T.C.

ISTANBUL AYDIN UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

ADDRESSING THE ELECTRICITY SHORTFALL IN PAKISTAN THROUGH RENEWABLE SOURCES

MASTER'S THESIS

M. Tayyab ANJUM

Department of Engineering

Electrical and Electronics Engineering Program

FEBRUARY, 2022

T.C.

ISTANBUL AYDIN UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

ADDRESSING THE ELECTRICITY SHORTFALL IN PAKISTAN THROUGH RENEWABLE SOURCES

MASTER'S THESIS

M. Tayyab ANJUM

(Y1913.300001)

Department of Engineering

Electrical and Electronics Engineering Program

Thesis Advisor: Dr. Öğr. Üyesi Eylem Gülce ÇOKER

FEBRUARY, 2022

APPROVAL PAGE

DECLARATION

I hereby declare with the respect that the study "Addressıng The Electrıcıty Shortfall In Pakıstan Through Renewable Sources", which I submitted as a Master thesis, is written without any assistance in violation of scientific ethics and traditions in all the processes from the project phase to the conclusion of the thesis and that the works I have benefited are from those shown in the Bibliography. (…/…/2021)

M. Tayyab ANJUM

FOREWORD

First of all, I would like to express my endless gratitude to ALLAH for being who I am right now and helping me to find patience, strength within myself to complete this thesis.

I feel very fortunate to have the Head of department Assist. Prof. Dr. Öğr. Üyesi Eylem Gulce Çoker is my supervisor for his essential advice, inspiration, and debates during the thesis's development. Words can't explain how crucial his encouragement and support were throughout the process. Working with him has been a tremendous honor and a fantastic learning experience for me.

I'd want to express my gratitude for Istanbul Aydin University's significant contribution to my life, not just academically, but also in terms of enabling me meet amazing individuals who inspire, challenge, encourage, and motivate me. I'd do like to grateful to my family for emphasizing in me the importance of never giving up on my aspirations. I have no words to convey my gratitude for having such a wonderful family who always supports me. My wonderful parents put forth a lot of effort to help me succeed.

January 2021 M. Tayyab Anjum

ADDRESSING THE ELECTRICITY SHORTFALL IN PAKISTAN THROUGH RENEWABLE SOURCES

ABSTRACT

The subject of study is addressing the shortfall of electricity by renewable energy sources. The shortfall in Pakistan is increasing because the electricity generation is low as compared to electricity demand, also there are some other causes which include growing household demand, financial management, governance issues, etc. All these causes are putting a huge bad impact on the stability of the system and this electricity shortfall is the main cause of slow economic growth. Pakistan is already making its electrical energy from coal, natural gas, biomass, hydro, and other renewable resources but that amount of energy generated is not sufficient to meet the energy needs of Pakistan. Because these fuels are not sufficient Pakistan is facing a shortfall of oil, coal, natural gas, and nuclear. So the alternatives such as renewable energy sources that can be used instead of fossil fuels are studied which are in excess amount and free. To overcome this shortfall and increase the overall electricity production the examples of China, India and Turkey are being studied and the lesson learned about how they have overcome their increasing electricity demand challenges. To check the feasibility of the RE sources to overcome the electricity shortfall the comparison of the QASP solar power plant Pakistan and the karapinar solar power plant based in turkey has been made which consist of the power output of the plant, specifications of the plant, and the benefits after the deployment of these solar power plants.

Keywords: Renewable Energy, Electricity shortfall, QASP

PAKİSTAN'DAKİ ELEKTRİK KISAĞININ YENİLENEBİLİR KAYNAKLAR YOLUYLA GİDERİLMESİ

ÖZET

Çalışmanın konusu, yenilenebilir enerji kaynakları ile elektrik açığının ele alınmasıdır. Pakistan'daki açık, elektrik üretiminin elektrik talebine kıyasla düşük olması nedeniyle artıyor, ayrıca artan hane halkı talebi, finansal yönetim, yönetişim sorunları vb. gibi başka nedenler de var. Tüm bu nedenler istikrar üzerinde büyük bir olumsuz etki yaratıyor. sistemin ve bu elektrik açığı yavaş ekonomik büyümenin ana nedenidir. Pakistan hali hazırda elektrik enerjisini kömür, doğal gaz, biyokütle, hidro ve diğer yenilenebilir kaynaklardan yapıyor ancak üretilen bu enerji miktarı Pakistan'ın enerji ihtiyacını karşılamaya yetmiyor. Bu yakıtlar yeterli olmadığı için Pakistan petrol, kömür, doğal gaz ve nükleer kıtlıkla karşı karşıya. Bu nedenle fosil yakıtlar yerine kullanılabilecek yenilenebilir enerji kaynakları gibi fazla miktarda ve ücretsiz alternatifler araştırılmaktadır. Bu açığın üstesinden gelmek ve genel elektrik üretimini artırmak için Çin, Hindistan ve Türkiye örnekleri incelenmekte ve artan elektrik talebi zorluklarının üstesinden nasıl geldikleri hakkında ders alınmaktadır. Elektrik açığını gidermek için yenilenebilir enerji kaynaklarının fizibilitesini kontrol etmek için Pakistan QASP güneş enerjisi santrali ile Türkiye merkezli karabiner güneş enerjisi santralinin karşılaştırılması, santralin güç çıkışı, santralin özellikleri ve Bu güneş enerjisi santrallerinin devreye alınmasından sonraki faydalar.

Anahtar Kelimeler: Yenilenebilir Enerji, Elektrik açığı, QASP

TABLE OF CONTENT

ABBREVIATIONS

AC	: Alternating current
DC	: Direct Current
DOE	: Department of Energy
LG	: Local Grid
MPPT	: Maximum power point tracking
MTON	**: Milli**on ton
PV	: Photovoltaic
RE	: Renewable Energy
RES	: Renewable Energy Systems
SCADA	: Supervisory Control and Data Acquisition System
SG	: Smart Grid
TWH	: Terrawatt- hour

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

Supply-demand conflicts have taken their toll in a number of places throughout the world in recent years. Supply and demand mismatches have resulted in blackouts and load shedding, as well as electricity shortages, for governments and utilities. While governments endeavor to avert future supply shortages by strengthening their planning capabilities and attempting to establish a more stable and sustainable electrical industry, future shortages remain a possibility. The contemporary economy can't function without energy. Energy is required for all human activities, including education, health care, agriculture, and work. force is essential to the survival of the planet. It is regarded as a significant component of the country's economy. Currently, Pakistan is an emerging market. A large quantity of energy is needed to keep up with modern advancements and provide support for the population and industry. The nation, on the other hand, is severely short of power. Summertime power outages have increased over the last several years, with an average of 10–12 hours in urban areas and 16–18 hours in rural regions, due to a widening disparity between demand and supply. Pakistan's annual demand for energy is increasing at a rate of more than 9%. Pakistan's electricity consumption is predicted to grow by eight times by 2030 and twenty times by 2050, according to the country's government. The primary justification for the authority Power production in Pakistan is complicated by the country's reliance on costly and scarce thermal resources such as coal, oil, and natural gas. Hydropower's market share has fallen precipitously in recent years. Only 0.3 percent of the country's energy demands can be met by renewable sources. Solar power is the only renewable energy alternative that can handle all of these issues. It has emerged as the world's most affordable technology.(Irfan et al., 2019)

The occurrence of electrical shortages, which can be caused by a variety of circumstances, is classified as an electricity crisis. When available capacity (generation and/or transmission) is inadequate to meet peak demand; or when available capacity (generation and/or transmission) is insufficient to meet peak demand, capacity restrictions occur. Energy constraints: over time, all end-users intended electrical consumption surpasses production levels (for example, owing to limited fuel availability, such as water resources or fossil fuels, or an increase in energy demand. (World Bank, 2010)

The components of a personalized reaction to a power crisis will be influenced by the following factors:

(i) The cause of the supply-demand imbalance

(ii) The projected length of the deficit

(iii) The identification and assessment of the shortfall.

The key supply-side remedies to power shortages are increased generating capacity and availability. Short- and medium-term opportunities to improve the performance of already installed equipment, which can be the most expedient approach to boost effective generating capacity, are supported by a country's long-term energy development strategy. Increasing the availability of manufacturing capacity (for example, through improved maintenance) or minimizing transmission and distribution losses are examples of this. Any attempts involving the purchase of capital equipment are unlikely to be successful in addressing a short-term power shortfall. However, if the crisis lasts more than a few months, such measures may be possible. Many countries feel that increasing producing capacity using diesel fuel is the most cost-effective alternative, although this is not always or even usually the case. Most governments have prepared emergency generating plans that feature reciprocating high-speed diesel engines or medium-speed engines that run on heavy fuel oil (HFO). Diesel fuel, on the other hand, is a costly option that is also subject to price fluctuations. Furthermore, putting in place petroleum-based power capacity can be time-consuming. Engineering, procuring, and building medium-speed engines might take anywhere from 24 to 30 months. Rehabilitating existing facilities, repowering, and mobilizing backup generation are often faster and more efficient methods of increasing electricity supply. (Malik, 2019)

To deal with electricity shortages, governments in several nations have leased temporary mobile generating stations and implemented various measures aimed primarily at improving electricity supply. This is frequently a pricey and ineffective approach. Choosing the technology or solution to apply will be determined by the country's unique conditions. The expenses of swiftly bringing in more capacity should be weighed against the costs of using slower, less expensive methods. In addition, each solution will incur implementation costs such as incentive payments, expediting fees, spare components, and additional capital, all of which should be assessed on an individual basis. The actions chosen will be based on a review of the options in light of the nature of the crisis and other significant factors. The measures chosen will be based on how soon the effects must be felt. For any system, there will be a variety of options for increasing supply and decreasing demand. In the short term, there are frequently very few opportunities to increase generation capacity (less than six months).

A. Importance of the Study

This study was prompted by Pakistan's reliance on oil imports, which make up a large part of its budget. In 2011-12, the government spent $14 billion of its $43 billion budget on oil imports to power its factories and cars. This means oil imports accounted for 32.5% of the budget. Oil imports cost $9.36 billion in 2008-2009. If oil prices remain unchanged over the next decade, which is unlikely, the government will spend more than 140 billion dollars on oil imports. Two-shift autos fueled by alternative fuels are rare. If we support renewable energy sources, which are more ecologically benign, the government can spend more on infrastructure, education, and health care.

Another reason for using such tactics is that the country's electricity shortage has impacted every aspect of life. Not only has it resulted in job losses, but it has also prompted the majority of the country's industries to transfer to Bangladesh, where labor costs are lower and electricity is more reliable. As a result, the country's financial progress will be permanently hampered. According to a reasonable estimate, Pakistan loses 1.5 to 2% of its GDP per year due to lost industrial output due to power outages.(Hameedi, 2012)

This study has clear implications for the country's developing economy. Pakistan's energy crisis slows economic growth by almost 2% annually. Importing furnace oil has been the primary source of power generation over the past 20–25 years. In the last two decades, demand has quadrupled, growing by 9 percent annually. This number will rise by 2030. Energy availability influences economic advancement and stability, quality of life, enhanced governance, and a safe environment, according to IEA and other studies. Global energy demand is expected to "nearly double in 2050 compared to 2000 levels," with most of the rise coming from emerging countries. Today's "brilliant game" is to fulfill current fossil fuel demands while researching alternative and sustainable energy solutions to meet expanding power demand.

Pakistan's electricity distribution and transmission network is old and weak. Solar power can free this common electrical network and turn it into another traditional electricity in remote areas, where grid electricity is not available. Solar energy is already gaining popularity worldwide. Current work is still under way to improve the storage capacity of the cells used in it solar PV. It is also important at this time to formulate effective policies, which are followed by clear strategies and models to reflect solar energy in the world. In this regard, public-private partnerships can be reversed very fruitful. Various solar applications are used in Pakistan, including solar thermal, solar PV and desalination. Meanwhile, solar thermal energy production and solar water heater also they had great power. Reliance on fossil fuels for power generation can also be reduced the need for electricity and the supply gap can be met by using solar panels effectively home, community and industrial areas. In addition, it will also ensure the sustainable development of nation. (Irfan et al., 2019)

Solar power in Pakistan can generate 100,000 MW (8.76 108 MJ) and wind power 45,000 MW (3.94 108 MJ). Despite the state's potential ability to generate 41,722 megawatts (3.65 trillion megajoules) of hydroelectric power, over 40,000 communities lack electricity. Spain, China, and India are using renewable energy to meet their expanding energy needs. We can learn from them.(*Addressing the Electricity Shortfall in Pakistan through Renewable Resources | Semantic Scholar*, n.d.)

B. Energy Crisis and its Consequences

As a source of energy, electricity is a vital component of the manufacturing process. It is hard to maintain a high level of economic development over the long run without a steady supply of electricity. Using Pakistan as a case study, we can see how electricity shortages have impacted GDP growth and industrialisation, as well as job creation and the state's budget, resulting in hardships for the typical household. Demand for power is increasing in Pakistan's cities, but traditional oil is being utilized less. There is an acute shortage of electricity, particularly in rural regions where blackouts are widespread.The supply of electricity has dropped by 32 percent due to the need for good governance, mismanagement in the energy industry, and the lack of investment in electricity generation infrastructure. Although commercial measures for private sector distribution companies are in the works in the energy sector, they are moving at a much slower pace to reduce inequality in supply needs and stop ongoing power outages. Pakistan's economy, social welfare, and stability are all suffering as a result of these blackouts. (*Power Shortages in Pakistan: Causes and Solutions Pakistan's Energy Crisis and Its Consequences*, n.d.)

1. Slow Economic Growth

According to a study by Pasha et al. (2013), power outages cost 7% of Pakistan's GDP and reduce the country's economic growth rate by 2%. Transmission and distribution networks (T&D) are overcrowded, outdated, and inefficient, as well as power losses on the consumer route, forcing businesses to invest in expensive, inefficient, but reliable internal power supply from time to time from the power grid. Power shortages have also hampered the manufacturing sector's ability to create jobs, contributing considerably to Pakistan's rising unemployment rate. Meanwhile, industrial customers pay substantially higher power tariffs than their counterparts in neighboring nations, rendering Pakistan's exports uncompetitive in global markets. Inflation arose as a result of higher electricity rates, raising the cost of living for consumers and households across the country.(*Power Shortages in Pakistan: Causes and Solutions Pakistan's Energy Crisis and Its Consequences*, n.d.)

2. Risk to Stability

Over the last decade, frequent power outages have triggered significant law and order crises in Pakistan, as well as huge protests. However, the situation has improved marginally in the previous two years, lessening the frequency of these protests. Repeated outages, on the other hand, degrade the state's legitimacy and capacities, making it more difficult to counter the influence of insurgent groups. As a result, resolving the electrical crisis is crucial not just for economic stability but also for political stability.

