tise transition, innovation and sustainability environments

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TREND OF SUSTAINABILITY IN EUROPE AND PAKISTAN: A COMPARATIVE STUDY ON ENERGY

Master's thesis for obtaining the academic degree

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submitted by

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I dedicate this piece of work to our Earth for nurturing us, with the hopes that the people living on it get more knowledge out of this research to work for the better of all.

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This time will forever be remembered.

Abstract

Climate change poses a pressing global threat, forcing immediate action to mitigate its impacts. A crucial aspect of this effort is the transition of the energy sector towards sustainability, as it is a predominant source of greenhouse gas emissions. This study examines the past trends and future projections of primary energy consumption (PEC) and greenhouse gas (GHG) emissions in Pakistan and the EU-28, aiming to inform policymakers, decision-makers, and business leaders. Employing a quantitative approach, 30 years of data, from 1992 to 2021, are analysed, which include PEC, GHG emissions, population, urbanization, and GDP per capita. This research utilizes multiple linear regression models, employing the Ordinary Least Squares method to explain historical trends, and autoregression in Autoregressive Integrated Moving Average (ARIMA) model for five-year predictions.

The results show an alarming forecast for Pakistan, with unsustainable energy consumption and GHG emissions predicted to rise in the next five years. Conversely, the EU-28 shows declining PEC and GHG emissions, which are expected to continue decreasing. Drawing insights from past policies and energy mixes, this research highlights the importance for both regions to diversify their energy sources, foster collaboration to leverage respective strengths, and accelerate the transition towards a sustainable energy future.

Keywords: Energy Sector, Sustainability, Energy Consumption, Greenhouse Gas Emissions.

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Introduction

As the world faces the threat of climate change and over-exploitation of natural resources, our global energy consumption still consists of 84.3% of fossil fuels as of 2019 (Ritchie et al., 2022). It has scientifically been proven that using high-carbon fossil fuels contributes majorly to GHG emissions and therefore climate change (Hansen et al., 2013). From the industrial revolution to touching 8 billion in the global population, it is obvious that the causes of climate change are anthropogenic. To survive, humans need energy and to thrive, humans need even more energy. Understanding and analyzing the sources of energy, and therefore the consumption of energy is becoming of high importance in the contemporary world.

Despite the introduction and increasing use of renewable energy sources, it is seen that the global consumption of non-renewable energy sources is still increasing (BP, 2022). Global energy consumption has grown drastically from 8588.9 Mtoe (1995) to 13,147.3 (2015) (Dong et al., 2020). Ideally, the energy provided by green sources should replace the energy needed from non-renewable sources but that is not the case. As the use of renewable energy increases, the use of fossil fuel-based energy is also on the rise. The most probable cause is the increase in energy demand for *more* people every year and the increasing electrification of our daily life. Systems and technologies might be becoming more efficient but the presence of more units of electricity-consuming technology draws more energy. This situation could be taken as an example of Jevon's Paradox where more efficiency will lead to more consumption of that specific resource (Font Vivanco et al., 2016). So, due to the increase in demand and high energy density, fossil fuels are still the dominating energy source to cater to the increase. This is leading to the worsening of the climate crisis which again points the finger towards the energy sector. If the use of coal and fossil fuel is converted with the consumption of clean energy, the climate loss can be decoupled from development (Commer Soc Sci et al., 2019).

To transition towards a sustainable future, energy must be kept at the core of this shift. One of the major challenges that we face is transforming the current infrastructure, which is heavily dependent on non-renewable energy sources, into a greener energy infrastructure. Hence, it requires a systemic shift (Lawrence & Laybourn-Langton, 2021)

that will change the environmentally degrading system from the ground up. At the same time, the pace of this transition will be different in the global north as compared to the global south. The reasons are perhaps the difference in economic, political, educational, technological, and socio-cultural systems; This paper aims to explore these.

In the pursuit of transitioning toward a greener future with sustainable energy systems, policymakers, scientists, and practitioners will have to make informed decisions while keeping the future in perspective. Therefore, if this shift has to be effective with successful initiatives, it will surely be knowledge-intensive (Clark, 2001). With sustainability in the limelight nowadays, it is, therefore, important to see the approaches to policies devised by both sides regarding the economy and the environment. This paper, therefore, aims to provide a great foundation for the suggestions and recommendations to be given to policymakers and businesses. Moreover, reflexivity is an important trait of well-functioning and successful governance (Voß et al., 2006). Foresight is at the core of reflexivity (Kastrinos & Weber, 2020) and this is where this study comes in: to provide a foresight into the future so that the decisions for the future are based on an in-depth scientific study.

The goal of this research is to conduct a quantitative comparative study on the trend in the transition/shift towards sustainability between Europe (EU-28) and Pakistan. The highlight of this study will be the energy sources and energy consumption patterns. Amongst many questions that will be answered as a result of this study, the following are the major questions that will be explored:

1. How do Europe and Pakistan compare in terms of energy consumption, energy economy, and sustainability trends?
2. What factors possibly contribute to the differences in sustainability trends between Europe and Pakistan, including economic, social, and political factors?
3. What Pakistan, mostly, can learn to develop a healthy energy mix free from causing environmental hazards?

Based on the empirical data and analysis, this research will understand correlations between different factors and variables which are at play in this complex field. A deeper understanding of the science behind energy usage and the results of the empirical data

will hopefully provide new findings in this comparison of Pakistan and Europe which is still novel in the current pool of research and assist the stakeholders in both regions.

Since Europe is a developed region and Pakistan is currently developing, it will be an important comparison between the energy consumption patterns of both regions. Moreover, it will be insightful to not only understand the differences but all the possible similarities. The core aspect of this study will highlight the trend in the transition toward sustainability. In the transition of the whole globe, it will be relevant and vital to see the current state and contribution of Europe and Pakistan. Both sides will have different methods, speeds, goals, problems, and opportunities in the pursuit of a greener future in terms of energy.

Europe is chosen as a whole region due to its advancements in the shift towards sustainable energy. Their efforts for research and innovation are quintessential in this regard. Initiatives like “Horizon Europe” has been active since 2014 and it was boosted again in 2017 due to its success (*Horizon 2020*, 2020). The struggling economy, Pakistan, needs to leap-frog in terms of sustainable best practices in terms of energy use and sourcing. Asia is projected to be the largest shift in energy use in non-OECD countries (IEA, 2017) and Pakistan is one of those countries which will contribute to the increasing energy demand. Unlike the global north, Pakistan does not necessarily have to develop the energy infrastructure by going through the mass adoption of fossil-fuel energies but rather they can adopt the best technologies which are cleaner. As easy as it may seem, this transition has many strings attached to it for the case of Pakistan.

A long-term benefit of this research will be to help the researchers in Europe understand their past and current trends of sustainability and how they are performing in this sector. Moreover, they will also see how a developing economy like Pakistan is performing in the global setting and how they can contribute to help it. Through the perspective of Pakistan, the paper can help local researchers compare how well Pakistan is doing with respect to Europe, which is considered the flag-bearer of the transition to sustainability. More so, it can help unveil any opportunities for the country and any chinks in the armour which might get in the way of it achieving green energy.

1. Literature Review

Upon conducting secondary research from the pool of online research material, it was seen that such comparative studies between Europe and Pakistan are lacking, especially in the context of energy and sustainability. Mentioned in the following sub-headings are the works of literature which were close to the topic in focus and are therefore to justify this research.

1.1. Sustainability

This term refers to a broad range of topics that are crucial for addressing climate change and managing natural resources sustainably. To explain it more clearly, we can define it in the context of sustainable development. This is famously described in the Brundtland Commission's final report "Our Common Future" as: "[A development that] … meets the needs of the present without compromising the ability of future generations to meet their own needs"(Brundtland, 1987). According to an article published by the Office of Sustainability at the University of Alberta, sustainability has three pillars: Environment, Economy and Society (*What Is Sustainability?*, n.d.). To contribute to the economic and environmental aspects of sustainability, this paper focuses on energy trends.

Research in 2012 published that in the near future, there will be high energy demand and consumption due to increased transportation (Chu & Majumdar, 2012). This is because the world was globalising at a rapid pace, the population was increasing, and connections (physical and social) were being made swiftly. This study also concluded that gas and coal were being used at a great rate. As written later in this paper, it is true that energy usage was increasing and the sources providing this energy are not clean either. Moreover, the technologies that help us find and extract fossil fuels are also improving. Hence, we can safely connect it with the objectives of this paper: to understand the trend of sustainability in Europe and Pakistan. In a way, the conclusions given by Chu and Majumdar correctly predicted that sustainability will be compromised in the future.

Another angle which can tell about the current state of Pakistan's corporate sector's contribution to sustainability is through the lens of CSR projects implementation. Companies and organisations in Pakistan follow Corporate Social Responsibility (CSR)

projects which theoretically encompasses three themes: Social CSR, Economic CSR and Environmental CSR. A study was conducted in Pakistan where multiple respondents were asked about CSR. The resulting thematic analysis shows that the SME sector is primarily concerned with social and economic dimensions which then removes the limelight from the environmental-related responsibilities they have (N. Ahmad et al., 2021). So, this study builds upon the existing qualitative research that highlights the neglect of environmental aspects in CSR projects in Pakistan.

1.2. Policies and Regulations

Policies and Regulations are the backend of the sustainability which pushes the transition towards a future with sustainable energy use. Therefore, overall effectiveness of policies and the working of the energy policy in both regions is important to study. Only then it will support quantitative findings in this study. Although the primary objective of this paper is not to discover all possibilities that can explain any behaviours in the trends but find supportive arguments.

This paper mainly investigates political instability since it can create hurdles in the adoption of sustainability agendas and practices. So, any findings might be correlated to the political stability of the region. During political instability, the attention of the policymakers is considered to be diverted hence new policies might not made or implemented in the long run. This case is especially evident in Pakistan where each new government does not carry on the baton of initiatives and projects from the previous government after elections. Hence, as per the author's personal experience in the country, if a government has initiated an environmental-centric project, the successor government will discontinue it. Therefore, the efforts and the capital does not come to fruition. In the past, such events have occurred often due to rifts and weak communication between the governments after elections. In tangent to this view, a study was conducted in Pakistan to see the impact of political instability on CO_2 emissions (Al-Mulali & Ozturk, 2015; Sohail et al., 2022). The study showed asymmetric relations between variables (primarily political stability, clean energy, and carbon dioxide emissions) which suggested that political instability had a more predominant and strong impact on clean energy and

carbon dioxide emissions. But political stability did not have such a strong impact on the environment.

Despite the many successes, the EU's policies regarding Circular Economy are less restrictive and there might be other imperfections. A study done in 2018 by Julian Khirchherr et. al. listed 15 important hurdles in the adoption of the circular economy. During the study, the majority of the respondents kept "obstructing laws and regulations" at 9th rank out of 15: the ranking was done to show the most relevant as 1st rank and least relevant as 15th rank. (Kirchherr et al., 2018)

Norway can be taken as a flag-bearer in terms of policy mix which has proven constructive to sustainability adoption. The policy mix created by a government can be the engine to change and enforce certain essential rules in society. It is crucial for sustainability initiatives to be implemented. Therefore, Norway adopted a dynamic policy method where they targeted the elite and simultaneously alleviated the general public. This transition was systemic and incremental but despite the clear goals, rifts and conflicts did surface. One of the major reasons for the success of this policy mix was consistency from the government's side and clear communication (Nykamp, 2020). So, building on research by Nykamp, this paper will correlate any quantitative findings with the conclusions of this research to provide robust recommendations to the policy and decision-makers.

Overlapping with the latter topic, "Energy 2020" was one of the policies that set Europe on the path to sustainability with targets to achieve a 20% reduction in GHG emissions, 20% improvement in energy efficiency, and 20% of the total energy mix to be renewable (Heaslip et al., 2016). This is said to be achieved well by the region (with country-wise differences included). Moreover, the reviewed literature conducted semi-structured interviews with managers of energy projects. The findings can be compared with Pakistan's data and trends with the same factors in the study.

1.3. Energy Consumption

Abbasi et al. (2021) conducted a study related to Pakistan in 2021 analysed the factors that contributed to economic growth (Abbasi et al., 2021). Their results, based on data from 1972 to 2018, showed that economic growth is positively impacted by energy

consumption, industrial growth, CO_2 emissions, and urbanisation. Therefore, electricity consumption also had a positive and a significant impact on economic growth. Another research also concluded similar results (Baz et al., 2019). They also recommended the use of gas as a transitioning fuel source which will later be challenged in this paper.

This shows that researchers are still supportive of fossil fuels as a source of energy. Studies have shown that Natural Gas emits 30% less carbon dioxide than Oil (Tollefson, 2013) and might be a suitable transition low-carbon fossil fuel (Baz et al., 2019) but it is still ignited and burnt to generate energy which means that gas is still not a carbon neutral source of energy (Climate Reality Project, 2018).

A study by Rizvi S. (2022) analysed and assessed electricity generation techniques from the lens of transition to a greener pathway for Pakistan. It lacked the correlation with Carbon Dioxide emissions to prove the sustainability of the electricity generation technologies (Rizvi et al., 2022). This study aims to bridge this gap in the availability of researches and see energy generation holistically and compare it to Europe's energy trends.

Europe on the other hand is on the trajectory to achieve its 2020 Climate energy goals based on 20/20/20 (20% reduction in GHGs, 20% share in REs, and 20% increase in energy efficiency) (Benasla et al., 2019). This research by Benasla et al. (2019) focused on the ongoing trend towards sustainability in Europe for which it explored pathways to import/connect energy transmission lines from North-African solar power sources. After proving the viability of this transition towards adopting solar energy, it added that the lack of expansion capacity of the grid and energy storage facilities will be the biggest drawback for Europe's agenda to incorporate renewable energy sources. They quoted the ten-year network development plan which mentioned that in 2020, 80% of the bottlenecks are due to the renewable energy sources integration. In our paper, this factor will be kept in perspective when developing causal loop diagrams and deriving important information from the data analysis.

According to a study by T. Ahmad and Zhang (2020), global energy consumption is projected to rise by 30% (T. Ahmad & Zhang, 2020). The European Union (EU) is

expected to experience a 12% increase in energy use from 2006 to 2021. Additionally, EU Natural Gas usage is anticipated to witness a significant surge of 40% by 2021.

Conclusively, with respect to the energy consumption and overall research, this paper aims to analyse the implications of the projections mentioned above and correlate them with the trends observed and predicted based on the data in this thesis. Specifically, this study will examine the fact of the EU's 3% reduction in oil consumption over the next 15 years (2006-2021). Moreover, this research will aim to suggest better, sustainable, and more suitable recommendations based on the more updated data analysis. Resultantly adding to the research gaps in this topic of study.

2. Sustainability Lens

Sustainability being a vast term encompassing many topics, it is important to give it context in this study. The aspect of sustainability that this research focuses on is the sustainability of the energy sector. It is no doubt that energy is an essential part of our lives and to stop climate change, the energy sector plays a pivotal role. Hence, deriving from the definition given at the Brundtland Commission (Brundtland, 1987), sustainability in terms of energy refers to the ability to meet the energy needs of the present without compromising the ability of future generations to meet their own energy needs. It involves developing energy sources and using them in ways that will minimize negative environmental impacts, promote economic growth, and ensure social equity.

Sustainable energy sources include renewable energy sources like solar, wind, geothermal, hydroelectric, and biomass energy, which can be replenished naturally and do not produce harmful emissions or waste. These sources of energy are often contrasted with non-renewable sources like fossil fuels, which are finite and release greenhouse gases into the atmosphere, contributing to climate change.

