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CONTENTS

STATOIL - OPPORTUNITIES AND THE RISK OF ENTERING NEW FOREIGN MARKETS IN THE CONTEXT OF THE ECONOMIC, POLITICAL, CULTURAL ASPECTS AND DIMENSIONS OF HOFSTEDE'S NATIONAL CULTURES

Alicja Wiącek

Abstract

Equinor (formerly Statoil) deals in the exploration, production, transport, refining and sale of crude oil and petroleum products. Recently, the oil industry has experienced the deepest crisis since at least the nineties. Despite the resignation of many important investors, it should be remembered that the population is growing, the world is also demanding energy. Therefore, despite instability in the oil market, Equinor wants to develop its operations. Of course, the company has place an emergency plan for "worse times", which is why it is developing towards renewable energy sources. It also does not cease operations at all stages from exploration to production in the oil sector. Therefore, the purpose of this work is to present new mining areas for Statoil.

Introduction

Statoil is not only the world's largest offshore operator but also a Norwegian-based energy company with operations in more than 30 countries. Since 1972 they have explored, developed and produced oil and gas on the Norwegian continental shelf, where there are a leading operator (Olsen P.I., 2000:132). From the early nineties they have built a global business, with strongholds in Europe, Africa, North America and Brazil. So much effort is put on safe and efficient operations, innovative solutions, sustainable development and technology. While providing every day energy for 170 million people, they want to extend their operations and find another countries which markets they can reach (Equinor, 2019). The oil industry heavily relies on the exploitation of water and other natural resources. Furthermore, in recent years much attention has been paid to renewable energy resources such as hydropower, solar power, wind and tidal energy. Although Statoil is highly concerned with searching for alternative resources and operating in a more sustainable way, there is no doubt that they will continue to dig up oil[*]. However, a rising global demand for oil and the fact that oil reserves are expected to last until 2071, pressures Statoil to expand its operations globally to seek for new sources of oil. To increase the area of activity, companies often use the theory of internationalization - choosing the Uppsala model or strategic approach (Fonfara, 2009). The use of these theories aims to reduce the risk associated with the bankruptcy of the enterprise. These theories are used when a company wants to enter a new "uncertain" market. This uncertainty is related to political, social or cultural problems. Managers who use the strategic structure strive to choose the best way to enter new markets. The "best way" is selected based on the assessment

[*] 15 March 2018 - Statoil, the largest Norwegian oil company, changed its name to Equinor. The reason was the idea of develop the scope of activity beyond oil and gas extraction. The rebranding costs are estimated at 230-250 million norwegian kroner. The name Equinor refer to the English words equality and equilibrium, which means equality and balance, and "nor" means the Norwegian origin of the company. The Norwegian government controls 67 percent. company. Despite this change, the this article will use the name (Fryc J., 2018).

of the given market, by analyzing the political, economic and cultural situation. Choosing the right form of internationalization leads to maximizing profits using the company's resources, reducing the risk of possible losses. Progressing globalization shows a lot of barriers, but thanks to appropriate marketing research, companies can reduce the risk and costs of failed production. For this reason, the purpose of the article will be to show a detailed analysis of the three countries that can be a good alternative to expanding activities for Statoil. The possibilities and risk of entering new markets will be presented - as two basic elements of the SWOT analysis - an analysis that is necessary when analyzing the attractiveness of a given foreign market. These factors will be analyzed based on the current political, economic and cultural situation. In order to properly analyze individual countries, an analysis of the country's work culture based on Hofstede criteria will also be presented.

The countries to be examined are Egypt, Ecuador and Kuwait. I chose this country because of the close neighbourhood of countries, where Statoil is already involved in the production and has got strong position, I mean Algeria. Algeria is largest gas producer in Africa. Libya has long been a major exporter of oil and gas, but the industry has been badly affected by political and security challenges in the country since the revolution in 2011. The Mabruk field has been shut down since an attack in 2015 but production in Murzuq resumed in the beginning of 2017. Maybe this is a good reason to enter the Egyptian market too?

The following article will present an analysis that will answer the above hypothesis. Therefore, the ultimate goal of the article is to choose a country that will reduce the risk of company bankruptcy and increase the chances of international development for Statoil.

Exact analysis of state Egypt

Starting from the general information about the country, Egypt is a lower middle income country ,an important non-OPEC (Organization of the Petroleum Exporting countries) energy producer. It has the sixth largest proved oil reserves in Africa. Over half of these reserves are offshore reserves. It is worth noting that Egypt is the second largest producer of natural gas on the continent, while Algeria ranks first. Egypt is a very important actor on international energy markets. Its important significance concerns the operation of the Suez Canal and the Suez-Mediterranean (SUMED) Pipeline. An important historical affair was the Egyptian Revolution of 2011. Its main reasons were for example unequal distribution of wealth, lack of free elections and freedom of speech, unemployment, political censorship, corruption, food price rises. After this revolution, since 2014 Egypt’s economy is on its way to recovery and become a significant and attractive place for foreign investors (O&G, 2016).

Chances in entering the market

It should be noted that, after the Revolution in 2011 Egypt is looking to get its economy back on track. Foreign investment will increasingly become the main support for the development. Egypt has planned and made different investment reforms, which can help the foreign investors to create their business there for example fuel subsidy, simplified bankruptcy proceedings, the companies' law which allow non-Egyptian investors to open their brands and companies in Egypt (Doing Business, 2018).

The next important aspect is that Egypt's economy is third largest in Africa. There is so much ways to develop it even better with good policies which ensure money flow and by different investments the economy growth in the long run will be provided. The example is Modernization Program initiated by the Egyptian ministry of petroleum. The project was created in order to unblock the potential of the country and, as a result, transform it into the Regional Oil and Gas Center. The key assumption of the project is to address the competitive and business-oriented industry. The project also assumes the improvement of the mining sector's efficiency through the introduction of new technologies and capacity building. Thanks to this project, many investors have decided to cooperate with Egypt, which in turn will contribute to the social and economic development of this country. (Tarek E.M., 2017).

The third example to increase the chances of entering this market is the fact that Egypt possess the largest refinery capacity in Africa. The Egyptian government currently updating existing refineries, while a new private-sector refinery also begins the development of its production. Egyptian investments in petrochemicals sector are planned for the next five years.

Fourthly, it should be noted that, despite the instability of oil prices on world markets, Egypt is expanding its operations by establishing cooperation with major international oil and gas companies. The number of free trade agreements and other deal is also promising. Egypt has several oil and gas pipelines, so the infrastructure is good but maybe not that modern (not environmentally sustainable).

The final aspect is the fact that Egipt located in the eastern part of North Africa. Egypt is the main point where roads connecting Europe, the Middle East, Africa and western and eastern Asia cross. Egypt is located on the Mediterranean, Red Sea and Suez Canal. Its strategic location allows the development of trade not only in Egypt but also around the world. (Arab Republic of Egypt, 2018).

Risk in entering the foreign market

The long history of late payments with EGPC is undoubtedly a challenge faced by international investors in the oil sector in Egypt. Of course, government has made efforts to encourage foreign investors to undertake cooperation in the field of exploration and development in the oil sector, trying to pay back the arrears in relation to the IOCs. Despite the will, the government still lags behind. The government has reduced arrears to USD 1.2 billion as of June 2018 and planning to repay all by end of 2019. (Halime F., 2013).

Undoubtedly, the biggest risk is political and social instability. There are some regional uncertainties for example relationship with Israel and terrorism threat. The last bombing was in January 2011 during the Egyptian Revolution.

Another difficulty is excessive bureaucracy that makes it difficult to do business as well as high-levels of corruption. If peoples salaries are not high enough and people are underpaid it affects their motivation and incentives. In order for a company to succeed, it needs both experienced and educated employees as well as well-motivated to operate and achieve the set goal. In this case, the company must provide adequate remuneration and social benefits that will positively affect the motivation of the employees. Otherwise, when employees are underestimated, they can find a different way to meet your needs. Most often they supplement their income "unofficially". Cooperation with the government and providing ideas such as tax exemptions, loans for investors has no business support, because if no one checks it, it creates further opportunities for corruption. From the other side: refusing taking a bribe sometimes can be seen as something strange by Egyptians and it might not help in building mutual trust and respect, especially businesses (Strong Ch. B., 2014: 100-101).

The last aspect is the risk resulting from economic and political instability. Egypt's natural gas production declined while the consumption increased. Natural gas discoveries have been undeveloped because the price that Egypt's government was willing to pay foreign operators for the natural gas was too low, so the companies didn't want to invest into it. The risk in this aspect is slowly getting smaller, because the awareness of the Egyptian government is increasing. In recent years, the Egyptian government has decided to change the tactics of state development by concluding agreements with foreign production operators, raising the price for natural gas.

Exact analysis of state Ecuador

Due to its geographical characteristics and its privileged situation in the planet, it is a country where it can be found one of the largest concentrations of bio-diversity in the world. In the past, the country suffered from social and economic instability, but the last decade has brought more stability. At present, the economy is dependent on oil, agriculture and money that is sent to Ecuador from workers abroad. The government of Ecuador is highly dependent on the revenues from the energy sector to support its budget and finance state projects (Energy Information Administration, 2017).

Chances in entering the market

Firstly, in Ecuador, oil is produced in the northern part of the Ecuadorian Amazon basin. There are about 1.67 billion barrels of oil under the Yasuni Reserve. In recent times, a new naphtha field has been opened, which means that the current oil production will increase from 550,000 to 570,000 barrels a day. Crude oil has been the main export of Ecuador for the last four decades and is likely to continue in the coming years. (Bustamante R., 2018).

The second opportunity to enter the market in Ecuador is that, economy is fully dollarized, which anchors inflation expectations and largely reduces transfer and currency risk. Despite this, monetary policy is limited, while the Central Bank unfortunately can not act as a lender of last resort. Liquidity in the economy depends on external surpluses, foreign investment inflows or increasing debt. These are good indicators and adequate profitability, but nevertheless, the banking system is particularly vulnerable to liquidity shocks. In this sense, the Fed's tapering will impact negatively the national banking system, credit growth and liquidity available in the economy (Euler Hermes Economic Reserch, 2016).

The important for new investors in the oil sector is that ecuadorian road network has undergone major improvements mainly because of recent investments in the country's infrastructure, supported by the introduction of road tolls. While less than 20% of the highways are paved, the Pan-American Highway forms the backbone of the country's road network, linking all the major highland towns and cities from north to south. Other major routes are the Spondylus Route and Ruta del Sol (along the Ecuadorian coastline) and the Amazon backbone (crossing north to south along the Ecuadorian Amazon). In the Oriente Region the road system is least developed and serves almost exclusively the needs of the local oil industry. The network's biggest problem has always been the weather, with floods and landslides both being common, knocking out roads for weeks at Times (Factsheet, 2018).

The last important fact is that GDP per capita and social indicators have improved significantly over the past years. GDP is one of the basic measures of national income. GDP is the aggregate (total) sum of final goods and services produced in a given country within a certain period of time (most often a year). The only criterion is the place of production of goods, the origin of capital is irrelevant. In 2016, GDP per capita in Ecuador amounted to around 6,046.3 U.S. dollars. Statistics show that in 2020, GDP will be 6,426.5 (The Statistics Portal - Ecuador, 2012).

Risk in entering the foreign market

The first risk of entering the market is slow economic growth due to the lower-than-desired crude prices to numerous corruption investigations incriminating government officials. Crude oil is in many ways crucial to Ecuador's economic prosperity . Dependence on oil production and high vulnerability to global oil prices. The economy is very dependent on oil, this is why Ecuador broke the OPEC quotas last year. "There's a need for funds for the fiscal treasury, hence we've taken the decision to gradually increase output" (Perez C., 2017). Quotas were established to support oil prices and deal with oil oversupply. Oil accounts for around 30% of government revenues.

In Statoil goals there is also written about changing people's lives in the countries which market they are entering, so maybe the good solution here is to provide better development policies, cooperation with local investors to not only dig for oil but also to make Ecuadorians life better. This country needs very broad reforms may be difficult and not beneficial to enter, but for sure can very beneficial for Statoil's image.

Secondly, Ecuador has a big problem with bribes, corruption, even the former hydrocarbon minister took bribes in exchange of grating state contracts. It is also worth mentioning that - 4 Januar 2019, the President of Ecuador, Lenin Moreno said that about half of the $ 4.9 billion intended for the five infrastructure projects related to oil was associated with corruption (Pipoli R., 2019). Developing smart technology by international companies which have got more money to invest can help. It can be for example the use of online platforms for checking the government' s interactions with civil society and the business community. It can be successful in different areas for example: tax collection, public procurement, and red tape(too much bureaucracy). If this would cost too much, establishing the international legal framework for corruption control can be an option for which the government can be open for because it is not that costly (having a reform is not that costly, but checking if people follow it-it is) (Business Anti, 2016).

Thirdly, almost half of the reserves are in the environmentally very valuable region in the Yasuni National Park. Even if the country would like to increase or maintain the production almost half of its estimated reserves are in the most biologically diverse natural parks, the Yasuni National Park. President Lenin Moreno is backtracking on a promise to protect the Amazon. So here is the risk: if the Statoil wants to be perceived as a environmental friendly company drilling in this territory would ruin the company's reputation (Ramirez Chiriboga J.I., 2014).

The next fact is that 80 percent of oil production is now in the state's hands. Hydrocarbon resources are exclusively owned by the state, and Ecuador limits foreign investment in the oil sector. Foreign oil and natural gas companies are allowed to enter into service contracts that offer a fixed per-barrel fee for their exploration and production activities. The move away from production-sharing agreements to service contracts has increased the government's share of revenue and state oil production.

Exact analysis of state Kuwait

Kuwait is a very small country, rich in raw materials, located on the top of the Persian Gulf. Kuwait is one of the richest countries in the world, thanks to enormous oil reserves. This country is strategically located, because in the neighborhood there are powerful neighbors such as: Saudi Arabia, Iraq and Iran. A country, in distinguish from its powerful neighbours have got very open politics system and pro-western stance. The main vision of the can be perceived as full of independence and openness, but the major religion in Kuwait is Islam, so any criticism about Koran, The Muslims and The main emir is prohibited (Baker J.A.).

Chances in entering the market

One of the most important elements that affects the ability to enter new markets is the political stability of a given country. Since its independence in 1961, Kuwait maintained strong international relations with most countries, especially nations within the Arab world. Its huge oil reserves gives it a prominent voice in global economic forums and organizations like the OPEC. Regionally, Kuwait has a unique foreign policy that is characterized by neutrality. The country is in very good and stable political situation, has got very good relation with other countries. In essence, Kuwait's foreign policy is based on the principles of clarity, straightforwardness and quiet diplomacy. It aims at strengthening constructive cooperation with other countries on the basis of mutual respect, and non-intervention in the internal affairs in accordance with the principles of fairness and justice. Kuwait's foreign policy is also concerned with the maintenance of its own independence, sovereignty and freedom of political decision. It is Oasis of peace and safety in this turbulent region (Naser M., 2017).

Secondly, Kuwait has an abundant oil resource. From 1930s the discovery of massive oil reserves revolutionises the country's economy. Kuwait's oil reserves are the fourth largest in the world. Kuwait is the world's eleventh largest oil producer and seventh largest exporter. This country's oil production accounts for 7% of world-wide oil production. Since the government of Kuwait owns the oil industry, it controls a lot of the country's economy. Kuwait's oil exports depends on internal needs and from the economical point of view from an international demand and prices, production quotas fixed by the OPEC, of which Kuwait is a member. Oil will last for another 88 years. Gas reserves have a life time of over 100 years (Craig A., 2018).

Then, it should be emphasized that Kuwait, as well as other countries which economies are based on oil felt the sharp drop in oil prices in 2014. It has turned the fiscal balance from years of huge surpluses, to large deficits. That's why the newest development plans includes spending US$116 billion on energy and infrastructure projects and strengthening of the role of the private sector.

Fourthly, attention should be paid to the authorities good reaction during the crisis. Despite the global financial crisis, the authorities have managed to maintain financial stability[†]. Of course, there have been negative effects of the global crisis such as the decline in oil prices and production. The crisis also influenced reduction investors' confidence and triggered a steep fall in real estate. The current financial stability is due to the appropriate reaction of the authorities during the crisis. The authorities implemented strong measures in the banking system (International Monetary Fund –Kuwait, 2010).

The last factor that increases the probability of success of Statoil in Kuwait is the fact that the authorities invest in urban infrastructure. The government invested large portions of oil revenues in infrastructure and urban development, creating in the process a modern metropolis. This investment also presents the positive activity of the authorities for the development of the country.

Risk in entering the foreign market

The first risk is the unfavorable location of the Kuwait state. Kuwait is situated in a section of one of the driest, least-hospitable deserts on earth. Generally flat and undulating with low hills and shallow depressions. The climate is dessert, that's why there are high temperatures in the summer (app.44 degrees Celsius). Unfortunately, this is a factor that nobody can influence.

Another negative factor is high degree of public ownership and control of oil and gas sectors results in a generally weak private sector. The country remains too closed to foreign investment because of its laws restrictions to the establishment of non-citizens - the purchasing shares of a publicly traded companies by private investors or working with the local sponsors/business partners with a 51-49% split in favour of the Kuwaiti partner. From 2015 there is a law which excludes foreign investments from extraction of crude petroleum and natural gas. This law was enacted after oil prices dropped in 2014. The government wants to have more diversified economy. So if there will be no partner for cooperation entering this location might be impossible.

The last fact is that over the last years OPEC strongly fights for determining quotas for oil extraction, due to world's oil oversupply and environmental problems (Capeotway Associates, 2016). For countries which are rich in oil it is difficult to enforce it, because the companies

[†] The global financial crisis, which took place from mid-2007 to mid-2009. Crisis contributed to large turmoil on stock exchanges, which improved after two years of decline. As a direct cause of the global financial crisis, from the middle of 2007, the favorable situation on the mortgage market has been assumed. These were subprime loans, or loans with higher risk, which were provided by US banks (Terazi E., Şenel S.).

usually want to extract more oil and gas and in that way just earn more money. Kuwait as well as other countries have been accused of violating them. In main opinion it is a very big risk. If the oil extraction in this country is already very high there could be no place and no possibility for other companies to join and make profits (Yergin D., 1991). The solution for that can be co-partnership with local agents. Statoil, following the company's goals can provide environmentally sustainable technology and modern solutions for oil extraction and in that way have rights to extract oil. This business opportunity is really good especially that in the very close neighbourhood is United Arab Emirates, where Statoil already works and extract oil. Being that close to Kuwait can make entering its market easier.

Characteristics of Egypt, Ecuador and Kuwait work culture based on Hofstede framework

Interculturality in running a business refers to different areas and does not end with negotiations and signing a contract. Many problems appear already in the implementation phase of the project. Sometimes the difficulties in intercultural communication or the reading of statements and inaccurate asking questions leads to problems with the implementation of the contract and, as a result, to the problems of the company as a whole. We must also remember about cultural sensitivity when planning a marketing strategy. Ignorance may, in fact, undermine the chance of making investments, hence it seems necessary to prepare for functioning in an intercultural environment. It should be noted that in many countries, entrepreneurs receive state aid in acquiring foreign markets in the form of intercultural preparation for foreign operations. Companies conducting international business and contacts with representatives of other cultures are exposed to cultural shock and difficulties in understanding the other side. The following aspects of the impact of cultural dimensions on the nature of business negotiations indicate how programming the mind of the partners influences their behavior, way of thinking and perception.

In today's management of organizations, the role of organizational culture is a very important element. Hofstede and other scientists describe national culture as a "collective programming of the mind" of specific nationalities and people who have a specific national character, representing the cultural programming of their minds. In the connection of the presentation of three countries in which Statoil can develop its activity, the analysis of Hofsted's dimensions is a key element (Hofstede G., Hofstede G.J., Minkov M., 2010).

The first dimension is power distance. Egypt scores high on this dimension score of 70, while Ecuador achieved the 78 result in the PDI ranking[‡]. Kuwait achieves high marks in this dimension, up to 90 points. All three countries have the same characteristics in this dimension and characterized by a paternalistic style of decision making, which is based on the fact that an employee or subordinate is afraid to present a different opinion from the superior, and is happy to

[‡] PDI is an indicator of the distance of strength, which is credited to the Dutch social psychologist Geert Hofstede. It is an indicator measuring the distribution of power and wealth among people in business, culture or nation. (Andrijauskienė M., Dumčiuvienė D., 2017)

accept and implement decisions taken by the superior. Inequality in this matter is generally acceptable and even desirable.

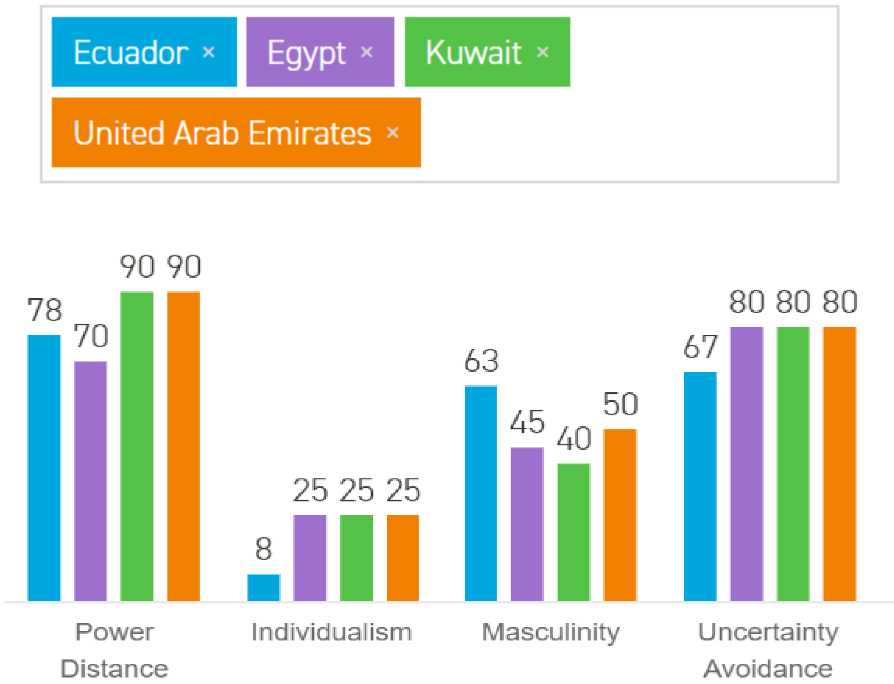
The next dimension is Individualism. Egypt and Kuwait have the same number in this dimension - score of 25. Ecuador, on the other hand, is considered the most collectivist culture in the world because it scores is 8. All these countries are characterized by a collectivist culture. These dimensions refer to the group that characterizes is a manifest in a close-term commitment to the 'group'. Relations between the employer and the employee are perceived in moral terms and resemble family ties, and decisions regarding employment and promotion depend on the group membership of employees.

The third dimension is masculinity. Egypt scores 45 on this dimension. Kuwait scored 40, while Ecuador scored 63 points. These results mean that countries considered a relatively feminine society. Women's culture underlines the importance of good relations and mutual cooperation and undertaking charity work. Feeling safe and being a parent is seen as very important. In women's culture, failure is treated as an ordinary case, not as a personal failure, as in the case of male culture. Caring and tenderness and showing weaknesses are not perceived negatively. At the political level, universalist prosperity, assuming the pursuit of democracy, support and help for all, and care for the environment are ideal. Disputes are resolved through negotiation and compromise.

A very important dimension is Uncertainty Avoidance. Egypt scores 80 on this dimension. Kuwait has gained the same dimension as Egypt, whereas, Ecuador has a score of 67. These countries are characterized by a high preference for avoiding uncertainty. Cultures with a high level of this indicator refrain from taking risks and are reluctant to use new methods, preferring tried and tested methods and solutions. Proper life uncertainty is perceived as a constant threat that must be fought. This causes a high level of stress and anxiety. Society has a strong need to capture everything in the framework of laws and regulations and to take time and thought with hard work. However, these activities are based on the pursuit of building a sense of security, recognition and belonging (Khashman N., 2014).

The chart below compares countries that can open development opportunities for Statoil. In addition, the United Arab Emirates have been presented. This dependence is the result of Statoil already operating in the United Arab Emirates. Kuweit and Egypt are in close proximity to the Emirates and have similar results in Hofsted's dimensions, which is why the possibilities for entry into new markets by Statoil are much larger. The company has already been researching interculturality and has experience in the development of activities in countries with such culture.

Chart no. 1 Comparison of countries based on Hofstede dimensions



Source: Hofstede - Insights, Country Comparison. https://www.hofstede-insights.com/country-comparison/ecuador,egypt,kuwait,the-united-arab-emirates/ (access: 24.01.2019)

Conclusions on the basis of the above analysis of three countries

Each company needs a good organizational structure to enter new markets. Competences and resources are integrated in and across business units. This is one of most effective way to gain benefits from specialization of labour. It makes it possible to concentrate on the concrete tasks and coordinate the activities of departments. Effective cooperation can reduce costs and improves quality. In order for Statoil to be successful in new markets, it needs smart hiring practices.

The countries analyzed above are characterized by problems related to corruption. One of the solutions that Statoil can apply in such a situation is hiring local people. If Statoil will be treats employees appropriately and provide them with social, medical and financial care, he can get rid of the problem of corruption. Another important element is cooperation with local governments. In politically unstable countries, adequate diplomacy and good communication with the authorities of the country are the best solution. Good relations with local authorities will also allow you to bring to the market the new technology. Statoil prioritize caring about environment, using "cleaner" technology. If Statoil wants to maintain a good corporate image, it must adapt its management to local requirements.

Countries that I have chosen are similar to each other if it comes to working culture, that's why I need a structure that provides high uncertainty avoidance, and employees always know who should they ask for help. Also very important is to have a person from Norway in the representatives (in every country)to spread Statoil's culture and values. It must be people who had previous entrepreneurship, so they must be quite experienced. They should know what to expect and know how to deal with problems.

In Kuwait, when the merge with the local company must be done, the structure can be very difficult to describe because it depends on how the local Kuwait company structure looks like. From the cultural description I can only suspect, that it can be something hierarchical (high power distance dimension) and strictly controlled (low individualism) by the government and other units. This market is really hard to enter and closed for investors, but as I mentioned before, they are kind of willing to work with somebody stronger than they so it is not impossible. Cooperation is possible only by investments, technology and know-how. Norwegians engineers have got very high level solutions in technology, which can be interesting for Kuwait's partners.

The problem here is that Kuwait technology is also in very high standard so the Norwegians technology solutions should be very innovative All in all cooperation between best can be quite beneficial for both on the sides. So it is something new in Equinor market's entering. In the company's vision and philosophy it is written that the company wants to have a continuous development, so here is a way to realize it. For Equinor very important is balance between the need to ensure a secure and cost-efficient supply of energy and to reduce carbon emissions. Technology and innovation are key to solving these challenges. Maybe this is the right way to cooperate with Kuwait.

