KADIR HAS UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF ENGINEERING AND NATURAL SCIENCES

POTENTIAL AND STATUS OF RENEWABLE ENERGY DEVELOPMENT IN ENERGY IMPORT-DEPENDENT COUNTRIES, TURKEY AND PAKISTAN

MOHSINA MAJEED
PROF. DR. VOLKAN Ş. EDİGER

MASTER’S DEGREE THESIS

ISTANBUL, JULY, 2021

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SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES
WITH THE AIM TO MEET THE PARTIAL REQUIREMENTS REQUIRED TO RECEIVE A MASTER’S DEGREE IN THE PROGRAM OF ENERGY AND SUSTAINABLE DEVELOPMENT

ISTANBUL, JULY, 2021

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JURY:	SIGNATURE:
Prof. Dr. Volkan Ş. Ediger , (Advisor) Kadir Has University	_______________
Prof. Dr. Ahmet Yücekaya, Kadir Has University	_________________
Asst. Prof. Dr. Emre Çelebi, Yeditepe University	_______________
Assoc. Prof. Dr. Gokhan Kirkil, (Co-Advisor) Kadir Has University	_______________
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I confirm that the signatures above belong to the aforementioned faculty members.

____

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Director of the School of Graduate Studies

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AEDB	Alternative Energy Development Board
BE	Biomass Energy
BP	British Petroleum
CCoE	Cabinet Committee of Energy
EIA	Energy Information Administration
EUAS	Electricity Generation Corporation
EIGM	General Directorate of Energy Affairs
EMRA	Energy Market Regulatory Authority
EXIST	Energy Exchange Istanbul
EU	European Union
FIT	Feed-In-Tariff
IEA	International Energy Agency
IPPs	Independent Power Producers
GOP	Government of Pakistan
GE	Geothermal Energy
GDP	Gross Domestic Product
GW	Gigawatt
GHG	Greenhouse Gas
GENCOs	Generation Companies
GHG	Green House Gases
IMF	International Monetary Fund
IRENA	International Renewable Energy Agency
IPPs	Independent Power Producers
KWh	Kilowatt hour
KES	Karachi Electric Supply
MENR	Ministry of Energy and Natural Resources
MW	Megawatts
MWe	Megawatt electric
MWh	Megawatt hour
MTOE	Million Tons of Oil Equivalent

NDC	National Determined Contribution
NDRC	National Determined and Reform Commission
NEPRA	National Electric and Power Regulatory Authority
NTDC	National Transmission and Dispatch Company
PPIB	Private Power Infrastructure Board
PES	Pakistan Economic Survey
RED	Renewable Energy Development
RE	Renewable Energy
REN21	Renewable Energy Policy Network for the 21st Century
REP	Renewable Energy Policy
REPs	Renewable Energy Projects
REs	Renewable Energy Sources
RETs	Renewable Energy Technologies
SE	Solar Energy
TWh	Terawatt hour
TEDAS	Turkish Electricity Distribution Corporation
TEIAS	Turkish Electricity Distribution Corporation
TETAS	Turkish Electricity Trade and Contracting Corporation
UNFCCC	The United Nations Framework Convention Climate Change
WE	Wind Energy
WAPDA	Wind and Power Development Authority
YEGM	General Directorate of Renewable Energy
YEKDEM	Renewable Energy Resources Support Mechanism, Turkey

THE POTENTIAL AND STATUS OF RENEWABLE ENERGY DEVELOPMENT IN ENERGY IMPORT-DEPENDENT COUNTRIES, TURKEY AND PAKISTAN

ABSTRACT

Human life cannot be imagined without the use of energy. Demand for energy, meanwhile, is increasing daily across the globe, while the uses and sources of energy have changed over time. Fossil fuels have dominated other energy sources since the 19th century but began causing problems such as climate change. In order to address these problems, renewable energy sources (RES) were accepted as an alternative energy sources in recent years and technical and economic developments make possible the energy transition from fossil fuels to renewables at an accelerated rate. Turkey and Pakistan are both developing countries with large populations and high levels of energy-import dependency, 77% and 80%, respectively. At the same time, Turkey and Pakistan both have enormous potential for RE such as solar, wind, hydro, biomass and geothermal, according to the validated RE-potential maps of these countries. Turkey and Pakistan are realizing renewable energy transition and seeking to shape their current energy structure in the favor of RES. The factors affecting RED in Turkey and Pakistan are enormous RE potential, supportive RE policies by government and energy security issues. There are some political, economic, technical and social problems for RED in Turkey and Pakistan that include lack of proper RE policies, extended and time-consuming governmental procedures, the lack of domestic production of goods, and other financing problems for RE projects. If proper policy support and efficient investment become available, RES can provide enough power to fulfill the country's energy demand and bring prosperity and sustainability to both countries. Current RED in these countries is not sufficient for complete energy transition from fossil fuels to renewables. However, RE potential in these countries is enough for complete energy transition. According to SWOT analysis Pakistan's RE sector has various investment opportunities for Turkish investors. It has a validated RE source mapping system and untapped highly potential solar and windy areas. Mini-hydro plants is also a successful RE business model in Pakistan. The government of Pakistan is also offering various incentives for RE investors.

Keywords: Renewable energy transition, sustainability, solar, wind, fossil fuel

ENERJİ İTHALATINA BAĞLI ÜLKELER, TÜRKİYE VE PAKİSTAN'DA YENİLENEBİLİR ENERJİ GELİŞİMİNİN POTANSİYELİ VE DURUMU

ÖZET

Enerji kullanılmadan insan hayatı düşünülemez. Bu arada, enerji kullanımı ve kaynakları zaman içinde değişirken, enerji talebi dünya genelinde her gün artıyor. Fosil yakıtlar 19. yüzyıldan itibaren diğer enerji kaynaklarına egemen olmuş ancak iklim değişikliği gibi sorunlara neden olmaya başlamıştır. Bu sorunları gidermek için yenilenebilir enerji kaynakları (YEK) son yıllarda alternatif bir enerji kaynağı olarak kabul edilmiş ve teknik ve ekonomik gelişmeler fosil yakıtlardan yenilenebilir enerjiye hızlı bir şekilde geçişi mümkün kılmıştır. Türkiye ve Pakistan, sırasıyla %77 ve %80 ile yüksek nüfusa ve yüksek düzeyde enerji ithalatı bağımlılığına sahip gelişmekte olan ülkelerdir. Aynı zamanda, bu ülkelerin onaylanmış RE-potansiyel haritalarına göre, hem Türkiye hem de Pakistan güneş, rüzgar, hidro, biyokütle ve jeotermal gibi yenilenebilir enerji için muazzam bir potansiyele sahiptir. Türkiye ve Pakistan, yenilenebilir enerji geçişini gerçekleştirmekte ve mevcut enerji yapılarını YEK lehine şekillendirmeye çalışmaktadır. Türkiye ve Pakistan'da RED'i etkileyen faktörler, muazzam YE potansiyeli, hükümetin destekleyici YE politikaları ve enerji güvenliği konularıdır. Türkiye ve Pakistan'da RED için uygun YE politikalarının olmaması, uzun ve zaman alıcı hükümet prosedürleri, yerli mal üretiminin olmaması ve YE projeleri için diğer finansman sorunları gibi bazı siyasi, ekonomik, teknik ve sosyal sorunlar bulunmaktadır. Bu ülkelerdeki mevcut RED, fosil yakıtlardan yenilenebilir kaynaklara tam bir enerji geçişi için yeterli değildir. Ancak bu ülkelerdeki yenilenebilir enerji potansiyeli, tam bir enerji geçişi için yeterlidir. SWOT analizine göre Pakistan'ın YE sektörü Türk yatırımcılar için çeşitli yatırım fırsatlarına sahip. Doğrulanmış bir RE kaynak haritalama sistemine ve kullanılmayan yüksek potansiyelli güneş ve rüzgarlı alanlara sahiptir. Mini hidroelektrik santraller de Pakistan'da başarılı bir YE iş modelidir. Pakistan hükümeti de yenilenebilir enerji yatırımcıları için çeşitli teşvikler sunuyor.

Anahtar Kelimler: Yenilenebilir enerjiye geçiş, sürdürülebilirlik, güneş, rüzgar, iklim,değişikliği, fosil

ACKNOWLEDGEMENT

First and foremost, I would like to thank my thesis supervisor, Prof. Dr. Volkan. Ş. Ediger, for accepting me as a Master student at Kadir Has University's Energy and Sustainable Development Master Program and also for his guidance and direction since my arrival at Kadir Has University. Their insightful remarks and recommendations helped me to complete this thesis. He always supported me and direct me towards better.

My heartfelt gratitude also goes to my Kadir Has University colleagues who stood with me and I am grateful to Hazal Mengi and Amir Gaur for their encouragement and warm support. I also like to thank Dr. John V. Bowlus for his assistance with grammatical correction.

Last but not least, I'd want to express my gratitude to my family and especially to my mother, who always stand behind me with her best wishes.

To My Dearest Family...

1. INTRODUCTION

The use of energy sources has changed over time, from wood to coal, from coal to oil, and finally from oil to natural gas. People have tended to switch from one energy source to another if the new source was better (Solomon and Krishna, 2011). Three characteristics made one source better: secure supplies of the new source were assured, higher calorific value, greater practicability in use, and lower environmental impact.

Primary energy resources before fossil fuels primarily consisted of wood and other biofuels, but coal replaced these at the start of nineteenth century due to its applicability for industrial use and high calorific value (Fouquet, 2010). The extensive use of coal made it the dominant resource, especially for the steam engines during the Industrial Revolution. As the technology improved in the twentieth century, petroleum became the dominant energy source (Fouquet, 2010). Oil was better than coal in terms of calorific value, practicability, and cleanliness. When natural gas became accessible for large-scale use in the 1950s, it was chosen along with oil because of its advantages over coal and other sources.

The energy transition is a dynamic and ongoing process and is still advancing towards better sources. At present, the world is transiting from fossil fuels to renewables (Ediger, 2019). There are many factors that are triggering this transition, such as the unsustainable nature of fossil fuels and their environmental impacts (Ediger and Kental, 1999), price fluctuations, depleting reserves of fossil fuels, and insecure energy supplies for importing countries. Renewable energy technologies (RETs) are also improving rapidly, and costs have fallen significantly in recent years. The governments have, moreover, started to support RES with greater importance and seriousness. According to the International Renewable Energy Agency (IRENA), the share of RES in the world's total energy supply will be two-thirds in 2050 (IRENA, 2018).

Pakistan and Turkey are also embracing this transition by introducing RE policies and making effective plans for future energy generation. Rapid progress is seen in RE sectors, but Pakistan has to do considerably more in deploying RETs to catch up with Turkey. In 2015, Turkey prepared the Energy Efficiency Strategy Paper for the efficient utilization of its renewable resources and set a target of making RES 30% of its total consumption by 2023 (Uğurlu and Gokcol, 2017). On the other hand, the Government of Pakistan set targets for 2025 as 20% and for 2030 as 30% (Abdullah et al., 2019).

Turkey and Pakistan have their own unique geographic and geopolitical importance in world politics. Turkey is situated between Asia and Europe and, due to its unique geographical location, can act as a barrier as well as a bridge between the two continents. It is also a natural energy bridge between major energy-producing countries in the east and major energy-consuming countries in the west. It plays a significant role in the energy-security problems of the European Union (EU) (Kansu, 2019). The European Union is the third largest energy consuming country in the world after China and the US. EU imports energy from regions where oil and natural gas imports are economically favorable, including Russia, the Caspian region, the Near East, and Nigeria (Thomas, 2014).

Since Turkey is bordering most of energy rich countries on one side and Europe on another side, it plays a vital role for greater energy supply security of Europe (Ruchir, 2010; Akdemir, 2011). Ten natural gas-producing countries with 35.5% of global natural gas reserves are interested in using Turkey as a transit route. The EU considers Turkey as a reliable bridge for its energy-supply security (Tekin and Walterova, 2007). Most of Central's Asia energy sources move through the Russian's pipelines to the Black Sea and then to pipelines in Turkey. Some oil and gas also flow through pipelines westward from the Caspian and across Turkey to terminals on its Mediterranean shores (Cohen, 2003; Siddi, 2017).

Pakistan, officially known as The Islamic Republic of Pakistan, also occupies a strategically important location in the center of Asia, acting like a bridge between Middle

East and Far East countries. It is thus an important center of trade and communication in the region. A vast transport system covers this wide strategic location, which includes three major international airports and 38 domestic airports, and three sea ports: Gawadar, Port-Qasim and Karachi. It is a main sea route between Europe and Indian subcontinent. Due to its strategic location, it becomes one of the busiest shipping routes in the world. For instance, China, the second largest economically developed country, depends on Pakistan's sea routes for its oil and gas imports (Rehman and Ali, 2021) from Central Asia, the Middle East, and other regions (Brutlag, 2011). Pakistan's deep-sea ports, Gwadar and Karachi, are found near the Persian Gulf and Strait of Hormuz, through which 40% of world oil passes. These routes are also reachable from Iran for energy transportation to other Asian countries. China initiated a mega project, the China-Pakistan-Economic-Corridor (CPEC) to get access to the Pakistan's land and sea routes for energy transportation (Ranjan, 2015). Similarly, Pakistan is a transit corridor for sourcing gas from Iran, which has the world's second largest natural gas reserves, toward India and other far East Asian countries (Lall and Lodhi, 2007). Many natural gas pipelines such as proposed pipelines IPI and TAPI are passing through Pakistan from producers to consumer countries (Sahir and Qureshi, 2007). Many landlocked countries in Central Asia, including Afghanistan, find Pakistani routes more suitable for transit traffic.

Energy-import dependency is an issue of great importance for many countries, threatening energy-supply security during the on-going energy transition. The oil crises of the 1970s highlighted this issue most obviously (Hughes, 2012). Energy-import dependency is a serious issue especially for developing nations because of the exponential growth of their energy needs and their inability to spend a large portion of their annual budgets to import fossil fuels (Berk and Ediger, 2018).

Turkey and Pakistan are typical energy import-dependent developing countries. Their energy demand is growing rapidly due to growth in gross domestic production (GDP), population and industrialization. According to the IEA's list of largest energy-consuming countries, Turkey increased its rank from 22 to 17, and Pakistan from 34 to 32 between

2010 and 2018 (EIA, 2018). However, they meet their energy needs through importing oil, natural gas, and coal. Pakistan is spending $26 million annually to import energy, more than its export revenues, while Turkey is spending $168 million annually on energy imports. In 2018, Turkey was the 8th largest importer of natural gas in the world, while Pakistan was the 21st largest (EIA, 2018). The import dependency ratio is 75% in Turkey (Yilmaz et al., 2015), while in Pakistan, it is 80% (Komal and Abbas, 2015). Pakistan is also surrounded by energy- rich countries such as Qatar and Iran etc. so there is more likely to import dependency in Pakistan. Pakistan has good relations with Qatar and other nearby energy rich countries. The share of imported crude oil, natural gas and coal in total primary energy mix of Pakistan is 56%, 13% and 32% respectively. In Turkey, the share of imported natural gas and crude oil in total primary energy supply is 30% and 20%, respectively. In order to overcome this dependency on fossil fuel imports, these countries see domestic and RE development as the only option (Ghafoor et al, 2016; Dursun and Gokcol, 2011).

The main purpose of this thesis is to examine the current situation of RE potential and development in Turkey and Pakistan. I try to answer the following questions: is renewable energy development (RED) in Turkey and Pakistan sufficient for a successful energy transition? what factors are affecting RED in these countries? what are the major problems or hurdles for RED in Turkey and Pakistan? and finally, are there investment opportunities for Turkish companies to cooperate with the Government of Pakistan and other private companies operating in Pakistan?”

Over the last two decades, several international organizations such as International Renewable Energy Agency (IRENA), International Energy Agency (IEA), and World Bank, companies such as British Petroleum (BP), and governmental organizations such as Energy Information Administration of the US Secretary of Energy (EIA) and European Commission (EC) have carried out research on this subject. They published reports on the potential of RED of different countries, installed RE capacities, and other related RE topics. RE is now studied and researched all over the globe. For example, Xu et al. (2019) researched the global RE development status, future political and economic perspectives and various factors that are responsible for worldwide RE transition. Abu-Rumman et al. (2020) and Baky et al. (2017) highlight the potential and status of RED in Bangladesh. Meanwhile, Salah et al. (2020) discussed the role of RED in Palestine for solving the energy crisis and published work on the potential and status of RED.

Similarly, there is a large body of literature available on RED in Turkey and Pakistan, the potential for different RE sources, their present status, and RE policies. Kaygusuz (2001), Balat (2005), Comakli et al., (2008), Bascetincelik et al. (2009), Saygin and Çetin (2010), Kilic (2016) and Gokcol and Dursun (2012) have all written about Turkey's RE development and the potential of different RES. Demirbaş and Baki (2004) and Rzayeva (2018) highlight Turkey's water resources and hydropower potential and how this renewable resource can effectively be used. Celik and Özgü (2020) analyzed Turkey's solar energy potential and prospects for further utilization. Kankal et al., (2016) studied the role of and potential to expand the use of hydropower for sustainable development in Turkey. Kilickaplan et al. (2017) focused on the energy transition pathway for Turkey to achieve 100% electricity from RE sources in the future. The authors describe in considerable details the contribution of different RE sources such as wind and solar for maximum clean energy generation. Nalan et al. (2009) also published a work on RE barriers in Turkey and their solutions, while Balat (2006) provided an overview of RE sources in Turkey, specifically studying geothermal energy potential and development.

Similarly, a lot of research has been carried out on RED and RE potential in Pakistan and its present status, including Raza et al. (2020), Ghayur and Ahmad (2007), Harijan et al. (2010), Elliott (2011), Munasinghe (2013), Umar and Hussain (2015), Saghir et al., (2019), Ghafoor et al., (2016), Shami et al., (2016) Kamran (2018), Rauf and Ashraf, (2019), Saleh and Ahmed (2019) and Irfan et al., (2021). Kamran et al., (2015), Shami et al (2016) and Rabbani and Zeshan (2020) specifically studied the wind energy resources of Pakistan and its development status. Mirza et al., (2008), Qureshi and Akintug (2014), Khan and Zaidi (2014) analyzed the water resources of Pakistan and their potential for maximum electricity generation. Mirza et al (2009), Raza et al (2015), Khattak et al (2006) and Solangi et al (2021) studied the RED barriers in Pakistan and investigated how to overcome these barriers. Piracha (1994), Rijal (1999), Aized et al (2018), Shah et al (2011) and Zafar et al (2018) studied the RE policies of Pakistan to examine its vision for the future of RE. Furthermore, Karakosta et al. (2016) investigated the Eu-Turkey RE cooperation investment opportunities using SWOT analysis. Su et al., (2020) studied and compared the RED of different EU countries, while Madurai Elavarasan et al., (2020) compare and analyze the RED of US and China. Kamran et al. (2020) analyzed the potential of the RE sector in Pakistan and described business opportunities for foreign investors, but no work has been done to compare the RE situations of Pakistan and Turkey. Furthermore, Humaiyun (2016) wrote a thesis, an evaluation of energy and electricity in Pakistan. He discussed the energy infrastructure and energy issues in Pakistan. In this thesis, the energy situation of both the countries Turkey and Pakistan are comparatively analyzed and the role of RE in solving energy issues of these countries is also figure out.

These previous studies provide a comprehensive literature on RED in Turkey and Pakistan as standalone cases. This thesis will thus further contribute to current academic literature because no work has analyzed and compared the RE potential, status, and developments in Turkey and Pakistan. There is still a room to make detailed energy analysis of these two countries that will be useful in the literature. Turkey and Pakistan have abundant RE sources, including solar, wind, hydro, and geothermal due to their geographical characteristics (Ediger and Kentel, 1999; Balat, 2005; Kirtay, 2010; Buckley, 2018; Ghafoor et al., 2016). Turkey has a total potential energy from renewable resources of 495.4 TWh/year, of which 196.7 TWh/year is biomass, 124TWh/year is hydropower, 102.3 TWh/year is solar, 50 TWh/year is wind, and 22.4 TWh/year is geothermal (Evrendilek and Ertekin, 2003). Similarly, Pakistan has a 2,900-GW potential of solar energy, 120-GW of wind energy, 100-GW of hydro energy and 5.7-GW of biomass (Farooqui, 2014). The geothermal energy potential in Pakistan is still under observation, but it comprises 2% of RE in Pakistan. Furthermore, this thesis will be the first research work to comparatively analyze the energy transition of Turkey and Pakistan and the potential and investment opportunities in RE sector of Pakistan for Turkish RE investors or developers. This thesis will thus be of benefit for the mutual cooperation of these countries. There is already a good and friendly relationship between Turkey and Pakistan and this thesis can add to it.

