A bottom-up Modelling Analysis of Indian Coal Sector

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Presentation Outline

Introduction: Why coal is important for India?

Analysis Framework and Model Development

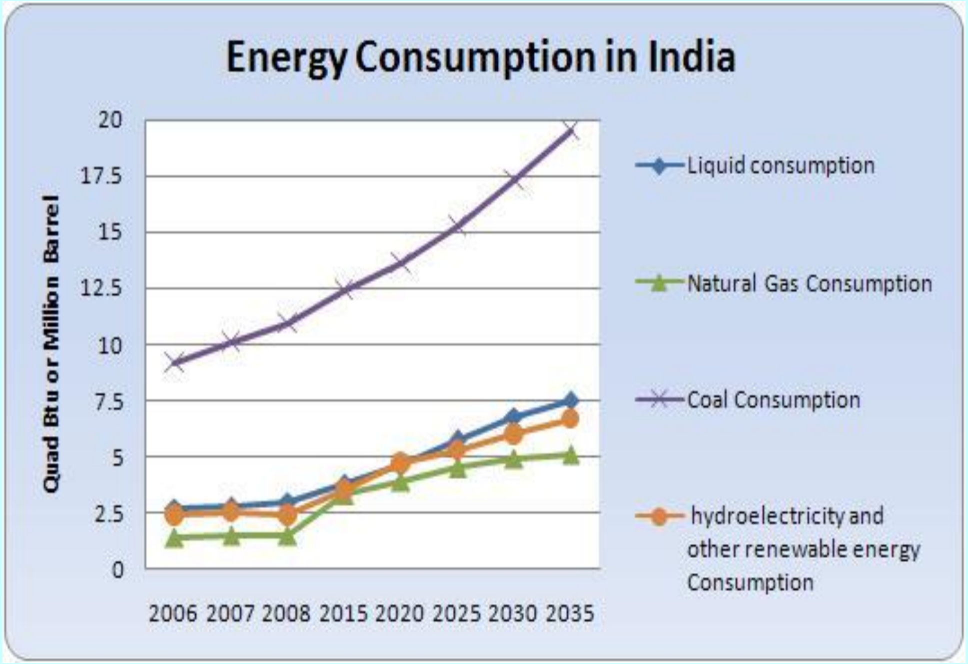
Results and Discussions

Future Work

Why coal is important for India?

- Energy is a priority for economic growth for developing countries
- High energy demand at increasing rate
- Coal is a major player in energy supply mix
- Energy security concerns
- Availability, affordability, reliability safety and easy transportation
- Major challenges
  - Environmental concerns especially climate change
  - Functional and structural shortcomings

Key Learning from existing literature



Coal Fraternity is committed to –

- Supporting major research efforts to make cleaner technologies affordable;
- Raising awareness within the industry;
- Providing credible input to policy making; and
- Demonstrating leadership in implementing the Guiding Principles for the Coal Industry

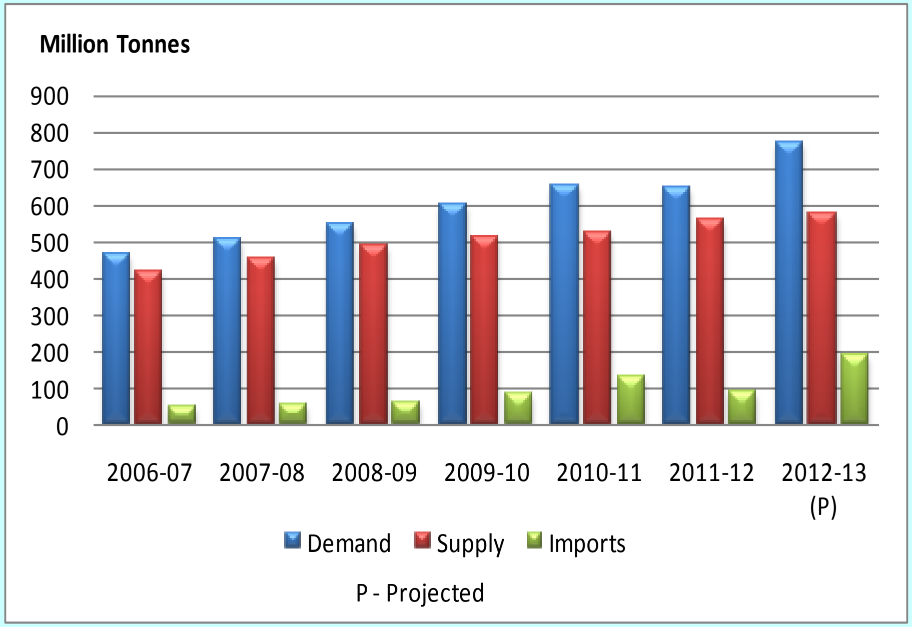
- Previous studies give meaningful insights
- Coal will continue to dominate in medium to long term
- Substantial capacity addition in the power sector is coal based and it is to be viewed in the context of domestic supply, imports, infrastructure and regulations related to policy and market
- Strong directives needed to optimize efficiencies in coal value chain like economic, technological, operational, regulatory & policy
- These need to be integrated in the model to have robust analysis
- Scenario analysis is possible with the help of bottom-up modeling

Major gap to be addressed….

