A STRATEGIC AND TECHNOLOGICAL ROADMAP FOR A SUSTAINABLE FUTURE IN INDIA

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Abstract:

Climate Change and Energy Security are the two major challenges the world is facing today. Meeting the needs of billions of people who still lack access to basic, modern energy services while simultaneously participating in a global transition to clean, low-carbon energy systems. Both aspects of this challenge demand urgent attention. Energy today is at the heart of every economic, environmental and developmental issue. Developing countries like India need to expand access to reliable and modern energy services to alleviate poverty and increase productivity, to enhance competitiveness and economic growth. Sustainable development has environmental, economic and social dimensions. Sustainable development paths can reduce vulnerability to climate change and reduce GHG emissions. It is widely accepted that renewable energy sources are the key to a sustainable energy supply infrastructure since they are both inexhaustible and non-polluting. But the major problem with renewable energy suppliers is that they are generally intermittent which needs to be addressed. Therefore, poverty eradication and improvement in social well-being are biggest priories for countries like India. Against this backdrop, the paper attempts to outline the sustainable growth elements, challenges and opportunities across key social themes including food security and agriculture, energy efficiency, use of low carbon energies, green housing and waste management. This review also examines the current state of renewable energy technologies and the challenges for their implementation. Other technologies for sustainable growth like Clean Coal Technologies, CCS are also discussed. This paper chalks out a clean roadmap for a sustainable growth by taking various measures.

Introduction

Millions of different things live in our world. From the giant blue whale to the tiny ant, from the tallest redwood trees to the tiniest blade of grass, every living thing is dependent on everything else. Fossil fuels took millions of years to create-and it would take hundreds of millions of years for today's plants and animals to create new fossil fuels. Pollution happens when part of the environment is poisoned or harmed by human activity. Most pollution in the atmosphere is caused when people burn fossil fuels to produce energy. Air pollution is a major factor in global warming. Pollution of any kind disturbs the ecosystem. Ecosystems are delicate systems that support a variety of life forms.

"Many people today assume mistakenly that the Earth is so big that we humans cannot possible have any major impact on the way our planet's ecological system operates. That may have been true at one time, but it is not the case anymore. We have grown so numerous and our technologies have become so powerful that we are now capable of having a significant influence on many parts of the Earth's environment."- Al Gore, former vice president and Nobel Prize-winning environmentalist.

Scientists believe that the human-induced or anthropogenic enhanced greenhouse effect will cause climate change in the near future. Even some of the global warming skeptics argue that though global warming may be a minor influence, natural climate change does occur on human timescales and we should be prepared to adapt to it.

People often switch between the terms "climate change" and "global warming" to describe the same thing: rising temperatures. But technically, there's difference between the two meanings.

Climate change refers to significant alternations in a region's long-term weather patterns, like average temperature, precipitation or wind.

Global warming, on the other hand, refers specifically to the overall increase in the earth's temperature, which can in turn affect global climate patterns.

As the climate continues to warm, more changes are expected to occur and many effects will become more pronounced over time.

The evidence of climate Change: extends well beyond increases in global surfacr temperatures. It also includes:

- Changing precipitation patterns.
- Melting ice in the Arctic.
- Melting glaciers around the world.
- Increasing ocean temperatures.
- Rising sea level around the world.
- Acidification of the oceans due to elevated carbon dioxide in the atmosphere.
- Responses by plants and animals, such as shifting ranges.
- Intensified and more frequent weather events, like floods, droughts and hurricanes.
- Water and food supply shortages.
- Disease and health problems,
- Disruption of ecosystems.
- Habitat destruction and species extinction.
- Coral Reefs – Live coral reduced 50-93 per cent.

The IPCC international science study of climate change predicts readings will be 2-6° C higher by 2100 if emissions of heat trapping industrial gases are not reduced. By comparison, the world has warmed by 5-9° C since the depths of the last ice age, about 18,000 years ago. The same climate models predictive of temperature rise also show the atmosphere heating faster at the poles than other places on the planet.

The last years of the 20th Century were the warmest years of the past thousand, and the first years of the 21st continue a long-term trend toward a much warmer climate. Scientists report that since the mid-1970s, the average global surface temperature has increased at a rate of more than 2° C per decade. The most recent report by the Intergovernmental Panel on Climate Change (IPCC) states that there is clear evidence for a 0.6° C rise in global temperatures and 20 cm rise in sea level during the 20th century. The IPCC synthesis also predicts that global temperatures could rise by between 1.4° C and 5.8° C and sea level could rise by between 20 cm and 88 cm by the year 2100. In addition, weather patterns will become less predictable and the occurrence of extreme climate events, such as storms, floods, and droughts, will increase.

