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Article

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Factors Influencing Renewable Energy Technological Innovation in Malaysia

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ABSTRACT

The objective of the research paper is to investigate the factors that influence innovation in renewable energy technology in Malaysia. The study has been designed to assess this newer means of generating energy through the means of wind, water and other resources. The researcher has aimed to evaluate these factors and find its influence on the Renewable Energy Technological Innovation. This study has analyzed the influence of the independent variable of the study over the dependent variable with the help of statistical analysis tool, which is Stata. Furthermore, using the Stata, researcher has applied two tests mainly in this study such as descriptive analysis along with that ADF. Moreover, based upon the factors of the study, ARDL model has been applied in to execute the study in an efficient manner. In case of renewable energy consumption, one of the most important aspect necessary to mention is that the domestic and commercial users who are not producing renewable energy at their own does not experience any difference while using the renewable energy as compared with the energy produced by conventional methods.

Keywords: Renewable Energy, Technological Innovation, Energy Consumption, Wind, Solar
JEL Classifications: O32, K32

1. INTRODUCTION

The renewable energy technologies, for example, the solar energy, hydropower energy, nuclear energy, wind energy, geothermal energy, bio mass-energy and others have now been used for enhancing the way of living and reducing the issues of energy within certain areas. According to the assessment of Johnstone et al. (2017), the utilisation of renewable energy has several advantages as it is ethically suitable and is more sustainable for the environmental conditions. The government of Malaysia has been developing the means of renewable energy for meeting the requirements of the people. It has been observed that the use of renewable energy has been found all around the world and have much more importance within the environment as the use of fossil fuel may harm the environment, therefore, the organisations must utilise the newer ways of energy generation to control and manage the pollution and the green environment. The use of these renewable energy technologies have supported the environment and have facilitated the industrial and agricultural development. Lin and Zhu (2019) have added that the use of renewable energy is lesser reliable as it is generally based on natural sources.

The importance of renewable energy technologies have been recognised in the early 18th century and has been used by then. As the consumption of energy sources has been increasing with the increase in population in different developed and developing countries such as Malaysia. However, it has been argued by Irandoust (2016) that the countries have been relying on the non-renewable energy sources that are limited and can be finished. The use of these resources has led towards the formation of the gap that the presence of renewable energy shall be there for ensuring that the use of natural resources shall be there for dealing with

the energy crisis in the countries. According to the assessment of Böhringer et al. (2017), the use of solar energy is found to be common within differ counters as it is environment friendly and is a major source of renewable energy technology. Moreover, the technological developments have also led towards the discovery of solar photovoltaic, wind, micro-hydropower and biomass energy conversion for the countries for gaining better forms of renewable energy technologies according to the assessment of Surie (2017).

The rationale behind the following investigation is to provide the favourable means of energy that can be used by the environment for dealing with the issues of lack of energy within the country Malaysia. According to the arguments of Schmidt and Sewerin (2017), the use of natural resources for the development of energy can be replaced with renewable energy sources for better outcomes and gaining better results. Therefore, the following study is aimed to investigate the major issues that are there and influences the renewable energy. The investigation has been designed to understand the important aspects of renewable energy that can be used along with the technological innovation in the countries for meeting the issues of lack of energy. Reichardt et al. (2016) have claimed that the energy crisis is one of the major issues that has created the poor growth and development of the industrial and agricultural sector that can also affect the overall performance of the economy. As the sources of solar energy are found to be one of the safest, cleanest and the reliable sources for the generation of electricity. Additionally, other sources of energy can also be used and are also reliable that utilises the coal, gas and other water supplies.

Therefore, the countries need to investigate the use of renewable energy to facilitate the users and make it more reliable for them for the selection of most appropriate methods of power and electricity. It has been observed that the necessity of having renewable energy is present within the system to meet the needs of the people and to manage the requirements in real-time. Moreover, it has also been observed that renewable energy may be very feasible for the future growth and development of the organisation and to enhance the economic growth of the country. It has been assessed that the government and other major institutions have been solving the issues of the energy due to the reason of having better forms of electric supply on order to meet the needs of the people in the country.

