Energy Security Aspects of India

Joydip Ghosh, Dr. Soupayan Mitra

***Abstract*— India is a country with more than 1.3 billion people accounting for more than 17% of world's population.India has 28 states and 7 union territories. It faces a formidable challenge in providing adequate energy supplies to users at a reasonable cost. It is anticipated that India's nominal GDP will exceed US $ 2 trillion by March 2014. India's nominal GDP crossed the US $ 1 trillion mark in 2007-2008 which means that the annual growth rate of nominal GDP during the period is stupendous 18 %.Energy security is the uninterrupted availability of energy sources at an affordable price.Energy.Security has long term aspects in a country's economy and growth. As per the estimates made in the.Integrated Energy Policy Report of Planning Commission of India, 2006, if the country is to progress on the path of this sustained GDP growth rate during the next 25 years, it would imply quadrupling of its energy needs over 2003-04 levels with a six-fold increase in the requirement of electricity and a quadrupling in the requirement of crude oil.The supply challenge is of such magnitude that there are reasonable apprehensions that severe shortages may occur. Due to rapid economic expansion, India has one of the world's fastest growing energy markets and is expected to be the second largest contributor to the increase in global energy demand by 2035, accounting for 18% of the rise in global energy consumption.Given India's growing energy demands and limited domestic fossil fuel reserves, the country has ambitious plans to expand its renewable and nuclear power industries.**

***Index Terms*— Energy Security,Energy demand-supply, Renewable energy, Dependency,growth, Power Generation.**

I. Introduction

Energy security is defined in terms of reasonable assurance of access to energy and relevant technologies at all times with an ability to cope with sudden shocks. Energy security does not mean complete energy independence, it only means an ability to meet reasonable requirements with reasonable assurance of stable supply or an ability to pay for import needs. According to the Twelfth Plan(12th FYP) projections, total domestic energy production will reach 669.6 million tonne of oil equivalent (MTOE) by 2016-17 and 844 MTOE by 2021-22. Import dependence for coal is also projected to increase from 18.8% in 2011-12 to 22.4% by the end of the Twelfth Plan. It is further estimated that import dependence for coal, liquefied natural gas (LNG), and crude oil taken together in the terminal year of the Twelfth Plan is likely to remain at the Eleventh Plan level of 36%. According to the Ministry of Statistics and Programme Implementation (MOSPI) Flash Report for February 2014, of 239 central-sector infrastructure projects costing 1000 crore and above,99 are delayed with respect to the latest schedule and 11 have reported additional delays with respect to the date of completion reported in the previous month.The additional delays in respect to projects relating to the petroleum, power, steel, and coal sectors are in the range of 1 to 26 months**.** The total original cost of implementation of these 239 projects was about 7,39,882 crore and their anticipated completion cost is likely to be 8,97,684 crore, implying an overall cost overrun of ` 1,57,802 crore (21.3% of the original cost). The expenditure incurred on these projects till February 2014 was 4,10,684 crore, which is 45.7% of the total anticipated cost.

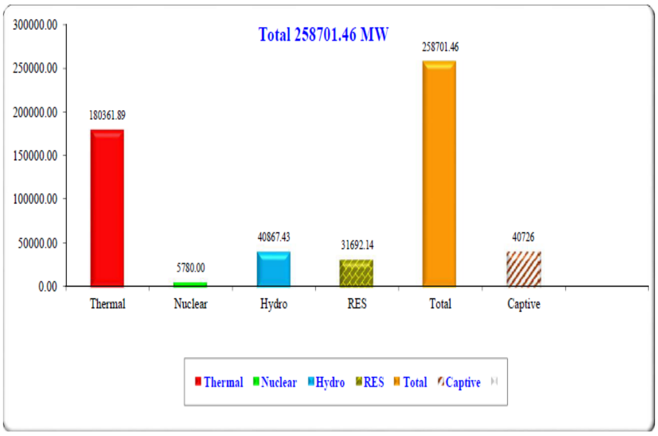
Manuscript received March 23, 2015.

Joydip Ghosh,Post Graduate Scholar ,Mechanical Engineering Department , Jalpaiguri Government Engineering College,Jalpaiguri -735102,West Bengal,India.

Dr.Soupayan Mitra, Associate Professor, Mechanical Engineering Department,Jalpaiguri Government Engineering Colllege,Jalpaiguri -735102, West Bengal,India.