Variations of the Earth's surface temperature: 1000 to 2100

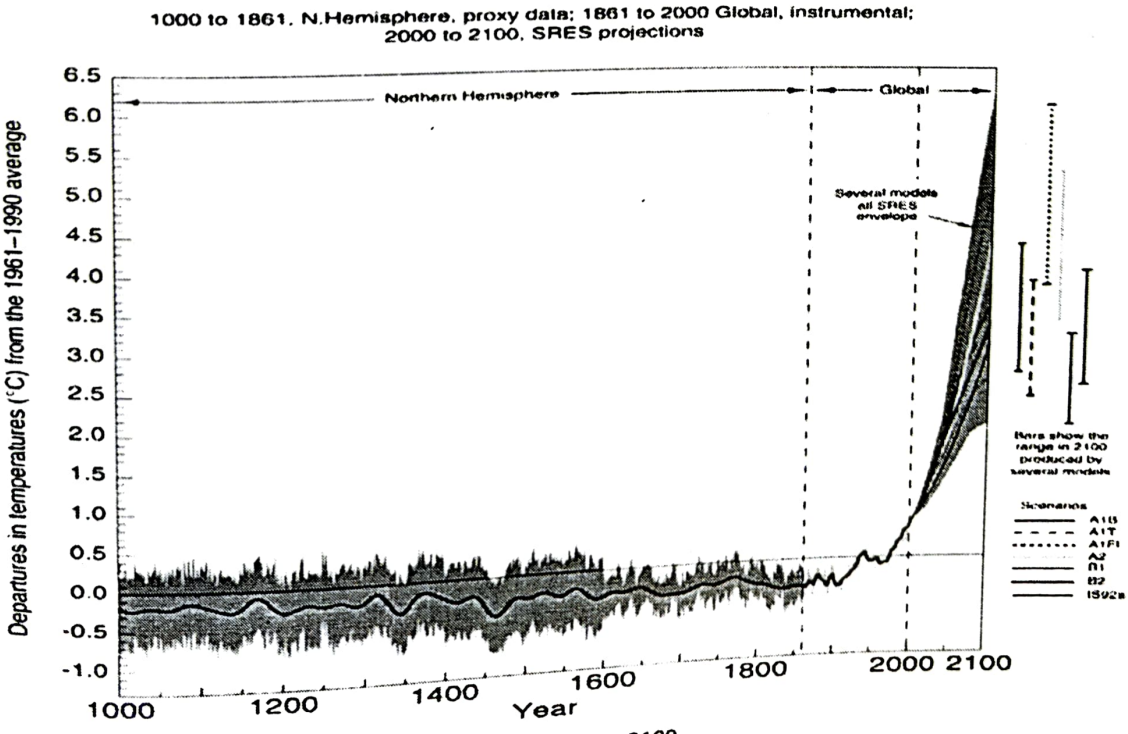


Figure 1: Variations of Earth's surface temperature: 1000 to 2100.

Global warming is one of the most controversial science issues of the 21st century, challenging the very structure of our global society.

The problem is that global warming is not just a scientific concern, but encompasses economics, sociology, geopolitics, local politics, and individuals' choice of lifestyle. Global warming is caused by the massive increase of greenhouse gases, such as carbon dioxide, in the atmosphere, resulting from the burning of fossil fuels and deforestation.

Naturally occurring greenhouse gases include water vapour, carbon dioxide, ozone, methane, and nitrous oxide, and together they create a natural greenhouse or blanket effect, warming the Earth by 35° C.

The three main indicators of global warming are temperature, precipitation, and sea level.

Addressing Climate Change

Addressing climate change means meeting rising energy demand while reducing emissions at an unprecedented scale. Our goal should be to protect the global climate system from further harm due to emissions of greenhouse gases and help humanity and the natural world adapt to unavoidable climate change and also, meeting the needs of billions of people who still lack access to basic, modern energy services while simultaneously participating in a global transition to clean, low-carbon energy systems. Both aspects of this challenge demand urgent attention. The first because access to reliable, affordable and socially acceptable energy services is a pre-requisite to alleviating extreme poverty and meeting other societal development goals. The second because emissions from developing countries are growing rapidly and are contributing to environmental problems, such as climate change and poor air quality.

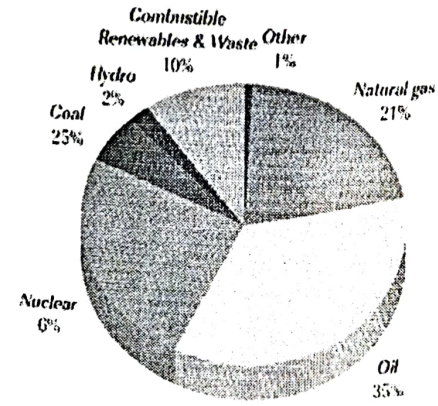
Energy Utilization

Since the dawn of the industrial age, the ability to harness and use different forms of energy has transformed living conditions for billions of people, allowing them to enjoy a level of comfort and mobility unprecedented in human history and freeing them to perform ever more productive tasks. For most of the last 200 years, steady growth in energy consumption has been closely tied to rising levels of prosperity and economic opportunity in much of the world. As societies have industrialized, they have not only used more energy but they have used energy in different forms, typically switching-as household incomes rise-from such traditional fuels as wood, crop residues and dung to such commercial forms of energy (i.e. fuels that can be bought and sold) as oil, natural gas, propane and electricity. Now, however, humanity finds itself confronting an enormous energy challenge. This challenge has at least two critical dimensions. On the one hand, it has become clear that current patterns of energy use are environmentally unsustainable. Overwhelming reliance on fossil fuels, in particular, threatens to alter the Earth's climate to an extent that could have grave consequences for the integrity of vital human and natural systems.

Recent years and months have seen increasing attention being paid to the issue of energy security. There are a number of concerns and fears such as:

- Oil and other fossil fuel depletion (peak oil, etc)
- Reliance on foreign sources of energy
- Geopolitics (such as supporting dictatorships, rising terrorism, "stability" of nations that supply energy)
- Energy needs of poorer countries, and demands from advancing developing countries such as China and India.
- Economic efficiency versus population growth debate
- Environmental issues, in particular climate change
- Renewable and other alternative energy sources.

