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Energy Modeling for Sustainable Industrial Sector Development in Islamabad, Pakistan

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Abstract

This study presents an overview of the status of energy consumption, associated emissions and their modeling in industrial sector of Islamabad. It critically examined the efficient utilization of the existing resources to reduce future burden of energy demand. For this purpose, a computer based energy model Long range Energy Alternatives Planning System (LEAP) was used to project the future energy demands. The base year 2012 was extrapolated till year 2042 for calculating the future energy projections. In alternative scenarios the feasibility of future scenarios based on the potential and use of resources was analyzed with the aim of determining their possible impacts on the energy system. The study described a simplified integrated approach that could enable to formulate policies for sustainable development and to limit the future demand for energy as well as to reduce air pollution from industries in Islamabad.

Keywords: Industrial sector, Energy modeling, Islamabad, Scenario analysis.

Introduction

The need for energy in today's world is increasing day by day. Nowadays for any country the issue of energy is a tough situation to handle. The global energy consumption increased by 5.6% in 2010-2011 as compared with the global energy consumption of the year 2009-2010; which is the strongest one since 1973[1]. Supply of energy is too much less as compared to the demand. This results in energy crisis. With this increase in consumption of energy the natural resources all over the world are decreasing day by day. Pakistan's energy infrastructure is not well developed, rather it is considered to be underdeveloped and poorly managed. Despite of strong economic growth and rising energy demand during past decade, no serious efforts have been made to install new capacity of generation. Moreover, rapid demand growth, transmission losses due to outdated infrastructure, power theft, and seasonal reductions in the availability of hydropower have worsened the situation. In many areas of Pakistan especially in big cities, the industrial units are also established without Environment Impact Assessments (EIA) and Environmental Managements and Planning (EMP).

Islamabad which was formerly considered as one of the beautiful cities in the world now got enough pollutions both in the air and water due to increase in the number of industries. Industrial pollution is a major problem in all big cities of Pakistan. However, severe problems are arising in Karachi, Lahore, Faisalabad, Sheikhupura, Multan, Hyderabad, Peshawar, Rawalpindi and Islamabad[2]. Industrial Estate Islamabad (IEI) was established in early sixties. It houses more than 250 industries. The Capital Development Authority (CDA) is managing the Industrial Estate Islamabad. IEI is spread over 625 acres of land on the border of cities of Rawalpindi and Islamabad. Islamabad IEI was isolated from residential area through a buffer zone, but now residential area has developed very close to it to the south and west due to elimination of buffer zone by CDA. IEI, therefore, is posing a pollution threat to the residents of the I-9 and I-10 sectors. Industry at IEI has been categorized into eight segments i. e. steel melting furnaces, re-rolling mills, flour mills oil and ghee marble cutting and polishing, pharmaceuticals, galvanizing and metal working engineering[3].

Ecologically sound development of the region is possible when energy needs are integrated with the environmental concerns at the local and global levels. Energy planning entails preparation of area bases decentralized energy plan for meeting energy needs for subsistence and development with least cost to the environment and the economy. A large number of models have been developed for energy system analysis till date, which are based on different fundamental approaches and concepts[4,5].

In present study, energy model LEAP was used to analyze the energy demand and emissions associated to industrial estate of Islamabad. The study aimed to explore the feasibility of using energy models as planning tools for industrial sector of Islamabad and utilizing these results to formulate energy policy in Pakistan in the context of the energy security and sustainability concerns. LEAP has had a significant impact in shaping energy and environmental policies worldwide. For example in California, LEAP was used for energy forecasting

and identifying alternative fuels[6]. In Mexico, it was used to determine the feasibility of future scenarios based on moderate and high use of biofuels in the transportation and electricity generation sector[7]. In Lebanon mitigation options were assessed to reduce emissions from electricity generation with emphasis on the usage of renewable energy resources[8]. Energy demand and emissions analysis was done with the help of LEAP model in Pakistan[9]. The electricity demand model in residential sector in Iran was developed by using LEAP model[10]. Up till now LEAP has been successfully used in more than 150 countries worldwide for different purposes.

Materials and Methods

This study used a scenario based energy-environment modeling platform called Long range Energy Alternatives Planning System to estimate and assess the demand of energy of Islamabad industrial sector with the environmental impacts. LEAP is a bottom up model developed by Stockholm Environment Institute (SEI), Boston in 1997 which serves as a database and forecasting tool. It can make scenario analysis by designing different schemes on future energy demand and environment development. LEAP model has been extensively used in environmental impact, energy demand and economic evaluation[11].

LEAP system was simulated to model energy scenarios as a group of responses affecting the industrial sector. The industrial sector was broadly classified into four manufacturing sub-sectors i.e. Steel melting furnaces, Marble, Soap and Other industries. Other industries included, flour mills, oil and ghee mills, pharmaceuticals, galvanizing, metal working and engineering units (Figure-1). LEAP model was used to analyze and forecast energy demand and its related emissions under alternative strategies in the industrial sector of Islamabad of the planning period of 2012-2042. The central concept in LEAP is an end use driven scenario analysis. The demands under each scenario were balanced with plausible sources of energy production and transformation. The input and assumptions for energy demand and supply were defined from an extensive literature review and data collection. Data was collected from national statistical publications, economic survey of Pakistan, energy year books, local and international research studies and different research reports. The transformation program simulated the infrastructure of electricity generation and distribution including data on natural gas and oil etc. The primary supplies in the transformation program were matched with the calculated energy demand, once the energy requirements were calculated in the demand analysis program.

