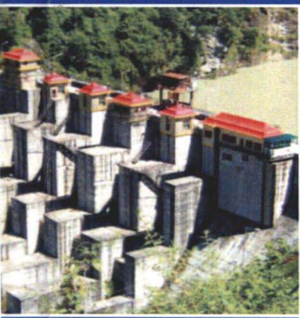
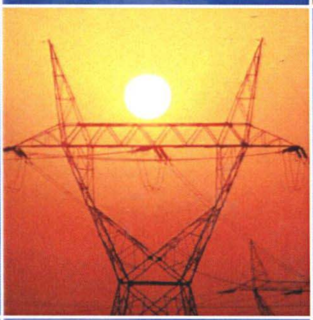
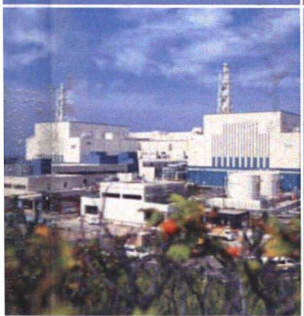
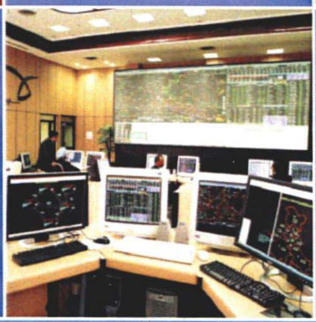
Green Power for Energy Security and Environmental Sustainability





Vinod Krishna Sethi

Green Power for Energy Security and Environmental Sustainability

A Scoping Study

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Green Power for Energy Security and Environmental Sustainability

Preface

Despite the fact that we in India have taken a giant leap forward in increasing the installed capacity from a mere 1713 MW in 1950 to over 2,28,000 MW as on date, the renewable energy sources, however contribute merely 13% with total capacity of over 29,000 MW. But this contribution has a major social and economic impact on rural and remote area population.

The growth of clean energy technologies for mega power generation, such as the Solar Mega Power under Jawaharlal Nehru Solar Mission, both Solar Thermal and PV, Clean Coal Technologies, CCTs, i.e., Supercritical power plants, Integrated Gasification Combined Cycle (IGCC) and fluidized bed combustion (FBC) are key to the success Green Power Mission for India.

Carbon Capture and Sequestration (CCS) is considered the frontier Green Energy technology. CCS technology is still in the demonstration phase, and it is important that India is not left behind in this area. While there is a considerable amount of work already underway domestically, there may still be a need for research collaborations and knowledge sharing and transfer. These areas of research in CCS include development of new adsorbents, better process integration of capture equipment, and conversion of CO_2 to useful products, among others.

Low carbon technology vision for india together with strategies, challenges and opportunities in green power for energy security environmental sustainability put forward in this book as a monograph may provide readers an opportunity for course-correction in their line of thinking in green energy technology.

The practising power engineers and postgraduate students and researchers in green energy technology will find it a reference book which has been produced as a blend of theory and practice on the subject.

The author sincerely thanks its previous organizations, the RGPV, Central Electricity Authority (CEA), Department of Atomic Energy for various inputs in preparation of chapters related to planning and research. Thanks are also due to Department of Science and Technology (DST) for sponsoring an impact project on CCS, which has given thrust to the chapters on CCS – a frontier green technology.

Vinod Krishna Sethi

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1 Chapter

Executive Summary: Energy Security and Environmental Sustainability

Man's expanding need for energy has become almost synonymous to the growth and developments in the modern S&T propelled agro-industrial society. It is however quite clear that increased energy consumption has resulted into serious problems such as global warming and erratic climate changes currently being experienced around the world. In India too, the prolonged summer in some parts, draughts in other, melting of glaciers and untimely flush floods in yet other parts of India have created an urgency to seriously examine the possible routes of green energy technologies for significantly augmenting the current levels of energy generation to meet the increased demands both for agriculture as well as for industries and transportation. Our power sector, mainly the coal-based conventional power plants, emits almost 56% of our total CO_2 emission which is at the level of about 1600 MTPA million tonnes per annum (world total emission being at the level of above 29,000 MTPA).

The major contradictory challenges faced by the developing countries like ours are:

- Quest for increased generation capacity
- Climate change – rising GHG level
- Continued focus on coal-based generation

Combating these challenges is the key to shaping the future of our sustainable power scenario. The shape of our future will be largely determined by how we generate and apply technological innovations to the energy sector and also to simultaneously enforce compliance of energy efficiency and environment management regulations. The technology options of Green Mega Power suggested here will have a strong transforming effect on the power industry and on the well-being of the society as a whole in the coming decades.