Energy data on the potential and total installed capacities of different RES such as solar, wind, hydro, and geothermal are collected from the official national energy websites of Pakistan and Turkey. For Pakistan, these include: Alternative Energy Development Board (AEDB), National Electric Power Regulator Authority (NEPRA), Ministry of Energy, Power Division (MEWP), National Transmission and Dispatch Company (NTDP), Private Power and Infrastructure Board (PPIB), National Renewable Energy Laboratory (NREL), and Pakistan Council of Renewable Energy Technologies (PCRET). For Turkey, these include: Energy Market Regulatory Authority (EMRA), Ministry of Energy and Natural Resources (MENR), Turkish Electricity Transmission Corporation (TEIAS), the Turkish Statistical Institute (TÜİK). Data is also gathered from journals and research reports, annual energy reports from ministries of energy of Turkey and Pakistan, and extract data from governmental or private energy organizations. For the same purpose, different international organization and agencies such as International Renewable Energy Agency (IRENA), International Energy Agency (IEA), U.S. Energy Information Agency (EIA), World Bank, Renewable Energy and Energy Efficiency Partnership (REEEP), and other related organizations were also used. The data used will be explained and interpreted to examine the RED in Turkey and Pakistan. Furthermore, I used the SWOT (Strength, Weakness, Opportunities, Threats) analysis method in order to analyze successful RES business opportunities and the potential of the RE sector in Pakistan. Through this method, I searched for the secure energy paths through which the Government of Turkey can join in hands with Government of Pakistan and make their bilateral relations more favorable through energy ties.

The rest of the thesis is structured as follows. In the second chapter, I describe the energy systems of Turkey and Pakistan, including their total primary energy supply (TPES), energy consumption, local and imported energy resources, and share of different energy resources in total energy mixes. Furthermore, I illustrated the natural energy reserves of these countries and potentials for different RES and the current status of ongoing different

RE projects such as wind, hydro and solar etc. and I mention the current energy issues in these countries. In this chapter, the privatization and development of power sector of these countries is also explained. I also discuss and analyze the potential and status of RED in the way of energy transition for these countries. In the third chapter, I focus on the strategies adopted by Turkey and Pakistan for RED. The fourth chapter is about problems for RED in Turkey and Pakistan and effect of COVID-19 pandemic on the development of RE in these countries. Furthermore, I figure out the factors responsible for RED in these countries. I also mentioned the nature of RES that is problematic for employing their full RE potential. In the following chapter, investment opportunities in Pakistan's RE sector are explained. Finally, in the conclusion, the major findings of the thesis, together with solutions, are presented.

2. ENERGY SITUATION IN TURKEY AND PAKISTAN

2.1 Energy Outlook

Turkey is a developing country with a population of about 80 million. Its economy has been growing at an average rate of 6.8% since 2008 (TÜİK, 2018), and is the 18th largest economy in the world. In order to maintain economic growth, energy consumption is vital, as Turkey has one of the fastest growing demands for energy in the world (BP, 2020). The energy demand of Turkey has doubled between the years 2000-2010 and will increase fivefold between 2000 and 2025 (Demirbas and Bakis, 2004; Balat 2004). Turkey relies on fossil fuels for 87% of its energy. At the same time, its net import-dependency for fossil fuels is 77% (EIGM, 2018; Paksoy, 2018). Turkey's primary energy consumption was 6.49 exajoules, or 155 million tons of oil equivalent (mtoe), which consisted of oil (32.3%), coal (27%), natural gas (24.8), hydroelectricity (8.6 %), and renewables (5.4%), in 2019 (BP, 2020). The total installed power capacity of Turkey is 91.267 megawatts (MW) in 2019. This capacity consists of 31.2% hydraulic, 28.4% natural gas, 22.2% coal, 8.3% wind, 6.6% solar, 1.7% geothermal, and 1.6% other resources (TEİAŞ, 2019). As can be seen, fossil fuels have an important place in Turkey's electricity generation with the share of 58.9%. With these values, Turkey ranks fourth in primary energy consumption and third in electricity generation in Europe. The comparison of Turkey and Pakistan with highly energy consumption countries worldwide is shown in figure 2.1. Turkey ranks on 5th number after Germany and China (Shaheen et al.,2020). It can be noted that Turkey needs to be more secure energy supplies as compared to Pakistan.

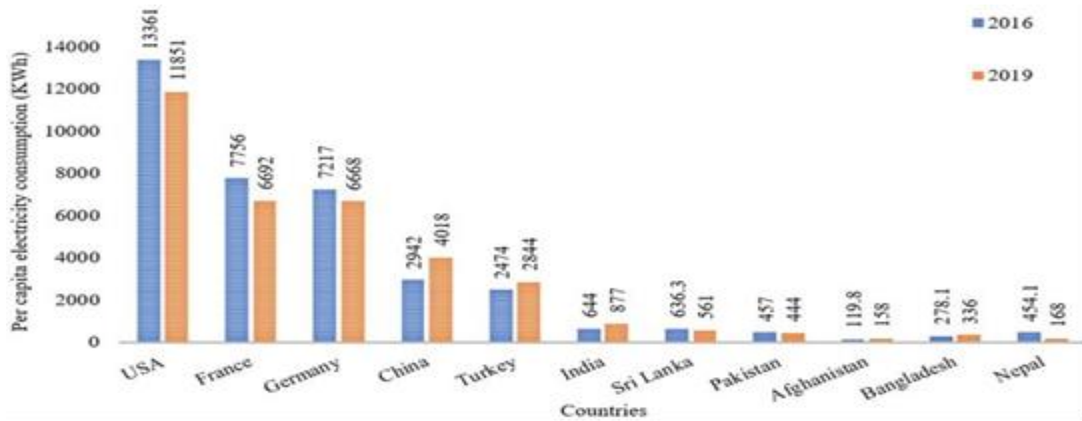

Figure 2.1 High Energy Consuming countries

Source: Shaheen et al., (2020)

Turkey does not have rich reserves of fossil fuels, and its energy imports are a major contributor to its high foreign trade deficit (Kilci, 2019). In 2019, the value of imported energy reached US$41.731 billion, which corresponds to 20% of total imports (T.C Ticaret Bakanlığı, n.d.). The changes in global energy prices have also affected Turkey's energy bill and created the need for external financing. Renewable sources, however, are abundant in Turkey; due to its geographical characteristics, there is adequate potential for solar, wind, hydro and geothermal energy (Ediger and Kentel, 1999; Balat, 2005; Özgür, 2008; Kırtay, 2010; Melikoğlu, 2017; Kılıçkaplan et al, 2017). Biomass potential is also ample to generate economical electricity (Toklu, 2017).

Pakistan is also a developing country; it is the sixth largest populated country in the world and second largest populated country in south Asia (Mirjat et al., 2018) with a population of 207,906,209. Pakistan is the 40th largest economy in the world, and its economy is growing at a lower rate of 5%. Pakistan has been facing economic challenges for the last 20 years in which electricity crisis is the most significant. Electric power consumption is increasing gradually at a rate of seven to eight percent per year, whereas power generation capacity is increasing at a rate of nearly five percent per year (IFC, 2016). In Pakistan, the average demand for energy is 17,000 MW, but average power generation is 14,000 MW in any season, leaving an average deficit of 3, 000 MW that may reach up to 5,200 megawatts in the summer. (Kessides, 2013). The total primary energy consumption of Pakistan is 3.56

exajoules, which consists of oil (25.2%), natural gas (46%), coal (15.4%), nuclear energy (2.2%), hydro (8.9) and renewables (1.6%) in 2019 (BP, 2020). The total installed capacity of Pakistan is 33,452 MW which consist of thermal (61%), hydro (29%), wind (3%), solar (1%), biomass (1%) and nuclear (4%) (NEPRA, 2019). It can be seen that thermal resource has a greater in Pakistan energy mix as seen in Turkey's energy mix.

Moreover, a large portion of Pakistan's total GDP is spent on importing fossil fuels, the major part of its consumption in power generation, causing the issue of circular debt (Jamal, 2016; Mirza and Khalil, 2011). Pakistan imports $15-$16 billion worth of oil annually that is the 34% of its GDP. The consumption of oil in Pakistan is 19.68 million tonnes/annum and the supply from local refineries is 11.59 million tonnes per annum, while the rest of the 8.09 million tonnes are imported (Rasheed et al., 2020; PES, 2020). This situation places a heavy burden on the economy. The imports and production of oil and natural gas is shown in figure 2.2. It can be seen that the share of energy imports is greater than the share of energy production. The energy demand of countries cannot be fulfilled by domestic energy supply, so imports are mandatory. Energy sources can be categorized into three types: fossil fuels, renewables, and nuclear sources.

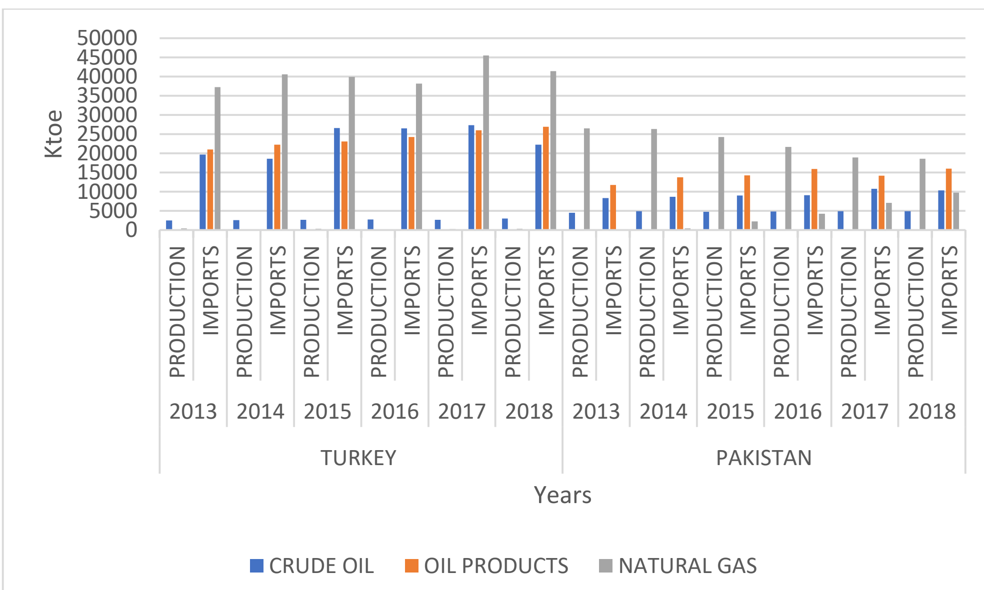

Figure 2.2 Energy Imports and Production, Turkey & Pakistan
Source: (IEA, 2018)

2.1.1 Fossil fuel reserves

Turkey is not rich in domestic sources of fossil fuels. Its main fossil fuel sources are coal, natural gas and petroleum (Kiliç and Kiliç, 2006; Akdeniz et al., 2002). It has 9.4 billion tons of coal reserves (Kasap et al., 2020) and reserves of asphaltite and peat. Turkey's lignite deposits account for a significant percentage of the country's overall coal reserves. The Zonguldak province in the Western Black Sea Region is home to Turkey's largest hard coal basin. The other resources are found in Hazro (Diyarbakir) and Kemer (Antaly) (Capik et al., 2013). Turkey has limited reserves of crude oil and natural gas.

Therefore, almost all of the oil and gas supply for the country's economy is imported by paying high costs (Kaya and Kilic, 2015). Natural gas producing fields of Turkey are found in Thrace and South East Anatolian regions such as, Hamitabat, Umurca, Karacaoglan, Degirmenkoy, Karacali, Tekirdag, Camurlu, and Hayrabolu. Its natural gas reserves, including proven, probable and possible reserves, are 23 billion cubic meters (bcm). Furthermore, the total production of natural gas was 11.3 bcm, and remaining recoverable gas was 6.2 bcm (EIA, 2021). The West Black Sea, Marmara, and Middle Anatolia regions are seen as hopeful fields for new exploration (Kiliç, 2005; Toksari, 2010). The total oil reserves, meanwhile, are 931 million tons (Topçu and Ulengin, 2004). Turkey has proven reserves of approximately 229 million barrels of oil, most of which is in the Hakkari Basin in the southeast. These are small oil fields with small deposits. However, about 20 oil companies in Turkey have been exploring for new deposits in the south and southeast of Turkey, in the European provinces, and in the shelf region Black Sea (Balat, 2004).

Pakistan lacks sufficient oil and natural gas reserves and import vast amounts of crude oil and petroleum products to meet more than 80% of its oil needs. The country's natural gas reserves are small, but its coal reserves are enormous but undeveloped. Its reserves of natural gas in Pakistan are nearly 885.3 bcm. Currently, natural gas is obtained from six fields: Sui, Mari, Pirkoh, Meyal, Dhurnal and Toot (Pakistan Petroleum Ltd, Karachi, 1984, 1986a). The last three are actually oilfields producing both natural gas and oil. Currently, thirteen major gas fields have been explored in the country, including the newly discovered field at Pirkoh in Baluchistan province, while gas fields in Sindh province include Golarchi, Khairpur, Kohthar, Kandhkot, Mazarani, Sari, Mari and Hundi. Those within the Punjatj are located at Dhulian, Meyal and Dhodak. The other two are in Baluchistan province at Sui and Pirkoh (Nizami and Nizami, 1987).

In term of coal resources, Pakistan has the sixth largest coal reserves in the world at nearly 175 billion tons, which can be approximated to 618 billion barrels of crude oil (Atil et al., 2020). Coal resources are found in all four provinces of Pakistan. Its largest reserves are found at Thar, Lakhra, Sondra Jehrruck, and Meting jhimpir in Sindh Province (NEPRA, 2004). Oil resources are located in Potowar region of province Punjab at Meyal, Balkassar, Dhulian, Toot, Adhi, and Khour. In Sindh province, they are found at Khaskhely in District Badin. A comparison of the different energy sources of Pakistan and Turkey is shown in Table 2.1.

Table 2.1 Comparison of Energy Reserves, Turkey & Pakistan
Source: (EIA, 2021; Kasap et al., 2020; Atil et al., 2020)

Energy Reserves	**Turkey**	**Pakistan**
Coal	9.4 billion tones	175 billion tones
Oil	0.05 billion tones	0.06 billion tones
Natural gas	2 million tones	420 million tones

2.1.2 Nuclear power plants:

Currently, there is no nuclear power plant in Turkey. Turkey is considering starting a nuclear power program with plans to construct three nuclear power plants (NPPs) for a total of 12 nuclear reactor units. In 2010, an agreement was made with the Russian Federation to construct its first nuclear power plant in Mersin province called Akkuyu NPP. Accordingly, in April 2018, the construction of Akkuyu NPP began, but it will not be fully operational until 2023. In the 2000s, Turkey cancelled the planned construction of a power plant of 1400 MWe at Akkuyu Bay (Ulutaş, 2005). A second NPP named Sinop will be constructed in Sinop province. The location for the third one is not decided yet. There is a law No. 5710 regarding the construction and principles for constructing NPP and set prices for selling nuclear energy (Official Gazette, 2007). Turkey has 9,129 tons of total uranium reserves (MENR, 2020).

In 1956, the Pakistan Atomic Energy Commission (PAEC) was institutionalized to endorse the safe use of nuclear energy in the world. Currently there are two nuclear power plants operating in the country, and one power plant is under construction. The first nuclear power plant was operated in 1972 named Karachi Nuclear Power Plant (KANUPP) with a total capacity of 137 MW. It is under the control of PAEC. The Chashma Nuclear Power Plant (CHASNUPP-1) is the second nuclear power plant with a capacity of 325 MW became operational in 2000s. In 2010, the share of nuclear energy in the total energy mix of Pakistan was 2.14%, and generated electricity was 2,667 GWh (Mustafa, 2011). In 2005, with the cooperation of PAEC, an energy security plan (ESP) was made to target the nuclear energy generation of 8,800 MW in 2030. Uranium reserves are found in central and southern part of a country (Akhter et al., 2018).

2.2 Energy Issues in Turkey and Pakistan:

Pakistan is facing an energy crisis where the amount of energy generation is less than the amount of energy required to meet the demands due to a growing economy and population. There is an 18% energy deficiency in Pakistan to fulfill the energy demand (Shaheen et al., 2020). The reasons for this energy-supply gap are weak infrastructure, unstable government, inefficient governmental policies, high levels of capital required to invest in energy-supply resources, and late enactment of energy policies (Aized et al., 2018).

Turkey is also a developing country with a fast-growing population, economy and industrial sector. The main problem is that the major portion of energy is generated from fossil fuels, which Turkey imports from other countries (Russia, Iran and Iraq), except lignite (Gönül et al, 2021). Energy consumption in Turkey and Pakistan is shown in figure 3.1. Another issue for Turkey is energy, both technical and non-technical, losses. In the transmission process, about 15% of energy is lost. There is also a large gap between energy production and consumption. For example, the largest hydropower dams, such as Keban and Atatürk, are in the eastern parts of the country. However, energy demand is very high in the western part of the country (EMRA, 2018). So, energy losses happen. However, there is significant potential in rural areas for solar to reduce these costs. If this potential could be used efficiently, there will be a considerable amount of energy generation. In order to reduce energy losses and create a more decentralized, efficient system Turkey should promote the use of small-scale solar PV.

2.3 Status and Potential of RED in Turkey and Pakistan

Pakistan and Turkey have a great potential of renewable energy that is describing in detail below:

2.3.1 Solar energy:

Solar energy plays the most important role as a renewable source of energy. Solar energy reaches the earth in form of solar radiation (WOC, 2009). Like other countries, Turkey is receiving enormous amounts of solar energy (Table 2.2, Figure 2.3). In the southern part of Turkey, mostly peoples are generating electricity from solar energy and also use it as a source of heating.

According to the REN21 (2018), there are 7.2 hours a day and 2,460 hours a year of solar radiation in Turkey (Table 2.3), which is more than many other Europe countries, but unfortunately, it is not in use until now. Solar energy is 0.7% of overall energy consumed and 5.8% of overall installed capacity (MENR, 2018; TEİAŞ, 2019). Solar energy and its different technologies can be considered an importance source in fulfilling the major part of country's energy requirements (Evrendilek and Ertekin, 2003; Kırtay, 2010; Kılıçkaplan et al., 2017).

There is a highly attractive solar market for international companies in Turkey. The Turkish government agreed to impose a new tax in 2017 to attract domestic producers. The primary motivation was to grant contracts and reward the growth of production capacities in their own country in order to generate tax revenue. As a result, since June 2016, the Turkish Ministry of Economic Affairs has strictly restricted the import of PV modules from other countries. However, an additional anti-dumping rule for module imports from China has been proposed. A corresponding law was passed on April 1, 2017. The cost of modules imported from China would rise by $20-25 as a result of this rule (Official Gazette, 2017). In addition,

Table 2.2 Solar Energy Potential by Regions, Turkey

Source: YEGM, 2018

Regions	**Total Average Solar Energy**	**Max Solar Energy**	**Min Solar Energy**	**Avg. Sunshine Duration**	**Max. Sunshine Duration (June)**	**Min. Sunshine Duration (Dec)**
	(KWh/m²)	**(KWh/m²)**	**(KWh/m²)**	**hour/year**	**hour**	**hour**
South Eastern Anatolia	1460	1980	729	2993	407	126
Mediterranean	1390	1868	476	2956	360	101
Eastern Anatolia	1365	1863	431	2664	371	96
Central Anatolia	1314	1855	412	2628	381	98
Aegean	1304	1723	420	2738	373	165
Marmara	1168	1529	345	2409	351	87
Black Sea	1120	1315	409	1971	273	82

the device usage fees for unlicensed solar power plants (SPPs) tripled on January 1, 2018. Revenues from plants are forecast to decline by 20%. As a result, the government approved solar power generation, primarily in the form of Renewable Energy Resource Areas (YEKA) as well as domestic module makers. According to the Turkey Legislation of RES, there is a reward of $0.13 for each kilowatt electricity produced through solar energy under ideal conditions. Currently, 700 power stations with installed capacity of 17,400 MW are benefitting from YEKDEM (Renewable Energy Resources Supporting Mechanism) (EXIST, 2018). YEKDEM sells electricity to local markets on a contractual or daily basis. TEİAŞ controls market prices and guaranteed prices. The government started to maintain licensing of solar power in order to make it easier for state and local power plants after 2017. Moreover, these tenders resulted in electricity production on a larger scale. An association of Kalyon Energy Group and Hanwa Cells succeeded in winning Turkey's 1-GW solar PV tender in March 2017 with production of $6.99 cents/kwh (MENR, 2017).

