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Impact of National Socio-cultural Context and Geography on the Feasibility of Energy Transition

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Abstract:

This study aims to explore the feasibility and development paths of global energy transition by analyzing the economic, geographic, social, and political characteristics of various countries in their energy transition processes. The results show significant differences in the progress of energy transition among countries. Developed countries, with their economic strength and technological capabilities, can advance energy transitions more quickly, while developing countries face more obstacles. These insights highlight the importance of tailored strategies based on the unique challenges and resources of each country to promote global energy transition. A review of existing literature reveals that current energy transition research primarily focuses on individual countries. This paper categorizes countries into three groups, summarizes their common characteristics, and analyzes their impact on energy transition, particularly the relationship between economic development, income inequality, education levels, and population size. The study data indicate that countries with higher per capita GDP, lower Gini coefficients, and higher proportions of university-educated labor forces are more successful in energy transition. The paper advocates for a holistic approach that includes socio-economic reforms in addition to technological advancements to promote energy transition.

Keywords: Energy transition, economic development, geographic conditions, socio-cultural factors, sustainable development.

1. Introduction

1.1 Background

Energy resources provide the material basis for the existence and development of human society and are an important driving force for world economic activity. The development and use of fossil energy has contributed to the rise of modern industrial civilization, but has also brought about serious environmental and climate damage. The international community has recognized the need to curb dependence on fossil energy, improve the efficiency of energy use and achieve a low carbon energy transition in order to maintain sustainable development. Therefore, in the context of the global response to climate change and the promotion of sustainable development, energy transition has become a focus of attention for governments, enterprises and academia. This paper argues that the core of energy transition lies in the shift from a traditional energy structure dominated by fossil fuels to a modern energy structure dominated by renewable energy.

Under the leadership of global sustainable development thinking, the economic development model of energy saving and emission reduction, low carbon and environmental protection has become mainstream. Governments have adjusted their national energy development strategies to make clean, low carbon renewable energy a priority. The signing of the Paris Agreement in 2016 clarified the long-term goal of limiting the global average temperature rise to less than 2°C and endeavoring to control it to less than 1.5°C. In 2021, the Glasgow Climate Convention called for an end to inefficient fossil fuel subsidies and a gradual reduction in fossil energy sources such as coal use, further reinforcing the international consensus on energy transition. Meanwhile, major developed countries such as the European Union and the United States, and emerging economies such as Russia and India, have made commitments to reduce emissions and put forward carbon neutral timetables. The EU has proposed to achieve carbon neutrality by 2050, the US has returned to the Paris Agreement and announced that it will achieve carbon neutrality by 2050, and China is striving to achieve its carbon neutrality target by 2060. These commitments show that achieving the energy transition has become a common goal for major countries around the world.

However, energy transition is not only about technological progress, but also involves economic, geographic, social and political factors, which together affect the process and effectiveness of energy transition in each country and determine the path of each country in addressing climate change and achieving sustainable development. As a result, there are significant differences in the energy transition process in different countries. Developed countries, with greater economic strength and technological capacity, as well as social support, have been able to advance the energy transition more quickly, while emerging economies and developing countries face more economic and technological challenges. Understanding these differences and the reasons behind them is of great significance for promoting the global energy transition and achieving sustainable development goals.

1.2 Significance of the Study

Most of the existing studies analyze the feasibility and influencing factors of energy transition from the perspective of a single country, or mainly consider the enlightenment of successful transition cases for a specific country. At the same time, the existing research mainly focuses on the impact of economy and policy on energy transition, while the research on other aspects, such as culture and society, is relatively lacking.

This study believes that energy transition is an important task that needs to be completed by the whole world, so the research in this direction should not only focus on a single country, but from the perspective of the world to explore the feasibility and development path of energy transition under the background of globalization.

1.3 Research Methods and Innovations

1.3.1 Research Methods

This study primarily employs the PESTLE analysis method, literature review, descriptive statistical analysis, correlation analysis, and causation analysis. Data will be sourced extensively from various national websites, as well as from international organizations such as the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), to support the data analysis in this study. Additionally, public documents released by the European Union and national government departments will provide substantial factual support for policy analysis.

1.3.2 Thesis Structure

This thesis is structured into an introduction, a literature review, and four chapters. Chapter One categorizes different countries based on their stages in the energy transition process and then analyzes data from economic, geographic, social, and political perspectives for different types of countries. The research data includes: Economic: GDP, Gini coefficient, energy consumption structure, energy dependency, and the scale and development level of the energy industry. Geographic: Geographic location, distribution of natural resources, climatic conditions, and geographic barriers. Social: Population structure, education level, public environmental awareness, and social cultural habits. Political: Government energy policies, political stability, legal framework, and international cooperation status.

The analysis will summarize the common characteristics and differences in these aspects among different types of countries. Chapter Two delves deeper into the findings of Chapter One, identifying the key factors that significantly influence energy transitions and the degree of impact each factor has on the energy transition process of different countries. These factors will be ranked according to their relevance. Chapter Three proposes feasible solutions for different types of countries to promote the global energy transition process. Based on the specific circumstances and challenges faced by various countries, we will provide targeted policy recommendations and practical pathways. These solutions aim to offer practical guidance and assistance for global energy transitions, helping countries achieve sustainable development goals. Chapter Four discusses the main obstacles hindering national energy transitions and offers methods and suggestions to help countries facing difficulties in accelerating their energy transition processes.

1.3.3 Innovations

This study hopes to compare the differences among countries that have successfully carried out energy transition, countries that have made major breakthroughs in energy transition in recent years, and countries with difficulties in energy transition by exploring their economic, geographical, cultural and political characteristics, and explore the correlation between these characteristics and the progress of energy transition. From this, the reasons that hinder the energy transition of some countries can be found, and how to help countries facing difficulties in energy transition accelerate the process of energy transition.