Despite the fact that we in India have taken a giant leap forward in increasing the installed capacity from a mere 1713 MW in 1950 to 2,11,766.22 MW as on date, the renewable energy sources, however, contribute merely 12% with total capacity of over 25,856.14 MW. But this contribution has a major social and economic impact on rural and remote area population. The growth of clean energy technologies for mega power generation, such as the Solar Mega Power under Jawaharlal Nehru Solar Mission, both Solar Thermal and PV, Clean Coal Technologies, CCTs, i.e., supercritical power plants, integrated gasification combined cycle (IGCC) and fluidized bed combustion (FBC) are key to the success Green Power Mission for India.

The tightening environmental regulations and commitments to "Combating Climate Change" will force us in India to accelerate the pace of deployment of clean coal technologies; all categorized as advanced fossil fuel technologies. This will however not be enough to measure up to the necessity of heralding the erratic climate change unless a much greater attention is paid in a tropical country like India to the rapid growth of the green energy technologies.

The global concern for reduction in emission of greenhouse gases (GHG) especially CO_2 emissions are likely to put pressure on Indian power system for adoption of improved fossil fuel based generation technologies. Mitigation options for CO_2 reduction which need to be taken up vigorously include GHG emission reduction in power sector through adoption of cogeneration, combined cycle, clean coal technologies and coal beneficiation. The CO_2 emissions per unit of electricity generated are significantly high in India as large proportion of power generated comes from low sized, old and relatively inefficient generating units which constitute over 50% of our total installed capacity. The technology upgradation through life extension of old polluting units is expected to increase the generating efficiency of these units thereby reducing CO_2 emissions.

A major thrust on CO_2 reduction on long term and sustainable basis would however come through advanced technologies of power generation like supercritical/ultra-supercritical power cycles, integrated gasification combined cycles (IGCC), fluidized bed combustion/gasification technologies, the clean coal technologies

(CCTs). Government of India has declared its policy on CO_2 abatement by the announcement and adoption of the 'National Action Plan on Climate Change'. It has also made voluntary commitment at the Copenhagen Summit that the country shall decrease its carbon intensity by 20% by 2020 and 50% by 2050. The path chosen makes it imperative that the CO_2 which forms 95% of the GHG emissions be reduced. The bulk of CO_2 is emitted by the thermal plants in the power sector. For EPA regulations to be implemented there have to be a road map as to how this can be done without major impact on the cost or efficiency. Carbon capture and storage/sequestration (CCS) appears to be an answer for which concentrated R&D efforts are needed.

It has been concluded at several forums that CCS at present, is not a viable option for CO_2 mitigation because of its energy intensity, cost, and uncertainty in the long term of CO_2 storage and monitoring. CO_2 fixation and utilization to produce value-added products will be a better option for CO_2 mitigation. Research initiatives by various academic institutions, research labs, and industry R&D setups need to be focused towards development of process, science and technologies for CO_2 utilization.

The country therefore needs energy policy for power generation as "a perfect blend" of advanced fossil fuel technologies, affordable renewable energy technologies, and nuclear and hydropower. However, energy conservation and energy audit will continue to play an important role in significantly enhancing the energy efficiency and minimizing colossal waste being incurred in the transmission and distribution of power. Further, efforts for promoting conservation and efficiency improvement through a well-planned approach for creating the desired synergy between energy, ecology and environment to accelerate growth without sacrificing the interest of man and nature will go a long way in sustainable power development mission.

The mission Energy Security and Energy Independence thus encompasses the following for energy security and environmental sustainability by 2020 and energy independence by 2030, towards our commitment for combating climate change, the 'nature's fury':

- Minimum 20% power generation from renewable energy sources through various missions, on the lines of Jawaharlal

Nehru National Solar Mission leading to optimum level of MWh and not merely MW of installed capacity.

