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Addressing the Electricity Shortfall in Pakistan through Renewable Sources

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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

1. 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 growth of the contemporary economy is dependent on energy. To work efficiently, all human activities, such as education, health care, agriculture, and work, take a lot of energy. The world cannot succeed without the efficient use of force. It is regarded as a vital component of the nation's economy. Pakistan is still a developing nation. The country requires a substantial quantity of energy to keep things moving ahead, following the recent improvements and help for people and businesses. However, there is a shortage of electricity and the country is in dire need of electricity. The disparity between electricity supply has expanded over the years, and it was especially noticeable last summer, when total power outages of ten to twelve hours in metropolitan areas and sixteen-eighteen hours in rural regions occurred. Energy demand is growing by more than 9% a year in Pakistan. It is expected that power demand will increase 8 times by 2030 and 20 times by 2050 in Pakistan.

2. Importance of Study

Pakistan, as an oil-importing country, spends a considerable percentage of its budget on oil imports, which is the driving force for this study. The government spent $14 billion on oil imports in the previous years, out of a total budget of $43 billion, to keep its power plants and autos running. This means that oil imports accounted for 32.5 percent of the budget. The cost of oil imports in fiscal year 2008-09 was USD 9.36 billion. As a result, assuming oil prices remain constant over the next decade, which is unlikely in the current situation, the government would spend more than 140 billion dollars on oil imports to satisfy its needs. Although two shifting automobiles on non-conventional sources are difficult to come by at the moment. However, I think that if we encourage renewable energy sources, which are also a more sustainable way of producing power, the government will be able to put some of this money into infrastructure, education, and health care, all of which would benefit the country's socioeconomic advancement. 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)

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)

2.1. Energy Crisis and its Consequences

Electricity is an important part of the production system as a source of energy. It is impossible to achieve long-term, high-growth economic growth without a reliable, uninterrupted power supply. Pakistan is an example of research into the effects of power shortages, which have contributed to lazy GDP development, industrialization, negative job creation, a significant, negative impact on the state budget, and difficulties for the average family consumer. The consequences include as:

(i) Slow economic growth
(ii) Risk to stability

2.2. Roots of Energy Crisis

Pakistan's energy sector is in crisis due to insufficient power generation to meet the growing demand over the past decades. Debt relief, economic position, and electrical supply are the key culprits. Natural gas and oil are the primary sources of energy, with natural gas and oil accounting for more than 80% of all energy firms. Power shortages and insufficient electricity generation are mostly caused by low and inexpensive power output from hydroelectric and coal-fired power plants. Pakistan's energy consumption has grown as a result of the country's strong growth rate, which is projected to be over 3% each year. The usage of coal, natural gas, oil, and liquefied petroleum gas has increased to fulfill the country's expanding energy needs. (Rehman & Deyuan, 2020)

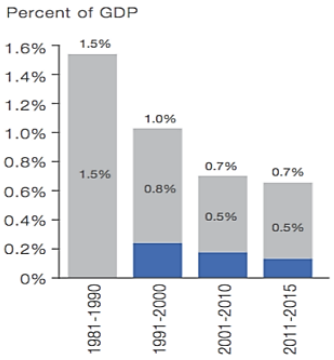

Figure 1 Percent GDP of Pakistan source usip.org

The factors are written below:

- Growing household demand
- Consumption that is inefficient
- Supply side power generation
- Financial management
- Government concerns
- Lack of Accountability

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: From June 1991 until 2020, total data is updated annually, averaging 64,465.000 GWh across 30 observations. In 2020, the data reached a new high of 112,070.000 GWh, while in 1991, it reached a record low of 31,534.000 GWh. The Ministry of Finance reports the whole data, which is still active in CEIC. In the Global Database, the data is

classed as Pakistan – Table PK.RB006: Electricity Generation and Consumption. (*Pakistan | Electricity Generation and Consumption | CEIC*, n.d.)