2. Literature Review

2.1 Current Situation of Energy Transition

Research

2.1.1 Energy Transition Definition

There are currently numerous definitions of energy transition. Zhang proposes that energy transition involves achieving a profound transformation of the economic system through measures such as improving energy efficiency, optimizing the energy structure, vigorously promoting electrification, and deeply decarbonizing the power system[1]. In the paper *New Power System with Renewable Energy as the Mainstay under the Dual Carbon Goals: Contributions, Key Technologies, and Challenges,* Xiao and Zheng define energy transition as the shift from a traditional fossil fuel-dependent system to one based on renewable energy and electrification, which includes replacing fossil fuels and reducing carbon emissions from power generation[2]. Zhu and Wang, among other scholars, view energy transition as a long-term structural change in primary energy, driven by energy prime movers and deeply evolving with the energy system[3]. This paper leans towards Xiao and Zheng's definition, as our research team focuses more on greenhouse gas emissions and environmental pollution. We believe that reducing greenhouse gas emissions and minimizing environmental pollution are critical goals in the energy transition process. This perspective not only emphasizes changes in the energy structure but also considers the impact on the environment. Consequently, our subsequent discussion in this paper will revolve around these aspects of energy transition.

2.1.2 The Significance of Energy Transition

The significance of energy transition lies in reducing environmental pollution and carbon emissions. Chen argues that after centuries of rapid development, human economic activities have depleted energy resources and caused global environmental and climate damage, necessitating international efforts towards energy transition to ensure sustainable development of human society[4]. In their paper, Zhao point out that urban energy consumption in China accounts for 85% of total energy consumption, exceeding the global average by nearly 20 percentage points, highlighting the urgent need for immediate energy transition tasks[5]. Xue argues from the perspective of IoT support for energy transition that it imposes significant pressures on the environment and fossil fuel resources, while also potentially causing economic losses[6]. According to the *Paris Agreement*, efforts are aimed at limiting the global average temperature rise to within 2 degrees Celsius above pre-industrial levels, with further aspirations to constrain it to 1.5 degrees Celsius to mitigate risks and impacts of climate change. However, current energy structures and consumption levels fall far short of meeting the requirements of environmental policies like the *Paris Agreemen*t. Therefore, energy transition is essential to ensure sustainable human development in the future. Moreover, for several Southeast Asian countries, energy transition and the expansion of electricity infrastructure can effectively enhance agricultural development and efficiency.

2.1.3 The Global Energy Transition Process

Many Nordic countries have achieved significant success and breakthroughs in energy transition. Denmark, Finland, Norway, and Sweden are among the world's most developed economies, with comprehensive welfare systems and relatively low population densities. In the *World Economic Forum's Global Competitiveness Report 2013-2014*, Denmark, Finland, Norway, and Sweden ranked 15th, 3rd, 11th, and 6th, respectively. The combined population of these Nordic countries is comparable to that of Taiwan, yet their per capita GDP is 2.4 times that of Taiwan, 1.5 times the OECD average, and 15 times that of China. These countries have completed industrialization and are in advanced stages of economic development.

Each Nordic country leverages its advanced technology and resource advantages, formulating comprehensive energy policies on biomass, solar, wind, and geothermal energy. Through international cooperation, they have achieved complementary advantages, striking a good balance between economic growth and environmental protection. Geographically, the Nordic countries benefit from abundant hydropower resources and extensive oil and gas fields in the North Sea, Norwegian Sea, and Barents Sea, providing them with considerable advantages in energy export and transition.

2.2 Related Research on Countries with Successful Energy Transition

2.2.1 Relevant studies on transition policies and economies in successful energy transition countries

Many scholars have studied the energy transition in the Nordic countries more extensively, and they have explored the positive effects and potential risks of energy policies in the Nordic countries from different perspectives. Some scholars study the energy transition strategies of the Nordic countries and the energy cooperation among the Nordic countries from the perspective of the Nordic region. For example, Ma and Dong explore the evolution of Danish energy policy since the early 1990s and explore the differentiated characteristics of Danish renewable energy policy in different periods. At the same time, using Danish energy economic data since the 1990s, it is empirically found that positive and active policies at the national level have a significant driving effect on renewable energy[7]. Nilsson analyses the relationship between Sweden's energy policy, its philosophy, policy framework and environmental protection. He argues that Sweden views energy as a market rather than an infrastructure, and that environmental protection of the climate is fully reflected in the energy policy framework, while crowding out other environmental issues[8]. Czarny's book *A Modern Nordic Saga: Politics, Economy and Society* describes the Nordic countries as having an integrated policy system that minimizes the impacts of energy use on health, the environment, and the climate by using advanced, modern, and intellectually connected technologies[9]. Czarny, in *The Nordic Dimension of Energy Security*, also puts the Nordic countries' energy policies in the context of the global energy security dimension and, while recognizing that the Nordic countries have achieved energy security through the energy transition, raises the question of how the Nordic countries urgently need to address the issue of how to adjust the status quo in some of these countries and continue to implement clear policies. countries to the status quo and continue with clear climate protection policies, and how to ensure sustainable innovation in new energy technologies, which requires more support from national financial instruments[10]. Singh discusses the role of ETI in combining macroeconomic, political system, social and geopolitical factors in favor of energy transition with several specific cases of energy transition and point out that ETI can provide a better understanding of the past and present state of energy transition around the world, which can lead to smarter energy transition policies and investment decisions. policy and investment decisions[11].