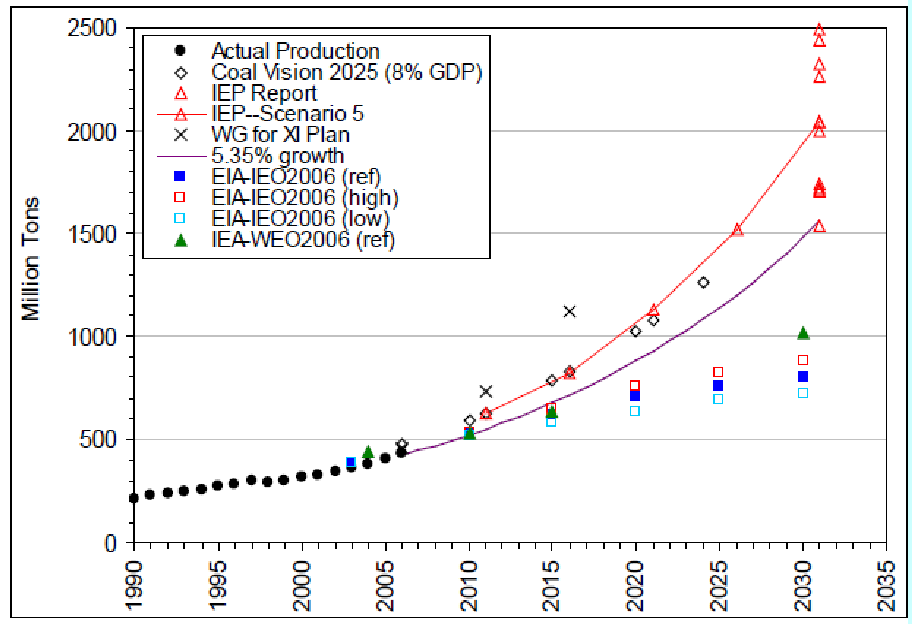
In India, effect of coal use on emissions has been extensively reported and discussed but effect of climate policies on coal sector growth and market development has not been analyzed using bottom-up modeling.

What would be the expected technology trajectory in future in view of changing requirement of local and global pollution control with special focus on coal sector for India?

Coal Facts for India



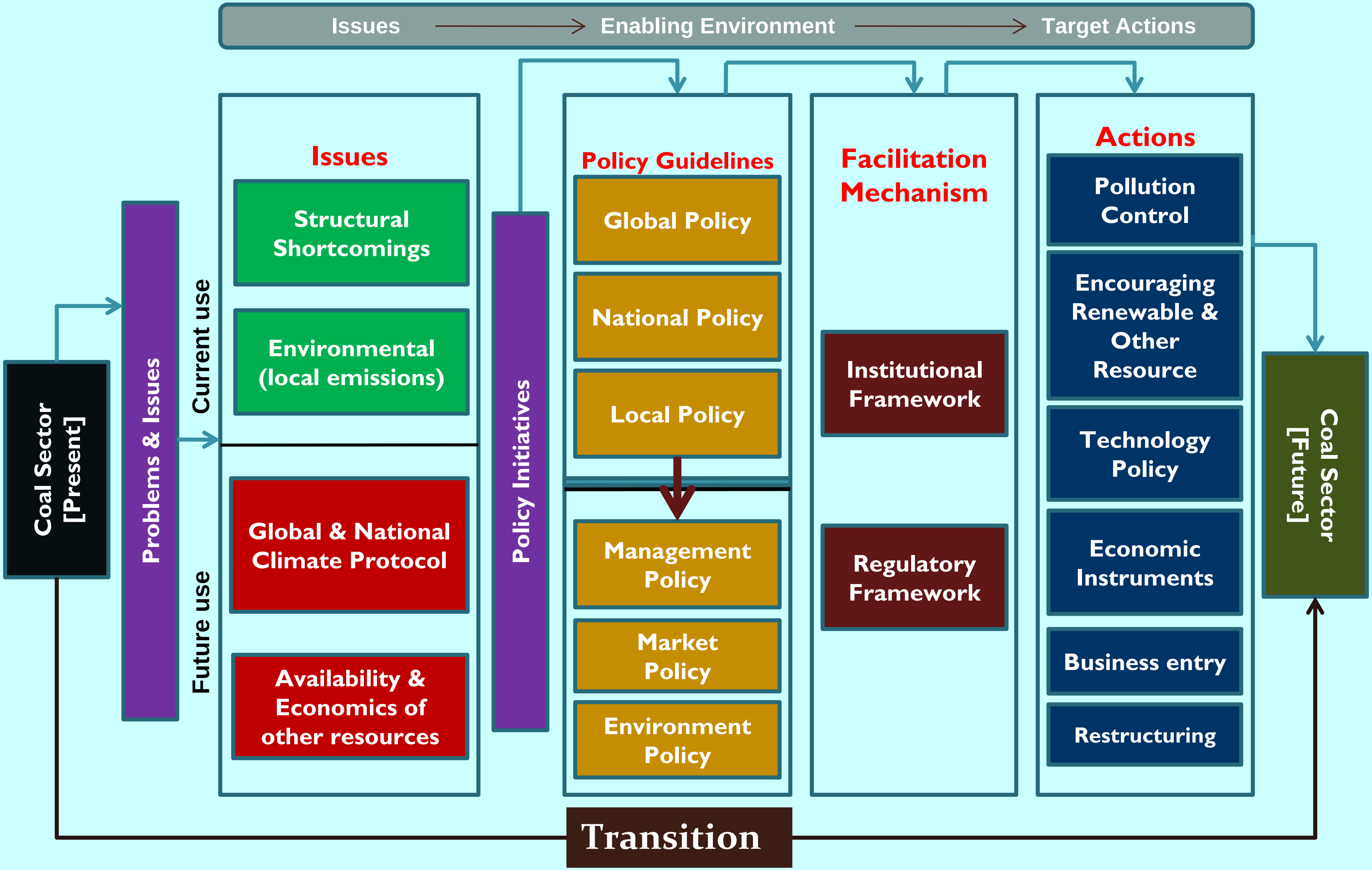
Coal Demand, Supply and Imports in India [Source: MOC, Annual Report (2011-12)]



