A Multivariate Analysis of Factors Influencing Green Energy

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Abstract. Non-renewable energy, fossil fuel are such sources which satisfy energy needs at environmental cost. But renewable sources such as solar, wind, hydrogen and biogas satisfy needs and also protect environment from CO₂ emission. The study took data of 2009 to 2019 of India in which relationship and impact of determinants were studied through correlation and multiple regression technique. Green energy drivers are energy security; CO₂ emission; and social & economic development. Only renewable energy consumption is positively correlated with Green Energy no other factor is positively correlated with Green energy. CO₂ per capita has negative relation with Renewable energy consumption. It means if Renewable energy consumption will increase then there will be decrease in CO₂ per capita. Moreover, more Renewable consumption led to Green Energy. The study revealed the impact of independent variables which represents that Renewable energy consumption per capita; Energy usage per capita; renewable energy consumption; and fossil fuel energy consumption plays significant role in influencing Green Energy.

1. Introduction
Energy is required to satisfy economic and social needs. Energy needs can be satisfied through renewable and nonrenewable sources. Nonrenewable sources negatively affect environment but renewable sources help to satisfy needs and also put no any negative impact on environment. Fossil fuel power generation increase CO₂ emission. Solar, wind, hydro, biogas etc. various technologies come under renewable energy sources. So green energy protects environment. There are some drivers for renewable energy. Energy security, social, economic development & reduction in CO₂ emission. Sustainable development goal 7th is to ensure Affordable and Clean Energy for nation. This paper studies green energy drivers in which energy security, CO₂ emission, social and economic development is included. The paper also studied determinants of green energy. Green energy is shown by renewable energy intensity or efficiency. The relationship between determinants is studied through correlation technique and impact of variables on green energy is studied by multiple regression analysis.

2. Review Literature
More usage of renewable energy resources rather than fossil fuel consumption is suggested to reduce CO₂ emission and to overcome climate related problem. There are various technologies for energy efficiency which acted as drivers for renewable energy [1]. Green sector’s area not very wide but it is most helpful for growth of any economy. The study suggested energy efficient technology for construction or for other projects. Energy saving programs and replacing fossil fuel energy with renewable energy technologies may help to grow the economy [2]. There are top seven companies of China which are dealing in EV batteries. The study stated various challenges faced by China. China focused on energy security, technologies and sustainable development so that renewable energy technologies must be cheaper. Largest wind and solar installed capacity are of China as shown in study [3]. There are several renewable energy technologies which may help to achieve sustainability and to study carbon footprints. It stated opportunities i.e. energy security; social- economic development; and impacts. Moreover, some challenges i.e. market; carbon dioxide; and availability of sources were also
studied. In addition, there are several opportunities like energy security; energy access; social-economic development; and climate change are also available to the country. The study suggested formulation of policies for more renewable energy usage and also increase awareness about renewable energy technologies [4]. Each renewable energy source is important to protect environment and to reduce CO₂ emission. Several renewable energy technologies like solar energy; wind energy; hydrogen energy; and biogas reduce GHG emission and global warming [5]. Through renewable energy GHG can be reduced to optimum level. GHG can be avoided through cost saving usage or by applying green power methods [6]. Government policies and regulations mostly affect costs and benefits of renewable energy. This cost and benefits of renewable energy put impact on employment, GDP and others (trade & welfare) [7]. The objectives of this paper are to study drivers of Green Energy; determinants of Green Energy; relationship of identified determinants with Green Energy; and to study the impact of identified determinants on Green Energy.

3. Research Methodology

This part presents methodology in which econometric model, hypothesis, research techniques and limitations of the study.

3.1 Sources of data

The study took data from 2009 to 2019 of all determinants. The data has been collected from reports of World Bank, International energy agency and other online references. Green energy is represented by Renewable energy intensity or efficiency in India.