The environment program uses the EDB in order to calculate the environmental impacts associated to the alternative scenarios. Emission factors in EDB represent average values gathered by the IPCC. Emission factors of different pollutants in the technology and environmental database (TED) module are linked to the device level to appraise environmental emissions for energy utilization during the planning horizon[11]. The evaluation program was used to compare alternative scenarios.

Scenario Construction: Scenario Construction is an important part of LEAP model. Business-as-usual scenario is usually considered as baseline scenario and others known as alternative scenarios are compared with it. This study consisted of three scenarios, which determined the energy demand and supply in IEI and their environmental impacts, and policy initiatives that would reduce total energy requirement and emissions. These scenarios are given in Table-1.

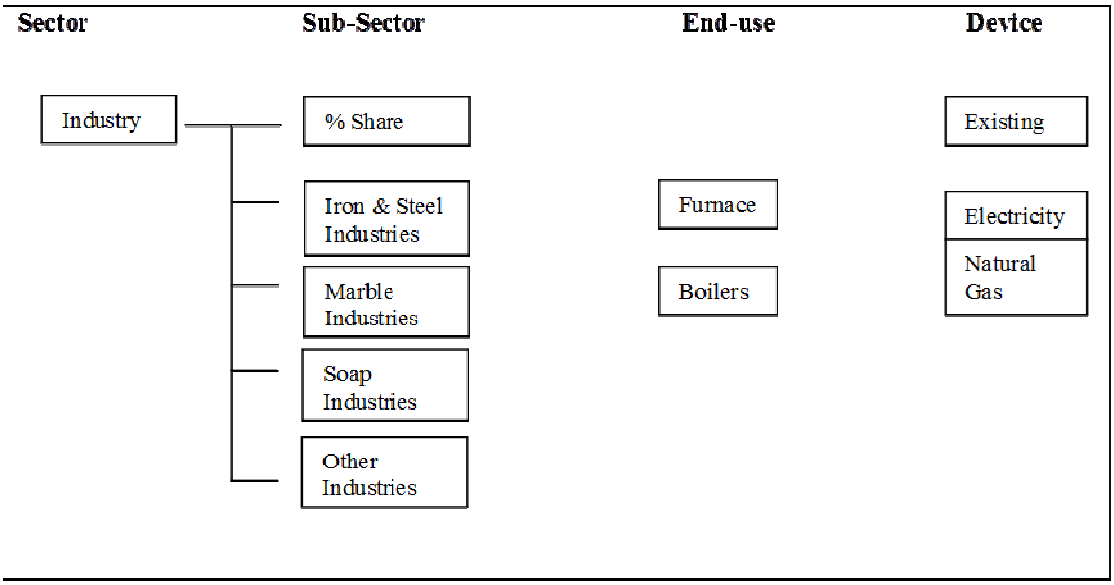

Figure-1
Structure of analysis using LEAP

Table-1
Scenarios Description

Scenarios	Description
Business-as-Usual Scenario (BAU)	Continuation of past trends. No additional measures to the current system
Biofuel Scenario (BIO)	Substitution of existing fuels by biomass fuels
Fuel Efficiency Improvement Scenario (FEI)	Maintenance of existing energy systems to reduce energy loss and associated emissions

Using LEAP the BAU scenario, called base case was established for 30 years from 2012-2042. This base case was a component of current accounts and future projections for energy demand and resultant emissions without any change. It was appraised on the basis of situation that already prevailed in industrial estate.

The BIO was aimed at reducing the energy shortfall and greenhouse emissions. Pakistan owns a better potential for biofuels that can partly relief country's fossil fuel requirements, 80% of which are straightaway being met through imports[12]. In BIO, the underlying assumption was that the installation capacity would be increased by 10% of total potential and biofuel based energy production would expand to 60% in 2042 with reduction in the share of fossil fuels based energy.

FEI addressed the gradual reduction of losses in the energy system up to 15% by the maintenance of existing devices in a period of 30 years. This alternative assumed that maintenance of devices and transmission links in all the industries would be even.

Results and Discussion

This section is representation of simulation results of energy demand obtained from LEAP model as well as an assessment of alternative scenarios as energy and environment friendly policy initiatives.

Energy Consumption: In the BAU scenario, results from the LEAP model revealed that the total energy demand in 2012 was 1.46 MTOE (Million Tonnes of Oil Equivalent) and in 2042 it was estimated to be 15.81 MTOE as presented in table-2. The energy requirement in 2042 was more than ten times energy demand in 2012.