2.2.2 Relevant studies on other aspects of research in successful energy transition countries

One group of scholars has attempted to gain a deep understanding of the Nordic energy transition process from an interdisciplinary perspective, with Johansson Maria arguing that behavioral change is expected to play an important role in the shift to a more energy-efficient built environment. This is assessed in the article, which shows that the Nordic countries have been assessed using a multidisciplinary approach, but with a limited understanding of individual behavior and the psychology of behavioral change. In conclusion, there is a need for the energy transition to also include environmental psychology to enhance interdisciplinary understanding of behavioral change, and a need to coordinate and combine assessments from different disciplinary approaches to improve understanding of the change process. Some scholars have analyzed the energy transition pathways in the Nordic countries from the perspective of the participating subjects, Bolwiga have built a framework for considering social acceptance in the modelling of energy transition pathways in their articles. The results show that e.g. social acceptance may significantly influence transition path scenarios based only on techno-economic variables. Therefore, the techno-economic, socio-technical and political dimensions of the co-evolution of the energy system should be considered when analyzing the long-term energy transition. Emphasis is placed on linking energy system modelling to the dynamic consideration of socio-technical factors[12].

2.3 Factors Influencing the Energy Transition

2.3.1 Political factors

Political factors influencing energy transition include government policies and regulations, financial support for clean energy projects, political stability for consistent long-term planning, and international cooperation on reducing carbon emissions. According to Germanies *The political logics of clean energy transitions* by Breetz for instance, has been successful in integrating renewable energy into its national grid due to strong political will and supportive policies[13]. Germany is actively promoting the transition to renewable energy through its "Energiewende" policy. The policy includes subsidizing renewable energy sources such as wind and solar and phasing out the use of nuclear and coal. Moreover, Germany is currently cooperating with other EU countries to reduce the emission of carbon dioxide as its objective[14].

According to *Renewable Energy Systems: A Smart Energy Systems Approach to the Choice and Modeling of 100% Renewable Solutions*, Denmark has aimed for particularly in wind power, and promote energy efficiency[15]. Denmark is currently pursuing policies to increase the share of renewable energy. Moreover, Denmark has set a goal of completely ending the use of fossil fuels by 2050. Also, due to the government's continued financial support and investment in the wind energy industry, Denmark is positioned as a model country for the energy transition.

According to *Short Circuiting Policy: Interest Groups and the Battle Over Clean Energy and Climate Policy in the American States*, U.S. energy policy is highly dependent on political changes[16]. For example, while the Obama administration pursued policies focused on clean energy and climate change, the Trump administration has taken a stance of supporting the fossil fuel industry and denying climate change. This is the major movement of energy transition to reduce carbon dioxide. Moreover, The Biden administration has rejoined the Paris Agreement and is actively engaged in international climate cooperation with other countries.

According to Tongia and Gross, A *Vision for a Secure and Sustainable Power System for India*, India is also contributed to energy transition movement. India is actively pursuing the transition to renewable energy amid a rapidly growing energy demand. The government is aiming for 100 GW of solar power generation capacity by 2022 through the National Solar Mission. The government is also expanding our investments in a variety of renewable energy sources, including wind, biomass, and hydropower[17].

2.3.2 Economic factors

Social factors influencing energy transition include how much people care about protecting the environment, community support for new energy projects like wind or solar power, ensuring fairness in access to clean energy, and adapting new energy technologies to local customs and traditions.

For example, Germany is cited as an example due to its significant investments in renewable energy, robust funding mechanisms, and effective market incentives which have supported its transition towards sustainable energy sources. Moreover, Germany decided to phase out nuclear energy by 2022. The United States is a large and diverse economy, and the economic factors associated with the adoption of renewable energy are significant. Investments in solar and wind power have been increasing, especially in recent years, fueling the energy transition through technological advances and economic benefits. China is a country with rapid economic growth and a surge in energy demand. The government is promoting large-scale renewable energy projects, which are having a positive impact on the domestic economy. Manufacturers of solar panels and wind turbines, in particular, are competitive in the global market.

2.3.3 Other factors (environmental, social and technological)

There are even more factors that are influencing the energy transition. For example, there are environmental, societal, and technological. The following environmental factors are availability of renewable energy sources like solar, wind, and hydropower. The following social factors are public awareness, education, and support for renewable energy. Lastly, the technological factors are advancements in renewable energy technologies, energy storage solutions, and grid infrastructure.

The article *Causes and effects of the German energy transition in the context of environmental, societal, and technological* specifically examines Germany. The study highlights Germany's efforts in transitioning to renewable energy, driven by environmental concerns, strong public support, advanced technology development, and robust governmental policies and incentives[18].

For environmental factors, the Energiewende, was designed and implemented to combat climate change. In response to climate change, Germany has significantly increased the share of renewable energy, which is reducing greenhouse gas emissions. The German government's strong environmental policies and climate goals have been a major factor in accelerating the energy transition.

For social factors, in Germany, community involvement and advocacy have played an important role in the success of the energy transition. Local communities have shown support for wind and solar projects, which has been an important factor in helping governments and businesses effectively pursue energy transition projects.

For technological factors, Germany has made great strides through intensive research and development (R&D) investments and technology deployment in solar and wind technologies. This has led to a decrease in the cost and increased efficiency of renewable energy technologies, which has further accelerated Germany's energy transition.

2.4 Review of Literature

Most existing studies analyze energy transition from the perspective of a single country, and there are few studies that divide countries into different categories and compare the feasibility of energy transition in different categories of countries from the perspective of the category.

Scholars such as Gao, by analyzing the energy transition practices of major powers such as the United States, Germany, Japan and China, have pointed out that energy transition is an arduous task that needs to be carried out under an open international perspective[19]. This study believes that energy transition is an important task that needs to be completed by the whole world, so the research in this direction should not only focus on a single country, but from the perspective of the world to explore the feasibility and development path of energy transition under the background of globalization.