C. The Roots of Energy Crisis

Pakistan's energy sector has lacked the ability to meet expanding demand for decades. Debt restructuring, finances, and electrical supply all contribute. 80% of energy businesses rely on natural gas and oil. Low-cost hydro and coal-fired power plants contribute to power shortages and inadequate electricity production. Pakistan's energy demand has risen due to its 3% annual growth rate. The energy business is using more coal, natural gas, crude oil, and LPG. Pakistan's energy consumption was 38.8 MTOE in 2015 and 70.5 MTOE in 2016..(Rehman & Deyuan, 2020)

Economic growth and development rely greatly on energy availability and consumption. Electricity, a constantly changing energy source, is crucial to economic prosperity. A lack of energy policy and production has contributed to economic stagnation in several countries. This research classifies power shortages as demand- or supply-based. China's FDI offers Pakistan three advantages over other sources. The next paragraphs explain these three criteria.

1. GrowIng Household Demand

Over the last 42 years, household power usage has increased at an annual pace of 10% on average. In addition, the government was electrifying the countryside. As a result, home power use rose from 12% to 47% between 1971 and 2000.. In the meantime, the industry's proportion of total electricity usage fell from 54 percent to 30 percent over the same time. These variables combined result in a rapid increase in the number of users and per-user electricity consumption, hence increasing household electricity demand. Changing energy consumption has also made industrial taxes unsettled in various categories and slabs, especially in a situation where budget subsidies are being abolished and all the various subsidies are covered by high charges for industrial and commercial consumers.

2. Consumption that is Inefficient

Between the year 2000 and 2007, there was a credit-driven spending boom in Pakistan, which increased the use of electrical appliances. Inefficient residential use added to the power problem as a result of this rise. Inefficient appliances waste more than a quarter of a family's power, according to a 2008 Asian Development Bank report.

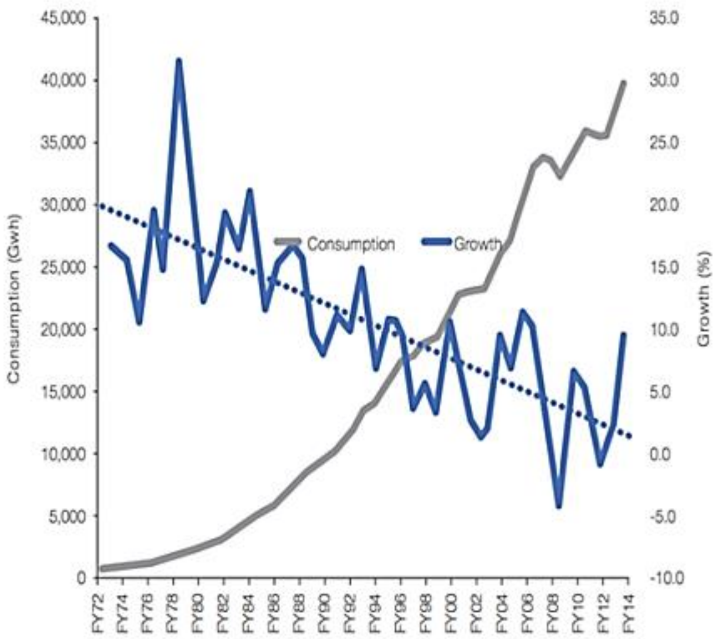

Figure 1: Increasing consumption of inefficient appliances [63]

3. Power Generation (Supply Side)

Despite having a diverse range of natural resources, Pakistan's ability to generate electricity is severely limited. Investing in the industry plummeted between 1995 and 2010, resulting in slower-than-planned capacity development and lost efficiency improvements.

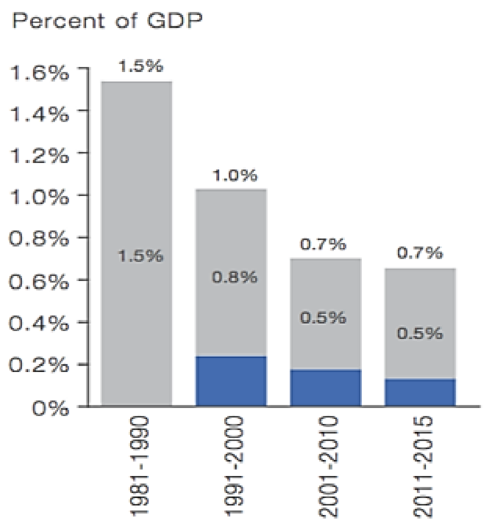

Figure 2: Percent GDP of Pakistan [54]

4. Financial Management

Power generation has been hampered by Pakistan's inability to pay for the electricity it generates. Most of the power sector's financial difficulties may be attributed to inadequate governmental policies and bad administration, including mismanagement and a failure to adjust consumer rates despite considerable increases in generating costs. Any country's economic growth and development depends heavily on its ability to access and use energy. An important factor in the growth of the rest of the economy is electricity, which is active and fosters economic activity. In the last several decades, a lack of energy policy and production has led to economic stagnation in a number of nations. Economic stagnation has been the result of Pakistan's energy policy failures over the last several decades..(Rehman & Deyuan, 2020)

5. Governance Concerns

There is a paucity of human resources, corruption and rent-seeking, and a regulatory capacity deficiency in the management of organizations. While Pakistan's T&D energy losses have decreased marginally (from roughly 25 to 28 percent of total power production in 1995 to 20 percent in 2015), the pace and scope of progress remain lower than many other emerging nations. For both utilities and the government, T&D losses have continued to be substantial, resulting in enormous financial losses for all parties. There are several factors that influence the need for energy in Pakistan, such as fast population increase, economic expansion and rising power costs. Due to theft, misuse, overuse, and production and corruption, as well as exaggerated, inappropriate, or inferior institutional maladministration and political conflicts over major power projects in Pakistan's short-lived power crisis.(Rehman & Deyuan, 2020)

6. Lack of Accountability

In terms of boosting performance and reducing electricity theft, poor performance demonstrates a lack of accountability among energy sector personnel. Although the government has sought to put in place systems to track performance and ensure that it improves over time, little evidence of real enforcement has been found. These initiatives are more likely to succeed when government activities are backed up by equivalent actions from other parties. For example, improved enforcement may be seen in the swift steps taken by the police and courts to prevent power theft and losses.(*Power Shortages in Pakistan: Causes and Solutions Pakistan's Energy Crisis and Its Consequences*, n.d.)

D. Structure of Thesis

In **chapter 2** of this thesis the literature review of the previous research done on the problems faced by Pakistan has been studied whereas the solutions provide in background by different researchers is provided.

In **chapter 3** of the thesis the challenges faced by Pakistan to overcome the shortfall of electricity are discussed.

In **chapter 4** the generation of QASP plant and Karapinar power plant has studied and the benefits of both power plants are discussed in detail and the difference between them are provided.

In **chapter 5** the conclusion of the research done is provided which specify the benefits of using the RE sources to overcome the shortfall.

II. LITERATURE REVIEW

In 2020, Pakistan's electricity consumption is expected to reach 112,070.000 GWh. This is a rise above the 109,461.000 GWh total from the previous year. Electricity Consumption in Pakistan: Since June 1991, annual energy usage has averaged 64,465,000 GWh. According to published statistics, 2020 will see 112,070.000 GWh and 1991 31,534.000 GWh. Finance Ministry still receives CEIC data. Pakistan - Table PK.RB006 includes electricity generation and consumption.(*Pakistan | Electricity Generation and Consumption | CEIC*, n.d.)

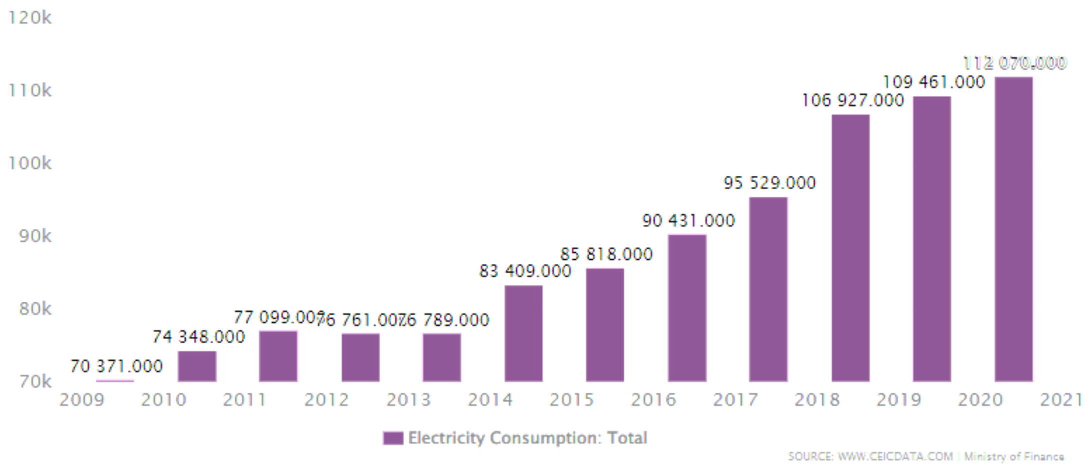

Figure 3: Electricity Consumption year 2009-2021 [63]

In 2020, Pakistan Fossil Fuels Consumption was estimated to be 4,875,302.000 TOE. The total of 2,640,347.000 TOE is up from the previous year's total of 2,640,347.000 TOE. Pakistan's use of fossil fuels. From June 2004 through 2020, coal data is updated annually, with 17 observations averaging 72,568.000 TOE. The data peaked in 2020 at 4,875,302.000 TOE, after falling to a low of 28,204.000 TOE in 2013. Pakistan's Hydrocarbon Development Institute reports coal statistics, which is still functioning in CEIC. Pakistan's Hydrocarbon Development Institute reports coal statistics, which remains active in CEIC. Pakistan is the subject of the information. Electricity Generation and Consumption in the Global Database, Table PK.RB006. (*Pakistan | Electricity Generation and Consumption | CEIC*, n.d.)

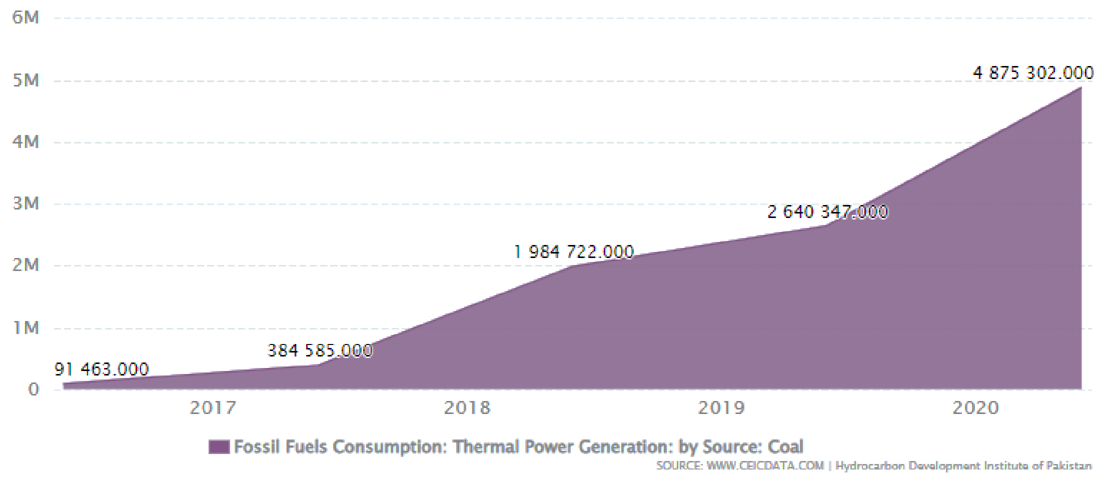

Figure 4: Coal consumption year 2017-2020 [64]

Pakistan's energy demand has surged by over 45 percent in the last decade. Energy output, on the other hand, has taken a flatter path, widening the demand-supply imbalance significantly. The energy sector will be unsustainable if this trend continues for the next few decades. In this chapter, the current situation of Pakistan's energy sources and domestic power are being discussed.

The following is Pakistan's current energy scenario:

Pakistan had 66.0 million tons of oil equivalent (toe) in 2013 and 2014, with 45.3 mton (69.5%) coming from local production and 21 mton (31.46%) from imports. Domestic energy sources include natural gas, hydropower, a third of crude oil distribution, and modest quantities of coal and nuclear energy.*Natural gas 50%*

- *Oil 31%*
- *Hydel energy 13%*
- *Coal 7%*
- *Nuclear Energy, Low pressure gas, & imported electricity combined share of 0.74%*

A. Oil

On a yearly basis, the nation refines 12–13 million tons of oil domestically. The "Pak-Arab Refinery Complex (PARCO)," which began operations in late 2000 and with a refining capacity of 95,000 barrels per day, is the country's largest oil refinery. The country's three key oil-producing regions are located in the Southern

Indus Basin, and the bulk of produced oil originates from proven deposits in the country's southern half." 27 In 2006, domestic crude oil output averaged 58,000 barrels per day. The nation is severely reliant on imported oil to cover its energy demands due to its meager domestic oil output. Pakistan now imports more than a third of its primary energy requirements, largely from foreign sources, at a cost of over $15 billion per year.

B. Natural Gas

British colonization made oil and gas the primary sources of energy. In Punjab's Mianwali District, the first well was drilled in 1887, which signified successful drilling (now Pakistan). Then, wells were dug in Baluchistan province. Later, exploration was carried all around the country. After finding 10 trillion cubic feet of gas reserves in 1952, the Baluchistan province of Sui has become a major player in the energy sector. A number of major oil companies signed agreements after the discovery of the Sui gas field in 1954. These included Standard Vacuum Oil, Hunt International, Shell, Sun, and Tidewater (1958). Pakistan's government opted to explore hydrocarbon resources through two state-owned firms after the failure of franchise agreements in Pakistan.

The supply-demand disparity is always expanding. "Even taking into account projected natural gas imports, Pakistan's energy imbalance would reach around Oil equivalent (MTOE) production will reach 15 million tons by 2020," according to figures compiled by the Pakistan Institute of Petroleum (PIP). Pakistan's real-time natural gas availability and consumption are estimated to be approximately 40 billion cubic meters per year, according to the most recent government figures (Bcma).

C. Coal

Despite considerable energy advancements, coal still accounts for the greatest proportion of all energy resources in the world, accounting for nearly 39% of worldwide power output. There are other advantages to coal. It is plentiful, very affordable, and safe to store and transport. The following are the top nations in terms of coal dependence as a source of energy generation: In Poland, coal is utilized to generate about 95% of electricity, 92 percent in South Africa, 77 percent in China, and 76 percent in Australia. Despite environmental concerns, the use of coal as a source of energy is increasing at a greater rate than any other energy source, including hydro, oil, gas, renewables, and nuclear. Despite Pakistan's estimated 3,362 million short tons (MST) of known recoverable reserves, coal plays a modest role in the country's energy mix, according to the research. 41. Despite these large, verified resources, Pakistan only consumes roughly 3.5 million metric tons of coal for energy generation each year, which is a small part of the country's current energy mix. The Geological Survey of Pakistan (GSP) and the United States Geological Survey identified massive coal deposits in Tharparkar (Thar) in Sind Province in 1992. (USGS). Over 200 holes were bored as part of this research project, which spanned over 350 square kilometers.