The current global energy situation can be summarized as follows: energy demand and carbon dioxide (CO2) emissions have been on the rise (Ahmad & Zhang, 2020). This increase poses significant risks, especially considering our heavy reliance on a single source of energy. To mitigate these risks and ensure a sustainable future, it is crucial to diversify our energy sources and shift towards renewable alternatives. Venezuela is an example of risks related to energy. As shown in the Figure 4.1, the energy sources are dominated by gas and oil with hydropower sources only recently increasing. This study proves how important it is to shift to renewable energy sources and that sustainability should be the primary agenda for any country. (Pietrosemoli & Rodríguez-Monroy, 2019)

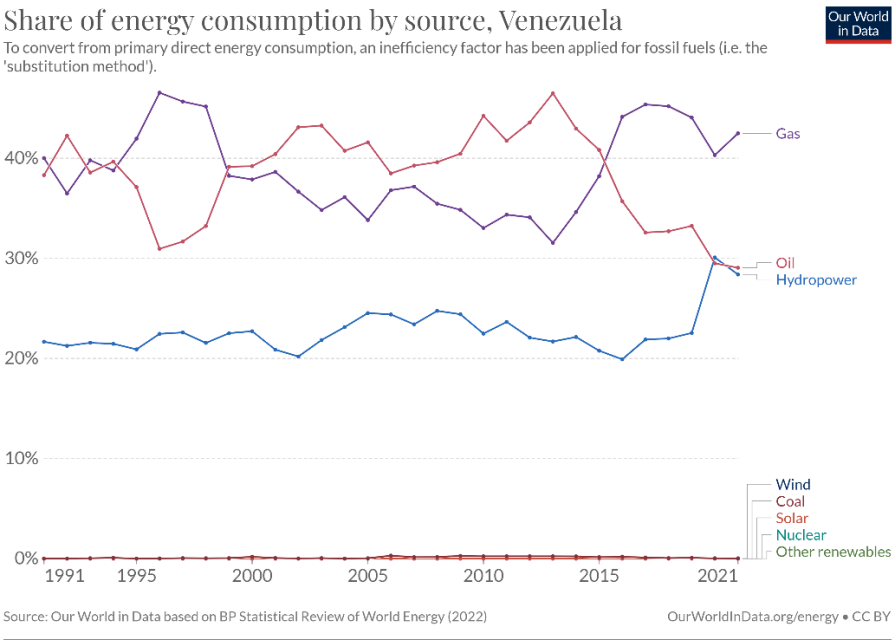

Figure 2.1 Share of energy consumption by source, Venezuela.

Source: BP Statistical Review of World Energy. https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

Overall, the 6 different variables which are chosen to identify the trend in the sustainability of Europe and Pakistan through the lens of energy are further justified below. It is hoped that these will depict at least the tip of the iceberg for the trend towards sustainability for the two regions.

1. **Energy Consumption**: People consume energy for their daily routines like heating houses, lighting up the place, heating the water etc. The amount of energy required relates to how efficient is the energy system in a region of study. This in relation to other variables can show if a country is adopting efficient energy methods while growing economically or demographically. For example, if energy consumption is reducing but the population is increasing, it depicts that consumption per person is reducing and hence trend towards sustainability exists.
2. **Energy Mix:** How the energy is produced and sourced is key to understanding the trend towards sustainability. The energy consumption may be reducing but it is possible that the energy mix is heavily dependent on non-renewable sources.

Therefore, how the energy is being generated over time can indicate how sustainable a country or a region is.

3. **Greenhouse Gas (GHG) Emissions**: This variable will directly show if the energy consumption or generation is clean or not. Reducing CO_2 equivalent emissions adds to the fact that the region is moving towards a cleaner future and energy use. Therefore, if the increasing energy consumption levels out the GHG emissions or reduces them, it shows that the carbon-intensive sources of energy are being used less.
4. **GDP Per Capita:** This is taken as an independent variable which will show the overall consumption of the population of Europe and Pakistan and compare it with the energy consumption and CO_2 equivalent emissions. Although it is not considered the perfect economic metric to judge the performance of a country, but in terms of general consumption, it might provide useful insights.
5. **Population:** One of the reasons why facts can be misleading is because of the exclusion of the size of the population. Hence, the population can also add to the information about the consumption and prediction of future energy use. To have a clear contrast, the trend of population growth is compared with per capita variables so that any reduction in per capita consumption is not misunderstood as a sustainable transition. This approach prevents any decrease in per capita consumption from being falsely perceived as a sustainable transition.
6. **Urbanization:** More people shifting to urban cities means that their per capita energy consumption will increase. It was seen in a Chinese study that the higher the urban sprawl index was noted, the more energy consumption was seen (Zhao & Zhang, 2018). Hence, the inclusion of urbanization patterns will make the insights more robust and precise. At the same time, urban cities can be the key to a quick transition to sustainable consumption of energy. The pollution is also less spread out over the region which is why it becomes easier for it to be controlled and regulated through standards, policies, and technological advancement.

A study was conducted in Pakistan which listed 8 significant categories to indicate green technologies in Pakistan. Of this, our study's variables are in the domain of the three

indicators' categories defined by the study of M. Ikram et. al (2021): Environmental Quality, Resource Utilization and Energy Utilization.

To incorporate sustainable development in all spheres of life, the United Nations set 17 Sustainable Development Goals under "The 2030 Agenda for Sustainable Development" (Ikram et al., 2021) of which the paper will address the following five:

- SDG 7: Affordable and Clean Energy.
- SDG 10: Reduced Inequalities.
- SDG 11: Sustainable Cities and Communities.
- SDG 12: Responsible consumption and Production.
- SDG 13: Climate Action.

3. Methodology

The author of this thesis aims to contribute to the aforementioned literature by conducting a quantitative analysis of sustainable energy trends in Pakistan and Europe. The quantitative analysis will also enhance the current understanding of the environmental impact of CSR projects in Pakistan and provide evidence-based recommendations for future sustainable energy practices in this context. Moreover, any successes seen in Europe can serve as potential solutions or sources of inspiration for addressing the challenges faced in Pakistan.

This thesis will adopt a quantitative research method based on yearly data. A comparative study will then be done between Europe and Pakistan given their demographic and socio-economical variables. To see if the regions are shifting towards sustainability and how, the trend of the energy mix, and consumption will be studied, calculated and analyzed using econometric tools including the Gaussian ARIMA model (Hillmer & Tiao, 1982). The variables chosen to study are the following:

Table 3.1
Variable names and descriptions..

Variable Name	Code	Units	Remarks
Primary Energy Consumption	pec_toe	Tonne oil equivalent	This is the amount of energy consumed by the country/region. It includes the energy consumed by the energy sector itself.
Primary Energy Consumption per capita	pec_pc_toe	Tonne oil equivalent	This is the amount of energy consumed by the average person in the country/region. It includes the energy consumed by the energy sector itself.
Carbon dioxide equivalent emissions per capita	co2e_pc	Tonnes	This is the total greenhouse gas emissions in weight equivalent to carbon dioxide.
Population	population	Unit	Number of people living in the region/country
Urbanization	urbanization	Unit	The number of people living in urban regions of the country.

Gross Domestic Product per capita	gdp_pc	USD ($)	Quantified at constant prices.

Source: Author's work

The variables chosen will be answering the research question 1 predominantly and simultaneously partially answer research question 2. To understand how the energy consumption is leading to GHG emissions CO_2 equivalent emissions will be correlated to the primary energy consumption. To gain more insight and see other factors, population, urbanisation, and GDP per capita will be analysed. GHG emissions will indicate the trend towards cleaner energy and the shift towards sustainability. Moreover, the number of people will also play a great role in this transition especially when relating it to energy consumption. Although GDP is not the perfect economic indicator, it denotes the overall consumption of the population which can be correlated with energy consumption.

3.1. Data Collection

The period considered for robust and accurate prediction is 30 years (1992-2021) of past yearly data despite the recent uncertainties and fluctuations due to the pandemic and the Russia-Ukraine war. The data to be used will be from existing secondary sources for Europe like Eurostat, Ember, Worldbank, and other sources. EU-28 was taken as the sample for Europe which includes the United Kingdom as for the majority of the time, it was a part of this union. Therefore, the countries which are included in the study are Austria, Belgium, Bulgaria, Croatia, the Republic of Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

It is seen that the quality and quantity of the required data are robust and are available up to 2022 for most of the study parameters. Since some variables did not have data until 2022, this paper will use complete data up until 2021. On the other hand, it is difficult to find organized and accurate data publicly for Pakistan. Therefore, primary data will also

be attempted to gather from energy-sourcing and energy-distributing companies. With this, secondary data will also be used. Providers like WAPDA, Karachi Electric (KE), and others will be contacted for the provision of data. Data, other than the specific variables mentioned above, will be collected to support the study. Such data will include energy mix, findings from policy documents, and other relevant information.

3.2. Data Analysis

This research undertakes the quantitative data analysis on the collected past 30 years of data for both Pakistan and Europe separately. As the first method, Multiple Linear Regression (MLR) models are built using the Ordinary Least Squares (OLS) method. R Program is used to run this regression analysis and show correlations of different variables based on the quantitative data. Secondly, since this data is time-series data, the ARIMA model is used to make predictions. The reason for using autoregression is due to the nature of the data being a time-series dataset and a study by Abbasi et al. (2021) used a similar method to analyse the economic variables and showed robust results (Abbasi et al., 2021). The variables are almost similar to that study which is why the analysis will be accurate and efficient.

After the collection, data was cleaned and organised into one Excel sheet for ease. The data for primary energy consumption was collected in kWh so it was converted into units of a tonne of oil equivalent for consistency. Then the per capita consumption was calculated by dividing the total consumption by the population of the region (Europe or Pakistan). For Europe especially, each country's sum was taken for the total population, urbanization, primary energy consumption, and GHG emissions. The GDP per capita of the EU-28 was calculated by taking the weighted averages of each country.

To study the baselines of each region, MS Excel was used to plot graphs of respective variables of study. They were paired with another variable (e.g. PEC vs GDP) so that a correlation or causality can be seeing from the surface level. The baselines were first done for each region individually so that the facts and past trends are clarified before the comparison of the two regions.

The data analysis is done individually for Europe and Pakistan in R studio. Following linear models were made for both regions to give a starting direction:

Energy Consumption

1. $Energy\ Consumption\ per\ capita = Population + GDP\ per\ capita + Urbanization$

Which is denoted in R as:

$pec\_pc\_toe = population\ + gdp\_pc + urbanization$

GHG Emissions

2. $GHG\ emissions\ CO_2e = population + Energy\ consumption\ per\ capita + GDP\ Per\ capita + Urbanization$

Which is denoted in R as:

$co2e\_pc = population\ + pec\_pc\_toe + gdp\_pc + urbanization$

Further tests are done on each model to validate its robustness. One of such tests is the Breusch-Pagan (BP) test which is a statistical test used to assess heteroscedasticity in a linear regression model. One of the assumptions for linear models is that the data should be homoscedastic. Another test is the Shapiro-Wilk test is a statistical test which formally assesses the null hypothesis that the residuals are normally distributed. For them to be valid, the p-value of each test should be greater than 0.05.

In addition to the quantitative empirical data analysis, the majority of desk research and literature review is done as a qualitative study. In order to find causality through qualitative

means, the literature review will be of support and general research, in nexus to the quantitative analysis.

When the data was imported into R Studio, four different models were built and tested with the tests mentioned above. The four models included GHG emissions and Primary Energy Consumption models for both Pakistan and EU-28. These are considered the primary/core variables that will show the past trends. This will form a basis for the comparison of Europe and Pakistan since the models will show what explains each variable of the region better and what variables are important for each region.

These models will also show a magnitude difference between the two regions and the significance of each variable in that model. For EU-28, it shows the sum of all the values and weighted averages for GDP per capita whereas for Pakistan there are all raw values. To make true comparisons and see a clear picture of the data, a year extra, that is 31 years, of data was used. This is because when differences are taken, the first year is negated. The following formula was used to see the changes per year of the specific variables:

$$difference = \frac{d2 - d1}{d1}$$

The above proposed models of primary energy consumption and GHG emissions were not very robust when the data was used to make them. The analysis showed that the p-values of the variables were higher than 5% which resulted in remaking of the models. Multiple combinations of variables were used to best explain the trend of the two main variables and the best of them are mentioned later below. Once the multiple linear models were defined, the tests mentioned previously were conducted to ensure the validity and reliability.

Initially 10 years of past yearly data was used to execute autoregression but that yielded no significant results when ARIMA model was used. The “auto.arima” function yields the suggested amount of lag and differencing to use in the ARIMA model but with 10 years of data it generated error proving that the data pool is less. The data pool was then

increased up to 30 years so that “auto.arima” function in R studio gave more accurate results of the lag level to be used. With the help of that, AR of degrees 2 and 3 are used in the upcoming predictions of GHG emissions and the PEC.

4. Baselines

4.1. Pakistan

Having an area of almost 800,000 km^2, Pakistan is a developing economy which is situated in South Asia. The population of this growing country is at 230 million as of 2021. This number ranked Pakistan 5^{th} in the world in the year 2020 as the most populated country (Worldometer, 2020).

Pakistan occupies a strategically important position at the crossroads of the Middle East, Central Asia, and South Asia, endowing it with a significant role on the global stage. The nation boasts a vast territory encompassing diverse geographical features, including majestic mountain ranges, fertile plains, and a picturesque coastline. This unique blend of landscapes contributes to Pakistan's allure as a captivating destination. Furthermore, Pakistan's historical legacy, exemplified by ancient civilizations and architectural masterpieces, coexists harmoniously with a youthful population that serves as a driving force behind innovation and economic growth. The country's cultural fabric, characterized by a mosaic of ethnicities, languages, and religious beliefs, further enhances its appeal. Pakistan's natural splendour, accentuated by towering peaks and breathtaking scenic wonders, completes the portrait of an intriguing destination worthy of scientific exploration.

4.1.1. Economy

Relative to the global economic setting, Pakistan is categorised as a developing economy since it has not reached its potential yet. With an increasing population and limited resources, the country is struggling to make ends meet. Pakistan does not have the economic capacity to adapt to the risks posed by climate change. The forte of this country is its agricultural and livestock market which exports its goods on a large scale. It is ranked 7^{th} in the world in terms of Agricultural output as of 2021 latest (The Global Economy, 2021). This reliance on the single sector has made Pakistan very vulnerable to climate change. It was witnessed in the recent floodings, Pakistan had to rely heavily on international monetary aid. With 33% of the country underwater, there was no institutional

strength or monetary capacity to pull the country out. Under normal circumstances, Pakistan is dependent heavily on agricultural activities and cannot meet its economic targets without this sector (Baz et al., 2019). Therefore, with food security, the economy is also at a higher threat level with respect to climate change.

Pakistan currently finds itself in a situation of circular debt by importing energy and providing it at a subsidised rate which shows that initial investment in energy does not have a greater output. In a similar light, the nexus of energy and economy is closely knit. The initial capital required to set up renewable sources of energy to be provided to households and industries is very high compared to the high-carbon sources of energy like coal, oil, and gas. To be sustainable is to use green sources of energy which reduces GHG emissions and hence controls climate change. But, in this situation, Pakistan does not have the money to invest in the kind of large-scale sustainable energy sources which can contribute to a big part of the country's energy mix.

To further see the trend of the Primary Energy Consumption of Pakistan and the GDP, the graph below is made with data from 1991-2021.

