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Novel research methods on the net-zero economy of climate finance in the energy sector

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ABSTRACT

This is a perspective, about the future climate policy of Pakistan, to improve the harvest of Green Climate Funds (GCF). This paper takes upon the calculation of climate financing potential in the context of the energy sector of Pakistan by estimating the potential of becoming a net-zero sector in Pakistan's Economy. The study has identified several options for the government to reallocate the energy mix and tie the energy demand targets with climate targets for a green future of Pakistan. The study has used basic excel tools to calculate facts from the available data sets in Pakistan. The study found that, if Pakistan chooses to shift from dirty sources of energy production to the use of cleaner inputs for energy production, Pakistan can generate a significant amount of climate finance by reducing the emissions from energy production, which are recordable, traceable, and can be evaluated by any of the third-party evaluating organization. The initial cost for Pakistan will cause some discrepancies in some of the macroeconomic indicators and may also cause budget imbalances it will surely help the economy to achieve the targets of becoming a net-zero economy and be able to harvest Green Climate Funds in long term with much faster rate, which can overpass the investments made or being made in this sector and will create a significant amount jobs in the economy, which will be green jobs, promoting environmental friendly output and sustainable growth.

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1.1. Introduction

It is a commonly known fact that low-income countries are more vulnerable to current climate variability and future climate change than rich countries because the rich countries have the bounce-back capacity (Fankhauser & McDermott, 2014; Kreft et al., 2013; World Bank, 2013). Pakistan is facing a severe level of threats from

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climatic changes and has faced both human life losses and economic losses in the last few events caused by human-induced activities. The action against changing climate has a specific amount of cost for a household or organization. The study by Aslam et al (2017) conducted a Cost-benefit analysis of sector-specific adaptations in Pakistan. The study established that an Increased frequency of floods will result in increased annual losses of USD 66.8 to 79.3 billion over a sharp period of time. However, some floods with selected adaptation options will result in a reduction of loss from USD 66.8 billion to USD 55 billion annually. Pakistan is far behind in the race of receiving the Climate financing and has not been acknowledged considerably by the international communities around the world [Kaleidoscope, that is Pakistan CHP 13 p 159 (Imran et al, Nov 2019)] Mobilizing climate finance in developing countries can help to achieve targets against climate change across the globe [Pickering et al. (2015)].

Unfortunately, Pakistan still remains on the list of least attended countries on the climate appeals made by the experts for compensation against drastic impacts of climate change driven by the emissions of developed countries. Pakistan can improve on the list, by overcoming the issues related to the lack of consistent data sets, which has constrained Pakistan's willingness to face climate change and has strengthened financial losses in terms of adaptation costs for more than 3.0 percent of Gross Domestic Product GPD annually. Government reports that mitigation cost is increasing over time with an expected value of 5.5 percent of GDP in coming years (GoP (2017). The study of Khattak and Ali (2015) highlighted that the temperature is rising in Pakistan, indicating that the climate is changing, and evidence of global warming can be observed across all the provinces, only by looking at the data on temperature and other climate indicators. Exposure to climate change index indicates that Pakistan ranks at the topmost climate risk listed countries [German-watch in (2017)].

The emission trends of Pakistan suggest that there is a consistently increasing trend of CO2 emissions which provide a breeding ground for Green House Gases and elevates the temperature and thus causing changes in the climatic conditions of the country. During recent years, the carbon emissions and ecological issues have emerged due to economic development and use of excessive non-renewables and fossil fuels (Shahzad et al., 2021a; Zhao et al., 2022; Shahzad et al., 2022) Professionals have projected that the most vulnerable developing countries are required to bring up innovative investments of up to $3000 Million by the end of every twelve months, which will be amplified to $500 billion each year by the end of FY 2030, to reduce their growing greenhouse gas emissions in line with a global equilibrium target of 450 parts per millions of CO2 equivalent Venugopal and Srivastava (2012). It is obvious that reducing emissions to the target level will cost the economy in terms of reducing productivity or shifting to cleaner inputs may be comparatively expensive for the future production of goods and services in the energy sector. Knowing that climate change is a threat to human survival on planet earth, Pakistan is still not currently able to finance climate change targets [Zhongming & Wei, (2017)].