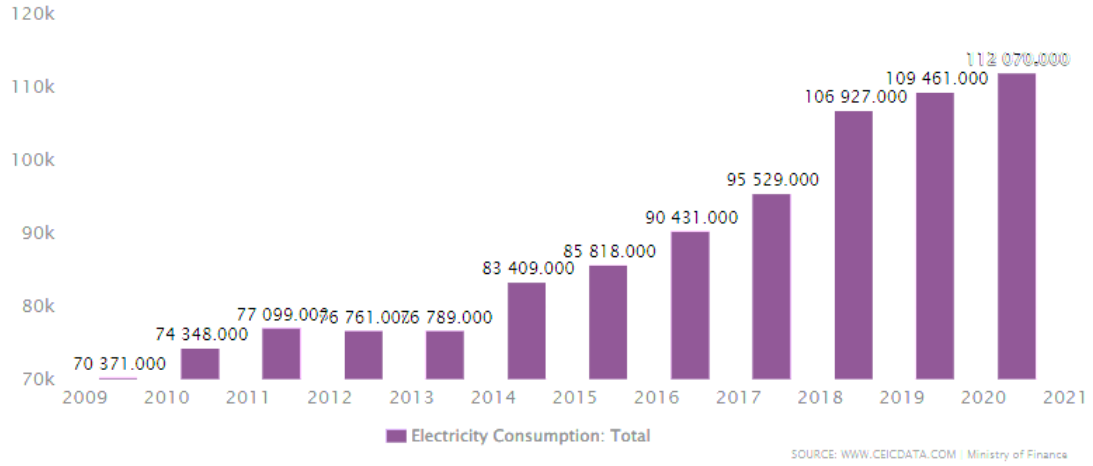

Figure 2 Electricity consumption of Pakistan year 2009-2021 source CEICDATA

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. (*Pakistan | Electricity Generation and Consumption | CEIC*, n.d.)

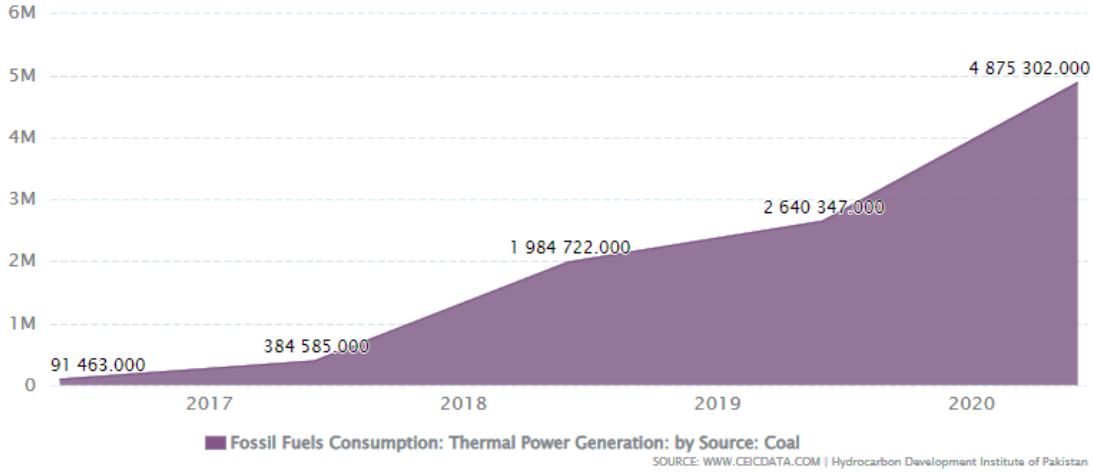

Figure 3Pakistan Increasing consumption of fossil fuels every year source CEIC data