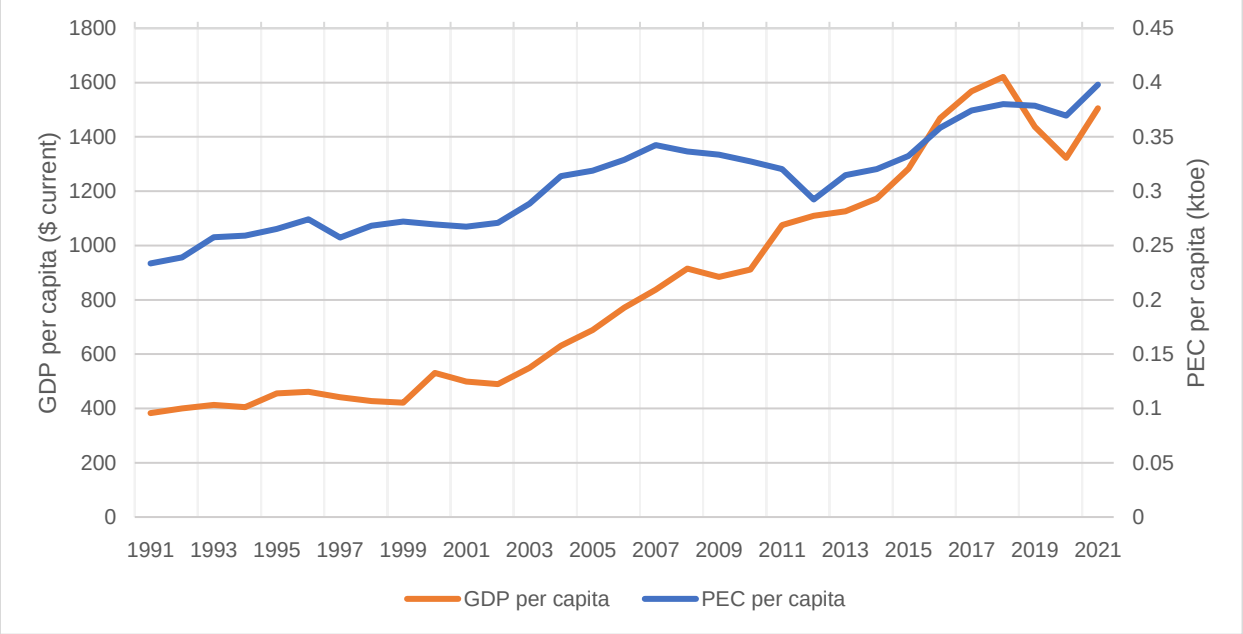

Figure 4.1 Pakistan's GDP per capita vs Primary Energy Consumption per capita comparison.

Source: Author's compilation based on (BP Statistical Review of World Energy, 2023)

If GDP per capita is assumed to be the representative of the economy, then it is seen that the buying power per person has increased over time with greater jumps from 2003-2008 and 2015-2018. Consequently, the primary energy consumption per capita is also increasing but not with the same level of gradient as that of GDP per capita. The most obvious conclusion is that an average Pakistani can afford more energy and is consuming it more. There seems to be a direct relationship between the two factors but a strong causal linkage is not seen. It is possible that an increase in energy consumption may be contributing to an increase in GDP per capita and not the other way around.

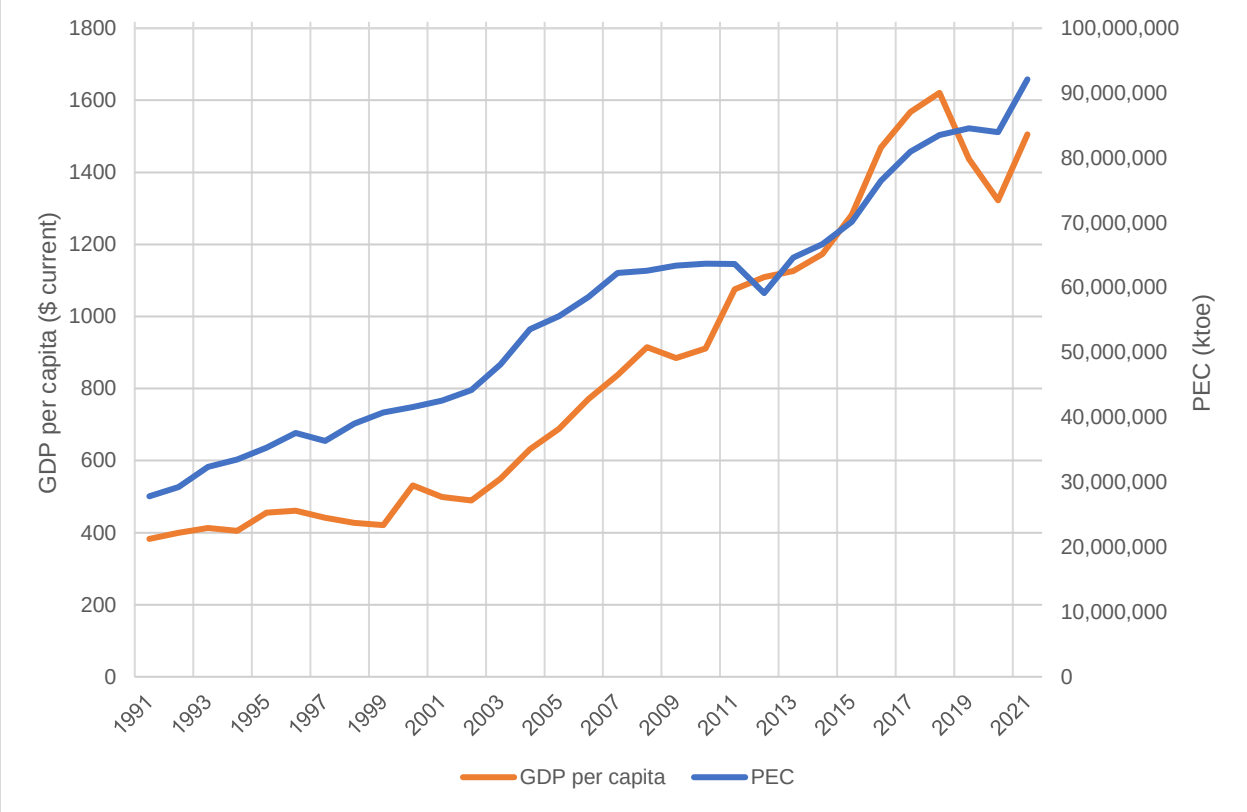

Figure 4.2 Pakistan's GDP per capita vs Primary Energy Consumption comparison.

Source: Author's compilation based on (BP Statistical Review of World Energy, 2023)

To further clarify the relationship between energy consumption and the economy, we take the total primary energy consumption of Pakistan. The graph now shows that the total energy consumption is actually increasing much more than what was shown in the graph

with PEC per capita. Thus, it elucidates the fact that increasing population and increasing per capita consumption have led to an even higher total consumption of primary energy.

4.1.2. Policies

The government of Pakistan had a policy devised in 2006 related to the sustainable energy sector. The “Policy for Development of Renewable Energy for Power Generation” was made by the Ministry for Water and Power to adopt renewable energy sources and diversify the energy mix (Government of Pakistan, 2006). This policy aimed to reduce the dependency on fossil fuels, enhance energy security, mitigate environmental impacts, and aid the socio-economic development of the country. After its introduction, in 2011, its use was prolonged (Aized et al., 2018). Ever since then, it is still being used to date as the core framework to implement projects in the field (Data, 2018). The evidence of this policy’s positive might be seen in the energy consumption’s approximate flattening in Figure 5.2 but it is not clear since the onset of the global financial crisis of 2008 could also have had some effects on the consumption and availability of energy sources. Nonetheless, the reimplementation of this policy in 2011 shows a slight decline in greenhouse gas emissions in Figure 5.5 which can be assumed is due to the adoption of clean energy sources but this was effective only until late 2014.

A study used a Non-Linear ARDL approach and concluded that political instability not only reduces the consumption of clean energy but also leads to damage to environmental quality in the long run in Pakistan (Sohail et al., 2022). This poses a threat to Pakistan since political stability is not plausible with the most recent unrest being caused by the arrest of Imran Khan on 9th May 2023 (Al Jazeera, 2023). In such national-level unrests, the policies that form the basis for transition towards a sustainable future are neglected.

4.1.3. Energy

The country's total consumption has increased quickly since 2014 with a rate of 4% per year. In comparison with the time between 2008 and 2013, it was progressing at a rate of 1.5% per year (Enerdata, 2020). The reason might be the increasing population and

overall consumption per person which is analysed below. Moreover, it is important to know that this increase was mostly in the regime of one political party. This also hints at the impact of the policies introduced or enforced during that period.

As of now Pakistan's majority of the fuel-wise capacity is with Hydel power which accounts for 24.7% of the total capacity of Pakistan but out of the total electricity generated, thermal power accounts for 60.9% (*Pakistan Economic Survey*, 2022). On the contrary, according to the UNFCCC NDC report submitted by Pakistan, its global contribution to GHG emissions was 0.9% which ranks Pakistan as 19th in the world as of 2019 (Friedrich et al., 2023; Government of Pakistan, 2021). Despite this, Pakistan must leapfrog to catch up to the sustainable developments adopted by Europe in this energy sector.

In recent years, the country has been struggling to keep up with the energy demand of the people. Most recently, there was a total outage of the electrical grid in the whole country causing a lot of businesses and daily activities to come to a halt (DAWN, 2023). Due to such a situation, people started using fossil-fuel-powered generators, UPS (Uninterruptable Power Supply), and, only in recent years, solar power panels. Even these are limited in capacity in the face of the length of the power outage that the country witnesses. A study mentioned that the reason for not being able to meet the energy requirements are bad governance and erroneous policies (Baz et al., 2019).

Now, the increasing population plays a major role in the generation of energy demand. The increase in population is very steady since 1991 which no doubt means that there are now more people with energy needs. The graph below shows this relationship.

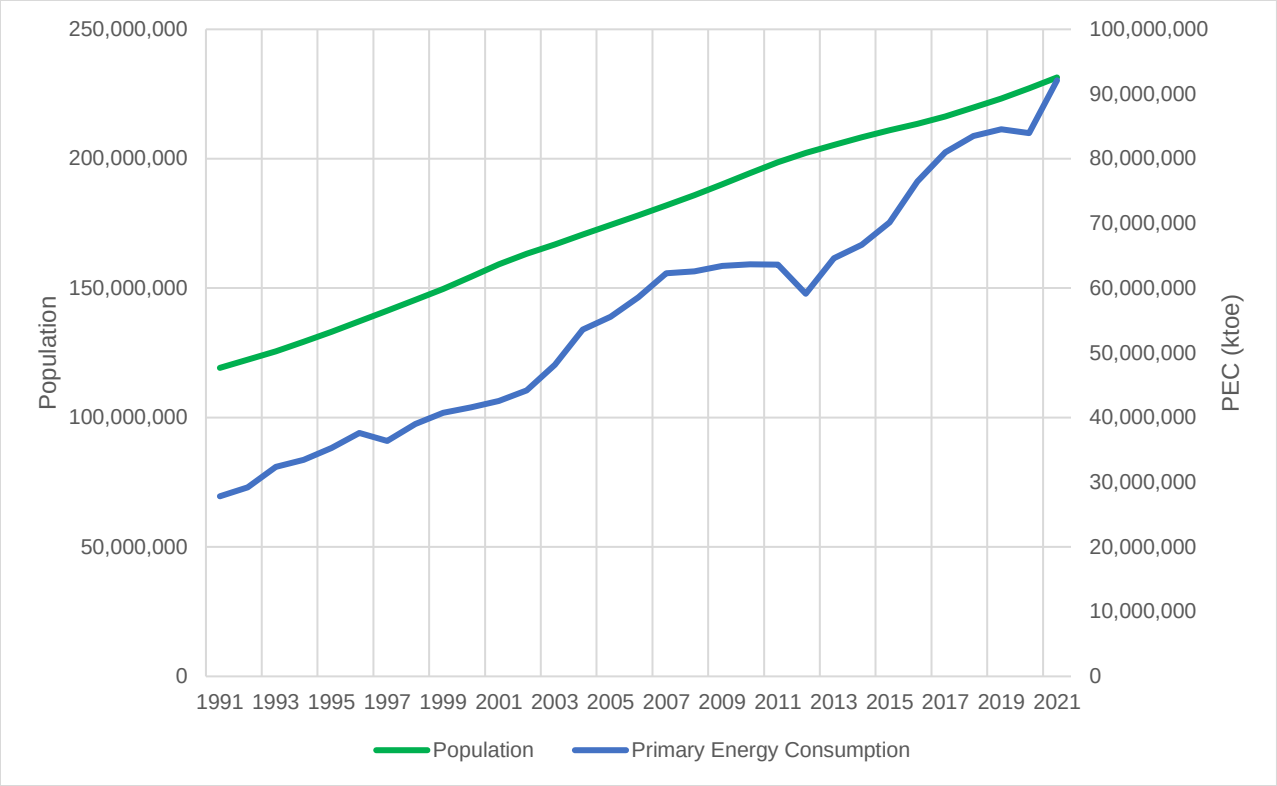

Figure 4.3 Pakistan's Primary Energy Consumption and Population's comparison.

Source: Author's compilation based on (BP Statistical Review of World Energy, 2023)

This dataset shows that both the population and the energy consumption have been increasing over time. The drops seen in energy consumption can be hence justified that the reason was not related to population change. Due to economic turbulence, the first drop in consumption of energy was seen and the second drop was due to the onset of COVID-19. Overall, it is seen that the population has doubled in the past 30 years.

It is very crucial to see where the energy consumed comes from. Even though the energy consumption might be reducing, it is possible that the sources are becoming unsustainable. Therefore, the graph below is used to see the relative sources of energy in the total energy consumption.

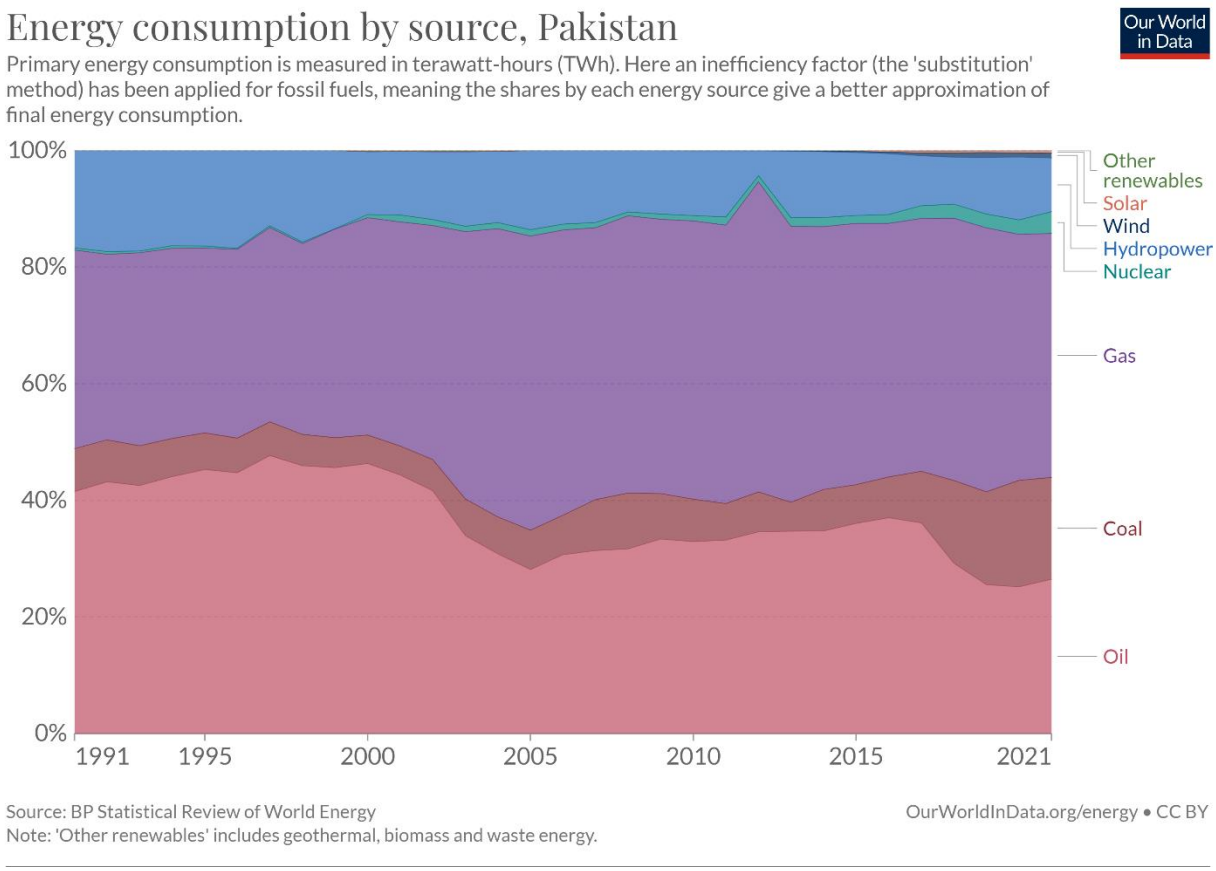

Figure 4.4 Pakistan's energy mix. Data relative to 100%.