D. Hydroelectrıcıty

Pakistan's current peak usage is barely 21,000 megawatts, compared to 60,000 megawatts. Hydroelectricity is cost-effective and ecologically friendly. Only 11% of Pakistan's hydroelectric potential is utilised, leaving 89% undeveloped. Hydroelectric plants produce 6,720 megawatts. The country's most significant power plants are Terbela, Mangla, Warsak, Guddu, and Chashma. In Azad Jammu and Kashmir, the Hydro-Electric Board (HEB) and the Gilgit-Baltistan Water and Power Department (WPD) supervise hydroelectric projects administered by SHYDO (AJ&K). The following tables show installed projects' management sector, location, and generating capacity.(*Energy Crisis in Pakistan*, n.d.)

E. Nuclear Energy

A total of 462 MW is currently being generated by two nuclear power facilities. Managing Pakistan's two nuclear power stations, PAEC is a government agency (Pakistan Atomic Energy Commission). When the Karachi Nuclear Power Plant (KANUPP) was built in Karachi in 1971, it was Pakistan's first nuclear power plant, built under a turnkey arrangement with Canadian General Electric. It was in 2000 when the second Chashma Nuclear Power Plant-1 (CHASNUPPI), built by China National Nuclear Corporation under a turnkey deal, went into service. A second KANUPP reactor, known as CHASNUPP-II, has been ordered by the Pakistani government after the first reactor, KANUPP, was built successfully in

China.

F. Other Renewable Energy Sources

Wind and solar electricity are plentiful and endless resources in Pakistan that, if utilized efficiently, may boost energy security and independence. The Alternative Energy Development Board (AEDB) was created in May 2003 as a center for developing and promoting renewable energy technologies, strategies, policies, and production technologies. of Pakistan's renewable energy plants. The Pakistani government has tasked the AEDB with ensuring that renewable energy technologies can contribute 5% of total national power generating capacity by 2030. The country's total renewable energy production now stands at 40MW, representing for 0.21 percent of total installed generating capacity of all sorts. In the short to medium term, the country's renewable energy sector would require around 16 billion dollars in investment. Given Pakistan's present economic circumstances, such a massive expenditure is not feasible at this time.

Renewable energy is quickly growing over the world, according to IEA estimates. Renewable energy (including hydropower) provided around 21% of global electricity in 2011, with forecasts that this figure would rise to almost 25%–30% by 2040. But attempts in Pakistan to diversify the country's energy mix or even solve the massive supply-demand imbalance by replacing fossil fuels with renewable energy sources (except significant hydro) have failed for a number of reasons. According to its charter, the AEDB's primary objective is to "enable, promote, and encourage the development of Renewable Energy in Pakistan," with the "mission to introduce Alternative and Renewable Energies (AREs) at an accelerated pace."

G. Wind

We have come a long way since the days of windmills. Wind turbines convert wind energy into electrical energy. Measured windmills are attached to towers 300 feet or more in height. The wind is fast and unpredictable at high altitudes. Any number of vertebrae are connected to the energy transfer on the state scale, producing energy as the wind moves the wings and turbine. Wind power has grown dramatically in popularity in the United States and many other countries over the past two decades. The Bureau of Property Management (BLM) maintains more than 20 million hectares of state-owned wind power in 11 western states, and has authorized wind power operations in public places since 1982. Air provides around 6% of the world's energy. Wind turbines may be placed anywhere with strong wind speeds, including mountain summits, plateaus, and the open sea coast, although the most typical sites are California, Texas, Oklahoma, Kansas, and Iowa. Service roads enhance the environmental effect of most land-based wind farms. This subsystem employs environmentally harmful metals and fossil fuels. In their current state, rotor blades cannot be reprocessed or recycled, but other wind turbine components may be. NREL scientists employed thermoplastic resin to construct wind turbine blades. Thermoplastic polymers allow rotor blades to be reused and reduce energy usage.

- About 31 wind power IPPs (1810 MW) with AEDB are presently under construction, with the following projects currently under development:.
- 50 MW First Wind Farm Pakistan (Pvt.) Limited in Jhampir Sindh's Three Gorges, Jhampir Sindh
- 50 MW Foundation Wind Power-I Ltd. at Gharo, Sindh.
- 50 MW wind farm owned by Foundation Wind Power-II (Pvt.) Ltd.

H. Solar

An hour and a half of sunshine can power the earth for a year. In solar technology, photovoltaic (PV) modules or mirrors direct sun radiation to create electricity. This kinetic energy may be stored in a battery or thermal energy storage device.

Solar energy can heat water in buildings, homes, and pools. It heats greenhouses and other buildings. Solar thermal plants can heat fluids. Calculators, watches, and other tiny gadgets employ PV cells. Multiple PV panels and arrays with numerous solar cells may power a dwelling. Solar panels Large-scale PV facilities may power thousands of homes.

Photovoltaic systems have low environmental impact on buildings and don't release pollutants or CO2. Solar energy's minor limitations include fluctuating sunshine levels. Geography, time of day, season, and climate affect sunlight. To capture enough solar energy, you need a large region of Earth's surface.

Pakistan's PM opened a 100-MW solar energy project on May 5, 2015. 33 letters of intent have been granted for solar PV power facilities totaling 888.1 megawatts (MW). The AEDB authorized just one of four businesses' feasibility studies. Other sponsors are learning lessons. On January 21, 2014, NEPRA gave 50 MW solar installations an upfront tariff.(Hassam Aziz et al., 2018)

i. Biomass

About 4.8 percent of US energy consumption and about 12 percent of all renewable energy is produced from organic resources such as wood and agricultural waste, respectively. Wood is the most widely used biomass energy source. Biomass power plants in the United States today number 227. The United Kingdom has 35 operating, 15 under construction, and 17 in the works.. Biomass, on the other hand, is it really renewable?(*Is Biomass Really Renewable?*, n.d.)

Burning organic matter to uses heat or run steam turbines and generators, going to burn organic matter to generate energy in heat exchangers (when merged with electricity generation, it's called "combined heat and power"), starting to turn biofuels into biofuel production, and extracting gas from landfills are all examples of ways to generate energy from biomass. Bioenergy is considered an effective energy source since its inherent energy comes from the sun and it can replenish in a short amount of time. When trees die, they take CO2, alter it to bioenergy, and then emit it back into the air. Trees emit the very same quantity of carbon into the atmosphere whether they are burnt or degrade naturally. The theory is that if trees cut for biomass are seeded as quickly as the biomass is burned, young trees actually take the carbon released by the burning, the carbon cycle remains in equilibrium, and no more carbon is contributed to the environmental balance sheet—thus biomass is potentially "carbon neutral."(*Is Biomass Really Renewable?*, n.d.)

Biomass energy, on the other hand, is now classified as renewable and hence eligible for tax credits, subsidies, and incentives in the United States. This included the Renewable Electricity Output Tax Credit, which ends up paying sealed (organic material planted solely to generate power) biomass power producer in the world $.023 per kwh of electricity and open-loop biofuels (any other waste or residue) energy production $.012 per kwh of electricity; and Renewable Energy Certificates, which earn a credit that can be sold, traded, or bartered for every megawatt of electricity produced by biomass, providing its owner the right to claim. Under IPP mode, these Biomass/Waste-to-Energy projects are underway:

- SSJD (12MW) Sindh
- Lumen Energia, Punjab (12 MW)
- Biomass Power Generation (12 MW), Faisalabad
- Green Sure Environmental Solutions (12 MW), Mardan, KPK

In addition, a framework for power The Economic Coordination Committee (ECC) approved Co-generation 2013 (Biomass/Bagasse) for bagasse/biomass-based sugar sector projects. In the next 2-3 years, 1500-2000 MW of power is predicted to be created.

J. Practical experience needs to be learned from China, Turkey and India

This study's main purpose is to assess China, India, and Turkey's strategies for optimizing renewable resource value and to determine whether Pakistan may employ similar tactics. These chapters focus on the case study technique used to solve this question. A power outage hinders Pakistan's economic growth during a challenging growth phase. Winter river levels cause a daily power loss of 7,000 MW (602 toe). According to the Pakistan Energy Year Book 2011, oil and gas make up 35% and 27% of Pakistan's energy output. A third of the budget goes to oil exports, which outweigh all other government spending by $14 billion.(Hameedi, 2012)

There is a pressing need for Pakistan's government to concentrate on the development of renewable energy sectors. As a result, Pakistan's renewable energy sources will become more affordable for its citizens. The government's support for renewable energy is critical. Pakistan is preparing for renewable energy because of its abundance of rivers. The use of rivers, wind, and solar energy is widespread throughout the nation. Pakistan's renewable energy resources may be promoted using the following methods.

1. Enhancing Consumer Awareness in Pakistan

By making energy more visible and removing the expense of getting information, recent technology advancements in the energy market provide a chance to bridge the gap between awareness and action on energy-saving behavior. There have been numerous recent studies looking at the impact of reducing the electricity consumption of real-time home-based data; some studies report energy savings of 8-22% (Aydin, Brounen, & Kok, 2018; Grnhj & Thgersen, 2011), while others claim that the display response has no bearing on power consumption. A limited sample size and "suitable circumstances" may lead to findings that are biased or lead to hypotheses, despite the fact that these studies are incredibly useful. (Trotta, 2021)

Consumers will require greater information about their power consumption and an active participation in limiting their energy use as demand for electricity is expected to rise in residential areas and more periodically renewable resources are allocated in the supply chain. Consumer indifference and ignorance are, unfortunately, all too common, particularly in places where people have a lot of authority. Using a novel survey and actual monthly electricity consumption data, the study planned to measure the level of electricity bills, prices, and costs among other Finnish families as answers to six questions and investigate whether high levels of electricity "Electricity awareness" are associated with energy savings. For this survey, we also looked at the readiness of respondents "who are aware of electricity" or "unconscious electricity" to learn more about ways to save money on their utility bills. This country's administration must take steps to raise public awareness about the need to save energy. Because power plants will have to generate less energy as a consequence of consumers saving more energy, this will have a reduced impact on the environment. Advertising in print and electronic media may aid with this. Energy for Growth and Sustainable Development was the focus of an event conducted by the Punjab government in February 2012. Customers' energy consumption was a major topic of the conference. (*Addressing the Electricity Shortfall in Pakistan through Renewable Resources | Semantic Scholar*, n.d.)

2. The Strategy of Enhancing Capacity of Hydro power Adopted by China

Hydropower accounts for barely 33.6 percent of Pakistan's total power generation, despite the fact that rivers flow through almost all of the country's most important regions (see the graphic at the bottom of the page). Small hydroelectric dams along Pakistan's rivers should be built as soon as possible. Small hydro dams would be expensive for Pakistan to build, but I feel they are critical to the country's future. Counter-strategic in the monsoon flood war, it will lessen damage to infrastructure by the end of the season.

The federal and provincial governments may save money by living more simply, especially when it comes to fancy government buildings, procedures, and security, when it comes to budgeting. Consequently, the government will encourage its citizens to join this good cause. The importance of the Indus River cannot be overstated since it runs through the whole country, with the rest of the rivers serving as its tributaries. Many people believe hydro dams with a lesser environmental impact are better for the environment. Increased water storage capacity and reduced flood risk are only two of the benefits that a system of modest hydro dams might provide for Pakistan. To combat winter water shortages and raise subsurface water levels all around the nation, Pakistan would benefit from this all-encompassing water management system. You can't neglect to point out that a big network of little hydro dams will allow remote regions to become self-sufficient, with each little hydrodam providing just for that region's energy needs. This would be careless of me. As a result, Pakistan's distant rural regions will benefit from a more decentralized energy distribution system. For the most part, the government has the authority to recruit construction workers who live in the region where the dam is to be built. Rebuilding trust in the democratically elected government and stoking a construction boom throughout the nation would be a win-win situation for everyone. When it comes to this issue, Pakistan's government might seek advice from its Chinese counterparts. Small hydropower facilities in rural China now power 300 million people. The installed capacity of China's small hydroelectric dams is expected to reach 75,000 megawatts by the end of 2020, up from 51,000 megawatts in 2008. A similar strategy might be used in Pakistan in order to provide electricity to distant sections of the nation. According to estimates, hydropower can produce 41,722 MW of electricity. The remaining 8–10% of this potential is still under development, meaning that only around 15% of it has been put to use yet. As a consequence, only around seventy-five percent of the potential has been fulfilled. (Hameedi, 2012)

3. Use RE-Source Name As PV Panels Adopted By India

The concept that solar power may be a one-stop solution to all of India's environmental and independence issues has been developed. No question that India is a devotee of the sun god, and with more than 300 bright days a year, solar power is a viable option for the country's energy needs. Fishing, on the other hand, is still a popular pastime: the sun is only out for half of the day, and relying too much on solar power may be perilous in the dark. The government has set a goal of increasing its installed solar capacity from 4000 MW in 2015 to 100,000 MW by 2022, an almost 25-fold increase. In order to meet this ambitious goal of 100 gigawatts in the next seven years, India would need to spend around 14,000 MW of solar energy per year for the next seven years. In the preceding five years, India only managed to add 2000 MW of solar capacity.

Similarly, Punjab's rural parts have a well-developed canal and barrage system to satisfy the country's agricultural needs. Canals in Pakistan cover 62,648 kilometers (km), and since they are exposed to sunlight for at least six to eight hours a day, water loss is especially high in these regions. On the other hand, solar panels mounted on canal rooftops would prevent evaporation while simultaneously generating power. The Punjab area, which is the country's breadbasket, would benefit from the installation of solar panels atop canals.

K. Challenges and obstacles to Overcome the shortfall in Pakistan

This country's energy issue is well-entrenched, as seen by the events of 2014 and the beginning of 2015. Lack of efficient institutional and organizational procedures has aggravated Pakistan's current position. Pakistan's looming energy issue will not be alleviated just by boosting energy production or building new infrastructure, it must be acknowledged. Because present production capacity and peak time demand are almost equal, it is natural to conclude that management defects (including governmental, institutional, and political hurdles) are the primary impediment to stabilization.

Another problem with current generating capacity is that it is not being used to its fullest extent, according to an ADB report provided in February 2014. Due to a shortage of fuel, all eleven of the state's public thermal power plants were forced to shut down in May of 2013. Because of a lack of cohesiveness and unity at the top, Pakistan's energy corporations are unable to formulate long-term, forward-looking strategies. Oil and gas regulation is the responsibility of the Oil and Gas Regulatory Authority (OGRA).

1. Physical Supply Shortfalls

Pakistan depends on coal, oil, natural gas, and hydropower, along with traditional and commercial fuels. Petroleum, natural gas, and other fossil fuels provided 24.8%, 31.7%, and 34.9% of Pakistan's energy in 2012. The remainder was hydropower, coal, and nuclear. Pakistan's power production relies on basic fuels and protects people, companies, and other economic sectors. 35.9% of Pakistan's energy comes from fuel oil in 2013, followed by hydropower, natural gas, and nuclear power (28.1 percent).Oil has grown its share in electrical generation since the 1990s, while hydroelectric sources have stayed mostly stable. Hydroelectric power plants provide energy for around 20% to 25% less than other fuels, but they have greater upfront construction costs than oil or coal plants. As a result, despite the fact that hydropower is Pakistan's cheapest source of electricity, obtaining the necessary funding for such projects is extremely difficult. Pakistani administrations have tried unsuccessfully for more than a decade to get donor funding for the Diamer Basha dam and other infrastructure projects.