Summary

A really important step in the company's development was changing a name to Equinor. Company wants to increase and follow the newest project and trends connected with renewable energy. Projects aim is to reduce emissions from oil and gas production, and projects that will provide more energy to meet the world's increasing energy needs. "We're taking great steps to lessen our footprint. If a company is to succeed over time, it must adapt at least as fast as its surroundings. Equinor is no exception, and we're now taking great steps to further develop the company from a focused oil and gas company to a broad energy major" (Equinor, 2018).

I analyzed three countries in which Statoil is not involved into production. It is Egypt, Kuwait and Ecuador. There are some similarities between them for example: their economy strongly depends on oil, in Egypt and Ecuador investments and modernization have to be done. Kuwait s quite risky country to enter, the same as Ecuador, but in my opinion there are not so many countries now in the world which are not entered by Equinor but have great opportunities for investing in oil. It wasn't my goal to choose three similar countries. My very first idea was to choose countries quite safe, politically stable, with abundant oil resources and strong economy, which are in the close neighbourhood to the countries, where Statoil is already involved into production. But after my research I didn't find proper ones. I think that these 3 that I finally choose are quite good for making oil business, but I had lots of doubts about Ecuador. State-owned companies account for most of the oil production. Solution is working for example with Petroecuador, the national oil company of Ecuador and provide up to date technologies. Ecuador must change the energy policy. There are fields not yet leased and lying outside the rainforest. I chose Ecuador because it has a very strong neighbor. It is Brazil. Equinor has a strong position in Brazil and it is seen as a core area for long-term growth. But I think that entering this market is very risky. There is not as much oil left as in other countries, lots of investments and modernization have to be done. As for Kuwait, it could be very good country for having an oil business, this closed economy is not that well affected. However, it is worth remembering that when entering this market, you must comply with local laws and regulations. This market is characterized by a lack of confidence in new investors, therefore building business relationships takes time. Of course, it is worth pointing out that building these relations "works both ways". After negative experiences related to the Northern Oil Fields project and the well-known Petrochemical problem of KDow, there is also a reluctance of cooperation on the part of international investors.

The analysis showed that Egypt is a very open country to foreign investment and has a much better situation in which it is now after the Egyptian Revolution from 2011. If Egypt wants to follow Statoil in caring about environment Egypt must invest in the technology that will limit the pollutions while digging for oil. Statoil has a very developed strategy for the protection of nature. "Always safe, high value, low carbon. We are committed to long-term value creation in a low carbon future" (Equinor, 2018).

The analysis of the three countries presented above, in which Statoil can expand its activity, confirmed my opinion that the best country for the company's development is Egypt. Despite the possible risks, the analysis ultimately shows that entering this market can be very beneficial. Therefore, I confirm the hypothesis presented in the introduction.

Bibliography

1. Andrijauskienė M., Dumčiuvienė D., *Hofstede's cultural dimensions and national innovation level*, 2017.
2. Arab Republic of Egypt - Ministry of Petroleum, *Investment Elements*, http://www.petroleum.gov.eg/en/Investment/InvestmentElements/Pages/default.aspx [access: 04.01.2019].
3. Baker J.A., *The political, economic, social, cultural and religious trends in the Middle East and the gulf and their impact on energy supply, security and pricing*. Institute for Public Policy of Rice University, http://large.stanford.edu/publications/coal/references/baker/studies/tme/docs/TrendsinMiddleEast_MainStudy.pdf [access: 17.01.2019].
4. Business Anti - Corruption Portal, *Ecuador Corruption Report*, 2016, https://www.business-anti-corruption.com/country-profiles/ecuador/ [access: 10.01.2019].
5. Bustamante R., *Oil Regulation*, Ecuador, 2018, https://gettingthedealthrough.com/area/24/jurisdiction/32/oil-regulation-ecuador/ [access: 10.01.2019].
6. Capeotway Associates, *The Global Oil Market*, 2016, https://www.energy.gov.au/sites/g/files/net3411/f/the-global-oil-market-a-review-paper-2016.pdf [access: 17.01.2019].
7. Craig A., *World's Top 10 Oil Exporters*, 2018, https://www.investopedia.com/articles/company-insights/082316/worlds-top-10-oil-exporters.asp [access: 17.01.2019].
8. Diagnostic tool, https://globaledge.msu.edu/tools-and-data/diagnostic-tools [access: 08.01.2019].
9. Doing Business 2018 - *A World Bank Group Flagship Report*, http://www.doingbusiness.org/content/dam/doingBusiness/media/Annual-Repor [access: 04.01.2019].

10. Equinor, *Information about an international energy company*, https://www.equinor.com/en/about-us.html [access: 03.01.2019].
11. Euler Hermes Economic Reserch, *Country Report Ecuadro*, 2016, http://www.eulerhermes.us/economic-research/Documents/ecuador-country-report-dec16.pdf [access: 10.01.2019].
12. Factsheet: Urban Mobility Challenges in Ecuador and Quito, https://www.sutp.org/files/contents/documents/News/Factsheet-Ecuador-ENG.pdf [access: 10.01.2019].
13. Fonfara K., Istota u zakres procesu interacjonalizacji firmy [w:] *Zachowania przedsiębiorstw w procesie interancjonalizacji. Podejście sieciowe*, PWE, Warszawa 2009.
14. Fryc J., *Statoil chce zmienić nazwę na Equinor*, https://businessinsider.com.pl/wiadomosci/statoil-chce-zmienic-nazwe-na-equinor/9lj0d44 [access: 03.01.2019].
15. Halime F., *Egypt's Biggest Oil Debts*, June, 2013, http://rebeleconomy.com/tag/egpc/ [access: 08.01.2019].
16. Hofstede - Insights, *Country Comparison* https://www.hofstede-insights.com/country-comparison/ecuador,egypt,kuwait,the-united-arab-emirates/ [access: 24.01.2019]
17. Hofstede G., Hofstede G.J., Minkov M., *Cultures and Organizations: Software of Mind*, Mc Graw–Hill, USA, 2010.
18. International Monetary Fund, *Kuwait: Financial System Stability Assessment—Update*, 2010, https://www.imf.org/external/pubs/ft/scr/2010/cr10239.pdf [access: 17.01.2019].
19. Khashman N., *Investigating the Application of Hofstede's Model of Cultural Dimensions to Arabic Web Interfaces*, McGill University, 2014, http://digitool.library.mcgill.ca/webclient/StreamGate?folder_id=0&dvs=1547763828018~86 [access: 17.01.2019].
20. Naser M., *Kuwait's Foreign Policy towards Regional Issues in the Middle East from 2003 to 2014.* Faculty of Economics and Political Science, Cairo University, Egypt 2017, https://www.researchgate.net/publication/320718473_Kuwait's_Foreign_Policy_towards_Regional_Issues_in_the_Middle_East_from_2003_to_2014 [access: 17.01.2019].
21. O&G - *World Oil and Gas Review 2016*, https://www.eni.com/docs/en_IT/enicom/company/fuel-cafe/WOGR-2016.pdf [access: 03.01.2019].
22. Olsen P.I., *Transforming Economies: The Case of the Norwegian Electricity Market Reform*, Nordberg 2000.
23. Perez C., Ecuador's Oil Minister, television, [in]: Markets Insider, *TSX May Ride Oil Prices Higher - Canadian Commentary,* 2017. https://markets.businessinsider.com/news/stocks/tsx-may-ride-oil-prices-higher-canadian-commentary-1002182567 [access: 10.01.2019].
24. Pipoli R., UPI - Energy News, *Ecuador audit finds $2.5B lost in oil infrastructure corruption,* 2019, https://www.upi.com/Ecuador-audit-finds-25B-lost-in-oil-infrastructure-corruption/9981546603653/ [access: 10.01.2019].
25. Ramirez Chiriboga J.I., *The environmental impact of humans in yasuni national park - Ecuador*, 2014, http://repositorio.educacionsuperior.gob.ec/bitstream/28000/3250/1/T-SENESCYT-00896.pdf [access: 10.01.2019].
26. Strong Ch. B., *The Oil and Gas Law Review*, [in]: Eissa R., Haggag A., *EGYPT (Anti-corruption) - Chapter 8*, November 2014, http://www.sharkawylaw.com/wp content/uploads/2015/02/Oil-AndGasReview.pdf [access: 08.01.2019].
27. Tarek E.M. - Minister of Petroleum and Mineral Resources, *Egypt Oil and Gas Sector: Strategies and Action Plans*, May, 2017.

28. Terazi E., Şenel S., *The Effects of the Global Financial Crisis on the Central and Eastern European Union Countries*, International Journal of Business and Social Science, http://www.ijbssnet.com/journals/Vol_2_No_17/25.pdf [access: 17.01.2019].
29. U.S. Energy Information Administration, *Country Analysis Brief: Ecuador*, 2017, https://www.eia.gov/beta/international/analysis_includes/countries_long/Ecuador/Ecuador.pdf [access: 10.01.2019].
30. Yergin D. *The Epic Quest for Oil, Money and Power, Simon and Schuster*, London 1991.

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ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH: A VAR MODEL FOR THE NEW ECONOMY OF PAKISTAN

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Abstract

The economy of Pakistan had always been plunged due to its severe electricity shortages over the last two decades and persistently faces challenges in revamping its electricity supply network. The China Pakistan Economic Corridor (CPEC) is considered as a productive shock which has opened up new avenues for the energy sector in Pakistan. This study is an endeavor to incorporate the impact of such shock in the production function and to revisit the dynamics between electricity consumption and economic growth (ECEG) in the new economy of Pakistan for the time span of 1971-2018. The study has employed Vector Autoregression (VAR) model, including capital formation, labor participation, openness of the economy and financial development. The findings of the study affirmed the neutrality hypothesis while cointegration estimates jagged long run effectiveness for ECEG nexus. Keeping in view the internal and external bottlenecks, it is thus recommended to revise the ECEG model for the new economy of Pakistan keeping in view the revival of industrial sector removing the inefficiencies of the power sector.

Keywords: Electricity Consumption, Economic Growth, CPEC, VAR Model.

Introduction

Background of the Study

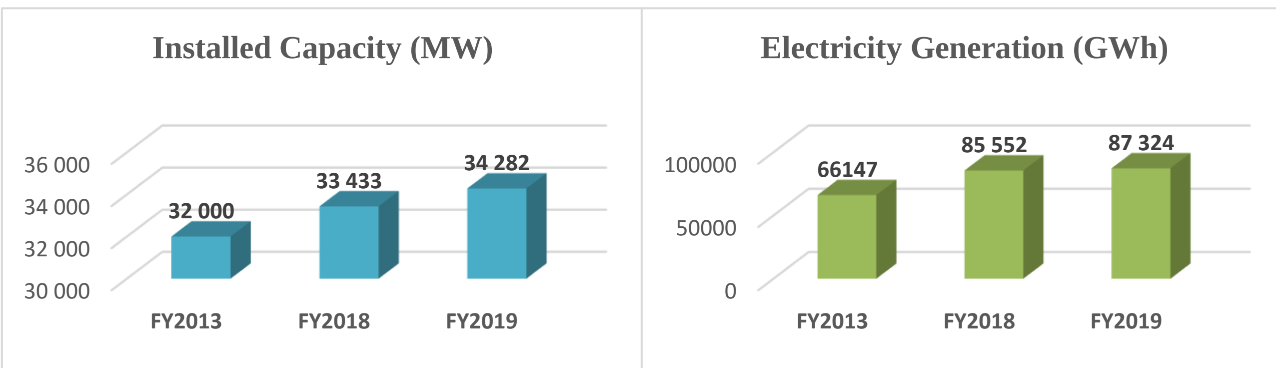
It is a well-established fact that economists of contemporary era are more concerned to explore the dynamics of energy economics due to its increasing demand and supply gaps. These gaps are alarming not only for economic activities but also in the globalization process. Hence, the conventional theory has not enough to say about the association between energy and economic growth. This could be the reason that a comprehensive model of growth incorporating energy as main determinant is missing in economic theory. Turning to the plausible explanation of this gap in theory, it could be attributed to various reasons. First, economists argued that energy is an essential input for growth and development while its consumption is supposed to play a preventive role as other inputs may perform well without energy (Razzaqi, Bilquees, & Sherbaz, 2011). Second, the growth of the energy sector relies on the economic structure of the economy under consideration which may or may not be taken into account in recent years. Despite, energy economists decline these arguments based on the differences at the micro and macro level as economic processes require different methods (direct and indirect) of production. Intuitively, this conflict opens up a wide range of macroeconomic parameters to be included in the energy-growth model.

The economy of Pakistan had been plunged due to its severe electricity shortages over the last two decades and thus persistently faces a significant challenge in revamping its network responsible for the supply of electricity (Nawaz, Iqbal, & Anwar, 2013). This in turn had created a huge gap in demand and supply of electricity showing inability of the electricity sector to meet the demand for the growth of the emerging economy of Pakistan. The China, Pakistan Economic Corridor (CPEC) is considered as a productive shock which has opened up new avenues for the energy sector as it endowed a major segment of its investment in the generation of electricity in Pakistan. According to Pakistan Economic Survey (PES) 2018-19, Pakistan has successfully detached bottlenecks of the electricity generation after the completion of the early harvest stage, during last tenure. This demands a comprehensive assessment of the electricity sector, specifically in lieu of the inauguration of CPEC.

Overview of Electricity Sector in Pakistan

This section provides a brief overview of the electricity sector in Pakistan through the lenses of installed capacity and electricity generation. Figure 1 presents the comparison between the two in Pakistan from Fiscal year (FY) 2013 to 2019. The figure provides a glimpse that installed capacity of Pakistan has been persistently increasing since 2013 while showing a growth of 2.5 percent in the given time period.

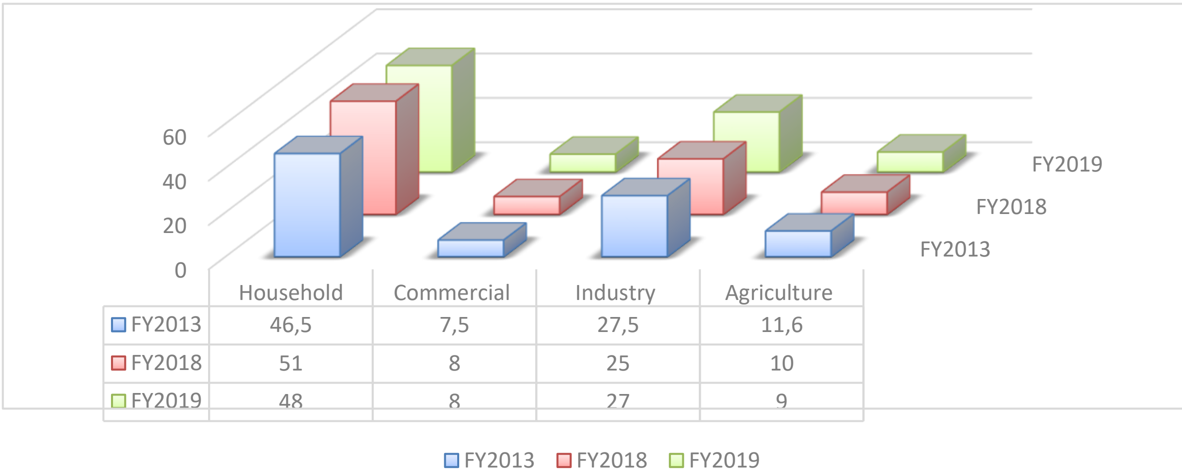
Figure 1: Comparison between Installed Capacity and Electricity Generation



Source: Ministry of Energy, Hydrocarbon Development Institute of Pakistan (HDIP)

Furthermore, the electricity generation varies from year to year and showed a surge in generation from 66 Gegawatt hours (GWh) to 87 Gwh in last few years (2013-19), however, this trend has not been assertively transmuted in electricity consumption. This could be due to the reliance of electricity sector on input inaccessibility, financial constraints and low performance of Generation Companies (GENCOs) of the public sector (PES, 2018-19).

Figure 2: Percentage Distribution of Electricity Consumption



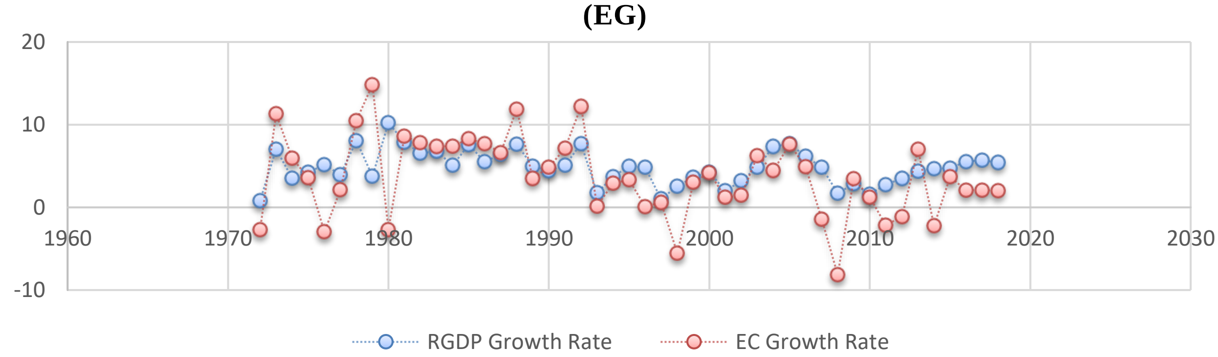
Source: Hydrocarbon Development Institute of Pakistan (HDIP); Pakistan Economic Survey, 2018-19

Turning to the consumption of the generated electricity, the segmentation reveals a significant deviation in the electricity consumption by its buyers from 2013-2019. In the preceding year, there was a decreasing trend in electricity consumption of household and agriculture sector due to consumer rationalization and enhancement in electricity tariffs. A slightly positive trend had also been observed in the industrial sector pointing a revival of deteriorating industrial sector, despite, household segment is yet a major consumer (PES, 2018-19).

Trends in Electricity Consumption (EC) and Economic Growth (EG)

The electricity consumption and economic growth (ECEG) nexus has been widely discussed in the literature due to its supposed prominence in determining the growth patterns of the economy. Figure 3 elucidates trends in electricity consumption (EC) and economic growth (EG) of Pakistan.

Figure 3: Trends in Electricity Consumption (EC) and Economic Growth (EG)



Considering the growth rates, it is well evident that there is an inconsistent link between electricity consumption and real gross domestic product (GDP) from 1970s to 1980s due to inefficient and ineffective policy measures (Zeeshan & Ahmed, 2013). Besides, after 1980s and at the end of 1990s, the trend was steady while in later years a variation had been notified. It can be concluded that ECEG data are found to be symmetric for initial years while it showed a little irregularity in the late few years. The probable clarification for this pattern is the process of rapid urbanization, industrialization and electrification in rural areas had experienced an inducement effect on overall demand of electricity (Nawaz et al. 2013). The incompatibility of energy policy making with the growth policies of the economy was also a prominent factor.

Contemporarily, the electricity sector of Pakistan is going through structural and institutional changes, this study is an endeavor to revisit the ECEG model in the context of new economy of Pakistan with few innovations. First, the ECEG model has been revisited bringing the insight of the high - volume shock of CPEC in the power sector. For this reason, we have applied the Vector Autoregression (VAR) model with a divergent set of control variables. The stability of the variables to such shocks has been tested and evaluated through the Impulse Response Function (IRF) and Variance Decomposition (VDC) methods. The findings of the study are integrated with the internal and external bottlenecks with discussion on the power sector reforms of the new economy of Pakistan.

Literature Review

The energy-based literature was pioneered with the study by Berndt and Wood (1975) as the authors observed the energy consumption and associated its substitution with labor and complementarity with capital in the industrial processing. In an extended study with the same data, Griffin and Gregory (1976) contradicted the complementarity of capital with energy consumption. Turning to the development of econometric methods, the study of Kraft and Kraft (1978) had been extensively quoted as inventive in the ECEG literature. Since then, continuing efforts were made to investigate the ECEG model featuring different countries subjected to the objectives of the respective studies. Table 1 provides a compilation of different studies in panels to figure out the gist of the existing literature. This has assessed to segregate the studies in different panels and meanwhile to figure out the gap in the national literature.

Table 1: Compilation of Studies on EGEC Nexus

S.No.	Author (s) & Year of Publication	Country (s)	Data	Methodology	Findings
Panel I: Aggregate Compilation					
1	Yasar (2017)	Panel of 119 economies	1970-2015	Panel ARDL & Granger Causality	EC →EG
2	Omay (2014)	G7 economies	977-2007	Exponential Smooth Transition (ESTAR) model & Panel VECM	EC →EG

3	Dogan (2014)	Sab-Sahara African economies	1971-2011	Johansen Cointegration	EC →EG
4	Razzaqi et al. (2011)	D8 (Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan & Turkey)	1980-2007	VEC Modeling & VAR Granger Causality	EC →EG (Iran & Nigeria) EG →EC (Bangladesh, Egypt, Malaysia, Pakistan & Turkey) Neutral (Indonesia)
5	Apergis & Payne (2010)	OECD economies	1985-2005	Panel Cointegration & ECM	Bidirectional Causality between EC & EG
6	Lee & Chang (2008)	16 Asian economies	1971-2002	Panel Cointegration & Causality	EC →EG (long-run only)
7	Akinlo (2008)	11 Sab-Sahara African economies	1980-2003	Panel ARDL, Granger Causality & VECM	Bi-directional (Gambia, Ghana and Senegal) EG →EC (Sudan and Zimbabwe) Neutral (Cameroon and Cote D'Ivoire) No causality (Nigeria, Kenya & Togo)
8	Mehrara (2007)	11 selected oil exporting economies	1971-2002	Panel Cointegration	EG →EC
9	Asafu-Adjaye (2000)	India, Indonesia, Philippines & Thailand	Unbalanced Panel data 1973-1995 (India & Indonesia), 1971-95 (Thailand and Philippines)	Cointegration & ECM	EC →EG (India & Indonesia) Bi-directional (Thailand & Philippines)
10	Soytas & Sari (2003)	G-7 economies	Unbalanced Panel data	Granger Causality & ECM	Neutrality
Panel II: Disaggregate Compilation (International Studies)					
11	Khan et al. (2018)	Kazakhstan	1991-2014	ARDL Bound Testing & VECM Granger Causality	EC →EG
12	Shahbaz et al. (2017)	India	1960Q1–2015Q4	Non-Linear Autoregressive Distributed Lag (NARDL)	EC →EG (Asymmetric causality due to negative shocks only)
13	Solarin et al. (2016)	Angola	1971-2012	ARDL, Granger Causality & VECM	EC →EG
14	Pempetzoglou (2014)	Turkey	1945-2006	Linear Granger Causality Test & Nonparametric	EG →EC

				Diks-Panchenko Causality Test	
15	Kasperowicz (2014)	Poland	2000-2012	Granger Causality Test	EC →EG EG →EC
16	To et al. 2012	Australia	1970-2011	Bound Testing Cointegration & Multivariate Granger Causality	EC →EG (Direct yet weak link between EC & EG)
17	Shahbaz et al. (2011)	Portugal	1971-2009	ARDL, Unrestricted Error Correction Model (UECM), VECM	Bi-directional causality between EC & EG
18	Odhiambo (2010)	Kenya	1972-2006	Cointegration & ECM	EC →EG
	Zang & Cheng (2009)	China	1960-2007	Causality, Generalized Impulse Response	EG →EC
19	Odhiambo (2009)	Tanzania	1971-2006	ARDL Bounds Testing & Causality	EC →EG (Long –run causality between EC &EG)
20	Altinay & Karagol (2005)	Turkey	1950-2000	Granger Causality & VAR	EC →EG
21	Paul & Bhattacharya (2004)	India	1950-1996	Engle-Granger Cointegration & Granger	EG →EC (Engle-Granger) EC →EG (Granger)
Panel III: Disaggregate Compilation (National Studies)					
22	Nadeem & Munir (2016)	Pakistan	1972- 2014	ARDL Bound Testing & Granger Causality	Long run causality between EG and EG
23	**Zeshan & Ahmed (2013)**	Pakistan	1971-2012	Structural Vector Auto-regression (SVAR)	Instable model of EC and EG
24	**Nawaz et al. (2013)**	Pakistan	1971-2012	Smooth Transition Autoregressive (STAR)	Long-run association between EG and EC
25	**Shahbaz & Lean (2012)**	Pakistan	1972-2009	ARDL Bounds Testing, Granger Causality, VECM Granger Causality	Bi-directional causality between EC & EG
26	**Shahbaz & Feridun (2012)**	Pakistan	1971-2008	ARDL & To-daYamamoto	EG →EC (Long span causality)

				and Wald-test causality	
27	**Atif & Siddiqui (2010)**	Pakistan	1971-2007	Engle & Granger Cointegration Tests	EC →EG
28	**Aqeel & Butt (2001)**	Pakistan	1956-1996	Cointegration &Hsiao's version of Granger Causality	EG →EC

Panel I show that aggregate studies revolved around exploring the causal associations between the core variables of EC and EG. These studies were supposed to provide sophisticated findings and thus the scholars preferred panel Auto Regressive Distributed Lag (ARDL), Vector Error Correction Model (VECM) and cointegration analyses. The studies of Yasar (2017), Omay (2014), Dogan (2014), Lee and Chang (2008); and Asafu-Adjaye (2000) ended up on on-way causality running from EC to EG. Akinlo (2008) and; Apergis and Payne (2010) found a two-causality using same econometric methods while Mehrara (2007) explored an evidence of conservative hypothesis for ECEG model given the selected samples of economies. Additionally, Razzaqi et al. (2011) quoted country-specific causalities in the panel of D8 economies and; Soytas and Sari (2003) found the neutrality evidence. It is pertinent to mention here that there is a limited literature on ECEG nexus for South Asian economies pointing a research gap in the literature. Turning to the time trend analyses in panel II, it consists of huge literate that discusses all three main hypotheses focusing the ECEG nexus. The hypothesis of growth were recently affirmed by Khan et al. (2018), Solarin et al. (2016), To et al. (2012); and Odhiambo (2010, 2009) for the economies of Kazakhstan, Angola, Australia, Kenya and Tanzania respectively. Further, Zang and Cheng (2009) explored conservative causality for China while Shahbaz et al. (2011) disclosed two-way causality for Portugal. On a concluding note for trend studies, scholars continued to explore the nexus through different model specifications, providing diverging findings even for same economies. For instance, Shahbaz et al. (2017) indicated a one-way causality from electricity consumption to economic growth in the economy of India employing the non-linear estimation technique. The author also pointed an asymmetry in the model due to negative shocks in the economy, denying the possibility of reverse causality. Contrary to this, Paul & Bhattacharya (2004) already declared two-way causality favoring the feedback hypothesis of ECEG in India using two different Granger techniques of causality. Additionally, Pempetzoglou (2014) and Altinay and Karagol (2005) quoted causalities in a different direction for the economy of Turkey.