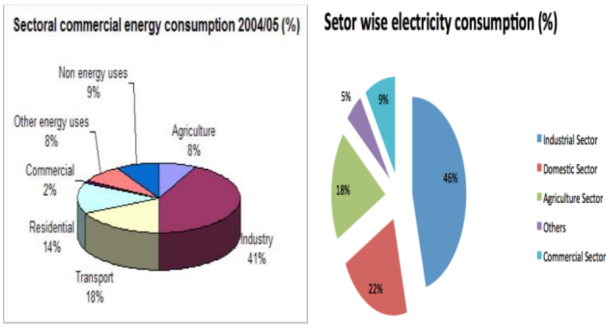
II. POWER GENERATION & PRESENT SCENARIO

- Electricity generation by power utilities during 2013-14 was targeted to go up by 6.9% to 975 billion units. The growth in power generation during 2013-14 (April-March) was 6.0%,as compared to 4.0 % during April 2012 to March 2013.Generation capacity as Jan 2015 as below. 3rd largest producer of electricity in the world,4th biggest consumer.
- Low per capita electricity consumption .
- India 717 kWh
    - US 14,000 kWh
    - China 2500 kWh
    - World 2800 kWh
- Peak shortage ~ 5%
- 800,000 MW in 2030 – 40
    - ~ 25,000 MW per year .
- Environmental concerns
    - India 3rd largest emitter of CO2 behind China and US.
    - 38% of emissions from power sector.
- Energy security concerns.
    - 67% power from coal-based thermal plants - need to depend on imports.
    - Prototype breeder reactors to exploit thorium reserves.



III. ENERGY CONSUMPTION

In last four decades, i.e. from 1970-71 to 2011-12, the compound annual growth rate (CAGR) of production of the primary sources of conventional energy, namely coal, lignite, crude petroleum, natural gas, and electricity (hydro and nuclear) generation, was 4.9%, 6.2%, 4.2%, 8.7%, and 4.3% respectively. In the same period, consumption of coal, lignite, crude oil in terms of refinery throughput, natural gas (off-take), and electricity (thermal, hydro, and nuclear) increased at a CAGR of 4.9%,6.2%, 6.0%, 10.7%, and 7.1% respectively. Per capita energy consumption grew at a CAGR of 4.1% during this period. The consumption pattern of energy by primary sources expressed in terms of peta joules shows that electricity generation accounted for about 57.6% of the total consumption of all primary sources of energy during 2011-12, followed by coal and lignite(20 %) and Crude petroleum (18.8%).



.

As per June 2014

IV. THE CHALLENGES OF UNMET ENERGY

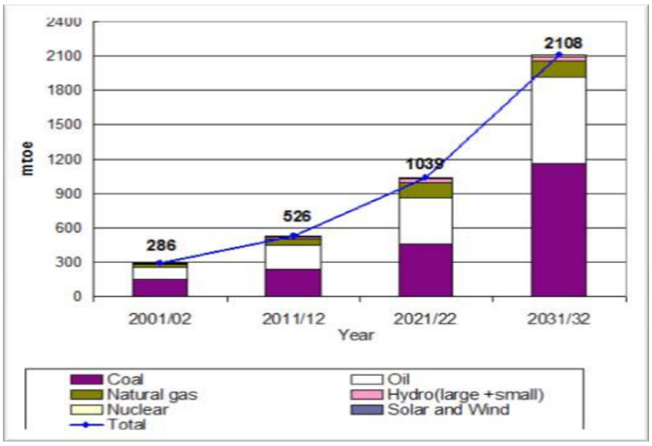
According to World Bank estimates, around 35% of the country's population subsists below the poverty line ($1/day, 2000 PPP) and does not have access to basic amenities and clean energy forms. Even by 2001, around 44% of house-holds did not have access to electricity (Census of India, 2001). The country continues to face electricity shortages, with an overall power shortage of 8.4% and a peaking power shortage of 12.3% in 2005/06.

Despite gradual urbanization, around 72% of the country's population resided in rural areas in 2001. The rural urban divide in India is manifest not only by the differences in the levels of energy requirement but also in the availability and choice of fuel and technologies to meet the same useful energy needs and services.Energy demands of several households, especially those in the rural areas, continue to be met primarily by inefficient traditional energy forms like fuel wood, crop residue, and animal waste as depicted in Figure 1. These fuels are not only inconvenient to use and cause indoor air pollution, but also adversely affect the health of women and children who are exposed to the use of these fuels.

On a per capita basis, India's energy consumption is still a fraction of that in developed countries. In 2003, India's primary energy consumption was 439 ktoe per capita, compared with 1090 in China, 7835 in the US and a world average of 1688.