For almost a decade, Pakistan failed to spend appropriate resources in upgrading the system's capacity and keeping pace with rising demand, which led to the current energy shortfall. While Pakistan's neighboring countries have higher levels of investment, it is much less than in Pakistan. Because of the decline in the national savings rate, the country will be unable to make up for the loss of foreign investment by increasing its asset base. 10 Security concerns and the failure of the electrical industry to pay all expenditures via tariff revenues have weakened Pakistan's reputation as a foreign investment destination over time. The power industry is particularly vulnerable to a drop in investment since it requires such large sums of money to produce and distribute electricity. Pakistan's biggest difficulty is this. Savings and investment losses in the power industry are a symptom of wider macroeconomic trends that are cause for worry.

Pakistan's electrical sector has lost international investment in recent years. Since the 1990s, practically every corporation that invested in private-sector enterprises has sold its shares. Uch Power is the sole exception. Several Pakistani oil and gas enterprises were sold to local and foreign investors.

2. Demand Growth

State-owned and commercial power plants make up Pakistan's 22,812 MW electrical grid as of June 2013. Under Pakistan's 2013 electricity program, new coal power plants would be developed to take use of hydropower and coal. The government wants to increase 16,545 MW of electricity capacity by 2018, mostly via new coal plants. Installed capacity and output differ greatly. Due to fuel and budgetary restrictions, plant maintenance, and other challenges, supply peaked in July 2013 at 14,000 MW, or 60% of installed capacity.

In contrast, annual energy consumption climbed by only 0.4 percent during the next five years. The major reason for the delay was a shortage of supplies. The industrial and agricultural sectors, respectively, utilized 3.2 percent and 3.9 percent less energy per year. Despite the supply bottleneck, home energy demand climbed by around 5% every year. Over the previous five years, the annual increase in power usage was also low, at only 0.9 percent. Across the board, there was a drop in growth.

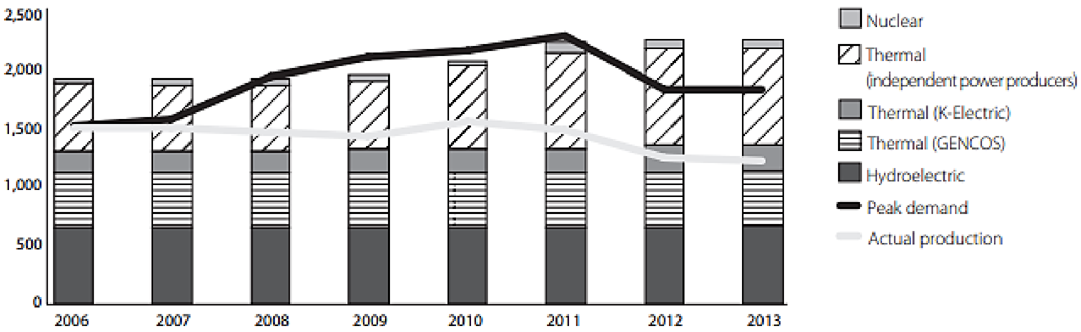

Figure 5:Actual Generation vs Peak Demand [62]

Energy consumption, especially the demand for electricity, has increased with rising wages, but power stations, government, and the private sector have failed to invest to meet this growing demand. The installed power generation capacity increased by only 3,000 MW (less than 2% per annum) between 2006 and 2013, while the supply of electricity remained stable at 95–98 hours of terawatt-hour

(TWh). 16 The current difference in the supply of electricity began to emerge in 2007. Since about 3,000 MW, the gap has increased over time, exceeding 7,000 MW in 2011, as demand continues to rise while supply remains stable.

3. Financing Troubles

The present power crisis is caused by underinvestment in energy generation and delivery. When operating capital or credit is limited, businesses may not utilise all of their present capacity and new capacity may be delayed. The industry depends extensively on government subsidies to fill the financing gap between available financial resources and production costs, worsening investment and supply mismatches. Since 2003, electricity rates have been below NEPRA mandates. Successive administrations have kept power prices below NEPRA estimates through tariff differential subsidies. Due to late or irregular payments to fuel suppliers, electricity producers, and distribution businesses, they have weighted down government budgets by 2% of GDP yearly over the previous five years. WAPDA's financial stability must be protected to relieve industry financial limitations. WAPDA's capacity to invest more in hydropower will reduce energy prices. The reverse is typically desired. WAPDA payments are more limited than IPP payments. When the government invests in WAPDA, it has written down receivables and used cash as a buffer. This is wrong. WAPDA's cash reserves are a well-deserved prize. WAPDA's financial reserves will expand year after year thanks to this money.

4. Pakistan’s Electricity Generation Capacity and Energy

Hydro's proportion of total energy generation has reduced in FY2021, compared to FY2020. The bulk of electricity is presently generated by thermal power plants. Furthermore, its percentage share in FY2021 has increased compared to FY2020. The growing usage of RLNG in the energy mix has helped to improve power plant supply. RLNG is supplied to the fertilizer industry, as well as the industrial and transportation sectors. The following is a table that compares the installation and generating capacity of various power sources:

Table 1: Pakistan generation capacity w.r.t. different sources [53]

Type of Source	Installed Capacity in MW	Percentage Share
Hydel	9,874	26
RLNG	7325	19.66
RFO	6274	16.84
Coal	4770	12.80
Gas	4529	12.15
Nuclear	2490	6.68
Wind	1235	3.31
Solar	400	1.07
Bagbasse	364	0.98
Total	37,261	100

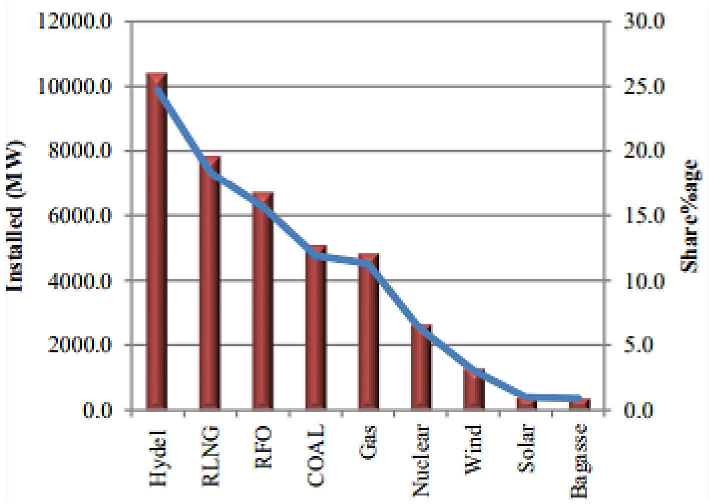

Figure 6: Pakistan generation capacity w.r.t sources in percentage [61]

Electricity installed capacity reached 37,261 MW in April of FY2021, an increase of 3.6 percent.

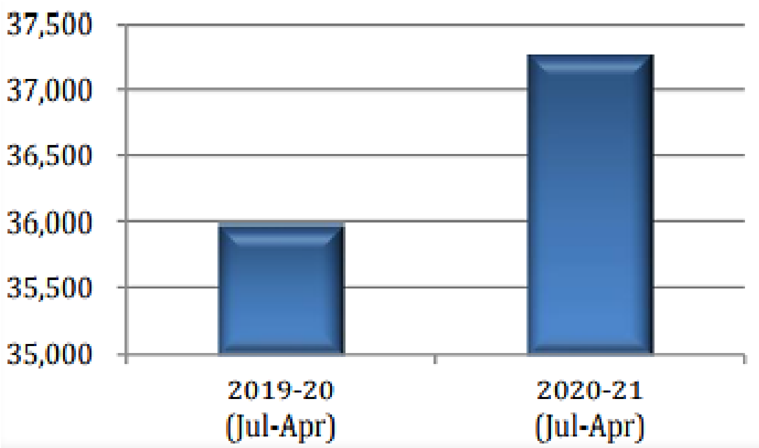

Figure 7: Pakistan generation capacity in mega watts

(2019-2021) [57]

Pakistan has been less reliant on imported coal, indigenous coal, RLNG, and natural gas in recent years. Pakistan's natural gas dependency is diminishing as reserves deteriorate and LNG enters the market. Renewable energy's percentage in overall energy mix has grown. The government is also considering adding hydropower and nuclear power to the energy mix.

These developments will affect how we drive, heat, and power our homes and companies as global energy networks evolve. In the future decades, these advancements will affect organizations, governments, and individuals. Pakistan has created an Electric Vehicle Policy 2020-25 to use these advancements domestically.

Power outages in Pakistan have lasted 16 hours. Lahore Electric Supply Company (LESCO) has resorted to unplanned load shedding due to a shortage in energy supply, and grid station strain is generating additional feeder excursions. Geo News reports that a scarcity of water in Tarbela Dam and gas and oil in power plants have impeded electricity generation. Several cities in Pakistan, including the capital Islamabad, lost electricity in January. In 2015, a lack of infrastructure, malfunctioning meters, and theft caused a 29% energy shortage and a 15% power loss. Due to underpricing and difficulty to collect electricity bills, "circular debt" has caused power outages. Lack of grid electricity promotes kerosene lights, which pollute the air and raise the risk of respiratory ailments and TB. If Pakistan's whole population was linked to the grid and electricity was accessible 24/7, $4.5 billion in family income and $8.4 billion in business losses might be averted.

L. Gas Shortfall

Pakistan's energy crisis is not only a problem but also a serious gas disaster. The country has been constantly accessing domestic resources for the past 50 years to meet the needs of the national gas pipeline network, which serves about 20 percent of households and a large number of industrial and commercial users. This abundance of cheap gas supply has stimulated industrial and economic growth. However, the supply and demand dynamic has switched from affluence to scarcity. In reaction to the shortage, gas load shedding and supply limits have become normal measures. During the winter season, almost every sector was affected, including residential, industrial, and commercial. If this tendency continues, the government will fail to respond promptly, forcefully, and effectively to the crisis. According to projections, by 2030, the demand-supply imbalance would have grown by eight times..(*About the RepoRt*, 2015)

M. Short Fall of Water

Water is recognized as one of the most valuable resources on the planet. This is due to the fact that it is the source of all life. As a result of population growth, urbanization, industrialisation, and habitat change, water resources have been severely strained across the world. There are also concerns that global water supply wars will explode shortly. In 2001, former UN Secretary-General Kofi Annan remarked, "Fierce competition for fresh water may probably become a source of future disputes and wars." the year 2007 (Diner) Ismail Serageldin, Vice President of the World Bank, said in 1995 that the next century's battles will be fought for water. Under the current circumstances, when Pakistan must preserve every drop of available water, it can only be regarded as a national tragedy that over 30 million acre-feet of water is lost every year into the sea when it could otherwise be properly capitalized. As a result, catching this water became practically vital for a number of purposes, including electrical generation, agriculture, and drinking. Pakistan looks worried about such a valuable supply of power at a time when several dams are being developed in India and China. It will be extremely difficult for Pakistan to maintain and strengthen its socioeconomic conditions and national sovereignty in the coming days if it does not change its attitude toward meaningful exploitation of its water resources for various applications in general, and for electricity generation in particular.

N. Rising Energy Demands in Pakistan and Alternatives

Pakistan is experiencing an energy crisis in terms of natural gas, electricity, and oil. Pakistan's total energy demand is predicted to rise from fourty eight million to fifty four million tons of oil equivalent (MTOE). Natural gas is a major component of Pakistan's energy mix, accounting for fourty nine percent of total consumption and used mostly in the power, residential, and industrial sectors. Oil accounts for thirty one percent of the total, the majority of which is imported.

O. Alternative Measures

1. Supply Increase

The government's execution of power policy has been most visible in plans to add additional generating capacity. The 6,600 MW coal-fired Gaddani Power Park, which will be finished in 2018 with funding from China and Middle Eastern investors, a 1,000 MW solar power complex in southern Punjab, and 1,410 MW of additional generation capacity at Tarbela are among them. With China's help, the government has also stated its plan to build up to 8,000 MW of additional nuclear generating capacity by 2030, although little specifics about the scheme have been made public. Pakistan's total installed capacity would expand by nearly two-thirds over present levels if all of the government's new generating projects are finished. While coal-fired plants will account for more than 70% of the additional capacity, the remaining 30% of planned generating capacity will be based on a range of fuel sources and technologies.

2. Learning from Neighbors' Experiences

Several Indian states have energy grids that are similar to Pakistan's national system, despite the fact that both countries are large. Pakistani authorities may learn from India's electrical business. Rapid growth rates in both supply and demand have been seen in the Indian system during the last five years. Economic growth was hindered by power supply concerns in India in the early years of this decade and in 2008–10. A large percentage of Indian and Pakistani utilities depend on government and state subsidies for 10–12 percent of their overall financial resources. Two important improvements implemented by the Indian government have enabled the country to attract substantial international investment. Energy merchants and utilities may now buy and sell electricity thanks to the Electricity Act of 2003. In the second reform, availability-based pricing and a system for unexpected interchanges were first implemented for publicly-owned generation units. Excess power generated by generators may be sold on the market at relatively high prices under these regulations (and therefore attractive). It is easier for project creators to invest in a given market if they know they are not at the whim of the distribution company management for payment and have other options for selling their work.(Hameedi, 2012)

The review had a significant impact overall. India's power generation capacity quadrupled between 1991 and 2012, reaching 214,000 MW. The private sector's share of energy sector investment has increased from about 3% to 29% over the period. Investments that include private sector participation exceeded $ 100 billion between 2005 and 2011. Between 2009 and 2012, state institutions increased their fixed assets from Rs 2.3 trillion to Rs 3.3 trillion, while major projects continue to rise from Rs 960 billion.

1. The Road Ahead

As a result of power outages and other fuel shortages in Pakistan, the economy has been severely affected. Efforts to strengthen domestic and national savings and improve domestic and international investment compensation are essential to ensuring enough capital expenditure to balance energy demand and supply. In order to learn from the mistakes made by other nations with high power prices and poor energy production, Pakistan may learn from the mistakes made by countries with low energy production and high electricity costs. Pakistan must keep these goals and facts in mind as it works to address its electricity problem:

A long-term goal of expanding the physical power supply should not be met in the next five years, and all efforts should be made to avoid creating unrealistic expectations. There can be no repeat of the mistakes of the past when it comes to importing fuel oil for new generating capacity. In order to minimize this danger, projects should be held to the lowest possible cost requirements and under intense competitive pressure. Certain investment incentives may be required in the outset. For long-term savings, however, they must only be used to the initial round of projects.(Asif, 2009)

III. RESEARCH AND METHODOLOGY

A. Quaid-E-Azam Solar Power 100 (MW)

Pakistan has been experiencing severe electricity shortages for the past few years. As a result, we have a critical need to close the gap between electricity supply and demand. These energy crises have a significant impact on Punjab, which is Pakistan's largest energy customer. Thus, the Punjab government decided to use renewable energy sources to create power. In terms of renewable energy, solar power is the most conspicuous. (*Solar Resource Maps and GIS Data for 200+ Countries | Solargis*, n.d.)