Starting from the national study of Nadeem and Munir (2016) in panel III, the ARDL estimation provided a recent declaration favoring the ECEG association (long run) for the time span of 1972-2014. Shahbaz and Lean (2012) also developed the same dynamic model of ARDL and elucidated a bi-directional ECEG causality. In the same year, Shahbaz and Feridun (2012) developed the ECEG model for a different time span and concluded a reverse causality between the two core variables. Atif & Siddiqui (2010) found a one-way causality while Aqeel and Butt (2001) ended up on reverse causality from EC to EG. Contrary to the literature on ECEG perspective, there is recently a turn in national studies from traditional causality analyses to more impressive yet sophisticated econometric applications and findings. In this regard, Zeshan and Ahmed (2013) applied the SVAR for the time period of 1971-2012 and found an instable ECEG model. The authors stressed-on enhancement of energy inputs to facilitate capital stock in consonance with more labor utilization. Correspondingly, Nawaz et al. (2013) explored the traditional long run perspective with the STAR model and further explored insensitivity of electricity consumption to prices and associated it with lack of electricity alternatives.

In the nutshell, there exist extensive studies capturing the causal associations and dynamics of ECEG nexus at both aggregate and disaggregate level. Further, there are variations in the findings due to multifarious data spans, econometric applications and analyses. Besides, national studies are now more inclined towards assimilating the issues of electricity sector with the advanced econometric techniques.

Methodology

Data

We have extracted six variables from the extensive literature on the ECEG linkage in order to maintain the compliance of the study. The data has been collected from both national and international data sources for the time span of 1971-2018. The variables of the VAR model include electricity consumption (EC), economic growth (EG), capital formation (KF), labor participation (LP), openness of economy (OE) and financial development (FD). The details of the variable in the model with proxies, units of measurement and sources of the data have been presented through table A1 in appendix A.

Unit Root Tests

The VAR model requires a stationarity test of all the variables included in the estimation. Thus, non-stationary series must be aptly transmuted prior to the model estimation to avoid spurious regressions and distortions in the model (Stock and Watson, 1989; Nelson & Plosser, 1982). Therefore, the traditional econometric procedure of Augmented Dickey Fuller (ADF) has been followed opting the Akaike Information Criterion (AIC) considering the intercept and trends.

Vector Autoregression (VAR) Model

The study has employed a VAR model to examine the contemporaneous outcomes of variables on each other (Ulrichs, 2018). This model is frequently used to predict multivariate system of time series and to analyze the dynamic yet random nature of the disturbance terms of the system. The VAR treats all variables in the model as endogenous and meanwhile it does not restrict to execute prior margins on structural connotations among variables (Soytas, Sari, & Ozdamir, 2001). As a result, doing so would allow to presume that deviations in particular indicator are linked to its lagged values and meanwhile to changes in other variables and their respective lagged values. Besides, VAR expresses exploratory variables in the form of lagged values (pre-determined); so here we represent the following reduced expression of the model;

$$y_t = c + \sum_{i=1}^{n} \varphi_i \, y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(\mathbf{1})$$

Where;
$y_t = Vector\ of\ all\ variables\ (n\text{x}1)$
c = Intercept vector of VAR $(c_1, \ldots.., c_5)$
$\varphi_i = ith\ matrix\ Autoregressive\ coefficients \qquad For\ I = 1,2,3, \ldots.., p$
and;
$\varepsilon_t = generalization\ of\ white\ noise\ process\ (\boldsymbol{\varepsilon_t}, \ldots\ldots, \boldsymbol{\varepsilon_{nt}})$

Equation 1 can also be transformed into the following Moving Average (MA) form (equation 2) in order to perform analysis of responses of variables in the system to shocks;

$$y_t = \mu + \sum_{i=0}^{\infty} \gamma_i \varepsilon_{t-i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(\mathbf{2})$$

Where, $\gamma_i$denotes identity matrix and μ shows the mean of the process.

On the whole, the illustration of VAR enables to explain a one-unit change in innovations on the variables of the system under consideration. Additionally, the MA form of VAR assesses to generate the forecasts (error variance) through IRF and VDC as both are employed to observe the nominal as well as the real significance of shocks.

VAR Stability Test

The stability test is a pre-requisite assesses to decide that whether the VAR model under consideration would be feasible or not. This implies that all the roots of the circle must lie within the range of the circle and modulus roots must be necessarily less than 1(Asmah, 2013).

VAR Lag Selection Criteria

The VAR selection criteria essentially describe the dynamic features of the model more precisely given the possibility of long lag lengths (Kilian & Lutkepohl, 2017). Whereas, scholars usually prefer to avoid long lags due to decrease in degrees of freedom. Practically, the lag length of VAR is calculated through various selection criterion with a rule of thumb of adopting the specific lag selected by maximum information criterion.

VAR Granger Causality/Block Exogeneity Tests

The data analysis proceeds with employing VAR Granger Causality tests to elucidate the causality in short span determining dynamic perspective appropriately (Sargent, 1977). The test has been applied to check the running between economic growth and electricity consumption and among other variables, given the fact that these may have or may not have effective consequences.

Impulse Response Function (IRF)

After the estimation of VAR, the efficacy of the model will be tested through applying the Impulse Response Function (IRF). The IRF signifies the mechanism through which any certain shock (positive or negative) exhibits spread over time. It has cointegrated arrangements and meanwhile considered essential in terms of forecasting (Hoffman & Rasche, 1996).The IRF predicts that if the shock declines to zero, then the system equations are considered as stable, showing short span converge of variable into its long-term value. Contrary to this, an unstable system would produce a volatile time path away from zero and value will diverge from its short run estimates.

Variance Decomposition (VDC)

The Variance Decomposition (VDC) of the VAR model traces out the proportion of forecast which shows variance in one variable explained by innovations that arise due to itself or due to other variables (Asmah, 2013). Hence, VDC measures the relative importance of fluctuations (nominal or real) in variables under consideration through Choleski Decomposition Method.

Cointegration Test and VECM

Engle and Granger (1987) pointed that if long term cointegration exists between two variables, then there would be a possibility of causality (one way or two way) among the variables. In this regard, VECM is applied to detect the controversial direction of ECEG causality. The VECM forms of the model are given below;

$$\Delta LOGEG_t = \beta_0 + \sum_{j=1}^{M} \beta_{1j}\, \Delta LOGEG_{t-j} + \sum_{j=1}^{N} \beta_{2j}\, \Delta EC_{t-j} + \sum_{j=1}^{0} \beta_{3j}\, \Delta KF_{t-j} + \sum_{j=1}^{P} \beta_{4j}\, \Delta LP_{t-j} + \sum_{j=1}^{Q} \beta_{5j}\, \Delta OE_{t-j} + \sum_{j=1}^{R} \beta_{6j}\, \Delta FD_{t-j} + \alpha E_{t-1} + \mu_t \quad \ldots\ldots (\mathbf{3})$$

$$\Delta EC_t = \delta_0 + \sum_{j=1}^{M} \delta_{1j}\, \Delta EC_{t-1} + \sum_{j=1}^{N} \delta_{2j}\, \Delta LOGEG_{t-1} + \sum_{j=1}^{O} \delta_{3j}\, \Delta KF_{t-j} + \sum_{j=1}^{P} \delta_{4j}\, \Delta LP_{t-j} + \sum_{j=1}^{Q} \delta_{5j}\, \Delta OE_{t-j} + \sum_{j=1}^{R} \delta_{6j}\, \Delta FD_{t-j} + \alpha E_{t-1} + \mu_{2t} \quad \ldots\ldots (\mathbf{4})$$

$$\Delta KF_t = \gamma_0 + \sum_{j=1}^{M} \gamma_{1j}\, \Delta KF_{t-1} + \sum_{j=1}^{N} \gamma_{2j}\, \Delta LOGEG_{t-1} + \sum_{j=1}^{O} \gamma_{3j}\, \Delta EC_{t-j} + \sum_{j=1}^{P} \gamma_{4j}\, \Delta LP_{t-j} + \sum_{j=1}^{Q} \gamma_{5j}\, \Delta OE_{t-j} + \sum_{j=1}^{R} \gamma_{6j}\, \Delta FD_{t-j} + +\alpha E_{t-1} + \mu_{3t} \quad \ldots\ldots (\mathbf{5})$$

$$\Delta LP_t = \rho_0 + \sum_{j=1}^{M} \rho_{1j}\, \Delta LP_{t-1} + \sum_{j=1}^{N} \rho_{2j}\, \Delta LOGEG_{t-1} + \sum_{j=1}^{O} \rho_{3j}\, \Delta EC_{t-j} + \sum_{j=1}^{P} \rho_{4j}\, \Delta KF_{t-j} + \sum_{j=1}^{Q} \rho_{5j}\, \Delta OE_{t-j} + \sum_{j=1}^{R} \rho_{6j}\, \Delta FD_{t-j} + \alpha E_{t-1} + \mu_{4t} \quad \ldots\ldots (\mathbf{6})$$

$$\Delta OE_t = \sigma_0 + \sum_{j=1}^{M} \sigma_{1j}\, \Delta OE_{t-1} + \sum_{j=1}^{N} \sigma_{2j}\, \Delta LOGEG_{t-1} + \sum_{j=1}^{O} \sigma_{3j}\, \Delta EC_{t-j} + \sum_{j=1}^{P} \sigma_{4j}\, \Delta KF_{t-j} + \sum_{j=1}^{Q} \sigma_{5j}\, \Delta LP_{t-j} + \sum_{j=1}^{R} \sigma_{6j}\, \Delta FD_{t-j} + \alpha E_{t-1} + \mu_{5t} \quad \ldots\ldots (\mathbf{7})$$

$$\Delta FD_t = \alpha_0 + \sum_{j=1}^{M} \alpha_{1j}\, \Delta FD_{t-1} + \sum_{j=1}^{N} \alpha_{2j}\, \Delta LOGEG_{t-1} + \sum_{j=1}^{O} \alpha_{3j}\, \Delta EC_{t-j} + \sum_{j=1}^{P} \alpha_{4j}\, \Delta KF_{t-j} + \sum_{j=1}^{Q} \alpha_{5j}\, \Delta LP_{t-j} + \sum_{j=1}^{R} \alpha_{6j}\, \Delta OE_{t-j} + \alpha E_{t-1} + \mu_{6t} \quad \ldots\ldots (\mathbf{8})$$

Where E_{t-1} represents respective error term, Δ is the first difference and; μ_s are serially uncorrelated random error terms while superscript of the operators shows optimal lag lengths employed in equations.

Estimation Results

It is pertinent to mention here that all estimations have been done through the EViews software (10). It is well elucidated in the table that all variables have been trended and meanwhile are stationary.

Table 2: ADF Unit Root Test

Variables	I(0)		I(1)	
	t-value	p-value	t-value	p-value
LOG(EG)	-1.637231	0.7624	-5.579437	0.0002
EC	-1.467863	0.8266	-6.016301	0.0000
KF	-2.260768	0.4462	-5.245996	0.0005
LP	-3.851361	0.0223	-7.512569	0.0000
OE	-2.352025	0.3989	-5.820766	0.0001
FD	-5.600013	0.0002	-6.625072	0.0000

Table 3 endorses that all values of root's modulus are less than 1 implying that the VAR model of this study satisfies the criteria of stability.

Table 3: VAR Stability Check

Variables	Root	Modulus
EG	0.858703	0.858703
EC	0.431760 - 0.058947i	0.435765
KF	0.431760 + 0.058947i	0.435765
LP	-0.190032 - 0.182683i	0.263601
OE	-0.190032 + 0.182683i	0.263601
FD	0.136289	0.136289

The ADF test statistics and proof of stability check criteria of the VAR model affirm that time series under consideration are stationary (Fang, Jia, Tu, & Sun, 2017). Meanwhile, the Inverse Roots of AR characteristic Polynomial also showed that no root lies outside the circle. Table 4 reveals a lag order selection of the VAR model through divergent selection criterion.

Table 4: Lag Selection for VAR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1359.202	NA	3.59e+19	62.05466	62.29796*	62.14488
1	-1291.402	114.0282*	8.60e+18*	60.60918*	62.31227	61.24077*
2	-1269.011	31.55051	1.75e+19	61.22778	64.39067	62.40073
3	-1226.431	48.38627	1.68e+19	60.92870	65.55137	62.64301

Notes:
* = Lag order selected by the criterion
LR = LR: Sequential Modified LR test statistic (each test at 5% level)
FPE = Final Prediction Error
AIC = Akaike Information Criterion
SC = Schwarz Information Criterion
HQ = Hannan-Quinn Information Criterion

As per the maximum selection criterion (LR, FPE, AIC and HQ), the study opted for regressions with one lag. Therefore, LR, FPE, AIC and HQ has been selected. After justifying the model, VAR parameters have been calculated and are shown in table 5. The table explains VAR parameters, and their respective coefficients of the standard deviation with t-statistics.

Table 5: Coefficient Estimations of VAR

	D(LOG(EG))	D(EC)	D(KF)	LP	D(OE)	FD
D(LOG(EG(-1)))	0.210851	152.1824	11.76159	8.998483	1.81E+10	-19.84304
	(0.16792)	(113.517)	(8.97857)	(10.6485)	(2.7E+10)	(27.3913)
	[1.25568]	[1.34061]	[1.30996]	[0.84505]	[0.67231]	[0.72443]
D(EC(-1))	0.000206	-0.010206	0.010647	-0.015603	1.46E+08	0.048455
	(0.00026)	(0.17789)	(0.01407)	(0.01669)	(4.2E+07)	(0.04292)
	[0.78470]	[-0.05737]	[0.75671]	[-0.93507]	[3.45570]	[1.12886]
D(KF(-1))	-9.05E-05	1.549617	0.183879	0.136201	7.43E+08	0.983690
	(0.00307)	(2.07472)	(0.16410)	(0.19462)	(4.9E+08)	(0.50062)
	[-0.02948]	[0.74690]	[1.12054]	[0.69983]	[1.51168]	[1.96494]
LP(-1)	0.001134	-1.867940	0.073879	0.394256	-5.78E+08	0.030883
	(0.00231)	(1.55966)	(0.12336)	(0.14630)	(3.7E+08)	(0.37634)
	[0.49165]	[-1.19766]	[0.59889]	[2.69477]	[-1.56440]	[0.08206]
D(OE(-1))	7.54E-15	-6.17E-10	-3.87E-11	-3.86E-12	-0.233909	1.35E-10
	(9.9E-13)	(6.7E-10)	(5.3E-11)	(6.3E-11)	(0.15850)	(1.6E-10)
	[0.00761]	[-0.92112]	[-0.73055]	[-0.06154]	[-1.47575]	[0.83621]
FD(-1)	-0.000521	-0.086446	-0.037950	0.089676	2.36E+08	0.933578
	(0.00057)	(0.38542)	(0.03048)	(0.03615)	(9.1E+07)	(0.09300)
	[-0.91463]	[-0.22429]	[-1.24490]	[2.48038]	[2.58335]	[10.0385]
C	0.027653	59.85839	-0.941870	13.04452	5.39E+09	2.666420
	(0.06072)	(41.0509)	(3.24688)	(3.85078)	(9.7E+09)	(9.90542)
	[0.45539]	[1.45815]	[-0.29008]	[3.38750]	[0.55478]	[0.26919]
R-squared	0.133068	0.154367	0.208368	0.421211	0.379349	0.797104
Adj. R-squared	-0.000306	0.024270	0.086579	0.332166	0.283864	0.765890

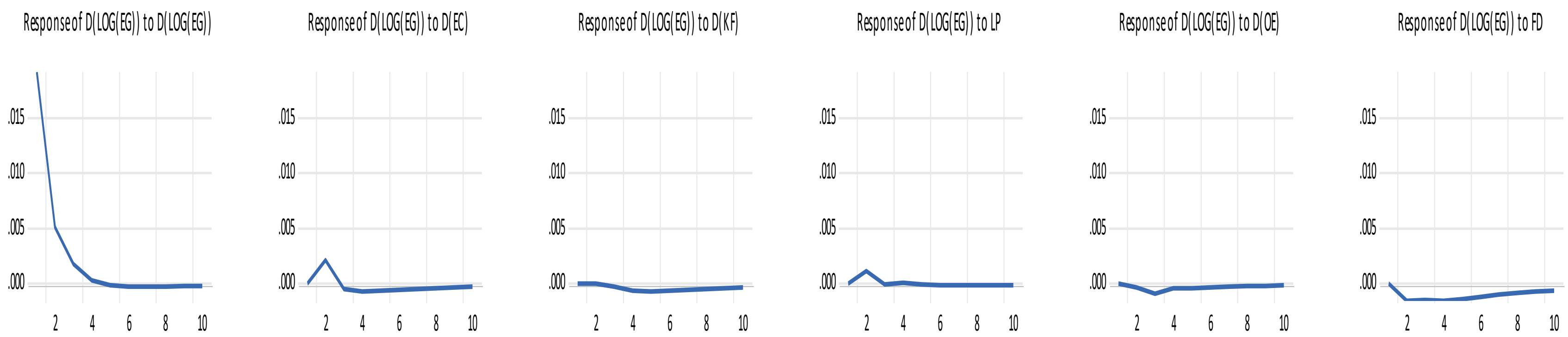
The causality of the variables in table 6 shows the acceptance of neutrality hypothesis between EC and EG. The same is true for the causality running from EG to EC. This finding is compatible with the findings of Sehrawat et al. (2015), Asghar (2008) and Soytas and Sari (2003). This could be due to the two prime factors in the context of Pakistan. First, the traditional energy conservative policies of Pakistan are found unsuccessful in determining the economic growth (Shahbaz et al. 2012). Second, the severe power outages and slow industrial growth had surged shut downs of productive industrial and commercial units, increasing unemployment. This in turn enhanced the process of deindustrialization over the last two decades (Yasmeen & Qamar, 2013).

The outcomes of VAR causality showed a deviation from the existing wide-ranging literature that assured one- or two-way causality between EC and EG. There is also a weak evidence of causality in the short run among other variables except of one-way causality between LP and FD; and between EC and OE. These reasonable findings suggest that there is still a need to introduce comprehensive policy measures in Pakistan interlinking the energy, growth, trade and financial development for sustainable growth (Khan, Jam, Shahbaz, & Mamun, 2018).

Table 6: VAR Granger Causality/Block Exogeneity Tests

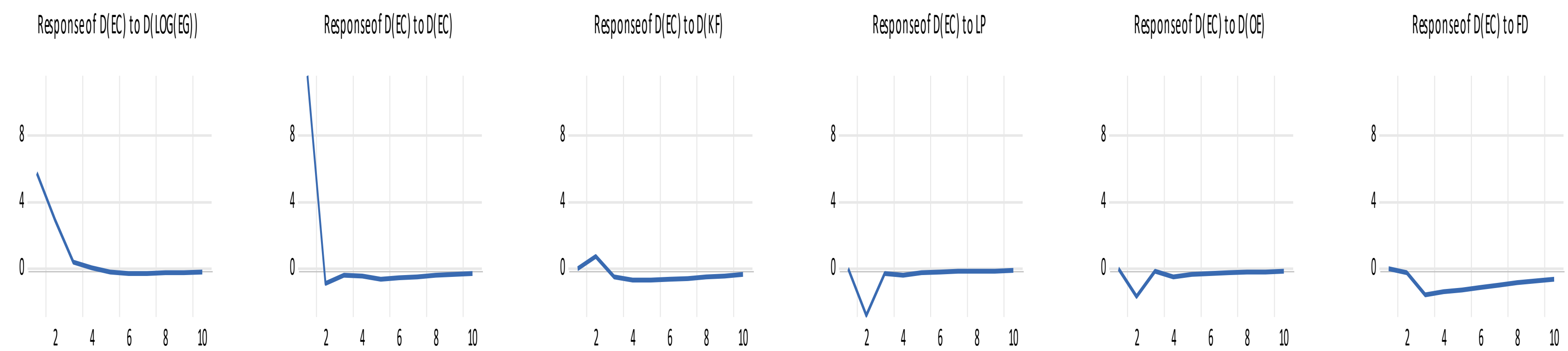
Excluded	Chi-squ.	Prob.	Neutrality Hypothesis
Dependent Variable: D(LOG(EG))			
D(EC)	0.615761	0.4326	Accepted
D(KF)	0.000869	0.9765	Accepted
LP	0.241719	0.6230	Accepted
D(OE)	5.79E-05	0.9939	Accepted
FD	0.836548	0.3604	Accepted
Dependent Variable: D(EC)			
D(LOG(EG))	1.797229	0.1800	Accepted
D(KF)	0.557867	0.4551	Accepted
LP	1.434390	0.2310	Accepted
D(OE)	0.848467	0.3570	Accepted
FD	0.050307	0.8225	Accepted
Dependent Variable: D(KF)			
D(LOG(EG))	1.716003	0.1902	Accepted
D(EC)	0.572604	0.4492	Accepted
LP	0.358667	0.5492	Accepted
D(OE)	0.533701	0.4651	Accepted
FD	1.549769	0.2132	Accepted
Dependent Variable: LP			
D(LOG(EG))	0.714102	0.3981	Accepted
D(EC)	0.874356	0.3498	Accepted
D(KF)	0.489768	0.4840	Accepted
D(OE)	0.003787	0.9509	Accepted
FD	6.152281	0.0131	Rejected
Dependent Variable: D(OE)			
D(LOG(EG))	0.451994	0.5014	Accepted
D(EC)	11.94188	0.0005	Rejected
D(KF)	2.285191	0.1306	Accepted
LP	2.447350	0.1177	Accepted
FD	6.673699	0.0098	Accepted
Dependent Variable: FD			
D(LOG(EG))	0.524795	0.4688	Accepted
D(EC)	1.274320	0.2590	Accepted
D(KF)	3.860976	0.0494	Accepted
LP	0.006734	0.9346	Accepted
D(OE)	0.699242	0.4030	Accepted

Figure 4: Response of EG to Cholesky one S.D (d.f adjusted) Innovations



Note: Generated from Eviews Software

Figure 5: Response of EC to Cholesky one S.D (d.f adjusted) Innovations



Note: Generated from Eviews Software

Figure 4 and 5 displays the impulse response functions of the EC and EG to one standard deviation structural shocks. The first graph in figure 4 shows that the response of EG to its own shocks is contemporaneously positive and strong for initial periods and approache zero at the end of the period. The response of EG to a shock in EC shows no impact in initial periods while the response will converge over the time horizons. This is also consistent with the causality outcomes of this study. Besides, the response of EG to the shock in KF; and LP are found stable while FD and OE have displayed slightly negative deviation from its stability. The IRF of the EC in figure 5 positively responds to its own shocks in its initial periods and latterly negative response and movement towards stability is observed. The response of EC for EG has a positive movement in initial periods with slight negative effect in subsequent periods, however, the IRF converges to its stability at the end periods. Additionally, KF is less responsive while LP, OE, and FD have experienced negative yet stable responses.

The results of the VDC estimates of the endogenous variable of EG from VAR are presented in table 7 at various quarters. The exercise explained that that the percentage of variance explained by own shock for EG originated from 97 percent in the second quarter and continues decreasing up to 92 percent in the 10th period.

Table 7: VDC of EG from VAR

Period	S.E.	D(LOG(EG))	D(EC)	D(KF)	LP	D(OE)	FD
1	0.020245	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.021193	96.98096	1.344841	0.064293	0.162351	0.193793	1.253762
3	0.021450	95.29003	1.417780	0.102306	0.167342	0.635900	2.386645
4	0.021629	93.73059	1.750607	0.226358	0.167110	0.750222	3.375113
5	0.021741	92.76686	1.919948	0.345221	0.168370	0.829665	3.969939
6	0.021810	92.19126	2.052733	0.418965	0.169229	0.869798	4.298015
7	0.021848	91.87857	2.126526	0.462527	0.170454	0.889200	4.472722
8	0.021868	91.71593	2.165787	0.485830	0.171320	0.899245	4.561892
9	0.021878	91.63302	2.186469	0.497784	0.171907	0.904202	4.606621
10	0.021883	91.59167	2.196903	0.503777	0.172281	0.906653	4.628719

This indicates that economic growth is highly endogenous with the remaining factors accounting for the volatility in the economic growth to varying degrees. Considering the fraction of economic growth forecast error variance attributable to variations in EC, it initiates with 13 percent at second period and then declines in the third quarter by the end of the 10th quarter up to 21 percent. Turning to the VDC estimates of electricity consumption in table 8, it shows that EC starts declining from 73 percent in the second period and the pattern continues till the 10th period with a decrease of 68 percent.

Table 8: VDC of EC from VAR

Period	S.E.	D(LOG(EG))	D(EC)	D(KF)	LP	D(OE)	FD
1	13.45021	19.11808	80.88192	0.000000	0.000000	0.000000	0.000000
2	14.16329	21.64756	72.94480	0.418902	3.594809	1.196524	0.197405
3	14.33567	21.23103	71.51232	0.550343	3.800076	1.178008	1.728218
4	14.46761	20.85167	70.27259	0.800937	3.878743	1.314716	2.881352
5	14.57369	20.55661	69.51709	0.978490	3.882458	1.378656	3.686698

6	14.64206	20.38176	69.03062	1.112806	3.860392	1.413766	4.200655
7	14.68346	20.28037	68.74832	1.192818	3.843236	1.437502	4.497758
8	14.70760	20.22338	68.59033	1.238513	3.831690	1.450494	4.665598
9	14.72105	20.19229	68.50351	1.263822	3.824864	1.457878	4.757628
10	14.72837	20.17557	68.45705	1.277359	3.821070	1.461966	4.806983

The endogeneity of the electricity consumption is explained in table 8 through economic growth with 21 percent and 20 percent for the second and last period respectively. Henceforth, like economic growth, the VDC of EC exercise also effectively demonstrates the momentous role played by the other variables of the model. In the next set of estimation, the dynamic perspective has been plugged through Cointegration and VECM methods. The Johansen cointegration method has been estimated as none of the series are integrated at second order.

Table 9: Johansen's Cointegration Estimates

No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	Prob.
None *	0.578239	113.8756	95.75366	0.0016
At most 1 *	0.465445	75.02639	69.81889	0.0181
At most 2	0.393846	46.84195	47.85613	0.0621
At most 3	0.333009	24.31401	29.79707	0.1875
At most 4	0.107168	6.089987	15.49471	0.6849
At most 5	0.021737	0.988945	3.841466	0.3200

The estimates of the Johansen cointegration in table 9 indicate that the series of the VAR model possess at least two cointegrating associations in the long run. This result validated the dynamic association between the variables of the model.