Comparison of Projected Future Demand for Coal in India [Source: Sathaye and Phadke, 2006]

The coal reserves in India up to the depth of 1200 meters have been estimated by the Geological Survey of India at 285.86 billion tonnes as on April 1, 2011 and Lignite reserve are around 40.91 billion tonnes. Coal deposits are chiefly located in Jharkhand, Odisha, Chhattisgarh, West Bengal, Madhya Pradesh, Andhra Pradesh and Maharashtra.

Analysis framework for managing the transition in the Coal Sector in India



Model Development

- Setting up of country-level AIM/End-use model for India had following steps:

1. Selection of sectors, services, technologies, base year
   - The model has traditionally been set-up with six sectors, namely the industrial, transportation, agriculture, commercial, residential and power sectors.
   - For better understanding separate coal sector has been especially added. Year 2000 has been taken as the reference year. Year 2010 has been used for fine tuning. A total of 141 technologies have been considered.

Model Development

2. Estimation of data for services and technologies

   - The data for technologies in the base year has been taken from published reports or journals. The values for fixed cost, variable cost and fuel consumption have been taken at current prices for the base year i.e. 2000. For the future technologies, which have not been commercialized, these costs are relative estimates taken on the basis of available literature.

3. Projection of service demands, technology shares and technology improvement

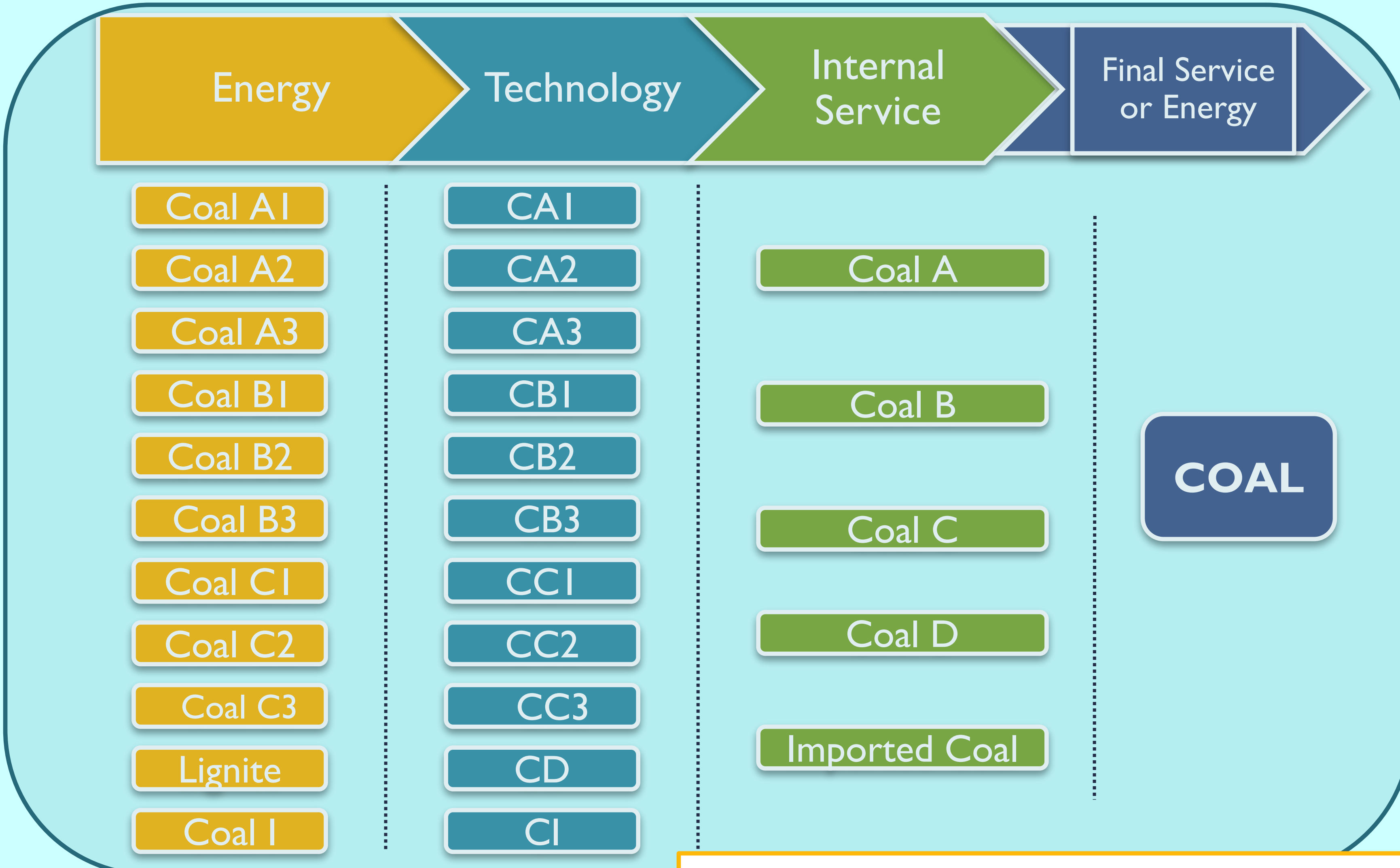
   - The improvements in the technology are estimates based on detailed studies of the various technologies. Not all technologies are suitable in all conditions. They depend on a number of factors like raw material and availability of other resources. So the penetration of a technology is not same in all countries. The maximum share in the model is the estimation of future scenario in the sector.