2. LITERATURE REVIEW

2.1. Renewable Energy and its Policies

According to the assessment of Anawar and Strezov (2018), renewable energy is one of the most commonly used systems for generating energy for the people and acquiring the methods of better living conditions. Renewable energy is a form of energy that does not deplete or can be finished within human lives. The commonly observed kinds of renewable energy are provided to be wind, solar, geothermal, biomass, and hydropower. These are major sources of generating energy and can be reused by people easily. These sources of energy can be utilised by the people for gene ting the sources of energy and creating the means of living for the people (Kuang et al., 2016). As compared to the non-renewable sources, renewable energy is better and can be long-lasting for human beings to gain better returns. It is referred to as the clean energy and can be constantly used upon the availability of time, weather and other necessary areas of the natural resources.

Moreover, different methods can be used by the government for dealing with the energy resources for better heating, lightning and having appropriate measures of growing. According to the assessment of Sekerci et al. (2017) different technology-push policies can be used for renewable technologies and creating the means of better support and development from the market. Furthermore, there are different kinds of policies that can be used for stimulating innovation and the use of technology for generating better means of technological growth and development. The use of policies for technological growth can be effective and can be more appropriate for renewable resources for dealing with greater innovation and technological growth within different areas.

2.2. Technological Innovation

According to the assessment of Kogan et al. (2017), technological innovation is the process of using technology or enhancing the processes and procedures to gain the success factors within the organisation. Moreover, it has been observed that the use of this technological innovation is not only effective but is also very essential for dealing with organisational progress and productivity. It has been observed that the organisations and the countries need to work out for the betterment of the economy and to gain higher returns. Therefore, according to the assessment of Azar and Ciabuschi (2017), the use of technologies create higher efficiencies and also create the means of market competitiveness as a whole. Within the context of the following study, the researcher has investigated for the assessment of renewable energy and dealing with technological innovation for the betterment of society. Coccia (2017) has added that the technologies that have been used for the creation of energy are found to be included in the renewable energy and creating the better system for increasing the overall economy of the country. Additionally, according to the arguments of Johnstone et al. (2017), the Energy-technology innovation (ETI) is another method that can be used for the economic, environmental and the societal tool for solving the energy-based needs of the people using the methods of technology and introducing newer methods and innovation for energy creation.

2.3. Renewable Energy Subsidies in Malaysia

The Malaysian government is paying a higher level of subsidy within the energy that is nearly up to 5% of the GDP. Moreover, there is a significant impact on the household and other energy-intensive sectors in terms of transport and other necessary businesses for gaining better energy resources and having improvement in the country's economy according to the assessment of Kardooni et al. (2016), It has been argued in the study of Kardooni et al. (2018) that the reduction and removal of the subsidies for the energy sector may lead towards the poor control towards the economy and households within the country. Therefore, the Malaysian government has been significantly improving the production cost of energy and has also been improving the methods of renewable energy for dealing with the issues rearing the crisis within the country. The development of better advancement within the technology sector has been creating the advancement within the economy of the country, it has been

observed that the use of this renewable energy has been creating a major decrease in the CO_2 emission and has been increasing the demand within the electricity and gas sector.

2.4. Benefits of Renewable Energy Technological Innovation

According to the assessment of Böhringer et al. (2017), it has been observed that the use of these renewable energy has been creating the economic growth and development by creating the employment opportunities for the people living in the rural areas. It has been assessed that the use of these technologies has been creating opportunities for economic growth. Chen and Lei (2018) have also assessed that renewable energy opportunism and the use of technological advancement within the means of energy can provide with efficient and effective methods for dealing with urban migration. As the use of technological innovation and the use of renewable energy has been one of the most effective ways of creating the better ways of employment and dealing with the issues related to the energy crisis in the country according to Tabrizian (2019). Moreover, the study of Haley (2018) has highlighted that the use of renewable sources of energy has created the means of lesser dependency on the fuels and having better options for the manufacturing and the installation of the organisations. Therefore, the use of technological innovation in the renewable energy has been creating the better options for the industries and the agricultural sector and has also been dealing with the opportunities for growth and development of the country as a whole (Irandoust, 2016).

2.5. Factors Influencing Renewable Energy Technological Innovation

2.5.1. Electricity consumption

The uses and the ingestion of different kinds and forms of energy are referred to as energy consumption. According to Zhang et al. (2017), each of the sector based on the technological advancement, industry and agriculture requires the consumption of energy in different forms. The factor of energy consumption has been used in the following study for investigating the rate of consumption of energy within the country. Moreover, the factor has been assessed using innovation in renewable energy measures. The countries have been developing the means of renewable energy for dealing with the issues of the energy crisis.