According to UNFCCC Action must come from governments, cities, regions, businesses, and investors. Everyone has a role to play in effectively implementing climate targets set in the Paris agreement. As per readings and knowledge of authors, there

are only a few studies, conducted on climate financing with respect to the energy sector but none of the studies has been conducted on the energy sector of Pakistan which attempts to measure the financing potential of the energy sector through real-time data. In his Book 'Kaleidoscope, that is Pakistan' CHP 13 p 159 (Imran et al, Nov 2019) explored this subject in qualitative research design.

The study of Zang et, al. (2020) explored the energy and climate financing, through a qualitative research approach but in the case of Pakistan, it has never been categorically estimated for the energy sector, which can help in policy making process against future climate challenges. However, it is not easy to compromise the development budget for climate financing. On one side, a country is facing the significant impacts of climate change in every sector but on the other side, a country is not able to support such kinds of expenses with very limited available resources. It is very important to tackle the influencing or triggering factors through external financing. The argument, that developed countries should pay for the expenditure of climate-related actions in less developed or developing countries, is an appeal for compensation against the brunt of development in developed countries. The Green Climate Funds program is one important source, which can be utilized for financing transparent climate actions taken to combat climate change in Pakistan. This paper is presenting an idea and a practical calculation of Pakistan's energy sector emissions and options to reallocate the energy mix, which can serve as a long-term goal for climate financing in Pakistan. This way Pakistan's energy sector can become a NetZero sector.

1.2. Potential of climate financing in the gas and electricity sector

INDC is intended for nationally determined contribution, which is a promise of countries to achieve climate-oriented goals and objectives of carbon reduction. There are certain targets set by climate experts to reduce the pas of changing climate. Control on carbon emissions has a specific economic cost for a country. To reduce emissions, either new environment-friendly technologies should be deployed in the production process, or the production of goods should be compromised. It is very important to calculate the optimum level of production, without impairing the climate-oriented targets of a country. The energy transition from highly polluted to environment-friendly options in the electricity sector can contribute a significant number of economic gains to Pakistan. Projected emissions of 2,685 MtCO2e up till year 2050 are expected from energy sector in Pakistan, which is the highest, followed by the agriculture sector projection of 1395 MtCO2e in 2050. The potential of climate financing can be observed in these two sectors specifically, with inputs composition change policy and mitigation policies. Mitigation techniques can also work for reduction of Co2 emissions in electricity sector, when production of electricity from diesel is shifted to solar or wind energy plants. The per unite emissions from energy sector in Pakistan is estimated 0.566 tCO_2/MWh (tons of carbon dioxide per megawatt hour) for wind and solar power projects and 0.478 tCO_2/MWh for hydro power projects excluding Karachi Electric Supply Company (KESC) grid and 0.606 tCO_2/MWh for wind and solar power projects and 0.505 tCO_2/MWh for hydro by including

KESC grid. This emissions factor is also an element of the amount of Certified Emission Reductions (CERs) that can be accumulated by employing clean Alternative and Renewable Energy (ARE) projects. The amount of CERs generated by an ARE project are also projected to earn the carbon revenue streams in near future [Abas et al. (2017)].

1.3. Potential of climate financing in coal power plants emissions offsetting

Climate finance can be generated by shifting from coal base production activities to oil, nuclear, Gas, and hydro-based electricity generation in Pakistan. This can be done by directly compromising the productivity of coal power plants or by improving the quality of coal in terms of the emissions factor of existing coal reserves Kang et al. (2020). Not only by shifting but also, If Pakistan can agree with trading partners to limit or reduce the subsidies for the export and import of inefficient coal power plant technologies, If Pakistan can substitute coal power plant to solar power plant under CPEC approved agreements re-alterations, which can reduce significant amount of emissions with minor intensification of incremental costs, which can be easily compensated through GCF and other organization struggling for the reducing of global emission.