Model Development

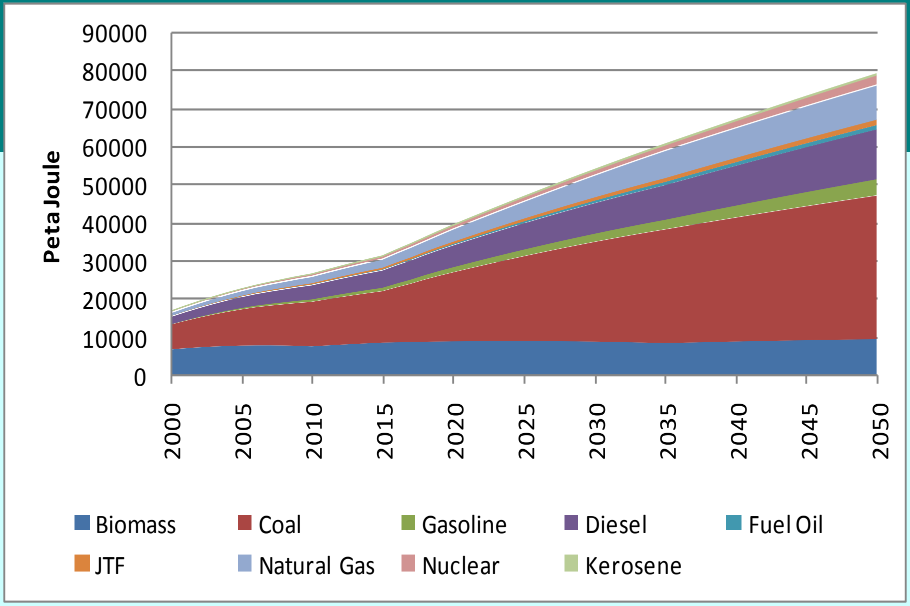
4. Scenarios Development: Three scenarios considered

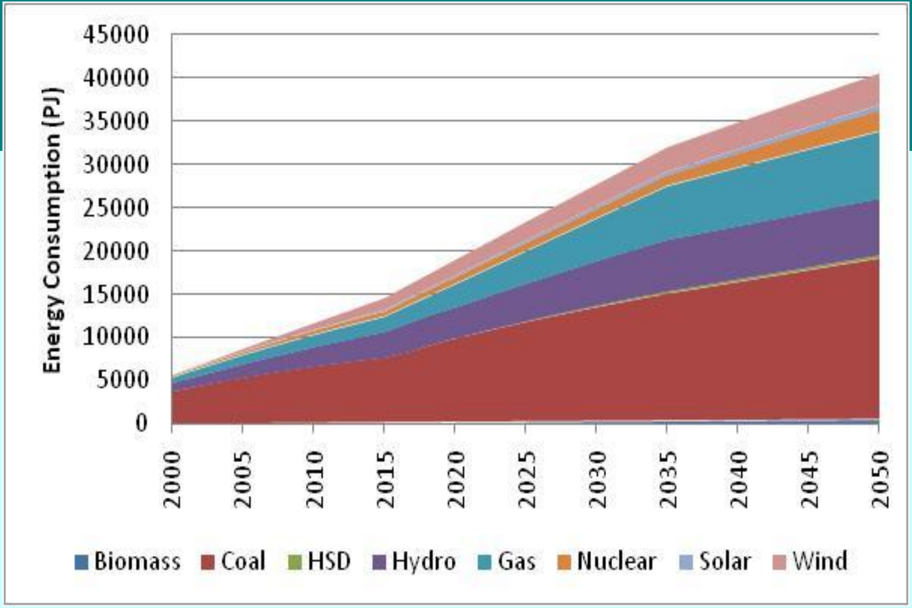
- **Business-as-usual scenario:** No action has been specifically directed at limiting greenhouse emissions or any technology. Assumes a continuation of current energy policies and a steady, but modest pace of technological progress.
- **Carbon Constrained Scenario:** Policies support mitigation efforts. CO_2 emissions are required to be reduced at some benchmark level. This scenario is developed as a policy analysis tool for understanding technology choices under different carbon constraint cases.
- **Carbon Capture Scenario:** In addition to reduction in the CO_2 emissions the emitted carbon can be captured and sequestered. This would specially focus on the possible reduction that can be brought up if capturing carbon and sequestration is introduced.