Table 10: VECM Estimates

Error Correction	**D(LOG (EG),2)**	**D(EC,2)**	**D(KF,2)**	**D(LP)**	**D(TO,2)**	**D(FD)**
CointEq1	-0.108562	202.3172	-15.31324	12.22487	3.29E+10	-22.61736
	(0.10085)	(76.5725)	(5.85389)	(6.36581)	(1.7E+10)	(16.8750)
	[-1.07644]	[2.64217]	[-2.61591]	[1.92039]	[1.88497]	[-1.34029]
D(LOG(EG (-1)),2)	-0.446080	27.04273	20.29255	-11.38359	3.47E+09	-12.70157
	(0.14371)	(109.109)	(8.34126)	(9.07070)	(2.5E+10)	(24.0453)
	[-3.10413]	[0.24785]	[2.43279]	[-1.25498]	[0.13926]	[-0.52824]
D(EC(-1),2)	6.37E-05	-0.307766	-0.006204	0.002604	1.45E+08	0.013362
	(0.00019)	(0.14232)	(0.01088)	(0.01183)	(3.2E+07)	(0.03136)
	[0.33968]	[-2.16245]	[-0.57019]	[0.22004]	[4.46221]	[0.42603]
D(KF(-1),2)	0.001010	-0.161232	-0.099087	-0.144341	2599733.	0.685178
	(0.00275)	(2.08617)	(0.15949)	(0.17343)	(4.8E+08)	(0.45975)
	[0.36766]	[-0.07729]	[-0.62129]	[-0.83226]	[0.00546]	[1.49033]
D(LP(-1))	-0.002358	0.519371	-0.179436	-0.407750	-7.63E+08	-0.210684

	(0.00255)	(1.93962)	(0.14828)	(0.16125)	(4.4E+08)	(0.42745)
	[-0.92298]	[0.26777]	[-1.21010]	[-2.52869]	[-1.72287]	[-0.49288]
D(TO(-1),2)	-7.51E-13	5.84E-10	-1.33E-10	1.20E-10	-0.268088	-1.73E-10
	(9.3E-13)	(7.1E-10)	(5.4E-11)	(5.9E-11)	(0.16160)	(1.6E-10)
	[-0.80497]	[0.82538]	[-2.46589]	[2.03261]	[-1.65893]	[-1.10939]
D(FD(-1))	0.000406	-0.624320	-0.125906	-0.024508	11361193	0.280617
	(0.00093)	(0.70608)	(0.05398)	(0.05870)	(1.6E+08)	(0.15561)
	[0.43657]	[-0.88421]	[-2.33250]	[-0.41751]	[0.07050]	[1.80339]
C	0.000213	-0.033436	0.071424	0.053513	2.78E+08	0.243192
	(0.00296)	(2.24644)	(0.17174)	(0.18676)	(5.1E+08)	(0.49507)
	[0.07184]	[-0.01488]	[0.41589]	[0.28654]	[0.54202]	[0.49123]

Table 9 explains the VECM estimates of the VAR model confirming the results of block exogeneity tests with statistically insignificant value of t-statistic (1.07). These results are inconsistent with the findings of panel study of Razzaqi et al. (2011) in the context of Pakistan.

Discussion

The econometric findings of the VAR model, IRF, VDC and VECM require plausible explanations in the context of both CPEC and ground realities of the electricity sector in Pakistan. Therefore, the discussion on electricity sector through the lenses of internal and external factors have been elaborated keeping in view the reforms of the new economy of Pakistan.

Internal Bottlenecks

According to the official website of CPEC (Pakistan), 15 power projects of CPEC are planned to meet the supply target of 11,110 MW out of which 7 projects are in operational position. Meanwhile, 6 projects are still in progress and are expected to enhance the generation capacity up to 6,910 MW. The status of remaining two projects is yet to be determined. The detail shows that CPEC power component is more focused towards electricity generation ignoring the needs of parallel distribution and transmission lines. Turning to the use of input of power projects, CPEC stressed on indigenous, renewable and clean resources, including coal (local and imported), solar, wind and hydel. On the other side of the story, use of imported coal in major projects is supposed to increase the cost exerting redundant burden on total outlays with transportation challenges. Further, despite the increasing trend in the use of renewable energy (solar), there are yet no prospects for such markets at domestic level in Pakistan. This would tend to induce more imports and deviations from fuel-based energy and thus calls for generating opportunities for the new energy markets (renewable) through complementary policy initiatives (Kazmi, Rehman, & Nasrullah, 2016). The other conspicuous feature of CPEC power projects is the financing through Independent Power Producers (IPPs) while these IPPs are responsible to pay the capacity payments and security costs during the operational period. In this scenario, delay in developing distribution lines would generate more pressure on circular debt (Ali & Badar, 2010). This would further spill over to the whole power supply chain, affecting payments and tariffs to domestic and commercial consumers. The other major bottleneck that could restrain the productivity of CPEC power projects is the insufficient capacity building and analytical support from China in the power sector which has yet not been traced out. Further, there is no plan to deal with peak oriented consumption of electricity that raises a quandary regarding the induction of additional power supply in Pakistan. Correspondingly, a declining share of electricity consumption by manufacturing sector would further exert devastated outcomes on the other sectors of the economy (Yasmeen & Qamar, 2013). Thus, the timely completion of Special Economic Zones (SEZs) is crucial to recuperate the industrial units specifically the large-scale sector deprived of deindustrialization.

External Bottlenecks

First and foremost, the existing installed capacity and upcoming increase in electricity generation is expected to overburden the transmission and distribution set ups as these arrangements are not only contracted but also an impediment to the financial sustainability of the power sector. According to the report of Asian Development Bank (ADB) of 2019, it is very urgent to overcome this issue as the probability of unscheduled outages and system failures will be surged due to on-stream electricity generation over the next three years. Second, this new capacity will substantially induce the volume of sales that will further increase circular debt putting more pressure on aggregate losses. This will further enhance the debt (unpaid) which travels from distribution companies (DISCOs) to generation companies (GENCOs) and fuel suppliers (Ali & Badar, 2010). Third, State Owned enterprises (SOEs) in Pakistan always show reluctance in improving their performance (financial and operational) while Independent Power Producers (IPPs) are also in the queue due to delayed disbursements from Central Power Purchasing Agency Guarantee Limited (CPPA-G). Fourth, the trap of circular debt initiates at the DISCOs that are short of revenues and reluctant to cover capital and operating costs. This happens due to setting tariffs below cost, and partial charging of electricity bills. Meanwhile, IPPs claim borrowing to meet their capital requirements further surges their operating costs despite getting government incentives (guarantees, profit margins etc.). Consequently, IPPs transmute the circular debt throughout the supply chain worsening payment schedules. Fifth, lack of coordination between inter and intra agencies of the supply chain hinders the process of solving the problem (ADB, 2019). For instance, department of sub-transmission at DISCO have limited communication with the handling departments of medium and low voltage systems (ADB, 2019). Last but not the least, the political economy of new Pakistan has to overcome the status quo factors restraining transparency and reforms in the power sector.

On the whole, a more comprehensive analysis is missing at both internal and external levels, which demands long term planning for power infrastructure through its advancement. This could conveniently be attained through commercialization and implications of the effective and defined policy appraisals and plans.

Power Sector Reforms of New Pakistan: A Way Forward for CPEC

Considering the recent plan of the power sector, the PES (2018-19) highlighted vibrant reforms for the sector that are supposed to take into account for better services and provision of electricity. In this regard, an immense stress has been provided to develop an **"Integrated Energy Plan"** which basically documents projections of electricity demand for the emerging energy generation in Pakistan. The focus of the plan revolves around energy mix and renewable resource with a detailed planning of the power sector. This will induce to address the issues of circular debt and capacity payments with evidence-based policy interventions. Apart from this planning side, there is also a dire need to harmonize the public levers and market forces of the power sector. On this perspective, the recent government is developing and incentivizing the business models of Energy Services Companies (ESCO) and Sustainable Energy Utility (SEU) to strengthen market forces of the power sector. The government is also working on the idea to design and process policies to transform the single buyer models into competitive market structures. Besides, the segregation of DISCOs on regional bases is also under consideration that will release the pressure on distribution chain of the electricity sector. Similarly, the efforts for closer regulatory cooperation between authorities of power and petroleum are also in the pipeline as it is crucial for the advancement of energy economics and democratization of the electricity sector. In the nutshell, the effective implementation of these initiatives would address the issues of the CPEC power projects more appropriately and more abruptly.

Conclusion

This study is an endeavor to revisit the ECEG model in lieu of the productive shock of CPEC for Pakistan. The empirical evidence has been developed through employing VAR model in compliance with IRF and VDC analyses. The estimation outcomes revealed that there exists no short run causal relationship among the variables of the model while estimates also affirmed a long run cointegration in the model. These findings endorsed a neutrality hypothesis which points out that energy conservation policies are ineffective to pronounce the ECEG in Pakistan. The IRF and VDC exercises approved that there exists stable association between electricity consumption and economic growth. After the econometric estimations, we endeavored to integrate the empirical findings through indicating the relevant internal and external bottlenecks. In the nutshell, it is presumed that failure to address issues would not only further deteriorate the prevailing scenario yet also crowd-out the investment of CPEC in the power sector. Further, lack of anticipation in determining the actual demand and supply gaps in the power sector and forecasting and planning for the future is the other weak area. At this stage of CPEC, upgradation of existing distribution lines and new set ups are essential. It is thus recommended to revise the ECEG model for the new economy of Pakistan keeping in view the revival of the industrial sector to induct the excess supply of electricity in order to remove the inefficiencies in the power sector.

Bibliography

1. Akinlo, A. E., Energy consumption and economic growth: Evidence from 11 Sub-Sahara African countries, Energy economics, Vol. 30, Issue 5, p. 2391-2400, 2008
2. Ali, S. S., Badar, S., Dynamics of circular debt in Pakistan and its resolution, *The Lahore Journal of Economics, Vol. 15*, p. 61-74, 2010

3. Altinay, G., Karagol, E., Electricity consumption and economic growth: evidence from Turkey, Energy economics, Vol. 27, Issue 6, p. 849-856, 2005
4. Apergis, N., Payne, J. E., Renewable energy consumption and economic growth: evidence from a panel of OECD countries, Energy policy, Vol. 38, Issue 1, p. 656-660, 2010
5. Aqeel, A., Butt, M. S., The relationship between energy consumption and economic growth in Pakistan. Asia-Pacific Development Journal, 8(2), p. 101-110, 2001
6. Asafu-Adjaye, J., The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries, Energy economics, Vol. 22, Issue 6, p.615-625, 2000
7. Asghar, Z., Energy-GDP relationship: a causal analysis for the five countries of South Asia, Applied Econometrics and International Development, Vol. 8, Issue 1, 2008
8. Asian Development Bank Report 2019, Pakistan: ADB's Pakistan: ADB's Support to Pakistan Energy Sector (2005–2017), htttps://www.adb.org/sites/default/files/…/space-pakistan-energy.pdf, [access: 15.7.2019]
9. Asmah, E. E., Sources of Real Exchange Rate Fluctuations in Ghana. American Journal of Economics, Vol.3, Issue 6, p. 291-302, 2013
10. Atif, S. M.,Siddiqi, M. W., The electricity consumption and economic growth nexus in Pakistan: A new evidence (2010), https://www.ssrn.com/abstract=1569580, Available at SSRN 1569580, [access: 25.7.2019]
11. Berndt, E. R., Wood, D. O., Technology, prices, and the derived demand for energy. The review of Economics and Statistics, p. 259-268, 1975
12. Dogan, E., Energy consumption and economic growth: Evidence from low-income countries in Sub-Saharan Africa. International Journal of Energy Economics and Policy, Vol. 4, Issue 2, p. 154-162, 2014
13. Fang, S., Jia, R., Tu, W., Sun, Z., Research on the influencing factors of comprehensive water c onsumption by impulse response function analysis, Water, Vol. 9, Issue 1, p. 18, 2017
14. Griffin, J. M., & Gregory, P. R., An intercountry translog model of energy substitution responses, The American Economic Review, Vol. 66, Issue 5, p. 845-857, 1976
15. Hoffman, D. L.,Rasche, R. H., Assessing forecast performance in a cointegrated system, Journal of Applied Econometrics, Vol. 11, Issue 5, p. 495-517, 1996
16. Kazmi, S. T. H., ur Rehman, I., Nasrullah, A., China's journey in renewable energy and its potential spillover effects through the CPEC in Pakistan (2016), https://www.pide.org.pk/psde/pdf/AGM32/papers/China%20Journey%20in%Renewable.pdf, [access : 5.8.2019]
17. Khan, S., Jam, F. A., Shahbaz, M., Mamun, M. A., Electricity consumption, economic growth and trade openness in Kazakhstan: evidence from cointegration and causality. OPEC Energy Review, Vol. 42, Issue 3, p. 224-243, 2018
18. Kilian, L.,Lütkepohl, H., Structural vector autoregressive analysis. Cambridge University Press, 2017
19. Kraft, J., Kraft, A., On the relationship between energy and GNP. The Journal of Energy and Development, p. 401-403, 1978
20. Lee, C. C., Chang, C. P., Energy consumption and economic growth in Asian economies: a more comprehensive analysis using panel data, Resource and energy Economics, Vol. 30, Issue 1, p. 50-65, 2008
21. Mehrara, M., Energy consumption and economic growth: the case of oil exporting countries, Energy policy, Vol. 35, Issue 5, p. 2939-2945, 2007

22. Ministry of Finance, Report 2019, Pakistan Economic Survey 2018-19, www.finance.gov.pk/, [access: 30.5.2019]
23. Nadeem, S., Munir, K., Energy Consumption and Economic Growth in Pakistan (2016): A Sectoral Analysis, https://mpra.ub.uni_muench.de/745691/1/MPRA_74569.pdf, [access: 15.7.2019]
24. Nawaz, S., Iqbal, N., Anwar, S., Electricity demand in Pakistan: a nonlinear estimation, The Pakistan Development Review, p. 479-491, 2013
25. Nelson, C. R., Plosser, C. R., Trends and random walks in macroeconomic time series: some evidence and implications. Journal of Monetary Economics, Vol.10, Issue 2, p. 139-162, 1982
26. Odhiambo, N. M., Energy consumption and economic growth nexus in Tanzania: An ARDL bounds testing approach, Energy policy, Vol. 37, Issue 2, p. 617-622, 2009
27. Odhiambo, N. M., Electricity consumption, labour force participation rate and economic growth in Kenya: An empirical investigation. Problems and Perspectives in Management, Vol.8, Issue 1, p. 31-38, 2010
28. Omay, T., Hasanov, M., Ucar, N., Energy consumption and economic growth: evidence from nonlinear panel cointegration and causality tests, Прикладная эконометрика, Vol. 2, Issue 3, 2014
29. Paul, S.,Bhattacharya, R. N. Causality between energy consumption and economic growth in India: a note on conflicting results, Energy economics, Vol. 26, Issue 6, p. 977-983, 2004
30. Pempetzoglou, M., Electricity consumption and economic growth: A linear and nonlinear causality investigation for Turkey, International Journal of Energy Economics and Policy, Vol. 4, Issue 2, p. 263-273, 2014
31. Razzaqi, S., Bilquees, F., Sherbaz, S.,Dynamic relationship between energy and economic growth: evidence from D8 countries, The Pakistan Development Review, p. 437-458, 2011
32. Sargent, T.J., Observations on improper methods of simulating and teaching Friedman's time series consumption model. International Economic Review, p. 445-462, 1977
33. Sehrawat, M., Giri, A. K., Mohapatra, G., The impact of financial development, economic growth and energy consumption on environmental degradation: Evidence from India. Management of Environmental Quality: An International Journal, Vol. 26, Issue 5, p. 666-682, 2015
34. Shahbaz, M., Feridun, M., Electricity consumption and economic growth empirical evidence from Pakistan. Quality & Quantity, Vol 46, Issue 5, p. 1583-1599, 2012
35. Shahbaz, M., Lean, H. H., The dynamics of electricity consumption and economic growth: A revisit study of their causality in Pakistan, Energy, Vol. 39, Issue 1, p. 146-153, 2012
36. Shahbaz, M., Tang, C. F., Shabbir, M. S., Electricity consumption and economic growth nexus in Portugal using cointegration and causality approaches, Energy policy, Vol. 39, Issue 6, p. 3529-3536, 2011
37. Shahbaz, M., Tang, C. F., Shabbir, M. S., Electricity consumption and economic growth nexus in Portugal using cointegration and causality approaches. Energy policy, Vol. 39, Issue 6, p. 3529-3536, 2011
38. Shahbaz, M., Van Hoang, T. H., Mahalik, M. K., Roubaud, D., Energy consumption, financial development and economic growth in India: New evidence from a nonlinear and asymmetric analysis, Energy Economics, Vol. 63, p. 199-212, 2017
39. Solarin, S. A., Shahbaz, M., Shahzad, S. J. H., Revisiting the electricity consumption-economic growth nexus in Angola: The role of exports, imports and urbanization, International Journal of Energy Economics and Policy, Vol. 6, Issue 3, p. 501-512, 2016
40. Soytas, U., Sari, R., Energy consumption and GDP: causality relationship in G-7 countries and emerging markets, Energy economics, Vol. 25, Issue 1, p. 33-37, 2003

41. Soytas,U., Sari,R., Ozdemir, O., Energy consumption and GDP relation in Turkey: a cointegration and vector error correction analysis. Economies and business in transition: facilitating competitiveness and change in the global environment proceedings, Vol.1, p.834-844, 2001
42. Stock, J.H., Watson, M.W., New indexes of coincident and leading economic indicators. NBER Macroeconomics Annual, Vol. 4, p. 351-394, 1989
43. To, H., Wijeweera, A., Charles, M. B., Energy consumption and economic growth–The case of Australia (2012), Business School, Southern Cross University
44. Ulrichs, M., Identification of financial and macroeconomic shocks in a VAR model of the Polish economy. A stability analysis, Economics and Business Review, Vol. 4, Issue 1, p. 29-43, 2018
45. World Bank Open Data 2019, World Bank Indicators, https://data.worldbank.org ›indicator, [access: 5.7.2019]
46. Yasar, N., The relationship between energy consumption and economic growth: Evidence from different income country groups. International journal of energy economics and policy, Vol. 7, Issue 2, p. 86-97, 2017
47. Yasmin, B., Qamar, W., The role of power generation and industrial consumption uncertainty in De-industrialising Pakistan, The Pakistan Development Review, p. 517-534, 2013
48. Zeshan, M., Ahmad, V., Energy consumption and economic growth in Pakistan. Bulletin of Energy Economics, Vol. 1, Issue 2, p. 8-20, 2013
49. Zhang, X. P., Cheng, X. M., Energy consumption, carbon emissions, and economic growth in China. Ecological Economics, Vol. 68, Issue 10, p. 2706-2712, 2009
50. Engle, R.F., Granger, C.W, Co-integration and error correction: representation, estimation and testing. Econometrica, Journal of the Econometric Society, p. 251-276, 1987

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Appendix A

Table A1: Description of Variables

Variable	Abbreviation	Proxy	Measurement	Data Source
Economic Growth	EG	GDP growth	Real GDP (constant prices)	World Bank Indicators
Electricity Consumption	EC	______	Kilowatt Hour (kwh) per capita	World Bank Indicators
Capital Formation	KF	Gross fixed capital formation	% of GDP	World Bank Indicators
Labor Participation	LP	Labor force participation	% of working age population	Handbook of Statistics & Labor force Survey
Openness of Economy	OE	Trade to GDP Ratio	Exports + Imports/ GDP	World Bank Indicators
Financial Development	FD	Broad Money	% of GDP	World Bank Indicators

Source: Tabulated by Authors

Table A2: Residual Serial Correlation LM Tests

Lag	LRE* stat.	df	Prob.	Rao F-stat	df	Prob.
1	34.32672	36	0.5483	0.949562	(36, 125.7)	0.5566
2	85.67389	72	0.1294	1.229534	(72, 125.5)	0.1555
3	118.5470	108	0.2295	1.082759	(108, 98.9)	0.3447
4	181.8047	144	0.0180	1.270367	(144, 66.3)	0.1370

Source: Estimated by Authors

Table A3: VAR Residual Heteroskedasticity Tests (Levels and Squares)

Chi-sq	df	Prob.
269.6997	252	0.2118

Source: Estimated by Authors

Table A4: VECM Residual Serial Correlation LM Tests

Lag	LRE* stat.	df	Prob.	Rao F-stat	df	Prob.
1	28.49422	36	0.8091	0.770908	(36, 121.3)	0.8144
2	65.70097	72	0.6862	0.879811	(72, 120.1)	0.7207

Source: Estimate by Authors

Table A5: VECM Residual Normality Tests

Component	Jarque-Bera	df	Prob.
LOGEG	0.406891	2	0.8159
EC	9.636324	2	0.0081
KF	0.368343	2	0.8318
LP	0.713557	2	0.6999
OE	2.704929	2	0.2586
FD	1.005982	2	0.6047
Joint	14.83603	12	0.2505

Source: Estimated by Authors

Table A6: VECM Residual Heteroskedasticity Tests (Levels and Squares)

Chi-sq	df	Prob.
298.5662	294	0.4150

Source: Estimated by Author

Appendix B

Figure B1: Response of KF to Cholesky one S.D (d.f adjusted) Innovations

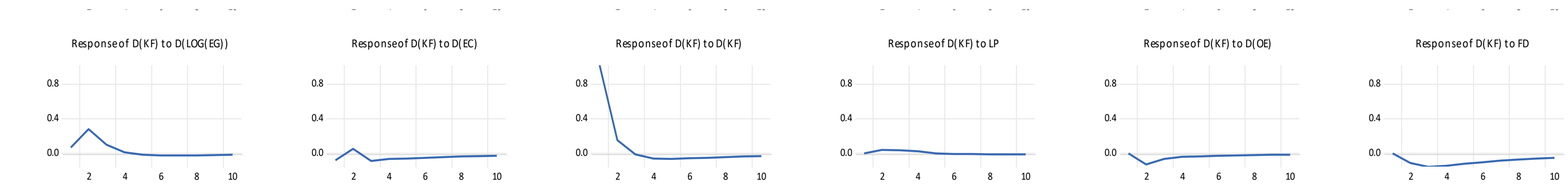


Figure B2: Response of LP to Cholesky one S.D (d.f adjusted) Innovations

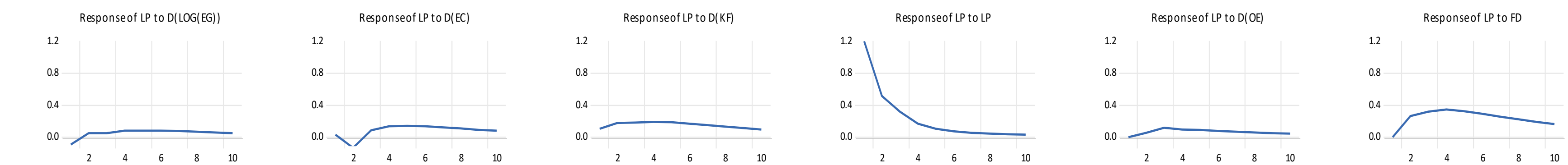


Figure B3: Response of OE to Cholesky one S.D (d.f adjusted) Innovations

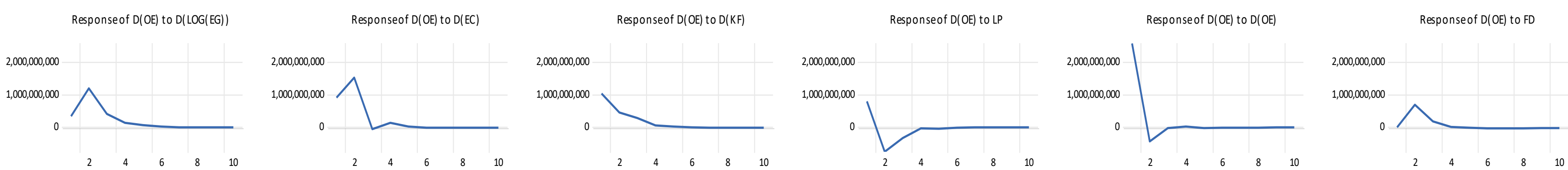
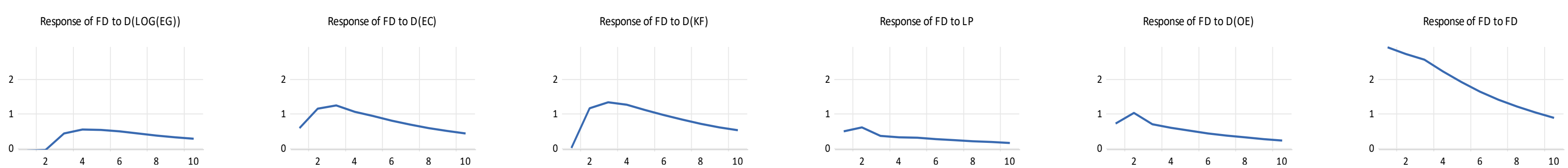


Figure B4: Response of FD to Cholesky one S.D (d.f adjusted) Innovations



OFFSHORE WIND FARMS IN EUROPE AND WORLDWIDE – THE POSSIBILITIES OF SELECTED COUNTRIES AND THE STATE OF DEVELOPMENT OF INSTALLATIONS IN POLAND

Jakub Prugar

Abstract

The offshore sector is one of the most dynamically developing branches of the economy. The countries with access to the sea in this sector see an opportunity to produce cheap clean energy. One of the countries which may become beneficiaries of the development of this technology is Poland, because the Baltic Sea has excellent conditions for generating energy by means of wind farms.

Key words: offshore, renewable energy sources, Baltic Sea

Introduction

The debate on the fundamentals of the development of offshore wind energy (OWE) in Poland has been going on for a decade. Offshore wind energy is one of the most dynamically developing technologies for the production of electricity, particularly in Europe. The development of this branch of the economy is supported above all by relatively low operating costs, the possibility of generating stable ecological energy and the negligible impact on the social and environmental conflict. The annual capacity increase is over 30% (WindEurope, 2016, 7-12). The installed capacity in Europe is more than 11.5 GW (McKinsey&Company, 2016, 4-22).

The main aim of the article is to present the situation of the offshore sector and installed capacities, including in selected countries, as well as the state of development of installations in Poland.

The following hypotheses have been verified in the article in relation to the set objective:

1. The world leader in the offshore sector is the United Kingdom, which produces about 1/3 of the world's power generated by offshore wind farms.
2. The main factor influencing the pace of development of the offshore sector in Poland is the lack of clearly defined legal norms.

