçi University, Istanbul, Turkey (GPA: 3+, with honor degree)

07/2015 - 02/2016 Undergraduate, Erasmus+ Programme, Universidad Complutense de Madrid, Madrid, Spain

Work Experiences

09/2019 – Present Project Coordinator, Friedrich Naumann Stiftung, Istanbul Office

08/2018 - 09/2019 Programme and Communication Officer

04/2017 - 08/2018 Project Assistant

09/2016 - 03/2017 Research and Development Assistant, Istanbul International Center for Private Sector in Development (IICPSD), United Nations Development Programme (UNDP), Istanbul

05/2016 - 08/2016 Administrative Assistant, Istanbul Policy Center, Sabancı University, Istanbul

07/2015 - 09/2015 Research Assistant, Boğaziçi University, Istanbul

12/2014 - 06/2016 Secretary-General, Co-Opinion which is the non-governmental organization to address the problems of youth in the Middle East and North Africa.

06/2014 - 08/2014 Trainee, Trading & Treasury Departments, Turkish Finance Participation Bank, Istanbul

Society Membership

03/2019 – Present Member, Greenpeace

09/2017 - 06/2018 Chairwoman, Graduate Student Conference on Energy and Sustainable Development, Kadir Has University, Istanbul

09/2013 - 09/2015 Director, Center for European Studies Student Forum (CESSF), Boğaziçi University

Certificates

05/2019 Paper Presentation, “A Game Changer in Eurasia: Altai Gas Pipeline”, 7th Multinational energy and Value Conference, Center for Energy and Value Issues, Ankara, Turkey

05/2019 Training, “Digital Campaign Strategy Bootcamp for Social Changers”, International Academy for Leadership, Berlin, Germany

01/2018 Training, “How to Create a Communication Strategy: Translating Strategy into Action”, International Academy for Leadership, Berlin, Germany

10/2016 23rd World Energy Congress, World Energy Council, Istanbul, Turkey

08/2016 Youth Ambassador for Peace and Intercultural Dialogue, UNESCO

06/2016 Youth Unemployment Thematic Workshop, American University in Beirut, Lebanon

02/2016 Regional Development, Refugee Crisis, and Youth Unemployment, Hasan Kalyoncu University, Gaziantep and Kilis Oncupinar Accommodation Facility Kilis, Turkey

Computer Skills

Adobe Photoshop, Celtx Script Writing, Internet Browsers, SPSS, Windows Operating System, Word Office, Tableau

Languages

Turkish (native), English (advanced), Spanish (intermediate), German (intermediate)

Contact

Email elif.gney@yahoo.com