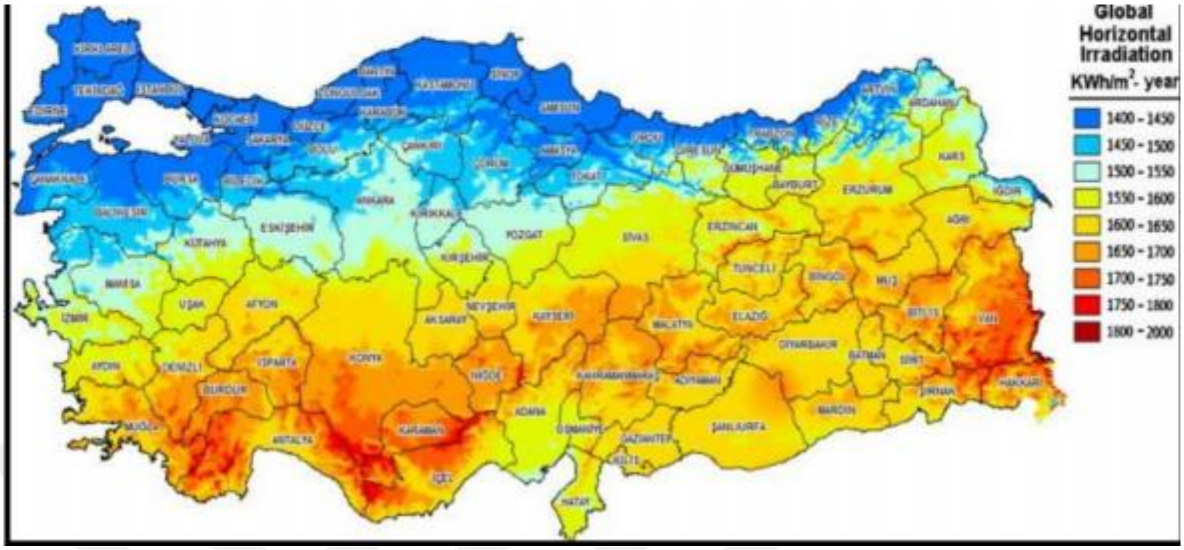

Figure 2.3 Solar Radiation Map of Turkey

Source: YEGM, 2017

The company has an offer of 15-years purchase assurance without any money exchange risk. The system is scheduled to start within 36 months and to have 500 MW of industry solar power operational within 21 months. Unfortunately, it could not be fulfilled due to financial issues, and Hanwa handed over its shares to Kalyon.

"National tariff" applications were continued from December 2015 to December 2020 as the eastern side of Turkey was facing deprivation (technical and non-technical issues). However, unbalancing between pay-back requirements and calculated distributed energy in 21 parts of Turkey will require the tariff continuously; otherwise, electricity tariffs will be more in the eastern part than in the western part (Taşdöven et al., 2012). This is not suitable for the eastern part because its low levels of economic development require lower electricity prices. EMRA managed the tariffs, which cannot be higher than by mutual contracts, if consumers either resident, commercial user and industrialist is suitable and legally registered. In the end, people reimburse the expenses of losses. These expenditures were lowered by acquiring decentralized solar energy.

The Turkish government was also influenced by decentralization movements, and as a result, created a more efficient energy system. Rather than vertical integration, the government has attempted to achieve a more horizontally decentralized integration by planning and legislation. It has succeeded in transferring responsibility from a single large corporation to many smaller ones, fostering privatization and resulting in a more competitive market structure.

Table 2.3 Solar Energy Potential by Months in Turkey

Source: YEGM, 2017

Months	Solar Energy Potential (Kcal/cm²-month)	Solar Energy Potential (KWh/m² -month)	Average Sunshine Duration (Hour/Month)
Jan	4.45	51.75	103
Feb	5.44	63.27	115
Mar	8.31	96.65	165
Apr	10.51	122.23	197
May	13.23	153.86	273
Jun	14.51	168.75	325
July	15.08	175.38	365
Aug	13.62	158.4	343
Sept	10.6	123.28	280
Oct	7.73	89.9	214
Nov	5.23	60.82	157
Dec	4.03	46.87	103
Total	**112.74**	**1311.16**	**2640**
Average	**30 Kcal cm²-day**	**3.6KWh\ m²-day**	**7.2 hour/day**

Prosumerism, a hybrid of producer and consumer, is a new trend that allows small-scale production and consumption at the same time. Prosumers may produce their own energy, use it in their homes, and sell the excess to the grid. This device is ideal for solar PV applications and has become increasingly popular in recent years. Policies are being tweaked to make the systems go more smoothly (Tükenmez and Demireli, 2012). As a result, self-consumption is increasingly driving solar PV installations, which are often accompanied by a feed-in tariff (FITs) for the excess electricity produced. Solar PV plants alone accounted for 93.57 percent of overall excess generation revenue, according to Table 2.5. The Turkish government will help by supporting and enacting the required legislation to hasten the implementation of this definition. Turkey also offers tailored FITs for and renewable energy market, as well as additional benefits for equipment manufactured domestically. To increase the viability of sustainable projects, the base FIT and the domestic equipment portion can be combined. Turkey has already stated its intention to raise renewable energy's contribution to primary energy supply from 10% to 30% by 2023 (Erdin et al., 2019). The establishment of small-scale solar PV systems is comparatively easier and economical than other RES plants. There are thousands of buildings in giant cities, and most of its solar potential is unutilized.

Like Turkey, Pakistan has enormous solar energy potential (Figure 2.4, Table 2.5), with 7.5 hours a day and 2,750 hours a year of solar radiation (Table 2.4). The annual mean daily solar isolation in Pakistan is 5.7 kW h/m^2. However, the minimal annual daily solar radiation is 4.3 kW h/m^2, which is higher than the global annual mean daily of 3.6 kW h/m^2. Solar shows the greatest potential among RES in Pakistan. In 2010, solar was introduced through the first solar power plant of 178.08 kW, which was installed in the Pakistan Engineering Council (PEC) building and Planning Commission building. This solar power plant is on grid after being inaugurated in 2012. This power plant also has a facility of net metering that means it can sell extra electricity to the distribution companies (DISCOs). Similarly, the second solar power plant of 2 MW was commissioned on the National Assembly building that also transfer power to the national gird instead of fulfilling its own needs. After this achievement, the National Assembly became the world’s first parliament building with installed solar capacity. The FIT of these two projects were set by NEPRA, an electricity price-setting company of Pakistan. After the success of these projects, many energy investors started taking interest in solar plants. As a result, 28 solar power companies proposed projects of 956.52 MW and obtained Letter of Intent (LoI) from AEDB. In 2015-16, Quaid-e-Azam Solar Park (QASP) was established with 100 MW of capacity and generates 25 GWh of electricity. The other three solar projects with a capacity of 100 MW each are under construction in QASP (PES, 2016).

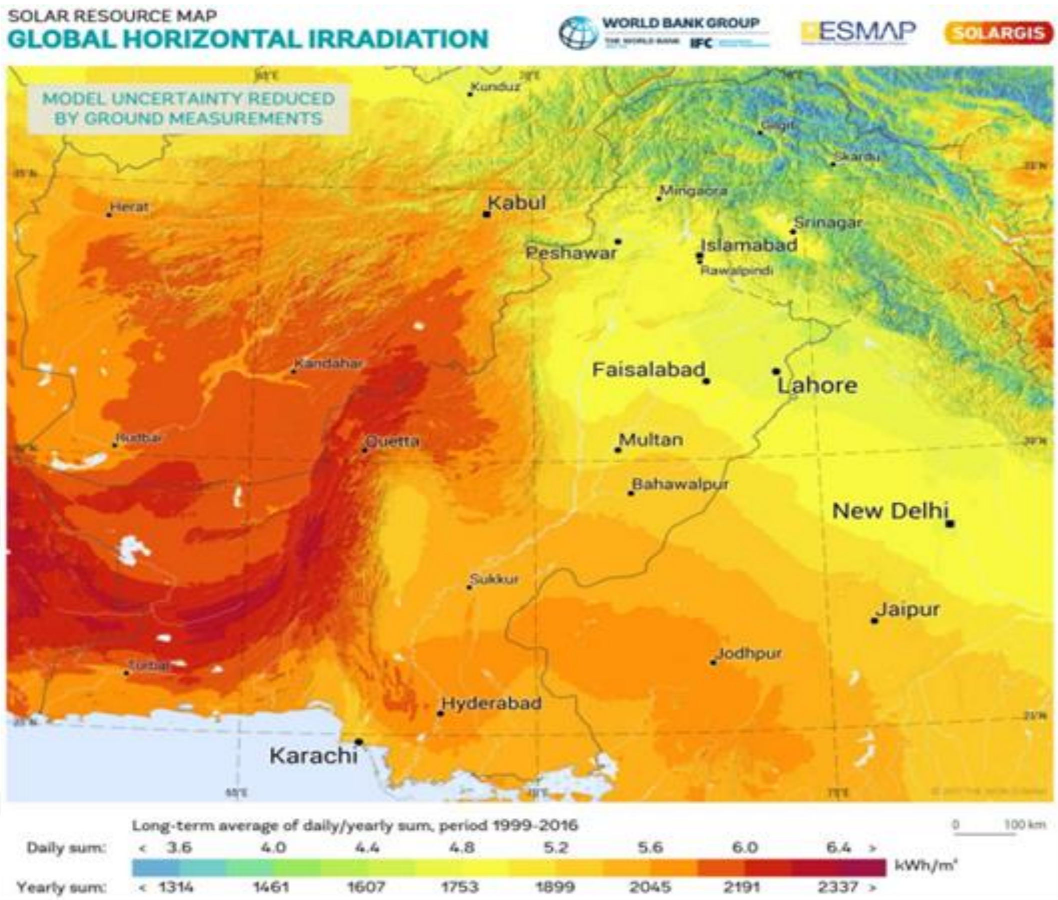

Figure 2.4 Solar Potential Map of Pakistan

Source: World Bank, 2017

Currently, AEDB is managing 22 solar power projects of 890.80 MW. Six power projects are operational, four of these power plants have received letters of support (LOS) from AEDB and are near to obtaining financial closing of their projects. Twelve projects have been obtained LOI from AEDB and are in developmental stages. According to the decision of Cabinet Committee of Economy, the last 12 projects that have LOI will also take part in a competitive bidding that AEDB will announce soon (AEDB, 2021a).

Table 2.4 Solar Energy Potential by Months, Pakistan

Source: AEDB, 2018; World Bank, 2017

	Solar Energy Potential		**Average Sunshine Duration**
Months	**(KWh/m²- month)**	**(Kcal/cm²-month)**	**(Hour/Month)**
January	128.7	11.07	115
February	157	13.50	140
March	188.7	16.23	160
April	210.3	18.09	180
May	219.3	18.86	250
June	206.4	17.75	320
July	176.7	15.20	380
August	177.3	15.25	320
September	184.8	15.90	250
October	169.2	14.55	200
November	141.3	12.15	170
December	120.9	10.40	125
Total	**2080.6**	**179.19**	**2750**
Average	**5.7KWh/m²-day**	**49Kcalcm²-day**	**7.5 hours/day**

In order to encourage the use of solar technologies in a country, government reduce or eliminate the tax for import of different solar products. Therefore, imports of solar products are rising every year. In 2013, 14,981 solar water heaters were imported and distributed in Pakistan. Similarly, 1,429 solar water pumping systems were imported and deployed for agricultural irrigation and for drinking (PES, 2013). After 2013, many local manufacturing companies began introducing solar water heaters and solar pumping systems. There is high demand for solar water heaters in northern areas of Pakistan due to the lack of access to natural gas and freezing temperatures. More than 5,000 solar cookers are used in Pakistan. Such solar cookers work on sunny days from 9:00 a.m. to 3 p.m. during the whole year. The

PCRET of Pakistan is conducting online training sessions to teach about the maintenance and use of RE devices (AEDB, 2021b). The amount of excess solar energy sold to the gird in Pakistan and Turkey is shown in Table 2.6.

Table 2.5 Solar Energy Potential by Regions in Pakistan

Source: World Bank, 2017

Provinces	**Total Average Solar Energy**	**Max. Solar Energy**	**Min. Solar Energy**	**Avg. Sunshine Duration**	**Max. Sunshine Duration (June)**	**Min. Sunshine Duration (Dec)**
	KWh/m^2	KWh/m^2	KWh/m^2	hour/year	hour	hour
Punjab	1956	2087	1898	3220	420	270
Sindh	2106	2200	2040	3285	470	240
Baluchistan	2208	2303	2120	3500	430	367
KPK	1825	1883	1766	3000	390	354
ICT	1755	1850	1704	2600	379	312

Table 2.6 Excess Energy Sold to the Grid, Turkey and Pakistan, 2019

Source: EMRA, 2020: NEPRA, 2020

Solar PV	**Turkey**	**Pakistan**
The amount of solar energy given to the system as surplus (MWh)	9,425,965.29	**1,587,925.2**

2.3.2 Wind energy:

In 1986, the first wind power plant in Turkey of 55-KW was built in Çeşme AltınYunus, which generates nearly 100,000 kWh per year depending on the area's conditions (Özdamar, 2000). In 1998, the first wind farm was built in Germiyan, Çeşme. Turkey has a normal wind potential, according to REPA (The Atlas of Wind Energy Potential) (Figure 2.5). Wind-powered plants (WPPs) are mostly concentrated in western Turkey because it has the most potential. According to the Turkish Wind Energy Statistics

Report (2018), WPPs in operation by region are the following: Aegean 39.06%, Marmara 33.74%, Mediterranean 13.38%, Central Anatolia 8.56%, Black Sea 3.91%, and Southeastern Anatolia 1.35%. Offshore wind potential is relatively lower than onshore potential.

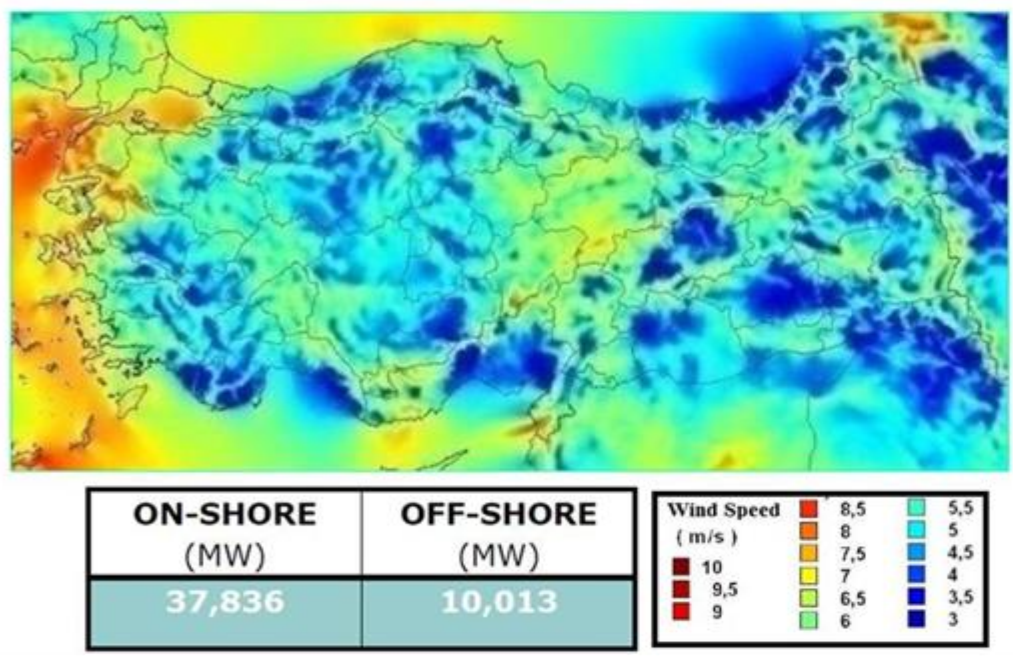

Figure 2.5 Wind Potential Map of Turkey
Source: Çalışkan, 2010; YEGM, 2016

The average wind potential of Turkey is from 7.0 m/s to 8.0 m/s. Turkey's wind energy capacity is 47,849 MW (29,259 MW of good potential, 12,994 MW of excellent potential, 5,400 MW of outstanding potential, and 196 MW of superb potential).

There is a lot of wind potential, however, that has not yet been achieved. There are currently 164 wind power plants in service, with another 26 under construction (Çalışkan, 2010). As of 2020, Turkey's total installed capacity was 8,832 MW (Table 2.7). It can be said that Turkey has pursued a successful wind energy strategy. It has increased its wind energy capacity in line with the RE targets of state and still has potential to exploit. In 10 years, it could increase its wind generation from 146.3 MW to 6,872.15 MW, a 47-fold increase (TÜREB, 2018).

Table 2.7 Yearly Installed Wind Capacities, Turkey

Source: TÜREB, 2020; IRENA, 2019a

Year	Total Installed Capacity (MW)	Capacity Addition (MW)	Increase rate (%)
2007	146.30	217.40	148.0%
2008	363.70	427.90	148.6%
2009	791.60	537.55	117.7%
2010	1329.15	476.70	67.9%
2011	1805.85	506.30	35.9%
2012	2312.15	646.30	28.0%
2013	2958.45	803.65	28.0%
2014	3762.10	956.20	27.2%
2015	4718.30	1387.75	25.4%
2016	6106.05	766.05	29.4%
2017	6872.10	558.78	12.5%
2018	7005	133	18%
2019	7591	586	77%
2020	8832	1241	14%

Since the 2000s, the number of wind power plants being constructed has grown. However, since 2015, this momentum has stalled due to bureaucratic barriers and licensing issues. Figure 2.6 depicts the evolution of power plant construction over time. Wind power plant construction increased from January 2012 to July 2015 (green arrows), but, due to government decisions, slowed after 2015 (red arrows). Some construction was completed in 2019 and 2020, but the trend has slowed.

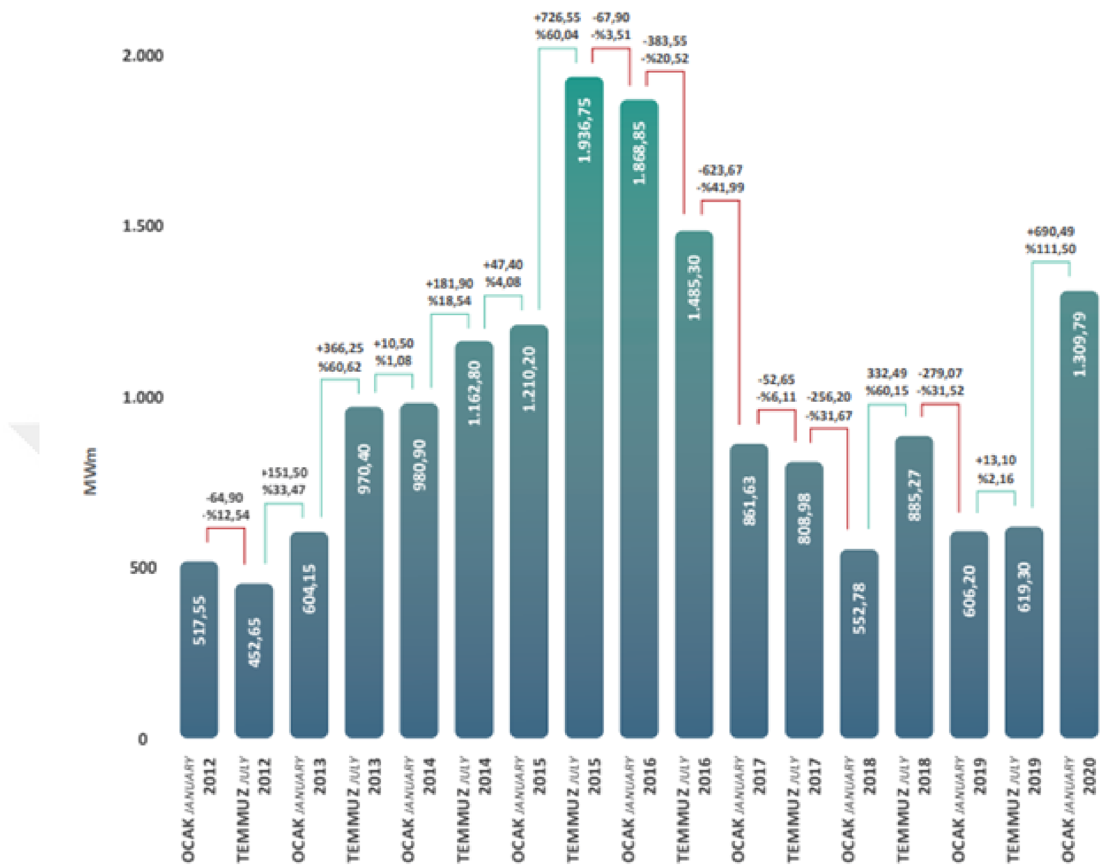

Figure 2.6 Wind Power Plants in Turkey

SOURCE: TÜREB, 2020

For manufacturers, licensing procedures are an issue. The government introduced a large-scale licensing scheme called YEKA and, in 2017, the Ministry of Energy and Natural Resources issued its first wind energy tender. The Siemens, Türkerler, and Kalyon consortium won the 1,000-MW tender with a price of $3.48 cents per kWh (DW, 2017). For a 10-year term, the consortium agreed to conduct R&D activities in various areas of wind energy, including turbine manufacturing, plant software, and technical research. Wind power plants would cost more than $1 billion to construct, would serve 1.1 million households and reduce carbon emissions by 1.5 million tons per year (DW, 2017). The second tender for 1,000 MW of wind power was declared in

2019, with four separate areas – Balıkesir, Çanakkale, Aydın, and Muğla – each with a capacity of 250 MW (BloombergHT, 2018).

Wind energy has an enormous potential in Pakistan (Figure 2.7). In 2013, the country installed its first wind power plant of 50 MW through the efforts of Fauji Fertilizer Company Energy Limited (FFC) (Ghafoor et al, 2016). Wind is abundant in Baluchistan and in the Sindh coastal areas, as shown in Figure 2.7.