In connection with the objective and hypotheses, the following research questions have been formulated: Which of the European countries utilise most in terms of offshore wind farm energy? Which country outside Europe is the most dynamically developing Offshore Wind Farms? What is the current status of offshore development in Poland? What are the estimates for electricity transfer from the Baltic Sea till 2030 in Poland?

The article mainly uses articles from industry portals, information available on investors' websites, and statements and interviews with specialists directly related to the sector, as source material.

Being aimed at a verification of hypotheses and constructed assumptions they made up their mind for using the analysis method of available information and documents. Using this method a situation and possibilities of chosen states will be presented in the sector offshore and state of Polish installations.

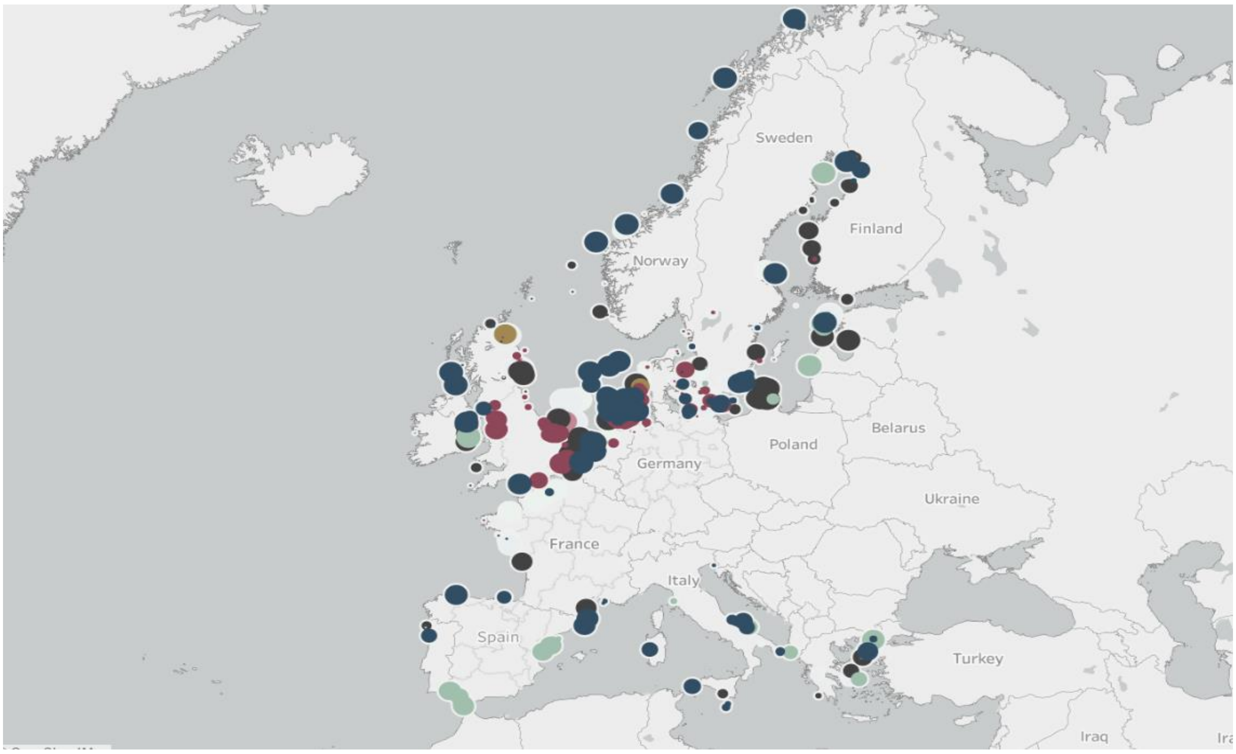
The first part is filing articles oneself from information concerning the state of the section of sea wind farms in Europe, with particular reference to of Great Britain and Germany. Additionally a state of the development was also presented Chinese of wind sea power stations.

The second part of the text constitutes presentations of the situation offshore in Poland. She is presenting plans, projects, the current state and future possibilities of the development of this sector in Poland. Also statistical data concerning future, possible powers for getting produced are given.

The state of offshore wind farms in the world on the example of selected countries

Europe is a clear leader in the construction of offshore wind farms. In 2017, the total power output of OWE in Europe amounted to 15.8 GW. Compared to 2016, this is an increase of 25% (WindEurope, 2017). The result was due to the launch of 13 new offshore wind farms, including the first offshore wind farm in Hywind Scotland. More than 4,000 offshore wind turbines operate in 11 countries on the Old Continent (Leonardo Energy, 2018). According to data from the Global Wind Energy Council (GWEC), 51.3 GW turbines were installed worldwide in 2018. From 2014 onwards, in each subsequent year, the growth rate will be at least 50 GW (Shipbuilding Portal, 2019). This potential is constantly being developed and new installations are being systematically implemented in successive countries. After analysing power generation from traditional and offshore wind farms, the results show that offshore wind farms account for only 1/10 of the total capacity. However, the Global Wind Energy Council predicts that by 2023 it will already have reached a quarter of its capacity. The major players in this area are the United Kingdom, Germany and China (World Economic Forum, 2019). The deployment of offshore wind farms (OWF) in Europe is shown in Figure 1.

Figure 1: Map of European wind farms



Source: WindEurope, 2019

It is worth noting that almost 98% of offshore wind farms in Europe are concentrated around a few countries, namely, the United Kingdom, Germany, Denmark, the Netherlands, and Belgium. The data showing the production capacity in Europe are presented in Table 1.

Table 1: Installed capacity of offshore wind farms in Europe (MW)

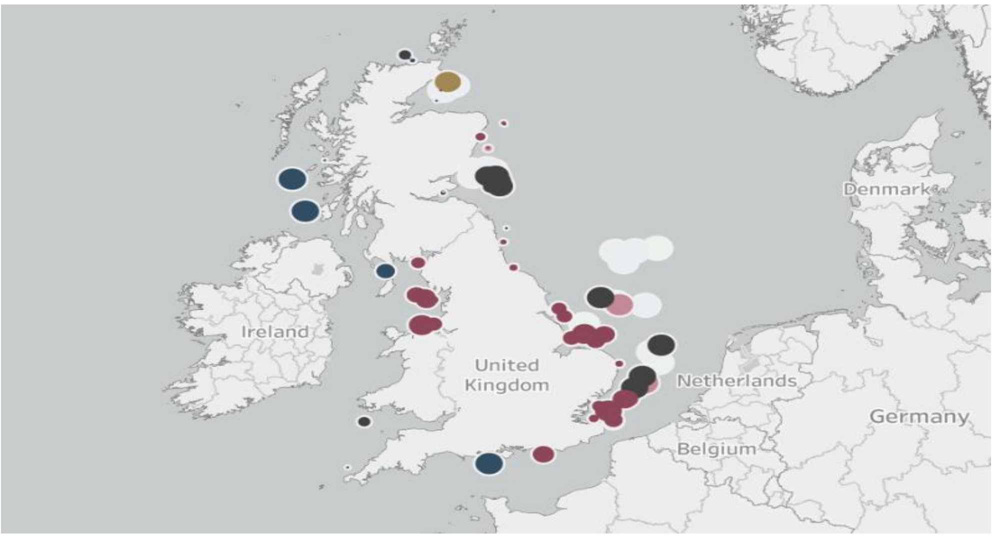
No.	Country	Installed capacities of OWE
1.	United Kingdom	8,183
2.	Germany	6,380
3.	Denmark	1,329
4.	Belgium	1,186
5.	Netherlands	1,118
6.	Sweden	192
7.	Finland	71
8.	Ireland	25
9.	Spain	10
10.	Norway	2
11.	France	2

Sound: WindEurope, 2019

The world leader in OWE is the United Kingdom. The British have 34% of the installed power. It is estimated that by 2030 1/3 of the UK's energy mix will be covered by offshore generation. The UK has been sector leader since 2008, when it overtook Denmark. *RenewableUK* estimates that the cost of new offshore energy fell by 50% in 2015 (World Economic Forum, 2019). This has been aided by factors such as:

- government policy encouraging investment in offshore and discouraging investment in onshore wind farms,
- geographical conditions favourable to the creation of offshore wind farms (Fig. 2).

Figure 2: Distribution of offshore wind farms in the UK

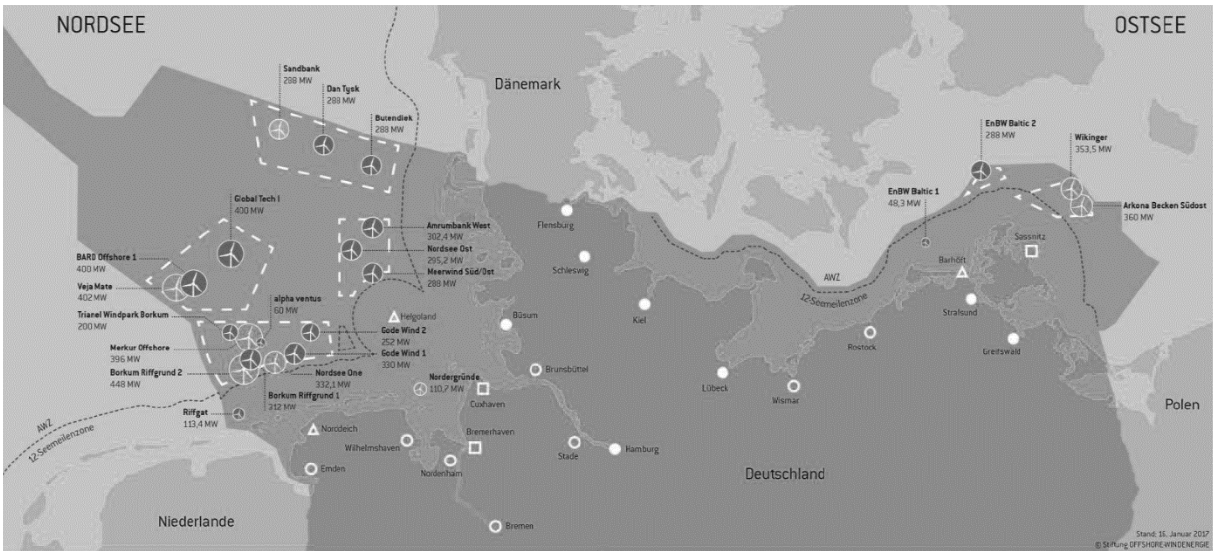


Source: WindEurope, 2019

China is experiencing dynamic growth in the offshore sector. The Chinese are leaders in investments in both onshore and offshore wind energy. In 2018, China launched 1.8 GW of OWE, which gave it a leading position in this period (Shipbuilding Portal, 2019). The Chinese plan is to double the rate of increasing their capacity by 2025. (World Economic Forum 2019). The development of the offshore sector is determined mainly by growing demand. According to the International Energy Agency, China's energy consumption increased by 3.5% or 1/3 of global demand (IEA, 2018). In the Chinese province of Jiangsu, 24 offshore development projects were approved. Their cost will be 18 billion dollars and will supply 6.7 GW (World Economic Forum, 2019).

German offshore wind turbines account for 28% of all offshore installations, and in 2018 they installed 136 new turbines. There are 6.4 GW of power installed in the maritime zones. Germany's first offshore wind farm was started by Alpha Ventus, the first offshore wind farm to start producing electricity, relatively late, in 2009. (World Economic Forum, 2019). The Federal Ministry of Economy and Energy has said that since 2013 investments amounting to 15 billion EUR have been made in the offshore industry. However, stakeholders in the sector, such as the German Wind Energy Association (BWE), the Association of German Mechanical Engineers and Equipment Builders (VDMA) and the Windenergie Agentur (WAB), are concerned that the current political situation in the country is not conducive to the long-term development of the sector (Renewable Energy World, 2019). The location of German wind turbines offshore is shown in Figure 3.

Figure 3: Distribution of offshore wind turbines in Germany



Source: Renewable Energy World, 2019

German offshore wind farms are located mainly within the North Sea. This is largely due to the increased location capacity, as the German part of the Baltic Sea is much smaller than the areas in the North Sea. Nevertheless, Germany is also planning to construct an installation in the Baltic Sea. By creating appropriate legislative conditions, it has become possible to separate the zone at a distance of 10 km from the coast and place up to 12 turbines in the Baltic Sea. Turbines of 13-15 MW unit capacity will be tested there (Gram w Zielone, 2019).

Offshore in the Polish Baltic Sea Region – current status

Offshore wind farms (OWFs) are in the government's strategic plans. The Polish offshore sector will eventually provide around 10 GW in 2040. In 2025, according to the National Energy and Climate Plan, the first installations are to be launched (State Energy Policy until 2040, 2018).

In the Polish economic zone in the Baltic Sea there are designated areas to be used in the energy sector. The area designated for this sector is approximately 2,000 km^2 (Rączka 2018, 12). The areas made available for use are presented in Table 2.

Table 2: Area of the Polish Economic Zone in the Baltic Sea to be used in the energy sector

No.	Terrain	Area (km^2)
1.	Odrzańska Sandbank	380
2.	Słupska Sandbank	1210
3.	Środkowa Sandbank	390

Source: Rączka 2018 p.14

It is estimated that wind turbines with a capacity of 4 to 5 MW can be installed per 1 km^2. This means that the production potential in the designated areas is in the range of 8-10 GW (Rączka 2018, 13). The expected time of completion of the first developments is estimated at 12-14 years. Projects implemented after this period are likely to be implemented much faster due to the experience gained and improvements in individual processes.

In the Polish economic zone of the Baltic Sea, 9 location decisions have already been issued for the following companies (Table 3) with a capacity of approximately 10 GW.

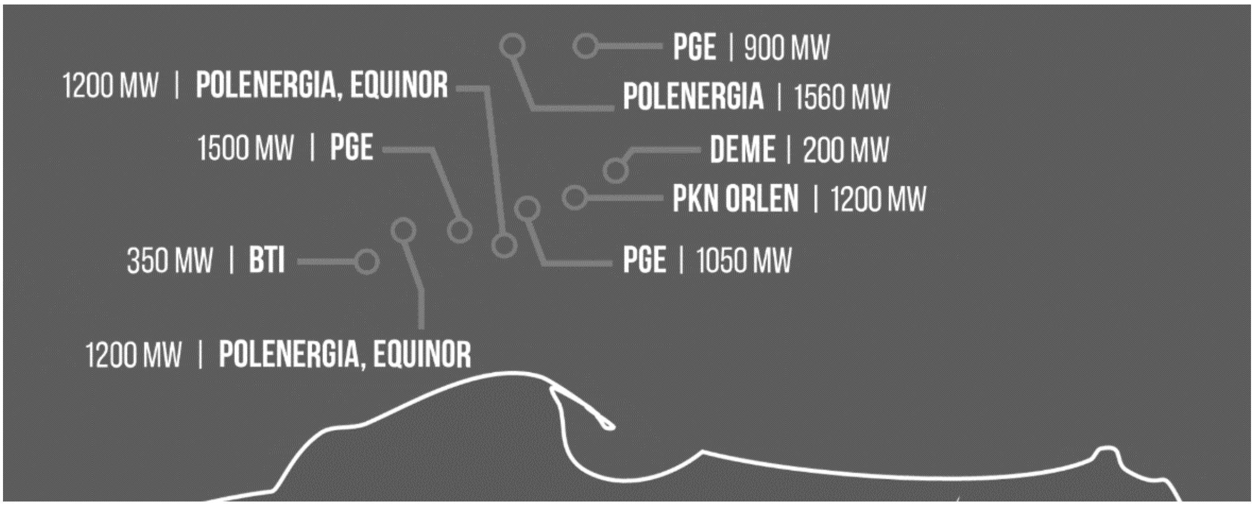
Table 1. Number of decisions for individual enterprises in the Polish maritime economic zone

No.	Investor	Number of decisions	Projected power (GW)
1.	Polenergia	1	No data
2.	Polenergia z Equinor	2	2.4
3.	Polska Grupa Energetyczna	3	2.55
4.	PKN ORLEN	1	1.2
5.	Baltic Trade & Invest	1	0.35
6.	DEME NV	1	No data

Source: Rączka 2018, p.15

It should be noted that the projects are at different stages of development. Some companies have already obtained the environmental decision and have already signed the connection agreements (Polenergia with Equiron). However, most investors are still applying for environmental decisions. Planned deployment of offshore wind farm projects in the Baltic Sea (Figure 4).

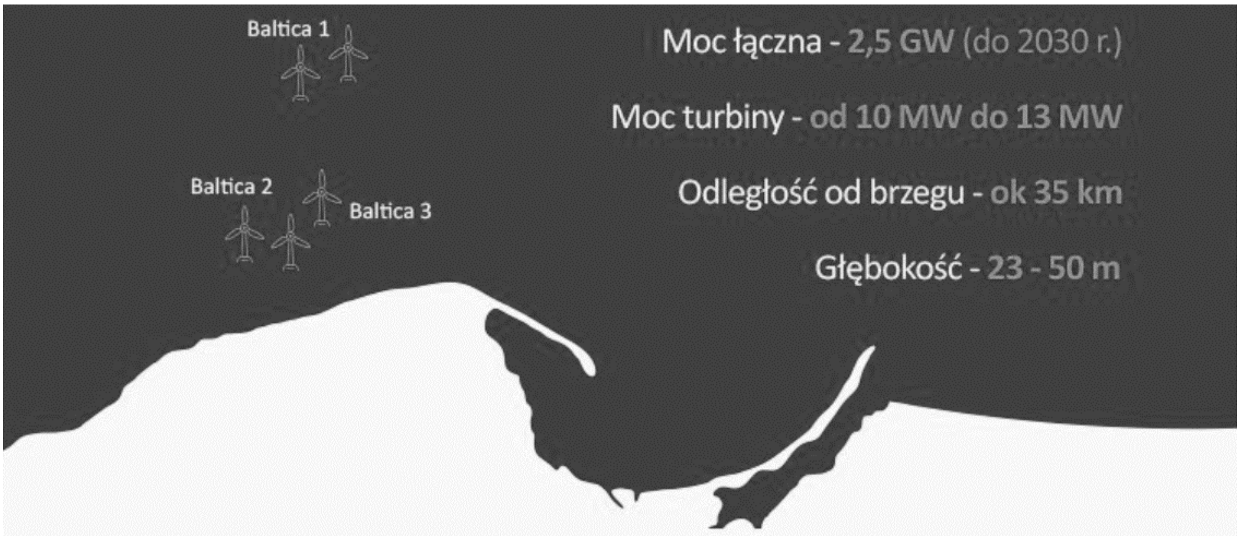
Figure 4. Distribution of OWF projects in the Baltic Sea



Source: Wysokie Napięcie, 2018

The National Energy Policy until 2040 provides that by 2030 Poland will hold 4.6 GW of OWE capacity. It is estimated that in the Polish offshore zone, the wind turbines will be commissioned after 2025. Then, Polenergia with Equiron and the Polish Energy Group projects will be commencing operations. In 2030, PGE want to have the power of 2500 MW and the turbines are to have the power of 10 to 13 MW (Fig. 5) (CIS, 2019).

Figure 5: Location and OWF technical data of PGE Baltica



Source: WNP, 2019

If Poland implements the assumptions of the State Energy Policy by 2040 and installs capacities in the Polish economic zone in the Baltic Sea amounting to approximately 10 GW, it will become a significant player in the European sector of the OWE (State Energy Policy to 2040, 2018).

Analysing the pace of work and preparations for the implementation and development of the offshore sector in Poland, one can assume optimistic scenarios for this branch of the economy. Nevertheless, specialists point out some problems that may hamper the work. One of the barriers is the institutional (political) uncertainty about the future directions of the country's energy policy development. Stakeholders claim that the basic condition for the dynamisation of the sector in Poland is the political decision to include offshore wind farms in the energy mix (Institute for Structural Research, 2018). Many experts emphasise that in Poland, specific legislative steps should be taken to regulate the issues related to offshore wind farms (Portalmorski, 2019). However, specialists point out that offshore in Poland is a great opportunity that should be used (Energetyka24, 2019). They also add that from 2023/2024, 1 GW of electrical power should be installed annually in the Baltic Sea on a cyclical basis. The first electricity supply from the Baltic Sea should be shipped in 2027 and by 2030, Poland should have energy of about 6 GW at its disposal (YouTube 2019).

Summary

Offshore Wind Energy is a young sector, but it is developing very dynamically. Offshore is an excellent alternative for countries that have access to the sea and who want to develop renewable energy sources. Offshore wind farms are an opportunity for development for countries without minerals and enables clean energy to be produced.

By analysing the market and the current state of offshore development in Europe and the world, the first hypothesis was confirmed, which assumed that the OWF sector is one of the most dynamically developing in the world. This is confirmed by the fact that it is a relatively young branch of the economy, in which numerous investments are constantly made. Countries with access to the sea are trying to maximise its potential. One of the biggest advantages of offshore wind energy is the production of clean energy far from inhabited places, which are not always in favour of the changes taking place.

The first hypothesis related to the statement that the United Kingdom is the world leader in offshore wind power generation. The statistics clearly confirm this hypothesis. The UK currently has the greatest potential for offshore energy generation. The potential of this country is also constantly being developed, so that the share of this energy carrier in the energy mix can be even greater.

The second hypothesis assumed that the main factor influencing the pace of offshore development in Poland is the lack of clearly defined legal norms. Opinions and statements by experts clearly confirm that offshore in Poland needs set legal standards in order to function properly. The introduction of specific regulations will lead to the concretisation and systematisation of the implementation of OWF in the Polish Baltic Sea area.

Offshore is a great opportunity for Poland in terms of development and continuity of electricity supply. The vast majority of power plants in Poland are located in the south of the country. It is very important to create an appropriate infrastructure also in the north of Poland, as this will contribute to increasing Poland's energy security.

Bibliography

1. Energetyka24.pl *Morskie farmy wiatrowe przyszłością polskiej energetyki?* https://www.energetyka24.com/morskie-farmy-wiatrowe-przyszloscia-polskiej-energetyki?fbclid=IwAR1PxfyQTb84D0IDNabGagpmXcTe5lO5ZaWSNsF_2KIEnEtEs5Fyh_UKK0U (access: 10.07.2019)

2. Gram w Zielone *Niemcy chcą stawiać na Bałtyku wiatraki o mocach 13-15 MW*, https://www.gramwzielone.pl/energia-wiatrowa/100490/niemcy-chca-stawiac-na-baltyku-wiatraki-o-mocach-1315-mw (access: 10.07.2019)
3. International Energy Agency, https://www.iea.org/statistics/?country=CHINA&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES (access: 04.07.2019)
4. Jan Rączka *Energetyka morska. Z wiatrem czy pod wiatr?* 2018
5. Leonardo Energy *Morskaenergetyka wiatrowa w Europie rośnie na potęge*, https://leonardo-energy.pl/artykuly/morska-energetyka-wiatrowa-w-europie-rosnie-na-potege-co-z-polska/ (access: 28.06.2019)
6. McKinsey&Company *Rozwój morskiej energetyki wiatrowej w Polsce. Perspektywy i ocena wpływu na lokalną gospodarkę* 2016 (access: 28.06.2019)
7. Ministerstwo Energii, *Polityka Energetyczna Polski do 2040 r.*, Warszawa 2018
8. Portal stoczniowy *Morska energetyka wiatrowa. Chiny światowym liderem w inwestycjach*, https://portalstoczniowy.pl/wiadomosci/morska-energetyka-wiatrowa-chiny-swiatowym-liderem-w-inwestycjach/ (access: 07.07.2019)
9. Renewable Energy World, https://www.renewableenergyworld.com/articles/2019/01/germany-adds-almost-1-gw-of-new-offshore-wind-in-2018.html (access: 04.07.2019)
10. Sawulski J., Gałczyński M., Zajdler R. *A review of the offshore wind innovation system in Polnad.* IBS Working Paper 06/2018
11. WindEurope *Offshore wind Europe grew*, https://windeurope.org/newsroom/press-releases/offshore-wind-europe-grew-25-2017/ (access: 04.07.2019)
12. WindEurope *The European offshore wind industry – key trends and statistics 1st half 2016*
13. Wirtualny Nowy Przemysł *Morskie turbiny wiatrowe PGE mogą mieć moc 13 MW*, https://www.wnp.pl/energetyka/morskie-turbiny-wiatrowe-pge-moga-miec-moc-13-mw,341888_1_0_0.html (access: 13.07.2019)
14. World Economic Forum *These 3 countries are global offshore wind powerhouses,* https://www.weforum.org/agenda/2019/04/these-3-countries-are-global-offshore-wind-powerhouses/ (access: 04.07.2019)
15. YouTube Instytut Polityki Energetycznej, https://www.youtube.com/watch?v=vLnezYwE-eGw&t=1933s (access: 07.07.2019)

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THE INFLUENCE OF PHOTOVOLTAICS ON THE IMPLEMENTATION OF THE CLIMATE AND ENERGY PACKAGE ON THE EXAMPLE OF THE RZESZÓW FUNCTIONAL AREA

Paulina Potyrańska, Justyna Puzio

Abstract

The aim of the study is to show the impact of investments in photovoltaic installations carried out by local government units on the implementation of the objectives of the climate and energy package in the Rzeszów Functional Area (ROF). It has been shown that such an important problem as the need to increase the share of renewable energy sources (RES) in electricity production is also solved locally. The methods of in-depth interview, case study and desk research were used. The application of modern technologies in the field of energy production with the use of photovoltaic cells in the ROF area is to contribute in 2019-2035 to the reduction of CO2 emissions; to the increase in the production of electricity from RES, and to the reduction of the use of fossil fuels for the production of electricity. Diversification of energy sources, also at local and individual level, can be beneficial not only for the environment, but also for the budget of energy consumers.

Key words: energy management strategy, energy efficiency, RES, photovoltaics, climate and energy strategy

Introduction

Increasing the ecological awareness of society, progressive climate change and the absolute necessity of adaptation to it, as well as restrictions in access to fossil fuel resources, make it necessary to search for new, environmentally friendly energy sources. In addition, from the point of view of the consumer, a very important issue is the rising cost of electricity, which, together with the increasing consumption of electricity, cause an increase in the maintenance costs of residential and public buildings.

The members of the ROF Association seek to meet these challenges by: increasing the energy efficiency of public utility buildings (deep thermo-modernisation); supporting heat exchange; supporting installation of renewable energy sources (RES) – photovoltaic cells in selected public utility buildings and properties of ROF residents. The measures taken are part of the implementation, adopted by the European Commission, of the objectives of the climate and energy package planned to be achieved by 2020, i.e.:
20% reduction of greenhouse gas emissions (relative to the level of 1990);
20% share of energy produced from renewable sources in total EU energy consumption;
increasing energy efficiency by 20%.