3.2 Econometric Model

\[ GE = b_0 + b_1 (RECPC) + b_2 (CO₂PC) + b_3 (EUPC) + b_4 (RECAP) + b_5 (REC) + b_6 (FFEC) + e \]

Where

- GE = Green Energy (Renewable Energy Intensity-REINT)
- RECPC = Renewable Energy Consumption per capita
- CO₂PC = Carbon Dioxide Emission Per Capita
- EUPC = Energy Usage Per Capita
- RECAP = Renewable energy capacity
- REC = Renewable energy consumption
- FFEC = Fossil Fuel Energy Consumption
- e = Error Term

3.3 Hypothesis

H₀₁: There is no significant impact of ‘Renewable Energy Consumption Per Capita’ on ‘Green Energy’.
H₀₂: There is no significant impact of ‘CO₂ emission Per Capita’ on ‘Green Energy’.
H₀₃: There is no significant impact of ‘Energy Usage Per Capita’ on ‘Green Energy’.
H₀₄: There is no significant impact of ‘Renewable Energy Capacity’ on ‘Green Energy’.
H₀₅: There is no significant impact of ‘Renewable Energy Consumption’ on ‘Green Energy’.
H₀₆: There is no significant impact of ‘Fossil Fuel Energy Consumption’ on ‘Green Energy’.

3.4 Research Techniques

The study used renewable energy intensity as Green energy. The formula is extracted from energy efficiency [8]. Renewable energy consumption is divided by GDP of the country to get Renewable energy intensity. The study also used correlation and multiple regression techniques to represent relationship between variables and impact of variables on renewable energy efficiency. Results are shown in table form so that it can be easily understood.

3.5 Limitations of the study

- The study used historical data in which renewable energy techniques are rarely used.
The study has not used other factors such as GDP, Environment policies etc.
Economic conditions such as inflation, deflation, exchange rates and other ups and downs of economy are totally ignored.
The study used only data of 2009 to 2019 which may not represent accurate results for such as wider topic.

4. Data Analysis & Interpretation
This part showed green energy drivers, determinants of green energy, relationship between determinants and impact of variables on green energy efficiency through correlation and multiple regression techniques.

4.1 Green Energy drivers
There are three drivers for Green Energy i.e. energy security, CO₂ emission and social & economic development which are explained as follows.

- **Energy Security**- Energy needs of domestic and business can be fulfilled by conventional and non conventional energy sources. Conventional sources fulfill energy needs by depleting environment. But non conventional energy sources helps to fulfill energy needs by protecting environment. Non conventional sources helps to fulfill needs through Green energy which will also help to achieve the objective of sustainability in which requirements of current generation can be easily satisfied without negatively affecting resources for future generations. Therefore, Green energy provides Energy security that there will be fulfillment of energy needs of current and future generation.

- **CO₂ emission**- More usage of conventional sources emits destructive gases in which main gas is CO₂. But if there is more usage of Green energy, then there will be no negative effect on environment.

- **Social and Economic Development**- When energy needs will be fulfilled through non conventional energy sources and also by protecting environment then there will also be social and economic development of country.

4.2 Relationship between Green Energy determinants

Table 1. Relationship between Green Energy determinants.

| Variables | GE    | RECPC | CO₂ PC | EUPC | RECAP | REC   | FFEC  |
|-----------|-------|-------|--------|------|-------|-------|-------|
| GE        | 1     |       |        |      |       |       |       |
| RECPC     | -0.8785 | 1     |        |      |       |       |       |
| CO₂ PC    | -0.6962 | 0.8009 | 1     |      |       |       |       |
| EUPC      | -0.7542 | 0.797 | 0.7142 | 1    |       |       |       |
| RECAP     | -0.2481 | 0.2828 | 0.52274 | 0.2148 | 1    |       |       |
| REC       | 0.8834 | -0.9599 | **0.8379** | -0.779 | -0.2998 | 1    |       |
| FFEC      | -0.6433 | -0.6951 | 0.6949 | 0.9655 | 0.2048 | -0.7354 | 1    |

The table 1 reveals that Green energy is only positively correlated with Renewable consumption except all other variables i.e. Renewable energy consumption per capita; CO₂ per capita; energy usage per capita; renewable energy capacity; and fossil fuel energy consumption. There is also negative relation between CO₂ per capita and renewable energy consumption. These relationships stated that if there will
be more renewable energy consumption then CO$_2$ per capita will decrease and more consumption of renewable energy will help to sustainable Green energy in India. Renewable energy consumption and renewable energy intensity is mutually positively correlate with each other.

