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Research Article

ASSESSMENT OF IMPACT OF RENEWABLE ENERGY ON POWER SECTOR WITH RESPECT TO CARBON EMISSION, ENERGY GENERATION AND COAL IMPORTS

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A B S T R A C T

With this huge potential, by 2022 India is targeted of achieving 175GW installed renewable energy (RE) capacity, which is 100 GW from Solar 60 GW from Wind and 15GW from other RE sources like biomass, tidal, geothermal etc. The paper deals with the Assessment of Impact of RE on Power sector with respect to Carbon emission, Energy generation and coal Imports. The goal of the paper was to determine the relationship of electricity generation, Carbon emission and coal imports and the correlation between them.

INTRODUCTION

The power sector in India is highly diverse with varied commercial sources for power generation like coal, natural gas, hydro, oil and nuclear as well as unconventional sources of energy like solar, wind, bio-gas and agriculture and stands world's fifth-largest electricity generation The demand for power has been growing at a rapid rate and overtaken the supply, leading to power shortages in spite of manifold growth in power generation over the years. The power sector offers tremendous opportunities for investing companies due to the huge size of the market, growth potential and returns available on capital. Industrialization, urbanization, population growth, economic growth, improvement in per capita consumption of electricity, depletion of coal reserve, increasing import of coal, crude oil and other energy sources and the rising concern over climate change have put India in a critical position. Being located in the equatorial Sunbelt, between the Tropic of Cancer and the Equator of the earth, India receives abundant radiant energy from the sun with an average annual temperature from 25°C to 27.5°C which offers huge potential for solar power generation, direct and indirect both. With this huge potential, by 2022 India is targeted of achieving 175GW installed renewable energy (RE) capacity, which is 100 GW from Solar 60 GW from Wind and 15GW from other RE sources like biomass, tidal, geothermal etc. The country stands globally at 4th and 6th position in global Wind and solar power capacity.

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This calls to strike a balance between economic development and environmental sustainability. One of the primary challenges for India would be to alter its existing energy mix which is dominated by coal to greater share of cleaner and sustainable sources of energy.

With lot of emphasis on RE from the GOI, there emerges great challenges, with respect to finance, technology, cost, policies etc. The decision of injecting RE in power mix of India will also has impact on it. It would worth undertaking a costly investment if RE are successful in giving a sustainable solution to India in terms of safety of supply, decrease in carbon emission, job creation, and accessibility of electricity.

Hence, the assessment of the impact of RE is justified. The organization of this paper is as follows. Section 2 provides literature review. Sections 3 is methodology of the study. Section 4 gives the analysis and the discussion of the results and conclusionare provided in Section 5 followed by the Section 6 which includes references.

LITERATURE REVIEW

This section provides a literature review of the calculation of impact of various variable on energy sector.

Kunert, *et.al* analysed the stock market reactions of 65 layoff announcements made by companies in the renewable energy industry in the years from 2005 to 2014 through regression analysis [1]. Thillairajan, *et.al* studied 148 power generation projects to find the impact of Private equity on Investment in RE [2]. Pubule, *et.al* analyzed the environmental impact assessment of power energy projects in Latvia for ten years

[3]. Seyoum, *et.al* examined the role of public and private transparency in attracting foreign direct investment (FDI) flows to developing countries through a cross-sectional model [4]. Anido *et al.* investigated the impact of wind power on electricity prices using a production cost model of the Independent System Operator e New England power system [5]. Yi-Hsuan Shih studied the social costs of nuclear, coal, gas, solar photovoltaic and wind energy in life cycle aspect, and compared these results with the European and Japanese estimates [6]. Galen Barbose *et.al.* studied the RPS (Renewable Portfolio standard) costs and benefits [7]. Galen Barbose *et.al* claimed the U. S. national-level assessment of state RPS program benefits and impacts, focusing on new renewable electricity resources used to meet RPS compliance obligations [8]. Omid *et.al*. estimated the costs and benefits of California RPS targets on electricity prices, greenhouse gas (GHG) emissions, criteria pollutant emissions, the electricity generation mix, the labor market, renewable investment decisions, and social welfare [9].