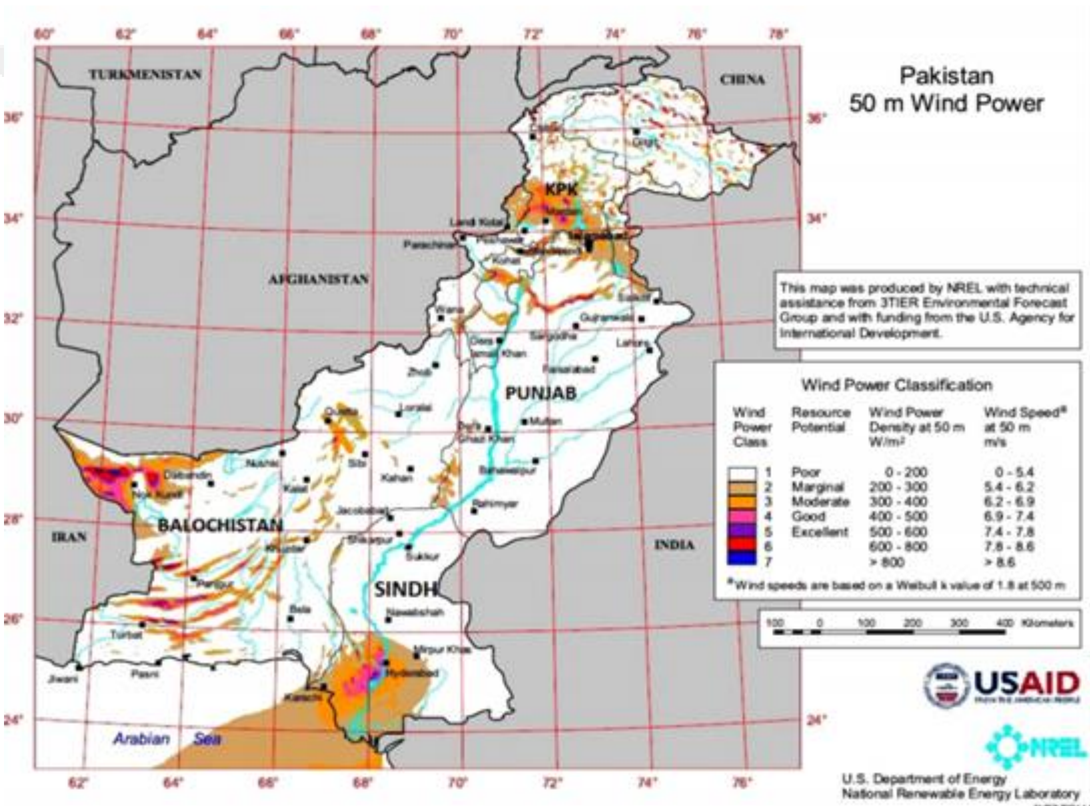

Figure 2.7 Wind Potential Map of Pakistan

Source: AEDB, 2019

It is found that Pakistan has a wind speed of 4-9 meters/second (m/s) at an anemometer height of 10 meters and 12.5 m/s at 50 meters (Ghafoor et al, 2016; Sheikh, 2010). The cumulative wind energy potential in Pakistan is 346 GW, but only 12 GW is feasible in Pakistan (Farooqui, 2014; Baloch et al., 2019). Higher wind energy potential lies in three provinces: KPK, Baluchistan and Sindh. The total capacity production in Baluchistan province is 146,145 MW, in KPK it is 58,545 MW, and in Sindh province it is 88,460 MW (Shami et al., 2016). The installed capacity of wind in 2018 was 1,048 MW, which was just 2.9% of the total electricity generation capacity. In 2020, the capacity reached up to 1,236 MW (Table 2.8). Currently, 24 wind power plants of 1,235.20 MW are operational under AEDB. This board is a one-window facilitator for RE projects except hydropower. The yearly installed capacities of wind energy are shown in Table 2.8. Twelve wind projects for a total 610 MW, 50 MW of each, are under construction and four projects are in the initial stages of development with cumulative capacity of 165 MW, as shown in Figure 2.8. The Majority of wind projects are located in the Gharo-Keti Bandur Wind Corridor in Sindh province in an area of about 60 Km x 170 Km (Ahmed et al., 2006). Compared to Turkey, Pakistan is lagging behind in the growth of its wind energy projects.

Table 2.8 Yearly Installed Wind Capacities of Pakistan
Source: IRENA, 2021

Year	**Total Installed Capacity (MW)**	**Capacity Addition (MW)**	**Increase Rate (%)**
2011	0	0	0
2012	106	106	100
2013	106	0	0
2014	206	100	48
2015	308	102	10
2016	591	283	47
2017	655	64	22
2018	1186	531	82
2019	1236	50	9
2020	1236	0	0

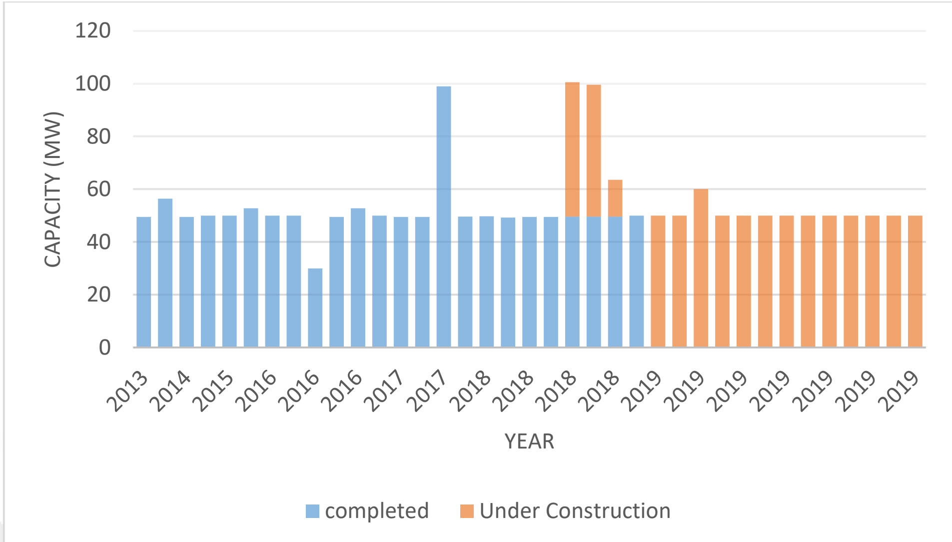

Figure 2.8 Development of Wind Projects in Pakistan
Source: AEDB, 2019

2.3.3 Hydro energy:

People have been utilizing hydropower for a long time, mostly for agricultural or irrigation purposes. The first hydropower station was built in 1902, and it quickly became a major domestic energy source for Turkey.

Table 2.9 Electricity Generation (MWH) by sources under YEKDEM

Source: EMRA, 2020

Type	2013	2014	2015	2016	2017	2018	2019
Solar	-	-	-	-	24.268	39.140	159.961
Unlicensed	-	-	222.724	1.134.024	3.031.558	8.212.478	9.829.448
Hydraulic	528.646	1.072.832	5.683.331	25.520.255	24.417.133	27.338.752	36.987.680
Wind	234.000	2.378.819	8.275.992	14.163.403	16.765.418	19.002.863	19.900.973
Geothermal	857.527	1.436.579	2.710.856	3.706.764	4.503.345	5.968.202	6.997.209
Biomass	750.715	925.516	1.050.796	1.306.057	1.789.053	2.047.082	2.817.209
Total	**2.370.888**	**5.813.746**	**17.943.699**	**45.830.503**	**50.530.776**	**62.608.517**	**76.692.480**

Hydro schemes started by the Ministry of Public Works in the 1930s. The Electrical Power Resources Planning and Survey Administration (EIE) was founded in 1935 to evaluate Turkey's energy demand and improve hydropower and other source potential (Erdoğdu, 2011). In 1954, the State Hydraulics Works (DSI) was created. The main goal of DSI was to increase water use by building and operating hydropower plants and dams. Until 2004, DSI and the public sector had constructed 537 dams and 133 hydropower plants (Ozturk, 2009). There are currently 645 hydropower stations (524 river type, 118 hydro dam) (TEIAS, 2019). Turkey's hydropower ability is projected to be about 45,000 MW and 140 TWh/year, accounting for 1% of global capacity and 14% of European capacity (Erdoğdu, 2011). Along with coal and natural gas, hydropower is one of Turkey's main energy sources.

Until the 1980s, coal and hydropower were commonly used to generate electricity (Greenpeace, 2015). As natural gas became widely available in the 1990s, the share of both sources began to decline in the following years (Erdoğdu, 2011). In 2005, Small Hydropower (SHP) was identified as a hydropower plant with a reservoir area of less than 15 square kilometers. Table 2.9 reveals the electricity generation (MWh) by sources under the YEKDEM scheme. This term permits the establishment of a plant by the private sector, which could then be supported with the FIT mechanism. The government began privatizing small-scale hydropower plants in 2010 (Greenpeace, 2015). Following the enactment of RES regulations and other changes, hydropower projects gained considerable traction. Owners of HPPs benefited from the FIT mechanism, which paid $7.3 cents per kilowatt hour plus extra premiums if they used domestic goods (Table 2.3). Within ten years, the installed capacity had nearly doubled (IRENA, 2019a). There were 642 hydro power plants in operation as of January 2019 (TEİAŞ, 2019). Of all RES, hydropower generates the most electricity (Table 2.9).

In recent years, hydropower energy demand has fluctuated (Table 2.10). Hydropower was eventually replaced by other RES such as wind and solar. Despite short-term volatility, hydropower generation is on the rise in the long run. By 2023, the government aims to have a cumulative installed capacity of 32,000 MW. DSI aims to hit 127.8 TWh by 2030 (Ozturk et al., 2009), and Greenpeace (2015) estimates that hydropower electricity production will rise by 30% by 2050.

Table 2.10 Hydro energy Consumption in Turkey & Pakistan
Source: BP, 2020

Year	**Turkey**		**Pakistan**	
	Consumtion (mtoe)	Change (%)	Consumption (mtoe)	Change (%)
2009	8.1	11	6.4	4.8
2010	11.7	16	6.6	4.9
2011	11.8	16.83	6.9	5.20
2012	13.1	17.90	2.3	1.73
2013	13.4	18	10.98	8.28
2014	9.2	12.57	7.16	5.40
2015	15.2	20.7	7.16	5.40
2016	15.2	20.7	7.40	5.58
2017	13.2	18.03	6.68	5.03
2018	12.89	17.6	6.20	4.67
2019	18.86	25.7	7.64	5.76
Total	142.65		75.42	

Pakistan is one of the few countries with significant hydropower capacity. The country's geographic structure, natural water flow systems, and irrigation systems all reveal hydropower capacity that can be harnessed to meet the country's growing energy needs. Aside from large hydro, the generation of small-mini-micro hydropower has real prospects. Small hydropower is regarded as one of the most profitable choices for electricity generation. The provincial government has overseen this sector for the most part. In Pakistan, first hydropower plant was installed in 1925 that was a canal project of 1.1 MW in the Renala region. Big dams such as Mangla and Terbela were built in 1967 and 1976 with installed capacities of 1,500 MW and 3,478 MW. In 1980, hydro-electricity provided 70% of electricity to the gird, but fell to 31% in 2014-15 due to water-deficient conditions and the dominance of other energy sources. The share of different energy sources in electricity generation is shown in Figure 2.9, which reveals that hydroelectricity has the second highest share in electricity generation. The hydropower energy potential in Pakistan is 60 GW. The cumulative potential of different natural falls and run of river sites at 815 locations in a country is 3,100 MW. These are micro hydro plants (Kamran, 2018). Several other hydropower projects are still under development. These projects are regulated by WAPDA.

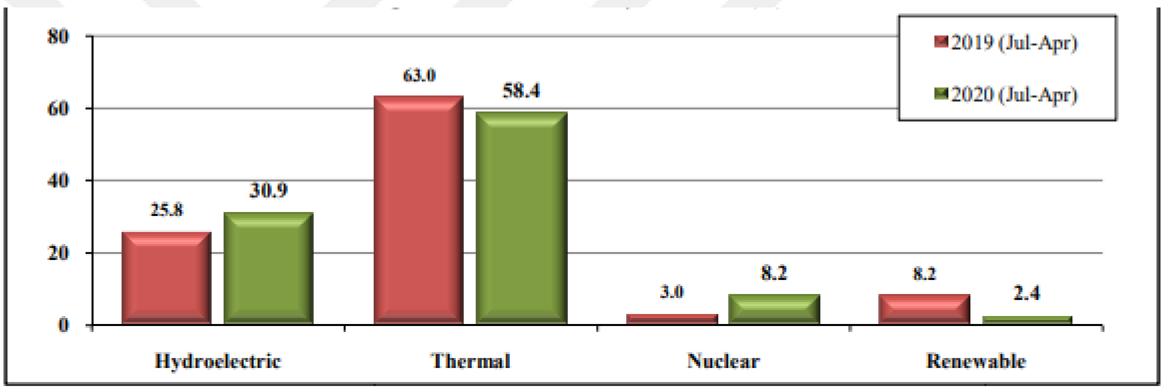

Fig: 2.9 Electricity Generation by Sources (Percent) in Pakistan
Source: PES, 2020

Currently, 128 MW of small hydro plants are operational in a country. Under the ADB, seven SHP projects with a total capacity of 76 MW are being built in KPK (03) and Punjab (04). There are programs funded by the provincial government. Additionally, the Pakhtunkhwa Energy Development Organization has listed nine SHP sites with capacities ranging from 11 to 36 MW for private sector development. The potential of SHPs in the country is shown in a Table 2.11.

Table 2.11 Distribution of Small Hydro Potential in Pakistan
Source: AEDB, 2019

Area	No. of Potential Sites	Potential Range (MW)	Total Potential (MW)	Remarks
KPK	125	0.2- 32	750	Small sites based on natural falls and flow
Punjab	300	0.2- 40	560	Canals
Sindh	150	5-40	120	Canals
Gilgit Baltistan	200	0.1-38	1300	Natural Falls
Azad-Jammu& Kashmir	40	0.2-40	280	Natural Falls

2.3.4 Geothermal and biomass energy:

Geothermal and biomass energy have been widely used mainly for heating. Melikoğlu et al. (2017) estimated that Turkey has a geothermal potential between 31 GW and 38 GW. Toklu (2017) estimated Turkey's biomass potential at roughly 33 Mtoe. Geothermal exploration began in the 1960s in İzmir (Serpen et al, 2018). Geothermal was mainly used for heating for the next fifty years. After the 2000s, this shifted from heating to electricity. Geothermal power plants sell electricity at a starting price of $10.5 cents/kwh. Electricity generation has increased accordingly from 2001 to 2019 (Figure. 2.10). In 2010, the 2023 energy targets aimed to have 600 MW of installed capacity of geothermal (MEU, 2010). In 2014, it was targeted to reach 1,300 MW installed capacity (MENR, 2015). Today, the installed capacity of geothermal is 1,302.5 MW (TEİAŞ, 2019). Governmental policies have accelerated the process, and Turkey ranks fourth after the US, the Philippines, and Indonesia in terms of total geothermal power capacity, and second after Indonesia in terms of geothermal power capacity addition since 2016 (REN21, 2018).

Geothermal resources were protected by declaring them state-owned under the Geothermal Law in 2007 (Şimşek and Şimşek, 2013). The validation of licenses for geothermal activities was limited to three years. A 30-year license is needed for operational activities and in the geothermal sector, this license can be extended by 10 years, and these licenses are delegable.

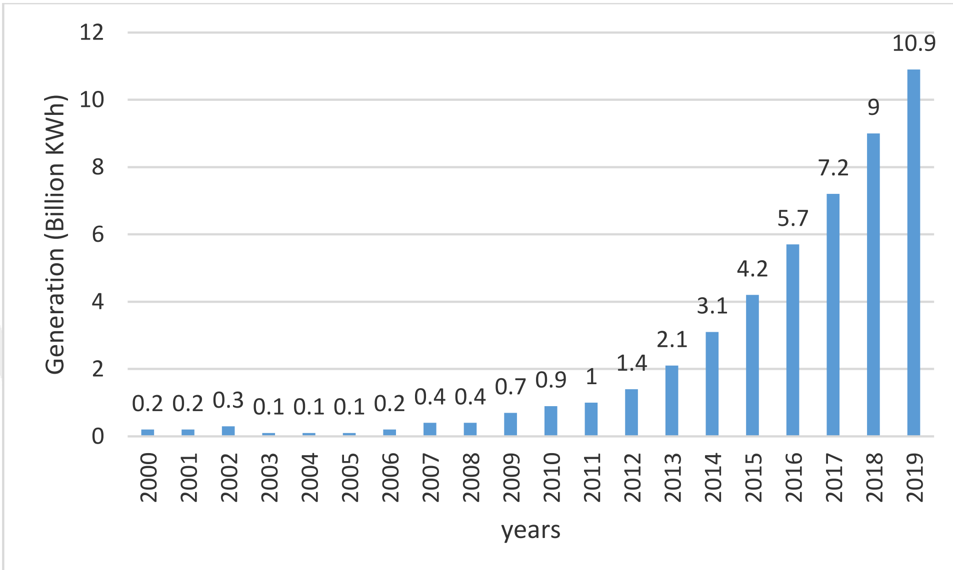

Figure: 2.10 Electricity Generation from Biomass and Geothermal in Turkey
Source: BP, 2020

Turkey's biomass potential is very suitable for the electricity generation because of the prevalence of agricultural and forest areas (Balat, 2008). Özgür (2008) estimated that Turkey has 465 TWh of technical potential with a 290 TWh/year available potential. Additionally, Toklu (2017) indicates that Turkey's annual total biomass potential is 168.7 TWh (19 GW). However, the potential has not been utilized properly. The share of biomass in total energy supply was only 1.72% in 2017 (MENR, 2018). In order to stimulate the biomass sector, proper regulations and efficient biomass technologies and governmental support are needed (Erdil and Erbıyık, 2015; Toklu, 2017).

Pakistan is an agricultural country with a huge potential for biomass energy. The biomass in Pakistan includes sugarcane waste, wheat straw waste, poultry litter, bagasse of sorghum stalks, animal dung and wood (Table 2.12) (Asif, 2009).

Table: 2.12 Biomass Potential in Pakistan
Source: Asif, 2019

Crop type	Type of residues	Annually residues potential (tones)	Annually residues energy Potential (GWh/year)
Cotton	Cotton stalk	6013	25054
Wheat	Wheat straw	6488	25952
Sugarcane	Sugarcane trash	3516	12306
Rice	Rice straw	8314	28868
Maize	Maize stalk	799	2885

According to the World Bank's Energy Sector Management Assistant Program (ESMAP), which mapped Pakistan's biomass resources (Figure, 2.11) there is potential for 58 GW (508.08 TWh) from annual crop residues (World Bank, 2020).

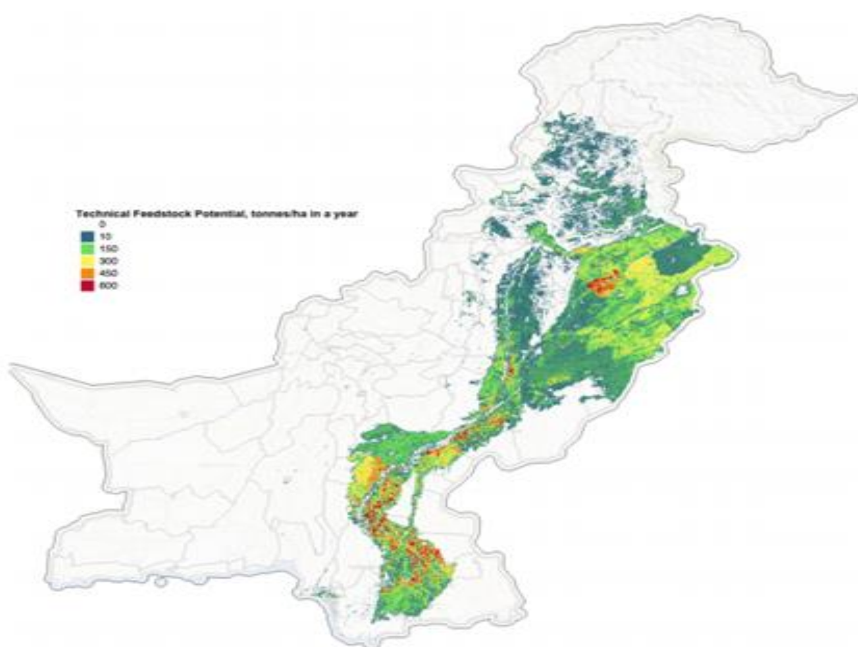

Figure: 2.11 Biomass Potential map of Pakistan

Source: AEDB, 2019

Currently 83 sugar mills are generating 3,000 MW of electricity. According to AEDB, eight bioenergy power plants with a total capacity of 260 MW are operational and 25 projects of 879 MW of capacity are in developmental stages. Similarly, from animal dung and crop residues, 27.2 million m^3 of biogas can be produced to generate 1,900 MW electricity on a daily basis (Kamran, 2018). PCRET, PCAT, AEDB, and Pakistan council of Renewable Energy Society (PRES) are working to develop new biomass technologies and installing biogas power plants to utilize the country's potential. The annual electricity generation from biomass source is given in a Figure 2.12.

