Relative Environment Economics Of Natural Gas and Other Fossil Fuels for Power Generation and Policy Options for India

A Petroleum Federation Of India Study

The Energy and Resources Institute (Knowledge Partner)
New Delhi

Overview

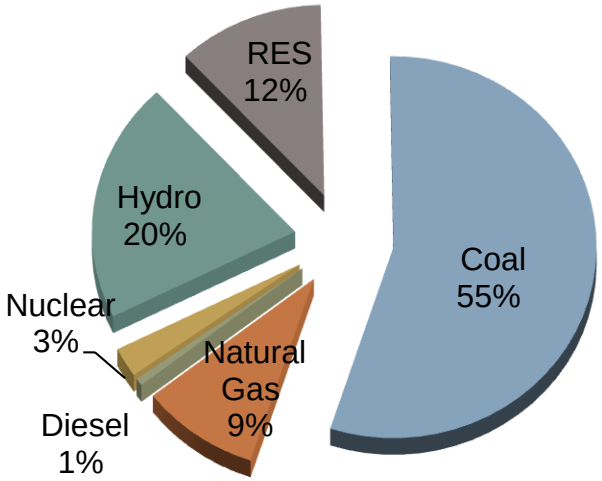
- Background
- Description of the study and findings
- Carbon Implications of power generation
- Domestic coal and gas availability and projected requirements
- International fuel markets
- Conclusions
- Suggestions – Policy Options
- Exclusion – nuclear, renewables, clean coal, hydro

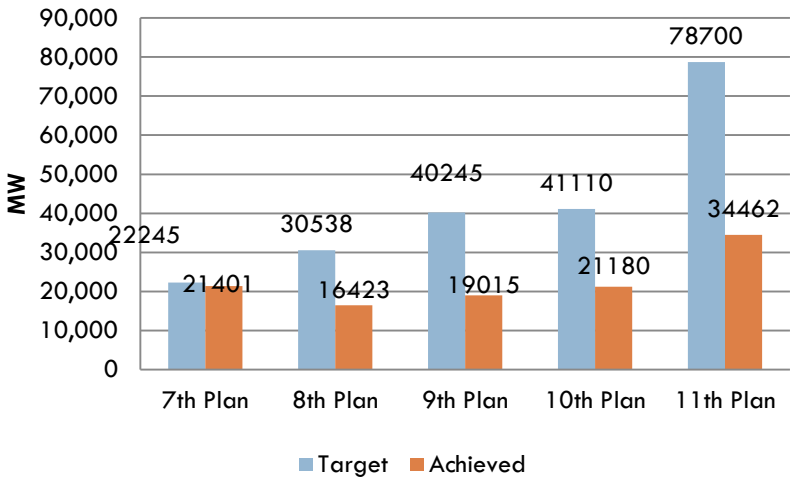
Background

- Growing demand for power in India
- Constraints on supply of fuel to meet the rising demand
- Need to explore all options for fuel
  - Coal and gas - the two major fuels for power generation in the country
  - Shortage of domestic fuel and rising dependence on imported coal and gas
- Rising concerns of climate change require a consideration of the relative carbon emissions
- Given the rising dependence on imports to meet demand, it is also essential to plan for the future keeping in view the evolving international markets

India's Power Sector

- Installed capacity in the country is based largely on coal
- Addition to capacity has been slower than planned with large gap between target and actual addition
- Availability of domestic fuel – a major factor constraining the production of power in India in the past few years
  - Stagnating domestic coal production
  - Declining gas production
- A generating loss of 11.7 Billion Units reported up to January 2013 due to shortage of coal supplies
- Gas shortages have also affected power generation
- Supply of gas up to January 2013 was 41.45 mmscmd as against a requirement of 86 mmscmd