Girish investigated the Spot electricity price forecasting performance of Autoregressive-GARCH models on Indian spot electricity prices [10]. Badi and Pryke examined the capacity of risk allocation to encourage the implementation of environmental innovation, particularly sustainable energy innovation (SEI), within the private finance initiative (PFI) project delivery model for UK government's building schools by qualitative research [11]. S.N. Singh, *et.al.*analyzed the impact of electricity prices in the competitive electricity markets having a uniform market clearing price mechanism and found that the electricity prices depend on the system loading, generation mix, etc. at a particular hour in the European market [12]. Jablonska, *et.al.* identified and characterized the side-effect of emissions trading on electricity spot market price behavior by statistically comparingprice behavior before and after emissions trading 2005 (emission trading was introduced) through regression models [13]. K.B.Porate proposes a combined working of Doubly Fed Induction Generator (DFIG) with coal based Synchronous Generator (SG) in the MATLAB software. In the light of the above discussion, it is found the not much of the study has been done on the financial front of RE. It is only the technical angle which has been the area of focus to reduce the cost [14].

METHODOLOGY

The data collected for the study is from the secondary sources. Annual time series data, which covers the 1990-2015 period, is used in this study. Data used in the study is obtained from different sources, including World Bank Statistical Yearbooks, Enerdataenergy statistical year book, (2017).

Data is analyzed in excel (Data analysis, Solver) using linear regression model and correlation in order to find the impact of various variables like carbon emission, Coal imports, and growth in electricity generation with respect to RE electricity.

Analysis and Findings

Regression analysis is an important tool for modelling and analyzing data. It is a form of predictive modelling technique which investigates the relationship between a dependent variable (target) and independent variable (s) (predictor). This technique is used for forecasting, time series modelling and helps for the cause n effect relationship between the variables.

$$\mathbf{Y=a+b \times X + e,}$$

Where,
a = Intercept
b = Slope of the line
e = Error Term
Y = dependent (target) Variable.
X = independent (predictor) Variable.

This equation can be used to predict the value of target variable based on given predictor variable(s). The study has considered carbon emission, total electricity generated, value of coal imported from the period of 1990 to 2016 as independent variable and the RE electricity generation as a dependent variable.

Carbon Emission the data of CO_2 emissions from fuel combustion ($MtCO_2$) is fitted in the linear regression model with RE electricity produced from Enerdata. R^2 provide an indication of the explanatory power in the analysis. $R^2$is the percentage of variance in the dependent Variable explained by the collection of the independent Variable. Through the analysis it is found that the R^2 of the Carbon Emission is 94%.

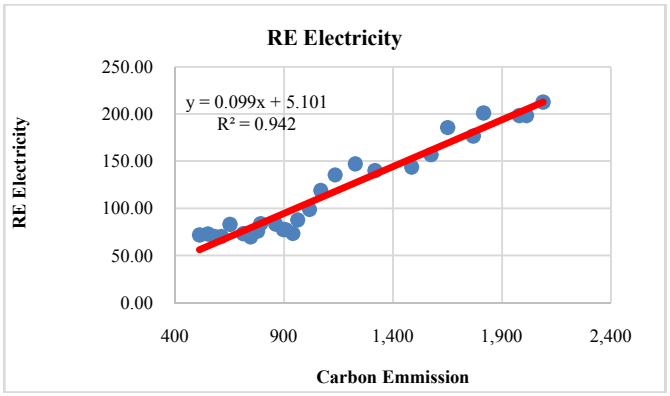

Fig 1 Relationship between Carbon Emission and RE electricity

Using the coefficient in the regression equation for the output. The coefficient for the constant is the value for the Y-Intercept. These values are used to calculate the next possible value of the dependent Variable. The Equation from this output:

Y = a + bx
Y = intercept + (Carbon Emission*0.0994)
Y= 212.7813 TWH
Which is exactly projected as given by the data source.With the help of the regression analysis the next projected value of RE with respect to carbon emission.