Definitions

a) Photovoltaic cells – devices in which solar energy is directly converted into electricity (Sarniak 2008: 28). These are devices made of semiconductor materials containing a p-n connector in their structure.
b) Insolation – the energy of solar radiation, also called irradiance, reaching a unit of surface within a specified time: an hour, a month, a year. The physical dimension of this size is J/m^2 or kWh/m^2 (Wolańczyk 2011: 21).

c) Sunshine – this is the total time in which direct solar radiation reaches the surface of the Earth in a given place, i.e. the solar disc is directly visible. The unit of sunshine is the time. Sunshine in Poland equals 1200÷1700 h (Wolańczyk 2011: 21).

Rzeszów Functional Area (ROF)

The ROF is the Municipal Functional Area of Rzeszów defined in the Development Strategy for the Voivodeship – Podkarpackie 2020 (adopted by Resolution No. XXXVII/697/13 of the Sejmik of the Podkarpackie Voivodeship in Rzeszów of 26 August 2013) covering the area of municipalities forming the ROF Association: the Municipality of Rzeszów, the Municipality of Boguchwała, the Municipality of Chmielnik, the Municipality of Czarna, the Municipality of Czudec, the Municipality of Głogów Małopolski, the Municipality of Krasne, the Municipality of Lubenia, the Municipality of Łańcut, the City of Łańcut, the Municipality of Świlcza, the Municipality of Trzebownisko, and the Municipality of Tyczyn.

The Rzeszów Functional Area was established in line with the desire to ensure the sustainable and long-term development of the cities and municipalities concentrated in the ROF and to strengthen partnership-based local government cooperation, and taking into account the opportunities defined by the European Commission within the 2014-2020 financial perspective for effective use of aid funds directed at the development of urban areas and increasing the involvement of cities and their functional areas in the management of EU structural funds – within the financial instrument of Integrated Territorial Investments (ITI). The ROF is a key area for the development of the entire Podkarpackie voivodeship and its mission is defined (at the level of the operational plan) by three development objectives:

I. Development objective ZIT 1 – Increase in the competitiveness of the economy by creating conditions for the development of innovative enterprises;
II. Development objective ZIT 2 – Improving the quality of life in the ROF through increasing access to modern public services and revitalisation of public space;
III. Development objective ZIT 3 – Improvement of the natural environment and support of the region's energy efficiency.

Within the scope of the third objective, the municipalities, in accordance with the Low-Emission Economy Plans developed and adopted by them, aimed at reducing particulate and CO_2 emissions and increasing energy efficiency (including: deep thermo-modernisation: reduction of demand for heat and electricity, installation of renewable energy sources), undertook joint actions in installing renewable sources of electricity (photovoltaic cells) on public utility buildings and real estate (including buildings) of the residents. Within the framework of this study, only those investments which have been implemented by ROF municipalities under joint ZIT projects have been included, and it should also be noted that the members of the ROF Association implemented and will certainly implement independently other projects which are part of the activities aimed at executing the assumptions of the climate and energy package.

Solar energy potential in Podkarpackie voivodship

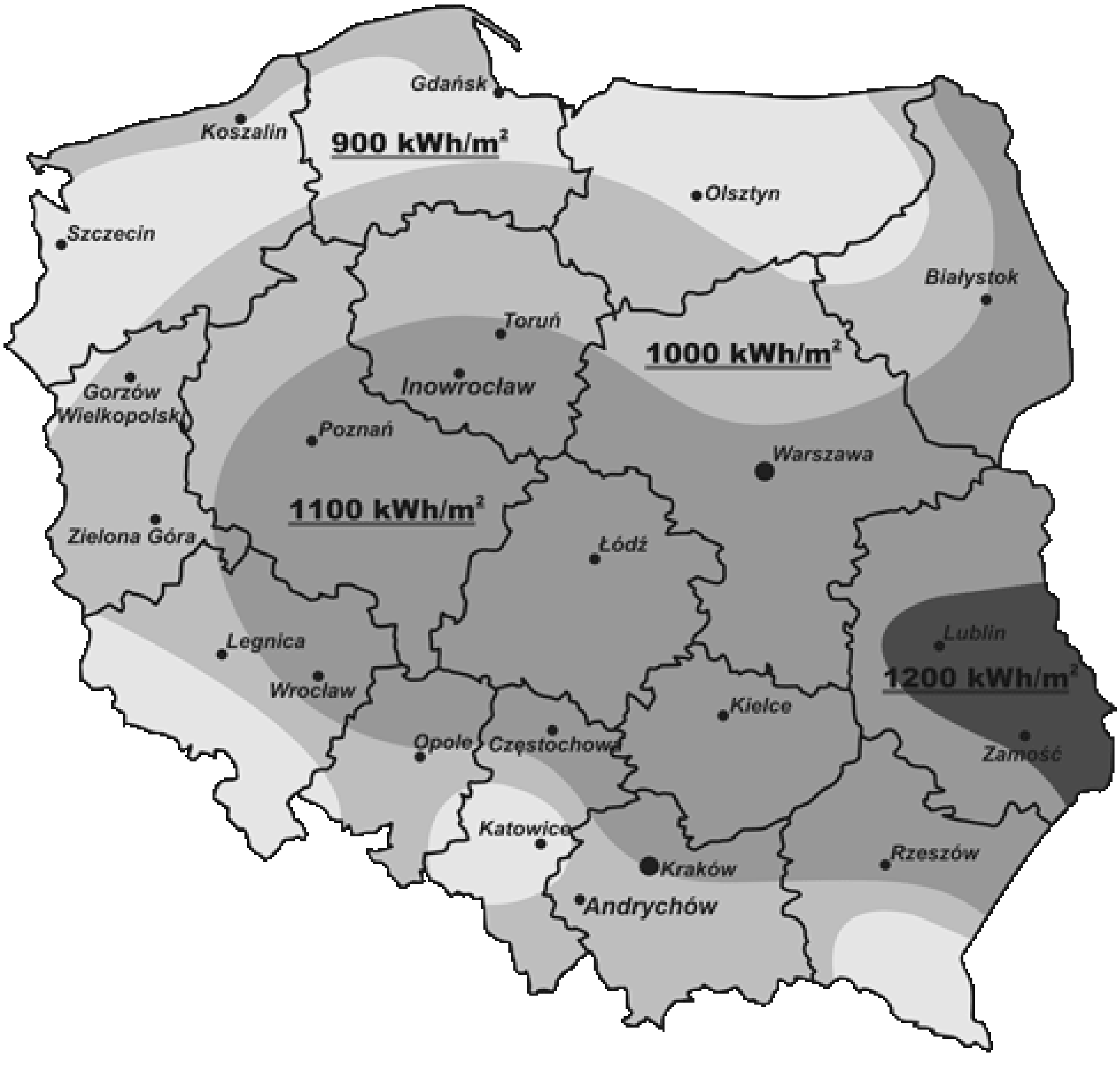
The dominant component of the Earth's energy balance is solar radiation (Jastrzębska 2013: 25). The solar energy potential exceeds the total global energy demand by as much as 15,000 times.

As can be seen from the map of the average insolation values (Figure 1), Poland insolation ranges from 900 kWh / m^2 to 1200 kWh / m^2. The Rzeszów Functional Area is located in an area of 1100 kWh/m2 of insolation. This places the ROF in second place in terms of irradiance in Poland.

Taking into account the map of average sunshine values (Figure 2), Poland is in the range of 1400 h to 1700 h. In the Rzeszów Functional Area, sunshine values are in the range of 1500 - 1550 h.

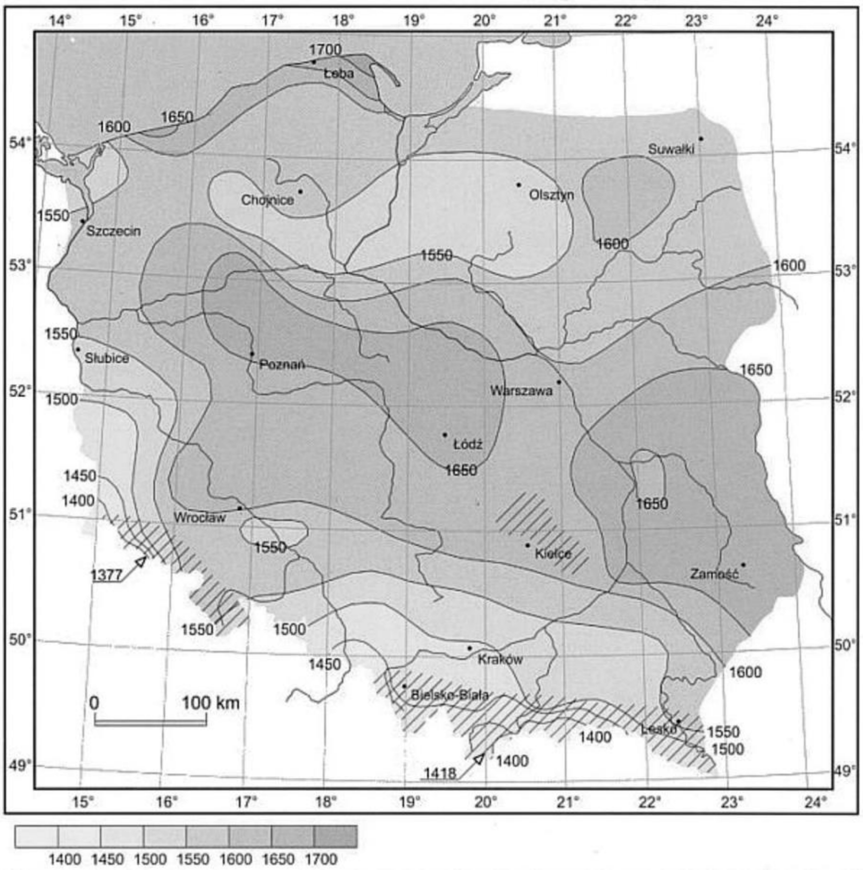
The above analysis of solar energy potential shows that the Rzeszów Functional Area has good solar conditions, therefore the development of solar energy in its area is a purposeful and appropriate measure to achieve the objectives of the climate and energy package, while having a positive impact on the operation of power grids and stimulating their essential modernisation.

Figure 1: Map of average insolation values in Poland



Source: http://azenergia.pl/dla-domu/fotowoltaika-turbiny-wiatrowe/mapa-naslonecznienia/

Figure 2: Map of average sunshine values in Poland



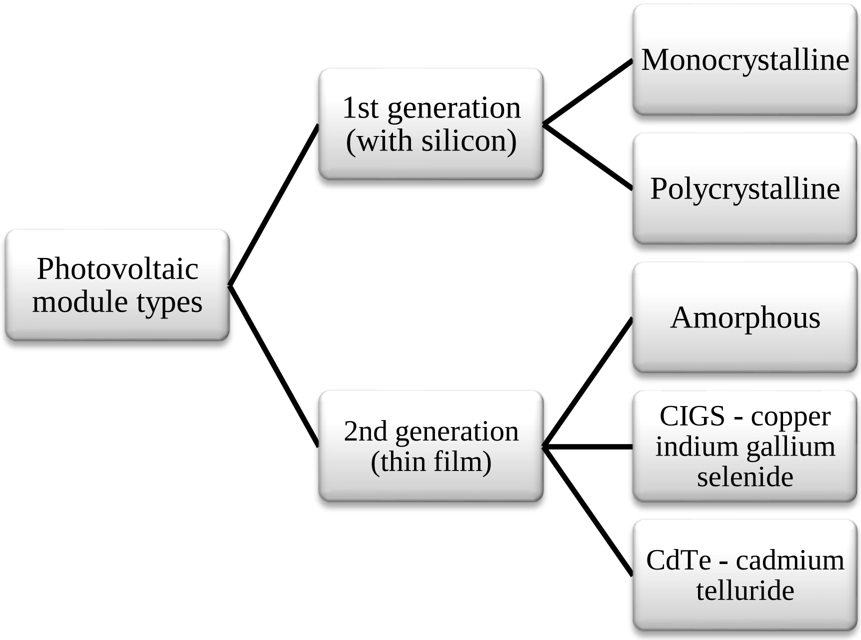
Source: Lorenc H, Atlas klimatu Polski., Instytut Meteorologii i Gospodarki Wodnej, Warsaw 2005.

Types of photovoltaic cells to be installed in the ROF area

Currently, several generations of photovoltaic cells are available on the market. In the ROF area, within the framework of projects, co-financing was and is provided for the purchase of both monocrystalline and polycrystalline cells, i.e. first generation silicon photovoltaic cells (Figure 3), creating installations of various capacities ranging from 3 kW (households) to over 1.2 MW (the Urban Water and Sewerage Enterprise Ltd. in Rzeszów). Mono- and polycrystalline cells are produced by cutting out elements from monocrystal and polycrystal with a thickness of approximately 200 µm (Purgał, Orman 2012: 73). Currently, more than 90% of produced photovoltaic modules are mono- and polycrystalline cells. In the ROF area, the installation of monocrystalline cells prevails. The main advantages of monocrystalline cells are greater power per unit area, and their smaller size and greater efficiency in comparison to polycrystalline cells.

Considering the price aspect, polycrystalline cells are cheaper but have a lower power output per unit area and larger sizes. The selection of the cell should be personalised to the technical specification of the object/building and the function it performs.

Figure 3: Types of photovoltaic cells



Source: Own calculations based on [1, 2, 5] .

Problems related to the functioning of photovoltaics in the ROF area

The application of RES solutions based on photovoltaic cells on an individual as well as public scale does not seem to present any technological problems related to the installation and operation of the installation. Of course, it is still difficult to store the energy produced on a massive and long-term scale due to financial (very high price) and technological reasons. It is to be expected that this problem will soon be resolved as technology advances. At present, the role of buffer and storage for generated and unused electricity is played by the energy grids, whose continuous development and modernisation is indispensable for efficient use of RES. Importantly, in the case of residents, educational facilities and public utility facilities, it is possible to balance accounts with energy suppliers by including energy produced and discharged to the grid in the settlement of consumed electricity – resulting in a reduction of incurred costs. For other entities it remains to sell excess energy. Both solutions are regulated by law in Poland, giving a certain stability in the long-term perspective.

System support for the installation of photovoltaic installations in the Rzeszów Functional Area within the ZIT ROF

Poland is obliged to increase the share of energy produced from renewable sources in the energy balance to 20% by 2020. Achieving this goal requires a significant and immediate increase in the number of projects in this sector. Therefore, the development of investments in photovoltaics seems to be advisable and justified. For this goal to be achievable, strong incentives such as favourable legal solutions, but also significant financial support (especially for residents) are necessary.

On 1 January 2019, the *Act of 9 November 2018 amending the Act on Personal Income Tax and the Act on Lump-sum Income Tax on Certain Income Generated by Individuals* (Journal of Laws Dz.U. of 2010, No. 33, item 259, as amended) entered into force. 2246), which includes thermal modernisation relief concerning personal income tax payers, and those paying tax according to the tax scale and paying a lump sum on registered revenues, being the owners or co-owners of single-family residential buildings in which thermal modernisation has been performed (including installation of photovoltaic installations). This relief consists in the deduction from income of expenses related to the implementation of thermomodernisation projects. The maximum limit of deduction per one time will be 53 000 PLN. However, the possibility of using the right to discounts when balancing the energy produced by the installations and unused energy in the long-term perspective, is also provided by the *Act of 22 June 2016 amending the Act on Renewable Energy Sources and certain other acts* (Journal of Laws 2016: 925). According to this law, it is possible to recover from 0.7-0.8 the value of energy produced by the installations, but not yet used and fed into the power grid.

It is worth noting that the effective co-financing for photovoltaic investments in the ROF area from the ZIT instrument exceeds 70% on average (VAT is not an eligible cost and is not subject to co-financing), which seems to be a sufficient incentive for both public entities and residents to undertake such investments. The table below (Table 1.) shows that the EU co-financing of projects is high (for the project: "Support for RES development in the ROF – umbrella project" it amounted to PLN 35.64 million, and for the project: "Increasing the share of energy from renewable sources in the ROF" it amounted to PLN 12.09 million). This level of co-financing at current energy prices means that the investment should pay for itself within a period of about 4 years, which, with a minimum of 15 years of installation life, is an additional incentive. The announced and unavoidable increases in electricity prices in the coming years will only accelerate the return on investment and increase its profitability.

Table 1: List of RES projects within the ZIT ROF

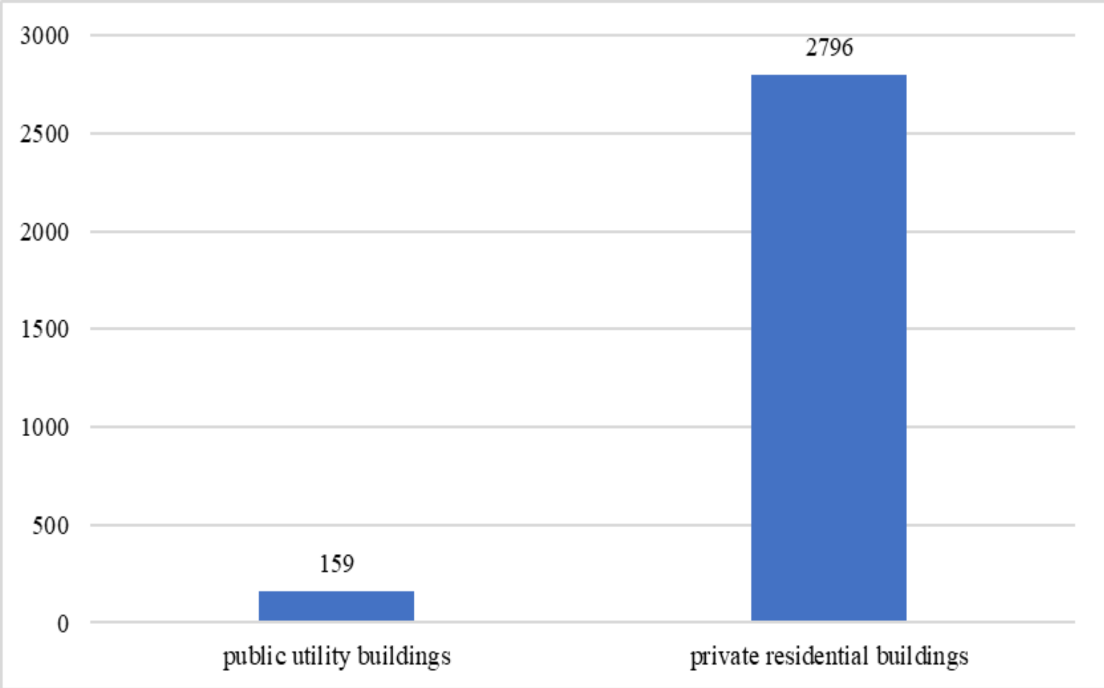
Project title	Beneficiary title	Project value (in PLN)	Value of EU co-financing (in PLN)	EU co-financing rate (in percent)
Support for RES development in the area of ROF – „umbrella project”	ROF ASSOCIATION	45.41 M	35.64 M	up to 85% of eligible costs
Increasing the share of renewable energy in the area of ROF		22.53 M	12.09 M	

Source: Own elaboration based on [2].

Analysis of the impact of the use of photovoltaic cells in the ROF area

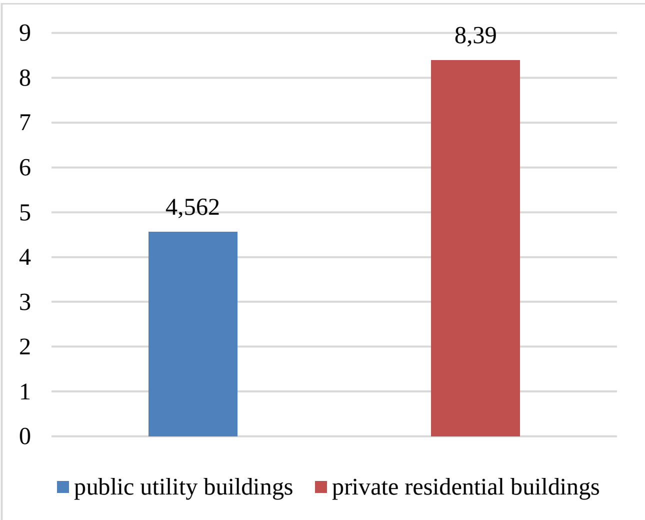
Taking into account the quantity and capacity of photovoltaic installations already installed and planned in the following years (Figure 3.) on public buildings and properties (including buildings) of the inhabitants in the ROF area, only in the framework of joint activities of ROF municipalities (including their municipal companies) within ZIT in 2018-2021 the total initial electricity generation capacity will exceed 12 MWe (Figure 4.).

Figure 3: Number of photovoltaic installations planned to be installed in 2018-2021 in the Rzeszów Functional Area within ZIT ROF



Source: Own calculations based on [1, 2, 5] .

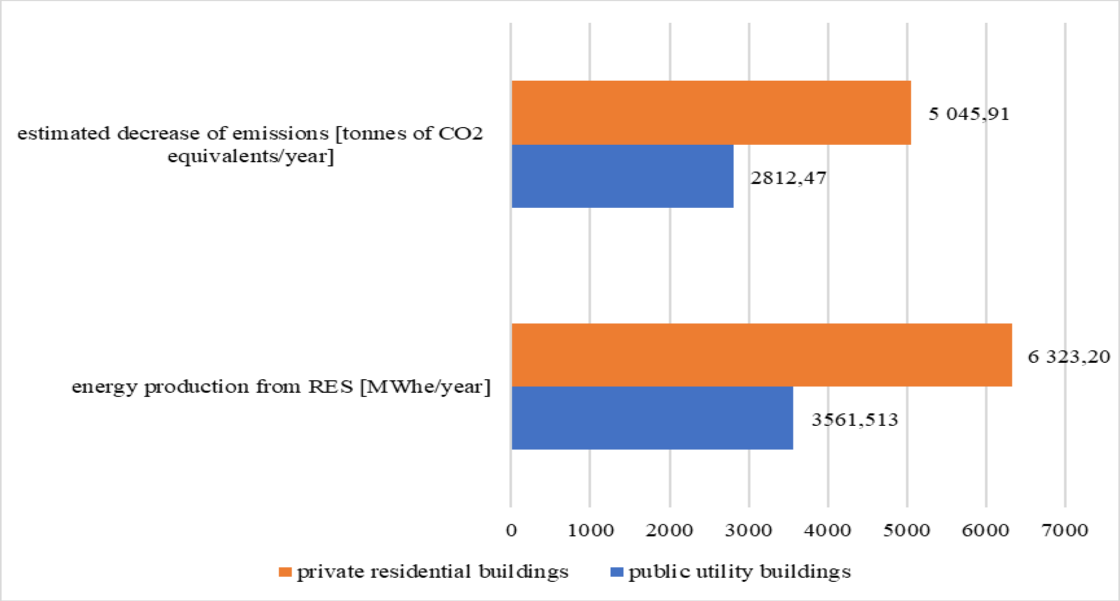
Figure 4: Total initial electricity generation capacity in [MWe], by installations planned to be installed in 2018-2021, in the Rzeszów Functional Area within the ZIT ROF



Source: Own calculations based on [1, 2, 5] .

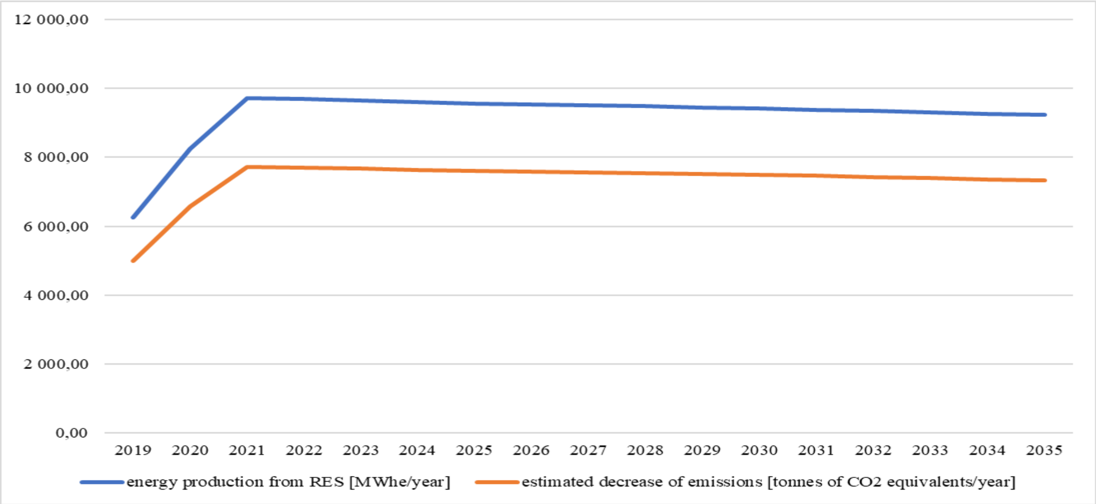
Taking into account the investment process spread over the years 2018-2020 and the assumed and natural decrease in cell efficiency over time (the annual decrease in installation efficiency was assumed to be 0.3 or 0.4% per annum), the amount of renewable energy sources possible to generate electricity was estimated and the corresponding decrease in CO_2 emissions by 2035 (Figure 5, Figure 6). Both parameters undoubtedly confirm that the measures taken will directly increase renewable energy production and reduce greenhouse gas emissions, as well as improve energy efficiency by reducing the need for fossil fuels.

Figure 5: Total initial decrease in CO_2 emissions and production of electricity from RES (for installations planned to be installed in 2018-2021) in the Rzeszów Functional Area within ZIT ROF.



Source: Own calculations based on [1, 2, 5] .

Figure 6: Estimated decrease in CO_2 emissions and planned production of electricity from RES in 2018-2035 in connection with the installation of photovoltaic installations in the Rzeszów Functional Area within ZIT ROF



Source: Own calculations based on [1, 2, 5] .

Summary

It is worth noting that it is still necessary to provide systemic support (mainly grants – non-refundable aid) for RES implementation activities, because only well-thought-out incentives at this stage seem to be the best factor stimulating further investments, although undoubtedly the reduction of maintenance costs is equally important and certainly in the coming years it may prove to be an important argument for many investors in itself. As a result of the implementation of the first stage of the "Umbrella Project" and the "Increasing the share of energy from renewable sources within the ROF" project, applications from 2,796 private residential buildings and 159 public buildings for co-financing the installation of photovoltaic cells qualified until 2021. At current prices of photovoltaic installations, the payback time (from energy savings) for RES is still too long and the economic aspect related to the impact on the environment and its degradation on local communities is insufficiently motivating. The application of modern strategies for diversification of energy sources with the use of photovoltaic cells in the ROF area will contribute in the years 2019-2035 to:

1) reduction in CO2 emissions by 124,547.95 tonnes of CO_2 equivalent;
2) increase in electricity production from RES by 156,619.76 MWhe;
3) reducing the use of fossil fuels to produce electricity by increasing its production from RES.

