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Assessment of Coal Energy Demand and Its Emissions by Using Leap Model in Different Energy Sectors of Pakistan

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Abstract: This research study analyses energy and environmental influences of three energy scenariosin three different sectors of Pakistan.Coal-fired energy is majorly used in the industrial sector as well as for the power generation in Pakistan. The LEAP (Long Range Energy Alternative Planning System) model was used to estimate total coal energy demand and the fired-coal emissions for the base year 2010and extrapolated till 2030 for the future predictions. This paper focuses on the total coal consumption per sector and the emission factors COx, NOx, SO_2 and CH_4 gas in the corresponding industries. Solar energy and biodiesel are proposed as alternatives to the coal energy in LEAP. Solar energy and biodiesel have potential of 2.3% and 1.9% respectively.The principal objective was to estimate the optimal energy source, which limits the future emissions. This study simulates the coal energy demand in order to find out economically viable energy mix with limited impact on environment.

Key words: Coal Fired Energy · Emissions · Scenario Construction · Biofuel · LeapModel

INTRODUCTION

For the economy of the country, energy is considered to be the most vital instrument of socioeconomic development, especially in the developing countries. In the developing countries like Pakistan, energy is not only essential for the economy but its supply is uncertain [1]. In this era of globalization, a rapid increase in urbanization, population and the energy demand indicate that energy will be the biggest problem in the developing countries as well as in the world in the next coming years.In Pakistan, energy generation sources comprised of gas, oil, electricity, coal and Liquid Petroleum Gas (LPG) with different levels of shares. Gas shares 43.9 percent in total energy mix of country followed by oil (27.9 percent), electricity (15.6 percent), coal (11 percent) and LPG (1.5 percent) [2]. Pakistan is blessed with up to 185 billion tons of coal. Thardesert constitutes about 850 trillion cubic feet spanning over 10,000 square kilometres.Fortunately, Pakistan has a very inexpensive source and a long-term solution to balance the demand and supply chain of energy in the country, which has the fifth largest coal deposits in the world [3].

Major use of coal is in cement industry, brick kilns and for the power generation constitutes about 42.7%, 56.6% and 0.76% respectively in Pakistan [2].As coal-fired energy is majorly used in all sectors which is mainly produced by the coal, by this many dangerous gases SOx, NOx, COx and many others are released in the air producing very harmful effects on the plants, animals, human beings as well as to the whole environment. Being low in quality, gasification and fuel cells are the two best options for its utilisation. Gasification is mostly done by two routes: underground coal gasification and coal mining followed by normal gasification. Coal gasification is comparatively cheap process, but it requires extensive analysis and measurements to ensure zero environmental effects. As coal mining and normal gasification is a tried and tested method, which is being utilised at a large scale around the world [4].

The need of focusing on this point is that whether the pollutants after coal combustion have to be purified before release into the ambient air orother alternatives should be considered not only for environmental protectionbut also for the better economy. Global warming and pollution are the concerns driving the interest in this

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safe renewable energy technology worldwide. Like all other developing economies of South Asia, Pakistan also needs sustainable renewable energy because its commercial energy needs are rapidly increasing day by day.Many renewable sources can be considered as fruitful alternative to the coal energy as biodiesel, solar energy, hydropower and the wind energy. For the present study the former two were considered [5].

Pakistan has got an immense resource in the form of sunshine for generating solar energy but this resource is going to waste. Solar power is the best alternative because it does not require any prior infrastructure. The raw material for solar cells (quartz and silica) is available in Pakistan. Quartz is available in abundance in our northern areas. It's safe for night operation and can generate power for other uses, such as charging cellphones or powering medical equipment, refrigeration of vaccines in remote areas, heat for brickkilns and many other industries as well [6]. On the other hand, bio fuels can work as mitigation against earth's heating up and equally they can be a cost effective alternative fuel. Bio Fuels refers to the fuel developed by crops or wood-based elements. This includes rice husks, corn, wood and molasses etc. that have potential to be converted in fuel [7].