The industries and the agriculture sector of the different countries require the production and development of energy using different means. According to Ang and Su (2016), the energy can be predicted using the fuel, nuclear fission and other methods of kinetic energy. The following research has been designed to investigate the methods used for renewable energy that can be used by the countries for confuting the different energy-based operations. The use of energy has led towards the discovery of renewable sources of energy that can be cost-effective as well as good for the environment.

2.6. Contribution of Renewables to Total Primary Energy Supply

The contribution of renewables to total primary energy supply (TPES) is one of the major factors that include the use of different raw material such as wood, water and wind for the production of energy. According to the assessment of Ahmar (2018), the use of these raw materials and the natural resources has been contributing towards the society and the environment. The use of these renewable energy resources has been contributing a major share towards the development and use of energy in different areas for the operation to be conducted easily. The use of these renewable energy sources is effective for the environment and the society as it reduces the carbon emission and also has better efficiency and low cost.

2.7. Share of Electricity Production from Renewable Sources

Based on the assessment of the statistics it has been assessed that the use of renewable sources for electricity production has been creating better sources of electricity and has a major share for electricity production. Within the general terms, the use of renewable energy has been creating nearly 26% of the share within the current electric supply and has been growing at a higher rate and has also been enhancing the means of energy for consumption in different sectors.

2.8. Renewable Energy Consumption

The renewable energy consumption has been found to have an important role within the gross inland and the energy renewable sources. The study of Bhattacharya et al. (2016) has argued that the methods of renewable energy consumption has created the means of better development and has also contributed towards the overall energy production of the countries as a whole. Renewable energy has a major role in increasing the overall production of energy and has also been enlacing the economic growth of the country.

2.9. Renewable Energy Investment

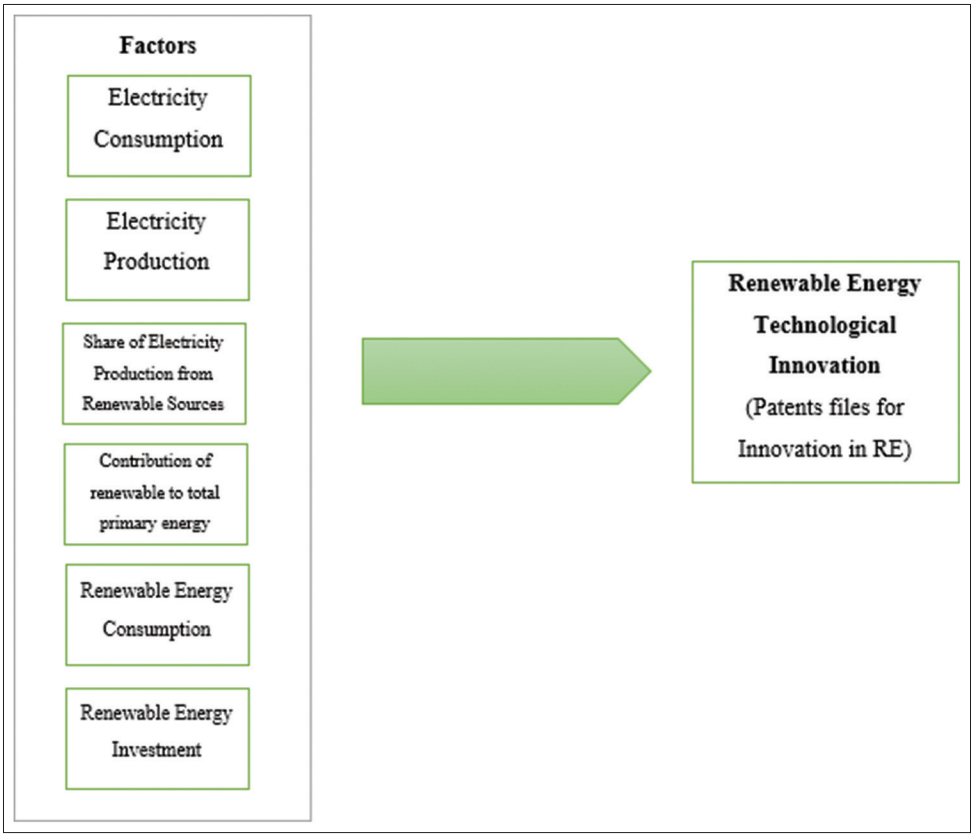
The countries have been making a huge investment within the field of renewable energy for gaining better outcomes and better production of energy as a whole. It has been observed that renewable energy is one of the nest suitable methods for the environment and society to deal with energy-based issues.