Modelled for finer understanding of coal supply curve



Disaggregated Detailing of Coal



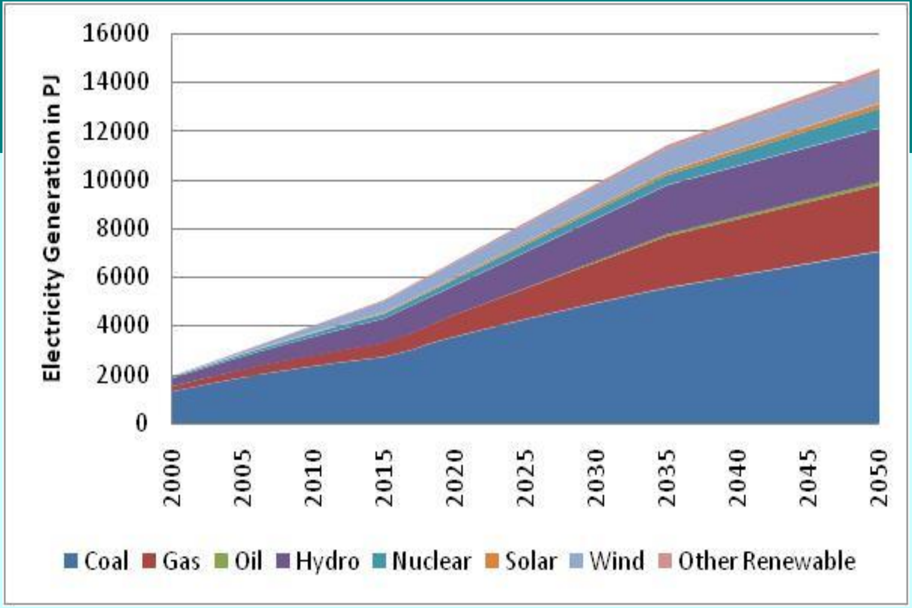


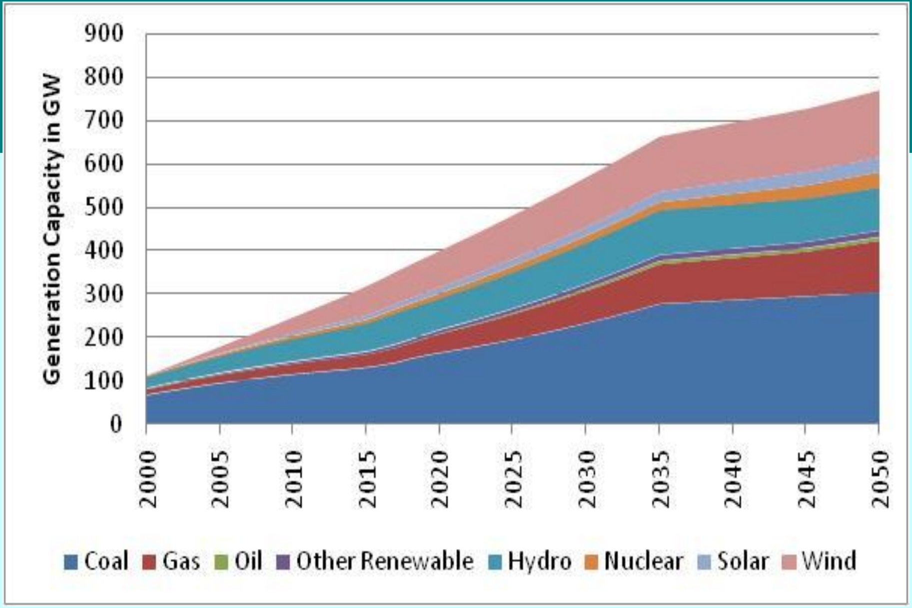
Fuel-wise Primary Energy Consumption in End-use Sectors in BAU

- Total energy consumption in India increases five times by the year 2050
- In BAU, the coal and nuclear consumption is grows rapidly.
- Energy mix is weighted towards coal and would contribute nearly 47% of the total energy requirement in 2050
- Gas would have about 16% share in the fuel mix.

Fuel consumption for Electricity Generation in BAU

- Some inter-switching between coal and gas is observed Coal share in electricity generation somewhat declines with increase in gas share.
- In this state of energy transition, the import dependence of energy needs would continue, as coal demand of the UMPPs, would be mostly met by imports.



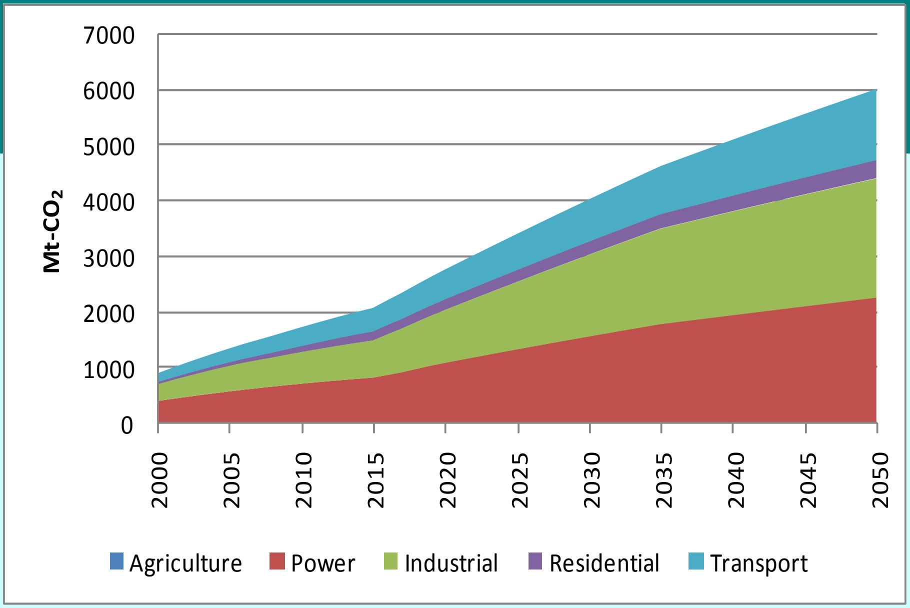


Technology-wise electricity generation in BAU

- The electricity generation is likely to grow at the rate of 4.2 per annum
- In the year 2000, the electricity technology mix based on fuel consists of coal 67%, gas 10%, hydro 17% and rest from oil, nuclear and renewable.
- The share of renewable is negligible in 2000 which is likely to grow to 12% excluding hydro in 2050.