1.4. Resource specific energy production potential and green-house gases (GHG) emissions in Pakistan

Small hydro power plants have the potential to produce approximately 4500 mega votes electric energy, which is cleaner production process in terms of minor GHG emissions emitted by the electric motors and the transmission line losses. This process does not contribute significantly to GHG emissions. However, electric energy consumption has higher GHG emissions as compared to production through small hydropower plants. Pakistan has a total estimated wind power potential of 346,000 MW[1] out of which around 60,000 − 70,000 MW is technically easily utilizable. The data on Wind resources shows that southern parts of Sind, Northwestern areas of Baluchistan, Central parts of Khyber Pakhtunkhwa, AJK, western Punjab, and Gilgit Baltistan areas could be potential wind corridors to produce sustainable energy for an increasing population. Bagasse, rice husk, straw, dung, and municipal solid waste has an estimated potential of generating 4,000 MW of power in Pakistan. Around 34 million hectares of marginal land is available in different parts of the country that is best suited for this purpose. This has an estimated potential to produce 50 million tons of biofuels per annum [(AS et al. (2014)].

1. To estimate the potential of the energy sector in becoming a helping hand for achieving the targets of the Net-Zero economy.
2. To answer that where Pakistan Energy sector stands in favor of the Net-Zero targets.

2. Methodology

The study is based on a quantitative approach, known as descriptive analysis. In this study, the authors have taken standards of carbon emissions and total production of the energy with respect to sources of energy production such as Coal, Oil, Hydro, Wind, and Gas. The study has calculated the carbon emission with respect to each source in different scenarios. The study has utilized secondary data for this purpose. The present study follows the empirical strategy and theoretical model from the (Bashir et al., 2020; Shahzad et al., 2021b).

2.1. Data description

Data for the energy section of the project was taken from the energy section of Economic survey of Pakistan (2016-17). The data of electricity generation was taken GW/h, which was converted to KW/h. Time series data was taken from (2000-2017), to estimate the climate financing potential in energy sector of Pakistan. To calculate emissions per KW/h different standards were collected from secondary sources like IPCC, Ministry of water and power reports Pakistan, American energy portal and Canadian electricity generation standards and research conducted by scholars across the world. Per unite emissions generated are calculated by multiplying specific kg/kw/h standards of source of energy used in production of electricity. The Monetary value of Per ton Co2 emissions is provided by international market price 2.15 $2017 Furthermore, the data was utilized for the construction of following indicators,

Monetary value of emissions offsetting

1. Monetary value of Co2 emissions caused from electricity Generation KW/h/$
2. Monetary value of Co2 emissions generated from Oil based electricity Generation KW/h/$
3. Monetary value of Co2 emissions generated from Gas based electricity Generation KW/h/$
4. Monetary value of Co2 emissions generated from Hydro based electricity Generation KW/h/$
5. Monetary value of Co2 emissions generated from Nuclear based electricity Generation KW/h/$

Shifting from dirty energy to clean energy and subsequent emissions calculation

1. To shift from Coal to Oil, Gas, Hydro and nuclear electricity generation, only 10 percent of Total electricity generation from Coal energy is Used, which is calculated from total production from coal.
2. To shift from Oil to Other sectors, 10 percent of total electricity production from Oil is used, which further used to calculate 10 percent Co2 emissions from Oil sector electricity.

3. The Difference of carbon emission is calculated by subtracting Co2 emissions of 10% Coal based produced electricity emissions from Co2 emission generated by the new source from same amount of electricity generation.