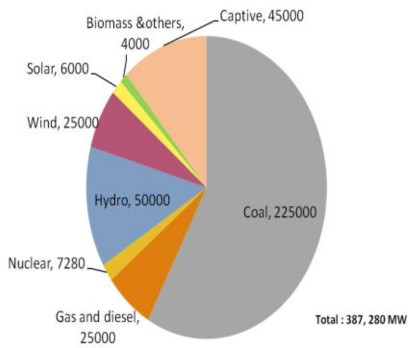
V. FUTURE ENERGY SCENARIO

- Various estimates indicate that India would need to increase its primary energy supply by at least 3 to 4 times and its electricity generation capacity by 5 to 6 times of the 2003/04 levels by the year 2031.



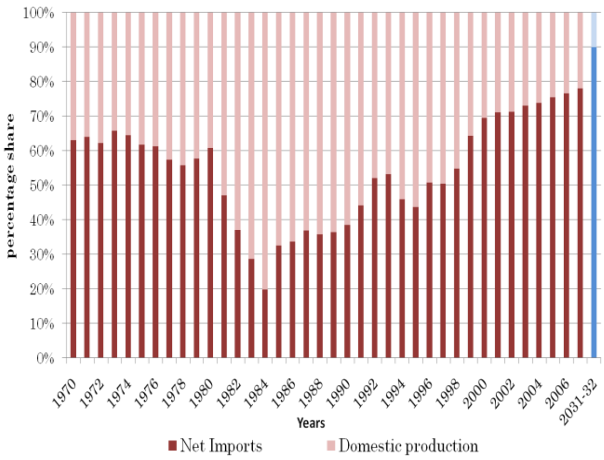
ENERGY REQUIREMENT SCENARIO

- Required capacity in 2020 assuming 8% growth is equal to 387,280 MW in BAU scenario should be legible, approximately 8 to 12 point type.



- Import dependency is another big concern

Share of net imports and domestic production in the total quantity of crude oil supplied to India economy, 1970-2007



VI. ANALYSIS AND REMEDIAL OBSERVATION

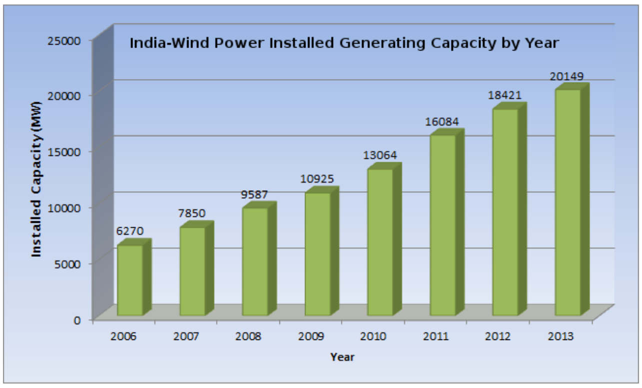
- How do we grow to ~ 2,000 billion kWh by 2020?
- How do we get 3,00 billion kWh of low-carbon power?
- What fuel options & technologies?
  - Wind

- Nuclear
- Solar
- Hydro
- Bio-fuels
- Carbon Sequestration
- Hydrogen & fuel cells
- Hybrid cars

1.Wind Power:- As of 31 March 2014 the installed capacity of wind power in India was 21136.3 MW mainly spread across Tamil Nadu (7253 MW), Gujarat (3,093 MW), Maharashtra (2976MW), Karnataka (2113MW), Rajasthan(2355 MW), Madhya Pradesh (386 MW), Andhra Pradesh (435 MW), Kerala (35.1 MW), Orissa(2MW), West Bengal (1.1 MW) and other states (3.20 MW). It is estimated that 6,000 MW of additional wind power capacity will be installed in India by 2014. Wind power accounts for 8.5% of India's total installed power capacity, and it generates 1.6% of the country's power. India's wind atlas is available.

POWER PROPORTIONAL TO =(Velocity of wind)^3

China	44, 733 MW
US	40,180 MW
Germany	27,215 MW
Spain	20,676 MW
India	13,000 MW



2. Solar Power:-

JNNSM launched in 2010 targets 22,000 MW by 2022

- Phase 1 (until March 2013).
- Target of 1300 MW : 800 MW PV and 500 MW CSP .25 years of guaranteed feed in tariff .
- Off-grid PV
- Target of 2000 MW by 2022

Challenges:-

- High nominal cost of generation : ~ Rs 15 per kWh.
- Water scarcity issues for CSP.
- Requirement of skilled personnel.
- India is capable of getting 5EWh/year of energy from solar reception with 300 clear sunny day.
- GDP use/Unit of energy use in case of India is $8 in 2011,whether China $4.9 and USA $7.4.
- 1 MW solar plant can generate 1.5 million unit of electricity but the installation cost is nearly 70-80million/MW as per CERC.But we can balance it from the carbon credit India gains.
- But if we decrease to generate 1.5 million unit or 1500 GW-h from coal then can decrease (1041*1500)=1561500 (As per EIA 1041ton carbon-di-oxide/GW-h of coal)ton of carbon di-oxide in air from where India can recover some amount of money that could be invested in installation.
  1carbon credit=1ton of carbon-di-oxide.
  carbon trading rate of recent days is nearly 12-15 EURO/credit.
  Then the cost becomes 12*1561500=18738000 EURO.Which could be invested later for renewable energy enhancement sector-wise.