In present study energy model LEAP was used to predict the future energy requirements from coal reserves of Pakistan. LEAP has had a significant impact in shaping energy and environmental policies worldwide. For example in California (2001) LEAP was used for energy forecasting and identifying alternative fuels [8]. Theenergy consumption and various types of emissions inconsumption sectors in Iran were analyzed by usingLEAP model. Up till now LEAP had been successfullyused in more than 150 countries worldwide for differentpurposes.

In this study, three scenarios were built; business as usual as reference, two alternative scenarios biodiesel and solar energy.

MATERIAL AND METHODS

Leap Model: In order to achieve the main objective of the research, the LEAP model was used to analyze and forecast energy demand and its related emissions under alternative strategies for the coal energy for the planning period of 2010 to 2030.In Mexico it was used to determine the feasibility of future scenarios based on moderate and high use of biofuel in the transportation and electricity generation sectors [9]. In Lebanon mitigation options were assessed to reduce emissions from electricity generation with emphasis on the usage of renewable energy resources [10].

Emissions: As coal releases very hazardous gases in the atmosphere; affecting air, water, soil as well as the human health and the whole environment. Coal emissions from base year projected to the end year, increasing day by day.

Scenario Construction: Forecasting the future is a challenging task. One method widelyused to foresee the future consists of setting a baseline, usuallya business-as-usual scenario and then alternativestrategies are evaluated by comparing them to that baseline.

Business-as-usual: In this scenario, 2010 was selected as the base year and 2030 as end year. This scenario was based on a continuation of recent trends. By extrapolating these trends, values were projected to 2030 without any change.

Solar Energy: The growth rate of solar energy is impressive and Pakistan has immense resource in the form of sunshine for generating solar energy. The potential for the solar energy was 2.3% in the base year 2010.

The potential of the solar energy from the year 2010 to 2030 was projected to foresee the future demand.

Biodiesel Scenario: Pakistan has a great potential for producing biodiesel or biofuel, Pakistan's land as rich in natural species of plants, can easily produce very fine quality of biofuel. Brassica, Pongamiapinnata and Ricinuscommunis are considered as plants that bear seeds that can firmly produce BIODIESEL in Pakistan.

RESULTS

LEAP model run under alternative scenarios to obtain estimates of the coal energy demand from 2010 to 2030.

Comparison of Base Year with Other Alternatives: The comparison of the energy demand of the baseline scenarios with the alternative scenarios was made by using LEAP. It forms the projection from the base year 2010 to the end year 2030. Solar energy and biodiesel have a potential of about 2.3%and 1.9% respectively. Comparison is shown in Figure 1.1.

Table 1.1: showing pollutants from fired coal, 2010 to 2013

	2010	2015	2020	2025	2030
Carbondioxide	92.6	108.4	126.9	148.6	173.9
carbon monoxide	150	175.6	205.5	240.6	281.6
Methane	10	11.7	13.7	16	18.8
nitrogen oxides	300	351.2	411.1	481.2	563.3
sulphur dioxide	0	0	0.1	0.1	0.1