- Solar for mega power generation, development of low cost solar photovoltaic cells and high efficiency CNT based PV cells.
- Development of technology of concentrated solar power for high temperature steam generation (>600°C). A pathway to coal substitution on a coal-fired power plant.
- Technology development in the area of low velocity wind turbines, hydrogen as fuel for future, biofuels from algae, biomass based generation in mission mode.
- Bringing energy efficiency and energy conservation on the top of the national agenda and promotion of carbon trading on the strength of R&D in energy efficiency and green energy initiatives.
- More than two-thirds of power generation in India is based on fuels which are polluting and create a large carbon footprint, mainly coal therefore the promotion of clean coal technologies, viz., 35 – 40% supercritical units in 12th Plan and 100% in 13th Plan and establishment of first integrated gasification combined cycle commercial unit in 12th Plan itself and accelerated installation of IGCC in 13th Plan period.
- Accelerated program on thorium-based nuclear reactor.
- Promotion of biofuels for railways and mass transport.
- Technology breakthrough in carbon capture and sequestration to produce useful multipurpose fuels.
- The strategic goals for energy independence by 2030 would thus call for a shift in the structure of energy sources. First, fossil fuel imports need to be minimized and secure access to be ensured. Maximum potential of hydro and nuclear power potential should be tapped. The most significant aspect, however would be that the power generated through renewable energy technologies may target to 25% against the present 12%. It would be evident that for true energy independence, a major shift in the structure of energy sources from fossil to clean coal, nuclear, hydro and renewable energy sources is mandated.

2 Sustainable Power Development Through Clean Coal Technologies

Chapter

2.1 INTRODUCTION

The shape of our future will be largely determined by how we generate and apply technological innovations to the energy sector and also to simultaneously enforce compliance of energy efficiency and environment management regulations. The technology options suggested here will have a strong transforming effect on the power industry and on the health of energy sector in the coming decades.

We are aware that the global concern for reduction in emission of greenhouse gases (GHGs) especially CO_2 emissions are likely to put pressure on Indian power system for adoption of improved generation technologies. Although India does not have GHGs reduction targets, it has actively taken steps to address the climate change issues. It is estimated that the green energy projects undertaken by Indian power sector will generate over 500 million certified emission reductions (CERs), by 2013. Mitigation options for CO_2 reduction which have been planned to be taken up by Indian power sector include GHG emission reduction in power sector through adoption of cogeneration, combined cycle, clean coal technologies and coal beneficiation. CO_2 emissions per unit of electricity generated are significantly high in India as large proportion of power generated comes from low sized, old and relatively inefficient generating units which constitute over 50% of our total installed capacity of about 2,12,000 MW. The technology upgradation through life extension of old polluting units is expected to increase the generating efficiency of these units thereby reducing CO_2 emissions.

A major thrust on CO_2 reduction on long term and sustainable basis would however come through adoption of advanced technologies of power generation like supercritical/ultra-supercritical power cycles, integrated gasification combined cycles (IGCCs), fluidized bed combustion/gasification technologies, and so on. In addition to clean coal technologies, India is currently sitting on a gold mine of opportunities of energy farming for biodiesel production, biomass gasification for decentralized power generation and for alternative rural energy security to a large extent. The planning commission report on biodiesel (2003) advocates for a substitute of 20% of current diesel demand by biodiesel through energy farming on the available 11.2 million hectare land comprising waste land, spare forest land and cultivation of Jatropha in rural areas and both sides of vast railway track. This would generate a vast sink for CO_2 while at the same time reduce exhaust emission through substitute of biofuels for transportation and other decentralized energy production needs.

A beginning towards adoption of clean coal technologies in the form of supercritical units has already been made in the country and it is foreseen that supercritical technology would almost universally be adopted for all large sized pithead units in the country. The attained efficiency gains of these technologies are likely to reduce the environmental emissions especially CO_2 significantly. Adoption of higher parameters for supercritical units after sufficient feedback and operational experience would further reduce these emissions to a great extent. A total additional efficiency of about 1.5-2% is normally achieved for adoption of supercritical parameters of 246 kg/cm^2 (g) and 537/565C, chosen for the first supercritical power plant under planning with unit size of the order of 660 MW. Adoption of still higher parameters would further enhance the efficiency. Attempts would also need to be made to further enhance the efficiency of conventional pulverized coal fired plant by adoption of ultra supercritical parameters. The main constraint being faced for adoption of these technologies is the availability of requisite material to withstand combination of high pressures and temperatures encountered. A consortium of several equipment manufacturers globally has pooled their resources to develop necessary materials to overcome the constraints for adoption of ultra supercritical technology.

Another option for CO_2 reduction is the increased use of natural gas. This provides improvement in generation efficiency together with reduction in CO_2 emissions but would facilitate environmental