So,this type of optimization could be done with specific data..

3.Nuclear Power:-

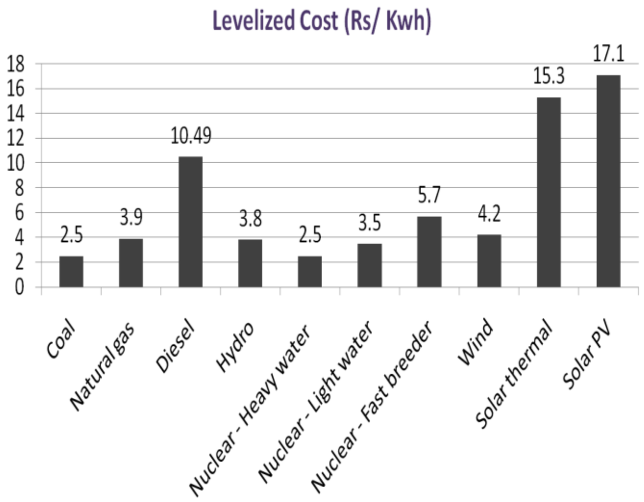
Nuclear power is the fourth-largest source of electricity in India after thermal, hydroelectric renewable sources of electricity. As of 2013, India has 21 nuclear reactors in operation in 7 nuclear power plants, having an installed capacity of 5780 MW. In October 2010, India drew up "an ambitious plan to reach a nuclear power capacity of 63,000 MW in 2032".

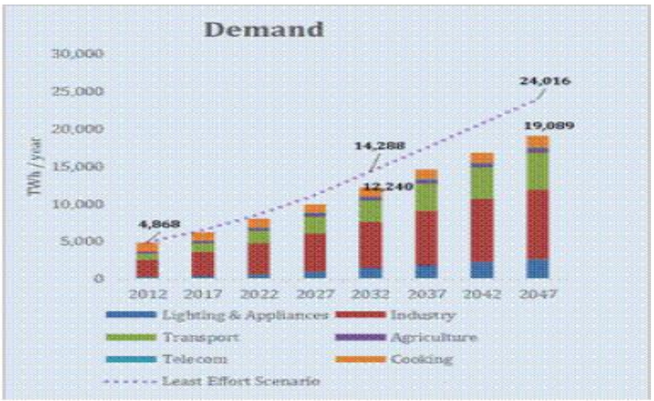
- Domestic Uranium reserves ~ 61,000 Tons
- Poor quality ore (0.01% - 0.05% Uranium)
- Large Thorium deposits
- But, Thorium is fertile and has to be converted to fissile U233 in a reactor
- Phase Nuclear Program
- Phase I Build Pressurized Heavy Water Reactors using domestic Uranium
- Phase II Reprocess spent fuel from Phase I to get Plutonium for Breeder Reactors
- Phase III Use U233 (obtained from Thorium) and use it with Plutonium
- Domestic Uranium reserves can sustain 10,000 MW PHWR for 40 years
- Low capacity factors due to Uranium mining constraints.

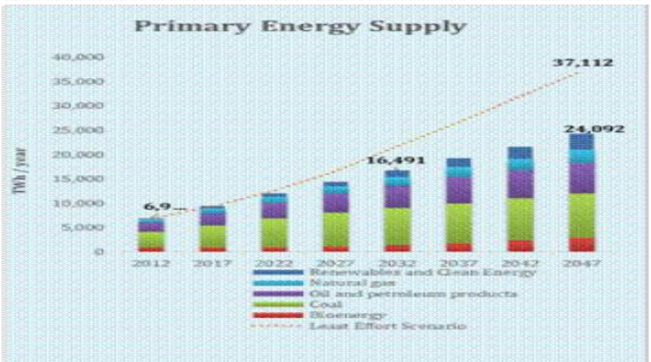
Type	Operating	Projections (2020)	Projections (2030)
Heavy Water Reactors	4,460 MW	10,000 MW	10,000 MW
Light Water Reactors	320 MW	9,300 MW	22,000 MW
Fast Breeder Reactors	-	1,500 MW	1,500 MW
Total	4780 MW	20,800 MW	33,500 MW