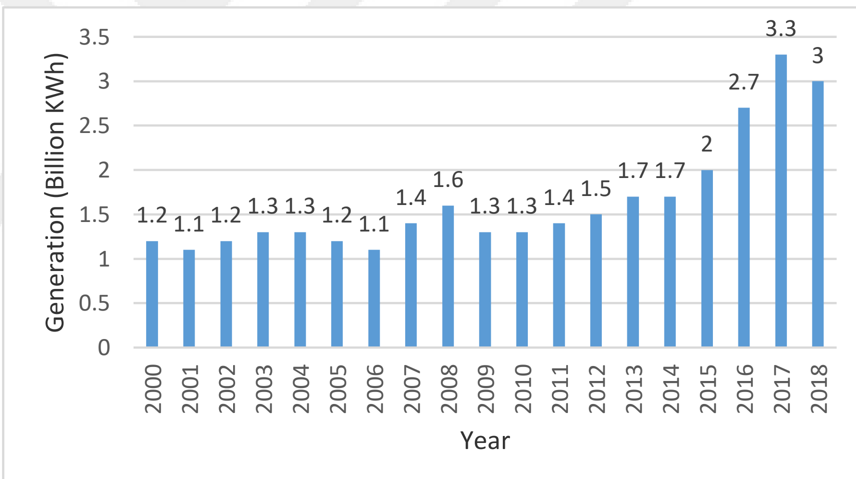

Figure 2.12 Electricity Generation from Biomass in Pakistan

Source: B.P, 2020

In 1976, for the very first time, PCAT installed 21 fixed dome-shaped biomass plants copied from a Chinese design. After it, researchers employed the Indian style biogas systems to make some changes in the original design that are movable-type power plants. Prior to 2002, different biomass projects had been initiated across the country, which installed 4,500 biogas plants. In 2002, a project named PC-1 was initiated to install 1,200 biogas plants in a country. This project was completed in 2006 with 400 plants instead of targeted 1,200. Currently, 5,357 biogas plants are working by the efforts of PCRET (Uddin, 2016). Many private organizations are doing business with biogas plants, and people are also individually starting these businesses at a local level.

The RE sector of Pakistan can also leverage its geothermal resource potential. Geothermal energy resources in Pakistan are present in mud volcanoes, hot springs, and geysers (Zaigham et al., 2009). Areas that have abundant geothermal energy resources are Karachi, Hyderabad, Northern areas, and Chagai. Geothermal energy is a climate friendly energy resource that generates electricity with very low carbon emissions as compared to fossil fuels. Geothermal is a new field to develop in Pakistan, but by introducing different techniques for maximizing its potential, different communities can adopt it and use the power for various purposes, such as space heating, greenhouse heating, dying, industrial space heating, food drying, laundering, and aquacultural ponds (Gondal et al.,2017). The comparison of hydro, wind, solar, bio and geothermal installed capacities is shown in table 2.13. It is noted that Turkey has more installed capacities as compared to Pakistan. The RE installed capacities in Turkey is increasing by year and hydro energy has the maximum share in total installed capacity. However, the potential of RE is higher in Pakistan as compared to Turkey (Fig 2.13).

Table: 2.13 RE Installed Capacities in Turkey & Pakistan
Source: IRENA, 2021

	Turkey		**Pakistan**	
Year	Capacities (MW)	Change (%)	Capacities (MW)	Change (%)
2011	Hydro=17,137 Wind=1,729 Solar=7 Bio=99 Geothermal=114 Total=19,086	8	Hydro=6,737 Solar=19 Bioenergy=262 Total=7,018	5
2012	Hydro=19,609 Wind=2,261 Solar= 12 Bio=142 Geothermal= 162 Total=22,186	13	Hydro=6,777 Wind=106 Solar=46 Bio=262 Total=7,191	2

2013	Hydro=22,289 Wind=2760 Solar=19 Bioenergy=172 Geothermal= 311 Total= 25,551	15	Hydro=7,088 Wind=106 Solar=101 Bio=268 Total=7,563	4
2014	Hydro=23643 Wind=3630 Solar=41 Bio=221 Geothermal=405 Total= 27,940	9	Hydro=7,218 Wind=206 Solar=165 Bio=324 Total=7,913	4
2015	Hydro=25886 Wind=4503 Geothermal=624 Bio= 271 Solar= 250 Total= 31534	11	Hydro=7,218 Wind=308 Solar=266 Bio=333 Total=8,125	2
2016	Hydro=26681 Wind=5751 Solar=834 Geothermal=821 Bio=359 Total= 34,446	8	Hydro=7,248 Wind=591 Solar=589 Bio=374 Total=8,802	7
2017	Hydro=27273 Wind=6516 Solar=3422 Bioenergy=472 Geothermal=1064 Total= 38,747	11	Hydro=7,400 Solar=789 Wind=655 Bio=374 Total=9,218	4
2018	Hydro=28291 Wind=7005 Solar= 5064 Bioenergy=587 Geothermal=1283 Total=40,947	5	Hydro=9,900 Wind=1,186 Solar=679 Bio=432 Total=12,197	15
2019	Hydro=28503 Wind=7591 Solar=5996 Bio=983 Geothermal=1515 Total= 44,588	8	Hydro=9900 Wind=1,236 Solar=713 Bio=432 Total=12,281	1

2020	Hydro=30984 Wind=8832 Solar=6668 Bio=1300 Geothermal=1613 Total= 49,397	10	Hydro=10,002 Wind=1,236 Solar=737 Bio=432 Total=12,407	1

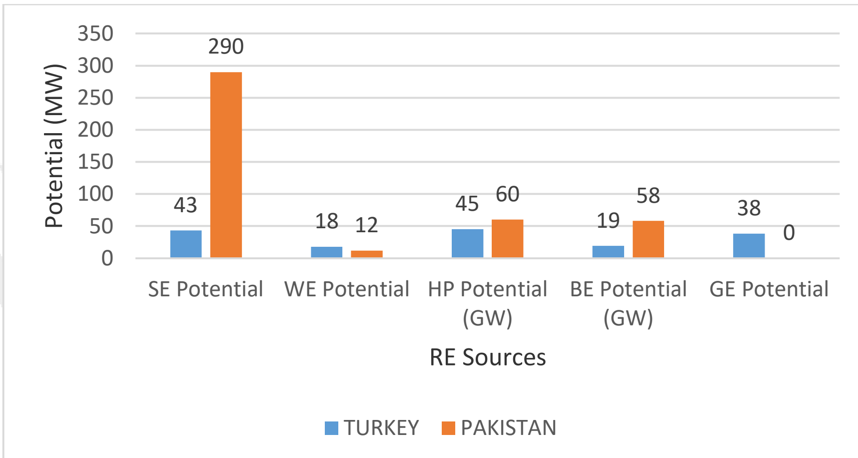

Figure 2.13 RE Potential in Turkey & Pakistan
Source: Kilic 2016; Gokcol and Dursun, 2012; Umar and Hussain 2015; Kamran 2018

2.4 Development and Privatization of the Power Sector in Turkey& Pakistan

Electricity was introduced in Turkey towards the end of the Ottoman era. The 2-KW water-mill hydro plant in Mersin generated the first electricity in Turkey, then it quickly became something everyone wanted and spread throughout the country (Yılmaz, 2012). The generation and supply of electricity was the job of the local government until the Turkish Electricity Institution (TEK) was created in the 1970s and assumed responsibility for electricity (Küfeoğlu et al, 2019). Then, in 1984, to meet rising demand and address the growing energy dilemmas facing the country, the government created more institutions for the management. At the time electricity was mainly controlled by the government because Turkey was not financially stable enough to be able to rely on the private sector, but the government began to slowly privatize the sector copying global fashion. Toward 1993, TEK split into the Turkish Generation and Transmission Corporation (TEAŞ) and the Turkish Electricity Distribution Corporation (TEDAŞ). In 2001, system went into further division by becoming the Electricity

Generation Company (EÜAŞ), the Turkish Electricity Trade and Contracting Corporation (TETAŞ), also the Turkish Electricity Transmission Company (TEİAŞ).

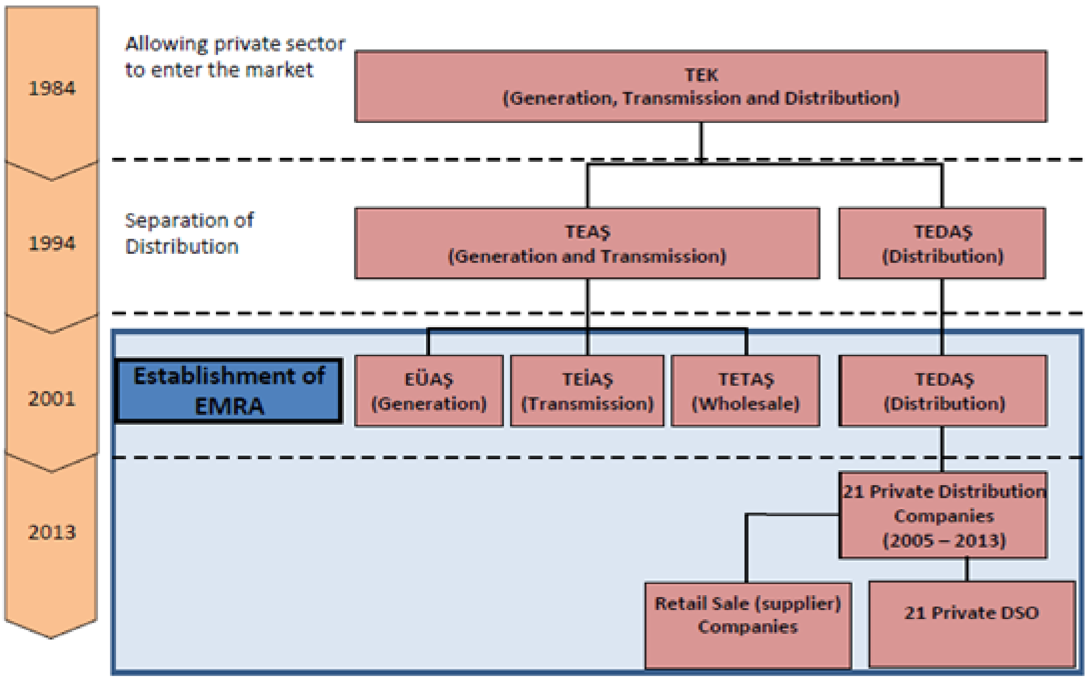

Figure 2.14 Development of Power Sector in Turkey

At the moment, generation of electricity/power is monitored by EÜAŞ, while TEAŞ controls the transmission of electricity and TETAŞ is responsible for the trade of wholesale electric power (Taşdöven et al, 2012). In 2001, another organization came into existence: EMRA or the Energy Market Regulatory Authority (Küfeoğlu et al, 2019), which privatized the electricity sector so everyone can invest and generate electricity.

Due to the increasing need of constant monitoring, the organization TEDAŞ was split up into twenty-one different companies in 2012, which were responsible for distribution at local level (TEDAŞ, 2019).

To encourage the trade of electricity, the Energy Exchange Istanbul EXIST was created in 2015. Its main aims are operating the day-ahead and intraday markets, monitoring financial transactions in the market, providing support to balance market efficiency, and organizing new potential energy markets (Yilmaz, 2012). The Ministry of Energy and Natural Resources (MENR), however, manages the entire energy structure. EMRA's occupation was to monitor the electricity/power market, since the trade of energy is critical to the Turkish economy. This development made it easier for the people who use electricity to communicate while carrying out their routine activities. (EXIST, 2019). Trading of energy is done through various calculated tools, such as electricity generators and making it possible for consumers to sign long-term agreements with conditions. EMRA issued a 49-year license to EXIST and also approves the regulations, licenses and tariffs introduced by EXIST.

EXIST has attracted foreign investors, and price changes and unreliability are less common. This has resulted in advantages for the Turkish economy through the export of energy through exchange market. Along with this, some derivatives are also monitored by EXIST. It also operates natural gas, oil and renewables market having generators, investors and consumers. The Capital Markey Board of Turkey (SPK) and EMRA manage the financial matters of energy market. They are also the supervisory committee for EXIST.

In Pakistan, KESC (Karachi Electric Supply Company Limited) was formed to supply electricity to the city of Karachi and its adjoining cities in 1913. However, at that time, Pakistan was not an independent state and was a part of British India. In 1947, when Pakistan became independent, Karachi became part of Pakistan, and KESC was the only electric system operating in Pakistan. Therefore, in 1959, Water and Power Development Authority (WAPDA) was formed to manage and authorize the increasing demand of energy (Nawaz et al., 2013). WAPDA did many useful acts to improve the power system but, in the 1980s, the country started facing blackouts and load shortages. There were many reasons for electricity shortfalls, including weak infrastructure, which was responsible for electricity losses and weak governance. At that time, the power sector was completely under state control. It was suggested to privatize the power sector to ensure a continuous supply of electricity and expansion of transmission lines efficiently (Malik, 2010). As a result, in 1985, the first private power policy was launched. This policy aimed to increase private sector investment in electricity generation.

In 1986, the private investment model Build-Operate-Own (BOT) was formed to encourage private investors but still it failed to capture the attention of investors due to a lack of enough incentives (Ullah, 2013). Since then, no remarkable private sector investment has occurred in the power sector, which has been managed by WAPDA and KESC, governmental bodies. Later on, various amendments were made after the efforts and suggestions of the Asian Development Bank (ADB), International Monetary Fund (IMF), and World Bank. A new power policy was institutionalized in 1997-98 with the goal of reconstructing the power system and opening up paths for privatization. According to the policy, the transmission and distribution sectors of WAPDA were transferred to 10 public distribution companies (Ullah, 2013) and, in generation sector, access was open for private investors in order to enhance market competition. The other supply company KESC was not amended, and was privatized to an extent, with 25.6% remaining under government control and 71.2 % handed over to a foreign consortium. However, for electricity purchasing, it was still connected to the system (KESC, 2012). The disaggregation of WAPDA resulted in 10 distribution companies (DISCOs), four electricity generation companies (GENCOs), a license of thermal electricity generation is also given to them and one transmission company, National Transmission and Dispatch Company (NTDC) (ICCI, 2011). Control over hydro generation remained under the WAPDA. Currently, independent power producers (IPPs), GENCOs and WAPDA are generated electricity then transferred to NTDC lines. DISCOs then distribute the electricity to final end users. The KESC in Karachi handled its own transmission and distribution systems and only purchase electricity from some IPPs. In term of privatization in Pakistan, it is most thermal electricity generation that is privatized.

In 1997-98, when the power policy was made, an agency named Pakistan Electric and Power CO (PEPCO) was established in the framework of WAPDA. The main aim of this agency is to maintain the newly formed electricity structure and make consolidation and integration between generation divisions GENCOs, transmission division NTDC, and distribution DIDCOs entities. PEPCO was also responsible for granting permission to thermal power plants operated by GENCOs. In order to check and balance the system's bills and payments, the Central Power Purchase Agency (CPPA) was also formed in 1998. There was still a need to grow private investments in the system and further incentives were given to private investors; so, the National Electric Power Regulatory Authority (NEPRA) was institutionalized under the NEPRA act 1997-98 (Malik, 2010). The main responsibility of NEPRA was to ensure fair competition in the electricity market and protect the rights and assets of producers, consumers and sellers. In line with NEPRA, Private Power Infrastructure Board (PPIB) was also formed to add further security to the private system and make new incentive plans for developers, investors and entrepreneurs. Since this time, the results were not progressive, even after the re-establishment of the entire power sector. After the power policy of 1998, new policies were also formed in 2002, 2006, 2008 and 2013 to increase the private sector's share in electricity generation. However, these policies brought few changes to the 1998 policy.

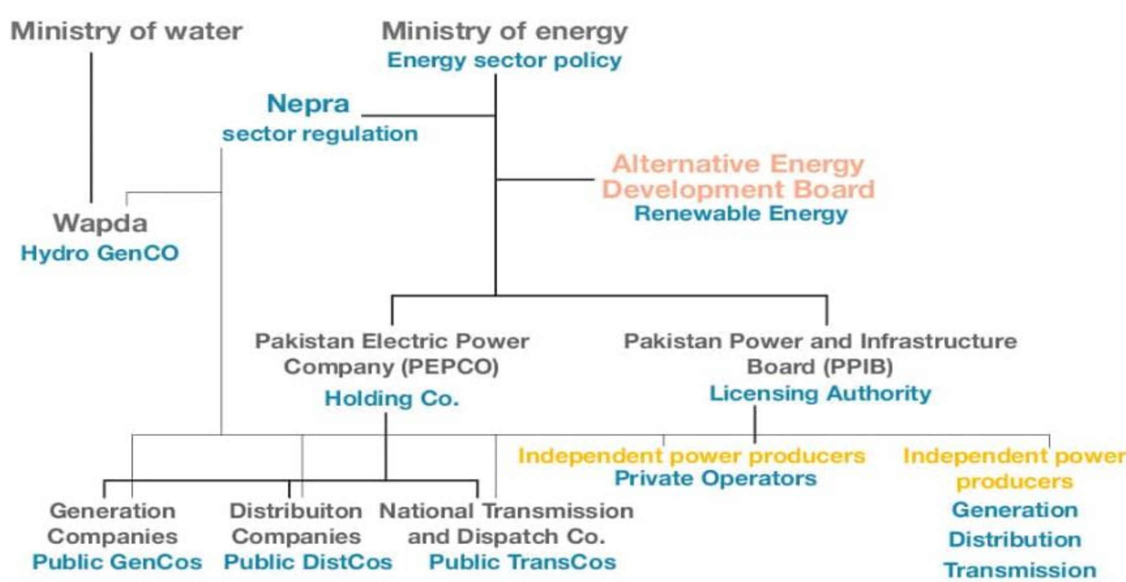

Figure 2.15 Development& Privatization of Power sector of Pakistan

3. STRATEGIES ADOPTED BY TURKEY AND PAKISTAN FOR RENEWABLE ENERGY DEVELOPMENT

In this chapter, Various RE strategies adapted by Turkey and Pakistan are discussed. Later on, I provide a deep analysis of the various RE policies and institutions that were formulated by Pakistan and Turkey. The various supportive mechanisms for RED are also stated. I also figure out strategies that should be learn by Pakistan from Turkey. Since, Turkey is more successful as compared to Pakistan in term of RED.

3.1 Policies for RED:

The milestones toward the RED that have led to the RE transition in Turkey were: the electricity market law (No.4628), promoting the RE generation in the country for the very first time, in 2001; the Electricity Market Licensing Regulation in 2002; and license regulation was further modified, demonstrating the RES of the country in 2003 (Simsek and Simsek, 2013).

The electricity market law and electricity market licensing regulations were the cornerstones of the electricity market regulations. Independent energy producers were required to obtain an EMRA license, of which there were two kinds: pre-license and full generation license. Pre-license holders are eligible for a full generation license. The total unlicensed, RE-installed capacity has grown to 6.309.27 MW in 2019, growing by 18.81% compared to the previous year (EMRA, 2019). Solar PV contributed a greater share in total unlicensed capacity in 2018 and 2019. In 2004, an independent research body was established, the International Center for Hydrogen Energy Technologies (ICHET), which resulted in an increase share of renewables and hydrogen technologies expenditures in governmental R&D expenditures. In 2005, a declaration of Renewable Energy Resource Utilization Law (No. 5346) for the purpose of utilizing RE for electrical generation was a valuable step. In 2007, the Geothermal Law (No. 5686) and Energy Efficiency Law (No. 5627) for deployment of RES in electricity generation were passed. The goal of these laws was to efficiently and economically generate the energy that charge less cost (Official Gazette, 2007).

In Pakistan the first private power policy was formed in 1985 to encourage private investors to invest in energy generation. In 1983-1985, the government took initial steps to introduce a financial strategy and invest 1.4 crore rupees for solar and bioenergy research. The power policy of 2002 was framed to put focus on the use of indigenous sources for power generation. This policy is still working today and aims to increase the share of RE sources in the power sector. The government announced its first renewable energy policy in 2006, launched by AEDB to encourage the utilization of RE sources and deployment of RE technologies. According to this, the country's energy mix must include a large share of RE, lower the share of fossil fuels through utilizing renewable sources and increase public awareness. An incentive mentioned in the RE policy was that electricity distribution companies could purchase electricity completely generated from RE sources. RE developers could sell their generated electricity to consumers by paying charges to the transmission assets owner. Net metering and billing offered by selling the extra generated electricity to the gird and later using their own generated electricity. RE developers that sold their power to national gird would not be responsible for the intermittent supply of power and changing potential of RES, such as any natural disasters; power purchasers bore that risk instead. By producing more power than planned, producers could be rewarded. Furthermore, RE producers received bonuses by generating clean energy and zero-carbon energy. An agreement would be signed between the power purchaser, the power producer and the government as part of its implementation. Customs or sales and income taxes on RE equipment imported from other countries were exempted. RE power producers could also accrue earnings through carbon credits. The FIT scheme was made for setting the tariffs for wind and solar.