3. Methodology and Analysis

3.1 Country Classification

This paper selects 17 countries based on the Energy Transition Index (ETI) and categorizes them into three groups according to their transition progress. First, we classify countries with successful transitions as Category A countries. These include Sweden, Denmark, Norway, Finland, Switzerland, and France. These six countries have consistently ranked in the top ten of the ETI in recent years, and we observe that most of the top ten countries are from the Nordic region. Category B countries are those that have made significant breakthroughs in energy transition in recent years. We ranked countries based on their ETI score growth from 2015 to 2024 and selected the top-ranking countries from different regions, including Estonia, China, United Arab Emirates, Australia, and Poland. Category C countries are those ranked in the bottom twenty of the ETI, indicating slow progress or obstacles in energy transition. In selecting the analysis objects, we excluded some very small countries and, after considering data availability, chose Iran, the Philippines, Nigeria, Bangladesh, Pakistan, and Botswana. The classification is shown in Table 1 Classification. Comparing the bottom twenty countries, we found that they mainly come from Africa and Latin America.

Table 1: Classification.

Type	Country
A	Sweden, Denmark, Norway, Finland, Switzerland, France
B	Estonia, China, United Arab Emirates, Australia, Poland
C	Iran, Philippines, Nigeria, Bangladesh, Pakistan, Botswana

By observing the ETI score trends of various countries from 2018 to 2024, shown in Figure 1 Energy Transition Index, we found that the overall ETI scores are rising. However, the scores of Iran, the Philippines, and Nigeria have declined, with significant drops for Iran and the Philippines in 2023.

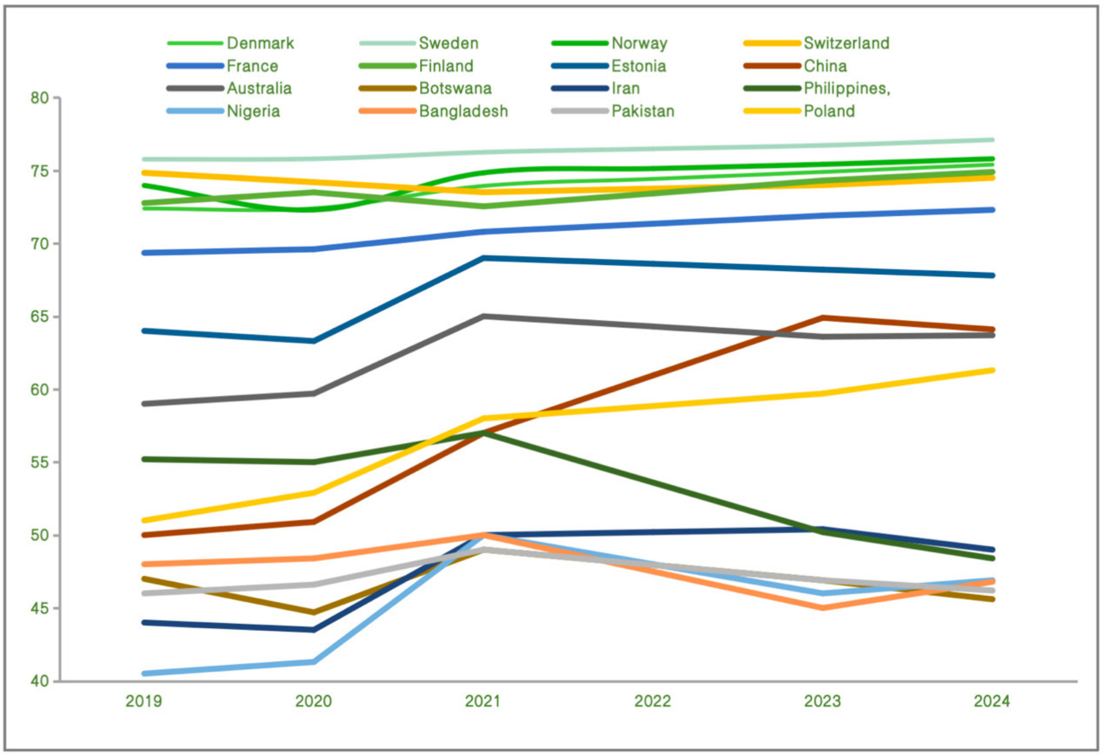

Figure 1: Energy Transition Index

3.2 Indicator Selection and Data Processing

3.2.1 Indicator Selection

Existing research often analyzes a country's energy transition process from the perspectives of policy or geographic environment. However, energy transition is influenced by multiple factors, including the country's development level, geographical conditions, and social willingness. Therefore, we selected indicators based on the PESTLE analysis method, analyzing the selected 17 countries from four aspects—environmental, social, geographical, and economic—across ten dimensions. In the environmental aspect, the indicators include the import and export of oil, natural gas, and coal, measured by whether a country is an importer of these fossil fuels. The geographical aspect includes geographical location and climate conditions. For the social aspect, we use the proportion of the labor force with a university education (referred to as the proportion of university-educated labor force) to measure the education level and whether there is government turnover and the presence of violent conflicts to measure social stability. The economic aspect is measured by GDP per capita and the Gini coefficient to assess economic development levels.