Share of World Primary Energy Supply in 2005



Source: IEA, http://www.iea.org/textbase/nppdf/free/2007/key_stats_2007.pdf, p.6

Growing global vulnerability in a rapidly changing environment:

The global economy is currently caught between a severe credit crunch, slowing demand in many developed countries and rising inflationary pressures in emerging and developing economies. This is compounded b y volatility in energy and commodities prices. The most pressing global challenges such as energy and climate change will now have to be addressed in an increasingly more fragile macroeconomic context, especially in poor developing countries. For the first time since 1973, the world is witnessing a combination of high oil and food prices, undermining gains achieved in fighting poverty. The current financial and economic crisis will require protracted adjustment as developing countries face a shortfall in capital flows, reduced demand for exports and rising inflation. For many developing countries, the recent food, commodities, and oil price shocks are already having severe implications particularly among the poorest.

Greater energy efficiency and new technologies hold promise for reducing greenhouse gases and solving this global challenge.

Energy and Economic growth in India

The Indian economy has grown rapidly over the past decade. The rapid economic growth has been accompanied by commensurate growth in the demand for energy services that is increasing the country's vulnerability to energy supply disruptions. To achieve a sustained economic growth rate of 8%-9%, till 2031/32 and to meet the lifetime energy needs of all its citizens, India needs, at the very least, to increase its primary energy supply by 3 to 4 times and its electricity generation capacity by approximately 6 times. Demand for energy will keep increasing because of accelerated industrialization, urbanization and an emerging consumer society. India is the world's sixth-largest energy consumer, with 3.5 percent of global energy consumption.

The per capita energy consumption in India is very low as compared to developed countries as well as to other developing countries. It is jus 4% of per capita energy consumption of USA and 20% of the world average. The per capita consumption of energy in India is amongst the lowest in the world: in 2006, it was 510 kg of oil equivalent (kgOE) of primary energy compared to 7740 in the USA and the world average of 1800. Economic growth will increase energy consumption.

Need to improve energy productivity

India relies on indigenous coal, and to a lesser extent oil, to meet its energy demand. While the country has had large reserves of coal, it now imports over 15% of its coal supply, relies on imported oil for more than 75% of its oil needs, possesses limited natural gas reserves while importing 30% of total supply and faces chronic electricity shortages. Installed electricity generation capacity in India was 177 GW in 2011, including 23 GW or 15% in the private sector. Over half of the capacity was coal fired and hydro, natural gas and renewable constituted much of the remaining share. Due to continued shortages of electricity supply, captive power generation continues to play an important role in providing electricity, albeit expensive, for industrial and commercial, and increasingly for urban residential consumers. The gap between electricity supply and demand in terms of both capacity (i.e.kWh) has been shifting annually in India. Electricity deficit increased from 7.8% of energy demand in 1990-91 to 11.1% in 2009-10. On the other hand, peak power deficit declined from 18.0% to 11.9% over this period. India has discovered new natural gas resources in offshore areas, which will reduce its projected dependence on the imports of fossil fuel. Coupled with deteriorating coal quality, India's energy situation is likely to worsen its vulnerability to volatile fuel prices in a tightening world oil and gas market.

Table 1: Electricity Generation Capacity, India

	Generation Capacity (2004-05)		Generation Capacity (June 2011)	
	(MW)	(%)	(MW)	(%)
Coal	68,434	55.5	96,743	54.7
Natural Gas	12,430	10.0	17,706	10.0
Oil	1,201	0.9	1,200	10.0
Hydro	32.135	26.0	37,367	0.7
Nuclear	3,310	2.7	4,120	21.1
Other (Renewable)	6,158	4.9	18,454	3.1
Total	123,668	100	176,990	10.4
				100
Captive (>1 MW)	19,103	23.8	24,986	
Captive (<1 MW)	23,000	76.2		
Total Captive	30195	100		

Source: Economic Survey, Govt. of India (2006), CEA (2005) 15, CEA (2009) 16.

Note: Captive power estimates for <1 MW are for 31 March 2004, and >1 MW are for 31 March. These vulnerabilities are being addressed through diversification of energy imports, the development of indigenous fossil and renewable energy sources, e.t.c., more efficient use of energy and renewable electricity generation thus has the potential to reduce the nation's vulnerability in both the imported fuels and electricity markets. Sustainable development paths can reduce vulnerability to climate change and reduce GHG emissions.

Sustainable development

Sustainable development has environmental, economic and social dimension. Properly designed climate change responses can be part and parcel of sustainable development, and the two can be mutually reinforcing. Mitigation, by limiting climate change, can conserve or enhance natural capital (ecosystems, the environment as sources and sinks for economic activities) and prevent or avoid damage to human systems and, thereby contribute to the overall productivity of capital needed for socio-economic development, including mitigative and adaptive capacity. In turn, sustainable development paths can reduce vulnerability to climate change and reduce GHG emissions.

Overview of the National Sustainable Development Strategy Indian Philosophy

The notion of 'sustainable development's is not new to India. Through the preaching of great saints like Mahavir, Buddha, Ashoka and Gandhi, the concept of sacrifice for others became the integral part of the oriental philosophy. The Sufis and Moulanas (Muslim religious leaders) have also contributed to this Indian (and oriental) philosophy of overcoming greed and desire. The inherent strength of this philosophy has helped the Indian civilization survive and thrive over five thousand years without invading or colonizing other countries. Though in its long history although being invaded many times, only the British – via the introduction of western science

– were able to impact the lifestyle and production system of this old civilization. Western science taught key sectors of the Indian population how to exploit and dominate nature; pre British India believed in co-existence with nature where agriculture, production system transportation, social and religious events were all planned as per the weather cycles. Oriental science respected nature. But modern science has taught how to mine coal and crude, build bridges and dams, pump out underground water to produce hybrid grains during off-season, genetically modify plants etc. Within two hundred years of the application of these forms of new knowledge, a country with five thousand years of sustainable existence (without any record of large scale famines prior to British rule) is now desperately searching for a viable model of sustainable development to rescue itself from the current environmental (also economic) mess.