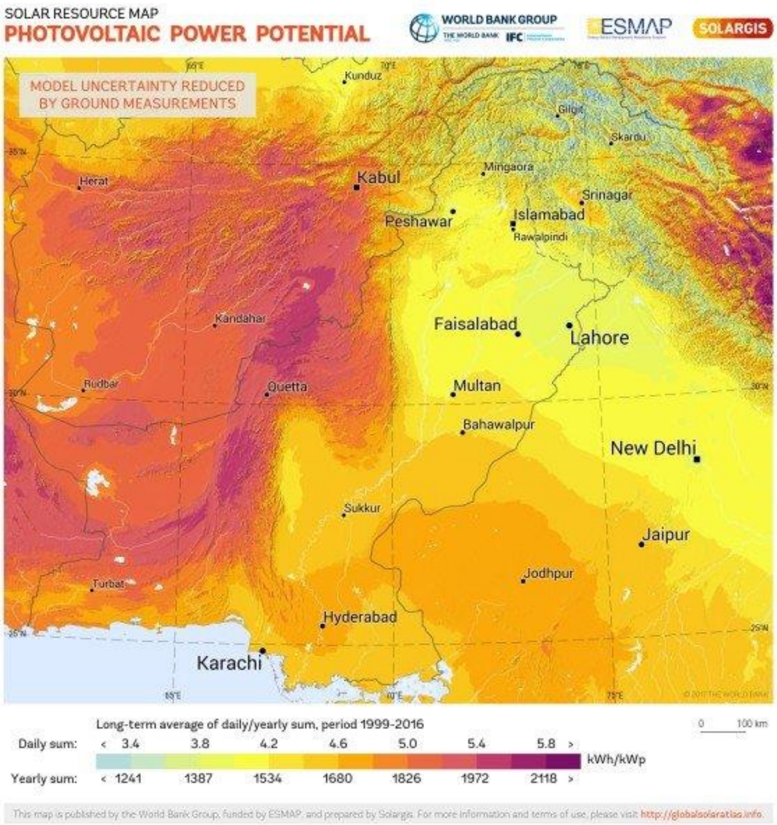

Figure 8: Photovoltaic potential of Pakistan source [68]

The key imitative towards this point of reference is Quaid-a-Azam solar power (QASP). QASP Park is 20 kilometers southeast of Bahawalpur in the cholistan desert. With a capacity of 100 MW in the first phase, 300 MW in the second phase, and 600 MW in the third phase, it is Pakistan's largest solar power plant. In 2008, 2009, and 2010, the total installed capacity of solar energy was 15 GW, 28 GW, and 32 GW, correspondingly. This figure was 302 GW by the end of 2016, indicating that solar energy is on the rise. Germany, Italy, China, Japan, the United States, and the United Kingdom, according to B Kumar, are the largest photovoltaic power generating countries.

PV modules produce the most energy when the sun is shining brightly, the irradiance is high, the temperature is low, and there is a strong breeze. Humidity and dust are the two main degrading causes for PV modules. As a result, there should be a method for minimizing these consequences. PV modules should be cleaned with fresh water and a variety of surfactants to maintain their power quality and efficiency. This article examines the performance of a 100 MW solar power installation in Bahawalpur that is already connected to the grid. It is critical to study and evaluate existing PV systems to improve the efficiency and cost-effectiveness of future generation solar systems. Solar irradiation, ambient temperature, and the thermal characteristics of photovoltaic panels all influence the performance of a solar PV system.

B. Description of the photovoltaic system installed at the Bahawalpur QASP site

The world's largest grid-connected solar power plant was inaugurated on May 5, 2015, and it began operations on July 15, 2015. At Standard Test Conditions STC, its installed capacity is 100 MW DC. It is 20 kilometers southeast of Bahawalpur in the cholistan desert. Pakistan has a daily average irradiance of 5.3 KWh/m2. The annual solar irradiation averages 19MJ/m2/yr. For QASP site Bahawalpur, the total global horizontal irradiance is 1896.5kWh/m2 and the average ambient temperature is 25.8°C.(*Solar Resource Maps and GIS Data for 200+ Countries | Solargis*, n.d.)

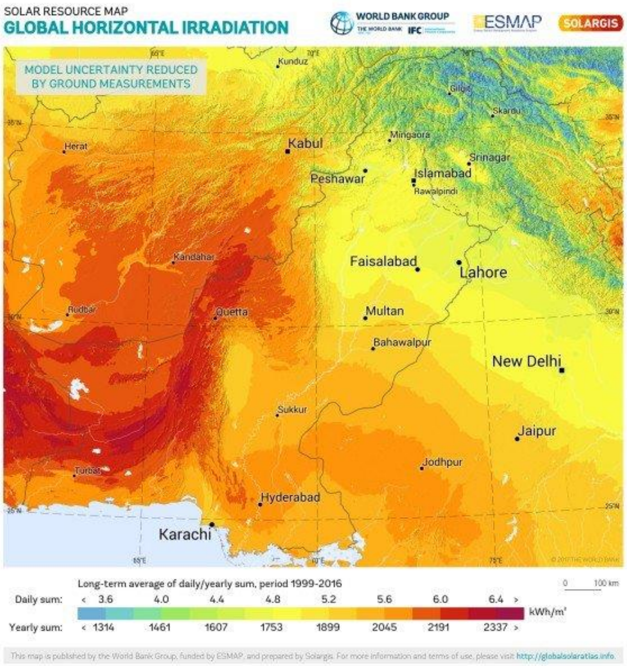

Figure 9: Irradiance change of QASP [60]

Table 2: Irradiance change of QASP throughout the year [51]

Month	Irradiance KWh/m2	Average ambient temperature throughout year
16 of January	87	12
16 of February	135	16
16 of March	152	22
16 of April	178	29
16 of May	213	35
16 of June	204	36
16 of July	198	34
16 of August	172	32
16 of September	186	31
16 of October	158	27
16 of November	115	20
16 of December	98	15
Total irradiance & Ambient Temp	1896.5	26

C. Site Details

In Bahawalpur, a QASP photovoltaic system has been installed. The park's general specifications are listed below.

Table 3:Site details of QASP [60]

Area Covered by Park	500 acres
Longitude and latitude of the site	71.670 E, 29.410 N
Maximum ambient temperature	50 degrees
Average ambient temperature	25.8 degree
Maximum wind speed	74km/h

Figure 10: Site view of QASP Bahawalpur [51]

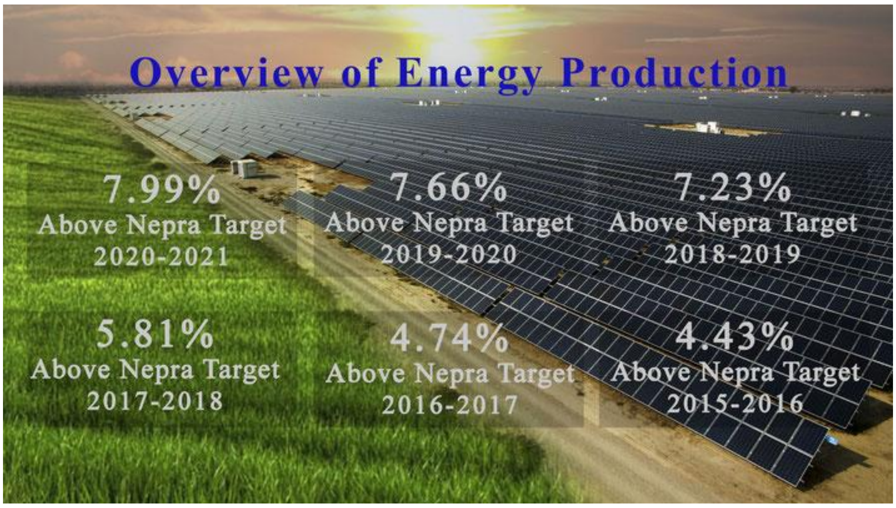

Figure 11: Energy production of QASP Bahawalpur [51]

D. Solar Panel/ PV Modules

JA Solar, based in China, manufactured the solar modules used at the QASP site. The QASP plant can evaluate PV module assessments under Standard Test Conditions (STC), which include 1000 W/m2 irradiance, Air Mass (A.M) 1.5, and a temperature of 25°C. PVLAB Germany[8] provides all solar system-related instruments. The following are examples of experimental results and nameplate evaluations.

Table 4: PV specifications and parameters used in QASP [59]

No	Parameter	Nameplate Reading	Measured Results
	Maximum Power	255	262.8250
	Open circuit voltage	37.82	38.23
	Maximum power voltage	30.29	31.054
	Short circuit current	8.980	8.91350
	Maximum power current	8.420	8.38150
	FF or Fill-Factor	......	76.37
	Overall Efficiency	......	17.8

E. Photovoltaic System

The Quaid-e-Azam solar power plant has a total of 392,160 modules. Each module has a 255 W nameplate rating. As a result, QASP's overall capacity is:

255Wx392160=100000800W=**100MW**.

A photovoltaic array is an interconnected structure of solar panels that functions as a single power-producing cell. The total number of arrays in QASP is 9800, with each array containing 40 modules.

Each array is subsequently separated into two strings: upper and lower. Each string has a total of 20 modules. The arrays' electricity is aggregated in a combiner box before being sent to the inverter for DC to AC power conversion. A step-up transformer raises the voltage to 33 kV, which is then raised to 132 kV in the substation.

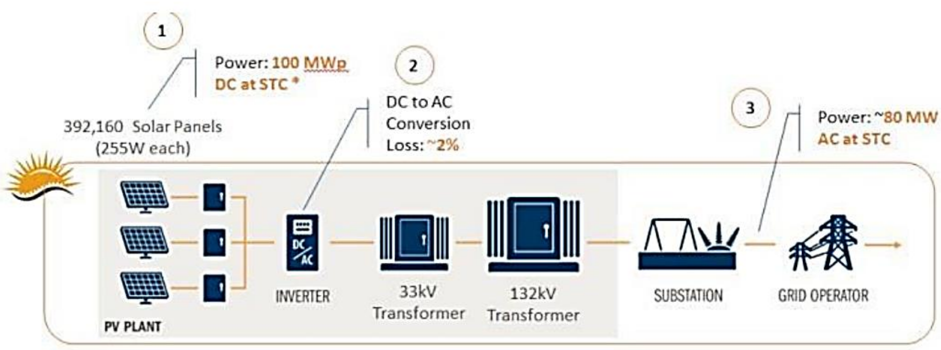

Figure 12: Power Extraction System at QASP [65]

The power conversion system is used to ensure that the power supply is of high quality and dependability, as well as to perform many functions.

- Pulsating loads are smoothed.
- Current harmonics should be avoided.
- Reactive power compensation

Single-stage three-phase inverters are utilized in this setup. A total of 100 units have been erected, each with a 1 MW capacity. Each unit includes two inverters, each with a 500kw capacity. High internal temperatures above 50°C have an impact on the inverter's performance. Due to direct solar exposure, the outer enclosure temperature of the Inverter can reach 68 degrees Celsius during the hottest days of summer. Shades are fitted over the inverters to increase inverter performance during extreme temperature conditions and to protect the inverter from overheating.

Table 5: QASP power parameters and specifications [60]

Each Unit Capacity	500kw
Model of Power Conditioner	TC500KH
DC Input Voltage Rated	1000V
Range of AC voltage	250-350 V
DC Current maximum	1344 A
MPPT range	460-950 V
Output Voltage AC (Rated)	315 V
Nominal Frequency	50 Hz
Efficiency	98.42 %

F. Combiner or Combination Box

The electrical connections are kept isolated from the arrays and the site area in an electrical combiner box. In the combiner box, the output of numerous arrays is combined, protecting against overvoltages, surges, and lights. This solar system uses metallic combiner boxes to connect several panels into separate charging strings. At the facility, 1400 combiner boxes with 16 inputs have been placed. As a result, 16 arrays are grouped in a box. In the combiner box, there are additional reverse blocking diodes to prevent power from flowing backward.

Figure 13: Connecting box at QASP Bahawalpur [61]

G. Monıtorıng Results

1. Production of Energy

Calculating the daily and monthly energy provided to the transformer can be used to evaluate the performance of a grid-connected PV system. After the DC to AC conversion, the total energy yield was measured. The annual energy produced by the facility is shown below.

Table 6: Production of Energy [53]

Year	Target Production in GWh	Actual Production in GWh
July 2015- July 2016	153.3	160.1
July 2016- July 2017	152.2	160.2

2. PR (Performance Ratio)

The performance ratio of a solar power plant is determined by the total solar energy turned into electrical energy. It's the proportion of actual to intended energy yield. PR can be calculated as follows.

For PV control plants, PR is most likely the right record. However, as the environment changes, the system's PR shifts. In the summer, for example, thermal losses rise due to the high temperature, hence PR decreases. QASP's PR for the year 2016 was 0.60. The best-in-class System has a PR of 0.8.

3. AC Power Generation

The inverter's output power is determined by:

• Array control at the inverter terminal

• Inverter losses

Switching, backup power, and ohmic losses in the semiconductor material all contribute to these losses. The inverter has a conversion loss of 2%, while the average total plant loss of 20%. At STC, the facility generates a total of 80 MW AC power.

H. Karabiner PV Solar Power Plant Turkey

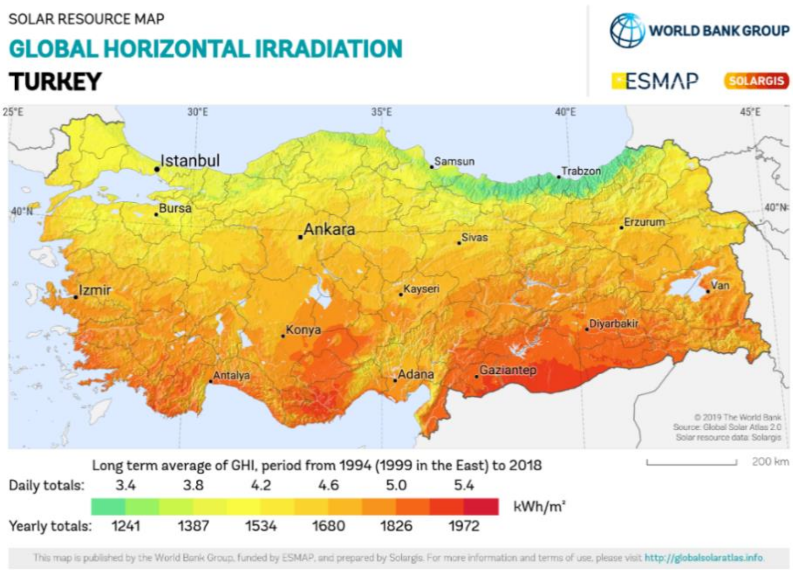

Figure 14: Turkey horizontal Irradiation [52]

Karapnar solar power facility located 4.5 km north of the D330 Konya-Adana motorway in Konya, Turkey. Central Anatolia's Konya airport is 100 kilometers from the project location. The first phase of Turkey's biggest solar project, Karapinar Solar Power Plant (SPP), has been completed, according to Energy and Natural Resources Minister Fatih Donmez. Turkey's first renewable energy YEKA tender, also known as GES-1, garnered local and international interest, according to Donmez. ' Turkey's solar capacity ranks 13th worldwide and 9th in Europe. We hope these numbers grow. Karapinar SPP, only 20% complete, is already generating electricity and will be fully operational by 2022. Kalyon and Hanwha received the first YEKA contract offer on March 20, 2017, for a Karapinar solar power plant at

$0.0699 per kilowatt-hour. After Hanwha left, CETC finished the project..(*Karapınar Solar Power Project, Konya Province, Turkey,* n.d.)