3. CONCEPTUAL MODEL

As mentioned in the previous section, the fundamental aim of this research is to assess the factors that influence technological innovation in renewables. Based on the aforementioned aim, this paper has followed the following model (Figure 1).

The above model indicates different factors that are found to be influencing technological innovation in renewable energy sources. The first factor is electricity consumption which is considered as driving factor for innovation in this sector as it triggers market demand (Di Stefano et al., 2012). According to the report of IRENA (2017), energy generation of a country has a role to play in encouraging the government of body to invest in advanced technology for renewable energy. Thus, the second factor taken in this research is electricity production in Malaysia. Moreover, the research model has also taken into consideration two important factors share of electricity production from renewable sources and contribution of renewable energy to total primary energy sources.

Figure 1: Conceptual model



Source: Author (2020)

These factors are significant because it is a comparative metric which shows the amount of electricity that is produced from renewable resources. The existing literature has shown mixed researches on the impact of investment on renewable energy sources on Innovation on RET (Emodi et al., 2015; Gan and Smith, 2011), thus, this research model has considered it as a factor.

4. METHODOLOGY

This study has focused the energy sector and specifically highlighted the renewable energies and the various elements in this regard such as power consumption, total investment and the patents being filed over the period. Therefore, in this study data has been collected for the period of the last 30 years ranging from 1989 to 2018. Before taking information from secondary sources such as databases and websites, it was assured that these platforms should be considered as authentic resources for data collection. In this study, there are mainly 7 variables and 6 out of these 7 are independent variables, which include electricity consumption, electricity production, the share of electricity production from renewable sources, the contribution of renewables to total primary energy supply, renewable energy consumption and renewable energy investment. On the other hand, the dependent variable of the study is patents filed for innovation in renewable energy, this study has analyzed the influence of the independent variable of the study over the dependent variable with the help of statistical analysis tool, which is Stata. Furthermore, using the Stata, the researcher has applied two tests mainly in this study such as descriptive analysis along with that ADF. Moreover, based upon the factors of the study, the ARDL model has been applied in to execute the study efficiently. Tests applied with the help of Stata has provided the results which are then analyzed and discussed to provide the conclusion covering the main aspects of the study.

Following is the equation which has been tested in this research:

$$PRE = \alpha+\beta_1 EC+\beta_2 EP+\beta_3 SEPRS+\beta_4 CRTPES+\beta_5 REC+\beta_6 REI+\varepsilon$$

Where,
PRE = Patents filed for innovation in renewable energy
α = Intercept
EC = Energy consumption
EP = Energy production
SEPRS = Share of electricity production from renewable sources
CRTPES = Contribution of renewable to total primary energy Supply
REC = Renewable energy consumption
REI = Renewable energy investment.

5. RESULTS

5.1. Descriptive Statistics

To study the statistical characteristics and to summarise the large data that was collected for this research, descriptive statistics have been run on Stata. Following are the results derived in Table 1.

Table 1: Descriptive statistics

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
Electricity consumption	30	90.60014	27.29955	53.42	136.9
Electricity production	30	76.40611	39.26372	19.35083	148.3
Share of electricity production from renewable sources	30	10.29194	4.277614	5.992659	24.37834
Contribution of renewable to total primary energy supply	30	2319.694	531.0074	1507.189	3690.206
Renewable energy consumption	30	8.804231	5.971412	3.989	25.64053
Renewable energy investment	30	1.60e+10	1.90e+10	7.77e+08	5.80e+10
Patents filed for innovation in renewable energy	30	8611.188	7313.212	539.9706	23683