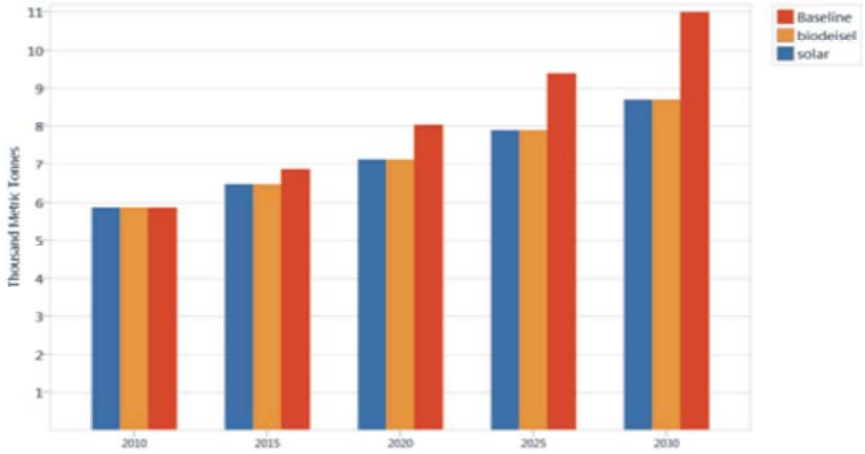

Fig. 1.1: Showing the comparison between three scenarios

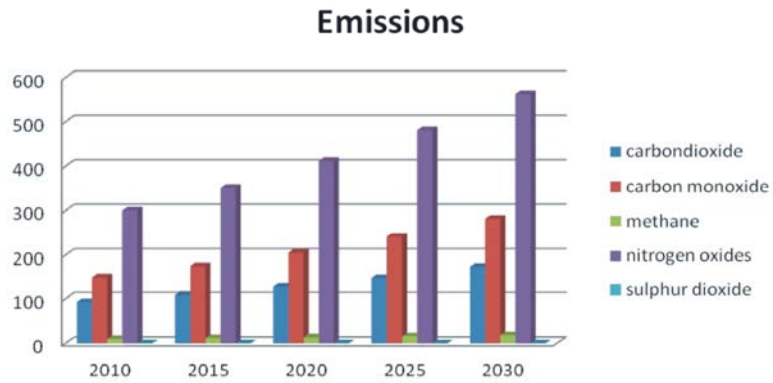

Fig. 1.2: Showing coal fired emissions projected till 2030.

Emissions: Coal fired emissions were calculated from the base year to the end year as shown in Figure 1.2. Pollutants released from the fired coal were showing the increasing trend as mentioned in Table 1.1.

DISCUSSION

In most of the developing countries, energy demand is being fulfilled by cheap and the parent sources of that country. Similarly Pakistan is facing energy crisis from many years though, it is blessed with very rich sources as water (for the production of hydro energy), coal (very cheap and easily available but of low quality), natural gas (domestic as well as for commercial use), petrol (transport and in many other sectors), wind (especially in the areas of Baluchistan), solar (rich with sunshine), biodiesel (large cultivable land, agricultural country) and many other sources. Renewable sources are much more reliable and long run as compared to non renewable energy sources. But for the comparison of the energy sources, large amount of data is required to assume the energy demand and the consumption but it requires some special tools [11].

LEAP used to make the energy scenarios by the base year 2010 to the end year 2030. In the base year, large amount of energy demand is fulfilled by the coal energy

in Pakistan in many sectors. Coal fired energy is used, which releases very hazardous gases Ox, SOx and many others. In the same sector coal energy can be replaced by renewable energy sources. In the present study, solar energy and biodiesel are proposed as alternative to the coal energy, have potential of 2.3% and 1.9% respectively. LEAP model form projections of the energy demand from the year 2010 to 2030. Both alternatives have much more potential that they can easily meet the energy even on low cost than the coal energy [12].

High potential of both alternatives suggests that brickkilns and cement industry using 42.7% and 56.6% respectively of coal energy can use solar energy or biofuel to meet this need of energy. Solar energy can be used for the power generation even on large scale [13-15].

Islas conducted research in 2007, in which biofuel was proposed as alternative to fossil fuels in Mexico Energy System particularly for the rural sector. Reduction in the carbondioxide emissions was observed by replacing renewable sources with non renewable sources [9].

We know that coal energy is cheap, viable and present in large quantity in Pakistan, but it releases hazardous gases during its processing in the environment. By using LEAP model, coal consumption and coal demand are considered by forming three scenarios in this model to estimate the energy demand from the base year 2010 to the end year 2030. Solar energy and biodiesel are proposed as alternative scenarios to the coal energy, solar energy and biodiesel have potential of 2.3% and 1.9% respectively. In the end year, both alternatives have potential that they can fulfil the maximum energy demand and can increase the economy of the country.

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