Social Sustainability

Energy, Poverty reduction and climate Change:

Energy today is at the heart of every economic, environmental and developmental issue. The world needs clean, efficient and reliable energy services to meet its long-term needs for economic growth and development. Developing countries like India need to expand access to reliable and modern energy services to alleviate poverty and increase productivity, to enhance competitiveness and economic growth. The demand for primary energy is expected to increase significantly in the next few decades. Increased energy demand will give rise to challenges in poverty reduction, development and macroeconomic stability worldwide. Some of these challenges are:

1. Energy and food security:

India ranks a low 134 among 187 countries in terms of the human development index (HDI), According to the "UN Human Development Report 2011: Sustainability and Inequality", India's HDI is 0.5 compared to 0.3 in 2010. India has been ranked 66, much lower than neighboring China (39), in the 2012 Global Food Security Index released by the American chemical company DuPont. In recent months, higher food and oil prices have pushed many more people into poverty. Food prices have been driven by a combination of rising fuel and fertilizer costs, bio-fuels production and unfavorable weather conditions, further accentuated by trade restrictions, low stocks and domestic supply constraints.

2. Energy for the Poor and Energy Access

- **Energy, Poverty and Economic Growth:** As per the Household Consumer Expenditure Survey for 2009-10, 29.9 per cent of the populations alone were under the Below Poverty Line (BPL) from 37.2 per cent in 2004-05. While energy services, by themselves, are not sufficient to eradicate extreme poverty, they are necessary for creating the conditions for economic growth and improving social equality.

- **Energy and education, health, gender equality:** Women and girls in many developing countries spend a huge amount of time collecting wood and carrying water: time lost for schooling and revenue generating activities. Furthermore, indoor air pollution from low quality solid cooking fuels (wood, charcoal, dung, waste) imposes a major health burden on those who spend their days close to the cooking area, again, women and girls, responsible for more than 1.5 million deaths per year.

- **Energy and Improved Quality of Life:** Current energy systems are failing to meet the needs of the world's poor. Worldwide, 2.6 billion people rely on traditional biomass for cooking and 1.6 billion people – about a quarter of the human race – do not have access to electricity. Accelerated use of renewable and more energy efficient technologies can provide 'win-win' options to tackle global and local development challenges. In the current context of rising and volatile energy pieces, many developing countries are looking for alternatives to imported energy sources. Local energy resources and improved energy efficiency help create local jobs and save foreign exchange. But they also contribute to increased energy security through increased energy supply and climate security through reduced greenhouse gas emissions.

Energy Efficiency and Renewable Energy

Efficiency improvement also has the potential to boost economic growth that can result in higher tax revenue for the Government. An analysis of the electricity efficiency potential for India shows that efficiency improvement in combination with new supply can eliminate electricity shortages at the same investment level as for a business-as-usual electricity supply scenario. The higher penetration of energy efficiency technologies reduces the construction of power plants

thereby reducing fuel imports and India's C02 emissions by 300 Mt C02/year by 2017, the end of the 12th Five Year Plan.

Combining wind and other renewable with electricity efficiency improvement options provides an approach for significantly reducing emissions and electricity supply costs while also increasing the GDP growth in India. A recent analysis that included both EE and RE options illustrates these benefits for 2022, which will be the end of India's 13th Five Year Plan. The Total capacity in the reference scenario adds up to 426 MW with 337 MW from thermal, hydro and nuclear units. In Scenario 3 which includes higher penetration of EE and RE options, the need for thermal units declines from 228MW to 132 MW, which results in 30% reduction in carbon emissions. The available capacity is large enough to eliminate the electricity shortages in the reference case. Increased availability of electricity also leads to an increase in business output and GDP growth.

Towards sustainable, Low-Carbon path to Development

India's Climate Change and Energy Vision

In July 2008, India released its first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programs addressing climate mitigation and adaptation (Table 2).

Table 2: India National Action Plan on Climate Change

Mission	Objective	Responsible Entity
National Solar Mission	20,000 MW of Solar Power by 2020	Ministry of New & Renowable Energy
National Mission for Enhanced Energy Efficiency	10,000 MW of EE Savings by 2020	Ministry of Power
National Mission for Sustainable habitat	EE in residential and commercial buildings, public transport, Solid waste management;	Ministry of Urban Development
National Water Mission	Water conservation, river basin management	Ministry of Water Resources
National Mission for Sustaining the Himalayan Ecosystem	Conservation and adoptation practices, glacial monitoring	Ministry of Science & Technology
National Mission for a Green India	6 mm hectares of afforestation over degraded forest lands by the end of 12th Plan	Ministry of Environment & Forest
National Mission for Sustainable Agriculture	Drought proofing, risk management, agricultural research	Ministry of Agriculture
National Mission on Strategic Knowledge for Climate Change	Vinerability assessment, Regards & observation, data management	Ministry of Science & Technology

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The Plan identified eight core "National Missions" running through 2017. The Plan includes eight missions, one of which is on energy efficiency, National Mission on Enhanced Energy Efficiency (NMEEE) its mission is to help save about 5% of annual energy consumption, and nearly 100 million tones of CO_2 every year by 2015, and another one on solar energy, National Solar Mission (NSM).