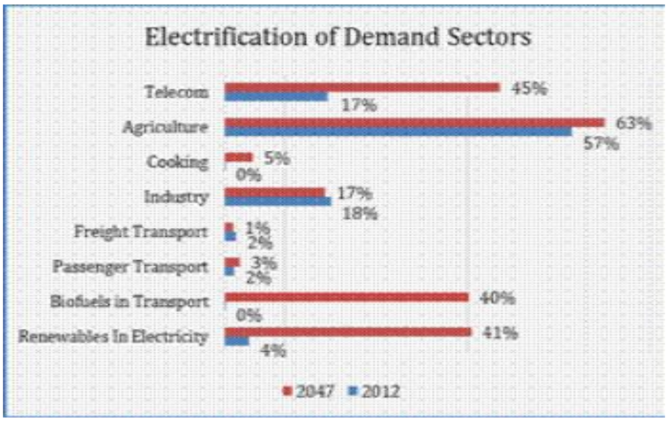
Nuclear capacity presently under construction : 5300 MW

❖ ELECTRICITY GENERATION COST COMPARISON









VII. POTENTIAL R&D DOMAINS

- ❖ New and affordable materials for photovoltaic.
- ❖ Clean coal technologies; carbon capture and sequestration.
- ❖ Low-speed wind power.
- ❖ Cellulosic ethanol.
- ❖ Efficient and affordable hybrids, electric vehicles.
- ❖ Energy storage – efficient batteries and condensers.
- ❖ Demand side management of power.
- ❖ Trained human resource.

VIII. FUTURE PROJECTED SCENARIO-2047

Least Effort Pathway:-In this pathway,there is an assumption that policies are not fully implemented on both demand and supply side.Technologies not fully satisfied to achieve breakthrough or are not adopted,exploration activities for fossil fuels achieve.

IX. TELECOM SECTORS CONSUMPTION

It has been observed that there are almost 4 lacs telecom towers and 7.14BTS in India.These towers runs by diesel generator for 10-12 hours in a day and the rest of the time by grid connected power sources.

- ➢ Calculated that total diesel consumption takes place is nearly 5.12 billion litre/year.
- ➢ Total carbon emission/year= 14MMT
- ➢ Cost of diesel/year=307 billion rupees
- ➢ 15litre/tower/day-12 hours
- ➢ Upto 3.5KW peak demand/tower/day-12 hours

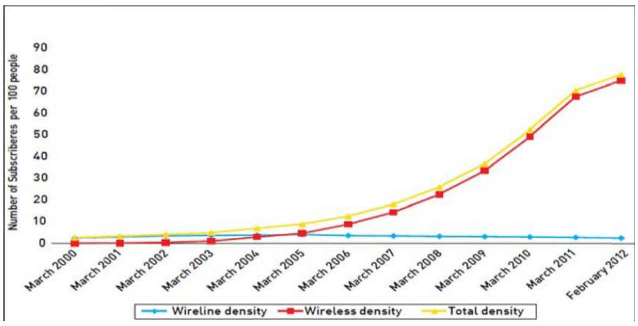
We can manage some money from this carbon credit if we replace this sectors with electricity with renewables or grid connected power.

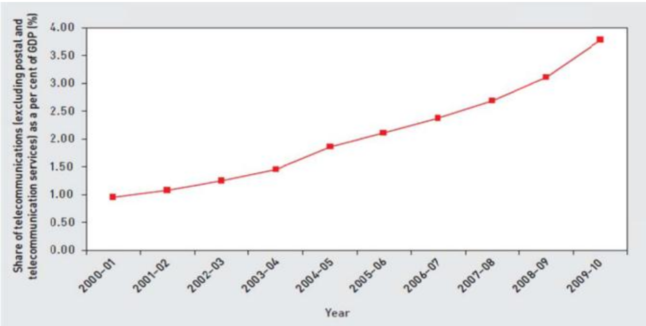
Carbon emission/litre= 5.85 pound for diesel as per EIA.

So,total carbon credit= 5.85*5.12 billion=almost 30 billion pound=13607771 ton

Which is equal to 13607771*12=163293252 EURO.

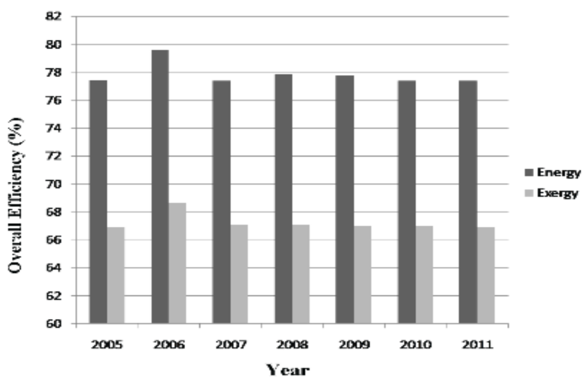
- ➢ India has gained total 250 million carbon credit in 2012.And 140 million in pipeline.