Table 1 Correlation between Carbon Emission and RE Electricity

	Carbon Emission	RE Electricity
Carbon Emission	1	
RE Electricity	0.970801	1

In addition to this, In Table 1 correlation between carbon emission and RE electricity produced has been established, and found that are statistically positively correlated. The reason of the same is that the proportion of the electricity produced through the RE is proportionately very small but growing at an increasing rate. Similarly, the carbon emission is growing due to increasing demand of electricity produced through coal and other factors contributing to the carbon emission.

Total Electricity produced. The Equation from this output:
Y = a + bx
Y = intercept +(Electricity Production*0.144)
Y= 218.44 TWH

Which is very near to the given value by the data source. With the help of the regression analysis the next projected value of RE with respect to total electricity proves the regression Model.

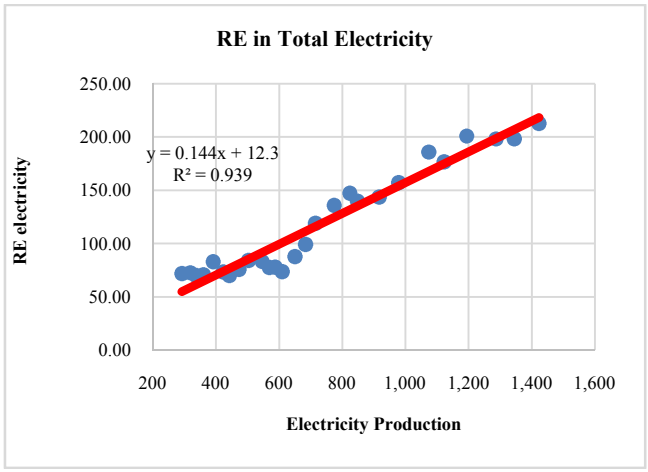

Fig 2 Establishes linear relationship between RE produced to total electricity produced in TWH.

Table 2 Correlation between Total Electricity produced and RE Electricity

	Electricity Production	RE in total Electricity
Electricity Production	1	
RE in Total Electricity	0.969173381	1

Correlation of the variables *i.e* total electricity produced and RE electricity produced has been established in table 2, and found that they are positively correlated. The reason is that the growth of total electricity produced and RE electricity produced grow simultaneously.

Coal Imports. The Equation from this output:
Y = a + bx
Y = intercept + (coal imports*0.00070)
Y= 211.97 TWH
With the help of the regression analysis the next projected value of RE with respect to Coal Imports is 211.97 TWH as against 212.79 TWH which is very close near to the given value by the data source. Hence justifies the regression Model.

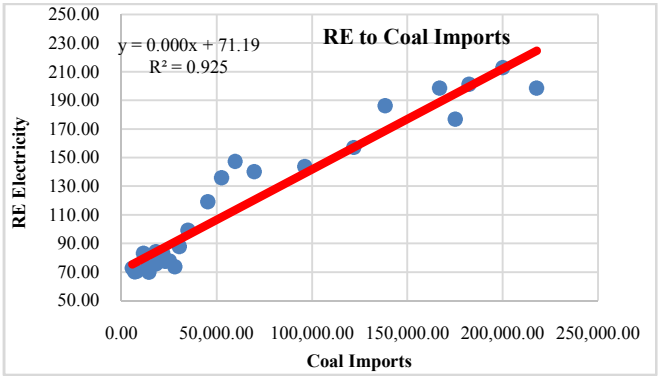

Fig 3 Establishes linear relationship between RE produced to Coal imports.

CONCLUSION

The data establishes a linear relationship and next year's projected value of RE electricity production can be easily projected through linear regression model. Carbon emission and coal imports should be ideally negatively related because of the social benefits of the RE. It does not happen because though RE electricity is rising but the proportion of RE electricity in total electricity is still very small hence are positively correlated. For the future scope of work the social cost benefit analysis of the RE can also be done for a better picture of impact of RE can be assessed on power sector.

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