Source: BP Statistical Review of World Energy.

The Figure 5.4 shows that the green sources of energy have dropped in relative usage. The majority of the renewables is hydropower which was introduced through two major dams named Tarbela and Mangla dams. Since then, the hydel power technology has become old no new technology has been implemented actively. Meanwhile, gas usage has increased over the years and now constitutes most of the energy mix. Coal has seen a recent increase in usage because of the China-Pakistan Economic Corridor (CPEC) project which started in 2015 under the bigger One Belt One Road (OBOR) initiative by China. Under CPEC, coal-fired power plants were built and used which is taking Pakistan in the opposite direction of sustainable development.

4.1.4. Greenhouse Gas Emissions

Greenhouse gas emissions are directly linked to unsustainable energy consumption, especially if the sources are fossil fuels or other high-carbon energy sources. Normally, it is assumed that if the energy sources are getting cleaner and the consumption remains the same, the GHG emissions will reduce. In Pakistan, the regulations related to this are very loose and not being implemented strictly. One of the major cities, Lahore, has been ranked one of the most polluted cities in terms of air pollution. The main causes are the Sulphur oxides (SO_x) and Nitrous Oxides (NO_x) which causes smog to develop and lots of health hazards. The relationship of GHG emissions, measured in CO_2 equivalent, is shown below with respect to the PEC.

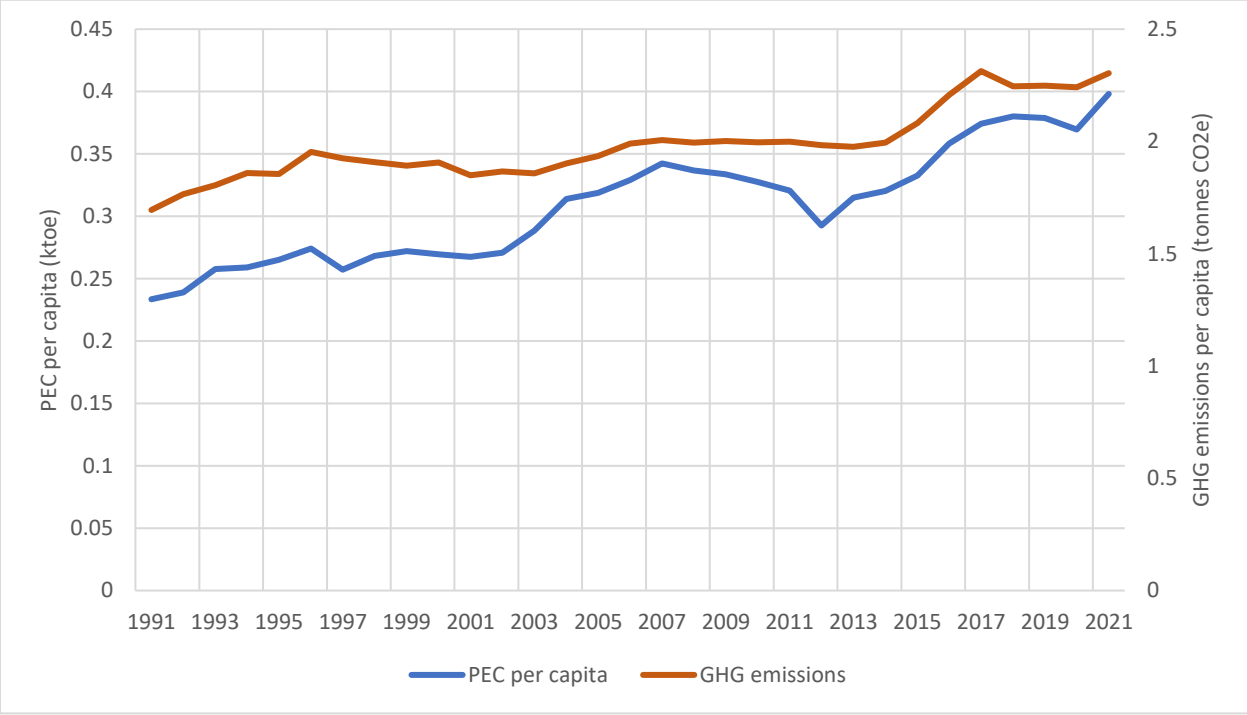

Figure 4.5 Comparison of Pakistan's GHG emissions and Primary Energy Consumption per capita.

Source: Author's compilation based on (BP Statistical Review of World Energy, 2023)

The per capita energy consumption shows an increasing trend and so does the GHG emissions. The graph approximately shows that the per capita consumption of energy

increases, so do the GHG emissions. This implies that in Pakistan when energy is being consumed more, there is more GHG emission. The emissions can be through transport, household energy consumption, industrial activity, or other demand areas.

Now, this points to another question about how Pakistan's growing population is affecting GHG emissions. The data below depicts this:

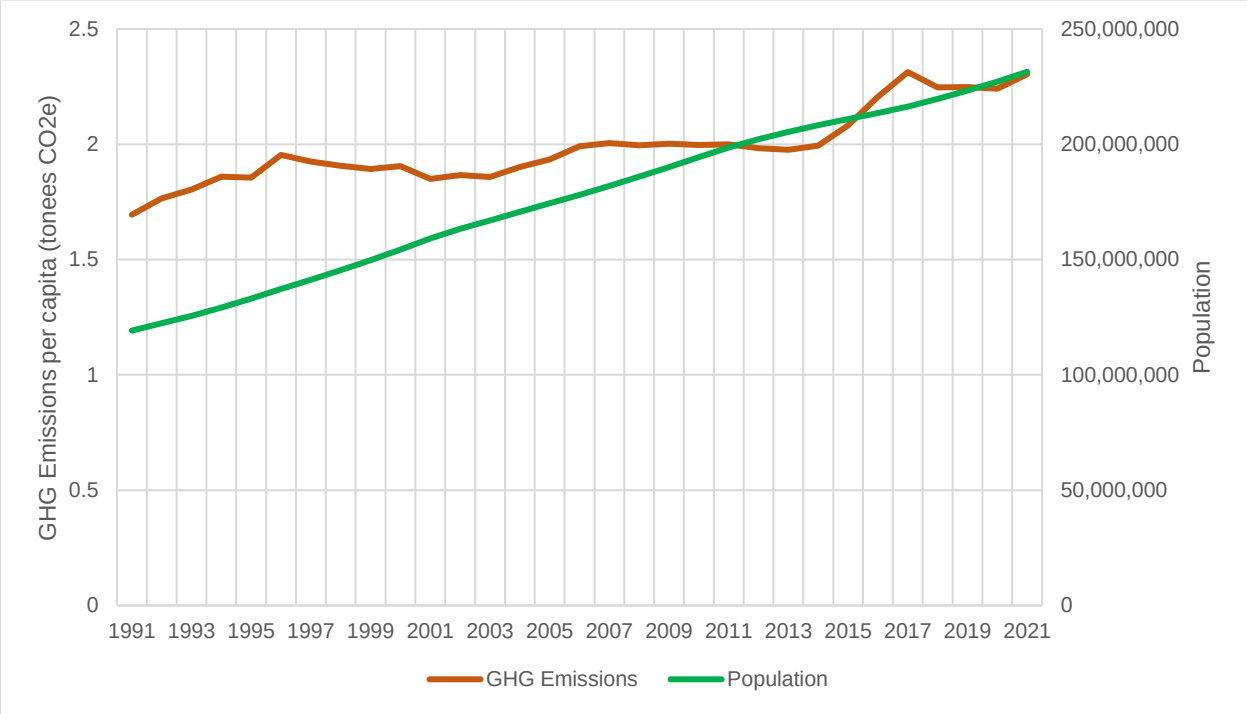

Figure 4.6 Comparison of Pakistan's GHG emissions per capita and the population.

Source: Author's compilation based on (BP Statistical Review of World Energy, 2023)

The relationship between the two factors is not as direct as it was between GHG emissions and PEC. Although, it is seen that both possess an increasing trend but the causality of one variable with the other is not visible. But in the future, with increasing per capita demand and increasing population, energy consumption will increase drastically. It remains a question if Pakistan will be able to meet the increasing demand.

4.2. Europe

Europe in this study specifically constitutes the countries in EU-28, which are listed earlier. The total population of the EU-28 as of 2021 is approximately 515 million. Europe has been a trailblazer in many green technologies and is seen to shift swiftly towards a sustainable future. But this does not mean that they have had a past with clean energy but rather a lot of pollution was generated here due to industrialisation. Europe is a prominent economic powerhouse that boasts a diverse and robust economy. With its strong industrial base, advanced technological infrastructure, and highly skilled workforce, Europe has emerged as a global leader in various sectors. The region is home to several major economies, including Germany, France, and the United Kingdom, which contribute significantly to its overall economic strength. While Europe faces occasional challenges such as economic disparities among its member states, it remains a key player in the global economy, fostering innovation, and driving economic growth.

4.2.1. Economy

Excluding the UK in recent years, the European Economic Area (EEA) is the region where cross-country trade takes place. The EEA facilitates the free movement of goods, services, capital, and people between the member states. This strong economic region is operated mainly through the currency Euro which is used in 20 out of the 28 EU-28 countries. The EEA provides these countries with access to the EU's vast market, promoting trade and economic cooperation. It also ensures that the EEA member states adopt and implement EU legislation related to the single market, allowing for regulatory harmonization. This area has contributed to economic growth, stability, and increased opportunities for businesses and individuals in its member states. Therefore, it is insightful to see how the GDP and Energy consumption trend has been over the past 30 years.

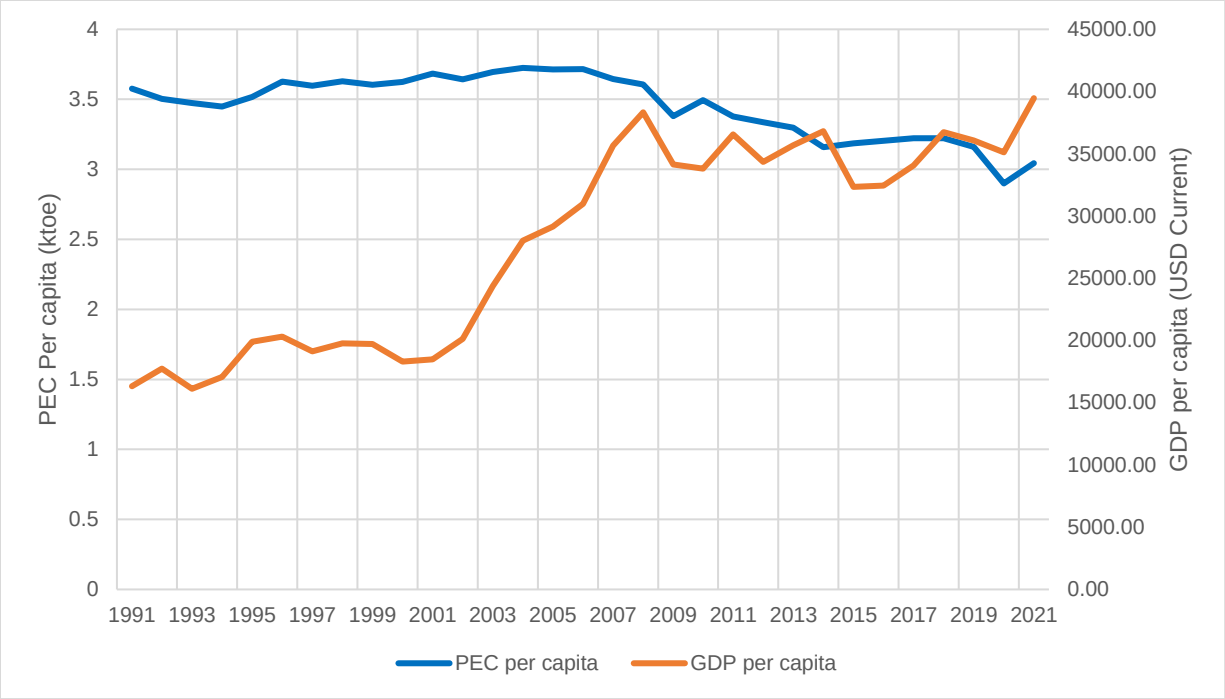

Figure 4.7 Comparison of GDP per capita and Primary Energy Consumption per capita for the EU-28.

Source: Author's compilation based on (BP Statistical Review of World Energy)

At first sight, it can be seen that this trend is completely different from Pakistan's. A huge increase in GDP was seen between 2002-2008 but possibly due to the great financial crisis, this increasing trend flatlined. Ever since that, the mean of the GDP has stayed approximately the same. GDP denotes the overall consumption value of the purchased items which can also include energy. Therefore, it seems that the PEC per capita is not affected by the GDP per capita of the EU-28. This might show that the efficiency of the energy consumed by every person is reducing since the GDP per capita is increasing while the PEC per capita reduces. Resultantly, the hints of a trend towards sustainability are highlighted here.