For each factor, the important values include their mean and standard deviation because they indicate the average and units from which the mean deviates in the data respectively. The data for the variables have been obtained from 1989 to 2016 which accounts for 30 years, through the value of mean and standard deviation. For the variable of electricity consumption, in the 30 year period, the average consumption of energy was recorded to be 90.6 billion kWh which was deviated from 27.2 units. For the variable of electricity production, in the 30 year period, the average production of energy was recorded to be 76.4 billion kWh which was deviated from 39.26 units. For the variable of Share of Electricity Production from Renewable Sources, in the 30 year period, on an average 10.29% of the electricity production in Malaysia was done from renewable sources, this value is found to have deviated from 4.27 units. For the variable of Contribution of renewable to total primary energy supply, in the 30 year period, on an average 2319,000 toe of the of the total primary energy supply included contribution of renewable sources, this value is found to have deviated from 531 units. For the variable of renewable energy consumption, in the 30 year period, the average consumption of renewable energy was recorded to be 8.8 Trillion W/H which was deviated from 5.97 units. For the variable of investment on renewable energy, in the 30 year period, the average investment on renewable energy was recorded to be 16,000,000,000 billion US$. The last variable is patents files for innovation in RET which on an average were 8,611.

5.2. Augmented Dickey-Fuller Test

For assessing the stationarity of each variable, the Augmented Dickey-Fuller test has been applied. Considering that this research paper has included data from economic indicators hence, the researcher has attempted to analyse that if there is a trend in the data or is it stationary. The null hypothesis for this test is that the unit root is present. The following Table 2 depicts the results of this test for each variable:

The value which is to be considered to interpret the results of the ADF test is P-value which states whether the null hypothesis is rejected or attained. The data for electricity consumption is found to show a trend or non-stationary because the null hypothesis is rejected (P = 0.03). The data for electricity production in Malaysia does not show a trend indicating its stationary data based on the P-value of (P = 0.9879). The data for Share of Electricity Production from Renewable Sources is found to show a trend or non-stationary because the null hypothesis is rejected (P = 0.00). The data for the contribution of renewables to total primary energy Supply in Malaysia does not show a trend indicating its stationary data based on the P-value of (P = 0.76). The data for Renewable

Table 2: ADF test

Variables	Test statistic	P-value
Electricity consumption	−3.052	0.0303
Electricity production	0.613	0.9879
Share of electricity production from renewable sources	−4.364	0.0003
Contribution of renewable to total primary energy supply	−0.967	0.7651
Renewable energy consumption	3.215	1.0000
Renewable energy investment	2.612	0.9991
Patents filed for innovation in renewable energy	−1.329	0.6159

Energy Consumption in Malaysia does not show a trend indicating its stationary data based on the P-value of (P = 1.00). The data for Renewable Energy Investment in Malaysia does not show a trend indicating its stationary data based on the P-value of (P = 0.99). Lastly, the data for Patents filed for Innovation in Renewable Energy in Malaysia does not show a trend indicating its stationary data based on the P-value of (P = 0.619).

5.3. ARDL Model

Concerning the fact that two of the variables in the conceptual model are non-stationary while the remaining are stationary (presence of unit root), this research paper has used auto-regressive distributed lag model to test the impact of factors on innovation in RET with mixed order of integration. Following are the results obtained from Stata (Table 3).

The Table 4 identifies the significance of the overall model as well as impact of each factor on the criterion variable that is Innovation for RET. Moreover, there are also values of R-square and Adjusted R-square that aid in interpreting the overall model in an efficient manner. For the variable of Electricity Consumption, there is no statistical significance which indicates that in Malaysia electricity consumption does not impact the technological innovation of renewable energy resources (P = 0.233). Electricity production in Malaysia has a sound impact on technological innovation of renewable energy resources given the P = 0.000. Its respective coefficient value shows that it will bring about 630 units of change in Innovation for RET if the predictor is increased by a single unit. For the variable of Share of Electricity Production from Renewable Sources, there is no statistical significance which indicates that it does not impact the technological innovation of renewable energy resources (P = 0.214). For the variable of Contribution of renewable to total primary energy supply, there is no statistical significance which indicates that it does not impact the technological innovation of renewable energy resources

Table 3: ARDL model

Variables	Coefficient	P-value
Electricity consumption	85.30144	0.233
Electricity production	630.6378	0.000
Share of electricity production from renewable sources	809.6155	0.214
Contribution of renewable to total primary energy supply	−11.35072	0.123
Renewable energy consumption	99.07528	0.895
Renewable energy investment	−8.49e-07	0.002
R-square	0.8998	
Adjusted R-square	0.8129	
P-value (F stat)	0.026	