3. Practical Experiences Needs to be Learned from China, India and Turkey

As previously stated, the major purpose of this research is to examine China, India, and Turkey's techniques for maximizing the benefits of their existing renewable resources, and to explore how similar tactics may be adopted in Pakistan. The case study method was utilized to respond to this question, and it is the focus of this and the next chapters. Pakistan is in the midst of a challenging growth phase, but the country's economic progress is being impeded by a power outage. It has a daily power shortfall of 7,000 MW (602 toe), which intensifies when the rivers' water levels drop to their lowest levels in the winter. According to the Pakistan Energy Year Book 2011, the country produces most of its energy from non-renewable resources, especially oil thirty-five percent and gas twenty-seven percent, which puts a strain on the economy because the country has spent so much time. $ 14 billion in oil exports, accounting for about one third of the total budget and exceeding all other government spending. (Hameedi, 2012)

In Pakistan, there is an urgent need for government to focus on creating renewable energy industries. This will not only provide people with more jobs, but will also significantly reduce the cost of renewable energy

sources in Pakistan. Government commitment to promoting renewable energy sources is essential. Pakistan is gearing up for renewable energy, as the country is blessed with rivers flowing across the country. Solar and wind energy, in addition to rivers, are widely implemented across the country. The following are some strategies for promoting renewable energy resources in Pakistan.

3.1. Enhancing consumer awareness in Pakistan

"Electricity awareness" are associated with energy savings. In addition, this study analyzes the willingness to obtain more information about energy efficiency and savings and how it differs between respondents "who are aware of electricity" and "unconscious electricity". The Pakistani government must implement initiatives to enhance public awareness about the need for energy saving in the country. Because more energy is saved at the consumer level, power plants will need to produce less energy, resulting in a smaller environmental effect. Advertisements in print and electronic media can help with this. The Punjab government organized a national conference on Energy for Growth and Sustainable Development in February 2012. The symposium's focus was on energy saving among consumers. (*Addressing the Electricity Shortfall in Pakistan through Renewable Resources | Semantic Scholar*, n.d.)

3.2. The Strategy of Enhancing Capacity of Hydro Power Adopted by China

Pakistan's government might seek counsel from its Chinese counterparts. China presently provides electricity to 300 million people in rural regions via small hydropower plants. Small hydroelectric dams in China produced 51,000 megawatts of power in 2008, and the total installed capacity is predicted to reach 75,000 megawatts by the end of 2020. Pakistan may employ the same method to provide power to its citizens in remote areas of the country.

3.3. Use RE-Source Name as PV Panels Adopted by India

Now the idea has been created that solar power could be a panacea to solve all the problems related to climate change and India's independence. There is no doubt that India loves the sun god and the whole country has been given more than 300 sunny days which makes it a very attractive way to generate electricity. However, there is still a lot of fishing: the sun is only available for half a day and as a result excessive reliance on solar energy can be very dangerous during the dark. Today the country plans to increase its solar power generation to 100,000 MW by 2022, which is a nearly 25-fold increase from 4000 MW of installed capacity in 2015. This means that every year India will need to invest about 14,000 MW of solar energy continuously so that in the next 7 years if this ambitious target of 100 gigawatts is to be achieved.

4. Challenges and Obstacles to Overcome Shortfall in Pakistan

Later 2014 and earlier 2015 incidents demonstrate that Pakistan's energy problem is cemented, with severe implications and expressions. Inefficient institutional and organizational processes, in addition to Pakistan's increased energy usage, are major factors to the current crisis. As a result, it's vital to acknowledge that just building energy infrastructure and boosting energy production won't help Pakistan deal with its impending energy problem. Given that total current generating capacity and peak time demand are virtually equal, it's reasonable to assume that management faults are the primary obstacles to the situation's stabilization.

4.1. Physical Supply Shortfalls

Conventional fuels like firewood, agricultural waste, and animal waste, as well as commercial fuels like coal, oil, natural gas, and hydroelectricity, are among Pakistan's significant energy resources. Conventional fuels accounted for 34.9 percent of total energy supply in Pakistan in 2012, with natural gas accounting for 31.7 percent and oil contributing for 24.8 percent. The rest was made up of coal, nuclear power, and hydropower. Pakistan's power sector creates electricity from primary fuels and acts as a backup source of energy for families, industrial, business, and other economic activities in the event of a power outage. In 2013, fuel oil accounted for 35.9% of Pakistan's electrical generation, followed by hydropower (31.1%), natural gas-fired power plants (28.1%), and nuclear power (28.1%).