3.2.2 Data Processing

We first conducted descriptive statistical analysis on the population, proportion of university-educated labor force, GDP per capita, and Gini coefficient of the 17 countries from 2013 to 2023. According to Figure 2 GDP per capita ranking (unit: USD) , Switzerland has the highest GDP per capita, while Pakistan has the lowest. Category A countries have the highest GDP per capita, significantly higher than Category C countries. This indicates a positive correlation between GDP per capita and the ETI index. In the Gini coefficient statistics, according to Figure 3 Gini coefficient ranking (unit: %) Category A countries have significantly lower Gini coefficients than Category B and C countries, with Category C countries having slightly higher Gini coefficients than Category B countries. Since the Gini coefficient measures income inequality, we find that countries with smaller income disparities have higher ETI rankings, indicating a negative correlation between the ETI ranking and the Gini coefficient.

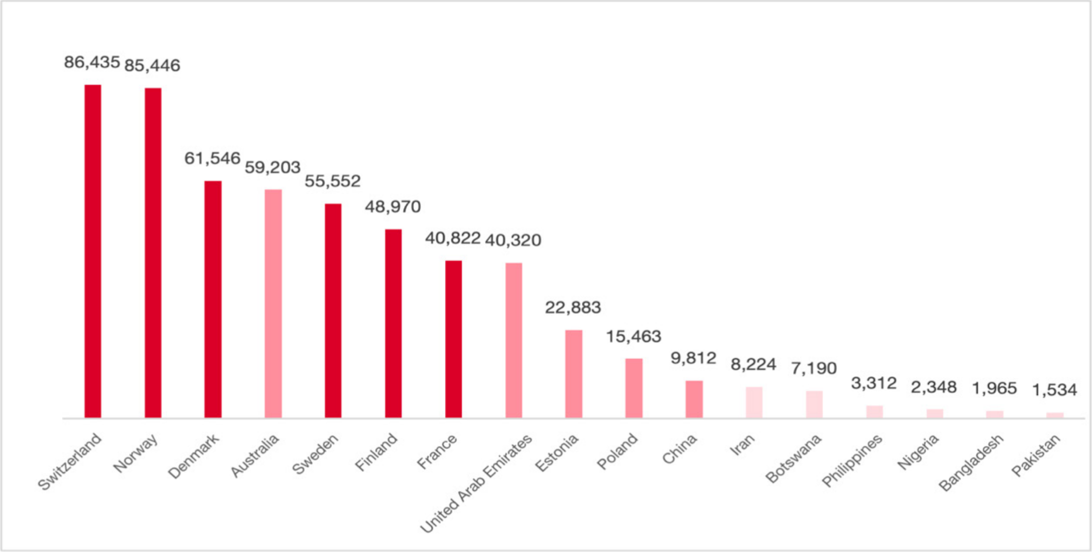

Figure 2: GDP per capita ranking (unit: USD)

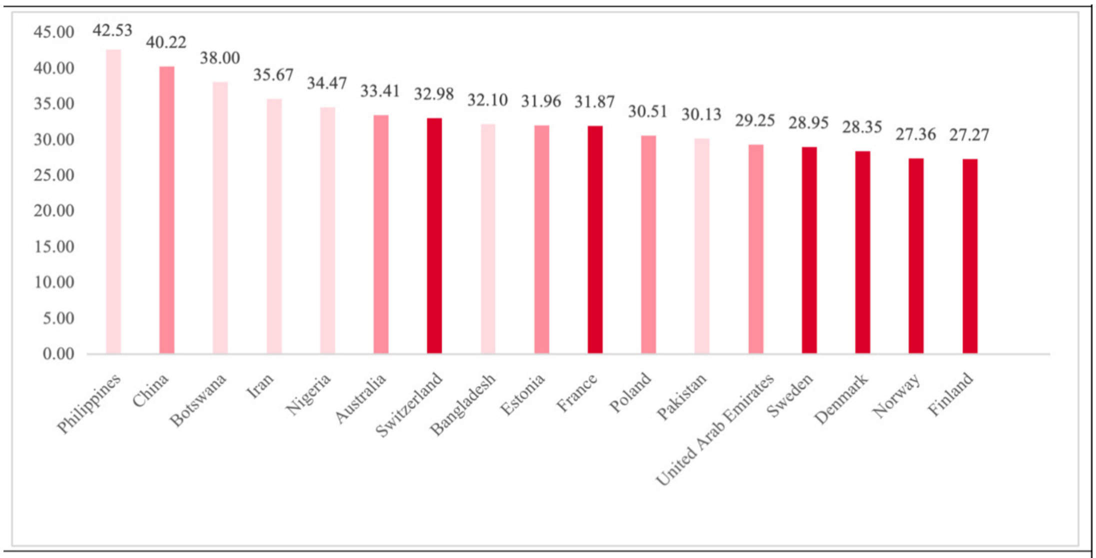

Figure 3: Gini coefficient ranking (unit: %)

Literature research shows that countries with higher education levels often have a more innovative and accepting population regarding new things. According to Figure 4 Proportion of university-educated labor force (unit: %), Category B countries have a significantly higher proportion of university-educated labor force than the other two categories, indicating that countries with notable breakthroughs in energy transition in recent years also have higher education levels. Therefore, the development of education also positively impacts energy transition, and we infer that the speed of educational development will promote energy transition.