The Plan's broad goals are consistent with the three Pillars of sustainable development – economic, social and environmental, which all need to be addressed in the provision of adequate energy supplies.

1. In recognition of the importance of energy conservation, the Indian Government created the Petroleum Conservation Research Association (PCRA) in 1978, PCRA continues to play an active role in the promotion of petroleum fuel saving strategies and functions as t think tank to the Government.

2. In 2001, the Indian parliament passed the **Energy Conservation Act 2001**, which established the Bureau of Energy Efficiency (BEE) with effect from 1st March 2002 under the Ministry of Power Some key activities that BEE is pursuing include the development of energy performance standards and labels for

refrigerators, motors, air conditioners, and other mass produced equipment, certification of energy managers and auditors, assisting industry in the benchmarking of their energy use, and energy audits of prominent Government buildings. Significant measures had been taken by GOI for promoting energy efficiency in household sector through BEE to name a few:

- The Bachat Lamp Yojana is a scheme developed by BEE under which long-life CFLs having an average rated life of 6000 hours and above would be distributed to grid-connected residential households in exchange of an incandescent lamp (ICL) & Rs.15.
- Energy efficient measures are being undertaken in municipalities where they buy energy for street lighting and supplying fresh water to households, in agricultural sector for efficient usage of pumps and also for small & medium enterprises e.t.c.

3. The Indian Parliament also passed the Electricity Act in 2003 (referred to as the Act) under which the Government of India is directed to prepare the National Electricity Policy and tariff Policy, in consultation with the State Governments and the Central Electricity Authority (CEA) for development of the power system based on optimal utilization of resources such as coal, natural gas, nuclear, hydro and renewable sources of energy.

Power Sector – Smart Grids

India's power grid is growing and was not built overnight. Based on 20th century design requirements, the Indian electricity grid has not sufficiently incorporated energy efficiency, environmental impacts and customer choice. These include improvements to the transmission and distribution systems, demand response to reduce energy use and peak loads, reducing congestion, improving reliability and power quality, energy storage systems, interoperability standards.

The worst power outage in India's history in the month of July-August, 2012 represents a "wake up call" over the failure of the creaking electricity system to keep pace with the growth of Asia's third-largest economy, it also indicates India's over dependence on coal-fire powered plants.

Sustainable Energy Technologies:

Integration of Clean Coal Technology, Carbon and storage (CCS) with IGCC

A cost-effective and significant step towards improving power plant efficiency and reducing the GHG emissions from the coal-fired power plants would be to increase the availability of clean beneficiated coals using appropriate beneficiation technologies. An alternative to achieving efficiency improvements in conventional pulverized coal-fired power station is through the use of gasification technology. IGCC Plants use a gasifies, where clean coal is combined with oxygen and steam to produce the syngas, which is mainly H2 and Carbon monoxide. The gas is then cleaned to remove impurities, such as sulphur, and the syngas is used in a gas turbine to produce electricity. Waste heat from the gas turbine is recovered to create steam which drives a steam turbine, producing more electricity – hence a combine cycle system. IGCC efficiencies typically hover around the 40-5-% mark 85% of global installed capacity is "sub-critical power plants" which have less thermal efficiency compared to advanced power generation technologies such as "supercritical" and "ultra-supercritical", "Circulating Fluidized Bed Combustion (CFBC)" and "Integrated Gasification Combined Cycle plants (IGCC)", which hold out the prospect of significantly raising the efficiency of the new coal-fired plants that will be built in the coming decades and reducing their emissions. Replacement of such inefficient plants could increase efficiency of plants by 10-15%.

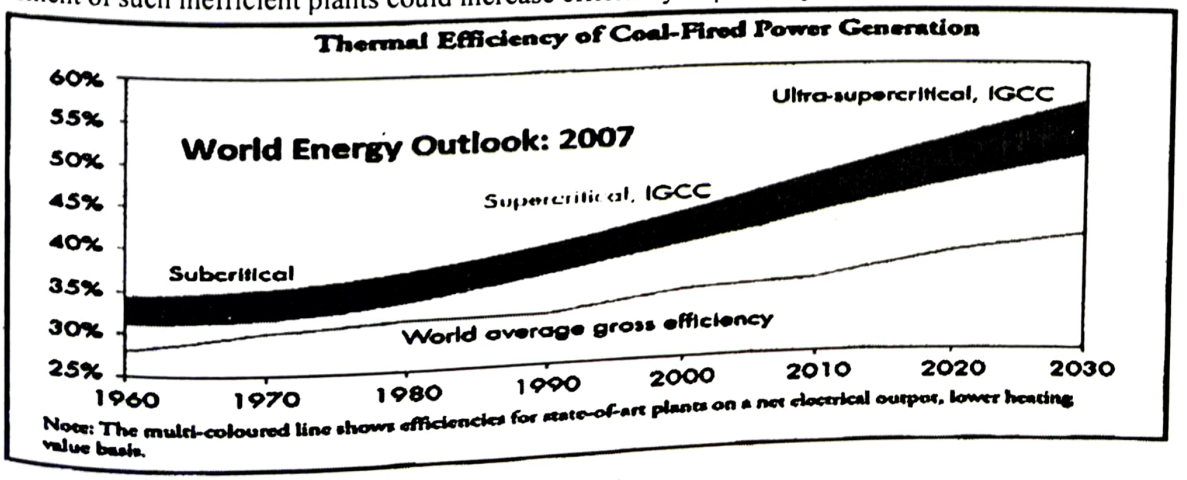


Figure 3: Thermal Efficiency of Coal-Fired Power Generation

The Step forward:

India has been keeping pace with changing times and has commenced work on the country's first and biggest IGCC power plant that would come up at Vijayawada in Andhra Pradesh. The 182 MW, 2500 crore plant is a joint venture between Bharat Heavy Electricals Ltd (BHEL), Department of Science and AP Genco, a state-owned power generator in Andhra Pradesh National Thermal Power Corporation (NTPC) recently joined hands with BHEL to set up a 100 MW IGCC Power Plant at Dadri near Ghaziabad in Uttar Pradesh at an estimated cost of 600 crores. The expansion of coal beneficiation capacity and use of IGCC in India, in order to achieve a significant potential benefit to energy security and environmental protection, is not fundamentally a technical problem. Policies need to be adopted that address the institutional barriers preventing widespread adoption of such technologies in India. Necessary changes will requires the co-ordination of various ministries that influence the coal mining, preparation, transportation and use, including the ministries of coal, oil and gas, and power, and environment and forest.

Table 3: Power Generation Costs in India by Energy Source (2008)

Energy Type	Electricity Generation Costs in INR/kWh (USD/kWh)[66]	Source
Coal	1-2 (0.02-0.04)	Mickinsey – Powering India
Nuclear	2-3 (0.04-0.06)	Mickinsey – Powering India
Large Hydro	3-4 (0.06-0.08)	Mickinsey – Powering India
Gas	4-6 (0.08-0.12)	Mickinsey – Powering India
Diesel	10 + (0.20+)	Mickinsey – Powering India
Wind (on-shore)	3-4.5 (0.06-0.09)	Industry Experts
Small Hydro	3-4 (0.06-0.08)	Industry Experts
Biomass	4-5 (0.06-0.10)	Industry Experts
Solar (CSP)	10-15 (0.20-0.30)	Industry Experts
Solar (PV)	12.20 (0.24-0.40)	Industry Experts

Renewable Energy:

As of June 2010, India was one of the world leaders in installed renewable energy capacity, with a total capacity of 17,594 MW (10% of India's total installed electric generating capacity). Of that total, 17,174 MW were grid-connected projects, and the remaining 2.4% of installed renewable capacity consisted of off-grid systems India has also installed 2,767 MW of small hydro plants (with sizes of less than 25 MW each), 1,412 MW of grid-connected cogeneration from bagasse, and 901 MG of biomass-based power from agro residues. Waste-to-energy projects have an installed capacity of 72 MW from hybrid systems. Renewable energy technologies are particularly attractive in dispersed, 'off-grid' applications and therefore represent an important option for rural areas that lack electricity transmission and distribution infrastructure. A number of renewable energy technologies have improved to the point where they can now provide electricity at lower cost than other supply options wherever grid extension is prohibitively expensive or uneconomic. There are six broad categories of renewable energy technologies-biomass, wind, solar, hydro, geothermal and tidal. For example, many

renewable energy sources are inherently intermittent. Thus their integration into a unified electricity grid can pose challenges, especially on a large scale. MNES is the governing body for RE in India.

Table 4: Estimates of Potential Capacities from Renewable Energy Sources (in MWs)

Source	Approx. Potential
Biomass Energy	19,500
Solar Energy	20,000
Wind Energy	47,000
Small Hydropower	15,000
Ocean Energy	50,000

Source: India Ministry of Non-Conventional Energy Sources

The sum of these renewable resource potentials, 152,000 MW, is greater than the current total installed energy generating capacity of India.

Some of the major renewable sources and their status.

1. **Bio-Energy:** Current situation and applications: India is very rich in biomass. It has a potential of 19,500 MW (3,500 MW (3,500 MW from bagasse based cogeneration and 16,000 MW from surplus biomass). Currently, India has 537 MW commissioned and 536 MW under construction. India has the largest available biomass resources which is the largest share of all renewable energy sources. Nowadays biomass is used in many other ways other than traditional uses like cooking, heating, etc.

a) Combustion of solid Waste: Municipal solid waste is used to produce heat, electricity or both in cogeneration systems.

b) Anaerobic digestion of wastes to produce biogas also landfill gas from wastes.

c) Biofuels: Liquid fuels from grains and dedicated energy crops (sugar crops), are used in the form of biodiesel or ethanol. Ethanol blends (5%-10%) are already in use in advanced nations.

d) The technology of biodiesel is available but measures are to be taken to make it cost-effective.

2. **Wind Energy:** The wind industry has achieved the greatest success in India with an installed capacity of 12,009 MW at the end of June 2010. Wind turbines have proven successful in of grid applications such as islands, northen areas, hilly regions and other remote villages. The current wind technology developed in India has lagged behind technologies produced around the globe. According to MNRE, turbines in India range in capacity from 250 KW to 2,100 KW compared to a global maximum of 5,000 KW. There is need for technology advancement and govt. incentives, tax benefits should be more pronounced Adoption of new policies will attract more market players.

3. **Solar Energy:** The India Energy Portal estimates that around 12.5% of India's land mass, or 413,000 km2, could be used for harnessing solar energy. Although India already has a strong solar cell production industry, until now, there has not been a high demand for them in the domestic market. In response to the announcement of JNNSM in November 2009, substantial expansion in the domestic solar market is anticipated. JNNSM's target of achieving at least 20,000 MW of grid-connected solar power by 2022 could make India one of the leading solar countries in the world, not only in total installed solar capacity but also in manufacturing components and technology research and development, R&D should concentrate on making it cost effective, financial support is also required.