4.2. Demand Growth

Pakistan's power system, which consists of a mix of public and private power plants, has an installed capacity of 22,812 megawatts (MW) as of June 2013. Pakistan's government announced in 2013 that it would build at least 16,545 MW of additional generation capacity by 2018, primarily through the construction of new coal-fired power plants, to take advantage of the country's vast but underutilized domestic resources, such as hydroelectricity and coal.

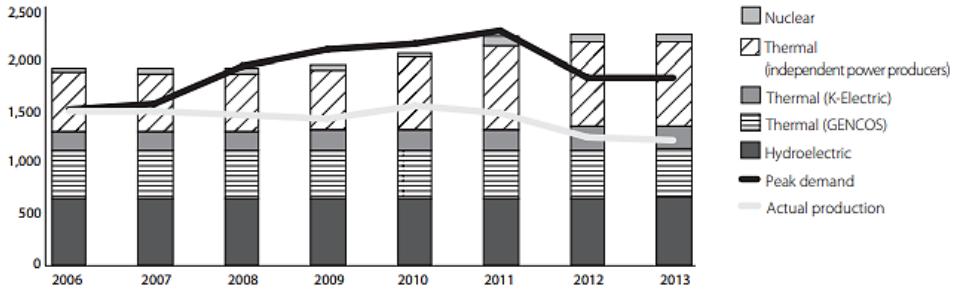

Figure 4 Actual Demand vs Peak Demand Source cdpr.org.pk

4.3. Financing Troubles

The present power crisis is mostly caused by a lack of investment in energy generation and delivery. In other circumstances, a shortage of operating capital or credit has prevented companies from fully utilizing present capacity, while further generation capacity has been delayed. The corporation's strong reliance on tax incentives to fill the gap among both available funds and cost of production magnifies the demand and spending imbalances. Power tariffs have remained lower than those established by NEPRA for the past 10 years under consecutive governments.

4.4. Pakistan 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.

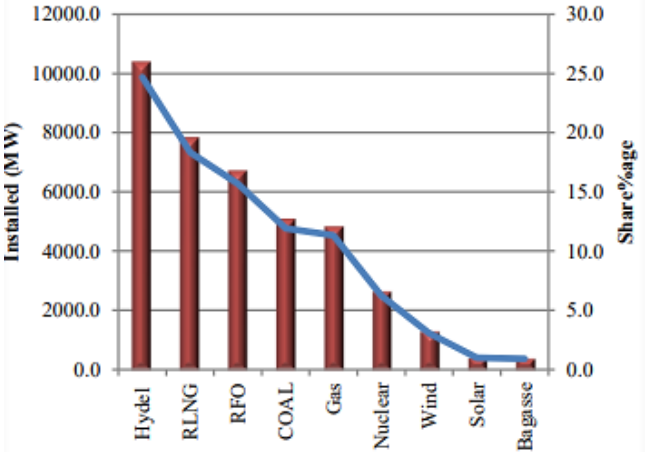

Figure 5 Pakistan Energy capacity w.r.t sources (esmap.org)

5. Comparison of Quaid-e-Azam power plant and Karapinar Solar Plant

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. As a result, the Punjab government choose to generate electricity from renewable energy sources. Solar energy is the most visible source of sustainable power among all the assets. (*Solar Resource Maps and GIS Data for 200+ Countries | Solargis*, n.d.)

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. 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

5.1. 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 255W*392160=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.