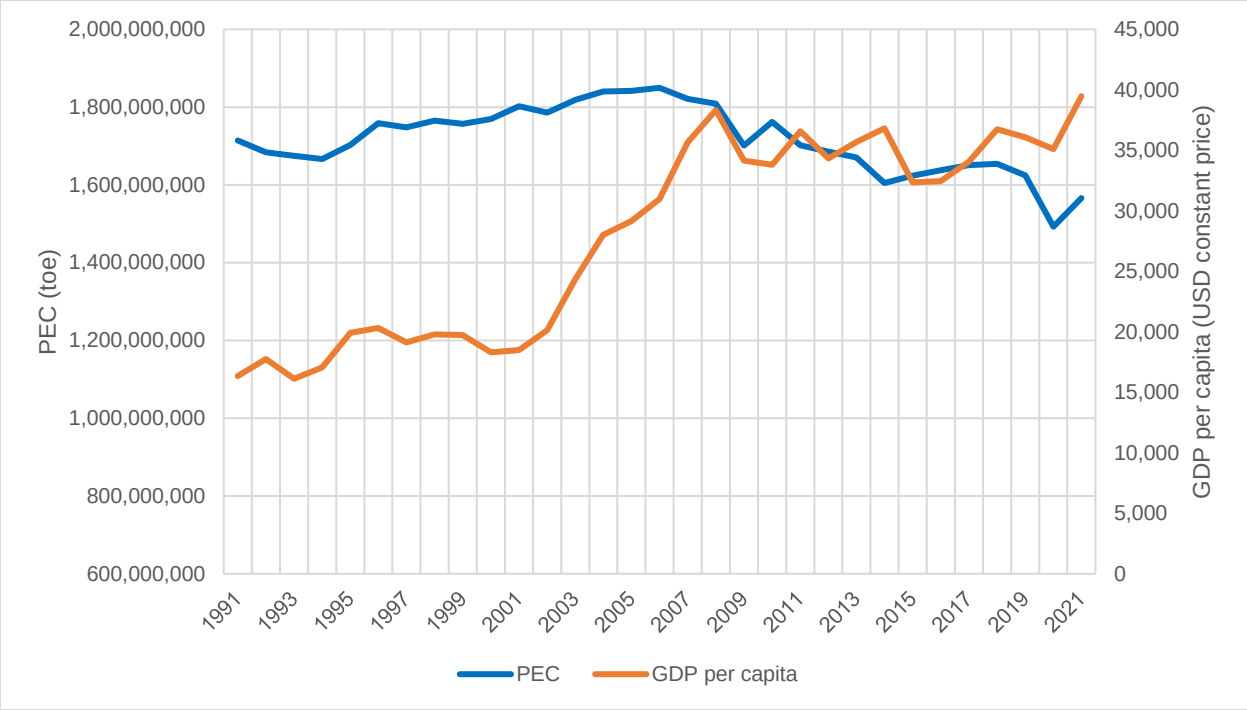

Figure 4.8 Comparison of GDP per capita and Primary Energy Consumption for EU-28.

Source: Author's compilation based on (BP Statistical Review of World Energy, 2023)

The graph above is of total PEC in comparison to GDP per capita so the population factor, which might be misleading sometimes, is seen from another angle. Now, since the efficiency seemed to increase in the previous graph, here it is confirmed by the fact that the PEC is reducing as well over time. The next question is how the population is affecting this trend because a reduction in population would normally lead to a reduction in the primary energy consumption.

4.2.2. Policies

European policies are known to be generally well-designed and implemented. The policies are usually defined at the European Union level which means that it is crafted for the whole of EU-28 (now EU-27 after Brexit). Although each country has their own individual policies which set them apart but are overall guided by the EU.

EU had initiated the *Horizon 2020* program which aims that "It tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth" (*Horizon 2020*, 2020). This initiative lasted from 2014-2020

with an investment of 80 billion Euros. Among the more successful projects was Project INTENT which aimed to make better reactor designs that improved the heat transfer system hence making it more resource and energy-efficient (European Commission, 2023). The successor initiative to the *Horizon 2020* was *Horizon Europe* which had increased funding to 95.5 billion Euros (European Commission, 2020). The aims and goals of this programme remain the same, but this will continue until 2027. One of the basics of this program since 2014 is to fund the research and innovation which are in line with the goals of SDGs. A core aspect of *Horizon Europe* is to develop nature-based solutions for which one of the important targets is to reduce the use of fossil fuel input per produced unit (Maes & Jacobs, 2017).

The BOHEMIA project triggered the inclusion of novel elements in the *Horizon Europe* Proposal: Attention to SDGs, preparedness and adaptivity, the need for ownership and participation and for giving room for alignment and experimentation. (Kastrinos & Weber, 2020)

The *Energy 2020* Project was one of the best target-setting initiatives by the European parliament. This project set a Europe-wide target to reduce GHG emissions by 20%, increase the share of renewable energy by up to 20% and reduce primary energy consumption by 20% (European Commission, 2010). As a result of this, 26 out of 27 EU member states achieved their targets, with the majority overachieving, and made their energy markets more sustainable (Douglas Broom, 2022).

4.2.3. Energy

The data collected from the World in Data sourced from BP Statistical Review of World Energy is a sum of all the EU-28 countries' energy consumption. Also seen earlier, the graph for primary energy consumption shows a decreasing trend. The total primary energy consumption for EU-28 peaked in 2006 and the per capita PEC peaked in 2004. The consumption has been declining since these two points in time. This is an eagle's eye perspective for Europe which means that the situation will differ for each country. This difference can be seen in some important countries of which their energy consumption behaviours are highlighted below.

Germany, being one of the most active economies in this region, remains heavily reliant on coal power, which from 2017 to 2021 generated 31% of the nation's electricity. Despite the dependence on carbon-intensive fossil fuel, wind and solar energy generation together made up more of Germany's electricity generation at 33% (23% for wind and 10% for solar). France is Europe's largest economy that primarily relies on nuclear power, with nuclear power making up more than half of the country's electricity production. The nuclear power production, as shown in Figure 5.11, is dominated by France in the whole EU-28 region.

From 2017 to 2021, Italy, the UK, and the Netherlands predominantly relied on natural gas for their electricity generation. Among the three, Italy was the most dependent, with 42% of its electricity generated from natural gas. However, the Netherlands (40%) and the UK (38%) were not significantly far behind in their reliance on natural gas for electricity production.

Spain stands out among major European nations as a remarkable success story in transitioning towards renewable energy sources. During the period from 2017 to 2021, the country relied primarily on natural gas, accounting for 29% of its electricity generation. However, in 2022, there was a significant shift as the contribution of natural gas dropped to 14%, while wind energy emerged as the leading source of electricity generation, representing a 32% share. This transition highlights Spain's remarkable progress in embracing and harnessing renewable energy, marking a substantial departure from its previous dependence on natural gas. (*Mapped: Europe's Biggest Sources of Electricity by Country*, 2023)

A recent report (data summary in the figure below) from Ember highlighted how the transition in EU-27 region made considerable progress in 2022, with solar and wind power (22%) overtaking natural gas (20%) in electricity generation for the first time ever (*European Electricity Review 2023 | Ember*, 2023). To further push this transition, sustainable energy cities are being purposely developed like in Denmark (Samsø and Aerø Islands) and Ireland (Cloughjordan) (Heaslip et al., 2016).

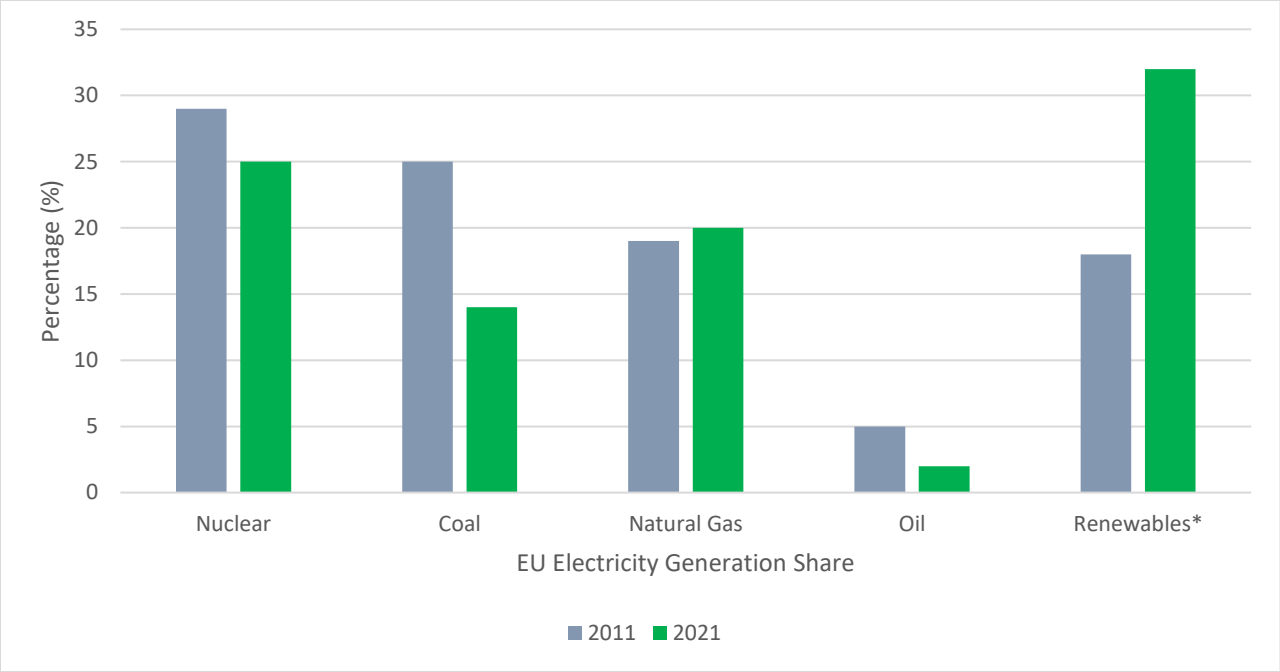

Figure 4.9 EU Electricity Generation Share 2011 and 2021

Source: Author's compilation based on (European Electricity Review, 2023)

The graph below takes a look deeper into the EU-28 region's PEC with respect to the population growth. Since the trend of PEC is decreasing since 2006, it is interesting to notice that the population is still on the rise. This further solidifies that the PEC per capita is reducing showing that energy efficiency is higher and the consumption per person is reducing over the years. Population of the EU-28 region is rather consistent but the peak of 2020 might either infer the effects of COVID 19 or just that the population has peaked and will no longer increase. The graph also proves that the PEC and the population growth are not related and have been decoupled.

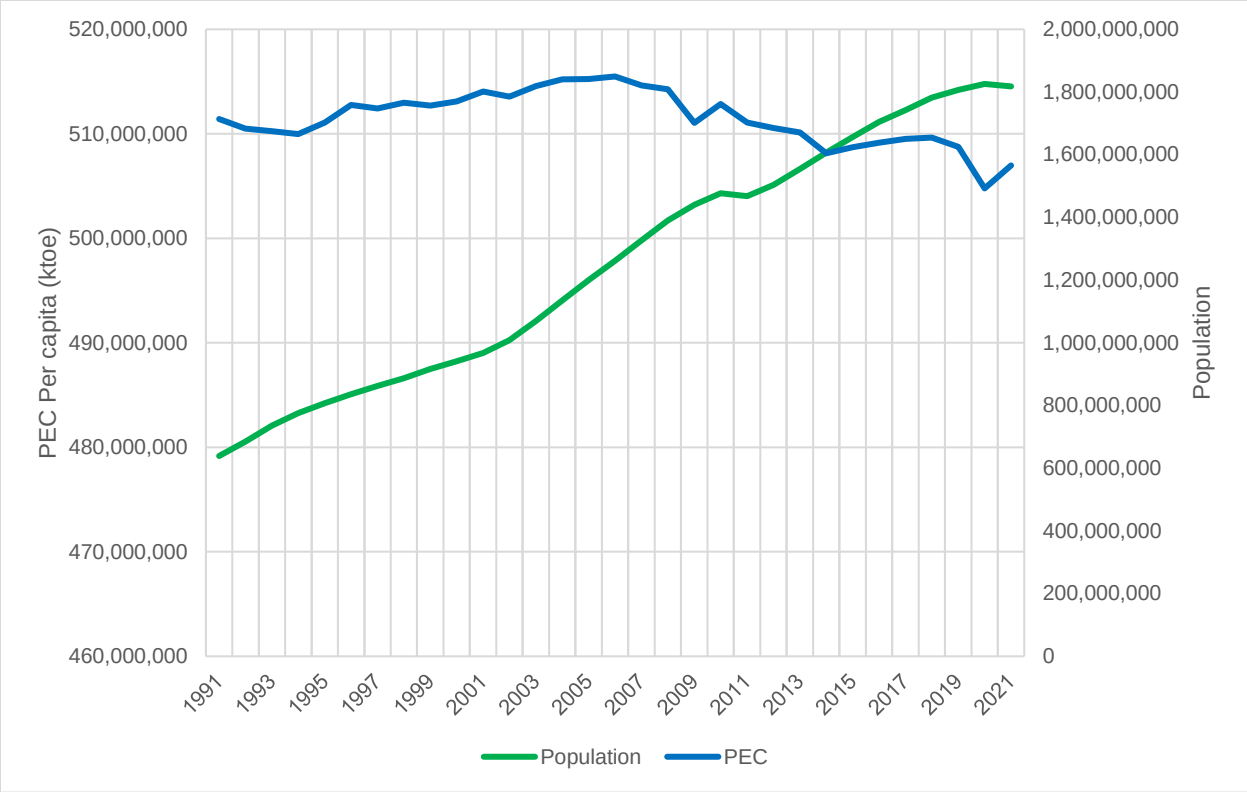

Figure 4.10 A comparison of the Primary Energy Consumption and Population of EU-28.

Source: Author's compilation based on (BP Statistical Review of World Energy, 2023)

The primary energy consumption decline is for sure a positive indicator with respect to sustainability. The next question is whether the types of energy sources are clean during this decline. To answer it, the graph below shows the energy mix of the EU-27 region.

A few important points can be noted from this crucial data. Firstly, the usage of oil is very persistent in the relative percentage of the total energy sources while the percentage of gas has been increasing. The usage of coal might be reduced but it cannot be denied that the energy derived from fossil fuels is still a constituent of the major chunk of the energy mix.

Secondly, renewable energy is starting to rise in percentage share of the total energy mix. Wind energy seems to have increased drastically relative to other renewable energy sources and solar energy has grown too. If nuclear energy is included in the category of green energy, renewables are accounting for almost a quarter of the energy mix.

Therefore, not only is the primary energy consumption reducing but the source of this primary energy is moving towards the adoption of renewable energy resources.

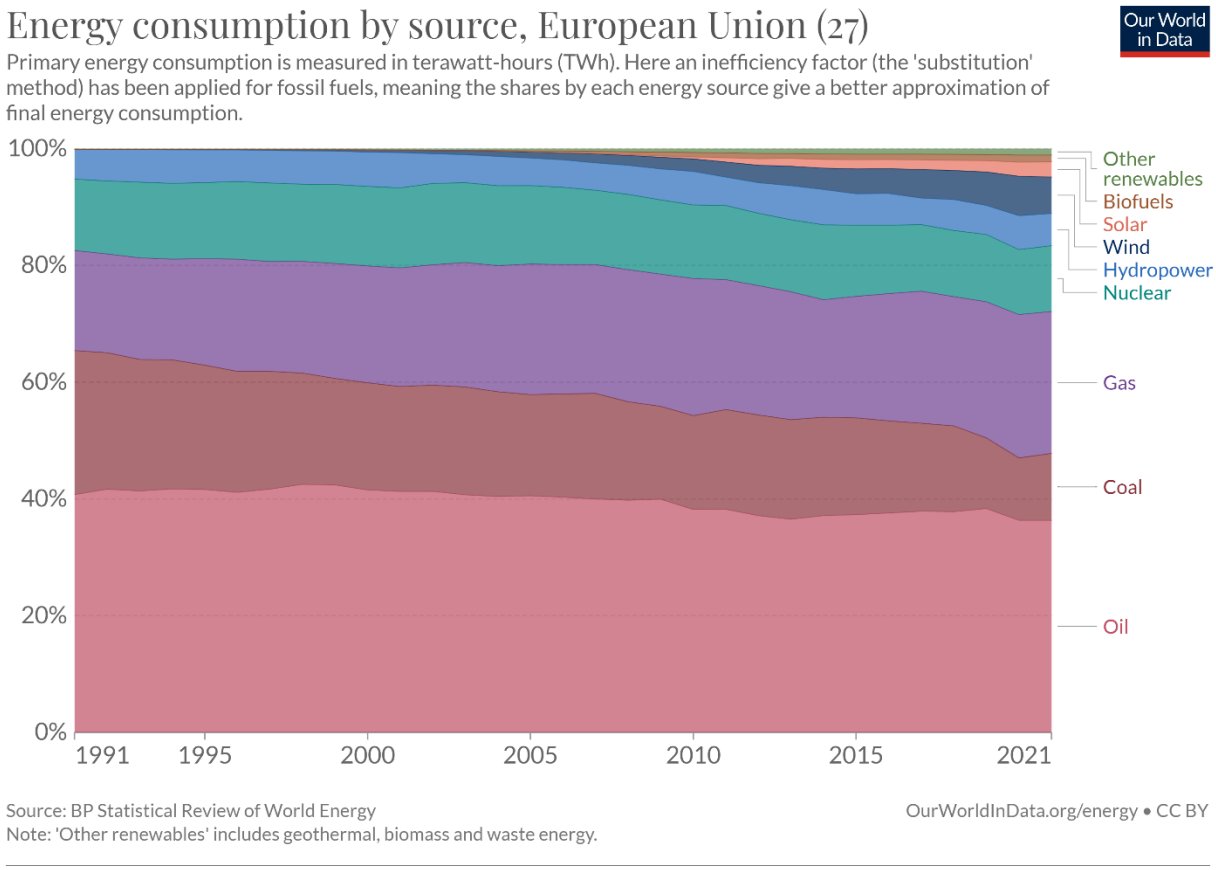

Figure 4.11 Relative-to-100% energy mix of the EU-27.