4.3 Impact of variables on Green Energy Efficiency

To study impact of variables on Green energy efficiency, Multiple regression analysis has been applied.

Table 2. Regression Statistics for Green Energy

| Statistics       | Value       |
|------------------|-------------|
| R                | 0.980306691 |
| R Square         | 0.961001209 |
| Adjusted R Square| 0.902503023 |
| Standard Error   | 0.012784933 |
| Observations     | 11          |

The table 2 is presented summary for regression statistics about Green Energy. The value of R$^2$ which is 96.1 per cent revealed the variation of Green Energy. Secondly, adjusted R$^2$ indicated value 90.25 per cent of variance of dependent variable. The value of R which is 98.03 per cent revealed that significant relationship is existed between dependent and independent variables.

Table 3. ANOVA (Fitness of the Model)

| Model     | df  | F     | Significance F |
|-----------|-----|-------|----------------|
| Regression| 6   | 16.428| 0.00866        |
| Residual  | 4   |       |                |
| Total     | 10  |       |                |

The results of ANOVA in table 3 revealed fitness of the model. The significance value of F statistics comes out 0.00866 which is less than 0.05. It indicates variation in dependent variables is well explained by independent variables.

Table 4. Impact of Independent variables on Green Energy

|          | Coefficients | Sig.       | $H_0$  | Conclusion |
|----------|--------------|------------|--------|------------|
| Intercept| -23.38558    | 0.023808   |        |            |
| REDPC    | 0.00175195   | 0.0404131 | Reject | Impact     |
| CO$_2$PC | 0.03213117   | 0.6395832  | Accept | No Impact  |
| EUPC     | -0.0059214   | 0.0152324  | Reject | Impact     |
| RECAP    | -3.41996     | 0.8617586  | Accept | No Impact  |
| REC      | 0.08187187   | 0.014584   | Reject | Impact     |
| FFEC     | 0.18780491   | 0.0168816  | Reject | Impact     |

The summary of multiple regression results has been explained in table 4. This summary revealed that hypotheses $H_{01}$, $H_{03}$, $H_{05}$, $H_{06}$ have been rejected which means that Renewable energy consumption per
capita; Energy usage per capita; renewable energy consumption; and fossil fuel energy consumption plays significant role in determining Green Energy.

5. Findings and Suggestions
This section contains findings and suggestions of the study which are explained as follows.

5.1 Findings
There are three drivers of Green energy i.e. energy security; CO₂ per capita; and social & economic development. It is presented that usage of non-conventional energy sources will help to fulfill energy needs by protecting environment. Only renewable energy consumption is positively correlated with Green Energy no other factor is positively correlated with Green energy. CO₂ per capita has negative relation with Renewable energy consumption. It means if Renewable energy consumption will increase then there will be decrease in CO₂ per capita. Moreover, more Renewable consumption led to Green Energy. The impact of independent variables stated that Renewable energy consumption per capita; Energy usage per capita; renewable energy consumption; and fossil fuel energy consumption plays significant role in influencing Green Energy.

5.2 Suggestions
As stated by the study, Renewable energy consumption has positive relation with Green energy. So, Renewable technologies must be used. Policies to decrease level of CO₂ emission must be formed so that there must be more usage of Green energy. Awareness about renewable energy must be increased so that use of renewable technologies can be increased. As stated by the study, Fossil fuel plays significant role to determine Green energy. So, use of fossil fuel must be decreased so that environment can be protected.

6. Conclusion
This paper focused on green energy in which drivers of green energy and relationship & impact of determinants on green energy was studied. Green energy drivers are energy security; CO₂ emission; and social & economic development. Only renewable energy consumption is positively correlated with Green Energy no other factor is positively correlated with Green energy. CO₂ per capita has negative relation with Renewable energy consumption. It means if Renewable energy consumption will increase then there will be decrease in CO₂ per capita. Moreover, more Renewable consumption led to Green Energy. The impact of independent variables stated that Renewable energy consumption per capita; Energy usage per capita; renewable energy consumption; and fossil fuel energy consumption plays significant role in influencing Green Energy. Fossil fuel plays significant role to determine Green energy. So, use of fossil fuel must be decreased so that environment can be protected. Therefore, everyone must be aware about use of renewable energy techniques so that CO₂ emission can be controlled.

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