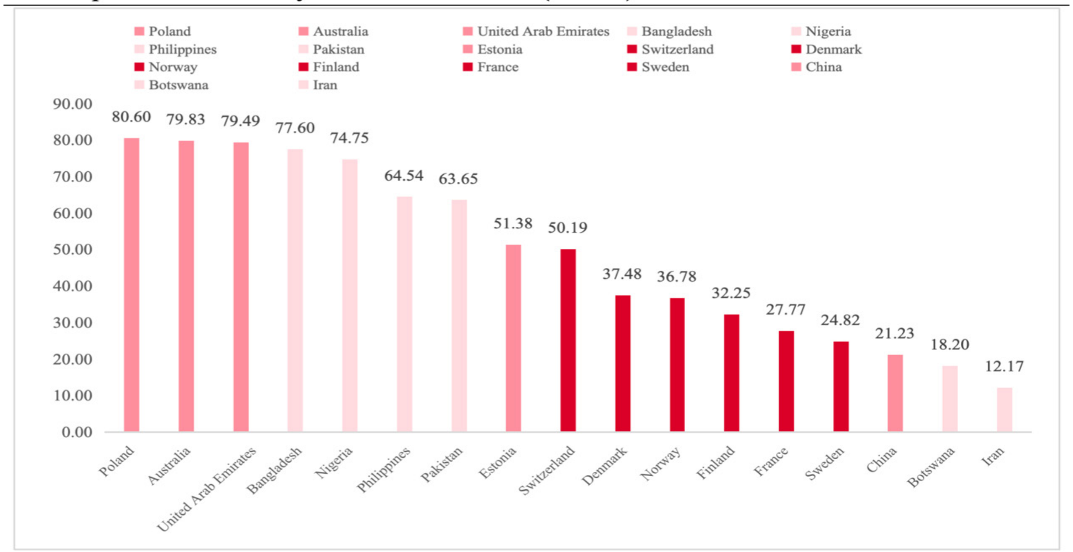

Figure 4: Proportion of university-educated labor force (unit: %)

In terms of population, as shown in the Figure 5 Population ranking (unit: thousand people) excluding China's impact due to its significantly higher population, we find that Category C countries have a larger population base. Countries with successful transitions mostly have smaller populations, indicating a negative correlation between the population base and the energy transition process.

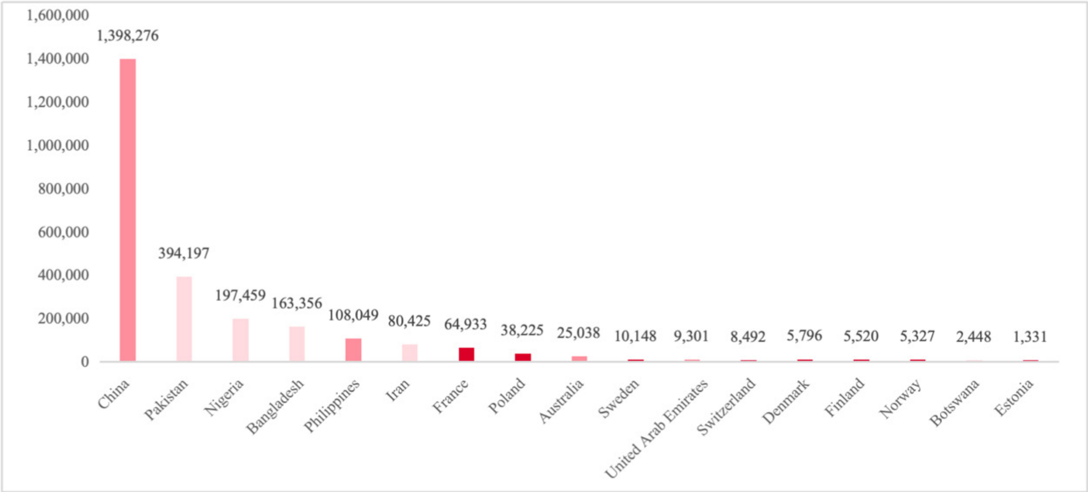

Figure 5: Population ranking (unit: thousand people)

3.3 Examination

We standardized the ten indicators for the 17 countries. The indicators were divided into three categories: data indicators, quantifiable but non-data indicators, and non-quantifiable indicators. The first category includes population size, the proportion of university-educated labor force, GDP per capita, and the Gini coefficient. The second category includes whether there is government turnover, the presence of violent conflicts, and whether the country is an importer of oil, natural gas, and coal. The third category includes geographical location and climate conditions, which were labeled but not scored.

For the data indicators, we scored population size, the proportion of university-educated labor force, GDP per capita, and the Gini coefficient on a scale of 0-6. Scores were assigned based on the ranking, with the top-ranking country receiving full marks. Subsequent countries were scored based on the proportion of their actual values to the top-ranking country's actual values. For the quantifiable but non-data indicators, we defined them as 0-1 variables, assigning 0 for the presence of violent conflicts and 1 otherwise. The same method was applied to government turnover. For the import and export of oil, coal, and natural gas, we also assigned 0-1 values, with 1 for energy importers and 0 for energy exporters. The non-quantifiable indicators were labeled but not scored.

Based on these statistical relationships, as shown in Table 2 Score, we further ranked and scored the data to verify the correlation between the indicators and the ETI. Since GDP per capita and education level are positively correlated with the ETI, we sorted these two indicators in descending order. The Gini coefficient and population are negatively correlated with the ETI, so we sorted these two indicators in ascending order. The scoring results are shown in Figure 6. The results indicate that except for the proportion of university-educated labor force, the other three indicators are positively correlated with the ETI.