Source: BP Statistical Review of World Energy.

4.2.4. Greenhouse gas emissions

The energy sector plays a vital role in the greenhouse gas (GHG) emissions of the region, making it a significant factor to consider. As energy consumption increases, so does the corresponding rise in GHG emissions. This can be attributed to the prevalence of unclean and non-renewable energy sources that continue to dominate the market. These factors contribute to an urgent need for a shift towards cleaner and renewable energy sources to mitigate the environmental impact caused by the energy sector.

GHG emissions, which are one of the factors indicating a transition to sustainable energy, are proving that the EU-28 region is heading in the right direction. Despite the increase in population, the emissions are reducing. As seen in the graph below, the lowest GHG emissions were seen during the COVID-19 lockdown period in 2020. The GHG emissions indicator might not entirely depict a sustainable transition towards the sustainable energy transition but with respect to the energy mix graph above, Europe's 28 countries seem to be heading towards a future with sustainable energy practices.

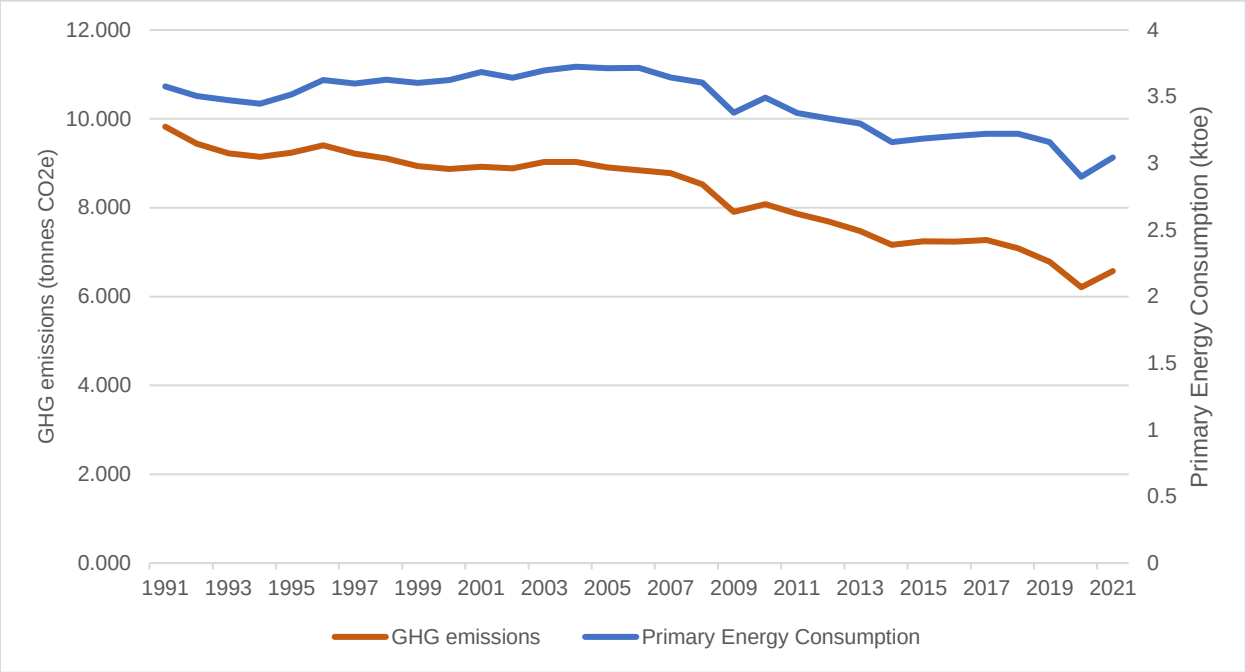

Figure 4.12 A comparison of Primary Energy Consumption per capita and GHG emissions of EU-28.

Source: Author's compilation based on (BP Statistical Review of World Energy, 2023)

Furthermore, the graph above possesses a diverging trend which means that PEC is not reducing at the rate that GHG emissions are. Therefore, it means that although the efficiency is increasing and the consumption reducing, the GHG emissions are being cut down by the adoption of cleaner sources of energy. In such a case, if the efficiency of the energy market is increasing and the consumption is reducing per person, the effect of shifting towards renewable energy has a multiplying effect.

Another interesting insight would be to compare the emissions and population of the EU-28 region. More population generally means that total energy consumed by the population increases given that the amount of energy used per person stays constant over time. In this case, the causal relation does not exist, which then reinforces the decoupling of energy with socio-economic dimensions. More population does not necessarily mean that GHG emissions will increase so here both are unrelated. This adds to the fact that clean energy is being adopted whilst the efficiency of general energy consumption is being increased. Hence, the increase in population does not affect the GHG emissions.

This connects back to the regulations set by the EU regarding GHG emissions which have limited unregulated emissions and pushed the EU towards finding efficient and cleaner alternatives. The industry's competitiveness also promotes healthy competition where the companies use sustainability initiatives to market themselves and attain competitive advantages. An overall sense of personal carbon footprint and sensitivity towards environmental protection is also growing in the general masses. This might be the reason which pushes people to make sustainable and conscious decisions.

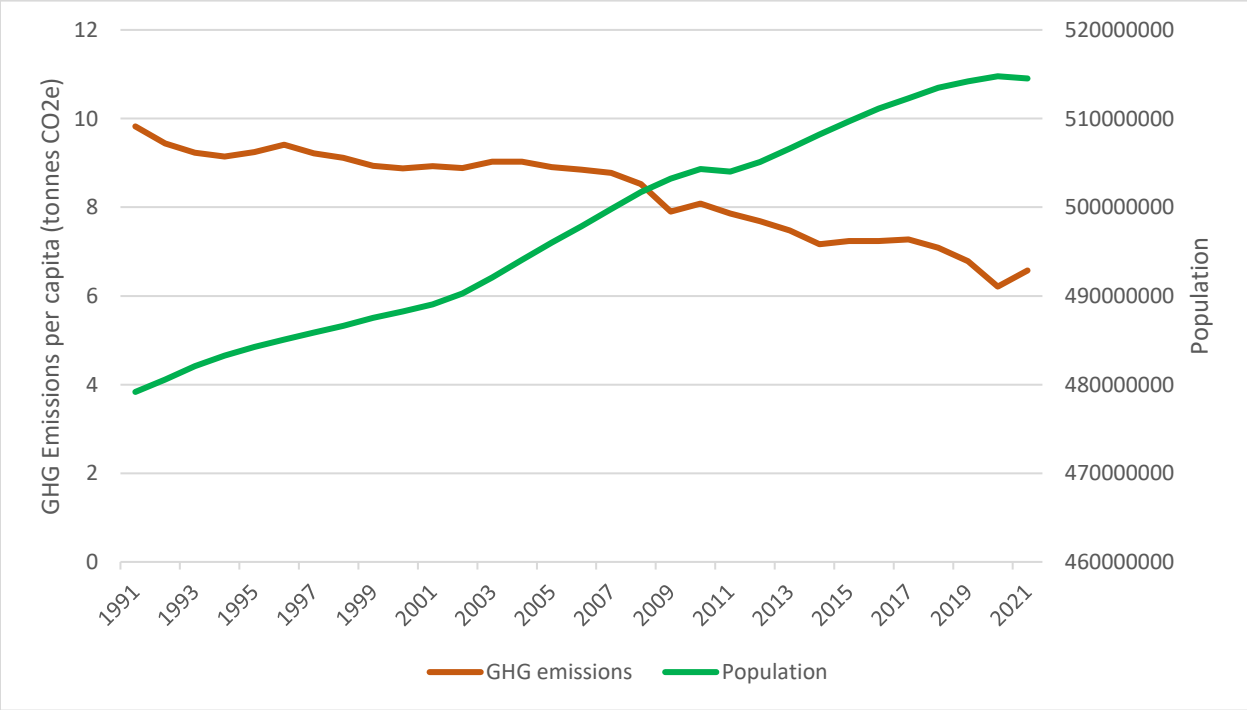

Figure 4.13 A comparison of GHG emissions per capita and Population for EU-28.

Source: Author's compilation based on (BP Statistical Review of World Energy, 2023)

5. Results and Discussion

A crucial aspect of this study is the comparison of the EU-28 and Pakistan. The general sense of this is majorly for the benefit of Pakistan but also at the same time proves to be a study for Europe to learn from and be sensitive towards. Therefore, during this comparison, multiple aspects of the trend towards sustainability in the energy market will be discussed. This includes taking a perspective of policies devised by both regions, how up-to-date they are, and how effective they are.

5.1. Policies

The policies of the two regions differ greatly because of one major reason and that is the fact that Pakistan is a country where EU-28 is a whole region. The EU's policies have been developed over time for the common purposes of all the states. On the other hand, Pakistan's policies are designed to cater for its needs based on the availability of resources and other challenges.

The European Union's policies with respect to the energy market have devised a holistic policy which takes into account the fact that each country will use different sources of energy. Therefore, their policies are more focused on renewable energy targets, energy efficiency, energy standards, and GHG Emission reduction goals. *Horizon Europe* and *Europe 2020* are a few of these examples which have set a certain goal for the region to achieve. To be inclusive and considerate of 28 diverse countries for policy making, which are now 27 after Brexit, takes huge amounts of effort and time.

When Pakistan is kept in the limelight, such policies may not be found. Over the years of political turmoil, Pakistan's major objectives have been to alleviate the poor economic conditions and provide basic needs and support to the people. *Roti, Kapra, Makaan* (translated as Bread, Clothes, house) was a slogan of Zulfiqar Ali Bhutto and has been used since his political campaign. This shows that these are the bare minimum that the people of the country want and still it is not being fulfilled. Therefore, it is only very recently that the country is starting to become aware of sustainability, especially in terms of energy.

Pakistan's policy of implementing renewable energy is outdated and after its reimplementation in 2011, the policy of 2006 is still being dragged on. Despite its presence, the enactment of these policies and enforcement is absent in the country. The EU has been revising and making new additions to the policies over the years since the Paris Agreement with the most recent push being due to the Versailles Declaration (*The Versailles Declaration*, 2022). It was targeted that by 2015, 10% of the energy mix of Pakistan will constitute of renewable energy but this plan did not come to fruition. This outcome reflects a common trend observed in various policy and project initiatives across different sectors in Pakistan. In comparison, the *Europe 2020* initiative was successful in 26/27 member states which is seen as a huge win. The target was overachieved by many countries too but Pakistan is still not in the position to achieve such big targets.

Khan et al. (2020) listed down top problems which Pakistan's Solar energy market is facing. They are listed below:

1. Lack of Competition with conventional energy systems
2. Lack of market-oriented policies
3. Lack of Financial planning and strategy
4. Lack of Infrastructure policy
5. Lacking behind in Info and Tech
6. Lack of Skilled personnels
7. Organizational issues
8. Lack of communal awareness and validation
9. Feed-in Tariffs
10. Lack of public sector participation
11. Lack of framework for Sustainable Energy projects (Khan et al., 2020).

Out of these problems, four are related to the policies of Pakistan. Moreover, it is important to highlight ranked Pakistan as one of the high potential countries globally in terms of its solar energy potential (Maguire, 2023). This ranking sheds light on the substantial renewable energy resources that Pakistan possesses. However, to fully capitalize on this potential, it becomes crucial to address the persistent policy and

implementation challenges. These challenges have hindered the effective harnessing of the available solar energy resources in the country.

5.2. Energy Patterns

5.2.1. Energy Mix

The cleanliness of the total energy consumed by a country can be told by analysing the data of the energy mix. This shows how much energy is being produced by what kind of source. If there is more contribution of renewable energy in this mix, that confirms that the energy consumed is coming from cleaner sources. This is one of the bases of comparison which tells us if EU-28 and Pakistan are transitioning towards adopting greener sources of energy into their energy mix.

With reference to Figure 4.4 and Figure 4.11 of Pakistan and EU-27 respectively, there is a great difference between the energy mixes of these two regions. For Pakistan, the share of renewables, with nuclear energy included, is 14.22% whereas in EU-27 it is 26.73%. The UK as of 2021 produces 19.38% and this is to be mentioned because the UK is being considered in EU-28. Note that biofuels are not being counted as renewable sources of energy because of the fact that their usage leads to direct GHG emissions. Biofuels, like methanol and ethanol, are burnt to give energy which in turn releases carbon dioxide.

In the overall trend, Europe shows a consistent adoption rate of renewable energies whereas in Pakistan it is seen to be rather erratic. In the latter, hydropower is considered to be a very popular source of energy, especially electricity. But in reality, this source is struggling to satisfy the rising consumption of the population (ref. to Figure 5.3) which is why the country turns towards the cheaper alternatives. Despite the high ranking in hydroelectric power and solar power potential, economic and political conditions prove to be the biggest hurdle. Contrary to this, Europe is seemingly much more robust in terms of economic standings which is why it adds to their consistency in the growth of the green energy market. Moreover, Europe’s cross-country trade of resources both material and

non-material (knowledge and skills) has helped it progress faster. Unlike Pakistan, it might have fewer risks of geopolitical barriers and hindrances.

If the specific countries of the EU are considered, recent data shows that the dependency of the important economies of the EU on natural gas is increasing over the past few decades (European Comission, 2021). This is an interesting finding since the energy mix might be turning towards sustainability but the dependency on this carbon-intensive fossil fuel shows the inertia of this specific energy market which is difficult to change. The consequences of this were seen after the Russia-Ukraine war when EU countries dependent on the Russian supply of gas had to shift quickly to other providers and other sources of energy. The main example is Germany which was heavily reliant on the supply of natural gas from Russia. Therefore, such high dependency on a single source of energy makes the EU more vulnerable to unforeseen future events.

Table 5.1
Energy dependency of EU-27.

In %	2000	2005	2010	2015	2019	2020
Dependency rate (all energies)	56.3	57.8	55.7	56	60.7	57.5
Dependency rate on natural gas	65.7	69	67.8	74.5	89.7	83.6

Source: EU energy in figures.