The installation and commissioning of 3.5 million panels will take around 36 months starting in August 2020. When the project is completed, enough energy to meet the demands of a city of 50,000 people for a week will be created in just one hour. To put it another way, this plant will generate enough electricity to power almost 2 million people for a year. In addition, 1.5 million tons of fossil waste and carbon emissions would be prevented.(*First Phase of Turkey's Biggest Solar Power Plant Completed | Daily Sabah,* n.d.)

Green energy is gaining traction in a number of nations. The governments of these countries are fully aware that other sources of carbon emissions contribute to climate change. In recent years, several affluent countries have made investments in renewable energy sources such as solar, wind, and geothermal energy. The world's major users of renewable energy are China and the United States in particular. Germany, Russia, and Brazil are among the countries that invest in renewable energy. Solar energy is an important renewable energy source that may suit a variety of power generation and cost-effectiveness needs because of their adaptability and environmental benefits, solar power plants are becoming increasingly popular. On the other side, the solar power plant industry creates new job opportunities. Turkey's government supports the building of renewable energy producing facilities, notably solar and wind power plants. Turkey has a lot of wind and solar energy potential. The western part of Turkey has a lot of wind energy potential, and the center region has a lot of solar energy potential. The Turkish government intends to construct a 3 GW solar power plant at Karapinar by 2025. This facility, which will be built on a 60-square-kilometer site, is being evaluated because it would have a large influence on the Turkish electricity grid. (*Invest in Konya - Energy,* n.d.)

The factors that make this project an ideal one are discussed below in detail.

1. High Renewable Energy Potential

The region's potential for solar power plants has an installed capacity of 4000 MW. The Power Substation, which the manufacturers will connect, is located on the declared land's edge. With the investments in the region, we believe that between 60 and 90 KWh of energy could be produced annually in an area of 1 m2. İt also has high irradiation as compared to Konya and Karaman as shown in the below figure. The green bar is showing the hourly ranges of the karapinar district in different months of the year.(*Invest in Konya - Energy*, n.d.)

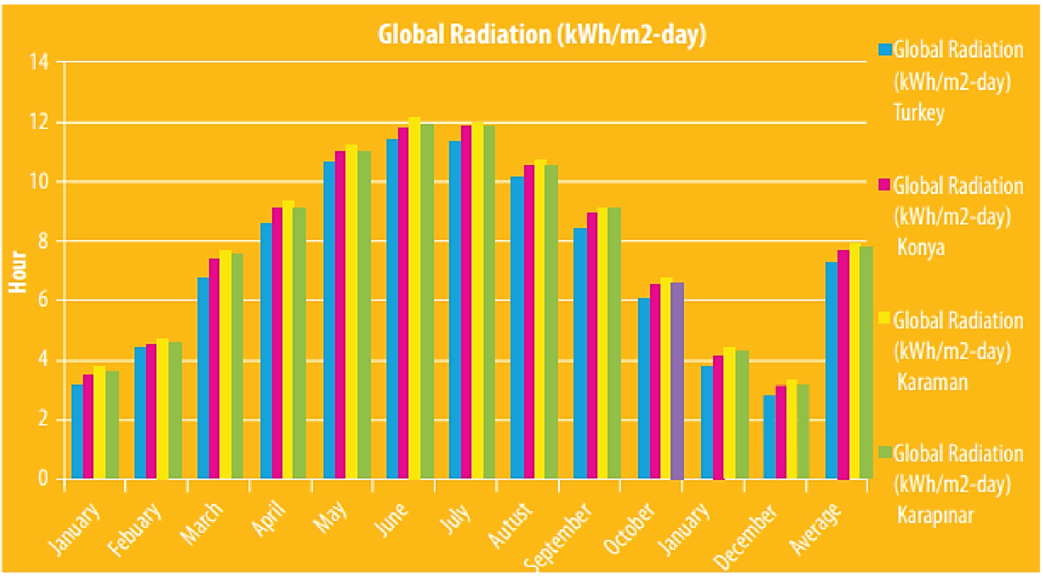

Figure 15: Irradiation change at Karapinar PV solar project [68]

The sunshine duration is shown below in the figure which is showing that the Karapinar has the longest duration of sunshine. So this means that the amount of energy produced from this area is more than the energy produced from other solar plants because of long hours of sunshine.

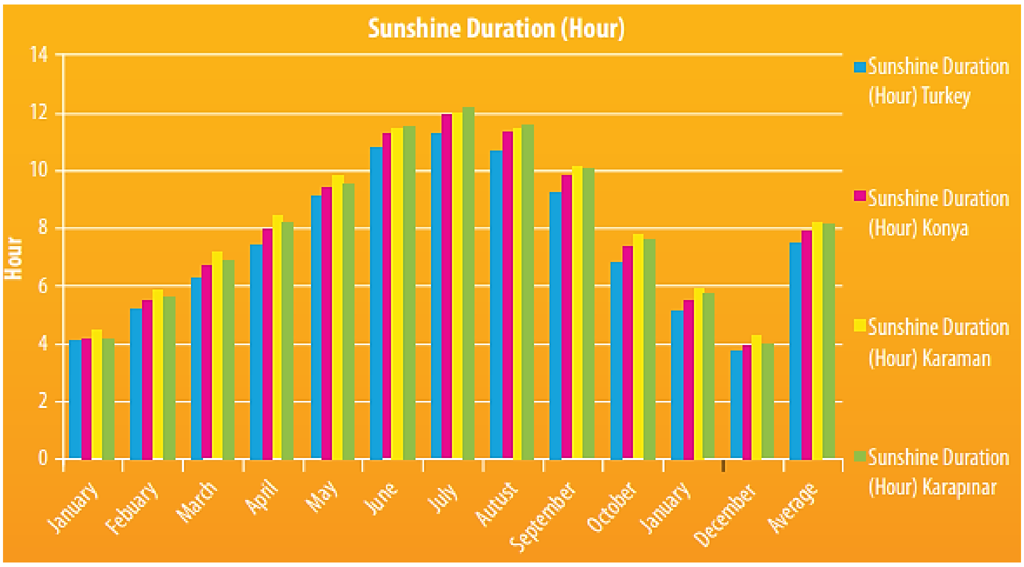

Figure 16: Sunshine duration of Karapinar source kalyonpv [68]

2. High Finance Capacity

The Turkish Ministry of Energy and Natural Resources has verified that Konya&Karaman has the most potential for solar energy development in Turkey. According to a research done by the Ministry and published in the official gazette on January 8, 2011, all of Turkey's regions might be approved for solar energy investments with a total capacity of 600 MW before the end of 2013. As a consequence of this study, investment permissions have been issued in 27 regions across Turkey. Among the 27 regions allowed, Konya has been recognized as the one with the largest capability.

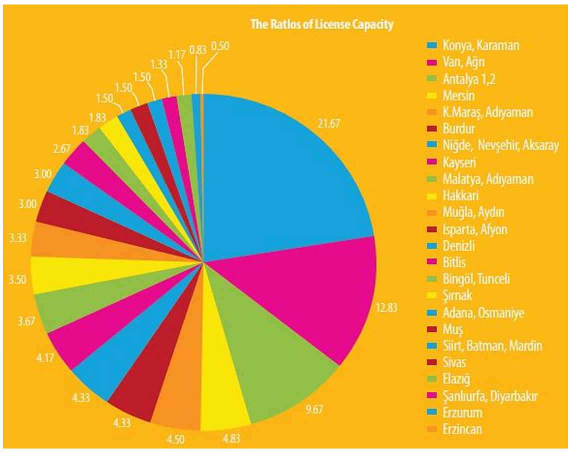

Figure 17: Finance issuance w.r.t different cities of turkey Ready to Used Infrastructure and Land [68]

The ready infrastructure and accessible land are two other features that make the Karapinar area excellent for energy development. There are large, useless regions in Konya, notably in Karapinar. In addition to the present incentive structure, investors will have access to 59.586.876 square meters of property designated as an Industrial Zone Specialized in Energy, which will enjoy extra advantages. Solar power facilities with a capacity of 4000 MW have the potential to be built in the region. The factories will link to the Power Substation, which is located on the designated land's perimeter. We estimate that 60 to 90 KWh of energy might be produced yearly in a 1 m2 area with the investments made in the region. This level of energy generation per square meter may provide at least USD 8/m2 in yearly income. The economic worth of this area is estimated to be roughly US$ 10 billion when compared to similar places. At addition, in Ayranci and Karaman, searches for Energy Zones with similar physical properties have been conducted.

3. Energy Incentives

One of the most compelling reasons to invest in solar power is the government's ten-year commitment to buy renewable energy. According to the Turkish Renewable Energy Law, the basic energy price is set at 13.3 USD cents per kilowatt-hour of investment that will take effect in 2015. If the production facilities are built with domestic resources, the government will buy the energy produced. in PV technology at a maximum of 20 cents per KWh for the first five years and 13.3 cents per KWh for the next five years.

4. Strong Industrial Infrastructure

The industrial infrastructure in the area is well developed. Among the 77 companies in the field of solar energy technology are PV panel, metal construction, EVA, glass, solar tracking system, gel, and jelly battery unit, electronic control system, inverter, control control, metering, connecting elements, cable and equipment, collector and relatives, CSP and PV plant engineering, steam turbine, and more. In addition, R&D courses will be conducted and the center will contribute to the development of the sector through the construction of a Renewable Energy Center, which will be located within the Regional Establishment Center to be established in Konya in 2014.

İ. Power Evacuation of Karapınar Solar Power Plant

The Karapnar solar power project will be built in two phases, the first of which will be 200MW and the second of which will be 800MW. Two electrical substations will be built as part of the project, one in the northern area and the other on the southern boundary of the property. It will use feeders with voltages of 400kV, 154kV, and 33kV, as well as an IEC 61850-based substation automation system. Through two independent connections, the electricity generated by the Karapnar solar power station will be evacuated to the national electricity system. Another 154kV power evacuation line will be connected to the Karapnar Substation for onward transmission into the grid, while a 400kV power transmission line will be connected to the Yeşilhisar Substation.(*Karapınar Solar Power Project, Konya Province, Turkey*, n.d.)

1 Proposed SolutIon

As we know that Pakistan is suffering from huge shortfall of electricity. Whereas in Various European countries the demand and supply for electricity has not been an issue. Following table explains the annual demand and supply from overall electricity and production companies:

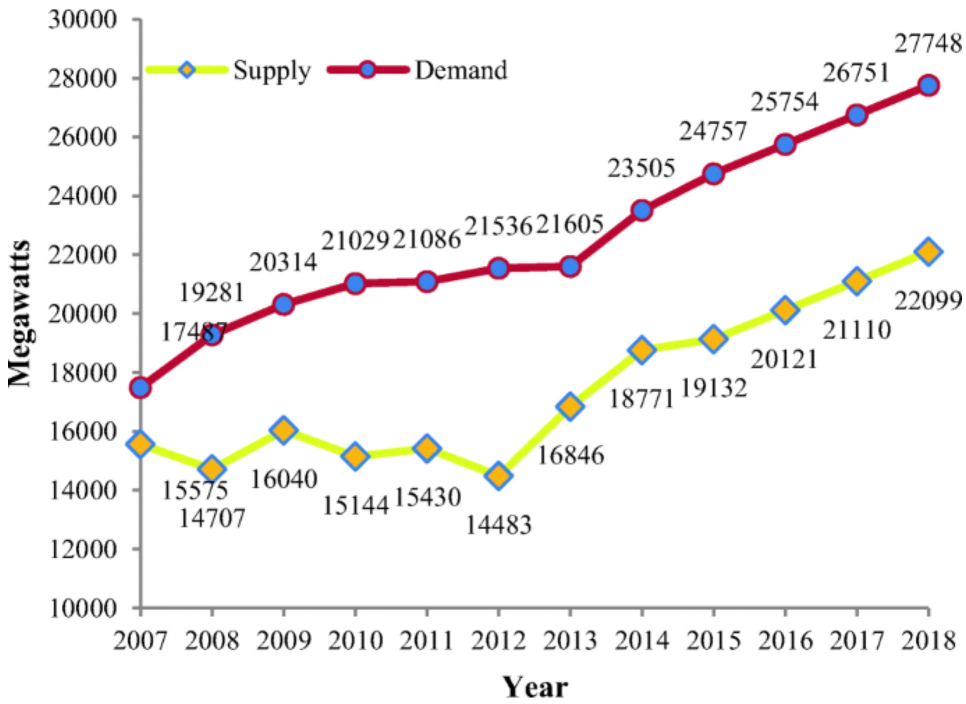

Figure 18: Pakistan yearly energy demand and supply graph [67]

The above graph has been used to understand the supply and the demand gap that has been used in this research to propose energy efficient solutions that could effectively solve the crisis.

Undestanding the ratio of sources used to maintain energy stability following data from some of the developed counteries was used:

J. Germany

As of 2020: Wind 27% Coal 24% Nuclear 13% Natural Gas 10% Solar 9% Biomass 3.7% Hydroelectricity 3.7 %. So far, there have been no issues.

K. France

A total of five primary energy sources are used to generate the country's electricity: coal, natural gas, liquid fuel, nuclear power, and renewable energy sources. In 2020, nuclear power will account for around 78% of total energy output. In terms of total energy consumption, renewables contributed for 19.1%. Currently, 72.3 percent of France's energy comes from nuclear power, while renewables and fossil fuels contribute for 17.8 percent and 8.6 percent, respectively, of total output. France has the world's highest percentage of nuclear power.

L. Norway

In Europe, Norway generates the most energy from renewable sources and emits the fewest greenhouse gases as a result of its electrical industry. Norway's power supply system will have 37,732 MW of installed capacity and an average annual output of 153,2 TW by the year 2020. The majority of Norway's energy comes from hydropower. Currently, there are 1 681 hydropower stations in Norway with a total installed capacity of 33 055 MW at the beginning of 2021.

