1. INTRODUCTION

1.1 Economic efficiency

Economic efficiency means efficiency in energy conversion and energy conservation. It offers a powerful and cost-effective tool for achieving a sustainable energy future. Improvements in energy efficiency can reduce the need for investment in energy infrastructure, cut fuel costs, increase competitiveness and improve consumer welfare. Environmental benefits can also be achieved by the reduction of greenhouse gas emissions and local air pollution. Energy security can also profit from improved energy efficiency by decreasing the reliance on imported fossil fuels. For these reasons, energy efficiency is one of six broad focus areas of International Energy Agency's (IEA) G8 Global Warming Programme. The IEA promotes energy efficiency policy and technology in buildings, appliances, transport and industry. Our analysis identifies best-practices, highlighting the possibilities for energy efficiency improvements and policy approaches to realize the full potential of energy efficiency for our country.

1.2 Energy security

Energy security means continuous availability of primary commercial energy at an affordable price. For the electricity sector, it requires adequate and timely investment in generation and network infrastructures. Markets are a powerful tool for achieving this goal efficiently. Yet, the ability of markets to deliver investment in power generation has been the subject of intense debate. Competitive electricity markets can work satisfactorily if they are well designed and regulated. Investment decisions must be made by market players who will insist on knowing the costs and risks of their decisions. Cost reflective electricity prices have in general been able to attract sufficient and timely investment. Most countries of Organizations for Economic and Cultural Development (OECD) electricity markets before reform were characterized by comfortable reserves of generating capacity and constant demand growth. When markets opened, this provided a cushion against supply security risks. As the cushion deflates, a real investment challenge has arisen out of demand growth and other factors. India's energy security concerns and response strategies are discussed in Section 3.2.
1.3 Environment protection

*Environment protection* science is well established and there still be concluding evidence on human activity induced global warming and the planet which we inherited from our forefathers was much cleaner than what it is today. It is our collective duty to pass it on to our future generations even cleaner than what we inherited. It was in 1850 that Arrhenius first established the term *Greenhouse Effect*. He concluded that sun radiation absorbed by CO₂ would warm the earth which is known as *Global Warming*. Majority of the scientists now believe that the rising concentrations of the greenhouse gases are overriding natural variability of the global climate, potentially leading to irreversible climate change. The increase in fossil fuel energy consumption directly increases atmospheric concentrations of greenhouse gases which disturb our ecosystem. Environment concerns from supply and demand side of fossil fuels have been discussed in Section 3.5 with respect to Indian conditions.

1.4 Vision

The broad vision behind this 3-E goals are to reliably meet the demand for energy services of all sectors including the lifeline energy needs of vulnerable households, in all parts of the country, with safe and convenient energy at the least cost in a technically efficient, economically viable and environmentally sustainable manner. Assured supply of such energy and technologies at all times considering the shocks and disruption that can be reasonably expected is essential in providing energy security to all. Meeting this vision would require that India pursues all available fuel options and forms of energy, both conventional and non-conventional as well as new and emerging technologies and energy sources. Coal shall remain India’s most important energy source till 2031-32 and possibly beyond. India will need to take a lead in seeking clean coal technologies and, given its growing demand, new coal extraction technologies such as in-situ gasification to tap its vast coal reserves that are difficult to extract economically using conventional technologies.

1.5 Approach

The approach is directed to realize cost-effective energy system for electricity generation. For this the following are needed:

a. Markets that promote competition
b. Pricing and resource allocation to take place under market forces under an effective and credible regulatory oversight as far as possible
c. Subsidies to be transparent and targeted
d. Improved efficiencies across the energy chain
e. Policies that reflect externalities of energy consumption
f. Policies that rely on incentives and which are implementable

A competitive market without any entry barriers is theoretically the most efficient way to realize optimal fuel and technology choices for extraction, conversion, transportation, distribution and end use of energy. The tax structure and regulation across energy sub-sectors should be consistent and institutional arrangements should provide a level playing field to all players. Social objectives should be ideally met through direct transfers. Environmental externalities should be treated uniformly and internalized, as far as possible, under the polluter pays principle. An energy market with the foregoing features would minimize market distortions and maximize efficiency gains. An integrated energy policy is needed to ensure that energy availability does not become a constraint on India’s economic growth and competitiveness.

While the medium to long-term challenges of ensuring competitive energy supplies are formidable, the immediate problem of power and coal shortages also requires policy actions. The medium to long-term issues are summarized in the Section 3.5.

The energy requirement in India is steadily increasing and this requirement is being met by both commercial and renewable energy sources. Due to the non-availability of sufficient resources and a considerable amount of emission of pollutants from commercial energy, it is now being felt that renewable energy has to be utilized to a greater extent.

1.6 Method
Review of India’s energy policy, demand and reserves estimation and developing a linear integrated model for optimum cost and energy security are explored in a systematic manner. The challenges in designing a reliable integrated electricity model are to find a combination of technologies where the pros of some types balanced out the cons of the others. Designing a combination of technologies where fluctuations in
production match a varying demand, such that any fluctuations in supply never lead to electrical production that cannot meet the demand can minimize this capacity. The model requires the assessment of the energy share of each of the supply inputs with the objective of achieving a minimum cost of energy generation by considering reliability and emissivity factors.

1.7 Thesis Organization

India's Energy Scenario, Energy Security, Energy efficiency and environmental issues are discussed in chapter 3, 4, 5 and 6 respectively. The integrated electricity model for energy security and the results are covered in chapter 8 and 9 respectively. The conclusion part is presented in chapter 10.