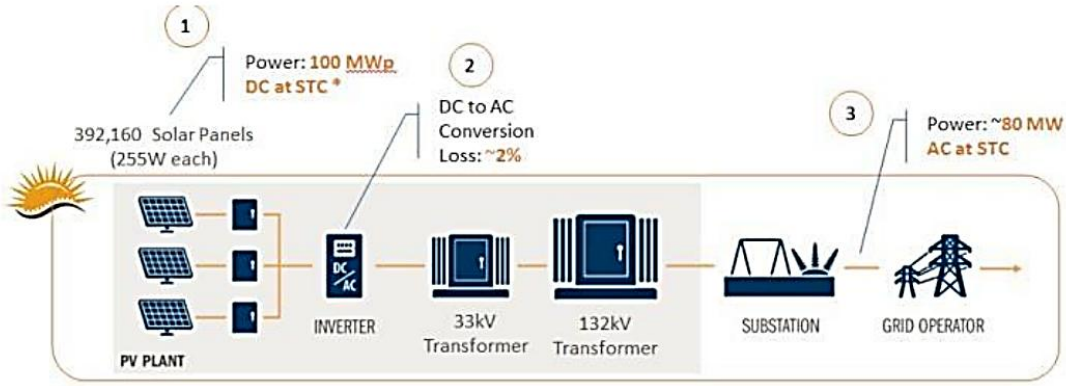

Figure 6 PV conversion System

Matlab Simulation

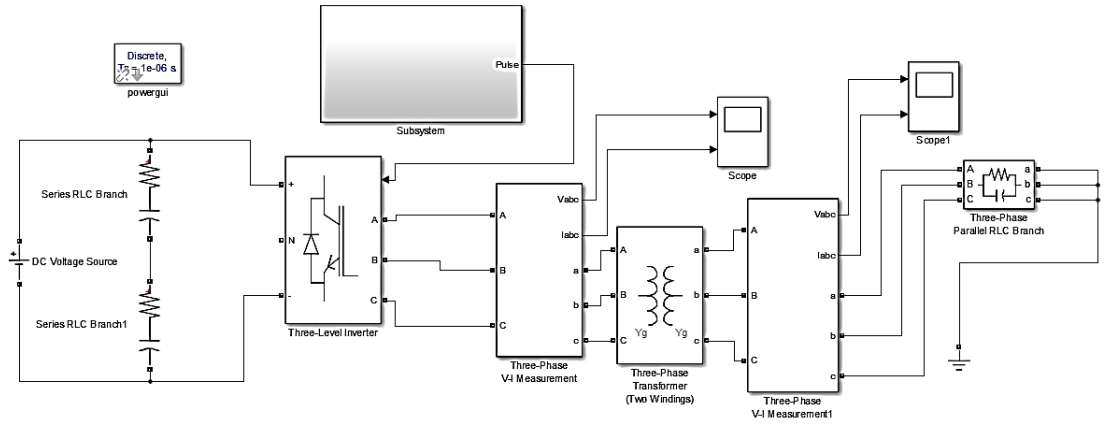

Figure 7 PV Conversion System simulation

The combiner provides the output of all solar panels in dc voltages form which is further transferred to a three-level inverter by using an RC circuit. The pulse of the three-level inverter is controlled by subsystem and the controlled output of the inverter is transferred to the three-phase transformer at the substation which is connected by the RC load.