Table 2: Score

Country	ETI	GDP/ Capita	Ave.	Gini	Ave.	PLC	Ave.	Popu.	Ave.	Total	Ave.
Sweden	76.3542	3.8562		5.6511		1.8479		2.1727		13.5280	
Norway	74.5767	5.9314		5.9802		2.7379		2.9989		17.6483	
Switzerland	74.1342	6.0000		4.9613		3.7365		2.3751		17.0730	
Denmark	73.9083	4.2723		5.7705		2.7900		2.8748		15.7077	
Finland	73.5742	3.3993		6.0000		2.4010		2.9459		14.7462	
France	70.8833	2.8337	4.3822	5.1339	5.5828	2.0670	2.5967	0.8589	2.3711	10.8936	14.9328
Estonia	66.8167	1.5885		5.1196		3.8251		6.0000		16.5332	
Australia	62.5500	4.1097		4.8964		5.9424		1.3832		16.3316	
China	57.9750	0.6811		4.0676		1.5801		0.1851		6.5139	
Poland	56.9583	1.0734		5.3620		6.0000		1.1195		13.5548	
United Arab Emirates	55.2333	2.7989	2.0503	5.5932	5.0078	5.9170	4.6529	2.2694	2.1914	16.5786	13.9024
Philippines	53.2333	0.2299		3.8464		4.8044		0.6659		9.5465	
Iran	47.8500	0.5709		4.5865		0.9057		0.7718		6.8348	
Bangladesh	47.6167	0.1364		5.0966		5.7767		0.5415		11.5512	
Pakistan	47.1083	0.1065		5.4292		4.7379		0.3486		10.6222	
Botswana	46.8583	0.4991		4.3053		1.3548		4.4236		10.5828	
Nigeria	45.4500	0.1630	0.2843	4.7466	4.6684	5.5642	3.8573	0.4925	1.2073	10.9664	10.0173

After excluding the influence of the proportion of university-educated labor force, as shown in Table 3 Score without PLC we re-aggregated the scores and found a greater distinction in the total scores. This further verified that GDP per capita, the Gini coefficient, and population impact the ETI, with GDP per capita having a greater impact than the Gini coefficient, which in turn has a greater impact than population size. The proportion of university-educated labor force has an insignificant effect on the ETI.

Table 3: Score without PLC

Country	ETI	GDP/ Capita	Ave.	Gini	Ave.	Popu.	Ave.	Total	Ave.
Sweden	76.3542	3.8562		5.6511		2.1727		11.6801	

Norway	74.5767	5.9314		5.9802		2.9989		14.9104	
Switzerland	74.1342	6.0000		4.9613		2.3751		13.3365	
Denmark	73.9083	4.2723		5.7705		2.8748		12.9176	
Finland	73.5742	3.3993		6.0000		2.9459		12.3453	
France	70.8833	2.8337	4.3822	5.1339	5.5828	0.8589	2.3711	8.8266	12.3361
Estonia	66.8167	1.5885		5.1196		6.0000		12.7081	
Australia	62.5500	4.1097		4.8964		1.3832		10.3893	
China	57.9750	0.6811		4.0676		0.1851		4.9338	
Poland	56.9583	1.0734		5.3620		1.1195		7.5548	
United Arab Emirates	55.2333	2.7989	2.0503	5.5932	5.0078	2.2694	2.1914	10.6615	9.2495
Philippines	53.2333	0.2299		3.8464		0.6659		4.7422	
Iran	47.8500	0.5709		4.5865		0.7718		5.9291	
Bangladesh	47.6167	0.1364		5.0966		0.5415		5.7745	
Pakistan	47.1083	0.1065		5.4292		0.3486		5.8843	
Botswana	46.8583	0.4991		4.3053		4.4236		9.2280	
Nigeria	45.4500	0.1630	0.2843	4.7466	4.6684	0.4925	1.2073	5.4021	6.1600

Next, we considered the impact of violent conflicts, government turnover, geographical location, and climate conditions. The study found that countries hindered by internal or external violent conflicts in recent years were all in Category C. Since there was no government turnover in the target countries of this study, we excluded this factor. From the perspective of geographical location, all Category A countries are Nordic countries. Category B includes countries from various regions globally, while Category C consists mainly of underdeveloped regions in Africa and Asia. Category A countries have better natural conditions and geographical locations, while Category C countries have harsher climate conditions. The results are shown in Table 4 Other factors. Therefore, we believe that geographical location and climate conditions also affect energy transition. Additionally, energy reserves impact the speed of national energy transition. We found that all Category A countries are energy importers, while energy exporters are mainly in Category C. Therefore, we believe that large energy reserves, i.e., no energy shortage or dependence on energy imports, reduce the incentive for energy transition.

Table 4: Other factors

Country	ETI	War	COG	CrucialOil	Coal	NaturalGas
Sweden	76.3542	1	1	1	1	1
Norway	74.5767	1	1	1	1	1
Switzerland	74.1342	1	1	1	1	1
Denmark	73.9083	1	1	1	1	1
Finland	73.5742	1	1	1	1	1
France	70.8833	1	1	1	1	1
Estonia	66.8167	1	1	1	1	1
Australia	62.5500	1	1	0	0	1
China	57.9750	1	1	1	1	1
Poland	56.9583	1	1	1	1	1
United Arab Emirates	55.2333	1	1	0	0	0

Philippines	53.2333	1	1	1	1	1
Iran	47.8500	0	1	0	0	0
Bangladesh	47.6167	1	1	1	1	1
Pakistan	47.1083	0	1	1	0	0
Botswana	46.8583	0	1	0	1	0
Nigeria	45.4500	1	1	1	0	0

4. Discussion

We hope to put forward some suggestions for those countries that cannot make the energy transition or encounter problems in the process of energy transition from the aspects of international mutual assistance and their own development:

Based on previous research and data analysis, countries should enhance their economic development to promote energy transition. Nations with higher per capita GDP are often more successful in achieving energy transition, with the Nordic countries serving as prime examples. For instance, countries like Switzerland and Sweden have higher per capita GDP compared to other Category B and Category C countries. This economic advantage provides these nations with more resources and capabilities to support energy transition. Their economic strength allows them to invest more easily in advanced renewable energy technologies and infrastructure, thereby accelerating the energy transition process.