The renewable energy policy of 2006 expired in 2018, and the new Alternative and Renewable Energy policy was formed (ARE policy 2019) in 2019 to bring sustainable development in the RE sector (AEDB, 2019). The main purposes of this policy are listed below:

- Increase the share of RE in the total energy mix in order to save the environment
- On-gird power generation on minimum cost
- AREPs are acquired in a timely and transparent manner via auctions.
- It is necessary to expand and open up the power market.
- ARET local manufacturing, professional human resources, and technology transfer were created.
- Enable private sector investment and involvement in AREPs and creative supply solutions, both on and off the grid
- Facilitate local people to invest in the energy sector

Over the last 30 years, many governmental research institutions were established for promoting RETs. In 2008, a policy was approved for the use of bio-diesel to replace conventional fuels. WAPDA with the cooperation of AEDB was made responsible for the national biodiesel program. Oil marketing companies would purchase bio-diesel from producers and then blend it with petroleum before supplying the fuel to end-users. The goal of this program was to increase the share of blending biodiesel in national diesel consumption by 10% in 2025. In 2009, a scheme was introduced for financing RE projects, in which the state bank of Pakistan would provide financing in the form of soft loans to various capacity-generating energy projects. In 2013, Pakistani Cabinet meeting launched a framework for the deployment of biomass and bagasse-based power for power generation and provided it a legal status as an amendment to the 2006 RE policy. This setup leant support for cogeneration projects using biomass. Upfront tariffs were also set by NEPRA for biomass-based power plants. In 2014, NEPRA set the upfront tariffs for solar PV projects.

For inventions of advanced technologies in the field of solar energy, the National Institute of Solar Technology (NIST) was created in 1981. In 1985, another institute named the Pakistan Council of Appropriate Technology (PCAT) was created to initiate technology developments for solar, wind and biomass. In 2002, a decision was taken to combine the NIST and PCAT to form a new council, the Pakistan Council of Renewable Technology (PCRET), to promote research in the RE sector. In 2003, the government institutionalized the Alternative Energy Development Board (AEDB) for the efficient utilization of RES, making it responsible for effective plans, national strategies and policies according to the vision of the government for increasing RES to the maximum share of the total energy mix. It is also responsible for checking, evaluating and certificating RE projects and products and for the electrification of 7,874 rural villages in Sindh and Baluchistan. During 2005 and 2007, the president passed a law creating AEDB on a legal basis; later on, in 2010, an AEDB act created a legal foundation through the directive of the Parliament. Various R&D institutions formed by the government accelerated the deployment of RE technologies. The comparison of different RE regulations between Turkey and Pakistan is shown in table 3.1.

Table 3.1 Turkey & Pakistan RE Policies
Source: Simsek and Simsek, 2013; Şekercioğlu and Yılmaz, 2012; Zafar et al 2018; Shah et al., 2018

Years	Turkey	Pakistan
2001	Electricity Market Law	
2002	Electricity Market Licensing Regulation	Power Policy Pakistan Council for Renewable Technologies
2003		Alternative Energy Development Board
2005	Law on utilization of renewables in electricity generation	
2006		Alternative and Renewable Energy Policy
2007	Law on utilization of renewables in electricity generation amendments Geothermal law Energy Efficiency law	
2008	Electricity Market Law Amendments	Policy Recommendations for use of Bio-diesel
2009		Scheme for financing renewable energy projects-soft loans
2011	Law on Utilization of Renewables in Electricity	Alternative and Renewable energy policy

	Generation amendments (No. 6094)	
2013	Electricity Market Law Amendments (No. 6446)	Framework for power cogeneration, biomass and bagasse
2014		Upfront generation tariffs for Solar PV Power Plant Feed-in-Tariff for solar generation
2015	Strategic Plan 2015-2019	Net Metering for Solar PV and Wind Projects
2017	National Energy Efficiency Action Plan 2017-2023	
2019		Alternative and Renewable Energy Policy

3.2 Supportive Mechanisms for RED:

One of the main purposes of Renewable Energy Resource Utilization Law (No. 5346) is to encourage the use of RES in Turkey through various support mechanism, and the feed-in-tariff (FIT) scheme was adopted under a RE law support mechanism. The FIT generated by renewables were also set that was €5-5.5 cents/kWh for all RES power plants. The second support mechanism was to give certificates to RE resource and purchase agreement with retail sales companies. These companies have to sell electricity generated from RES. The third support mechanism was to provide access to the grid and facilitats the procedures for completing RE projects such as land settlement and other administrative processes. This law also defined the solar, wind, geothermal, wave and tidal energy, biomass, bioenergy, mini hydro resource such as river type, canal type and hydropower generation plant of less than 15 km^2 reservoir area as RES.

In 2010, some amendments were made in the 2005 RES law. The first amendment was the formation of the Renewable Energy Support Mechanism (RESM). It was also applied to RE power plants constructed between 2005 and 2015. New tariffs were also determined for each RE power plant for 10 years such as 7.3 US cents/kWh for hydro and wind plants, 13.3 US cents/kWh for biomass and solar plants, and 10.5 US cents/kWh for geothermal power plants. Another support mechanism was incentives to those who use locally manufactured electro-mechanical equipment for RE plants. If the RE developer uses domestic components, an additional bonus will be added to its tariff, such as wind power plants are USD 0.008 for blades and USD 0.010 for generator and power electronics. In hydropower plants, USD 0.013 is for locally produced turbines, and USD 0.010 is for generator and power electronics. In 2011, the General Directorate of Renewable Energy (YEGM) was established by MENR. At the same time, the duties of EIE were handed over to YEGM, and EIE was closed. However, in 2013, the tendering system for solar PV projects was formed. The responsibilities included conservation of energy and energy efficiency. On July 10, 2018, according to the presidential decree, the responsibilities of YEGM were handed over to General Directorate of Energy Affairs (EIGM) (Official Gazette, 2018). There were also some other tasks that were assigned, such as RE sources deployment record, RES efficiency development, and analysis. In 2014, targets for 2030 were set that RE should be 30% of the total energy mix and 10% in the transportation sector. These plans were declared in the National Renewable Action Plan in 2014. Another energy efficiency target plan was to reduce energy per GDP by 10% in 2023 (EIGM, 2014). Later on, MENR announced strategic action plans in 2015 related with different RE resources. However, the plans related with the RE sector were to increase the share of RE in the total energy mix and RE installed capacity should grow to 46,400 MW (MENR, 2015). The National Energy Efficiency Action Plan (NEEAP) was formed for the year 2017-2023 in 2017. Its main goals were to increase energy efficiency in every sector and reduce energy consumption by 14% in 2023 (MENR, 2017). The revenue shared for the accomplishment of these goals was USD 10.9 billion.

Different supportive mechanisms, such as FITs, tax incentives, quotas, tendering mechanism, public and private incentives accelerated the renewable energy transition in Turkey. FIT significantly attracted the attention of private investors. Many independent solar, wind and geothermal power plants owners felt secure due to 10-year price guarantees. Energy purchasers were also guaranteed quotas, in which they formed an agreement of fixed energy purchases from certified RE power plants. Other small incentives included discounts for land use of ten years, concessions on taxes, and no license application fees. When RE power plants get licensed and are able to transfer its electricity to the gird, market insecurity was removed. In the light of these incentives, energy generation from RES is made more efficient and economic as compared to fossil fuels

Different supportive mechanisms were also introduced by Pakistan, including FITs for different RES, tax incentives, net metering, carbon credits and competitive bidding. By employing these incentives, the RE sector attracted more private sector entrants. In 2019-2020, 3,334 net metering licenses were issued with cumulative capacity of 65,86 MW (NEPRA, 2020). Other supportive measures included the Clean Development Mechanism (CDM), through which RE developers could earn financial returns by selling their obtained Certified Emission Reduction Certificates (CERs) in the international carbon market. Currently, 18 RE projects are earning 1.3 million CERs and 29 RE projects are under process for registration of 1.6 million CERs. Simplifying and shortening the regulatory and licensing procedures and make them more convenient to producers was also enacted. In case of excess energy generation, RE developer would receive extra rewards in their tariffs. Moreover, financial incentives or resettlement options were provided to local communities in the case of using their land, which helped allay public opposition to RE projects. Under the China Pakistan Economic Corridor scheme, a total of 396.6 MW of wind power projects went online in 2018, taking the total installed capacity to nearly 1.2 GW. There are four massive wind turbines projects: Dawood project (50 MW), the Sachal Energy wind farm (50 MW), the Three Gorges second wind farm project (100 MW), and the UEP project (300 MW) (Kanwal et al.,2019). In 2017, three wind power projects added 20 megawatts of output, and six projects with a total capacity of 285 MW became operational in 2016. AEDB will introduce training sessions and skill development facilities for local people (AEDB, 2019).

Compared to Turkey, Pakistan’s RE policies or regulations are more limited in terms of enforcing the utilization of RES, despite launching the privatization process at the same time. Pakistan cannot cope with the timely enactment of RE regulations according to the growing trend of RE and should learn various lessons and strategies from Turkey’s RE plans. In both countries, legislation and various incentive mechanisms were launched from the 2000s and are continuing to achieve the maximum RED goals. Each policy and action that was taken by both governments aim to grow the RE market, which included targets for future generation. Pakistan's future targets are 20x20 and 30x30: having a 20% share of renewables in the total energy mix in 2020 and 30% share in 2030. Turkey also set its future goal to have the share of renewables be 30% by 2023.

3.3 Policies for Carbon Emissions Reduction:

Turkey and Pakistan also accepted the Kyoto Protocol and UNFCCC and were signatories to the Paris Agreement. In Paris, Turkey committed to reduce greenhouse gas emissions (GHG) up to 21% (Kat et al., 2018), However, the agreement has not yet been ratified. (Ari and Yikmaz, 2019). Turkey also framed its Climate Change Strategy 2010-2023, as announced by the Ministry of Environment and Urbanization (MEU) at the start of 2010. In this strategy, there were three plans: a short-term plan (completed in 1 year), a mid-term plan (1-3 years), and long-term plan (up to 10 years). Short-term goals included encouraging the utilization of RE especially wind and hydro, installing solar PV in public places such as hospitals, parks and shopping malls, and certifying buildings based on their energy efficiency. Mid-term goals included making buildings energy efficient, expanding green and alternative energy sources, and reintegrating of long-standing thermal plants. Long-term targets included reducing emissions up to 7% by 2020 and increasing the share of RE in total energy mix up to 30% by 2023 (MEU, 2010). According to the BP Statistical Review of World Energy (BP, 2020), CO_2 emissions rose from 375.3 mt to 392.1 mt. It can be noted that Turkey could not achieve the set targets in these years. Useful plans and practices are needed.

Pakistan crafted its first climate change policy in 2010, the National Climate Change Policy (NCCP). This policy was considered as a milestone in achieving SDGS of Pakistan and offered a comprehensive policy framework that covered more than 120 policies related with different areas, including the energy sector. The aim was to initiate climate change-related activities and adopt energy-efficient methods. The important adaptations under this policy were divided into three categories, such as medium to long-term actions (2010-2030), near term actions (2020-2025). Various mitigation strategies were proposed such as increasing grid efficiency, minimizing energy losses, and making it accessible to RE power generators. Coal power plants should also be improved to reduce the GHG emissions and priority was given to generating solar, wind and hydroelectricity as low-carbon energy resources and decentralizing them. Finally, a carbon sequestration technique was mentioned as a way to reduce GHG emissions (Mumtaz, 2018). According to BP (2020), GHG emissions rose in Pakistan from 146 mt to 197.7 mt from 2009-2019.

Pakistan should also adopt efficient practices to hasten the energy transition from fossil fuel generation to clean energy, including various support mechanisms that are practicing in Turkey to adopt quotas and FITs to promote the use of RES (Ari and Yikmaz, 2019). Pakistan should look in to these mechanisms, as many unlicensed power producers are benefitting from them. The sum charged to RES generators who profit from the FIT scheme is normally met by suppliers withdrawing energy from the market. Manufacturers are then paid by the market based on their energy consumption. In Turkey, EXIST is responsible for the payment calculation and charges the companies on a monthly basis. In Pakistan, the NEPRA is responsible for this. The FIT function can be applicable in both directions. Suppliers would pay the price difference to EXIST or NEPRA at the end of the month if the existing market price is lower than the FIT price. Participants in the RES support mechanism in Turkey produced 50.5 TWh in 2017, an increase of 10%.

However, for the successful development of a system, FITs must be amended from time by time to create a new energy system. Initial policies can be changed according to new market conditions. Since policy-makers stop the supportive mechanism if circumstances allow, tenders become more common than the FIT mechanism REN21 (2018). It is noted that both the countries took a same start of developing RES but Turkey did more advancements as compared to Turkey. Pakistan did slow progress in this race. In terms of energy consumption, no significant change has been witnessed, and the share of RES in the total energy mix of Turkey has increased dramatically, but Pakistan showed an uneven increase of RES. Unfortunately, the share of RES has not reached its desired level. RED can only be achieved through rigid, efficient and long-term policy control and effective investment.

The RE sector in Pakistan is underdeveloped. Its main RE source is hydroelectricity but unfortunately it has declined in recent years. Nevertheless, the government is initiating RE projects, and AEDB is installing RE projects in different parts of a country as well as introducing solar heaters, cookers and other stuff. It is evident that Pakistan is a suitable country for RE. Pakistan can learn from the energy strategies of Turkey, which achieved greater developments in 20 years and institutionalized energy policies, such as YEKDEM (Renewable Energy Support Mechanism), which recently announced a new 10-year FIT and domestic production incentives for REPs for five years for 2021-2025. Pakistan can follow this path instead of building coal power plants and relying on existing primitive energy policies. Turkey, meanwhile, banned the import of solar and other RE-related machinery and spare parts to force the deployment of local manufacturing instruments. On the other hand, Pakistan facilitates the import of these machinery by tax exemptions that will no doubt raise the share of RE but the cost of energy will increase and the burden of imports will place further expense on the economy and people, so Pakistan should also ban the import of RE machinery and start focus on domestic production as like Turkey. According to the evidence, Pakistan (Figure 2.13) is rich in RES potential, so 100% RED is possible by following the efficient strategies and employing good governance.

Pakistan and Turkey can extend their relations in the field of renewable energy by opening joint RE research institutes. The researchers from both countries can work together to figure out the solutions for energy issues in Pakistan. Government of Pakistan should provide research positions for Turkish RE researchers that will guide the production of local RE types of machinery such as wind and solar turbines, which will help the Pakistani manufacturers or researchers to build their own RE factories. Hence, in this way, Pakistan can successfully bring renewable energy development.

In Table 3.2, indicators such as share of RE in total electricity generation (BP, 2020, PES, 2020), number of RE patents, jobs in the RE sector (IRENA, 2020a), total installed RE capacity (IRENA, 2020b), CO_2 emissions per capita (BP, 2020), global innovation index

(GII, 2020), environmental performance Index score (EPI, 2020), energy intensity (Enerdata, 2020) are provided. Turkey leads Pakistan in all of them. It is adhering to its stated energy policy goals, trying to achieve 100% RED in the near future. Current RED in these countries is insufficient for an 100% energy transition in near future.

Table 3.2 RE Transition Indicators of Turkey & Pakistan

	Turkey	**Pakistan**
RE share in electricity	43%	34%
Number of RE Patents	536	350
RE patent per 100.000 people	0,53	0,35
Jobs in RE sector	176	108.9
RE jobs/population (1000 people)	0,75	0,10
Total installed RE capacity (MW)	49397	12407
KW per capita	0,58	0,5
CO_2 emission (mt per capita)	383.3	198.3
Global Innovation Index	34.90	22.31
EPI Score	42.6	33.1

4. PROBLEMS FOR RENEWABLE ENERGY DEVELOPMENT IN TURKEY AND PAKISTAN

This chapter discusses the issues for RED in Turkey and Pakistan, including the development of RES during the Covid-19 pandemic Furthermore, I mentioned the various other problems for RED in these countries. In this chapter, Factors affecting RED in Turkey and Pakistan are also figure out.

4.1 Covid-19 Pandemic and RED:

The Covid-19 pandemic put the global economies in a period of temporary decline during which trade and industrial activities were curtailed. Pakistan and Turkey were also badly affected by the unprecedented economic and health issues.

Pakistan's GDP growth slowed by 0.4% in 2020. Private investments in RE sector were also show a declining trend, rising by 9.98 percent in 2020 as compared to a 10.29 percent in 2019 (PES, 2020a). In the total energy mix, the share of renewables also declined from 2019 to 2020 (Figure 3.2). Renewables were the most affected within energy sector of Pakistan such as it has a diverse effect on the objectives of the ARE-2019 policy for achieving future RE generation targets. Before the pandemic, the upgrading of the transmission network was planned, and a 660-KV high voltage transmission line was under construction from area of Matiari to Lahore, but the pandemic halted this project. Furthermore, the drop in oil prices worldwide slowed the growth of renewables, especially solar, in Pakistan. Because Pakistan is a developing nation where cheaper electricity generation is a main focus, even though it badly affected the Climate Policy, and the levelized cost of electricity (LCOE) of oil-based generation has decreased, thus making oil more competitive than renewables. The import orders of LNG were also slowed because of reduced consumption, and power authorities focused on the available import energy source instead of building new REPPs (Arfan et al., 2020).

Pakistan is not a very technically progressive country. Most of the were imported from neighboring China, which leads the world in solar production and wind energy technologies, but it was severely affected by the outbreak of COVID-19, therefore a large portion of imports to Pakistan were curtailed. China also banned the movement of Chinese workers and delayed shipments of parts to Pakistan and then delayed its RE projects there (Aslam et al., 2020). Moreover, the CPPA (Central Power Purchasing Agency) faced a burden of capacity payment with its IPPs on purchasing a fixed amount of electricity, because consumption was reduced during pandemic lock down periods but the CPPA is contractually bound to pay an agreed amount of electricity.

Covid-19 similarly affected the renewable energy market of Turkey negatively by postponing several projects and tenders, including mini renewable energy resource zone (YEKA) tenders for solar photovoltaic systems. Total electricity consumption fell during quarantines. However, the share of solar and wind energy in total electricity generation increased compared to the previous year because of the capacity of RE power plants increased (Figure 3.3) (Bulut, 2020). The comparison between Turkey and Pakistan for the share of energy sources in total energy mix during pandemic period is shown in figure 4.1 and 4.2.

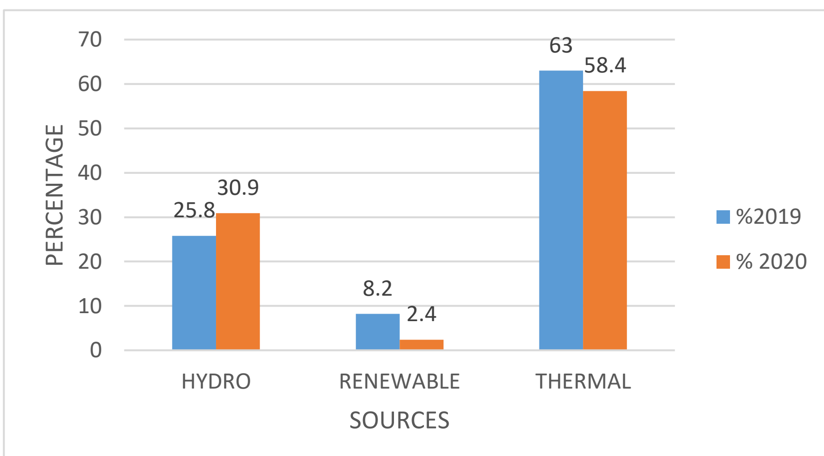

Figure 4.1 Share of Different Energy Sources, Pakistan

Source: (Bulut, 2020)

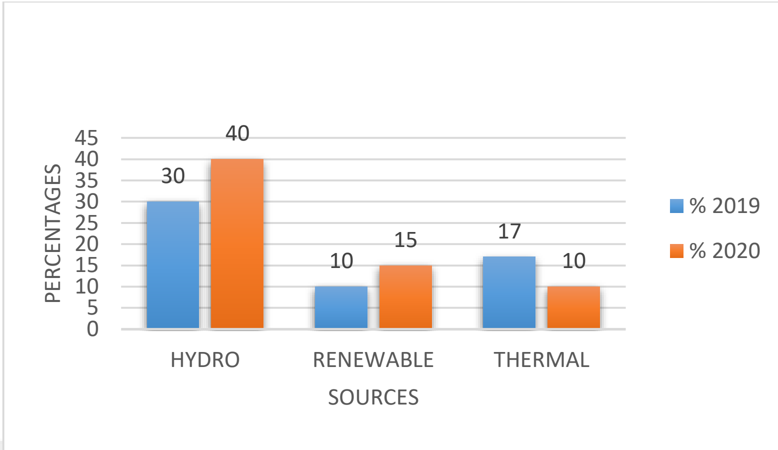

Figure 4.2 Share of Different Energy Sources, Turkey
Source: PES, 2020

The share of RE in the total energy mix of Turkey is higher than Pakistan during pandemic, while the share of thermal energy is lower in both countries.