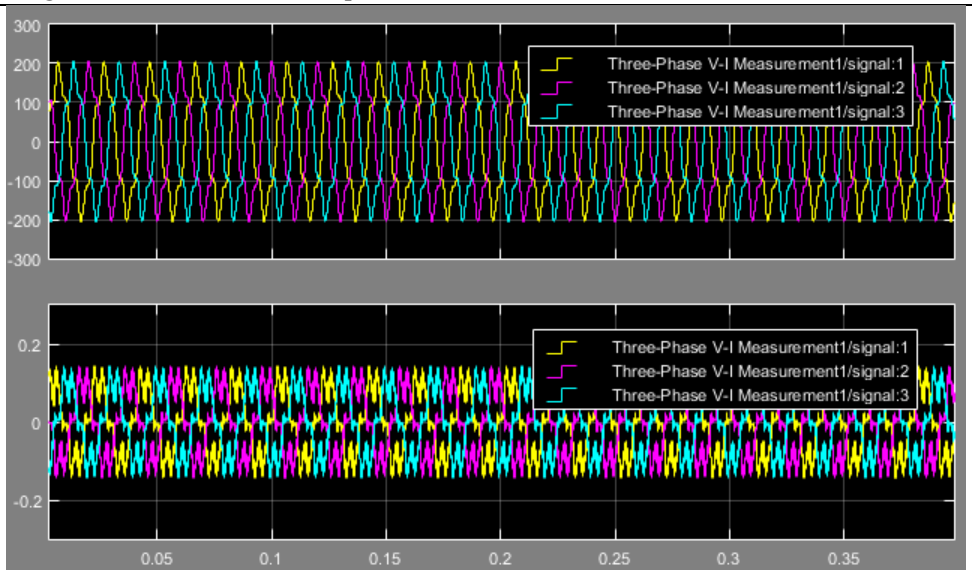

Figure 8 output after extraction of power from all panels

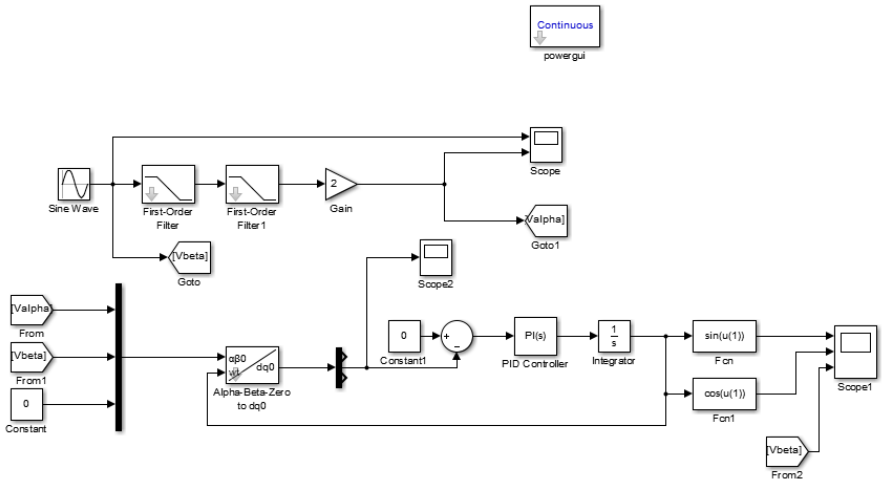

Figure 9 Current and Voltage control system for substation

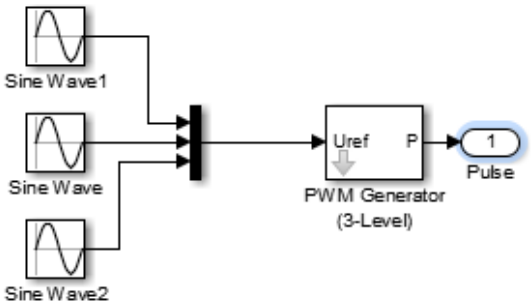

Figure 10 subsystem of control circuit

The phases and amplitude of the original signal are tracked using a phase locked loop. It's a fantastic tool for real - time communication. In the suppressed carrier method of communication, PLL captures the frequency band and generates a consistent carrier frequency inside the receivers for audio decoding.A PLL works in the same way as a traditional feedback loop. It adjusts the VCO's output frequency until it equals the input signal's frequency, i.e. until it is in synchronization with the original signal.