Under the BIO, the total energy demand was decreased up to 5.08 MTOE in 2042 as compared to the 15.81 MTOE in BAU. The share of the biofuel based energy would replace fuel in BAU by 43% in 2027 and 67.8% in 2042 (Table-2). Bio-energy is also getting importance worldwide for example Sweden[13] and Austria[14] have decided to include bio-energy as a part of their primary energy feed. Brazil's Protocol initiated has attenuated 47% gasoline imports by use of ethanol in Brazilian transport sector[15].

Under the FEI, the total energy demand up to 2042 was observed to be 8.6 MTOE. The efficiency in the energy system of different industries would account for 27% and 45% reduction in total energy consumption by 2027 and 2042 respectively (Table-2).

Emissions: Long-term prosperity of a country depends on the economic stability. Greenhouse gas emissions and pollutants are resulting from multiplying energy exaction causing environment and climate degradation. The LEAP counts the emerging emissions from energy based on emission factors and other technical characteristics taken from the Technology and Environmental Database (TED). As a result of its energy predictions, environmentalists and researchers use this model to mitigate global warming[16]. In this research, the global warming potential of different fuels was calculated under different scenarios for the specified time period. Table-3 elaborates that in BAU the total global warming potential in 2012 was 2.27 $MtCO_2$ increased up to 24.6 $MtCO_2$ in 2042. In the BIO, the global warming potential was observed to be 7.91 $MtCO_2$ in 2042 whereas, the global warming potential of FEI in 2042 was observed to be 3.4 $MtCO_2$ in 2042. BIO and FEI scenarios would represent 67% and 45.5% of the base scenario's emission in 2042 respectively, with regard to the avoided CO_2 emissions. Biofuels emit CO_2, the primary source of greenhouse gas emissions, just like those running on gasoline.

Table-2
Estimated energy demand (MTOE) of industrial sector Islamabad under different scenarios

Years / Scenarios	2012	2017	2022	2027	2032	2037	2042
BAU	1.46	2.17	3.23	4.80	7.15	10.63	15.81
BIO	1.46	1.80	2.21	2.72	3.35	4.13	5.08
FEI	1.46	1.96	2.64	3.54	4.76	6.40	8.6

Table-3
Estimated global warming potential ($MtCO_2$) of industrial sector Islamabad under different scenarios

Years / Scenarios	2012	2017	2022	2027	2032	2037	2042
BAU	2.27	3.38	5.03	7.48	11.12	16.54	24.6
BIO	2.27	2.8	3.44	4.24	5.22	6.42	7.91
FEI	2.27	3.05	4.10	5.52	7.41	9.96	13.4

However, because plants and trees are the raw material for biofuels, and, because they need carbon dioxide to grow, the use of biofuels does not add CO_2 to the atmosphere, it just recycles what was already there. The use of fossil fuels, on the other hand, releases carbon that has been stored underground for millions of years, and those emissions represent a net addition of CO_2 to the atmosphere. A few studies also targeted on control of greenhouse gas emissions produced by energy substitution[17,18].

The present study reviewed how fast energy needs might grow under conditions of limited growth. Hence fuel switching and alternative fuels could help to meet increased industrial energy requirements of Islamabad. The traditional approach and practices for energy planning at national level are no more feasible and the complex array of variables and parameters tied up with the energy issues of the contemporary world and the numerous elements of the national energy systems can only be handled at integrated level in a sophisticated analytical environment provided by the energy models.

Almost all of the developed nations and some of the developing nations as well have already started use of these models as energy planning tools and in order to precisely deal with their energy security and sustainability constraints. The developing nations like Pakistan have the option to develop their own indigenous energy models or adopt some standard modeling tools developed for this purpose through international initiatives. If we consider the specific energy system analysis and integrated level planning needs of Islamabad Industry, LEAP model seems to be a better choice. In either case the poor intellectual base, poor administrative setups, deficiencies of resources and infrastructure and above all the inadequate and unreliable data present potential barriers. In countries like Pakistan, some non-traditional barriers due to inefficient and corrupt economic, social and administrative infrastructure are also observed. However, even with all these limitations the model based integrated energy design allow studying of multiple scenario alternatives; which can compensate for the imprecise and poor quality data.

Conclusion

This study focused on energy consumption and global warming potential projections in industrial sector Islamabad from 2012 to 2042. Results render that if ongoing situation retains, the energy appeals will swell dramatically emitting pollutants like many other developing countries. The study offered some possible alternatives to make this energy sector functional as industrial growth is backbone of any country's economic development; therefore, this study could also be used as a reference for other cities at national as well as international level for sustainable industrial sector's growth. The study concludes that long term sustainable energy supplies for industrial sector of Islamabad can be ensured by effective policy instruments, based on realistic planning backed by quantitative analysis; for which energy models are the best option and, the rational strategies to precisely understand and wisely overcome the practical barriers due to the regional and global geopolitical scenarios and the domestic governance practices. In response to critical energy status alternative proxies require an integrated approach with combination of indigenous knowledge and co-operation between state, private sector and the general public with serious and bold initiatives to be taken in the near future.

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