Table 4: Hypothesis assessment table

S. No.	Hypothesis statement	P-value	Result
1	Electricity consumption has an impact on technological innovation of renewable energy sources	0.233	Rejected
2	Electricity production has an impact on technological innovation of renewable energy sources	0.000	Accepted
3	Share of electricity production from renewable sources has an impact on technological innovation of renewable energy sources	0.214	Rejected
4	Contribution of renewable to total primary energy supply has an impact on technological innovation of renewable energy sources	0.123	Rejected
5	Renewable energy consumption has an impact on technological innovation of renewable energy sources	0.895	Rejected
6	Renewable energy investment has an impact on technological innovation of renewable energy sources	0.002	Accepted

(P = 0.123).Renewable Energy Investment in Malaysia has a sound impact on technological innovation of renewable energy resources given the P = 0.002. Its respective coefficient value shows that it will bring about -8.48 units of change in Innovation for RET if the predictor is increased by a single unit.

Regardless of some factors not have a sound statistical impact on innovation for RET however, the overall model is found to be significant. Resultantly, it can be said that collectively all the factors successfully influence technological innovation of renewable energy source. The R-square value shown in the model indicates that the factors have the ability to predict 89.98 of variations that occur in the criterion variable.

5.4. Hypothesis Assessment Table

Based on the quantitative results of this research paper, following is the hypothesis assessment Table 4:

6. DISCUSSION

It has been observed that over the time global consumption of energy has been increased which has created a demand for the energy producers to produce more energy, however, in this regard, the conventional methods of energy production have a negative impact over the wellbeing of the environment. On the other hand, the increasing demand of environmental sustainability has created a need for the sustainable technologies which provided no or less harm to the environment and global industries have agreed over the point that even the cost of such production methods is high, the green production process should be preferred (He et al., 2019). Therefore, in this regard, the study has focused the increasing trend of renewable energy production all over the world and it has been observed that over the time not only the demand for the energy production but also the investment in this sector as well as the various aspects of renewable energy such as its contribution to the primary sources of energy. In addition to that, this study has also focused on the share of energy production from renewable energy sources to identify how the trend of renewable energy production is increasing. In case of renewable energy consumption, one of the most important aspects necessary to mention is that the domestic and commercial users who are not producing renewable energy at their own do not experience any difference while using the renewable energy as compared with the energy produced by conventional methods (Dincer and Yuksel, 2019). However, the trends have increased gradually that people have now started to prefer the renewable energy sources and also preferring the small energy production system as their homes and industries to produce energy at their own which does not only enable them to be environmentally sustainable but also cost-efficient at the same time.

6.1. Limitations

Technological innovation in the renewable energy sector is being focused in this research and for that particular reason, global data has been collected to analyzeand provide the conclusive remarks. Therefore, in this regard, the major limitation of this study is to identify how the trends would be changing country-wise, region-wise and similarly for separate entities such as commercial industries or domestic consumers. Moreover, it has been observed that this sector has shown significant progress where the companies have been entering this industry. However, the scope of this study was broadened and instead of focusing the information for respective entities, the researcher did not categorize the information and analyzed it in a general form. Another aspect which is not being included in this study is the cost comparison of the conventional energy production methods and renewable energy production which has a strong influence over the decision of entering the industry for the companies and filing a patent for innovation in the renewable energy sector. In the light of the study conducted by Liu et al. (2019), cost of renewable energies is usually high as it cost the companies to install larger equipment usually as compared with the productivity rate of conventional energy production methods which increases the fixed cost of the companies as well. Therefore, innovation in this regard has a great gap which can be filled through the continuous research process.

6.2. Conclusion

It has been observed that globally technologies have been developing and the industries are bringing innovation disruptively, therefore, this study focused on the renewable energy sector which

itself was an innovation before decades for the energy sector. However, in this regard, it was observed that there are some of the limitations for the energy producers due to which some of the times it is being preferred to use the conventional methods for the energy production. This study has focused on multiple factors to analyze whether these identified factors affect innovation in the energy sector and patent registration increased or not. Results have shown that the overall model of the study which was developed after the review of related literature is significant and the analysis is done through it has relevancy as well. In addition to that, six hypotheses were developed in this study to investigate the impact of identified independent variables over the dependent variable of the study. Results of the study have also made it clear that only electricity production and investment in renewable energy has a significant impact on innovation in this sector. However, the other factors such as share of electricity production from renewable energy, the contribution of renewable energy to primary sources, electricity consumption and specifically renewable energy consumption do not affect the technological innovation in this particular industry.

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