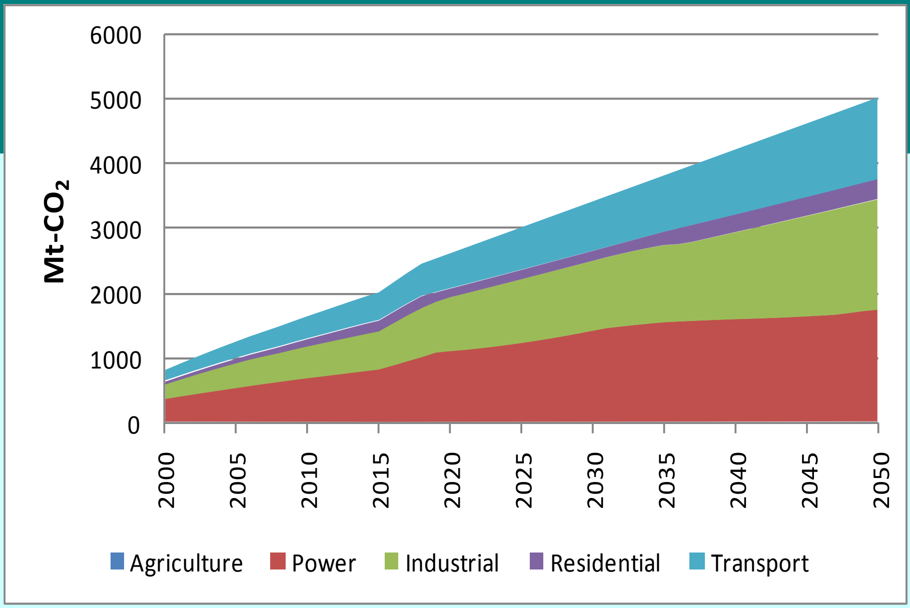
Electricity generation capacity in BAU

- In BAU 770 GW capacities by 2050.
- Coal capacity would increase fivefold.
- The share of solar and wind generation would be 1.4% and 8% respectively from a meagre share in the year 2000.
- More than 30% of new installed capacity would come from coal while 14% and 10% would be added by gas and hydro.
- Wind-based generation is also likely to contribute more



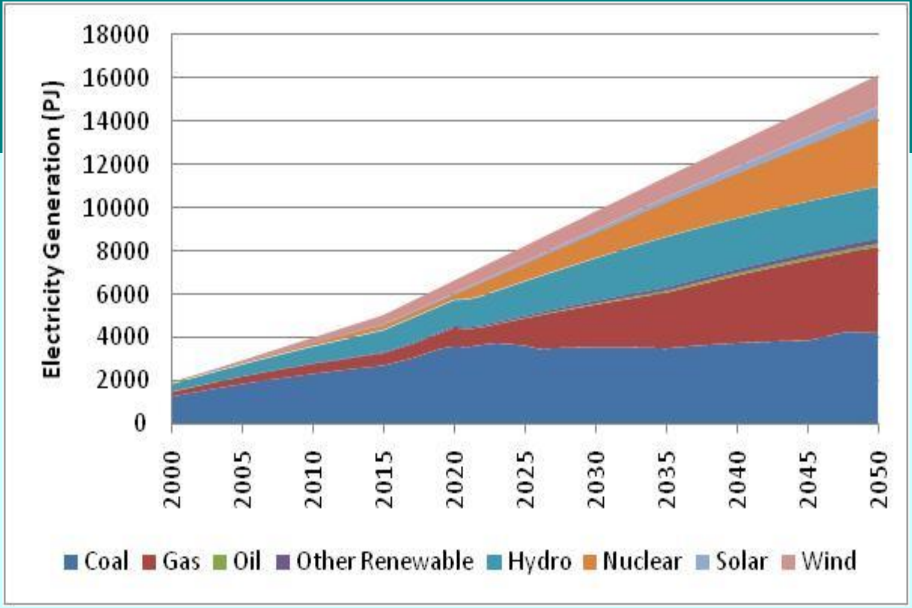
Enduse Sector-wise CO_2 Emissions in BAU

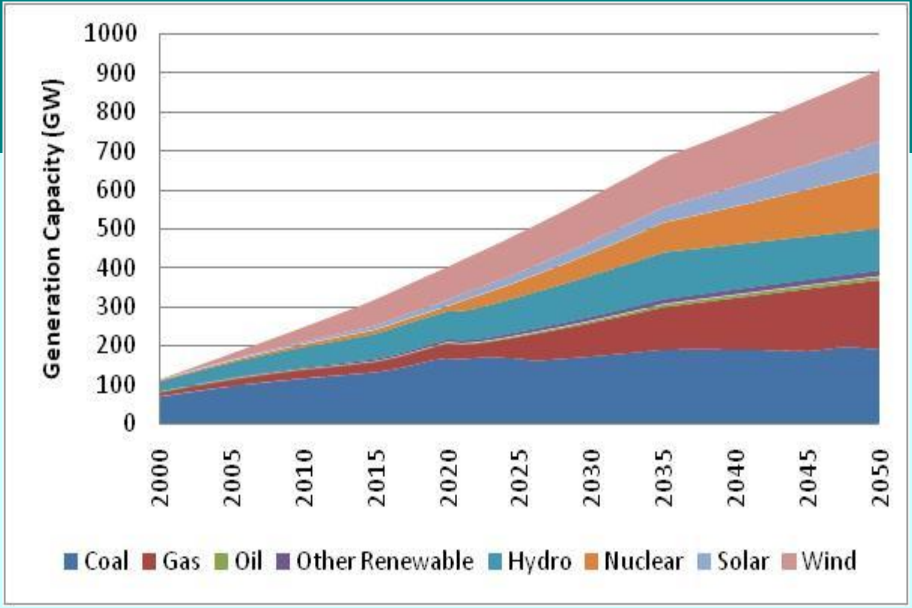
- Power generation 37% and industrial sectors 34% are major emitters of CO_2
- The high thermal capacity as reflected in analysis is also a sign of environmental concern due to having direct contribution in the CO_2 emissions.
- Power generation sector having the greater scope of reduction becomes the target for being used for environmental advantage. Other sectors have limited flexibility