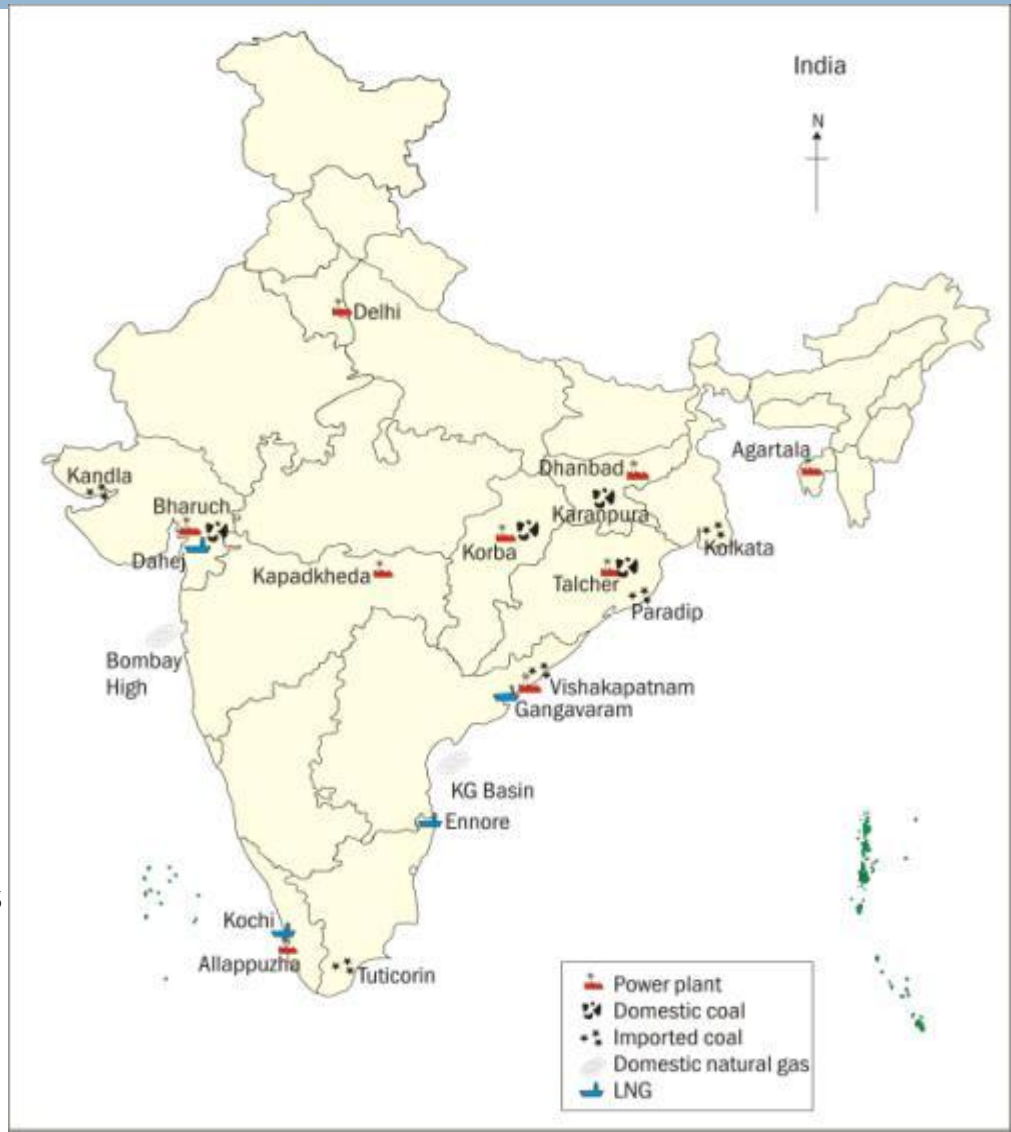


The Study

- Comparison of the cost of power generation using different fuels (i.e. coal and gas both domestic and international) across various locations in the country
- Including the cost of carbon emissions generated in the process of extraction and combustion of fuel
- Need to plan the energy future based on evolving international market dynamics of coal and gas while also accounting for the impact of energy on climate

Calculating the Cost of Power Generation

- Basic assumptions:
  - 9 locations across the country
  - Combination of pithead, port based and inland power stations
  - Dependence on a single fuel at a time (and not dual fuel)
  - Assuming availability of transportation infrastructure for both coal and natural gas
- Components of cost:
  - Fixed cost
  - O&M Costs
  - Fuel Costs
- All calculations based on CERC norms



Assumptions

Fixed Costs and O&M

Element	Unit	Domestic Coal	Imported Coal	Domestic Gas	LNG
Heat rate	kcal/kWh	2500	2500	2000	2000
Capital cost	Rs. million/MW	44	44	33	33
PLF	%	82	82	72	72
Auxiliary consumption	%	9.50	9.50	3	3
Life of plant	Years	25	25	25	25
Fixed operating cost as % of capital cost	%	3.49	3.49	4.65	4.65
Discount Rate	%	15.13	15.13	15.13	15.13

Costs of Fuel

Fuel Type	Price*
Domestic Coal	Rs. 1003.42 – 3056.02/tonne
Imported Coal	Rs. 6956.46 - 8827.86/tonne
Domestic Gas	Rs. 263.6 – 315.28/mBtu
Imported Gas	Rs. 578.05 – 609.22/mBtu