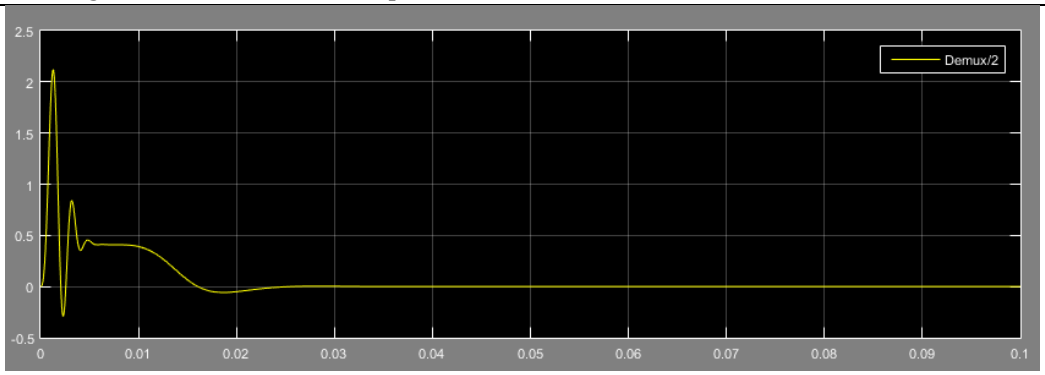

Figure 11 Output of controlling circuit

5.2. Karapinar Solar plant Turkey

The Karapinar solar power project is located about 4.5 kilometers north of the D330 Konya-Adana Highway in the Karapinar district of Konya Province, Turkey. The 19.2km2 project location is around 100 kilometers from the Konya airport in Central Anatolia. The first phase of Turkey's largest solar project, the Karapinar Solar Power Plant (SPP), has been completed, according to Turkey's Energy and Natural Resources Minister Fatih Donmez, with panel installation reaching 271 megawatts of capacity. The facility, according to Donmez, is the outcome of Turkey's first renewable energy YEKA tender, also known as YEKA GES-1, which attracted interest from both domestic and foreign corporations, pushing Turkey to take more renewable energy measures. ' Turkey is presently ranked 13th in the world and ninth in Europe, with 7,154 MW of solar capacity. These statistics, hopefully, will continue to climb year after year. The Karapinar SPP, which is presently 20% complete, will be completely operational by the end of 2022, but electricity generation has already started. On March 20, 2017, a Kalyon-Hanwha partnership received the first solar energy YEKA contract offer for the building of a plant in Karapinar, at a cost of $0.0699 per kilowatt-hour. Hanwha later backed out of the project, and CETC stepped in to finish it.(*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.)

Table 1 Comparison of Quaid-e-Azam power plant vs Karapinar Turkey source dailysabah

Serial #	**Parameter**	**QASP**	**Karapinar**
1.	Total Capacity	100MW	1000MW
2.	No of Panels used	392,160	3.5 million
3.	Power of each solar panel	255W	.....
4.	Carbon emission avoided	22,238,420.6	1.5 million tons
5.	Power Losses	20 percent	.....
6.	Area acquired	2023000 m2	59.710.000 m2
7.	The efficiency of PV panels used	17.9%	21%

As it can be seen that from the above table that the capacity difference of QASP and Karapinar is huge which obviously leads to use more solar panels to achieve that amount of electric output power. The solar panels used in QASP are of 255-watt power and total 392,160 solar panels are being used. Whereas in Karapinar total solar panels are 3.5 million. Both of power plants are RE or greener energy based power plant so both are

avoiding huge amount of carbon emission wrt their output capacities. The power losses calculated for the QASP is 20 percent calculated whereas the power loss for Karapinar is unknown for now. The efficiency of solar panels used in QASP is low as compared to the solar panels used in Karapinar which is 21 percent. In this comparison just want to show the SWOT (strengths Weaknesses Opportunities Threats) analysis for these two concentration Power Plants. We discuss the total strength number of panels used power for each panel carbon emission and even losses for these panels.

6. 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 Karapinar solar power plant has been done and it concluded that RE sources are the future of Electricity production and only using these sources the increasing electricity demand can be overcome.

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