İn Pakistan there are certain areas which facing of 12 hours of load shedding in a day to meet the energy demand. This load shedding also disturbing the industry sector by which the economic condition is going to worsen by each passing year. Pakistan has huge coal resources even though the energy made from these resources are increasing the temperature of Pakistan by two degrees every year, still they are unable to meet the demand of electrical energy. The real reason of doing the comparison of Turkey and various European countries and Pakistan is to compare the electric sector of all countries and to learn the strategies that Pakistan can used to meet the energy demand. So that the strategies can be point out by which Pakistan can also be in the list of countries where energy production is at least equal to the demand of energy.

In this research the by studying the electrical sector of Various European countries Turkey and comparing it with Pakistan electric sector. It can be seen that Turkey government is focusing heavily on greener form of energy production such as PV and wind. By comparing Turkey Karabiner and Pakistan Quaid-e-Azam solar plant it can see that there is huge amount of energy production difference.

M. Contribution

After studying the Concept of All these countries, the way, they produce electricity and overcome the problem arises. All the strategies by different regions should implemented in Pakistan Power generation. To meet the minimum Requirements for Supply and demand. Emphasis of this research is to use solar as an effective source rather than thermal that has been the main energy source for Pakistan.

1. Technical assistance from Germany

To Introduce the Coal Power generation İn Pakistan as we studied for the same technique they used for Germany.

2. Technical assistance from France

As we studied 78% of energy production in France is by nuclear energy. Pakistan has the source of nuclear energy. So, by the same technique the France used to overcome energy production needs just to install the Nuclear Power generation in Pakistan.

3. Technical assistance from Norway:

Norway Use to produce the Electric energy by Source of Hydropower. We have the Punjab and Sindh regions for İnstallation of Hydropower plants. Just using the proposing the same Hydropower Technical features as they installed in their hydropower projects.

4. Analyzing mathematical variables for energy sources to prove feasibility:

This research emphasizes the use of the main energy resources such as Solar. Wind turbines, solar panels, and hydro turbines are examples of renewable energy conversion components that may be included in a hybrid energy system, as can more traditional, nonrenewable power sources such as diesel engines, microturbines, and energy storage devices such as batteries. All or a portion of it may be found in a hybrid energy system. First and foremost, the modeling of individual components is necessary for selecting the suitable components and subsystems for appropriate system size. The modeling method aids in identifying and determining the features of the many components as well as aids in decision-making.

Table 7: Basic Parameters for Solar power [50]

Variable	Abbreviation	Units
Year		
Day of Year	DOY	
Local Time	LST	
Air Temperature	T_{air}	(°C)
Panel Temperature	T_{panel}	(°C)
Wind Speed		
Downward Solar Flux	SW_{dn}	W/m^2
Panel Solar Flux	SW_p	W/m^2
Power Generated	Power	kW, kWh/Mo

The accuracy of a model's prediction is reflected in its accuracy, although designing a flawless model is impossible or exceedingly time-intensive. Complexity and accuracy should be balanced in a model that is adequate. Deterministic and probabilistic techniques are used to model the performance of individual components. Here is a list of the general ways that an energy system can be implemented:

- **Solar Variable and power viability:**

The output of a photovoltaic array is determined by the amount of solar radiation and the temperature inside the system. This model's power output is computed:

$$P_{pv} = \eta_{pvg} \times A_{pvg} \times G_t$$

These values are η_{pvg} that is PV generating efficiency (%), A_{pvg} area (m2), and G_t solar irradiation in slanted module plane (W/m2) for the PV generators A η_{pvg} and G_t. As a result, η_{pvg} is defined as follows:

$$\eta_{pvg} = \eta_r \eta_{pc}[1 - \beta(T_c \times T_{c\,ref})]$$

While using MPPT, η_{pc} represents the power conditioning efficiency, which is set to one, and ($T_{c\,ref}$) represents the reference cell temperature in degree celcius β is temperature coefficient ((0.004-0.006) per degree celcius) , η_r represents the reference module efficiency, and _r represents the reference module efficiency. The following equation may be used to determine the temperature used as a standard for other calculations:

$$T_c = T_a + \frac{\text{NOCT } 20}{800} G_t$$

NOCT is the operating cell temperature (°C), and $G_t$is the tilted module plane solar irradiation (W/m2). When normal and diffuse solar radiation are included, the solar cell's total radiation is:

$$I_T = I_b R_b + I_d R_d + (I_b + I_d) R_r$$

- **Solar System modeling:**

The solar array's primary building component is the photovoltaic effect-capable P-N junction semiconductor solar cell. In order to create a PV array, a series-parallel design of 37 PV cells is used. Ns series-connected and Np parallel-connected array cells may generate a voltage-to-current relationship.

$$I = N_p [I_{ph} + I_{rs} \left(\frac{(\text{V} + R_{rs})}{\text{AKT} N_s} - 1 \right)]$$

The electron charge q (1.6×10^{-9}), This equation includes Boltzmann's constant K, the diode ideality factor A, and the cell temperature T. (K). The term "band gap energy" refers to the value that a semiconductor's band gap has when it is used in a cell (EG). Following is a representation of how the cell temperature and radiation affect the photo current Iph.

$$I_{ph} = [I_{SCR} + k_r \left(T - T_r \frac{S}{100} \right)]$$

I_{SCR} is the cell short circuit current at reference temperature and radiation, the temperature coefficient ki is the short circuit current temperature, and S is the solar radiation in (mW/cm2)

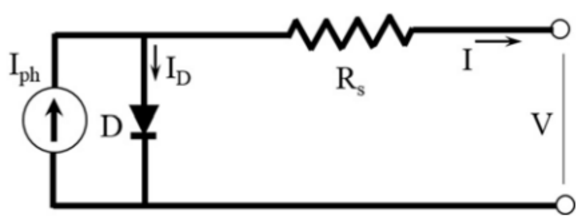

Figure 1:Ideal Diode PV cell [55]

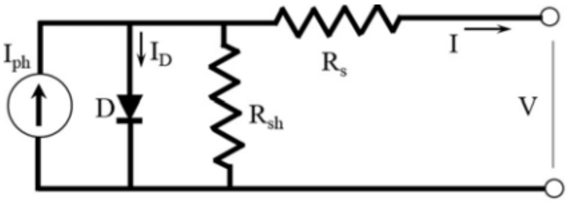

Figure 2:Single Diode PV cell [55]

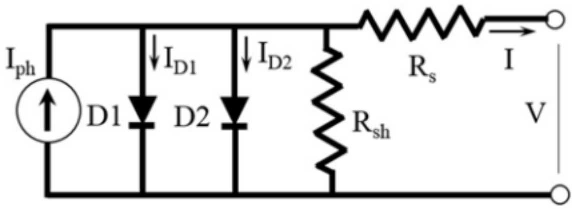

Figure 3:Double Diode PV array [55]

When adopting the single diode model, shunt resistance is added to the ideal-shunt-diode model. The I-V characteristics of a PV cell may be detrmined from a single diode model:

$$I = I_{Ph} + I_D$$

$$I = [I_{ph} + I_0 \ exp \left(\frac{q(\mathrm{V}+R_r I)}{\mathrm{AKT}} - 1\right) - \left(\frac{\mathrm{V}+R_{rs}}{R_{sh}} - 1\right)]$$

Modeling of PV systems using a simplified model:

$$V_{OC} = \left(\frac{V_{OC}}{cK \frac{T}{q}} - 1 \right)$$

Normal and diffuse solar radiation may be used to estimate the total radiation in the solar cell:

$$I_T = I_b R_b \times I_d R_d \times I_b (I + d)$$

- **Current Density**

The presentation of a sun-based cell can be depicted utilizing the central conditions of semiconductor gadgets. There are three sections in a sun powered cell - the construction, cell size, and lattice contact plan for the streamlining of sun-oriented cell execution.

The complete current thickness in the three locales can be processed utilizing the accompanying condition:

$$J_L = J_E + J_{SCR} + J_B$$

Short-circuit current density and open-circuit voltage may be used to calculate a solar cell's maximum operational power density (P_m). The specifics of the algorithm used to calculate the open-circuit voltage and short-circuit current density.

At a given solar intensity, the maximum operational power density (P_m) may be determined.

$$P_m = J_m V_m$$

With an intensity C of sunlight, the following are the equations for P_m, J_m and V_m :

$$P_m(C) = J_m(C)V_m(C)$$

Knowing that $J_m(C)$ and $V_m(C)$ are given below:

$$J_m(C) = CJ_m$$

$$V_m(C) = V_m + V_T \log(C)$$

5. Improving the power factor:

The current issue in Pakistani business is one of power. Motors that power dye machines and other industrial machinery are the primary source of electromagnetic load. Loads like motors and non-compensated fluorescent lights use reactive power in their magnetic circuits. Despite using the same amount of active power, the current flowing through the conductors might grow if the problem isn't addressed.

The site's electric installation must undergo a phase shift in order to accommodate the self-inductive load. Power factor is the term used to describe the phase shift angle.PF=Φ (https://electrical-engineering-portal.com/reduce-electrical-energy-losses-buildings)

If an example is quoted for a normal industry it would be easy to describe how to improve the power factor of that industry.

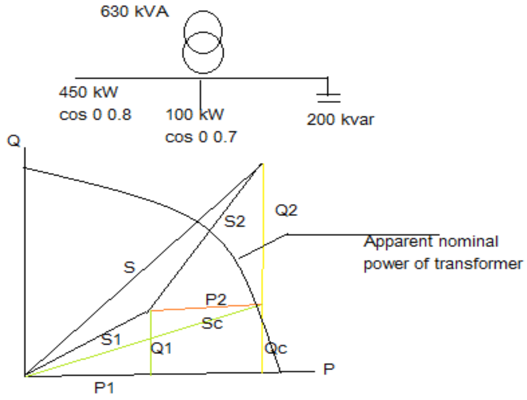

Figure 4: Adding power load to existing industrial facility. [50]

Requirements:

To add a power P2=100kW with cos Φ=0.7 to an existing industrial facility with a power transformer Sn= 630kVA, to supply an overall active power load P=450W with cos Φ=0.8.

If we will check primarily then the assumed values for the power and load, so according the upper diagram we can conclude

The apparent power consumed is

$$S_1 = \frac{P_1}{\cos q}$$

$$S_1 = \frac{450}{0.8} = \mathbf{563\ kVA}$$

• The reactive power is:

$$Q_1 = \sqrt{(S_1 2 \ - \ P_1 2)} \ = \mathbf{338\ KVAR}$$

• The apparent power of the additional load is:

$$\frac{S_2\,P_2}{\mathrm{cosp}} = \frac{100}{0.7} = \mathbf{143\ kV}$$

• Its reactive power is:

$$Q_2 = \sqrt{(S_2 2 \ - \ P_2 2)} \ = \mathbf{102\ KVAR}$$

The total apparent power to be provided by the transformer is:

$$S = \sqrt{(p^2 \ + \ Q^2)}$$

where:

- P= P1+ P2 = 550 kW
- Q=Q1+ Q2 = 440 kVAR i.e.
- S = 704 kVA

• The new power factor is:

cos q = $\frac{P}{S}$ = **0.78**

If we consider this the situation of the Industrial load the power of the existing transformer is insufficient to supply the overall load. That is the main issues occurring in most of the industry and power generation and result in Shortfall and less supply with demand of high.

N. The Solution for this Problem

Reactive power compensation Define the capacitor bank: to do this the corrected reactive power must allow the inequality:

S = $\sqrt{(P^2 + Q^2)}$ < 630 kVA

therefore:

Q max = $\sqrt{(P^2 + Q^2)}$ = $\sqrt{(630^2 - 550^2)}$ = **307 KVAR**

It is thus necessary to provide at least:

- Q, Qmax 440 307 133 kVAR to give a minimum:

  cos $\frac{P}{S}$ = $\frac{550}{630}$ = **0.873 200 kVAR**

- Capacitor bank is installed to give:

  Q = 440-200 = **240 kVAR**

  S=$\sqrt{(P^2 + Q^2)}$ = (5502 +2402) = **600 kVA**

  Where,

  cos o = $\frac{P}{S}$ = $\frac{550}{600}$ = 0.917

  Hence, the cost is € 12,000 (automated capacitor bank)

O. Advantages:

In active power corresponding to the heating of the circuits. 3,000 kWh/year, i.e €200/year.

- €2,500 per year at maximum electricity consumption (in kVA).
- Removed € 7,000 in fines annually (halt to consumption of 250,000 KVARh)
- A power reserve is still accessible, therefore a more powerful transformer is not required.
- Longer service life for the transformer due to improved operation.
- The return on investment is just 1.3 years.

P. Improving the PV loses in solar panels

1. Choosing the Quality PV panels

The most common form of solar panel is the monocrystalline panel, which is widely utilized for both small- and large-scale residential and commercial solar systems.

Table 1: Types of PV cells [56]

Type	Mono Crystalline	Polycrystalline	Thin Film
Composition	One Crystal	Multiple Crystal	Thin Silicon Layers
Efficiency	Up to 22%	About 15%	Maximum of 10%
Lifetime Duration	20-30 years	20-25 years	15-20 years
Cost	Expensive	Cheaper	Expensive

The **kW/m2** irradiance level is the most important factor to me, notwithstanding other considerations including as temperature and weather conditions. If your system is less than 5kW, it may be more cost-effective to increase the number of panels, but this may not be an option if your budget is tight. It's usually a good idea to try to minimize your losses.

Table 2: Factors of Losses of Energy by PV cells [66]

Cause of Energy Loss	Percentage Loss	Design of Maintenance	Total Losses
Shading	7%	Both	**28.8% loss**
Dust and Dirt	2%	Maintenance	
Reflection	2.5%	Design	
Spectral Losses	1%	Design	
Irradiation	1.5%	Design	
Thermal Losses	4.6%	Design	
DC Cable Losses	0.7%	Design	
Inverter Losses	1%	Design	
AC cable losses	0.5%	Design	

As mentioned above all the research and data gathered on the base of the research. I just want to implement the Same Technology used in various Countries who had already resolve the issues for their power generation. I will Make conclusion for the loss of Majority power by Different parts in Pakistan and Make them Exact Way to Work like in Discussed Countries. Take the primary steps to İnaugurate the Proposals for new Technology used by European countries and then make it Use to By Pakistan Electrical Management of power generation companies. So, this way we can achieve he task what I proposed in my thesis. Various problems that can also be resolved just by improving the Ways of Electrical energy generation.

The Pursuing Procedures would recommend the following measures for the improvement of power generation:

1. optimizing all plant operations via the use of new software and tools.
2. identifying and applying contemporary best practices
3. Employee training in energy-efficient operations.
4. Modernizing equipment like steam turbines
5. reducing the temperature

IV. CONCLUSION

The subject of this research is addressing the shortfall of electricity in Pakistan by the RE sources and comparing the techniques used by other countries to overcome the shortfall. After reviewing the literature review, Pakistan's current scenario of coal, biomass, natural gas, and hydro projects is being studied. Also, the energy being produced by RE sources is studied which is still very low as compared to energy by fossil fuels and the conclusion is that fossil fuels cannot meet the energy requirement of Pakistan. **The research on countries like India, China, and Turkey has been done to see how they overcome their energy needs and concluded that the only and best way to mitigate the shortfall is to increase the RE sources production**. Because RE energy is environment-friendly, cheap, and in unlimited quantity. To prove the benefits of **RE sources the QASP plant has been reviewed and its comparison with Turkey Karapınar solar power plant has been done and it is concluded** that RE sources are the future of electricity production and only using these sources the increasing electricity demand can be overcome.