5.2.2. Energy Consumption

The consumption of energy is another metric that helps us peek into the realities and trends of sustainability. Therefore, this being one of the core aspects of the study, Table 5.2 and Table 5.3 form the foundation of consumption comparison alongside the aforementioned graphs of baselines.

Different multiple linear models were created in R studio using Ordinary Least Squares (OLS) for both the regions' primary energy consumption (denoted by pec_pc_toe). This is calculated for per capita consumption since it will give insights into the trend of the

consumption of the individual in the population. Moreover, it provides a good basis for comparison with the GDP per capita.

In Table 6.2, which shows the PEC per capita of EU-28, the second model was the most robust with a high R^2 value (93%) and lowest p-values as compared to the rest of the values. The formula that described the past trend is therefore derived to:

$$pec\_pc\_toe = -10.10 + 0.44\, co2e\_pc + 1.995e^{-8}\ population$$

Table 6.3, representing Pakistan's PEC per capita, showed that model two was also the most robust out of the 6 generated models. It is shown below as:

$$pec\_pc\_toe = -0.1 + 0.15 co2e\_pc + 0.0062e^{-8}\ population$$

Comparatively, it is seen that the variables most effective were the GHG emissions of the past and the population of the region. Although the causal effect of the variables cannot be proven their correlation was the highest when compared to other models. Also, when the values of the equations are compared, it is proven that the average person in the EU-28 region consumes more electricity than the average person in Pakistan. It is important to note the great difference between the impact of the population on primary energy consumption. Its value is much less for Pakistan despite the low population compared to EU-28's constant for the variable of population.

Table 5.2
Multiple linear models' table of constants and variables for Primary Energy Consumption of EU-28.

Source: EU energy in figures.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
(Intercept)	1.68 ***	-10.10 ***	-14.06 ***	-11.66	-11.66	-672.61 *	-50.78
	(0.15)	(1.81)	(3.22)	(6.17)	(6.17)	(246.15)	(127.99)
co2e_pc	0.21 ***	0.44 ***	0.48 ***	0.49 ***	0.49 ***		0.47 ***
	(0.02)	(0.04)	(0.04)	(0.06)	(0.06)		(0.05)
population		1.995e^-08 ***	0.00 ***	0.00	0.00		
		(0.00)	(0.00)	(0.00)	(0.00)		
gdp_pc			-0.00	-0.00	-0.00		
			(0.00)	(0.00)	(0.00)		
urbanization				0.00	0.00		
				(0.00)	(0.00)		
log_pop						71.55 **	-5.50
						(23.48)	(13.13)
log_urb						-38.38 **	8.14
						(11.38)	(6.93)
N	30	30	30	30	30	30	30
R2	0.83	0.93	0.94	0.94	0.94	0.70	0.94

*** p < 0.001; ** p < 0.01; * p < 0.05.

Source: Author's calculations.

Logarithm usually makes the comparison of big-valued numbers easier with smaller numbers which is why the natural log of the population and urbanization were also included to make sure the outcomes are more accurate. But it was seen in both cases that the significance value (p-value) of model 6 with log variable was not as high as model 2 which is the reason why the latter was preferred.

Table 5.3
Multiple linear models' table of constants and variables for Primary Energy Consumption of Pakistan.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(Intercept)	-0.23 ***	-0.10 *	-0.16	-0.32 *	-0.28	6.75
	(0.04)	(0.05)	(0.08)	(0.15)	(0.98)	(3.58)
co2e_pc	0.27 ***	0.15 ***	0.18 ***	0.21 ***		
	(0.02)	(0.03)	(0.05)	(0.05)		
population		6.16e^-10 ***	0.00 **	0.00		
		(0.00)	(0.00)	(0.00)		
gdp_pc			-0.00	-0.00	-0.00 ***	
			(0.00)	(0.00)	(0.00)	
urbanization				0.00		
				(0.00)		
pec_pc_toe					2.88 ***	
					(0.25)	
log_pop						-1.88 *
						(0.72)
log_urb						1.63 **
						(0.56)
N	30	30	30	30	30	30
R2	0.85	0.91	0.91	0.91	0.94	0.86

*** p < 0.001; ** p < 0.01; * p < 0.05.

Source: Author's calculations.

It was also an interesting observation that GDP per capita did not have a significant correlation in any of the multiple linear models despite having a strong individual correlation. Although, a causal relationship is evident for Pakistan in the long run since

the increase in GDP per capita will mean people are capable of consuming more energy through purchasing energy-intensive assets; these include motorbikes, cars, electricity generators, air conditioners, etc. The absence of correlation of GDP per capita was expected for the EU-28 region since they have decoupled their economic growth from a direct relationship with trends of PEC per capita: an indicator for sustainable development.

The next step that was undertaken was the prediction of PEC per capita for both regions for the next 5 years. This standard amount of time was taken to show a general trajectory of the energy consumption of the study areas. As mentioned, these are generated with autoregression lag 2 (AR(2)) and a difference of 1. The code looks as such:

```
forecasts_pec <- sarima.for(dataeu$pec_pc_toe, 5, 2, 1, 0)
```

In this code, we are using an ARIMA model for forecasting which is a popular method for modelling time series data. To make the data suitable for time series analysis, we apply a technique called differencing. Differencing involves computing the difference between consecutive time points of the data. This helps us capture the changes in the variable over time and remove any trends present in the data. By doing this, the data was made more stable and easier to analyse using the ARIMA framework.

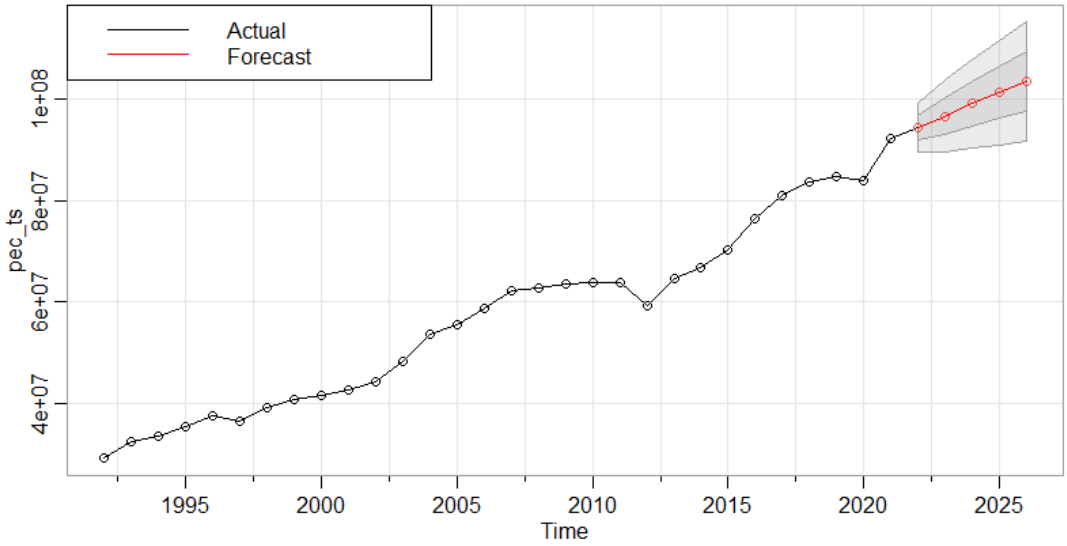

Figure 5.1 Primary energy consumption forecast for EU-28.

Source: Author's calculations.

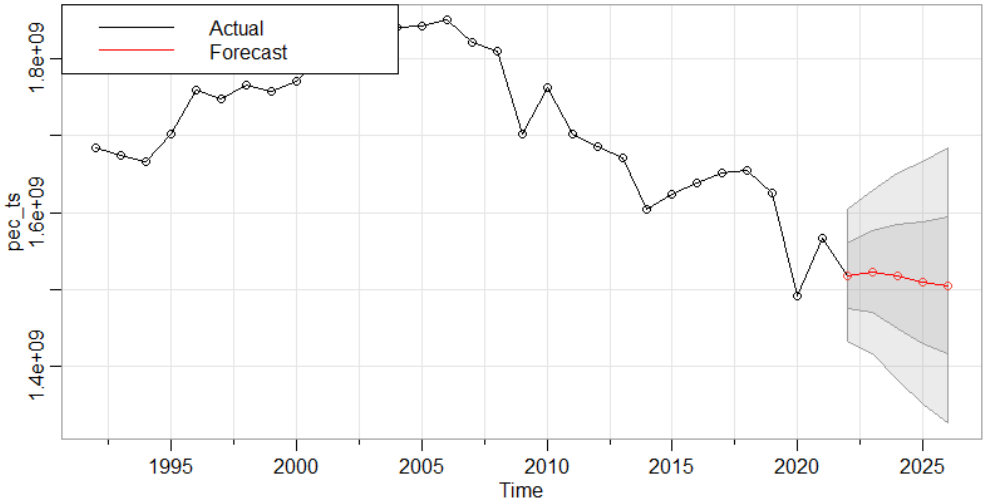

Figure 5.2 Primary energy consumption forecast for Pakistan.

Source: Author's calculations.

Figure 5.2 shows a very fluctuating past trend of the total PEC for EU-28 which is why the predictability is compromised. This is also shown by the confidence bars: the dark grey areas show that the predicted values will lie in this range with 95% confidence and the

light grey area represents a confidence level of 80%. Nonetheless, the future is relatively uncertain but the energy consumption of the EU-28 is expected to reduce.

Conversely, Pakistan is forecasted to increase its energy consumption in the next 5 years. The results are rather robust with more narrow confidence bars. The main reasons that could be inferred from the past data are the increasing population, increasing demand for

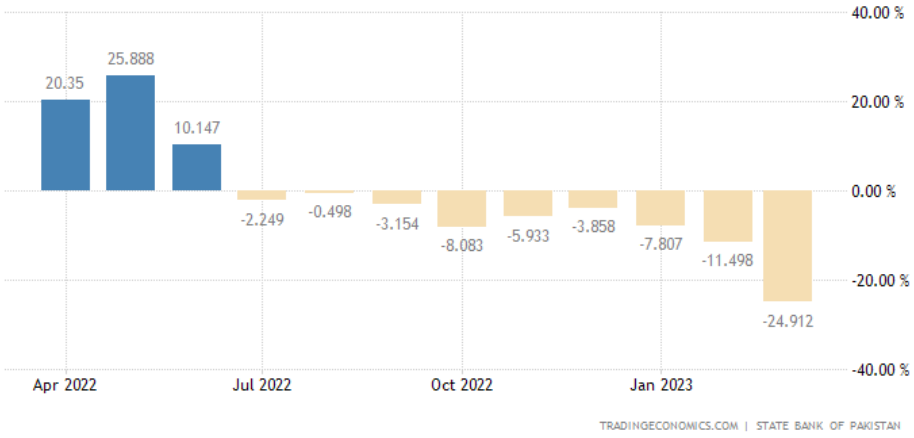

Figure 5.3 Industrial activity of Pakistan.

Source: planete-energies.com

energy, increasing GDP, and overall technological advancements. This conclusion is subject to the industrial activity of the recent quarters which is not included in the data pool used for the quantitative analysis. Pakistan's industrial activity has plummeted greatly which is why the accuracy of the predicted trend in energy consumption might not be very high. Rather, the gradient of energy consumption's prediction line might be lower at least for the first 3 years since the industry is not using energy to its full capacity.

5.2.3. GHG Emissions

Based on previous knowledge and literature review, it was expected that the population, urbanisation, primary energy consumption per capita, and GDP per capita would be contributing to the GHG emissions. After the data analysis, the multiple linear model differed slightly. Below are the tables that summarise the various models that best described the GHG emissions trend for he EU-28 and Pakistan.

For the EU-28, as shown in Table 6.4, Model 3 proved to be the model with the strongest correlation. This model is put into an equation in the following manner:

$$co2e\_pc = 36.54 + 1.71\, pec\_pc\_toe - 6.99e^{-8}\ population + 2.32e^{-5}\ gdp\_pc$$

Through a similar process, a model was derived from among the best models for Pakistan's GHG emissions. Model 3, when put into an equation yields the following:

$$co2e\_pc = 1.45 + 2.08\, pec\_pc\_toe - 1.95e^{-9}\ population + 2.87e^{-4}\ gdp\_pc$$

Now, the comparison of these shows that the population is contributing to lower GHG emissions which might not be surprising for the EU-28 since their emission control is stricter but it is interesting to see an inverse relation for Pakistan's GHG emissions with population. But it is important to see that the magnitude is much lower for Pakistan hence, the contribution to co2e_pc is also lower. Unlike PEC models, here GDP Per capita has a robust correlation with GHG emissions even though the magnitude for Pakistan is lower in comparison to that of the EU-28. To further add a layer of analysis, the forecast using autoregression is referred to.

Table 5.4
Multiple linear models for GHG emissions of EU-28.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(Intercept)	-5.12 ***	27.12 ***	36.54 ***	14.77	-0.28	19.35 ***
	(1.14)	(2.05)	(3.62)	(11.24)	(0.98)	(1.80)
pec_pc_toe	3.88 ***	1.94 ***	1.71 ***	1.53 ***	2.88 ***	1.56 ***
	(0.33)	(0.16)	(0.16)	(0.18)	(0.25)	(0.16)
population		-0.00 ***	-6.99e^-08 ***	0.00		
		(0.00)	(0.00)	(0.00)		
gdp_pc			2.32e^-05**	0.00 *	-0.00 ***	0.00 **
			(0.00)	(0.00)	(0.00)	(0.00)
urbanization				-0.00		-0.00 ***
				(0.00)		(0.00)
N	30	30	30	30	30	30
R2	0.83	0.98	0.99	0.99	0.94	0.99

*** p < 0.001; ** p < 0.01; * p < 0.05.

Source: Author's calculations.

Table 5.5
Multiple linear models for GHG emissions of Pakistan.

	Model 1	Model 2	Model 3	Model 4	Model 5
(Intercept)	1.01 ***	1.03 ***	1.45 ***	1.37 ***	2.08 ***
	(0.08)	(0.08)	(0.13)	(0.12)	(0.22)
pec_pc_toe	3.16 ***	2.75 ***	2.08 ***	2.01 **	1.85 ***
	(0.25)	(0.63)	(0.53)	(0.55)	(0.46)
population		0.00	-1.95e^-09 *		-0.00 **
		(0.00)	(0.00)		(0.00)
gdp_pc			2.87e^-04 ***	0.00 **	0.00
			(0.00)	(0.00)	(0.00)
urbanization				0.00	0.00 **
				(0.00)	(0.00)
N	30	30	30	30	30
R2	0.85	0.85	0.91	0.90	0.94

*** p < 0.001; ** p < 0.01; * p < 0.05.

Source: Author's calculations.

The ARIMA models prepared here were also of AR lag 2 and with differencing level 1. It yielded the following graphs that predict the GHG emissions for the EU-28 and Pakistan for the next 5 years (from 2022 until 2026).

For the EU, a decline is expected in the GHG emissions in the next 5 years. Even in the low-confidence scenario, it is not expected that the emissions from 2022-2026 will increase. Since energy consumption has a high correlation with GHG emissions, the lack of accuracy in the prediction of PEC can also lead to an increase in the unpredictability of GHG emissions.