Cost associated with shifting from current sources of energy to clean energy products

1. Per unite Cost of energy generation by source is available at website of ministry of Water and power and annual reports published by ministry of water and power, however the study has used per unite cost of electric energy generation from different sources. Economic cost and environmental cost = Total cost, calculated as the average production cost of electricity generated from specific source plus the average monetary value of generated carbon units.
2. To calculate, whether the economy will gain the benefits or will face the losses, from each source of energy per unit emissions/KW/h production of electricity available standards are utilized. The value of emissions, reduced by shifting from one source A to another source B are estimated and compared with shifting the cost of electricity generation from one source A to source B

3. Results and discussion

3.1. Energy production and co2 emissions for different sources

The data shows that, Pakistan is generating highest amount of electricity from Oil energy sources, which is 30200 Gwh on average annually, which is also the main source of Co2 emissions in the country, with average emissions of 9060255 Metric tons annually. In Pakistan Electricity production is significantly dependent some other sources like: Nuclear, Gas and hydro. These are also the important sources of electric energy generation in Pakistan. Coal is dirtiest input, to produce electricity, which emits 0.32 KG/KW/h on per unite production of electricity. Even though very small amount of electricity is produced from coal sources, but still the emissions produced are far more than nuclear source emissions, which generates 25 times higher electric energy on the average of last 18 years. Per unite emissions from hydro is energy generation is very low in fact the lowest comparatively. But due to higher share percentage of electricity generation in total energy production, the yearly average emissions of the hydro are higher than the average emissions from nuclear and coal. The results show that nuclear and hydro electricity generation should be promoted, subsidized to reduce the level of emissions from energy generation and consumption in Pakistan.

3.2. Economic and environmental cost of energy production from different sources

The Table 2 presents the economic and environmental cost of energy generation sources and associated emissions. Energy production from Oil sources is very expensive, which takes 8.02 rupees per KW/h energy generation, followed by the cost of Gas per unite KW/h energy generation, which is 4.24 per unite KW/h production of

Table 1. Sources of energy.

Source of energy	Per unite emissions Kg/ KW/H	Total Electricity generation GWh average (2000-2017)	Total emissions tons average (2000-2017)
Black Coal	0.32	132.041	42253.34
Hydro	0.000505	29022.47	14656.34
Oil	0.3	30200.85	9060255.49
Gas	0.21	30005.94	6301249.40
Nuclear	0.0032	3367.03	10774.50

Source: The data is taken from Pakistan Economic Survey and Energy year books and calculated by authors.

Table 2. Different energy sources.

Sources	Coal	Oil	Gas	Hydro	Nuclear
Per unite KW/h production cost	3.12	8.02	4.24	0.16	1.13
Average of total production KW/h (2000-2017)	132041716	30200851632	30005949549	29022472435	3367031454
Average Cost of total production PKR (2000-2017)	411970154	242210830086	123624512143	4643595590	3804745543
Average Cost of total production $ (2000-2017	3341201.57	1964402514.89	1002631890.86	37660953.69	30857628.08
Per Unit emission KG/kw/h	0.32	0.30	0.21	0.000505	0.0032
Average of Total emissions tons (2000-2017)	42253.34	9060255.49	6301249.405	14656.34858	10774.50
Per Unit $ Price CO2/Ton	2.15	2.15	2.15	2.15	2.15
Average monetary value of emissions (2000-2017) PKR	11201151.59	2401828429	1670429711	3885324.727	2856266.25
Monetary value of emissions average in US $	90844.70	19479549.3	13547686.22	31511.14	23165.17
Total Cost average ENV + ECO (2000-2017) US $	3350286.043	1983882064.19	1016179577.08	37692464.84	30880793.26

Source: The data is taken from Pakistan Economic Survey and Energy year books and calculated by authors.

electric energy from Gas. Hydro energy has the Lowest cost factor of less than one PKR, followed by cost of nuclear energy generation in Pakistan, which is 1.13 per unite KW/h. The dirty sources are all very costly for environment and economy of Pakistan. It is important to realize the implication of energy shift for economic and environmental benefits of Pakistan. Development of economically beneficial, and cleaner energy sources to satisfy the future needs of electricity is extremely important to reduce the emissions of sector to stabilize the target level of temperature. Average of total production from oil sources is 30200 GW/h which is 32 percent of total electricity generation in Pakistan. The production cost of this much electricity from Oil sources is $1964.40 million dollars in Pakistan. With the same amount of investment in Pakistan can generate 32 times higher electricity from hydro power stations, which is cheaper, cleaner and environment friendly. Pakistan has the expected installation capacity of 29,573MW by the end of February 2018, which was 22,812MW in June 2013 Economic survey of Pakistan (2017-18). The important is to allocate higher share of it in Hydro, wind, solar and nuclear energy power plants (Tables 1 and 3).