V. REFERENCES

ARTICLES

ASIF, M. (2009). Sustainable energy options for Pakistan. **Renew Sust Energy Rev,** 13(4), 903–909. https://doi.org/10.1016/j.rser.2008.04.001

ASIF, M. (2009). Sustainable energy options for Pakistan. **Renew Sust Energy Rev,** 13(4), 903–909. https://doi.org/10.1016/j.rser.2008.04.001

ENERGY CLUSTER SUSTAINABLE DEVELOPMENT Department Latin America & Caribbean Region A Guide for Policymakers **Managing An Electricity Shortfall.** (n.d.).

ENERGY CLUSTER SUSTAINABLE DEVELOPMENT Department Latin America & Caribbean Region A Guide for Policymakers **Managing An Electricity Shortfall.** (n.d.).

HAMEEDI, A. (2012). Addressing the Electricity Shortfall in Pakistan through Renewable resources. **Undefined.**

HAMEEDI, A. (2012). Addressing the Electricity Shortfall in Pakistan through Renewable resources. **Undefined.**

HASSAM AZIZ, M., AKHTER, P., BAHAWALPUR, P., HAMEED BABAR, A., & KHAN, U. (2018). **Performance Evaluation of An On Grid 100 MW Quaid-E-Azam Solar Power Bahawalpur** Kamran Iqbal Assistant Manager Technical Quaid-e-Azam Solar power.

HASSAM AZIZ, M., AKHTER, P., BAHAWALPUR, P., HAMEED BABAR, A., & KHAN, U. (2018). Performance Evaluation of An On Grid 100 MW Quaid-E-Azam Solar Power Bahawalpur Kamran Iqbal Assistant Manager Technical Quaid-e-Azam Solar power.

IRFAN, M., ZHAO, Z.-Y., AHMAD, M., & MUKESHIMANA, M. C. (2019). Solar Energy Development in Pakistan: **Barriers and Policy Recommendations.** Sustainability 2019, Vol. 11, Page 1206, 11(4),

1206. https://doi.org/10.3390/SU11041206

IRFAN, M., ZHAO, Z.-Y., AHMAD, M., & MUKESHIMANA, M. C. (2019). Solar Energy Development in Pakistan: Barriers and Policy Recommendations. **Sustainability** 2019, Vol. 11, Page 1206, 11(4), 1206. https://doi.org/10.3390/SU11041206

POWER SHORTAGES IN PAKISTAN: Causes and Solutions **Pakistan's energy crisis and its consequences**. (n.d.).

Power shortages in Pakistan: Causes and Solutions **Pakistan's energy crisis and its consequences.** (n.d.).

REHMAN, A., & DEYUAN, Z. (2020). Pakistan's energy scenario: A forecast of commercial energy consumption and supply from different sources through 2030. **Energy, Sustainability and Society,** 8(1), 1–5. https://doi.org/10.1186/S13705-018-0167-Y/FIGURES/4

REHMAN, A., & DEYUAN, Z. (2020). Pakistan's energy scenario: A forecast of commercial energy consumption and supply from different sources through 2030. **Energy, Sustainability and Society,** 8(1), 1–5. https://doi.org/10.1186/S13705-018-0167-Y/FIGURES/4

TROTTA, G. (2021). Electricity awareness and consumer demand for information. **International Journal of Consumer Studies**, 45(1), 65–79. https://doi.org/10.1111/IJCS.12603

TROTTA, G. (2021). Electricity awareness and consumer demand for information. **International Journal of Consumer Studies,** 45(1), 65–79. https://doi.org/10.1111/IJCS.12603

ELECTRONIC SOURCES

ABDUL-GANIYU, S. D. (2020). Investigation of solar photovoltaic-thermal (PVT) and solar photovoltaic (PV) performance: A case study in Ghana. Energies, 13(11), 2701. https://www.mdpi.com/728234 adresinden alındı

About the RepoRt. (2015). www.usip.org

ABOUT THE REPORT. (2015). www.usip.org

ABOUT THE REPORT. (2015). www.usip.org

Addressing the Electricity Shortfall in Pakistan through Renewable resources | Semantic Scholar. (n.d.). Retrieved February 1, 2022, from https://www.semanticscholar.org/paper/Addressing-the-Electricity-Shortfall-in-Pakistan-Hameedi/01ce8e3869d6ac45c5181175503cc17aebda2aa1

ADDRESSING THE ELECTRICITY Shortfall in Pakistan through Renewable resources | Semantic Scholar. (n.d.). Retrieved February 1, 2022, from https://www.semanticscholar.org/paper/Addressing-the-Electricity-Shortfall-in-Pakistan-Hameedi/01ce8e3869d6ac45c5181175503cc17aebda2aa1

ADDRESSING THE ELECTRICITY Shortfall in Pakistan through Renewable resources | Semantic Scholar. (n.d.). Retrieved February 1, 2022, from https://www.semanticscholar.org/paper/Addressing-the-Electricity-Shortfall-in-Pakistan-Hameedi/01ce8e3869d6ac45c5181175503cc17aebda2aa1

ADDRESSING THE ELECTRICITY Shortfall in Pakistan through Renewable resources | Semantic Scholar. (n.d.). Retrieved February 1, 2022, from https://www.semanticscholar.org/paper/Addressing-the-Electricity-Shortfall-in-Pakistan-Hameedi/01ce8e3869d6ac45c5181175503cc17aebda2aa1

AKHTAR, S. M. (2018). Advances and significance of solar reflectors in solar energy technology in Pakistan. Energy & Environment, 28(4), 435-455. https://journals.sagepub.com/doi/abs/10.1177/0958305X18758487 adresinden alındı

AKPOLAT, A. N. (2019). Performance analysis of a grid-connected rooftop solar photovoltaic system. Electronics, 8(8), 905. https://www.mdpi.com/516110 adresinden alındı

ALVES, B. (2022, April). Distribution of electricity generation in Pakistan in 2021, by source. Statista: https://www.statista.com/statistics/1237548/pakistan-distribution-of-electricity-production-by-source/ adresinden alındı

AZIZ, R. A. (2015). Pakistan's Power Crisis:. United States Institute of Peace. https://www.files.ethz.ch/isn/192262/SR375-Pakistans-Power-Crisis-The-Way-Forward.pdf adresinden alındı

BHANDARI, B. S.-T.-H. (2014). Mathematical modeling of hybrid renewable energy system: A review on small hydro-solar-wind power generation. international journal of precision engineering and manufacturing-green technology, 1(2), 157-173. https://link.springer.com/article/10.1007/s40684-014-0021-4 adresinden alındı

DOBRZAŃSKI, L. A. (2016). Comparison of electrical characteristics of silicon solar cells. Journal of Achievements in Materials and manufacturing Engineering, 1-2. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.563.7213&rep=rep1&type=pdf adresinden alındı

ENERGY CRISIS IN PAKISTAN. (n.d.). Retrieved February 1, 2022, from https://calhoun.nps.edu/handle/10945/47900

ENERGY CRISIS IN PAKISTAN. (n.d.). Retrieved February 1, 2022, from https://calhoun.nps.edu/handle/10945/47900

ENERGY CRISIS IN PAKISTAN. (n.d.). Retrieved February 1, 2022, from https://calhoun.nps.edu/handle/10945/47900

ENERGY CRISIS IN PAKISTAN. (n.d.). Retrieved February 1, 2022, from https://calhoun.nps.edu/handle/10945/47900

FINANCE. (2021). Energy. http://www.finance.gov.pk/survey/chapters_21/14-Energy.pdf adresinden alındı

First phase of Turkey’s biggest solar power plant completed | Daily Sabah. (n.d.). Retrieved February 1, 2022, from https://www.dailysabah.com/business/energy/first-phase-of-turkeys-biggest-solar-power-plant-completed

First phase of Turkey’s biggest solar power plant completed | Daily Sabah. (n.d.). Retrieved February 1, 2022, from https://www.dailysabah.com/business/energy/first-phase-of-turkeys-biggest-solar-power-plant-completed

FIRST PHASE OF TURKEY's biggest solar power plant completed | Daily Sabah. (n.d.). Retrieved February 1, 2022, from https://www.dailysabah.com/business/energy/first-phase-of-turkeys-biggest-solar-power-plant-completed

First phase of Turkey's biggest solar power plant completed | Daily Sabah. (n.d.). Retrieved February 1, 2022, from https://www.dailysabah.com/business/energy/first-phase-of-turkeys-biggest-solar-power-plant-completed

G. BONVICINI, A. V. (2020). Kalyon Güneş Enerjisi Üretim Istanbul, Turkey. https://kalyonpv.com/documents/Appendix-C-Climate-Change-Risk-Assessment-Report.pdf adresinden alındı

INVEST IN KONYA - ENERGY. (n.d.). Retrieved February 1, 2022, from http://www.investinkonya.gov.tr/en/sektor.asp?SayfaID=1

INVEST IN KONYA - ENERGY. (n.d.). Retrieved February 1, 2022, from http://www.investinkonya.gov.tr/en/sektor.asp?SayfaID=1

INVEST IN KONYA - Energy. (n.d.). Retrieved February 1, 2022, from http://www.investinkonya.gov.tr/en/sektor.asp?SayfaID=1

INVEST IN KONYA - Energy. (n.d.). Retrieved February 1, 2022, from http://www.investinkonya.gov.tr/en/sektor.asp?SayfaID=1

IS BIOMASS REALLY RENEWABLE? (n.d.). Retrieved March 17, 2022, from https://news.climate.columbia.edu/2011/08/18/is-biomass-really-renewable/

Is Biomass Really Renewable? (n.d.). Retrieved March 17, 2022, from https://news.climate.columbia.edu/2011/08/18/is-biomass-really-renewable/

KARAPINAR SOLAR POWER PROJECT, Konya Province, Turkey. (n.d.). Retrieved February 1, 2022, from https://www.nsenergybusiness.com/projects/karapinar-solar-power-project/

KARAPINAR SOLAR POWER PROJECT, Konya Province, Turkey. (n.d.). Retrieved February 1, 2022, from https://www.nsenergybusiness.com/projects/karapinar-solar-power-project/

KARAPINAR SOLAR POWER PROJECT, KONYA PROVINCE, Turkey. (n.d.). Retrieved February 1, 2022, from https://www.nsenergybusiness.com/projects/karapinar-solar-power-project/

KARAPINAR SOLAR POWER Project, Konya Province, Turkey. (n.d.). Retrieved February 1, 2022, from https://www.nsenergybusiness.com/projects/karapinar-solar-power-project/

KHALIQ, A. A. (2015). Quaid-e-Azam solar power park: Prospects and challenges. 2015 Power Generation System and Renewable Energy Technologies (PGSRET), 1-6. https://ieeexplore.ieee.org/abstract/document/7312186/ adresinden alındı

KHOSA, A. A.-U. (2020). Performance analysis based on probabilistic modelling of Quaid-e-Azam Solar Park (QASP) Pakistan. Energy Strategy Reviews, 100479. https://www.sciencedirect.com/science/article/pii/S2211467X2030033X adresinden alındı

MALIK, S. M.-H. (2019). Energy Security in Pakistan: A quantitative approach to a sustainable energy policy. https://www.think-asia.org/handle/11540/11326 adresinden alındı

MENGAL, A. N. (2019). Modeling of future electricity generation and emissions assessment for Pakistan. Processes, 7(4), 212. https://www.mdpi.com/444732 adresinden alındı

MINISTRY OF FINANCE. (tarih yok). Pakistan Electricity Consumption: Other Govt. CEIC: https://www.ceicdata.com/en/pakistan/energy-consumption-and-supplies-annual/electricity-consumption-other-govt adresinden alındı

PAKISTAN | ELECTRICITY Generation and Consumption | CEIC. (n.d.). Retrieved

February 1, 2022, from https://www.ceicdata.com/en/pakistan/electricity-generation-and-consumption

PAKISTAN | ELECTRICITY Generation and Consumption | CEIC. (n.d.). Retrieved February 1, 2022, from https://www.ceicdata.com/en/pakistan/electricity-generation-and-consumption

PAKISTAN | ELECTRICITY GENERATION AND CONSUMPTION | CEIC. (n.d.). Retrieved February 1, 2022, from https://www.ceicdata.com/en/pakistan/electricity-generation-and-consumption

PAKISTAN | ELECTRICITY Generation and Consumption | CEIC. (n.d.). Retrieved February 1, 2022, from https://www.ceicdata.com/en/pakistan/electricity-generation-and-consumption

PAKISTAN COAL CONSUMPTION. (tarih yok). CEIC: https://www.ceicdata.com/en/indicator/pakistan/coal-consumption adresinden alındı

Quaid-e-Azam Solar Power. (tarih yok). Quaid-e-Azam Solar Power pvt Ltd. adresinden alındı

SARAVANAN, V. S. (2018). Solar photovoltaic panels cleaning methods a review. Int. J. Pure Appl. Math, 118, 1-17. https://www.researchgate.net/profile/Sanjay-Darvekar/publication/338990581_Solar_Photovoltaic_Panels_Cleaning_Methods_A_Review/links/5e37c59592851c7f7f17baef/Solar-Photovoltaic-Panels-Cleaning-Methods-A-Review.pdf adresinden alındı

SHAH, S. A. (2019). A sustainable solution for electricity crisis in Pakistan: opportunities, barriers, and policy implications for 100% renewable energy. Environmental Science and Pollution Research, 26(29), 29687-29703. https://link.springer.com/article/10.1007/s11356-019-06102-0 adresinden alındı

Solar resource maps and GIS data for 200+ countries | Solargis. (n.d.). Retrieved February 1, 2022, from https://solargis.com/maps-and-gis-data/download/pakistan

SOLAR RESOURCE maps and GIS data for 200+ countries | Solargis. (n.d.). Retrieved February 1, 2022, from https://solargis.com/maps-and-gis-data/download/pakistan

SOLAR RESOURCE maps and GIS data for 200+ countries | Solargis. (n.d.). Retrieved February 1, 2022, from https://solargis.com/maps-and-gis-data/download/pakistan

SOLAR RESOURCE MAPS OF PAKISTAN. (tarih yok). solargis: https://solargis.com/maps-and-GIS-DATA/DOWNLOAD/PAKISTAN ADRESINDEN ALINDI

RESUME

Personal Information

Name: MUHAMMAD TAYYAB ANJUM

Education

2019-2021 Master Of Electrical & Electronics Engineerıng, Istanbul Aydin Unıversity, Turkey.

2014-2018 Bachelors in Electrical Engineering, Superior University Lahore

Publications

Integration of Hybrid Grids in Smart Grid, Volume 05 Issue 11, November 2021, PP 05-12 International Journal of Latest Research in Engineering and Management (IJLREM) ISSN: 2456-0766

Language Skills

Urdu/Hindi	English	Turkish
Excellent	Excellent	Good