End-use Sector-wise CO_2 Emissions in COC

- In this scenario simulation only 15% reduction is possible through advanced technology penetration in various industrial processes
- This scenario requires huge capital lock-in in both the demand and supply sectors for capacity expansion.



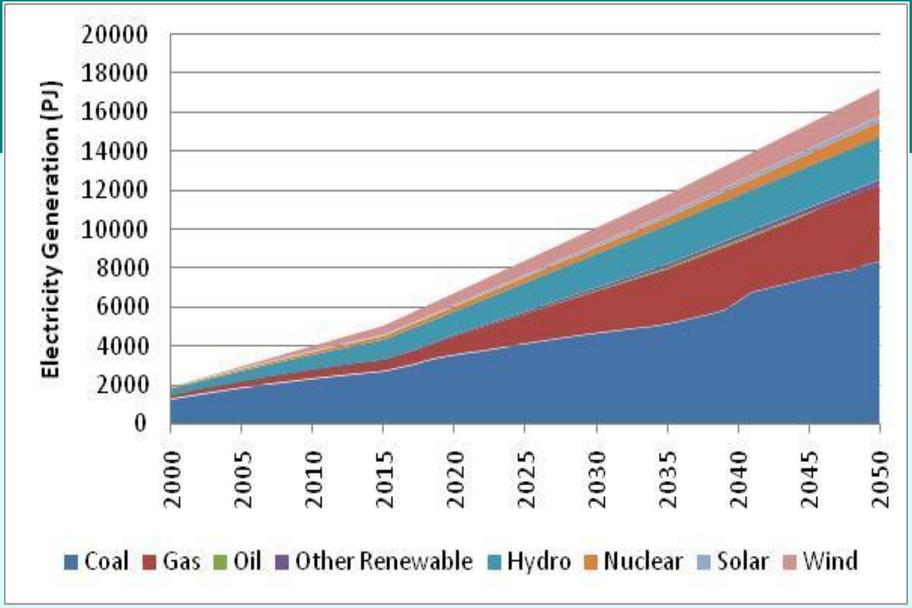


Technology-wise electricity generation in COC

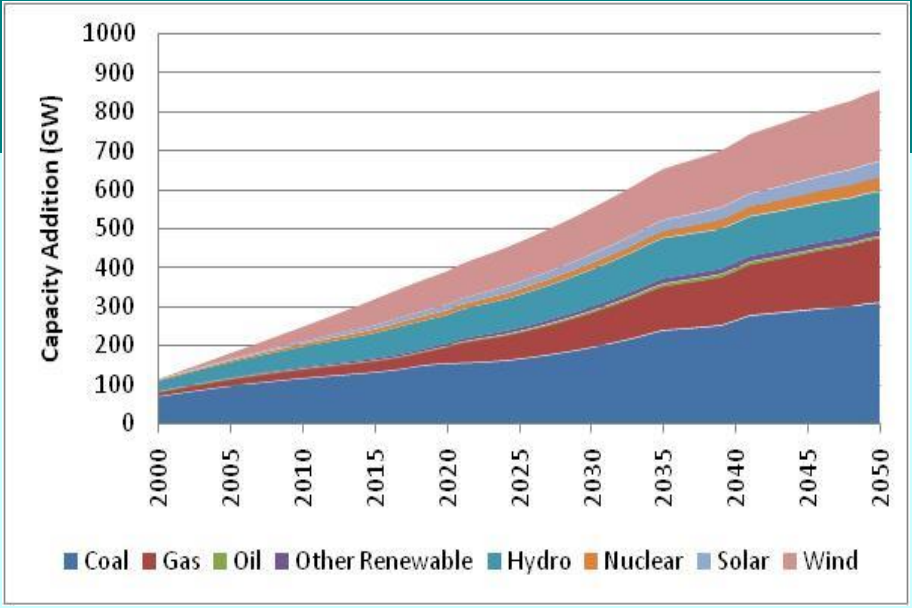
- With emission constraints major industrial activities, like cement production, steel manufacturing, pulp and paper, etc. would shift towards electricity based advanced technologies thereby reducing direct fossil fuel consumption.
- electricity generation increases more than 10% to around 16000 PJ

Electricity generation capacity in COC

- 900 GW of capacity would be required
- Hydro and nuclear would contribute around 15% and 20% of the total generation respectively
- The renewable would be contributing 11%of the total generation but it has nearly 28% of the total stock.
- This is because of low availability factor of renewable. About 27% would be coal based followed by gas which is contributing 24% of the total generation.