3.3. Substituting 10% energy generation and associated economic cost with different sources

The results in Table 2 show the values of cost and energy nexus based on 10% of total for each type of energy used for electricity generation. The results indicate, that

Table 3. Cost, emission and financing.

Source	Coal	Oil	Gas	Nuclear	Hydro
10 % of total Quantity generated kw/h	13204171.6	3020085163	3000594955	336703145.4	2902247244
Cost of 10 % Energy Production in US $	334120.15	196440251.49	103183476.1	3085762.80	3766095.369
Cost of Shifting 10 % electricity generation from coal $	–	858860.14	454060.72	121011.46	17134.36704
Change in cost shifting from coal $	–	524739.99	119940.56	−213108.69	−316985.79
Emissions reduction Shift from Coal, tons	–	−396.125	−1452.45	−3786.956	−4218.66
Climate finance generation $ Shifting from Coal to Oil, Gas, Nuclear and Hydro	–	851.66	2271.11	8993.62	9070.13
Cost of Shifting 10 % Actual electricity generation from Oil ($)	–	–	103853699	27677990.55	1525143.007
Change in cost shifting from Oil to others $	–	–	−92586552.45	−168762260.9	−196048350.7
Emissions reduction Shift from Oil tons	–	–	−241606.8131	−866160.4248	−874299.5543
Climate finance generation $ Shifting from Oil to Gas, Nuclear and Hydro	–	–	519454.6481	1862244.913	1879744.042
Actual electricity generation Cost with different prices of GAS 10% electricity $	–	–	–	27499369.82	3893716.081
Change in cost shifting from Gas to Nuclear and Hydro	–	–	–	−75684106.32	−96369473.01
Emissions reduction shifting from Gas to Nuclear and Hydro	–	–	–	−628108.5407	−628609.6401
Climate finance generation $ Shifting from Gas to Nuclear and Hydro	–	–	–	1350433.363	1351510.726

Source: The data is taken from Pakistan Economic Survey and Energy year books and calculated by authors.

10% of coal electricity generation in total is 13.20 GW/h electricity, which is generated from 10 percent of coal energy. Based on 10 percent share of oil total energy production 3020.085 GW/h of electricity is generated on average from last 18 years in Pakistan. The 10% share of Gas electricity generation is lower than oil's 10 percent in total from a specific source, which is 3000.59 GW/h on average. The share of nuclear is quite lower comparatively, which generates only 336.70 GW/h every year. This indicates the 10% energy generation from Nuclear out of total production from nuclear sources. Hydro is one of the major electric energy generation sources in Pakistan, which has 10 percent share of 2902.24 GW/h in total electricity generation from hydro every year. On 10% percent share, coal remains the lowest used energy source, with the lowest electricity generation in Pakistan, Oil has the highest share of all, followed by the share of gas and Hydro.

The cost of electricity generation associated with each source of energy is converted to Dollars using current exchange rates. The results show that oil energy use has the highest cost of 10% actual electricity generation followed by the cost required for Gas and Hydro energy generation. The production cost of 10% electricity production from Oil sources is 196.4 million dollars on average followed by the cost of Gas, which is 103.1 million dollars in Pakistan. Significant share of our investments for energy production are manifested in Oil and Gas sources for electric energy, which are comparatively dirty and costly sources of energy generation in Pakistan.