In this context, it is advisable to continue the implementation of the RES implementation strategy in the ROF and to monitor the effects achieved in subsequent years. The multidimensional and multifaceted approach to the RES implementation strategy will allow the actual energy and environmental effects to be verified. It is to be hoped that in the near future cheap and efficient RES energy storage will also be available, because at the moment electricity generated from most RES is not available on demand, as is possible with conventional power engineering. Undoubtedly, it is important that measures (including investments) related to the use of RES should be inspired and carried out at the supra-regional, regional and local levels. This also applies to all measures aimed at improving energy efficiency in all areas of life. It is very important that investment activities are accompanied by, and often preceded by, activities raising institutional and civic awareness, emphasising the changes taking place and showing the necessity and inevitability of adaptation to the changes taking place.

Bibliography

1. Internal documentation provided by the ROF Association.
2. information obtained from the Rzeszów Functional Area Association during an in-depth interview with a Member of the Board - I Vice President.
3. Jastrzębska, G., Ogniwa słoneczne. Budowa, technologia i zastosowanie., Wydawnictwo Komunikacji i Łączności, Warszawa 2013
4. Lorenc H, Atlas klimatu Polski., Instytut Meteorologii i Gospodarki Wodnej, Warszawa 2005
5. Materials of the ROF Association – rof.org.pl (access: 19.04.2019)
6. Purgał P., Orman Ł. J., Korzystanie z odnawialnych źródeł energii, Wydawnictwo Politechniki Świętokrzyskiej, Kielce 2012
7. Sarniak M. T., Podstawy fotowoltaiki, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2008

8. Website: azenergia.pl/dla-domu/fotowoltaika-turbiny-wiatrowe/mapa-naslonecznienia/ (accessed: 19.04.2019)
9. Website: ec.europa.eu (accessed: 19.04.2019)
10. Website: rpo.podkarpackie.pl (accessed: 19.04.2019)
11. Uchwała Nr XXXVII/697/13 Sejmiku Województwa Podkarpackiego w Rzeszowie z dnia 26 sierpnia 2013 roku
12. Ustawa z dnia 22 czerwca 2016 roku. o zmianie ustawy o odnawialnych źródłach energii oraz niektórych innych ustaw, (Dz.U. 2016, poz. 925)
13. Ustawa z dnia 9 listopada 2018 roku o zmianie ustawy o podatku dochodowym od osób fizycznych oraz ustawy o zryczałtowanym podatku dochodowym od niektórych przychodów osiąganych przez osoby fizyczne, (Dz.U. 2018, poz. 2246)
14. Wolańczyk F., Jak wykorzystać darowaną energię, Wydawnictwo KaBe, Krosno 2011

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ANALYSIS OF THE HUNGARIAN GAS SECTOR– PRESENT SITUATION AND FUTURE PROSPECTS

Przemysław Ogarek

Abstract

The main aim of this article is to determine the level of security of supply of the Hungarian natural gas sector and to provide forecasts of the potential sources of oil imports by 2025. The research questions posed by the author relate to self-sufficiency of the domestic gas sector, a high level of dependence on supplies from the east, the lack of diversification of suppliers in the market, and the impact of the possibilities of re-gasification of underground natural gas storage facilities to improve energy security in Hungary. The research hypothesis of the paper was that the level of self-sufficiency of the gas sphere will remain at a constantly low level, that the security volume will decrease until new gas supply routes are established, and that the role of underground gas storage facilities as a result of highly probable loss of transport through the territory of Ukraine will be crucial. In order to solve the research problem and obtain answers to the questions raised, the following energy indices were used: self-sufficiency index, Herfindahl Hirschman index, Residual Supply Index, and the ratio of underground storage capacity of raw material to quarterly demand for fuel. The source of information and data used, due to the lack of many current studies on Hungary's energy security, are reports of national and European energy organizations, as well as reliable industry portals rich in current information. The conclusions of the analysis show that Hungary is a country highly dependent on imports from the East and that its security of supply will decrease significantly as a result of the political turmoil between Ukraine and Russia. Underground storage facilities will be responsible for maintaining a safe gas volume in the demand of the domestic economy in the near future. And the more distant future of the Hungarian gas industry will continue to be connected mainly with the eastern exporter. This will be facilitated by the Turkish Stream connection and possible supplies from Nord Stream II.

Keywords: Natural Gas, Hungary, Energy Security, Turkish Stream

Introduction

The characteristics of the European natural gas sector can be divided into two groups. The western one, which is independent of supplies from the Russian Federation, and the eastern one, which is quite heavily dependent on gas imports from the fields of the eastern giant. The monopoly prevailing in the markets of the dependent countries usually has a rather negative impact on the structure of supplies. This is mainly due to their continuity and price, which is often very high due to low competition on the market (Turowski, 2016: 165-166). As a result of these characteristics, most Central and Eastern European countries are pursuing a diversification policy aimed at achieving the greatest possible diversification of their supplier structures. Such measures are currently very popular on the gas market and are supported by many different types of EU instruments, such as the Connecting Europe project or the Trans-European Energy Networks (TEN-E) programme (Gawlikowska, 2007: 6). An analysis of the actions of some EU member states shows that not every state dependent on supplies from the East minimises the share of the dominant supplier in relation to other sources. One of the countries of this type is Hungary, which, despite the fact that this part of Europe is subject to significant influence from Russia, acts quite differently from the plans of Europe in general. Planning to maintain a high share of supplies from the eastern tycoon. This article describes the current state of the gas sector in Hungary. It was determined how the supplies from the Russian Federation influence the level of energy security of the country. The resistance of the system to supply interruptions was tested. And the main factors specific to Hungary's energy policy were identified.

The general characteristics of the hungarian gas sector

Natural gas is a key raw material for Hungary's energy sector. In primary energy production, it ranks first. With a result of 33%, it outperforms the equally popular crude oil by 4% and by 16% the dominating atom in particular in the power industry (OECD, 2019: 1). Gas consumption in 2018 in Hungary amounted to (9.6 bcm) (BP, 2019: 34). This is a relatively small amount compared to the annual levels of blue fuel consumption of other countries in the region: Germany (75.9 bcm), Poland (17 bcm), Ukraine (26.3 bcm) (BP, 2019: 34). In Hungary, domestic demand for natural gas is falling slightly year on year. In relation to 2017, it decreased by 0.3 bcm, and over the last decade its volume decreased by 25% (2.7 bcm) (BP, 2019: 34). The domestic natural resources of the raw material are quite small and, according to the latest research, they are estimated at 1,639 bcm (MBFSZ, 2017). However, only 74 bcm of gas is stored in conventional deposits, and the remaining 1,565 bcm are difficult to extract and at the same time have low economic potential – unconventional deposits, including traces of shale gas, closed gas and methane deposits in coal deposits. Such scarce conventional sources do not allow for large annual production of raw materials. As a result, in 2018 it amounted to 1.73 bcm, which satisfied only about 18% of the total domestic demand (FGSZ, 2018: 18). The remaining amount of fuel, unattainable from its own production, was obtained from imports, which in base year 2018 reached 12.64 bcm (FGSZ, 2018: 19). The structure of blue fuel suppliers has been dominated by one major exporter. The Russian Federation, which last year sent to Hungary (7.69 bcm) (Gazpromexport, 2019), thus gaining about 60% of shares in Hungarian natural gas imports. As in previous years, the remaining transports of raw materials came from Germany and Austria.

In 2018, Hungary also played the role of an exporter on the European gas market. They are a transit country through which Russian gas is transported to other neighbouring regions of Europe, e.g. Croatia, Romania and Serbia. In 2018, the export volume amounted to (4.97 bcm) (FGSZ, 2018: 28). The receipt and transmission of raw material from outside the country was made possible by 7 interconnectors (ENTSOG, 2017). This includes 4 receivers (Fig. 1): Beregdaróc - 219 - (from Ukraine) 22.6 bcm, Balassagyarmat - 75 - (from Slovakia) 4.74 bcm, Csanádpalota - 57 - (from Romania) 0.09 bcm, Mosonmagyaróvár - 47 - (from Austria) 5.72 bcm, with a total capacity of 33.15 bcm, and 3 transmitters: Csanádpalota - 57 - (to Romania) 1.92 bcm, Drávaszerdahely - 58 - (to Croatia) 2.84 bcm, Kiskundorozsma - 48 - (to Serbia) 5.31 bcm, with a total transmission capacity of 10.07 bcm.

Figure 1: Transmitting and receiving points in Hungary

Source: https://www.entsog.eu/maps#transmission-capacity-map-2017 (20.06.19)

The Hungarian internal gas system consists of 5,873 km of high-pressure transmission routes connecting 7 main gas compressor stations and approximately 400 regional supply points (Figure 2) (FGSZ, 2018: 12). Importantly, in the area of energy security, the gas sphere of Hungary includes four underground blue fuel storage facilities: Zsana (2.17 bcm), Hajdúszoboszló (1.64 bcm), Pusztaederics (0.34 bcm), Kardoskút (0.28 bcm), whose regasification capacities reach 4.43 bcm (MGFT, 2018). The amount of gas stored in comparison with the domestic demand creates quite a rich emergency resource base.

Fig. 2 . Hungarian national gas system

Source: Own study based on FGSZ, Data of the Hungarian natural gas system, p. 18.

Energy security analysis - indicators

Starting the analysis of Hungary's energy security, it is worth focusing on the basic determinant of the level of energy security, which is the self-sufficiency rate (Ruszel, 2017: 7). The final result of the index used consists of domestic production of natural gas and the demand for blue raw material achieved in the analysed period of time. For the data from the audited year 2018, the value of the ratio was 18.02%. This result confirms the fact that due to such low extraction of raw material, the Hungarian economy is not able to function independently, efficiently and is forced to obtain gas from abroad. At the same time, it exposes itself to high costs, political influence on the part of exporters and, most importantly, the possibility of occurrence of raw material crises related to unexpected interruptions in fuel supply. Focusing on the future, it is necessary to take into account the downward trend in the country's demand for natural gas, which has been in place for several years. Therefore, if the current production level is maintained, the self-sufficiency ratio will be able to slightly increase. Mainly as a result of lower demand for gas imports. However, given the current trend towards the abandonment of hard coal and the huge role of natural gas as a transitional fuel in the modernisation of energy production, this scenario may change significantly as a result of increased consumption.

Formula 1: Self-sufficiency ratio

$$\text{WS} = \frac{1.73 * 100\%}{9.6} = 18.02\%$$

Where:

Domestic natural gas production in 2018 (FGSZ, 2018: 18) - 1.73 bcm

Domestic demand for natural gas in 2018 (BP, 2019: 34) - 9.6 bcm

Currently, the situation related to the acquisition of raw material supplies by Hungary is quite complicated. The Russian Federation's transit through Ukraine is under threat. The agreement between the Ukrainians and Gazprom has still not been extended and if the parties do not reach an agreement, its validity will expire on January 1, 2020 and Hungary will be cut off from the main source of imports (Cire, 2019). If no fuel is obtained from the East, stocks accumulated in relatively abundant gas storage facilities will probably be a defence against the negative effects of this phenomenon. However, this will be a temporary solution. And the period until the start of operation of the newly implemented gas pipeline projects, which are a plan for the future, including (Turkish Stream, Nord Stream II, LNG port on the island of Krk), has been extended for the time being. It is therefore necessary to focus on the most dangerous threat that may arise in the near future, namely the possibility of interruptions in imports. Analysing this fact, the question immediately arises: how could the Hungarian gas system function if supplies from its most important exporter are lost? Would the economy there still be able to function smoothly or would there be a serious crisis. In the base year 2018, the Russian Federation had the largest share in the fuel supply mix. Importing 7.69 bcm of raw material to Hungary (Gazpromexport, 2019). In relation to all imports in that period of time (12.64 bcm), this represented almost 60% of the total volume of fuel obtained. To assess the level of readiness of the Hungarian gas sector in this respect, it is worth using the RSI index (ACER, 2017: 11) created by ACER, which takes into account the total import of gas, domestic production, gas storage capacity, import volume from the supplier with the largest market share and the level of demand for a given fuel in a given year. The collected data allow us to examine the fact in case of loss of deliveries from the exporter with the largest share in the receiving department. The gas sector will be able to secure the necessary amount of gas from another direction. In the audited year 2018, assuming that gas storage facilities were full, the index volume reached 115.8%, which is a seemingly high value. Providing security in the event of a shortage of supplies from the East. However, one important aspect should also be taken into account. The export of the raw material includes the part of the gas that is exported further inland to Southern Europe. According to data from the analysed period, 4.97 bcm of natural gas was exported. Given this reduction in domestic volume, the Residual Supply Index would have fallen to 63.95%. As a result, in a blue fuel dependent sector, there would not be an excessive crisis but only if the underground gas storage facilities were full at that point in time. Filling the receiving capacity of the warehouses to the maximum in the current situation is a priority for Hungarians. And their activities since 2018 have been aimed at fulfilling this plan. This is evidenced, for example, by the agreement with Gazprom under which exports of raw materials were increased by 2 bcm (Biznesalert, 2019).

Formula 2: Residual Supply Index

$$\mathrm{RSI}_{2018} = \frac{18.8 - 7.69}{9.6} * 100\% = 115{,}8\%$$

Where:
Volume of natural gas acquired in 2018 (FGSZ, 2018) - 14.37 bcm
Gas stored in underground storage facilities (MGFT, 2019) - 4.43 bcm
Imports from the Russian Federation in 2018 (Gazpromexport, 2019) – 7.69 bcm
Total gas resources owned - 18.8 bcm
Domestic demand for natural gas in 2018 (BP, 2019: 34) - 9.6 bcm

In the event of a significant shortage of fuel, Hungary should look for opportunities to obtain raw material from other locations than Ukraine. Analysing the capacity in relation to the directions of supply, it turns out that Hungary currently operates in the rather unfavourable international characteristics of cross-border gas connections. They have 4 reception points. The largest of them connects the Hungarian gas system with Ukraine with a capacity of 22.6 bcm, the next largest on the border with Austria with a regasification capacity of up to 5.72 bcm, the next with Slovakia with a capacity of 4.74 bcm and the last with a very low off-take capacity connecting Hungary with Romania with a capacity of only 0.09 bcm (ENTSOG, 2017). The determination of the level of competition and the diversity of the sources of origin of the pipelines transporting gas to the interconnectors shows a study of capacity against supply directions using the Herfindahl Hirschman Index (Kosciuszko Institute, 2010: 22), which has a limit value between 0 and 10 000. Where 0 indicates a free market, great competition, values between 1 800 and 2 500 with high market concentration, a result above 2 500 with low competition and a limit value of 10 000 indicates that the market in question is fully monopolised. For 2018, the HHI volume amounted to 5150.6378, which confirms the fact that there is quite a high monopoly in the Hungarian receiving sector. The receiving capacity is dominated by the eastern direction, whose shares amount to 68.18%. And when analysing supplies from other directions, it can be concluded that they also indirectly inject or could inject gas from Russia into the Hungarian economy, since their gas systems also rely mainly on supplies from this global potentate. This includes the Austrians at around 75%, Slovaks around 75%, Romanians around 75% (Eurostat, 2018: 9). As a result, there is a problem because Denmark held back the Nord Stream II project and the start of pumping gas may be significantly delayed (Energetyka24, 2019). The construction of the South Turkish Stream is also still in the process of signing agreements and the completion of its construction and operation is unknown. The implementation of the last of the plans was stared but Hungary must wait for sourcing natural gas to 2021 year. With the begin exploatation in 2021 of Croatia's 2.6 Bcm/year LNG import terminal at Krk, Hungary will be able to source close to 1.6 bcm regasified LNG per year. Qatar may be one of the gas suppliers. This is for now only one project which can may to some extent change the current situation in Hungarian gas system. (S&Pglobal, 2019)

Formula 3: Capacity in relation to delivery directions - HHI

$$\text{HHI} = (14.3)^2 + (17.25)^2 + (68.18)^2 + (0.27)^2 = 5150.6378$$

Where (ENTSOG, 2017):

North 4.74 billion bcm - 14.3%
West 5.72 bcm - 17.25%
East 22.6 bcm - 68.18%
South 0.09 bcm - 0.27%

As a result of so much perturbation, it is important to wait for things to move forward. In the case of Hungary, it is important to prepare for even the most negative scenario. It is therefore worth looking at the underground storage facilities for natural gas. They are a priority element of the country's gas sphere, which has a positive impact on the level of energy security. And it is a factor that minimises the risks associated with the effects of an overly monopolised import sector. As mentioned earlier, they are relatively abundant in regasification capacity. Their capacity reaches 4.43 bcm (MVMgroup, 2019), which, given the demand in 2018 of 9.6 bcm (BP, 2019: 34) is a considerable amount. And when comparing the active capacity of underground gas storage facilities with the average quarterly domestic demand (Kosciuszko Institute, 2017: 14), it turns out that the maximum offtake capacity exceeds the value of energy sector needs in a given quarter (184.58%). This has a very positive impact on the level of security and reduces the effects of gas crises. Such as the one in 2009 as a result of the conflict between Russia and Ukraine, for example. Hungary used its strategic reserves and was forced to reduce the use of blue raw material by industry (Ruszel, 2015: 52-54). When analyzing this energy index, it is worth paying attention to the consumption of raw material in individual quarters. The highest gas consumption in Hungary in 2018 occurred in the 1st and 4th quarter (4.03 bcm, 3.26 bcm), in the 2nd and 3rd quarter gas consumption was (1.34 bcm, 1.24 bcm). In 1st and 4th quarters, the country's gas sector was most burdened and threatened in the event of unexpected interruptions in supply because gas consumption was higher. However, as the calculations confirm, the Hungarian gas sector could still work well with potentially full gas storage (coefficient value: 1st quarter - 110.7%, 2nd quarter - 346.76%, 3rd quarter - 369.1%, 4th quarter - 138.4%).

Formula 4: Summary of storage capacity and quarterly demand for raw material

$$\text{PMG} = \frac{4{,}43}{2{,}4} * 100\% = 184{,}58\%$$

$$\text{PMG(1stQ)} = \frac{4.43}{4} * 100\% = 110.7\%$$

$$PMG(2ndQ) = \frac{4.43}{1.3} * 100\% = 340.76\%$$

$$PMG(3rdQ) = \frac{4.43}{1.2} * 100\% = 369.1\%$$

$$PMG(4thQ) = \frac{4,43}{3.2} * 100\% = 138.4\%$$

Where:
Capacity of underground natural gas storage facilities (MVMgroup, 2019) - 4.43 bcm
Average quarterly gas demand in 2018 (BP, 2019: 34) - 2.4 bcm
Gas demand 1st quarter 2018 (FGSZ, 2018 : 30) - 4.03 bcm
Gas demand 2nd quarter 2018 (FGSZ, 2018: 30) - 1.3 bcm
Gas demand 3rd quarter 2018 (FGSZ, 2018: 30) – 1.2 bcm
Gas demand 4th quarter 2018 (FGSZ, 2018: 30) – 3.26 bcm

Summary - current hungarian gas policy

Hungary's policy towards the natural gas sector differs significantly from the policy promoted in the European Union, which the majority of its members are implementing. One of the main characteristics of Hungarian activities is cooperation with the Russian Federation. Unlike the other countries of Central and Eastern Europe, this country supports the energy strategy of the eastern state. This includes, inter alia, the expansion of new supply routes, opposition to the creation of transport routes for raw materials freem from Russian influence, cooperation with EU Member States in the field of fuel distribution to increase sales and attempts to take over shares in European energy infrastructure (Brodacki, 2017: 50-57). Hungarian politicians have for some time been trying to support Russian interests, support Russian ideas and even suggest in the European community that economic sanctions imposed on the Russian Federation should be abandoned (Forsal, 2018). According to year-on-year statistics, the share of Russian natural gas in Hungary is steadily increasing (Gazpromexport, 2019). It would seem that the current characteristics of Russian activities in the gas arena of the Hungarian region are not very favourable to them. The Eastern giant plans to withdraw from the extension of the agreement for transit through Ukraine and complete cut-off of supplies through the local transmission routes. Although talks are under way between Ukrainians and Russians, in which the European Commission is also taking part, it is very difficult to reach a final agreement because of the huge differences in interests. Despite the enormous risk of losing the main source of supply, Hungary is not against abandoning this import route and already consumes an additional 2 bcm of gas annually to fill its storage facilities and meet its domestic needs at this transitional stage (AboutHungary, 2019). This will consist of the loss of supplies from the territory of Ukraine in favour of sourcing from the same eastern supplier via the planned branch of Turkish Stream at the border with Serbia and possibly the Austrian hub Baumgarten, whose transmission capacity will be increased by the continuously expected start of exploitation of the Nord Stream II gas pipeline. Currently, the works related to the implementation of the first project (Turkish Stream) are in the commencement phase. The gas pipeline route will run through Turkey, Bulgaria and Serbia and will deliver gas to Hungary and Slovakia. The Hungarian Foreign Minister and the Serbian Energy Minister have already signed a joint agreement on the implementation of this project. Initially the plan is to start construction in summer 2020 and end it in the last quarter of 2021 (Biznesalert, 2019). If everything is completed as planned, the new connection may provide Hungary and Slovakia with up to 15 bcm of gas annually, replacing their existing supplies from the territory of Ukraine (Warsaw Institute, 2019). In the case of receiving deliveries from the second project, the situation is more complicated. The execution of the project is currently prolonged due to perturbations connected with the transition of NS II infrastructure through the territory of Denmark (Energetyka24, 2019). As a result, the start of gas production from that direction may be postponed. And what is also important is that it has not yet been officially confirmed whether there will certainly be a transfer of gas from the northern gas pipeline to Hungary.

These two strategic solutions confirm the fact that Hungary does not intend to diversify its natural gas suppliers, and its future is still linked to the Russian Federation. This is probably caused indirectly by a kind of coercion resulting from the lack of connections with routes independent of Russia and signing short-term agreements with eastern partners tempting with low gas prices, without the "take or pay" clause existing in previous years, which brings huge savings (1,500 billion ft/year) (Biznesalert, 2019). When talking about the current policy of Gazprom's southern European customer, it is worth mentioning that, although the Hungarian energy policy is highly pro-Russian in nature, they are beginning to look for other independent suppliers. An example of this is the willingness to agree with Croatia on the construction of infrastructure and the transport of raw materials from the LNG port on the island of Krk. Such an investment could enable them to obtain supplies from currently unavailable overseas countries. Everything is currently at the realization stage. If the process of creating connections can be successfully completed, from 2021 the Hungarian gas sector will be able to obtain 1.6 bcm of natural gas annually (probably from Qatari sources).

To sum up, the Hungarian gas sector is facing a major modernisation. In the next few years, the characteristics of the system have the opportunity to change significantly. Hungary is a country highly dependent on the activities of the Russian Federation. However, as you can see, they are not trying to totally reverse the situation. This is mainly due to the fact that doing business with Russia is, for the time being, economically and strategically profitable for them, and due to the existing infrastructure, also somewhat forced. As far as the assessment of their gas system is concerned, like most of the countries in the region, their supply routes connect mainly with the eastern direction. Their gas market is quite strongly monopolised. The advantages of their gas sphere include relatively large underground natural gas storage facilities.

Bibliography

1. Acer, *Statistical compendium of ACER Gas Target Model metrics for the year 2016*
2. BP, *BP Statistical Review of World Energy 2019*
3. Brodacki D., *Współpraca gazowa Federacji Rosyjskiej z Rzeczpospolitą Polską*, „Polityka i Społeczeństwo" 2017
4. Eurostat, *Eu imports of energy products – recent development*, 2018
5. FGSZ, Data of The Hungarian natural gas system 2018
6. Gawlikowska Fyk A., *Transeuropejskie sieci energetyczne,* „Biuletyn Urzędu Regulacji Energetyki" 2007, nr 5
7. Hungary signs new gas deal with Russia, http://abouthungary.hu/news-in-brief/hungary-signs-new-gas-deal-with-russia/ (access: 13.07.19)
8. Hungarian Gas Storage Ltd.,http://mvm.hu/mvm-group/hungarian-gas-storage-ltd/?lang=en (access: 14.07.19)
9. Underground storage facilities in Hungary, http://www.magyarfoldgaztarolo.hu/en/Tevekenysegunk/Gaztarolok (access: 14.07.19)
10. Orban przedłuża umowę gazową z Putinem,https://biznesalert.pl/orban-przedluza-umowe-gazowa-z-putinem-daje-prztyczka-opozycji-i-brukseli/ (access: 12.07.19)
11. Węgry i Serbia podpisały porozumienie o budowie gazociągu na potrzeby TurkStream, https://biznesalert.pl/wegry-serbia-gaz-energetyka-turkish-stream-energetyka/ (access: 12.08.19r)
12. Wspólnego stanowiska wobec Nord Stream 2 nie będzie – przez Węgry, https://biznesalert.pl/wspolnego-stanowiska-wobec-nord-stream-2-nie-bedzie-przez-wegry/ (access: 14.07.19)
13. Węgry nie chcą automatycznego przedłużania sankcji wobec Rosji, https://forsal.pl/artykuly/1262849,wegry-nie-chca-automatycznego-przedluzania-sankcji-wobec-rosji-kilka-panstw-w-ue-woli-dialog.html (access: 11.07.19)
14. Inventory of mineral resources,https://mbfsz.gov.hu/en/inventory-mineral-resources (access: 11.08.19)
15. Turecki Potok wkracza do Europy Środkowej,https://warsawinstitute.org/pl/turecki-potok-wkracza-europy-srodkowej/ (access: 11.07.19)
16. Rozmowy trójstronne KE - Ukraina - Rosja będą trwać, https://www.cire.pl/item,186608,1,0,0,0,0,0,rozmowy-trojstronne-ke---ukraina---rosja-beda-trwac.html (access: 11.08.19)
17. Bułgaria wybuduje przedłużenie Turk Stream, które ominie Ukrainę, https://www.energetyka24.com/bulgaria-wybuduje-przedluzenie-turk-stream-ktore-ominie-ukraine (access: 27.09.19)
18. Dania: Trudno przewidzieć termin wydania zezwolenia na budowę Nord Stream 2, https://www.energetyka24.com/dania-trudno-przewidziec-termin-wydania-zezwolenia-na-budowe-nord-stream-2 (access: 20.08.19)
19. Transmission capacity and system development maps, https://www.entsog.eu/maps#transmission-capacity-map-2017 (access: 14.08.19)
20. Gazprom's year-to-date gas supplies to Hungary exceed 2018 total, https://www.gazprom.com/press/news/2019/october/article489632/ (access: 20.08.19)

21. Hungary eyes Qatari LNG imports via Croatia from 2021, https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/102319-hungary-eyes-qatari-lng-imports-via-croatia-from-2021-minister (access: 14.08.19)
22. IEA, *Energy Policies of IEA Countries – Hungary 2017*
23. Instytut Kościuszki, *Bezpieczeństwo Energetyczne Polski 2010 – Raport Otwarcia,* Kraków 2010
24. OECD, Fossil fuel support country note 2019
25. Ruszel M., *Ocena bezpieczeństwa dostaw gazu ziemnego do Polski – stan obecny i perspektywa do roku 2025*, „Polityka Energetyczna" 2017
26. Ruszel M., *Wpływ rosyjsko-ukraińskich kryzysów gazowych na politykę energetyczną UE – ujęcie teoretyczne,* „Przegląd Politologiczny" 2015, nr 2
27. Turowski P., *Bezpieczeństwo Energetyczne na szczycie NATO w Warszawie: priorytetem dywersyfikacja ropy i gazu*, „Bezpieczeństwo Narodowe" 2016, nr 1

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THE ENERGY CONSUMPTION FORECASTING IN MONGOLIA BASED ON BOX-JENKINS METHOD (ARIMA MODEL)

Gansukh Zolboo, Bor Adiya, Enkhbayar Bilguun

Abstract

The primary products of the power industry are electric energy and thermal energy. Thus, forecasting electric energy consumption is significant for short and long term energy planning. ARIMA model has adopted to forecast energy consumption because of its precise prediction for energy consumption. Our result has shown that annual average electric energy consumption will be 10,628 million kWh per year during 2019-2030 which approximately 3.3 percent growth per annum. At the moment, there is not a practice solution for the storage of electricity in Mongolia. Therefore, energy supply and demand have to be balanced in real-time for operational stability. Without an accurate forecast, the end-users may experience brownouts or even blackouts or the industry could be faced with sudden accidents due to the energy demand. For this reason, energy consumption forecasting is essential to power system stability and reliability.