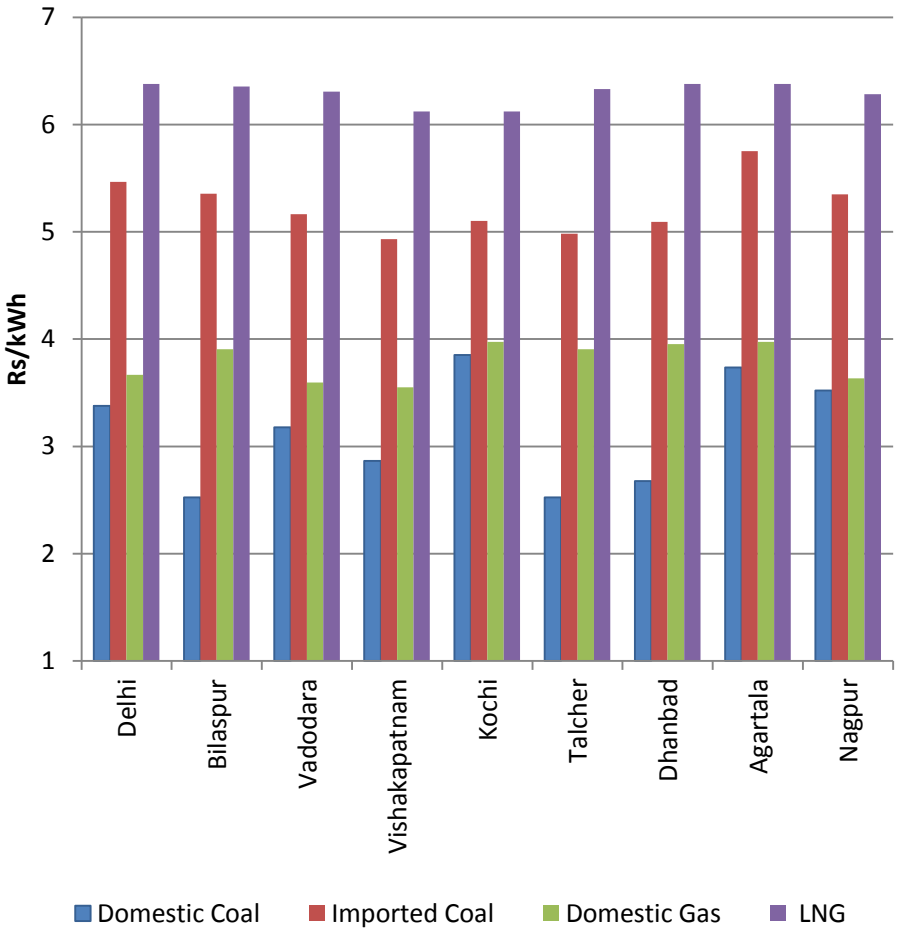
*The variation in prices is due to difference in transportation costs
Prices for domestic coal are as on January 2012, other charges for 2010-11 (Source: Coal Directory of India), prices of domestic gas are for KG D6 gas and APM gas, imported gas prices are for July-August, 2012 and imported coal – average for 2011-12 (Source: Coal Spot)

- Assumptions for power generation costs are based on norms specified by CERC (for 2009-14)
- Exchange rate – Rs 52.2/US$ as on August 2012

Financial Cost of Power Generation

- Domestic coal based generation at pit head power plants is less expensive than non-pit head coal based generation
- Imported coal is not as competitive as domestic coal due to its higher costs
- Domestic gas based power generation is more expensive than domestic coal based generation at all locations
- At locations away from the pithead, the difference between the cost of power generated using the two fuels reduces substantially. These are Delhi, Vadodara, Kochi and Agartala
- LNG is the most expensive fuel for power generation due to the high costs of fuel and the prevailing exchange rate