4.2 Problems for RE Development in Turkey and Pakistan:

There are social, economic, technical and legislative hurdles for RED in both countries. I categorize the hurdles into four types: social, economic, technical and policy. However, there are also specific issues related with solar PV, wind plants, and hydro power plants that constrain maximum RE development.

4.2.1 Social Problems:

In Pakistan, there is lack of necessary information about RES in the local community. People are not well informed of the benefits of RETs, the potential of RES, and how to utilize them. Similarly, the number of trained professionals for training, guidance, maintenance, operations and demonstration of RETs is limited. Guidance is not easily accessible and creates problems during the constructing and maintenance of renewable energy projects (representatives). The lack of knowledge about RETs for some investors, developers or cooperatives create a barrier in REDs in Pakistan because RETs carry technical risks, such as unfavorable weather conditions for solar PV output, energy losses issues due to module mismatching, temperature increases in PV, and cabling issues. This long payback period of RE project investments makes local developers unwilling to take a risk and invest in RES (Khalil and Zaidi, 2014). There are also no informative programs schemes for informing the country about RETs. However, informative seminars and television programs are also necessary because the participation of small-scale investors and community capacity building is limited to a few projects. This situation discouraged the decentralization of REPs in rural areas. There is a misperception among Pakistani peoples that fossil fuels power plants are more economic and reliable due to their performance as compared to RES. In the case of weak links with local organizations for the transfer of shared profit, the whole credits move toward the corporates that only want to take advantage of financial incentives rather than completion of RE projects. This situation also impedes the growth of renewable energy in local communities. Other hurdles are the unavailability of land for development of RES. In order to get access to the other’s land, various settlements between groups of peoples sometimes causes insecurities between RE developers and landowners. Land-purchasing risks, such as obtaining ownership for installing representatives, require proper documentation and clearance (Rani et al., 2020). Unfortunately, these situations exist in both Pakistan and Turkey.

In Turkey, a public prejudice is present about RE projects and its benefits. Renewable Energy Cooperatives (RECS) in Turkey are insecure to adopt new RE business models, are conservative in this manner, and think there is a risk to invest. Furthermore, the lack of public acceptance for constructing RE projects contributes to large investment losses (Ribeiro et al., 2014), for example when peoples do not easily agree to allow a RE project in their neighborhood due to many reasons, such as noise and the importance of a site such as historical, natural and touristic place. Even some small hydropower projects have faced opposition, leading to project cancellations. So, awareness is also a social hurdle in Turkey, public acceptance risks also postponed the RE project. The communities living in the vicinity of the RE project site disagree with the physical environmental changes in the region where the RE project will be implemented due to noise emissions, impacts on air quality and water supply. (Yuan et al., 2018), creating a social hurdle for RED. Sometimes, people also demand compensation for their financial loss. The construction of a hydro dam, for instance, requires a massive clearance of land and resettlement of peoples. In Pakistan, for instance, during construction of Mangla dam, 280 villages were cleared and 110,000 peoples were moved from that area. However, at that time, the government offered work permits to these people to resettle in the UK. So, the government should offer various incentives to encourage public acceptance about RETs (Hassan et al., 2018).

Other social risks include changes in the national RE and climate change policies, which are responsible for delaying RE projects and people feeling insecure about their investment in RE projects. Environmental impact assessment risks also delay RE projects, which ultimately can harm or change the physical environment. Therefore, it is the necessary for project developers to take into consideration the environmental damages. Public health risks, such as acute illnesses or accidents occurring in the area where the RE project was installed, also slow down RE projects activity (Smith et al., 2013).

4.2.2 Economic Problems:

The high cost of the land needed to implement solar and wind projects, high upfront costs to build RE power plants, a lack of financial infrastructure, and the growing cost of research and development are the major economic hurdles for RED in Turkey and Pakistan (Mirjat et al., 2017). The cost of RETs and their resultant electricity are high, so the people cannot afford to invest easily. They find it difficult to obtain adequate funding for renewable technologies. The failure to factor externalities into the cost of electricity generation and the money and interests already invested in existing infrastructure and technology are additional problems.

However, RE technologies need no fuel and their operation and maintenance cost (O&M) costs are generally lower. Nevertheless, it is their upfront capital costs that are relatively high per unit of capacity installed, which is the major barrier in deploying RE technologies. In Turkey, financing is also a major barrier. The cost of generating electricity from oil, coal, and gas is basically the cost of fuel, and this investment is made and recovered in relatively small increments over many years. With RE technologies, however, the initial capital expenditure is large and must be recovered gradually over a period of many years, making it more difficult to attract capital and thus discouraging investment. Given this long timeline to reach a breakeven point, the RE business seems risky (Maskowitz et al., 2009). These financial risks are considered by investors during investment in RE projects. It refers to the accessibility of financing for the installation of renewable energy projects, such as equity and public financing assistance programs. (Mazzucato and Semieniuk, 2018). If sufficient capital is not available, then it may lead to capital scarcity. Sometimes, agreements with landowner, engineering work, attainment and contracts of construction also delay or pose further hurdles. Contractual arrangements are required to develop RE projects, and different contracts may create an investment loss for the stakeholder. Similarly, development of RE technologies faces barriers in obtaining competitive forms of finance due to the lack of familiarity and awareness with these technologies as well as the high-risk perceptions and uncertainties regarding resource assessment.

Investments in RE technologies are not attractive under high-discount rates and short-payback period requirements. Under such circumstances, generation choices that have relatively lower capital costs, shorter gestation periods, high efficiency and availability are preferred. These situations are common in Pakistan and Turkey. Renewable energy technologies have intermittent characteristics and their site-specific nature places the developers of renewable energy at a disadvantage regarding organizing the contracts for power transmission as compared to non-renewable energy developers. Intermittency may also necessitate that the generator pays more per kWh to transmit power. The site-specificity of renewables is a disadvantage under some transmission-pricing schemes that travel a long distance. The facility of financial support to RETs, moreover, is restricted to the investment cost of the technology. There is no financial support for working capital requirements that prevents operating and maintenance of the equipment and for establishing consumer service infrastructure (Rafique and Rehman, 2017).

In Pakistan, the market position of RE technologies is limited due to the mismatch between consumer’s requirements and the levels of R&D in RE technologies. RE technologies in the market do not accord with user demands, and are mostly supply-driven, so that consumers want discounted and local solar panels, wind turbines and other new adoptable technologies (Saulat et al., 2020). Another reason is that, Subsidies for fossil fuel energy resources are sufficient as compared to RES. Market prices of fossil fuels, on the other hand, do not include environmental costs and damages and hide the enormous environmental advantages of the new and sustainable energy options. Furthermore, new markets prefer that electricity markets with competitive and consistent power supply tariff validations and exclusion of subsidies and grants slow down the penetration of RETs. The result is that modifications and unbundling under market reforms may reduce the incentives for distributed generation. Furthermore, there is no marketing set up for promotion activities, after-sales service infrastructure, quality-control parameters, etc. which further hinders the penetration of RETs. Lastly, the adaptation of RETs is undermined by the absence of successful and replicable business models (Malik et al., 2018; Uyar, 2017).

4.2.3 Technical Problems:

The lower renewable energy intensity per unit is also an issue in Turkey and Pakistan. In both countries, grid access risks are considered technical barriers for RE development namely integrating the RE generated electricity into the grid. Grid access grants are required to proceed with RE projects. If climate conditions are less than optimal, grid access risks can adversely affect the development of an RE project. Similarly, poor infrastructure in Pakistan leads to 20%-25% energy losses. Poor construction risks are also associated with damage during transport or due to natural hazards, as well as the unreliability of RE power plant components (Wakeel et al., 2016). The most significant one is the cost of wind turbines, as it is not developed locally and carries costs ranging from 64% to 85% of capital investment in Pakistan (Kamran et al, 2020). There are also higher operations and maintenance costs of RETs in Pakistan due to the newness and unpredictability of the technology, the lack of skilled experts to operate RE power projects and the unavailability of revenues for spending on RE technologies (Chu and Majumdar, 2012). R&D capacity needs to increase for fast growth of RED.

Similarly, in Turkey, technology development is insufficient, and technology policy does not align with economic policy, limiting the development of RETs. Other issues include cost, finance, marketization of RETs and spreading of RE knowledge to a local level and fiscal regulation. Meanwhile, the government's share in RE research and development expenditure is also low. Efforts are needed to overcome these problems. Some of the RE power plant's components are imported, especially hydro energy equipment, because domestic manufacturing companies do not play a sufficient role (Sirin and Ege, 2012).

Moreover, in both countries, there is lack of sufficient grid connections. Wind potential is mostly available at the seashore, mountain ranges, and coastal areas, to where the extension of the grid is must occur. An extension to transmit the electricity from the wind farm to end-users adds extra cost. An additional threat to the development of solar energy in Pakistan is the lack of supportive products like solar inverters and efficient DC home appliances (Kamran et al, 2017).

In Turkey, other hurdles are the lack of new effective RE business models for investors or cooperatives and, in the absence of efficient RE plans or schemes, no development can be achieved. In the field of biomass in Pakistan, there are not enough modern machines for collecting, transporting, and distributing biomass. Local people thus waste the majority of the exploitable potential of biomass. Roughly 62% of Pakistan's population is rural and mostly uses animal dung and crop residues for space heating and cooking (Parwez et al, 2015). The traditional and inefficient use of biomass causes air pollution inside homes and wastes of available energy resource. Therefore, modern and efficient machines should be used for the proper handling of biomass and high technology modern cooking stoves need to be introduced for indoor cooking (Butt et al, 2013).

4.2.4 Policy or Legislative Problems:

Policy is considered a main external barrier for RED at the regional and state levels. Inefficient legislation and the uncertainty of newly implemented policies does not engender an environment of trust (Özgül, 2020; Valasai., et al 2017). Similarly, RE developers face problems regarding administration, such as authorization of RE projects for getting licensing, and during project construction. Official procedures to obtain licenses is very extensive and complex in Turkey and Pakistan, sometimes taking several years. Many governmental bodies oversee the permission or licensing for new RE project. According to the Turkish legislation, RE cooperatives and local people cannot get generation licenses, except joint-stock companies. Local communities have faced many problems such as being required to establish companies to obtain a generation license, which is time consuming and has significant financial and legislative requirements. Therefore, local individuals are reluctant to invest in a RE project. When non-local companies initiate a RE project in a country, they face public hostility. According to recent changes in a RE policy, individuals without licenses can build an RE project and sell electricity to the gird but under a limit of 500 kW (Nalan et al.,2009).

In Pakistan, the number of stakeholders in the RE sector is extremely limited, so the sector is getting centralized, which is undesirable (Sen, 2017). The current government of Pakistan is not capable of introducing new incentives to attract the private sector (Rafique and Rehman, 2017). There are also project development risks in these countries that refer to the revenue loss due to project delay or cancellation of the license for the marketable operation and failure to attain all required documents to get grid access.

In Turkey, Renewable Energy Resource Zones (YEKDEM) provided a purchase guarantee for 10 years and also supported the local instruments used in RE projects (Yalılı et al., 2020), but MENR announced that YEKDEM will end soon, which discouraged investors about the security of their investments and purchase agreements. However, a new mechanism will be announced soon but the details regarding old mechanism vanished. A surety of purchase grant and incentives is essential for RE developers. So, according to that announcement, even if RE developers have signed a connection agreement, they will not be able to benefit from these rights. The state, however, kept buying the electricity produced by local developers without any incentives. This condition is a bad sign for future RE developers. In other words, the electricity is purchased at the retail one-time active energy price. In this fragile environment, the law of REPs is still inadequate and, as soon as possible, new regulations should be crafted so that policy uncertainties will not dissuade investment decisions for RE projects (Sendstad and Chronopoulos, 2020).

In Pakistan, there is insufficient price policy, which refers to the volatility within a stable policy regime, because risks arise when the policy design does not account for all revenue risks, such as price fluctuation. Similarly, with the power purchase agreement based on utilities buying power at fixed rates from generators, there may not be sufficient incentives for power generation with fluctuating costs. The lack of well-defined policies for private participation and delays in clearances and allotments for private sector projects suppresses private participation in renewable energy projects. In Pakistan, the complex approval system for installing and operating a RE power project means that energy planners must get several permits or licenses to approve the RE power project development (Ishaque, 2017). Furthermore, risks are associated such as unexpected and sudden changes in the RETs strategy as well as policy design parameters (Ghimire and Kim, 2018), similar to Turkey. In Pakistan, the energy market is dominated by fossil fuel technologies, so the RES need to compete with the traditional technologies that benefit from existing infrastructure and policies (Ellabban et al., 2014).

In both Turkey and Pakistan, the lack of coordination and cooperation between various ministries, agencies, institutes and other stakeholders hinders the progress of RED and its marketization. The absence, moreover, of a central body for overall coordination of energy sector activities results in duplication of R&D activities. Non-incorporation of renewable energy issues in the regulatory policy and lack of awareness among regulators also restrict technology penetration. Hydropower, being a long-term project, is always vulnerable to political instability. Existing governments start a hydropower project, but the next government deprioritizes this project, which causes an undue delay in its completion. The institutional framework for the RE sector must be strong enough to start a project and complete it without any external or internal political influence. The government also does not support programs to encourage RED by local people, such as capital grants program and long-term, stable policy framework. Similarly, there is no policy support for marketization of solar PV in Pakistan, while many wind projects fail, engraining a tradition of project failure.

These issues deter new investors from participating in the renewable energy transition. Potential producers should have their bureaucratic processes simplified by their governments, which often revise how new constructions are licensed. Instead of issuing individual licenses, they began issuing licenses on a large scale (YEKA).

4.3 Nature of RE Sources

There are other hurdles regarding different renewable resources such as hydro, wind, solar and biomass that also considered in the way of RED.

4.3.1 Hydro:

The main disadvantages of hydropower are initial investment cost and time dilation, such as for hydro-power dams that required five to 10 years to complete and governments or policies change during that time period, affect the development of particular project. Social and environmental concerns, such as effects of changing river flows on ecosystem regimes, need vast expanses of land that displace inhabitants and misuse of productive land, create silt deposition in a dam, and negatively affect certain sensitive species. Hydropower generation also depends on precipitation, which can be vary from year to year and thus affect the performance.

4.3.2 Solar:

Solar power suffers from the high initial cost of power generation and environmental problems such as the use of toxic chemicals, cadmium sulfide and gallium arsenide during their manufacture—these are highly toxic and stay in the environment for many years—and intermittency (Tahir et al., 2021).

4.3.3 Wind:

Wind also has higher construction and connection costs, such as cost of work directed for the connection of a wind farm with a small grid, environmental impacts include to disturb the flyways of migrating birds and wildlife refuges, electromagnetic interference with television and radio signals within 2–3 km of large installations, the noise of rotating blades, intermittency due to sudden changes in wind velocity and direction at small scales, and required back-up generators (Nazir et al, 2019). Hundreds of thousands of birds are killed by wind turbine blades every year, which is a direct threat to the existence of various bird species (Small wood, 2013). A wind speed database is required for an analysis to determine the possibility of installation.

4.3.4 Geothermal:

Geothermal is inhibited by the following: noise pollution associated with its construction, drilling and area testing stages that is very disturbing and scary to animals as well as human beings, release of non-condensable gases and direct steam during development, and air pollution from operation, including H_2S gas if generated in high amounts can pose a significant health risk. According to the World Health Organization (WHO), the lowest observed adverse effect level for H_2S is 15mg/m3 that may cause eye irritation (WHO, 2003), as highly toxic metals waste in the sludge are produced, including arsenic, boron, lead, mercury, radon and vanadium. Waste disposal issues and water shortages are additional related environmental concerns, while hydrogen sulfide is also produced that is potential air pollutant. After 40-100 years, the decline of geothermal energy source, surface instability and seismicity cause micro earthquakes. Prior to constructing a geothermal power plant, a careful study of the possible seismic impacts must be analyzed.

4.3.5 Biomass:

Biomass is less competitive because of little commercial activity, resource incompatibility, degradation of soil quality by sing wastes for fuel, and difficulties collecting biomass wastes that are scattered in nature. It is also difficult to handle the huge amount of biomass so it is improperly collected and distributed to end-users (Bhutto et al, 2011). Seasonal availability of biomass waste is another issue, as biomass wastes costs vary depending on the type of crop wastes or economic conditions (Nalan et al, 2009).

4.4 Factors Affecting Renewable Energy Development in Turkey and Pakistan:

There are social, economic, technical and political factors that are affecting RED in these countries. In terms of economic factors, Pakistan and Turkey are endowed with RE resources that play a main role for RED. There is growing renewable energy demand in these countries especially in Turkey that also favor the construction of RE power plants and installation of solar PVs at various buildings. Other economic factors include investment environment for renewable energy projects and economic returns in the form of incentives and FITs by government. Due to these economic factors RED seems raising in Turkey and Pakistan. Technical factors take the R&D of RE technologies such as establishment of various research institutions in Turkey and Pakistan that encourage the employment of RETs. Energy security concerns that Pakistan and Turkey facing also urged the government to invest in RE (Ali et al.,2020).

Political factors involve the completeness of the renewable energy policy system, the supervision of relevant government legislation, the stability of RE policy implementation and governmental RE policies. In Turkey and Pakistan, Government incentive policies and approaches play a critical role in facilitating the RED by providing R&D funds and establishing R&D institutions to achieve technological breakthroughs, granting preferential taxation, allocating financial subsidies, formulating reasonable feed-in-tariff for RE projects and resolving profit issues between power generation enterprises and power grid. Social factors also effect the focus on resident's awareness of RE, the environment, social resources, environmental effects and public acceptance of RE (Fatima et al.,2021).

5. INVESTMENT OPPORTUNITIES IN PAKISTAN'S RENEWABLE ENERGY SECTOR

In this chapter, I use the strengths, weaknesses, opportunities, and threats (SWOT) analysis for determining the viability of investment opportunities in Pakistan's renewable energy market. Pakistan has a wide potential of RES and an attractive potential market. The opportunities for investment in different RE fields are illustrated in this chapter as well as weakness and threats by employing deep SWOT analysis. The RE sector's strengths are examined in terms of available capacity, validated resource maps, environmental friendliness, and the increasing number of private investors, while inefficient technologies, large capital expenditure, an immature institutional structure, and technology-related environmental hazards are identified as internal vulnerabilities that must be addressed. Untapped capacity, micro and mini-installations, off-grid energy systems, and performance improvements are among the main opportunities to be capitalized for sustainable growth, while policy effects, lack of grid access, and competitive energy supplies are among the related threats to the RE sector's sustainability (Kamran et al.,2020).

Table: 5.1 SWOT analysis of renewable energy in Pakistan

Strengths	**Weakness**
1. Viable solar, wind, hydro, biomass and hydro potential. 2. Authentic and validated resource maps. 3. Increasing the number of private investors 4.strong institutional frameworks	1. High initial capital costs of REPPs 2 Noise pollutions 3. Ignorance of the most potential provinces such as Baluchistan 4.Lack of efficient solar DC appliances

5. Reduction in GHG emissions 6. Gharo-keti Bandar wind corridor, highly potential site 7. Solar PV has a high level of public acceptance. 8. Locally available biomass 9. Locally developed biomass technologies 10. Highest share of hydropower in total energy mix	5. Intermittency of solar radiation in winter and summer 6. Inadequate handling of biomass 7. Farmer's ignorance of energy crops 8. long time requirement in hydro power plants construction
Opportunities	**Threats**
1. Developing wind technology and increasing efficiency. 2.Development of small-scale off-grid installations. 3.China Pakistan Economic Corridor. 4.Mini and micro-hydro potential 5.Indoor photovoltaic system 6. Electrification of rural areas 7. Various incentives offered by government of Pakistan	1. Wind shear and turbulence by the improper site selection of the wind plant. 2. Environmental concerns. 3. Lack of grid connections in far-off potential sites. 4.No incentives to micro and mini solar PV installations 5.Political instability in Pakistan

5.1 Wind Energy

The strengths of wind in Pakistan are enormous, as the country possesses high wind energy (WE) potential, highly precise wind maps, GHGs emission-free resources, private WE project and a strong institutional framework. Therefore, various opportunities, which can attract Turkish RE developers, are present.

5.1.1 High wind potential areas:

The major strength of the WE sector is high potential. High potential sites are available at the coastal belts of province Baluchistan and Sindh with an average wind speed of 7 m/s at a 50-meter anemometer height (Shakeel et al, 2016). The potential coastal sites of Sindh are Jamshoro, Mirpur Sakro, Kati-Bandar, Thatta, Shah Bandar, Gharo, Nooriabad, Kotri, Thar, Hyderabad and Malti. Similarly, the good potential sites in Baluchistan are Gawadar, Ormara, Chowki, Pasni, Liari, Gadani, Jiwani and Hub. The coastal belt of Pakistan has 43-GW wind potential but only 11 GW is exploitable due to land prohibition at other sites (Siddique and Wazir, 2016; Farooq and kumar, 2013). According to the National Renewable Energy Laboratory (NREL), the total wind energy potential in Pakistan is 346 GW for electricity generation (Shakeel et al., 2016).