4. **Fuel Cell Energy:** Power generation is being advanced b y fuel cell technology. Fuel cells can be used to power a variety of portable devices, from handheld electronics to larger equipment such as portable generators. Thousands of portable fuel cell systems have been developed and operated worldwide, ranging from 1 watt to 1.5 kilowatts in power. The two primary technologies for portable applications are polymer electrolyte membrane (PEM) and direct methanol fuel cell (DMFC) designs. Distributed power has grown with stationary fuel cells that generate on-site power in critical areas: schools, apartment buildings or hospitals. The waste heat the fuel cell generates can be used in a cogeneration process to provide services like heating, cooling, and dehumidification. Fuel cells are among the

cleanest and most efficient technologies for generating power. For systems designed to consume hydrogen directly, the only products are electricity, water and heat. If a fuel cell consumes natural gas or other hydrocarbons, it produces some carbon dioxide, though much less than burned fuel. This carbon dioxide is emitted in concentrated form which makes its capture and storage, or sequestration, much easier. Use of hydrogen as a fuel could greatly reduce India's reliance on energy imports, particularly in the transportation sector. Hydrogen is used to power fuel cell vehicles & has efficiency twice that of the gasoline engines & with no harmful emissions. Major challenges are making it cost effective and too operate fuel cells at a higher temperature. For creating a market, a major technological breakthrough is required and large investments are needed to be done.

Barriers to Market Penetration:

The market penetration of energy-efficient technologies is often hampered by barriers that are influenced by prices, financing, international trade, market structure, institutions, the provision of information and social, cultural and behavioral factors. India is moving toward the adoption of policies and regulations that promote competition and more open markets, and is thus positively influencing the adoption of energy efficiency technologies. Stronger incentives will be required in developing countries like India to get consumers to adopt new technologies.

Diffusing Sustainable Energy Technologies:

The energy challenges confronting developing countries are significant and growing greater in time. Concrete list of policy actions that would help shift developing countries to a more sustainable energy trajectory are mentioned here.

None will be easy to implement. All will require the active engagement of all sectors of society, including individual consumers and local communities, non-governmental organizations, private businesses and industry, the science and technology research community, governments, inter-governmental institutions and donor organizations. Developing countries must take the lead in charting a new energy course for themselves, but developed countries must stand ready to provide support, recognizing that they have a vital stake in the outcome. These policy actions include:

1. Sustaining accelerated deployment of renewable energy systems/devices through indigenous design, development and manufacture apart from creating new sources of energy in furtherance of the aim of Energy Independence;

2. Promote energy efficiency and adopt minimum efficiency standards for buildings, appliances and equipment, and vehicles;

3. Enhanced Awareness and information dissemination amongst policy makers, regulators, general public;

4. Financing to encourage lending by capacity building outreach with banks: Consumers and banks are less aware of financial options and the benefits of energy savings, and have the perception that funds for energy efficiency projects carry very high risks;

5. Reform and re-direct energy subsidies: A gradual reduction in subsidies for conventional fossil fuels could be used to provide new subsidies for more sustainable forms of energy or more efficient technologies;

6. Seek developed-country support for the effective transfer of advanced energy technologies;

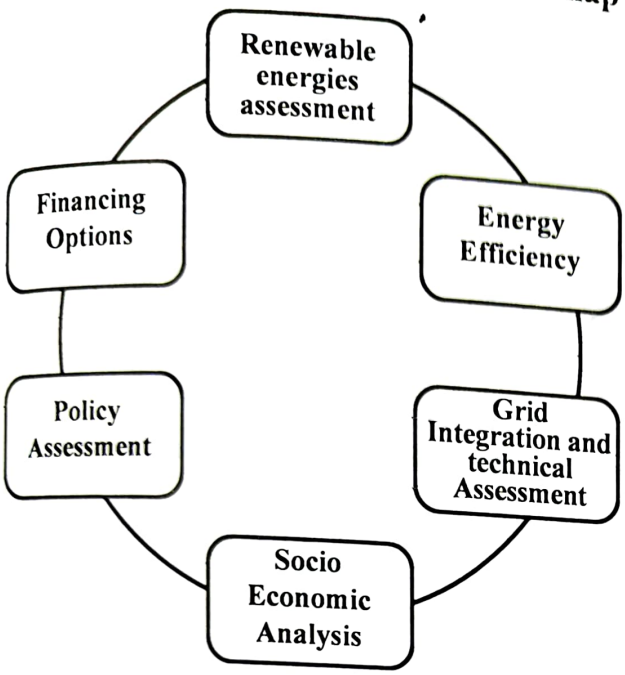
7. Capacity building of energy management professionals, policy makers, and other stakeholders; Sustainable energy policies are more likely to succeed if they also contribute toward other societal and economic development objectives.

Road Map for a Sustainable Future:

Thus a strategic roadmap for a sustainable and clean future has the following key points as described in the previous section.