Contrary to the EU-28, Pakistan's GHG emissions are going to increase with a confidence rate of 95%. As justified before, Pakistan's political stability and the efforts of the government will dictate how well the country will curb its emissions. While the trend is not in favour of Pakistan, it is important to see that as of 2021, Pakistan's GHG emissions per capita was 2.3 tonnes of CO_2 equivalent whereas for EU-28 it is 6.57 tonnes of CO_2 equivalent. This shows that although Pakistan is developing towards increasing GHG emissions, to reach the level of the EU-28's GHG emissions per capita, it will take Pakistan 40-45 years. This is when the rate is 0.1 tonnes of CO_2 equivalent emissions per capita increase per year and under the assumption that the rate stays constant.

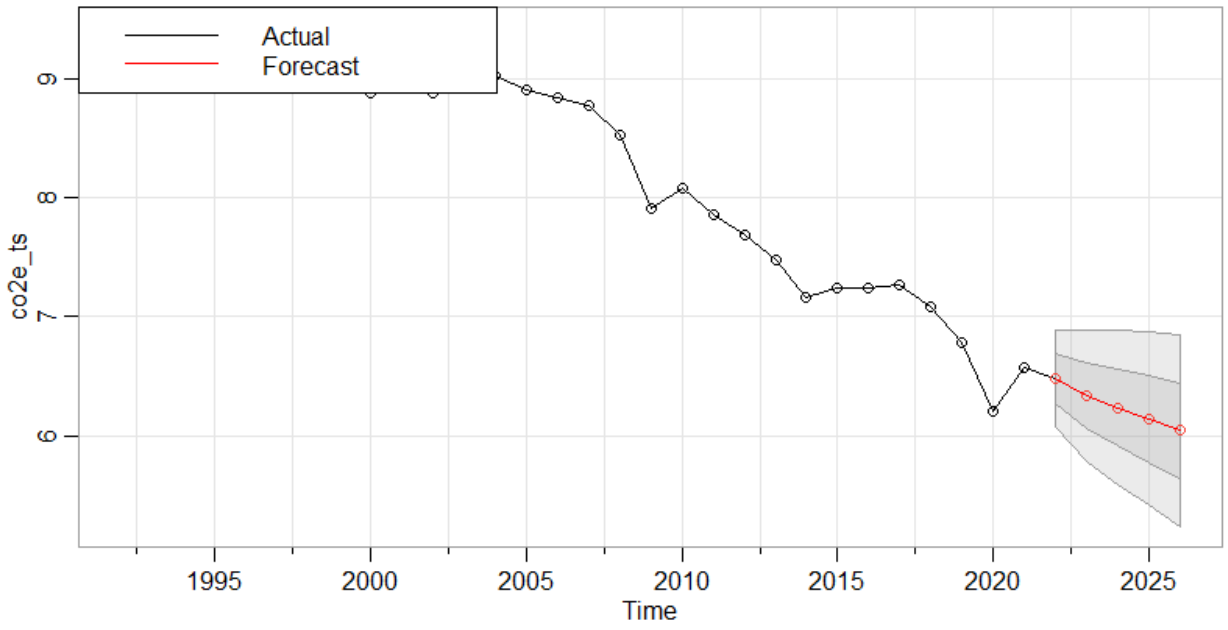

Figure 5.4 GHG emissions per capita forecast for EU-28.

Source: Author's calculations.

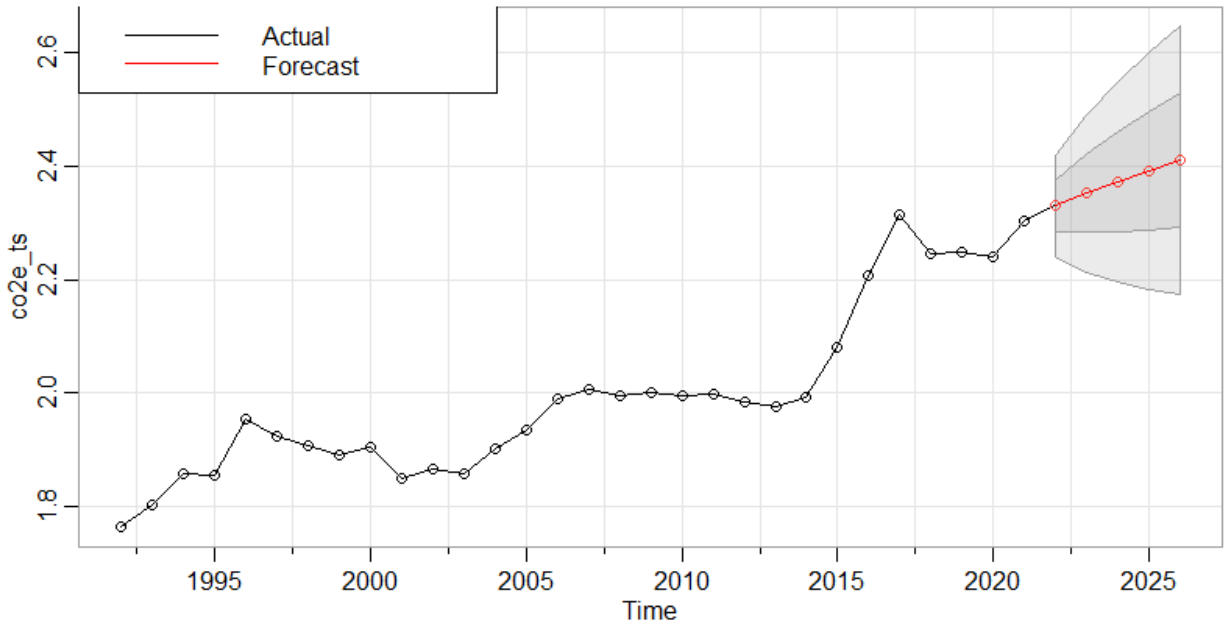

Figure 5.5 GHG emissions per capita forecast for Pakistan.

Source: Author's calculations.

Conclusion

The threat of climate change looms over the earth and all of its residents and the effects of it have already started taking a huge toll on humanity. From Australian wildfires to melting glaciers in the northern parts of Pakistan, this phenomenon affects everyone and knows no boundaries of countries. The core cause of this is anthropogenic, which means that the sole cause of climate change is human activity.

Humanity's increasing demand for energy has led to increased exploitation of natural fossil fuels and increased consumption of them. After industrialisation, this usage of carbon-intensive fuels has expelled huge amounts of carbon dioxide and other greenhouse gasses. The increase in the levels of carbon dioxide has been exponential which has caused global warming. Therefore, sitting at the core of increasing global temperature is the energy sector. Developed nations after having gone through development at the cost of the environment have recently started to shift towards the adoption of sustainable and renewable energy sources. To see how the trend has been for a developed region and a developing region, EU-28 and Pakistan were selected respectively in this study.

Five major variables were analysed in this quantitative study: Primary Energy Consumption, GHG Emissions, GDP per capita, Population, and Urbanisation. In the baseline studies for Pakistan, all these indicators had an upward trend with the most stable rate of increase seen in population. These indicators showed direct relationship with eachother since the individual correlations were high with respect to PEC and GHG emissions. Since Pakistan is a developing economy, the increasing emissions, energy consumption, and population was expected. In terms of predictions, Pakistan might see increasing PEC and GHG emissions for the next 5 years. Among the two core variables, PEC's prediction was more robust.

As for the EU-28, the baselines showed a transition towards sustainable energy usage. This means that their sources are becoming cleaner and over the years their efficiency in energy consumption is also improving. This was derived by looking at the correlation between GDP per capita, population, and the GHG emissions. One of the major findings was that Europe seems to have decoupled the effect of population on GHG emissions,

which proves that their sources are shifting to cleaner sources. Moreover, they have also decoupled the GDP per capita from PEC which means that per capita consumption does not mean that the energy is consumed in proportionate manner.

For both the regions, the MLR models for PEC showed that GDP was not a significant factor in explaining the past trends. Rather, GHG emissions per capita and the population had strong correlations with the primary energy consumption. This does not prove a causal relationship but only the magnitude of correlations. On the other hand, the models for GHG emissions for the two regions showed strong correlations of GHG emissions with PEC per capita, GDP per capita, and population. Another thing to notice was the difference in the magnitude of the constants which showed that GDP per capita has a lesser magnitude of constant with the GHG emissions in comparison to that of Pakistan which adds to the fact that the EU-28 has decoupled their GDP per capita from the emissions.

The past 30 years of data was analysed with the ARIMA model which predicted, for the next 5 years, an increase in per capita GHG emissions for Pakistan but showed a more robust prediction of decreasing per capita emissions for the EU-28 region. Although the EU-28 is also affected by climate change, Pakistan is far more vulnerable to it. The GHG emissions from the agricultural sector are expected to reduce due to the impacts of climate change, especially after the recent national level floodings. In terms of PEC, Pakistan is set to see an increase their PEC in the next 5 years, but this is contested given the negatively affected industrial sector's operations. When the industrial operations are low and compromised, the intensive energy demand might reduce and hence the PEC. The energy consumption of the EU-28 is expected to decline but not in a steep manner. This outcome is higher in uncertainty due to the turbulent geopolitical conditions risen as a result of the Russia-Ukraine war. Furthermore, the high dependency on natural gas as a source of energy has backfired some countries of the EU-28.

Despite the initiatives of Europe, it faces a lot of barriers to actually implementing sustainability in its models. A study on the barriers faced by Europe regarding the circular economy showed that one of the major barriers was the cultural barrier (Kirchherr et al., 2018). Despite the differing cultures in each country of the EU-28, the intra-EU trade unity

still remains which adds to the strength of the region in terms of economic resilience. On the contrary, one of the major hurdles in Pakistan's way to achieve energy sustainability is the economic health and the lack of stout policies. The effects of the lack of policies and their enforcement is seen by the behaviour of the GHG emissions and PEC graph. Since the policies are well versed and implemented in the EU, their progress, at least in the energy mix and achieving goals is much steadier.

Conclusively, it can be said that the EU-28 region, as a whole, is shifting towards sustainability in terms of energy but still has the inertia of old carbon-intensive energy infrastructure to overcome. In comparison to them, Pakistan is moving in the opposite direction with the energy mix not looking promising with respect to the adoption of clean energy despite the huge potential. But the magnitude of EU-28's PEC per capita is far higher than that of Pakistan's and so are the GHG emissions per capita which means that the EU is not as sustainable as Pakistan in terms of emissions and consumption.

The vulnerability of Pakistan in the face of climate change has ranked it 4th in the world. Reasons which are distilled as a result of this study show that firstly the direct impact of climate change is very high for this region and secondly, backed by our research, the economic conditions of Pakistan do not help adapt to the impacts. With circular debt and low financial capacity, the biodiversity, resources, and, most importantly, the people will suffer the worst consequences. The way forward, as an outcome of this research, directs us towards the EU which has very strong adaptation capabilities; they proved it during the peak war times when the gas supply was stringent and at risk but the provision of electricity and basic needs at home were not compromised. The EU has been able to adapt to such economic and limited environmental impacts very well while mitigating the consequences of climate change. They adapted using their collective power derived from their intellectual skills, the pool of technology, and adherence to the policies. Moreover, the EU-28 has tried to mitigate the climate change impacts by decoupling the relationship between PEC and population and others as mentioned above. Therefore, recommendations stem from this research primarily for Pakistan but also for the EU-28 region.

Recommendations

The findings of the analysis done by this study provides a number of recommendations for Pakistani policy-makers, businesses, and general decision-makers and also to the EU-28 region's stakeholders.

1. Given the projections of GHG emissions per capita and PEC, Pakistan must shift towards a diversified energy mix for the country that will not only relieve the pressure of not being able to meet the energy demands but will also be done through cleaner sources. In addition to this, the risk caused by dependency on non-renewable energy sources will reduce.
2. To improve the energy mix and energy efficiency through means of clean sources, the EU can assist Pakistan to tap into green energy sources by providing advanced technology and human resources. Pakistan lies in a very strategic position geographically and investment in this region will also lead to greater political ties between the two regions.
3. As mentioned, Pakistan has a huge potential for solar energy and hydel energy production which makes it a prime place for investment. Another such collaboration can be between France and Pakistan regarding nuclear energy production since the former is a leading producer of it. Pakistan's old methods and technology can be revamped with the help of French experts.
4. Pakistan has a great size of human resource which is why cross-border collaboration will be beneficial for both regions. The youth bulge in Pakistan is high with 64% of the population aged between 19-29, as compared to less than 33% in EU-28. Hence, the latter can benefit from this resource to not only improve their economy but also strengthen the youth of Pakistan by providing them with skills, opportunities, and better monetary support. With better international sustainability best practices learnt, the people of Pakistan in the EU-28 can then contribute back home in a more skilled way.
5. To counter the suggestions of some studies suggesting natural gas to be a transition source of energy (Baz et al., 2019), this research suggests tapping into the high-ranking solar potential in Pakistan and also hydel energy; the latter being

on micro-levels across the Indus River and its tributaries to avoid environmental impacts caused by mega-dam projects. It is very much possible to do so with international help and collaboration since Pakistan's energy infrastructure is not as mature as the EU's so transition/leapfrogging is a viable option. This recommendation will also be for the EU-28 region given their high dependency on oil and gas; developing innovative ways to diversify the energy mix based on clean energy sources should be the primary objective in the energy market because this region has the technological capacity to execute it.

6. The methods of executing policies and frameworks can be taken as an example for Pakistani policy-makers to learn from. This should only be an example and not an ideal which is why the policies should be tailored to the environment of Pakistan. What should also be worked on is refreshing the policies in the fast-paced world and the systems of Pakistan. With new threats in the arena, the policies must be robust, versatile, and enforceable.
7. Additionally, circular economic policies have to be strengthened for both regions. Decision-makers and policymakers should encourage businesses to adopt circular economy principles, such as recycling, reuse, and product lifecycle management. This can contribute to reducing environmental impacts and helps the region transition quickly towards sustainability. While Pakistan's governmental bodies might not be working at full capacity, the social institutions can use this opportunity to promote international collaboration.

Limitations

The research was successfully completed but due to the time restrained, the study faced a few limitations. These should be kept in mind while reading the study:

- Detail of data: The fidelity of the data was not high since the pool of data used was available in a yearly format. Therefore 30 years of data yielded only 30 points of data for a single variable.
- Reliance on secondary data: the data acquired was through secondary sources which is why accuracy is always compromised to some extent. Perhaps the ARIMA model will predict more accurately if primary data is attained.
- Limited variables and factors: This study limited itself to 5-6 variables in quantitative analysis and there were other unaccounted factors like industrialisation, war crisis, political instability, education level, etc.
- Country variations for EU: Comparing the EU-28 region with a single country might not be ideal despite being able to yield a solid eagle's eye perspective. Each country in the EU executes policies differently and the differences in each of them are high which also adds to the fact that this study is not very detailed.

This quantitative study seems to have yielded robust results for other researchers to consult as well as recommendations for policymakers, decision-makers and business people. The limitations above are mentioned only to emphasise the potential for further research in this field. Since there are other factors at play that dictate the GHG emissions and primary energy consumption in the two regions of study.

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Abbreviations and Acronyms

ARIMA – Autoregressive Integrated Moving Average

BP –British Petroleum

BP test – Breusch-Pagan test

CPEC – China Pakistan Economic Corridor

CSR – Corporate Social responsibility

EEA – European Economic Area

EU – European Union

GDP – Gross Domestic Product

GHG – Greenhouse Gas

MLR – Multiple Linear Regression

NDC – Nationally Determined Contribution

OBOR – One Belt One Road

OECD – Organization for Economic Cooperation and Development

OLS – Ordinary Least Squares

PEC – Primary Energy Consumption

RE – Renewable Energy

SDG – Sustainable Development Goal

SME – Small Medium Enterprise

UNFCCC – United Nations Framework Convention on Climate Change

UPS – Uninterrupted Power Supply.