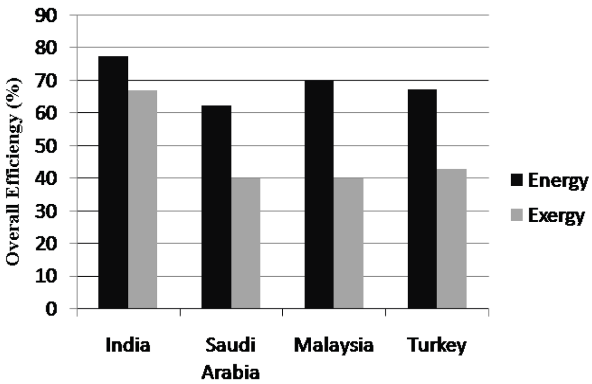




X. ENERGY & EXERGY EFFICIENCY

The overall mean energy efficiency and the overall mean exergy efficiency in the Indian industrial sector for the period 2005-2011 is 77.8% and 67.23%.This study also shows that domestic industrial contribution should be increased to improve the overall energy an exergy efficiencies of the Indian industrial sector.





If we can improve exergy percentage in use of power then we can save energy for future security.It means we can do same aount of work using less amount of power as the quality of use of energy is high.So for doing a work,net heat input to be implied is less in that case.As a result less power is required.

XI. TECHNICAL LOSSES AND ECONOMY

- ➢ In 2021-22 it is forecasted that the power demand will be nearly 300GW with almost 2000TW-h electricity.In 2010,losses during Transmission & Distribution(T&D) is 24%,which is a huge amount and cost for that loss is also a factor to the energy economy.
- ➢ According to the studies, theft of electricity in 2004 amounted 4.5 billion rupees.

- Achieving an energy saving of around 20% by 2020 in the industry sector.
- improving the average efficiency of vehicles by 15%.
- Maintaining the share of public transport in total motorized, road-based passenger movement at 70%.
- Accelerating the efficiency performance of the stock of household appliances

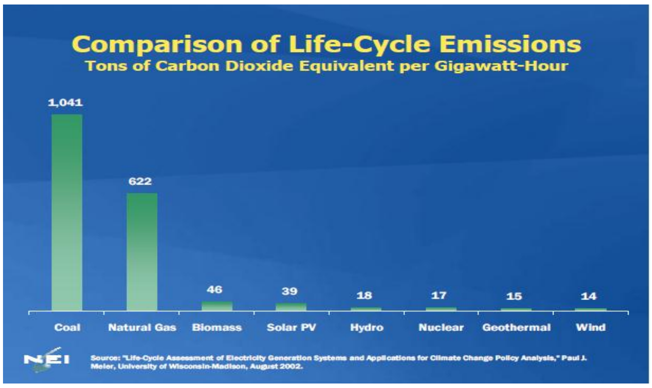
as follows:

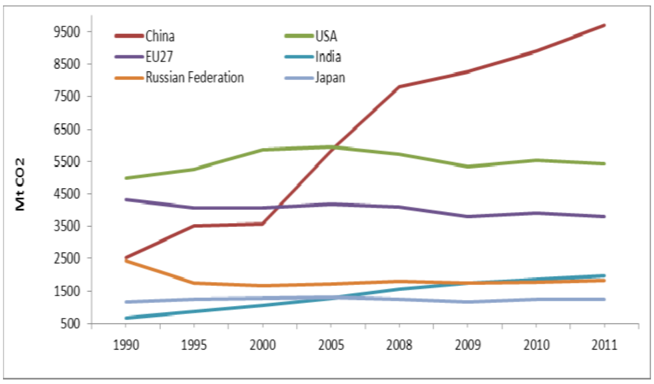
• *Refrigerators* By 7% over the autonomous efficiency improvements assumedin the business as usual (BAU)

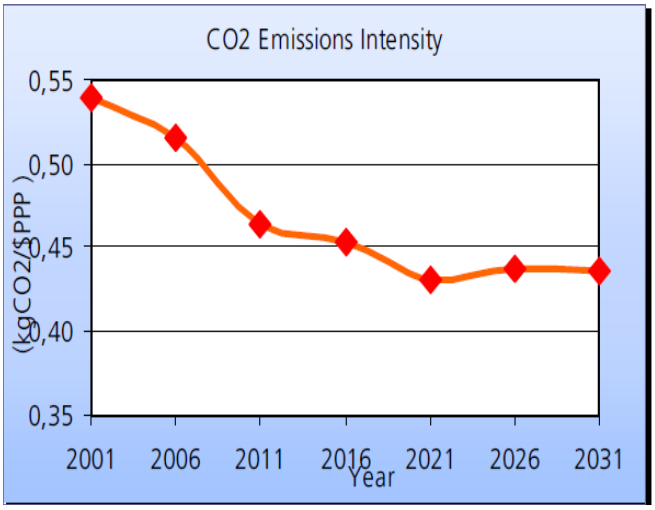
• *Air conditioners* By about 25% over the efficiency improvement in the BAU.