1. Resource Assessment
2. Efficiency Assessment
3. Socio-Economic Assessment
4. Financial Resources
5. Policy Assessment
6. Technical Assessment
7. Capacity Building

Figure 4: Sustainable Energy Roadmap



Participation of Civil Society, Public and Private Sector Enterprises

To date civil society's involvement in the energy sector has been limited to organizing awareness creation campaign on the role and need for new and renewable energy systems/devices in everyday life. Participation of civil society to assist in identifying opportunities for diffusion of renewable energy and to support the diffusion of renewable energy within the country's infrastructure and other socio economic sectors is highly recommended. In order to promote the effective use of renewable energy sources, which has tremendous potential in a vast country like India, strong, committed leadership is urgently required. The public sector oil-distributing companies such as the IOCL, HPCL and private enterprises like Reliance, Tata's etc., which have huge distribution network all over India including in the remotest villages, should be asked to distribute different renewable energy items such as solar lanterns, solar panels etc., as a part of the groups CSR activities.

Conclusion

India is a nation in transition. Considered an "Emerging Economy", increasing GDP is diving the demand for additional electrical energy, as well as transportation fuels. India is a nation of extremes. Poverty remains in areas with no energy services, while wealth grows in the new business hubs. Exclusive dependence on fossil fuel sources would aggravate the energy security risk posed by power disruptions. Energy efficiency offers a cost-effective solution to overcoming this risk that is almost entirely within the control of the Indian Government and Private Sector. Building capacity to plan and implement energy efficiency programs will help advance India's energy security and mitigate the local environmental and global warming impact of unbridled energy growth, specifically coal. Improving the country's energy productivity will require a concerted effort by all sectors. "Post-Fukushima, nuclear is facing uncertainty."

Yet, India is blessed with vast resources of renewable energy in solar, wind, biomass and small hydro. In fact, the technical potential of these renewable exceeds the present installed generation capacity. Unique in the world, India has the only Ministry that is dedicated to the development of renewable energies: the Ministry of New and Renewable Energy. This bodes well for the acceleration of renewable development throughout the nation – both to meet the under served needs of millions of rural residents and the growing demand of an energy hungry economy. Tapping India's wind, solar, biomass and hydro could bring high quality jobs from a domestic resource and also contribute to the elimation of electricity shortages, reduction of local pollution and carbon emissions from conventional power plants. Policies that promote faster growth of wind energy, development of new transmission grids, and ways to integrate renewable sources into the grid are needed to work upon. International concern about the issue of energy access is growing. The United Nations has declared 2012 to be the "International Year of Sustainable Energy for All" and the Rio+20 Summit represents an important opportunity for action Sustainable Energy Roadmaps help countries navigate that change so they can demonstrate individually that which has to happen globally. This paper is meant only as an overview in hopes that it will encourage even more rapid and extensive

development of the energy efficient & renewable energy technologies on the Indian subcontinent.

People can enjoy different levels of high-standard lifestyle with different levels of energy use and environmental impacts. A high standard of living does not necessarily translate into a high level of happiness or wellbeing.

If we don't change direction soon, we'll end up where we're heading.

References

1. Sustainable Energy: Choices, Problems and Opportunities by DAVID ELLIOTT
2. Sustainable energy for Developing Countries-A report to TWAS, the academy of sciences for the developing world.
3. Roadmap for India in energy efficiency by ArijitSengupta, Saurabh Kumar1, BEE,India.
4. India's Energy Efficiency and Renewable Energy Potential: Policies and Programs ByJayantSathaye Berkeley India Joint Leadership on Energy and Environment (BIJLEE).
5. Energy and Sustainable Development in India Report by: DipankarDey
6. Reassessing Wind Energy Potentials for India: Economic and Policy Implications.
7. Abhyankar N. and J. Sathaye (2011) Energy efficiency and renewable energy scenarios in the Indian power sector: Costs and carbon emissions.
8. SathayeJ., and A. Gupta (2010) Reducing Electricity Deficit through Energy Efficiency in India: An Evaluation of Economic and Emissions Benefits.
9. Renewable energy in India an assessment by Leena Mary Eapen
10. Renewable energy today by Rodney Janssen
11. Sustainable Adoption of Renewable Energy Technology application vs barriers by SB Rath
12. Renewable's for India's Energy Security by Pradeepchaturvedi
13. Growing India's Energy needs: Tapping renewables by S Bhaskaran
14. Barriers, Opportunities, and Market Potential of Technologies and Practices. Sathaye J. and Bouille D., et al. (2001)
15. Chapter in Climate Change Mitigation, Eds. B. Metz, O. Davidson, and R. Swart. Cambridge University Press for the Intergovernmental Panel on Climate Change for an overview
16. Sustainability: Will There Be the Will and the Means? Carlo Andrea Bollino and Paolo Polinori* Department of Economics, Finance and Statistics, University of Perugia (Italy)
17. http://www.pcra.org/
18. http://www.bee-india.nic.in/index1.php
19. http://powermin.nic.in/acts_notification/electricity_act2003/preliminary.htm
20. http://mnre.gov.in/file-manager/annual-report/2011-2012/EN/index.htm
21. Indian Renewable Energy Status Report Background Report for DIREC 2010 D S Arora (IRADe) et.al
22. http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_action.pdf
23. http://www.thehindu.com/multimedia/archive/00957/Poverty_Line_957814a.pdf
24. http://pdf.wri.org/working_papers/building_the_climate_change_regime.pdf
25. http://www.wri.org/charts-maps
26. http://www.wri.org/chart/world-greenhouse-gas-emissions-2005
27. http://moef.nic.in/downloads/home/GHG-report.pdf
28. http://www.powermin.nic.in/indian_electricity_scenario/policy_initiatives.htm
29. http://www.cea.nic.in/power_sec_reports/Executive_Summary/2009_04/27-33.pdf
30. http://www.worldwatch.org/programs/energy_climate