5.1.2 Highly precise wind energy maps:

The accessibility to highly accurate WE map are an additional strength of the sector. This meteorological data is helpful for investors, developers, and policymakers alike. The World Bank's Energy Sector Management Assistance Program (ESMAP) funded these maps to obtain accurate wind (Figure, 2.3) solar (Figure 2.6) and biomass (Figure 4.1) assessments. The measurement data is collected through using many years of mean satellite and ground-based data (World Bank, 2016).

5.1.3 Institutional structure and WE projects:

The growing interest of private investors and strong institutional framework is an important factor for strengthening the WE sector. AEDB is responsible for all the RE projects in Pakistan, acting as a one-stop facilitator, manage and regulator.

5.1.4 Local productive technology

The wind market of Pakistan is developing. Market can exploit maximum wind energy potential by introducing efficient wind turbines or micro turbines. Turkish wind turbine manufacturers can easily find potential customers by selling their efficient micro wind turbines or establishing a wind-turbine factory in Pakistan. Micro wind energy turbines will be also helpful in promoting micro and mini wind energy systems in Pakistan (Kamran et al.,2020).

5.1.5 China-Pakistan Economic Corridor (CEPC):

This internationally recognized secure and reliable project allows RE investors and developers to invest in various energy projects. The Government of Pakistan offers the following incentives to wind energy investors or developers (Ghori, 2012).

- Wind risk (hazard of inconstancy of wind speed) is not the issue for developers
- Ensured electricity purchases
- Framework arrangement is the duty of the buyer
- Assurance against political danger
- Appealing tariffs (cost in addition to 17% ROE), recorded to swelling and swapping scale variety (Rupee/Dollar)
- Euro/Dollar parity permitted
- Carbon credits accessible
- No import duties on equipment

- Exclusion on income tax/withholding tax and sales tax
- Repatriation of equity alongside profits uninhibitedly permitted
- Authorization to give corporate enlisted securities
- Offered cooperation provisions for investment in Pakistan are
- Direct foreign investment (DFI): participation of organizations being developed of RE power projects through DFI. The Legislature of Pakistan will give full assistance through AEDB.
- Financing for commercial wind power projects: banks and financing organizations may fund business projects through obligation and value sharing.
- Fare credit: to advance the equipment, government may give export credit to its OEMs.
- Technical assistance: support in limit building and specialized help of public substances/associations of Pakistan related with RE
- Coordinated effort in wind-turbine manufacturing: collaboration with Pakistani designing ventures for assembling/gathering of RE technology hardware/parts in Pakistan.

5.1.6 Threats and weaknesses:

The initial capital investment for wind energy technologies is very high, which is a major impediment. Several authors believe that lowering its LCOE would be possible if the costs of the balance of system (BOS), such as a wind turbine, base, construction, grid connection, and project creation and management, are individually managed and reduced. The most notable is the cost of wind turbines, which are not built locally and can cost anywhere from 64% to 85% of the capital investment (Smallwood, 2013). There are also environmental concerns related with wind farms: turbines are responsible for the deaths of birds as well as noise and visual pollution, while the exploitation of wind potential is inefficient. But Sindh and Baluchistan have considerable WE capacity. The capacity of Sindh's wind corridor is being fully exploited, whereas in Baluchistan, not a single project is operational or in the pipeline. Threats related with construction are poor site selection choices and vulnerability to small-scale changes in wind velocity and direction. The other main threat is the lack of grid connection in mountainous and coastal areas.

5.2 Solar Energy Field

Turkish RE investors can find enormous opportunities in the solar energy (SE) market of Pakistan due to its high resource potential, validated and accurate solar maps, inclusion of private investors in energy projects, and minimum operation and maintenance cost of solar PV.

5.2.1 Potential areas of Pakistan:

Pakistan is situated in an area with some of the highest solar radiation in the world. The average insolation is 5-7KWh/m^2 /day (Solangi et al, 2011). The deserted areas of provinces Baluchistan, Sindh and Punjab have high potential of solar energy development. However, Baluchistan alone accounts for a daily sunshine of 8.5 h/day producing 20MJ/m^2 solar irradiation on daily basis (Chaudhary et al, 2009). According to the NREL in cooperation with USAID, the total estimated potential of SE is 2.9TW (Ghafoor et al, 2016; Bhutto et al, 2012). The monthly sunshine hours in Pakistan, shown in table 2.4.

5.2.2 Highly accurate solar maps:

ESMAP, in collaboration with AEDP, measured the satellite and ground-based solar data of Pakistan. Different measuring stations were established in different parts of the country. For GHI and DNI calculations, multiyear (2000-2012) mean data was used (Stökler, 2016). So, the precise data of solar energy potential is available in Pakistan, shown in figure 2.3.

5.2.3 Private investments:

Public awareness is growing through various informative campaigns and awareness strategies, especially in rural areas. People have begun showing willingness to install PVs in their homes as a standalone energy system (Jabeen et al, 2014).

5.2.4 Low operation and maintenance cost (O&M)

Little maintenance is required after the installation of solar PV, such as changing of inverters and cleaning. However, no major maintenance is required for O&M of solar plants. It is assumed that the total maintenance cost is 1% of total capital cost (Bano and Rao, 2016). So, private companies can easily install solar PV or provide other services.

5.2.5 Other opportunities:

The price of solar PV is decreasing worldwide, making solar grid equality achievable, when the cost of electricity generation from solar PV is less than or equal to fossil fuel-based electricity (Breyer and Gerlach, 2013). The efficiency of solar PV is increasing and peoples are willing to use off-grid home solar systems. Indoor PV systems with temperature controllers are also in demand for the residential sector. This technology filters out other harmful radiation coming from the sun. Solar PV is gaining social and economic acceptance in Pakistan.

5.2.6 Solar Business models for private investors by governmental body:

The AEDB-suggests three business models for private companies or investors encourages private companies to provide services to customers to install solar energy plants.

- A specialist organization introduces the equipment, operates it after the sales service duration for one year, trains the undertaking group of customers and, after one year, transfers the operation to the customer. In this model, the customer needs to bear the capital and operational expenses.

- The energy service company, give a package deal to the client for installing equipment and operating it at its own expense for the after-sale services term, and get a return on investment in installments.

- Include banks for giving advances to the customers to set up such plants with a pre-condition to utilize their item. The customer at that point address backs the cost/advance to the bank in portions (Kamran et al.,2020).

5.2.7 Threats and weaknesses:

Solar has a high initial capital outlay. Solar DC appliances are also inefficient, and solar irradiance is inconsistent in the summer and winter. One threat to solar farm construction is the availability of traditional mature technologies which have an established market share and an army of experienced experts, operators, and technical personnel that want to the growth of solar in Pakistan. There are also no financial rewards for micro and mini-installations and a scarcity of effective and affordable solar-appliances (DC appliances, inverters, batteries, etc.) (Kamran et al., 2017).

5.3 Biomass energy:

As an agricultural country that is fourth in the world for producing sugar from sugar cane, Pakistan has a rich potential for power generation from biomass (table 2.12). Bagasse is produced as a by-product during sugar processing and is used to produce electricity. This biomass source is available locally in Pakistan in all areas but inefficiently used.

5.3.1 Strength and opportunities:

A complete validated map of bioenergy resources of Pakistan is presented by AEDB with the help of the World Bank funding program ESMAP. The map determines the total crop residues in Pakistan, the quality and quantity of available biomass fig 2.10 (AEDB, 2017). Proper exploitation of these resources with the help of the latest technologies can be a good source of energy and can provide electricity generation for rural areas (Naqvi et al, 2018).

In Pakistan, there is a raising trend of private investments in bioenergy plants. Currently, 5,357 biogas plants are working in different areas of a country and five grid-connected biogas plants (Naqvi et al, 2018). In rural areas, there is a demand for fixed-dome and moveable-dome biogas plants, which are cheaper and cause no pollution (Amjid et al, 2011). Although biomass resources have been utilized, there is still a lot of biomass waste that goes unused. There is, therefore, an opportunity for RE developers to harness Pakistan's biomass sources by introducing modern technologies and machinery.

According to a survey by ESMAP during its biomass mapping of Pakistan, 12 landfills have a total of 29 million tons of municipal solid waste (MSW) per day, of which 27 million tons goes unutilized and but which run anaerobic digestor-type power plants of 350-MW installed capacity (AEDB, 2016). They also surveyed three dairy farms that have waste of 100 tons per day that can run a digestor-type power plant of total capacity of 0.4 MW. The emission of gasses from biogas plants is lower compared to conventional energy resources but greater compared to other RES (Amponash et al, 2014).

There is, therefore, an opportunity to supply electricity to rural areas of Pakistan by utilizing rural biomass resources, especially given that 62% of Pakistan's population is rural, the majority of whom are farming and raising livestock (Butt et al, 2013). Yet grid connection electricity in villages is only 55% (Harijan et al, 2008). There is a need for electricity there by investing in biomass-based power plants and biogas production facilities.

5.3.2 Threats and Weaknesses:

The primary weaknesses with biomass are inadequate handling, as there are insufficient qualified operators, farmers lack knowledge about energy crops, and boilers and furnaces are inefficient (PES, 2017). Biomass heterogeneity is an issue. One threat is policies that prohibit the harvesting of forest timber. Biomass sourcing, moreover, is inefficient and experiences price volatility. Technology also has not been established locally, as Pakistan is still practicing outdated incineration methods for biomass combustion, while elsewhere countries are benefitting from more mature technologies. The use of anaerobic digestion methodology, for instance, can increase efficiency up to 60% (Bhutto et al., 2011).

5.4 Hydro Energy Field

5.4.1 Strengths and opportunities:

Pakistan has enormous hydropower potential, and RE investors can find huge opportunities. It is estimated that Pakistan has 100 GW of water potential (Shakeel et al, 2016). However, only 7.116 GW is utilized, and hydro is only 28% of the total energy mix (Kamran, 2018). In line with the vision of WAPDA, it will be reach up to 16 GW by 2025. Hydroelectricity is considered as the lowest cost option for generating electricity as compared to other RES (Asif, 2009). Furthermore, Pakistan has developed technology in hydro and well-trained constructors and developers. However, as much as 90% of its potential remains unexploited (Kamran et al, 2019). There is also an opportunity for micro-hydro plants to supply electricity to off-grid areas. Micro-hydro potential is available at natural falls, in the canal falls areas of Punjab, Gilgit Baltistan, and Khyber Pakhtun Khawa.

According to the RE policy of Pakistan, Private investors are invited to submit proposals in one of three categories: first, selling electricity to the grid as independent power producers. Second, self-use and eventual sale to the utility (captive power projects). Third, micro-scale initiatives (isolated grid power projects). Recently, some smart gird applications have been introduced in Pakistan by exploiting available sources and wireless technologies. Though these are in initial stages, investors can find ways to take advantage of the country's excellent RE potential. These innovations will contribute a great role in connecting the organizations and national girds. Furthermore, other techniques for smart girds have been researched and will be implemented soon (Khalil and Abas, 2014).

5.4.2 Weakness and Threats:

Again, initial capital investment cost is high, and there is a longtime required for construction in hydro dams. Another weakness is the degradation of existing dams and hydropower plants by sediment deposition. Threats regarding hydropower are the destruction of fish and wildlife habitats, as well as political unrest leading to cancellation and delay of projects. The last government started a project but current government halted it (Hanif et al.,2016). For example, the Terbela dam took eight years to construct, the Mangla dam took five years, and the Ghazi Brotha dam took 10 years to complete in Pakistan. The construction of Neelam Jehlum began in 2008 and is still ongoing, with the cost of the project rising from PKR 84 billion to PKR 500 billion due to the delay in completion (WAPDA, 2017).

The greatest opportunity in Pakistan's RE sector's is its vast hydropower potential. Pakistan's hydro potential is currently 93 percent untapped, and if properly harnessed, may be a lucrative investment opportunity. Another option in this respect is the micro-hydro concept, which might be used to electrify off-grid small populations living in far-off places. Every year, an inevitable flood devastates farmers' properties and crops in flood-prone areas of southern Punjab and Sindh. The lack of water storage capacity, according to Ashraf et al., (2012) is one of the causes of Pakistan's devastating floods. Flood risk can be reduced by constructing dams, and waste water can then be used to generate energy. Similarly, there is enough investment opportunity in solar energy sector of Pakistan. The operation and maintenance cost of solar PV modules is low. The inverters used have a ten-year warranty, and cleaning and other maintenance are performed twice a year. Because solar PV energy systems do not have rotational parts, they do not require extensive operation and maintenance (O&M). The facility requires no well-trained employees to run, and the system has no significant operating and maintenance costs. The majority of academics estimate that operation and maintenance costs are roughly 1% of the initial cost. Pakistani peoples are also willing to accept solar systems in their houses and offices.

The weaknesses and threats related to RE projects can be overcome, if foreign investors or developers will introduce highly advanced technologies in Pakistan and, in return, they can get profitable revenue by introducing them. Developers can also employ effective business plans and models for potential areas of Pakistan. However, the potential for wind, solar, hydro, and biomass energy sources is abundant and technically feasible. The number of local and international investors is rising each year as a result of the institutional structure and already operational RE programs.

6. CONCLUSION

Turkey and Pakistan are energy import-dependent countries; nearly half of the energy sources are imported. Given this fact, they should initiate more rapid shifts away from imported fossil fuels toward renewables. Their RE potential is sufficient to reform the country's energy policies (Balat, 2005; Erdil and Erbıyık, 2015; Toklu, 2017; Ghafoor et al., 2016; Sheikh, 2009). Comparatively, Pakistan possesses greater RE potential but Turkey has better executed RE policies. The LCOE of RE is decreasing worldwide, while RE technologies are becoming more efficient due to research and innovation (MIT, 2015; REN21, 2020; IEA, 2018). Renewable resources provide the best alternative for both country’s energy import dependency problems. Pakistan and Turkey's sustainability priorities for the future include the safe and sustainable utilization of domestic energy supplies and the maximization of the share of domestic energy sources in total energy mix. In terms of economy, population, culture, and geography, Pakistan and Turkey are very different countries. They do, however, share a reliance on non-RE resources. RES can assist them in overcoming this critical problem. As mentioned in previous chapters, the presence of the state is a vital component of a RE transformation; government-initiated policies are responsible for the success. Therefore, it will be difficult to meet theirs RE goals without the assistance of the government.

Energy issues in Pakistan can be solved by the efficient utilization of RES. In far-off places, where electricity is inaccessible in Pakistan, off-gird renewable energy supplies will be a better option. RE is a very good option for decentralization energy. 50-60% of the Pakistani population cannot access electricity so the installation of solar and wind farms in these areas will be a great solution to energy shortage in Pakistan. Pakistan also has an opportunity to get a RE technology knowledge from China that leads the world in total installed renewable energy capacity. In this regard, CPEC is a big energy cooperative project between China and Pakistan. CPEC is intended to rapidly upgrade Pakistan's required infrastructure and strengthen its economy through numerous renewable energy projects.

The initiation of energy transition process will be inherently different for Turkey and Pakistan. In Pakistan, the RE transition is being encouraged by government and government-initiated policies and incentives, but there is a lack of public awareness and motivation. There is no publicly-led green movements to urge the government to make further RE reforms. Furthermore, Pakistan as an under-developed country: it does not have a strong background in manufacturing machinery and other energy factories as well as it is inferior in the field of technology and innovation. In Turkey, however, the state and the public have both initiated the RE transition together. The Turkish people are very well familiar with the burden of energy imports and climate issues (Ediger et al., 2018). The Turkish government, meanwhile, also introduced RE policies and new technologies, but public preferences can spark a revolution, such as a political party, which can then have a direct effect on policy.

The RED in Turkey and Pakistan is not sufficient to achieve renewable energy transition. Turkey and Pakistan still many years to complete theirs transition because, as noted earlier, the share of coal and natural gas is still significant as compared to RE in total installed capacities. However, both countries did a good start through developing RE policies, long-tern energy plans and employing different RETs, but in order to 100% RE transition, serious practical steps should be taken to achieve fully RE transition. Turkey also needs to follow the energy strategies of highly RED developed countries that in the mature stages of their energy transitions, such as Germany and China.

There are various factors affecting RED in Turkey and Pakistan such as abundant of RE potential, some supportive governmental policies, environment friendliness nature of RES, to eradicate the energy import issues. Government incentive policies and approaches play a critical role in facilitating the RED by providing R&D funds and establishing R&D institutions to achieve technological breakthroughs, granting preferential taxation, allocating financial subsidies, formulating reasonable feed-in-tariff for RE projects and resolving profit issues between power generation enterprises and power grid.

Pakistan and Turkey have enormous RE potential, but the RE installed capacities and use of RES are quite low. The reasons include some economic, political, technical and social problems for achieving maximum RED. Economic problems include high cost of lands, high upfront costs, higher cost of R&D for RE technologies. In Pakistan, lack of market competition for RETs because fossil fuel dominated the market. Moreover, the adaptation of RETs is undermined by the absence of successful and replicable business models. Political problems consist of inefficient legislation and the uncertainty of newly implemented policies and the extensive official procedures to obtain licenses is very complex in Turkey and Pakistan, sometimes taking several years. In both Turkey and Pakistan, the lack of coordination and cooperation between various ministries, agencies, institutes and other stakeholders hinders the progress of RED and its marketization.

Technical problems include, grid access risks, lack of trained staff for RETs are considered technical barriers for RE development. Similarly, poor infrastructure in Pakistan leads to 20%-25% energy losses. For a successful energy transition, technology and R&D cannot be ignored. In this manner, Turkey is more developed than Pakistan. It is also producing domestic goods and building solar and wind factories. Turkey outperforms Pakistan in RE patents, total installed capacities, and the EPI index. The lack of domestic production is a clear hurdle for Pakistan. Although there is enough domestic production in Turkey, it still has to accelerate production as compared to other successful RE-developed countries. In order to further strengthen the RE transition in both countries, they should begin by educating the next generation in elementary school about RE ideas to safeguard the future. Developments will accelerate if the public is aware of the benefits of RES. The function of public awareness is thus crucial.

Pakistani People are not well informed of the benefits of RETs, the potential of RES, and how to utilize them so these are the social problems. On the other hand, in Turkey, a public prejudice is present about RE projects and its benefits. Renewable Energy Cooperatives (RECS) in Turkey are insecure to adopt new RE business models, are conservative in this manner. These are the social problems for RED in Turkey and Pakistan.

These various problems for RED can be resolved with greater cooperation between different governmental institutions and public. However, Pakistan is planning to diversify its energy consumption sources and building new RE plants. Similarly, Turkey is paving new energy paths for maximizing RE development. Another issue for the deployment of RETs is unstable political forces in both countries. There is no political body that explicitly supports environmental change in parliament and few of the political parties advocate for RE initiatives. There is no particular and significant political force, in other words, pushing for the switch to RE. On the other hand, states are turning their faces to the coal policies in an effort to minimize energy-import dependency. According to the 2023 energy goals of Turkey, coal is supported by government. The Pakistani government is also planning to construct coal power plants.

Turkey and Pakistan should also foster an environment that draws together people from all backgrounds to promote RED. The government, universities, and other independent institutions may work together more closely to establish a system that will allow Turkey and Pakistan to become more energy-independent. Turkey can be example for Pakistan as a RE developing country. A clear FIT structure and rules like in Turkey should be put in place in Pakistan. Another critical step is the decentralization and deregulation of the energy sector. Pakistan is its initial phases of RE development. On the other hand, Turkey successfully completed the initial steps of energy transition but still face serious challenges, and effective steps need to be taken. In order to catch up to other developed RE countries, Turkey should consider more private and public investments as soon as possible.

Turkey should also reconsider its energy strategies for successfully establishment of a sustainable energy structure. In the domain of energy production, it should adopt policies that maximize the share of RE to meet its growing energy demands. As compared to other RE-developed countries such as Germany and China, although Turkey’s government introduced incentives, the current situation should be improved, and the government should employ cost-effective methods for utilization of RE. It should also make more financial plans for R&D activities in universities and other research labs. The role of government is essential in formulating and implementing effective RE policies for RED. The private sector certainly has potential to invest and fund various RE activities, which will aid the growth of the sector. If these steps taken by the governments of Turkey and Pakistan, RES will be prioritized as primary energy sources and make the economies of the two countries more prosperous sustainable.

According to SWOT analysis, there are various opportunities for investment in Pakistan's RE sector such as enormous RE potential, validated RE resource maps, environmental friendliness RE and the increasing number of private investors in RE field. The CPEC in Pakistan is internationally recognized secure and reliable project allows RE investors and developers to invest in various energy projects. The Government of Pakistan offers the various incentives to wind and solar energy investors or developers in Pakistan. There is also a huge potential and opportunity in Pakistan's hydro energy sector, Turkish investors can invest and work satisfactorily in this sector.

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CURRICULUM VITAE

Personal Information
Name and surname: Mohsina Majeed

Academic Background

- Kadir Has University (2019-Cont)
- Energy and Sustainable Development (Master)

- PMAS Arid Agriculture University (2014-2018)
- Environmental Sciences (B.SC (Hons.)

Work Experience

- Tutored Pre-Med Students (Bio-Chemistry)
- Pakistan International School (2017-2018)

- Internee (2016-2017)
- Pakistan Agriculture Research Center