- ➢ Plant load factor(PLF) of natural gases is 25% because of shortage of gases.Thermal plant is running at an average of PLF 65%.So,if we make effort to increase that then,there will be a huge addition of energy.

XII. CARBON EMISSION AND ENVIRONMENTAL SUSTAINABILITY







India is still maintaining a balance between generation and emission with the Kyoto Protocol. In 2005, India accounted for 5% of global GHG emissions, with per capita emissions of 2.1 tons of GHG per head of population (MNP, 2007). Over the time period 1900–2005, India's contribution to the global total of cumulative energy-related CO_2 emissions was 2% (IEA, 2007b, p. 201).

India signed and ratified the Protocol in August, 2002. Since India is exempted from the framework of the treaty, it is expected to gain from the protocol in terms of transfer of technology and related foreign investments. At the G8 meeting in June 2005, Indian Prime Minister Dr.Manmohan Singh pointed out that the per-capita emission rates of the developing countries are a tiny fraction of those in the developed world. Following the principle of *common but differentiated responsibility*.

XIII. IMPACT OF POLICY AND VISION 2022

During the last many years the share of renewable energy has steadily increased due to the initiative taken by Governmentof India and as indicated . The share of various types of renewable energy is indicated in Ta All figures are in MW. It is estimated that total share of renewable energy will be 15.9% by 2022. In the larger perspective of grid power an innovative scheme is being tried in India called as tail-end grid.So far the emphasis has been on large plants whether they are wind, solar, hydro or biomass. Locations for wind and hydro are fixed. However, for biomass the difficulties of ensuring collection and transportation of fuel are leading towards smaller plants. For solar PV, a total of 100 MW capacity is being set upwith smaller plants of 100 KW to 2 MW, which are connected to grid through 11 kV feeders. It is expected that small plants would reduce the transmission losses by 5-7% with respect to large capacity plants of 50 - 100 MW size and improve both voltage and frequency at the tail end. The same approach is being planned for biomass based power plants of up to 2 MW capacity as the logistics of fuel management would become much more manageable and more environmentally friendly. It is envisaged that hundreds of such plants will be built in the next few years thus improving the transmission infrastructure.

Resource	Potential (MW)	Upto 9th Plan	Upto 10th Plan	11th Plan Target	Upto 30.09.10	Cumulative Achievement	12th Plan Projection (2017)	13th Plan Projection (2022)
Wind Power	48,500	1667	5,427	9,000	4,714	12,809	27300	38,500
Small Hydro Power	15,000	1,438	538	1,400	759	2,823	5000	6,600
Bio Power*	23,700	390	795	1,780	1,079	2,505	5100	7,300
Solar Power	20-30 MW/sq km	2	1	50	8	18	4000	20,000
Total		3,497	6,761	12,230	6,560	18,155	41,400	72,400

(Source: Ministry of New and Renewable Energy, Government of India)

XIV. CONCLUSION

The Indian Government has already undertaken or planned for several policies and initiatives that encourage sustainable energy growth – both in terms of improved efficiency of use and in terms of its environmental implications. Several policies and measures have for example focused on improving energy efficiency, enhancing renewable and clean energy forms, bringing about power sector reforms, promoting clean coal technologies, promoting cleaner and less carbon intensive fuels for transport, and addressing environ-mental quality.

➢ **Key recommendations**

- Move from being largely a fossil-fuel-driven energy economy,to one that is powered by energy from clean and renewable energy forms.
- Rapidly move to a high efficiency energy path, with relatively low gestation period but high returns, by designing the appropriate regulatory and incentive structures.
- Make solar energy the mainstay for satisfying national energy needs—both as a large-scale generator as well as a small-scale distributed provider of energy.
- Invest liberally in developing a bio-based economy in rural areas, supplemented with other locally available energy forms as appropriate (wind, solar, and small hydro).
- Rapidly, but optimally, deplete own coal resources so as to buy time for effective switchover to an alternate energy economy and avoid the risk of future stranded assets, while limiting the dependence on coal imports to a bare minimum.
- Aggressively pursue the development of nuclear energy while providing the essential emphasis on safety and addressing public perception issues.
- Develop a long-term integrated mobility and freight movement strategy that is aligned with the overall objective of driving India’s energy economy through clean energy forms.
- Move to a completely market-driven pricing mechanism for all energy forms under the regulatory oversight of, preferably a single, energy regulatory commission.
- Roll all energy subsidies (LPG, kerosene, electricity, and so on), differentiated by select income classes,

into a single energy subsidy delivered directly to the beneficiary through a system of biometric cards.