3.3.1. Shifting from coal to oil, gas, nuclear and hydro:

There is a significant difference of average cost, when we shift from one source of energy use to another source for production of electricity KW/h. The results show

that there will be a growth of $524739.9 cost, if the 10 percent of coal generated electricity is produced from Oil energy instead of coal. Shifting from coal to Oil is economically not feasible, because only $851.66 worth of emissions can be reduced, which is lower than the cost required to produce same amount of electricity from Oil. The cost difference of shifting on 10 percent of coal energy to Gas is 119940.56, which is going to be increased by the amount of $0.119 million dollars. This is quite rational that only shifting from Coal to Nuclear and Hydro energy generation is economically feasible and environmentally friendly. Because a significant amount of $213108.69 can be reduced, if 10 percent of coal total generated electricity is produced from nuclear energy sources and $316985.79 can reduced if we produce the same quantity of electricity from Hydro energy in Pakistan. This is the direct cost reduction of shift from Coal to Nuclear and Hydro but there is an indirect cost reduction as well, which is also a significant amount comparatively to other production choices of energy inputs. The monetary value of cutting Co2 emissions, while shifting from coal to Nuclear is $8993.62 and from coal to hydro is 9070.133.

3.3.2. Shifting from oil to gas, nuclear and hydro

Production cost of 10% electricity from oil is $196440251.49, if we shift from Oil to Gas electricity generation the reduction of $-92586552.45 can be observed in cost, which a substantial quantity of investment every year. Shifting Oil to gas will also reduce −241606.8131 tons of Co2 emission from the atmosphere in Pakistan. The monetary value of emissions reduced is $519454.6481, which is greater than the production cost of electricity generation from coal in Pakistan. Movement from dirty to clean energy is economically and environmentally feasible and rational choice. Pakistan can reduce the total cost of $168762260.9 by shifting 10 percent of electricity generation from Oil to Nuclear energy production, which will also reduce the Co2 emissions of 866160.4248 tons per year.

3.4. Neutralizing emissions through government policies

- Ministry of climate change has launched a billion-tree tsunami project with intended plantations up to billions of endogenous plants, which will help to sequester billions of tons of carbon in next 10 years.
- Through climate fund unite, Pakistan can initiate to design a climate harvesting project but creating climate inventories of transport sector and energy sector in Pakistan.
- Connecting local communities to climate funds can improve the harvesting rate of GCF in Pakistan.
- Government can compromise the productivity, but it is the last option

4. Conclusion

The study focused to calculate the climate potential of the energy sector in Pakistan, where electricity generation from different energy sources has different associated costs and environmental consequences, the dirtiest source is coal energy on the basis of per unit emissions it emits and the cleanest source is Hydro, while the most

expensive source input is Oil energy, which costs 8.02 PKRs per KW/h production and the cheapest source is Hydro, which costs, 0.16 PKRs on per unite KW/h production of electricity in Pakistan. The rational decision would be, that if the generation of electricity from Oil and coal sources is shifted to Hydro and upcoming new sources of Solar and wind energy, it will provide long-term economic and environmental benefits to Pakistan. By creating sector-specific inventory Pakistan can harvest the global climate funds in long term. The study concluded that Pakistan's energy sector can generate a significant amount of funds from GCF by maintaining records of changing energy mix and the subsequent carbon emissions. Generated funds can be further invested in green energy projects, which will bring the economy of Pakistan closer to achieving Climate targets by the end of 2 decades. Investment attracted towards the projects like the construction of dams, and the rehabilitation of forest mountains ecosystem can help the economy to improve the regeneration capacity and sustain in the mid-future with facing drastic losses from climate change. Taking this study as a case study can help to develop several other proposals with respect to the target sector. In the context of our findings, it is observable fact that Pakistan is an energy deficit country, the demand for energy is greater than the supply or production of energy and we are dependent on other countries in terms of energy supply. Pakistan needs to build energy sources that are sustainable and economical in long run. Hydropower plants can be one of the options, which can be built on available dams or the dams which are under construction. Hydropower plants are comparatively economical and sustainable in long run. One thing, that we understood quite clearly is that access to data for certain sectors is still not possible in Pakistan. The government of Pakistan should improve the quality of data available from online sources. This will help different institutions to produce good-quality proposals to attract climate funds for investment in Pakistan.

Note

1. USAID-NREL-AEDB-PMD study conducted in 2006

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