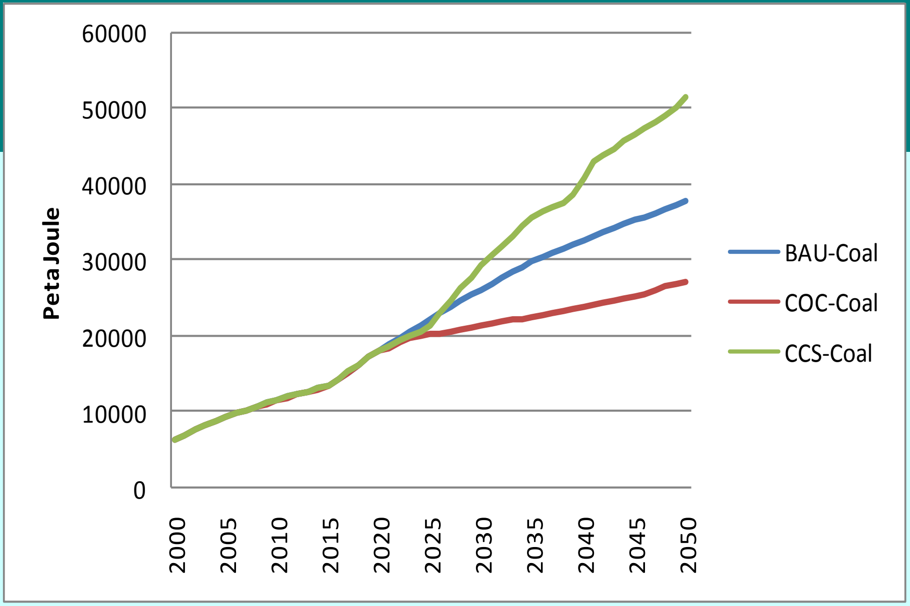


Technology-wise electricity generation in CCS

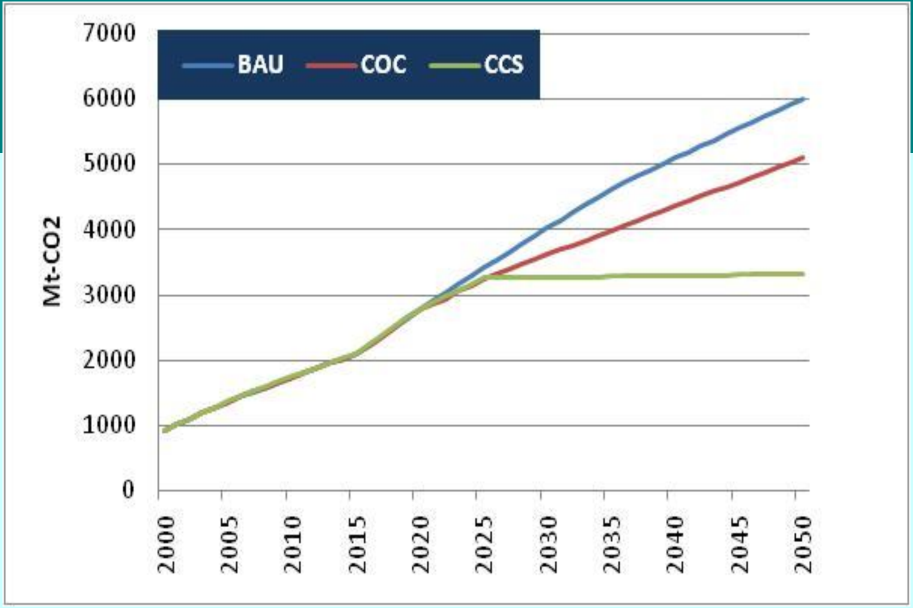


Electricity generation capacity in CCS

- CCS gives rise to the situation of using coal in a manner as green as possible
- Electricity generation would be further increased in CCS scenario but the electricity generation stock is less than the COC scenario
- Due to higher PLF of Coal based technologies as compared to renewable, less capacity would be needed



Coal Demand in BAU, COC and CCS



Comparison of CO_2 in BAU, COC and CCS

- Coal demand would substantially decline in COC and increase in CCS scenario
- This can be attributed to deployment of advance technologies with higher efficiencies.
- In Carbon Constraint case 15% reduction is possible whereas with CCS upto 40% reduction is achievable
- continuance of existing technologies would not result in emission reduction till 2025.
- Almost 90% of emission from highest coal consuming sectors especially power, steel and cement would be captured
- Introduction of new technologies with higher efficiency will favour CCS

Future Extension of Present Work

- Any future outcome would depend upon volatility of prices of fuels. A stochastic analysis can also be carried out for improving future estimates and better understanding of uncertainties.
- In the present work three scenarios have been analysed that mostly emphasised carbon cut vis-a-vis BAU. Other scenarios such as renewable push scenario in which role of subsidy, tax holiday and other promotional incentives can also be analysed.
- Cost burden of emission reduction has not been estimated. Further detailing can help in analysing the effect of emission mitigation on economy. It may be useful to look at the cost of mitigation policies in alternate low-carbon scenarios.

Major Findings

- Any effort of emission mitigation puts additional burden on power sector as other sectors move to electricity based technologies.
- Through advanced technology penetration only 15% CO_2 reduction is achievable. Further reduction requires carbon capture in future. Even with CCS only about 45% CO_2 emission reduction is possible by 2050.
- Many uncertainties associated with viability of CCS from both technical and economic point of view but the new investments in power sector can be made CCS compliant. Thus UMPP's are more suited to adoption of CCS.
- Implementation of CCS would result in additional cost and energy penalty that needs to be analysed further.

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