- Create a pool of technically qualified human resources to serve the domestic and international clean energy markets.
- Position India as a leader in clean energy policies, technologies, manufacturing, and services.

While the long term offers several opportunities for India, in concert with global developments to mitigate its energy security challenge, in the short term, energy efficiency would have to play a key role. What is clear from the above analysis is that India can, while pursuing an aggressive economic growth path, keep in
check its energy demand growth and consequent environmental impacts. The opportunity for doing so arises from the fact that a large part of its infrastructure is yet to come in place, and is contingent on adequate support in the form of access to efficient technologies and requisite financing.

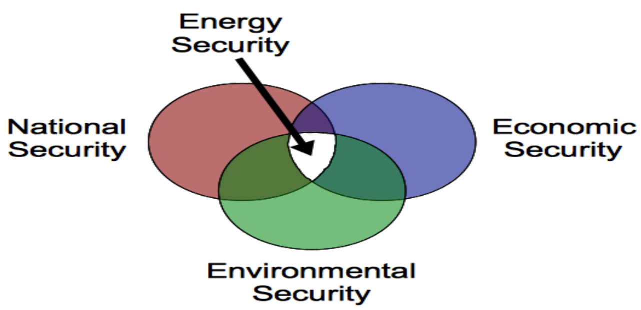
➢ **Attracting private investments**

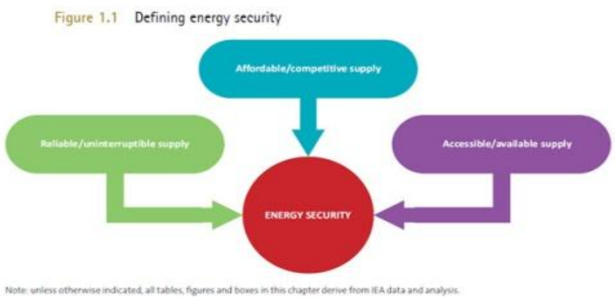
The scale of the energy challenge that the country faces compels it to seek aggressive private sector participation.While it is essential and non-negotiable to follow due process when awarding projects to the private sector, a few key points need to be kept in mind.

- Clear delineation of long-term policy and regulatory framework that would enhance investor confidence.
- The need to provide a level playing field to all players, including the public sector organizations.
- The high economic cost of delays .

➢ **R&D in the energy sector**

India's R&D efforts have often been criticized for being sub-optimal and lacking in goal orientation. The situation in energy-related R&D is perhaps even more serious. The challenge of the sector, as brought out in earlier pages, is too large for it to be continued to be treated as a vehicle of social largesse and diffused capacity building. While India may not be able to match the R&D resources of the developed world, it is all the more imperative that its scarce financial resources are targeted strategically—to bring about cost reductions, develop/exploit context specific resources, and develop relevant applications—and with purpose. Some technologies that could be on the verge of commercial deployment, with just an additional resource injection for design improvements, which the government could place on its priority list, include the following. Bio-mass gasification system,Bio-fuels,Solar energy,Wind energy,SME sectors,Smart grid technology.





Appendixes, if needed, appear before the acknowledgment.

ACKNOWLEDGMENT

The authors wish to acknowledge the support and enthusiasm provided by our h.o.d & faculties of jalpaiguri government engineering college(autonomous),jalpaiguri-735102,weset bengal,india

REFERENCES

[1] **TERI,Govt.of India,** http://www.teriin.org/
[2] **MNRE,Govt.of India,** http://www.mnre.gov.in/
[3] *http://www.eia.gov.in*
[4] *http://www.ficci.com*
[5] *http://www.worldbank.org*
[6] **Ministry of statistics and programme implementation,** http://www.mospi.nic.in/
[7] *IJERT/"An application of energy & exergy analysis in industrial sector of India" by Dr.S Mitra,Devashish Gautam,Jalpaiguri Govt.Engg.College.*

Joydip Ghosh (B.Tech, M.Tech)
Post Graduate Scholar,Department Of Mechanical Engineering. Jalpaiguri Government Engineering College (Autonomous) Jalpaiguri-735102, West Bengal, India

Dr.Soupayan Mitra [M.E, Ph.D(Engg.)]
Associate Professor,Department Of Mechanical Engineering. Jalpaiguri Government Engineering College (Autonomous) Jalpaiguri-735102,West Bengal,India