Keywords: energy forecasting; energy consumption; ARIMA model; Box-Jenkins method.

Introduction

The primary product of the power system is electric energy. Electric energy is the main factor for production, manufacturing and socio-economic activities. Growing technological and social developments are the main influencing factor for high energy consumption. For this reason, the article involves a time series analysis of the annual energy consumption of Mongolia by using ARIMA modeling. The methodology adopted Box-Jenkins method which is an application of autoregressive integrated moving average (ARIMA) modeling for describing discrete data where continuous observations are correlated(Oppenheim 1978). From mathematical point of view, employing the appropriate forecast could improve the decision to be made(Morales et al. 2014). The Box-Jenkins method ARIMA technique has become considerable recognition in recent years in energy-related forecasting(Albayrak 2010; Hor, Watson, and Majithia 2006; Lai et al. 2014; Li, Han, and Yan 2018; Nichiforov et al. 2017). Electric energy consumption forecasting is not only used for defining short or long-term energy supply but it helps for energy system planning and power system expansion. At the same time, energy demand and supply have to be balanced. At the moment, there is not any scientific research on Mongolian energy consumption forecasting. Hence, there are many researchers hypothesis assumed by the previous year's energy consumption.

In this article, we applied a univariate model for forecasting the future annual electricity consumption as a function of prior annual electricity consumption. ARIMA technique is well known for predicting economic variables and widely used for predicting future values of the power industry, health sector and economic activity and many others. Such as, some researchers(Etuk, Eleki, and Sibeate 2016) have established the ARIMA model by extending seasonal autoregressive integrated moving average (SARIMA) for the monthly natural gas production, the result showed some social constraints, as well as infrastructural inadequacies and economic depression, make limitation for production nevertheless its abundant reserve. The same method has used for forecasting Turkish energy demand between 2005-2020(Ediger and Akar 2007), where researchers concluded that the result of ARIMA is more reliable for future energy prediction. Few researchers(Jiang, Yang, and Li 2018) adopted ARIMA model by integrating several similar forecasting models as well as metabolic grey model (MGM) and back-propagation neural network (BP) for more precise prediction of energy usage. Some scholars(Mohamed and Bodger 2004) have proposed six different forecasting models for electricity consumption. According to the result, ARIMA model ranked as the best forecasting technique in short term prediction. Forecasting energy consumption has a vital role in market stability(Jiang et al. 2018) and reliability.

Methodology

Data source

The historical data regarding electric energy consumption during 1990-2018 are collected from the National Statistical Office of Mongolia(National Statistical Office). Considering the current circumstance of energy consumption of Mongolia over 93 percent(World Bank) generated by fossil fuels. Figure-1 shows the trend of energy consumption based on the collected data which shows that energy consumption has an increasing trend in the last 29 years except for early social transition years (1991-1996) of Mongolia.

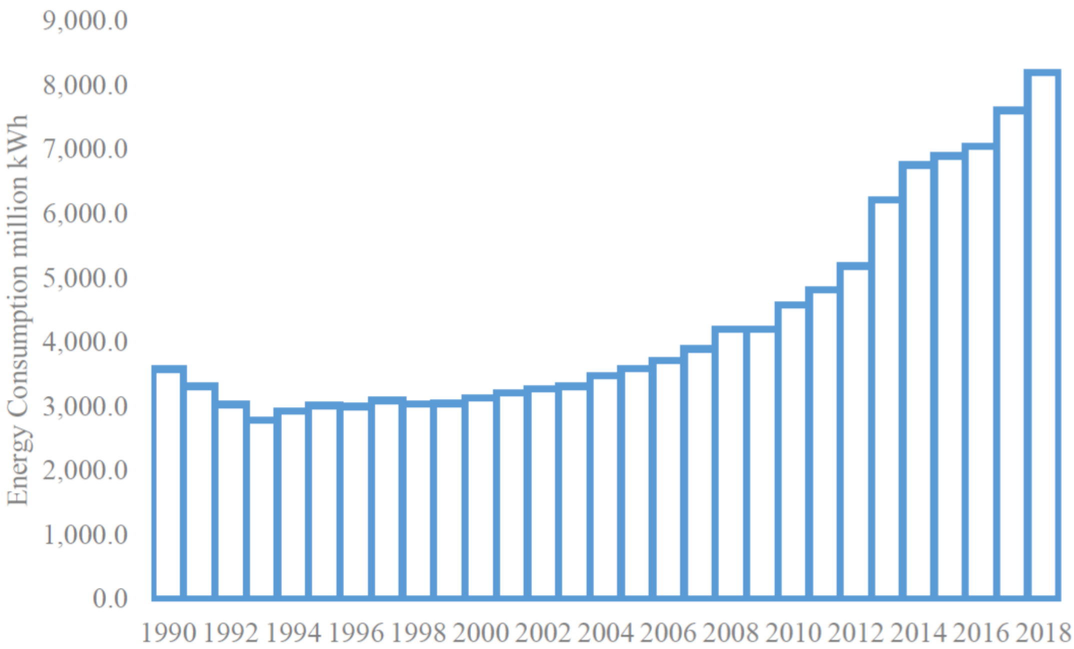

Fig. 1 Annual energy consumption variation

Model structure

ARIMA short for the "Auto-Regressive Integrated Moving Average" model was developed by Box and Jenkins in 1970 which is a time series analysis method based on the theory of random. The forecasting time series divided into two forms. The first is the *univariate time series forecasting* as we have adopted in analyzing which generally uses previous values of the time series to predict its future. The last form called *multivariate time series forecasting*. The ARIMA model has three basic types: Auto-Regressive model (hereinafter AR (p)), the moving average model (hereinafter MA (q)) and auto-regressive moving average model (ARMA (p,q).

Forecasting on the ARIMA model mainly includes four steps: First, the stationary test for an original sequence which means it uses its own lags as predictors because the ARIMA is based on a linear regression model. In most cases, the predictors are not correlated and are independent of each other, as a result need to make it a series stationary by differencing it. Accordingly, need to be a difference by subtracting the previous value from the current value. The value of d, therefore, is the minimum number of differencing needs to make the series stationary where d=0. Second, after time-series stationarity d=0, the parameters p and q will be determined. The parameter p is the order of the AR term. It refers to the number of lags of Y to be used as predictor. The actual mathematical formula for AR model is:

$$Y_t=\alpha+\beta_1 Y_{t-1}+\beta_2 Y_{t-2}+\ldots+\beta_p Y_{t-p}+\varepsilon_t \qquad (1)$$

where, Y_t is a function of the lags of Y_t, which means Y_{t-1} is the lag 1 of the series, β_1 is the coefficient of the lag 1 that the model estimates and α is the intercept term.

Next, the parameter q is the order of the MA term. It refers to the number of lagged forecast errors that should go into the ARIMA model. Here the Y_t is depended only on lagged forecast errors. The mathematical formula is:

$$Y_t=\alpha+\varepsilon_t+\phi_1\varepsilon_{t-1}+\phi_2\varepsilon_{t-2}+\ldots+\phi_q\varepsilon_{t-q} \qquad (2)$$

where the error terms are the errors of the autoregressive models of the respective lags. The errors ε_t and ε_{t-1} are the errors from the following equation:

$$Y_t=\beta_1 Y_{t-1}+\beta_2 Y_{t-2}+\ldots+\beta_0 Y_0+\varepsilon_t \qquad (3)$$

$$Y_{t-1}=\beta_1 Y_{t-2}+\beta_2 Y_{t-3}+\ldots+\beta_0 Y_0+\varepsilon_{t-1} \qquad (4)$$

That is our AR and MA model respectively. Third, the estimation of the unknown parameters in the model and examination of the rationality of the model. An ARIMA model where the time series was differenced at least once to make it stationary and by combining the AR and the MA terms. The general equation form becomes:

$$Y_t=\alpha+\beta_1 Y_{t-1}+\beta_2 Y_{t-2}+\ldots+\beta_p Y_{t-p}+\phi_1\varepsilon_{t-1}+\phi_2\varepsilon_{t-2}+\ldots+\phi_q\varepsilon_{t-q} \qquad (5)$$

In our ARIMA model predicted Y_t =constant + linear combination of lags of Y + linear combination of lagged forecast errors. The final step is diagnostic analysis to confirm that the obtained model is consistent with the observed data characteristics. Box and Jenkins (Box, et al.) were stated that these do not involve independent variables, but rather make use of the information in the series itself to generate forecasts. Therefore, ARIMA models depend on autocorrelation patterns in the series. The predominant contribution of Box and Jenkins were to grant a common strategy in which three levels of the model building (which are model identification, estimation, and diagnostic checks) had been given prominence(Hipel, McLeod, and Lennox 1977).

Empirical result

The research objective of this paper is the energy consumption forecasting for improving the energy planning of Mongolia. The energy consumption forecast depends on historical data where the dataset belongs to univariate prediction. The energy consumption in the next 11 years forecasting range relies on 2019-2030. Historical data at annual intervals over 28 years period was adopted the Box-Jenkins method iterative procedure to obtain the appropriate model. In the ARIMA modeling, each of the data set is considered independently for stationarity, identification, estimation, and diagnostic checking residuals(Mohamed and Bodger 2004) as we have mentioned earlier. In the first step we need to find the order of differencing (d) in ARIMA model. The aim of differencing is to make the time series stationary. We applied Augmented Dickey-Fuller (hereinafter ADF) test to inspect the existence of unit root in energy consumption. ADF test is the common method of unit root.

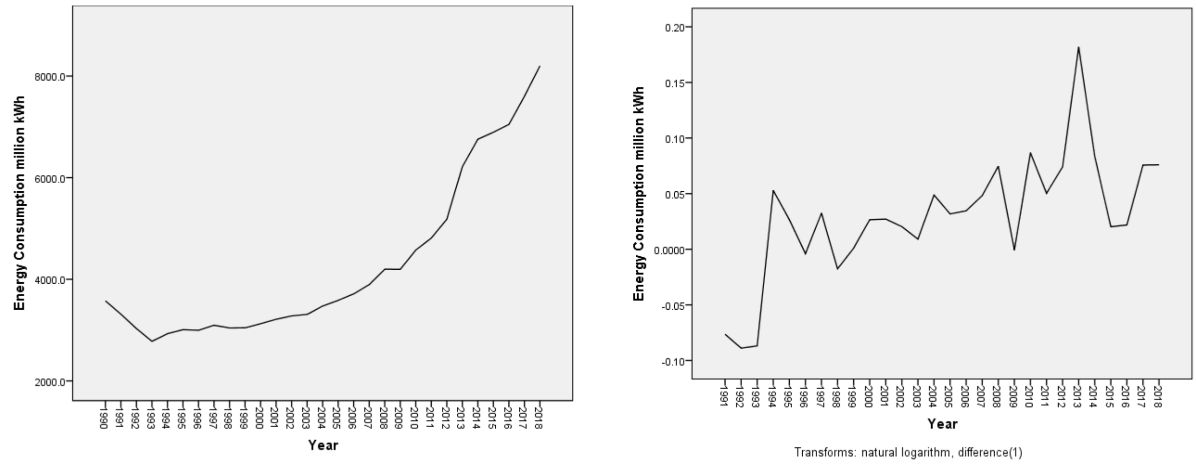

Fig. 2 Unit root level versus Unit root in 1st difference

According to the correlogram in Figure 2, stationary resulted in the first-order difference which is stable. Even though the series is not perfectly stationary but we fix the order of differencing as 1. Afterward, we made model identification which leads to the time series of energy consumption. In this step, we tested correlation coefficients for a stationary sequence. Figure 3 shows autocorrelation and partial-autocorrelation based on stationary sequence difference.

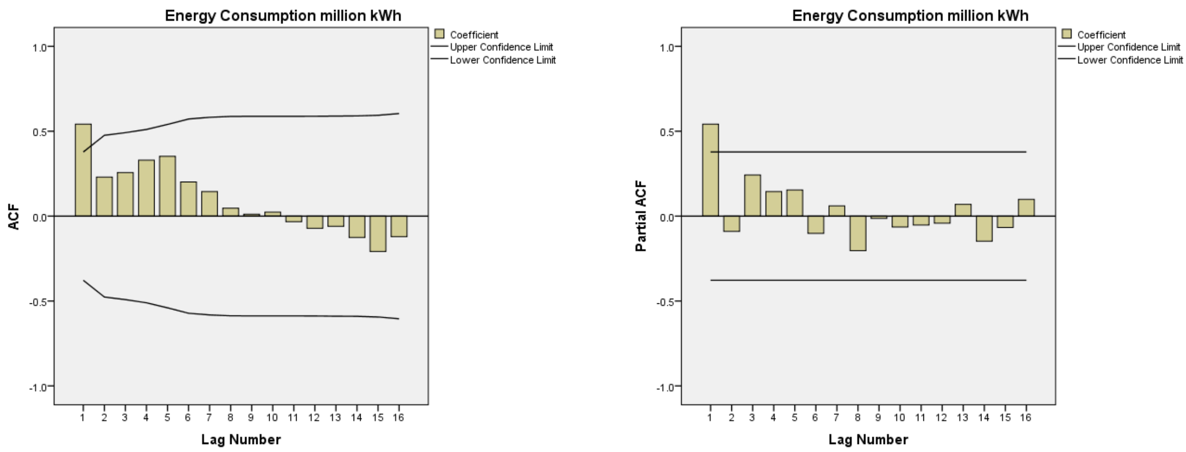

Fig. 3 ACF and PACF coefficients

Partial autocorrelation could be imagined as the correlation between the series and its lag, after excluding the contributions from the intermediate lags. Partial autocorrelation of lag (k) of a series is the coefficient of that lag in the autoregression equation of Y. The mathematical formula of PACF is:

$$Y_t=\alpha_0+\alpha_1 Y_{t-1}+\alpha_2 Y_{t-2}+\alpha_3 Y_{t-3} \quad (6)$$

In our case, suppose, if Y_t is the current series and Y_{t-1} is the lag 1 of Y, which means lag 1 Y_{t-1} is the coefficient in the above equation. According to Figure 3, we can observe that PACF lag 1 is quite significant, thus, we take p as 1. As in figure 3, we can see the ACF plot for the number of MA terms which is technical, the error of the lagged forecast. The ACF shows how many MA terms are required to remove any autocorrelation in the stationarized series. According to the coefficient result criteria of the ARIMA model, ARIMA (1,1,1) is preferable to be used for the forecasting where the process takes formulation as:

$$(1-\beta_1 Y)(1-Y)^d Y_t = (1-\phi_1 Y)\ \varepsilon_t \quad (7)$$

Right after, we have to determine the fit for the model. Figure 4 and Table 1 show that our determination of R^2 is 0.980, which means the fitting effect is good.

Table 1 Parameters of the fit for the ARIMA (1,1,1) model

Model Description

			Model Type
Model ID	Energy Consumption million kWh	Model_1	ARIMA(1,1,1)

Model Fit

Fit Statistic	Mean	SE	Minimum	Maximum	Percentile						
					5	10	25	50	75	90	95
Stationary R-squared	.326	.	.326	.326	.326	.326	.326	.326	.326	.326	.326
R-squared	.980	.	.980	.980	.980	.980	.980	.980	.980	.980	.980
RMSE	237.779	.	237.779	237.779	237.779	237.779	237.779	237.779	237.779	237.779	237.779
MAPE	3.815	.	3.815	3.815	3.815	3.815	3.815	3.815	3.815	3.815	3.815
MaxAPE	12.916	.	12.916	12.916	12.916	12.916	12.916	12.916	12.916	12.916	12.916
MAE	162.999	.	162.999	162.999	162.999	162.999	162.999	162.999	162.999	162.999	162.999
MaxAE	727.115	.	727.115	727.115	727.115	727.115	727.115	727.115	727.115	727.115	727.115
Normalized BIC	11.300	.	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300

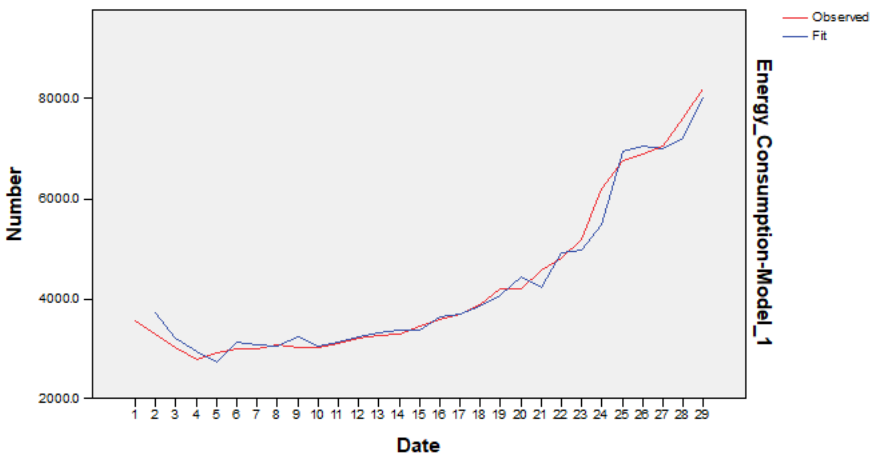

Fig. 4 Model calibration using historical data

The last step of the ARIMA(1,1,1) model is forecasting energy consumption from 2019-2030.

Table 2 ARIMA (1,1,1) model for energy consumption forecasting

ARIMA Model Parameters

					Estimate	SE	t	Sig.
Energy Consumption million kWh-Model_1	Energy Consumption million kWh	No Transformation	AR	Lag 1	.958	.089	10.799	.000
			Difference		1			
			MA	Lag 1	.587	.228	2.574	.016

Forecast

Model		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Energy Consumption million kWh-Model_1	Forecast	8635.0	9050.7	9448.8	9830.2	10195.5	10545.4	10880.5	11201.5	11509.0	11803.5	12085.6	12355.8
	UCL	9101.9	9843.0	10579.1	11316.4	12054.9	12793.2	13530.2	14264.6	14995.2	15721.3	16442.1	17156.9
	LCL	8168.1	8258.4	8318.5	8344.0	8336.1	8297.5	8230.8	8138.5	8022.8	7885.7	7729.2	7554.8

For each model, forecasts start after the last non-missing in the range of the requested estimation period, and end at the last period for which non-missing values of all the predictors are available or at the end date of the requested forecast period, whichever is earlier.

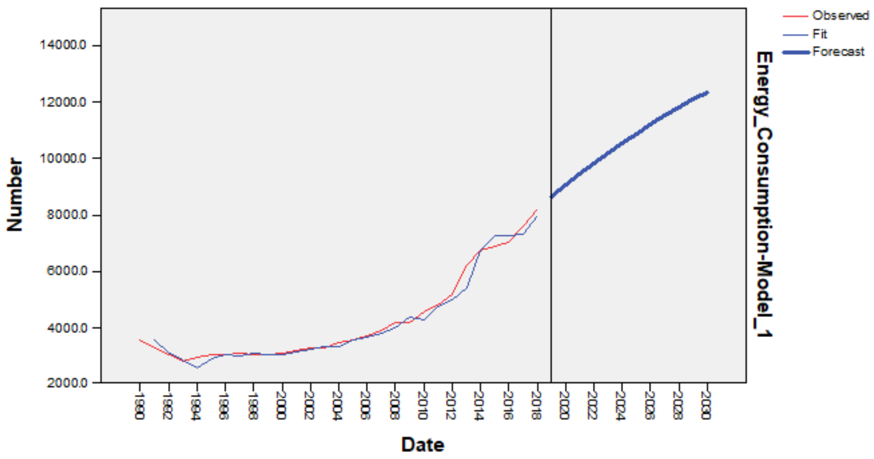

Fig. 5 Historical and simulated energy consumption

From Figure 4-5, the ARIMA(1,1,1) model seems to give a directionally correct forecast. And the actual observed values lie within the 95. The model of total energy consumption is a better overall fit that could be used to predict Mongolia's energy consumption in the next eleven years.

Conclusion

According to the stationarity analysis ARIMA (1,1,1) model has established in this paper for forecasting the energy consumption of Mongolia from 2019-2030. Since the ARIMA (1,1,1) model of total energy consumption is better overall fit. As looking back to figure 3, ARIMA (1,1,1) has high fitting precision and certain stability. As a result, the model adopted in this paper has a higher fitting degree. The result indicates that at the end of 2030 energy consumption predicted more than 12000 million kWh. The annual average growth rate of energy usage 3.3 percent. Moreover, the growth rate of Mongolia's energy consumption during 1991-1996 were declined due to the social structure transition. Currently, 20 percent of electric energy has been importing from Russian Federation and China(Sovacool, D'Agostino, and Bambawale 2011). Increasing energy consumption will result in shortage in the future as well and the imported energy could be increased. Thus, in our point of view Mongolia's energy strategy should integrate allocating more resources such as wind, solar and hydro generated energies for the development of energy technologies and stability of energy supply. And need to establish competitive energy market conditions through liberalization. Forecasting energy consumption has a vital role in energy planning and design to the national energy agency and policy-makers. Within the purpose of balancing energy independence and effective energy policies which promote industrial structure optimization and development the new industry with high technology. The forecasting technique gives more information for maintaining market stability and safety. Although coal reserves are high, this will be exhausting, so we need to find an optimal energy system. Year by the year huge coal reserves has been exhausting, as mitigating environmental impacts of fossil fuel, Mongolia need integrate renewable resources into the energy system. According to the statistics only 5.6% of renewable resources have been supplied by the renewables. Energy consumption forecasting could be done the basis of energy system planning and expansion. Based on this research, we will study system dynamic analysis for promoting renewable energy resource expansion and its integration into existing energy system.

Bibliography

1. Albayrak, Ali Sait. 2010. "ARIMA Forecasting of Primary Energy Production and Consumption in Turkey: 1923–2006." *Enerji, Piyasa ve Düzenleme* 1:24–50.
2. Box, George E. P., M. Ljung Greta, Gwilym M. Jenkins, and Gregory C. Reinsel,. n.d. *Time Series Analysis: Forecasting and Control, 5th Edition*.
3. Ediger, Volkan Ş. and Sertaç Akar. 2007. "ARIMA Forecasting of Primary Energy Demand by Fuel in Turkey." *Energy Policy* 35(3):1701–8.
4. Etuk, Ette Harrison, Alapuye Gbolu Eleki, and Pius Sibeate. 2016. "A Box-Jenkins Model for Monthly Natural Gas Production in Nigeria." *Journal of Multidisciplinary Engineering Science Studies* 2(11):6.
5. Hipel, Keith William, Angus Ian McLeod, and William C. Lennox. 1977. "Advances in Box-Jenkins Modeling: 1. Model Construction." *Water Resources Research* 13(3):567–75.
6. Hor, C. L., S. J. Watson, and Shanti Majithia. 2006. "Daily Load Forecasting and Maximum Demand Estimation Using ARIMA and GARCH." *2006 International Conference on Probabilistic Methods Applied to Power Systems* 1–6.
7. Jiang, Feng, Xue Yang, and Shuyu Li. 2018. "Comparison of Forecasting India's Energy Demand Using an MGM, ARIMA Model, MGM-ARIMA Model, and BP Neural Network Model." *Sustainability* 10(7):2225.
8. Lai, Sue Ling, Ming Liu, Kuo Cheng Kuo, and Ray Chang. 2014. "Energy Consumption Forecasting in Hong Kong Using ARIMA and Artificial Neural Networks Models." *Applied Mechanics and Materials*.
9. Li, Yiyan, Dong Han, and Zheng Yan. 2018. "Long-Term System Load Forecasting Based on Data-Driven Linear Clustering Method." *Journal of Modern Power Systems and Clean Energy* 6(2):306–16.
10. Mohamed, Z. and P. S. Bodger. 2004. "Forecasting Electricity Consumption: A Comparison of Models for New Zealand." in *Engineering: Conference Contributions*.
11. Morales, Juan M., Antonio J. Conejo, Henrik Madsen, Pierre Pinson, and Marco Zugno. 2014. *Integrating Renewables in Electricity Markets: Operational Problems*. Springer US.
12. National Statistical Office. n.d. "Mongolian Statistical Information Service." *Mongolian Statistical Information Service*. Retrieved July 8, 2019 (http://1212.mn/).
13. Nichiforov, C., I. Stamatescu, I. Făgărăşan, and G. Stamatescu. 2017. "Energy Consumption Forecasting Using ARIMA and Neural Network Models." Pp. 1–4 in *2017 5th International Symposium on Electrical and Electronics Engineering (ISEEE)*.
14. Oppenheim, Rosa. 1978. "Forecasting via the Box-Jenkins Method." *Journal of Academy of Management Science* 6(No3):206–21.
15. Sovacool, Benjamin K., Anthony L. D'Agostino, and Malavika Jain Bambawale. 2011. "Gers Gone Wired: Lessons from the Renewable Energy and Rural Electricity Access Project (REAP) in Mongolia." *Energy for Sustainable Development* 15(1):32–40.
16. World Bank. n.d. "World Bank Open Data | Data." *World Bank Open Data*. Retrieved July 8, 2019 (https://data.worldbank.org/).

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