Additionally, countries should implement policies to reduce income inequality. From Chart P3, it is evident that Nordic countries have significantly lower Gini coefficients compared to other nations. A lower Gini coefficient indicates more equitable income distribution and relatively low social inequality. This lower level of social inequality not only aids in maintaining social stability but also enhances public support and trust in government energy policies. Therefore, a lower Gini coefficient creates a favorable social environment for energy transition. By comparing data from Nordic countries with other Category B and Category C countries, it can be concluded that high per capita GDP and low Gini coefficients are critical factors for successful energy transition. High per capita GDP provides the necessary economic support, while low Gini coefficients help create a conducive social environment for policy implementation.

In analyzing the factors contributing to successful energy transition, it is crucial to differentiate between exogenous factors and those influenced by economic development, policies, or priority changes. Exogenous factors, such as the abundance of natural resources like solar, wind, or water, and geographical location impacting energy infrastructure construction, play a key role in the energy transition process and are difficult to change in the short term. For example, Saudi Arabia's abundant solar resources and Brazil's water resources directly influence their respective energy transition directions and implementation strategies. Economic development provides countries with the funds and resources needed for energy transition, supporting large-scale infrastructure construction and technological investments, which are essential for effectively integrating renewable energy. High levels of economic development promote innovation and technological advancements, reducing technology costs and increasing the prevalence of renewable energy.

For countries facing difficulties in energy transition, providing financial support can significantly help improve their economic infrastructure. International financial institutions, such as the Green Climate Fund, can offer financial assistance to these countries, aiding them in investing in renewable energy projects. This economic support is crucial for the success of energy transition.

Economic development is essential as it provides the resources needed for large-scale infrastructure construction and technological investment. Specifically, high levels of economic development enable a country to invest in modernizing the grid and storage technologies, which are vital for effectively integrating renewable energy. Additionally, economic development fosters innovation, driving advancements in renewable energy technologies, reducing costs, and increasing the prevalence of renewable energy. By providing financial support, the international community can help these countries strengthen their economic foundation, thereby better facilitating energy transition. Enhancing the economic base not only aids in building necessary infrastructure but also promotes overall societal development, creating a stable environment for energy transition. Therefore, economic development is a crucial driving force for achieving energy transition.

To promote the development of renewable energy, these countries can achieve their goals through establishing and implementing effective policy frameworks. Specific measures include offering financial incentives, setting long-term renewable energy targets, and optimizing policy support systems. Moreover, increasing education levels and public awareness can significantly enhance public recognition of energy transition and renewable energy. For instance, environmental campaigns can boost public support and involvement in renewable energy. Simultaneously, improving education levels can cultivate more highly educated talent, further accelerating the energy transition process through technological innovation.

Governments and other green organizations can effectively promote the development of green energy by implementing a series of incentive measures. These measures include tax incentives, financial subsidies, and other forms of economic incentives. Such policies can motivate enterprises to increase their use of renewable energy for economic benefits, thereby promoting the development of local renewable energy industries and reducing reliance on imported energy. For example, the Middle East and Africa, such as Saudi Arabia, with abundant solar resources, can accelerate the development of the solar industry with appropriate policy support, while Brazil can further develop its rich water resources to promote hydroelectric projects. These initiatives not only enhance energy self-sufficiency but also stimulate local economic development and support environmental protection.

Finally, an improvement in the economy and renewable energy incentive measures will also lead to improvements in energy infrastructure, such as investing in modern power grids to ensure renewable energy can be effectively integrated into the grid. This is also an effective way to improve energy efficiency and reliability. Investing in energy storage technologies, such as battery storage and pumped storage, in rural or remote areas can address the instability of renewable energy supply.

5. Conclusion

The primary purpose of this study was to explore the feasibility and development paths of global energy transition by analyzing the economic, geographical, social, and political characteristics of countries at various stages of the transition process. The findings highlight significant disparities between nations, with developed countries advancing more swiftly due to their economic strength and technological capabilities, while developing nations face greater obstacles. These insights emphasize the importance of tailored strategies that consider each country's unique challenges and resources to promote global energy transition.

Through reviewing existing literature, we found that current energy transition research mainly targets individual countries. This paper focuses on three categories of countries, summarizing their common characteristics to analyze their impact on energy transition, particularly the relationships between economic development, income inequality, education levels, and population size. The correlation between higher GDP per capita, lower Gini coefficients, a higher proportion of the labor force with university education, and successful energy transitions underscores the necessity of inclusive growth and equitable distribution of resources. The study data also shows that countries successful in transition are mostly energy importers, while energy exporters mainly face difficulties in transition. Additionally, violent conflicts can impede energy transition. These results advocate for policies that not only address technological advancements but also include socio-economic reforms to facilitate a more holistic approach to energy transition.

It is important to discuss other criteria that were not included. For instance, the study did not consider the influence of employment impacts, public and private investment, energy price volatility, and fiscal policies on energy transition. Government fiscal policies such as tax incentives, subsidies, and other financial incentives play a crucial role in promoting the development and adoption of renewable energy technologies. Effective fiscal measures can accelerate the energy transition process.

Furthermore, distinguishing between factors that are exogenous or fixed conditions and those that can be affected by economic development or changes in policy and priorities is essential. For example, geographical location and climate conditions are largely fixed, while economic development and government policies are adjustable and can significantly influence the pace of energy transition. Future research could explore the impact of cultural factors, the role of international cooperation in overcoming transitional barriers, and the effectiveness of various policy measures in different national contexts.

While this research provides valuable insights, it could be furthered by incorporating more comprehensive data from additional countries and exploring a wider range of influencing factors. Policymakers can utilize these findings to design more effective energy policies that consider both the economic and social dimensions of energy transition, ultimately contributing to global sustainable development goals.

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