Financial Cost of Power Generation



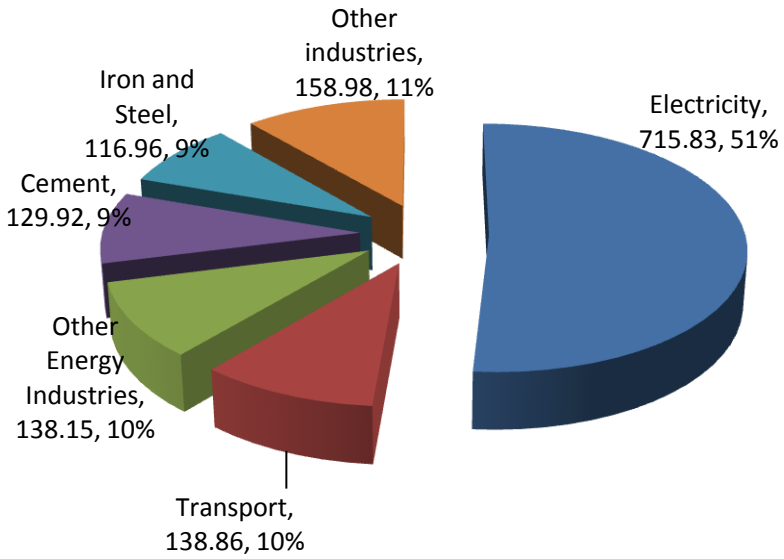
Plant Locations	Fuel Options			
	Domestic Coal	Imported Coal	Domestic Gas	LNG
Delhi	3.38	5.47	3.67	6.38
Bilaspur	2.52	5.35	3.91	6.36
Vadodara	3.18	5.16	3.60	6.31
Vishakapatnam	2.86	4.93	3.55	6.12
Kochi	3.85	5.10	3.97	6.12
Talcher	2.52	4.98	3.91	6.33
Dhanbad	2.68	5.09	3.95	6.38
Agartala	3.73	5.75	3.97	6.38
Nagpur	3.52	5.35	3.63	6.28

Carbon Implications

Carbon Emissions and Power Generation

- Electricity generation contributes the largest share to carbon emissions in India
- Carbon is emitted in the process of extraction of resource and during burning of fuel during power production
- Carbon emitted in the process of coal based power generation is nearly twice that of gas based generation
- These costs are internalised while computing the final cost of power generation
- There are other impacts on the environment generated in the process of power production but these are not incorporated in the current exercise

CO_2 emissions distribution (million tonnes) across sectors in 2007



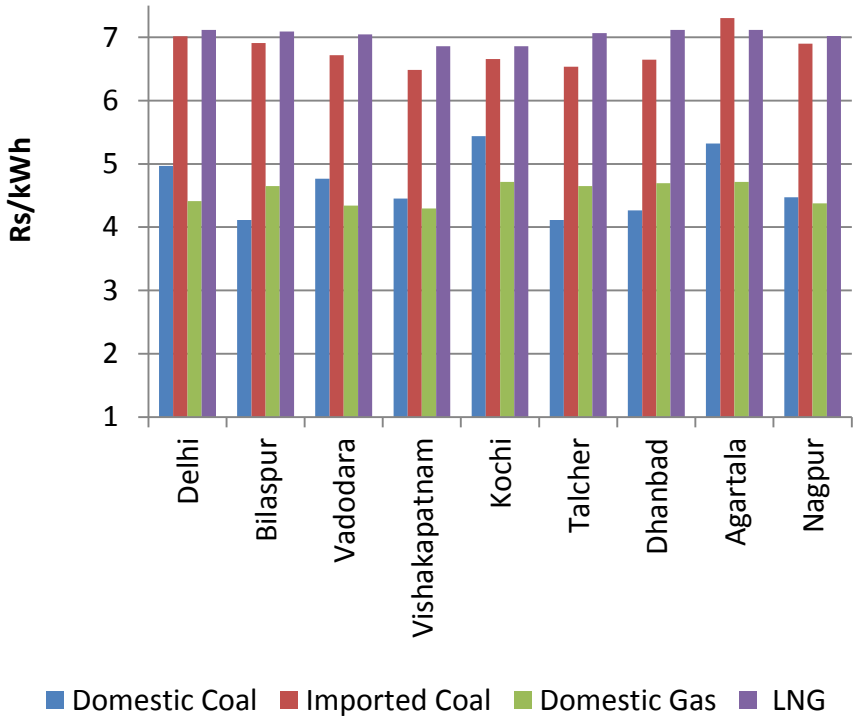
Source: Planning Commission , 2011

Calculating the Cost of Carbon

- There has been significant volatility in carbon prices
- Current Carbon Emission Reduction (CER) prices in European Emission Trading Scheme (ETS) have been affected by prevailing macroeconomic and market situation and have declined substantially in 2011-12
- Prices of carbon are based on the concept of Social Cost of Carbon – proposed by the Stern Review
  - Different levels of social costs have been calculated based on the projected trajectory of carbon emissions in the future.
  - In the BaU scenario, the social cost of carbon rises to as much as US$85/t$CO_2$e
  - "*If the target were between 450- 550ppm CO_2e, then the social cost of carbon would start in the region of $25-30 per tonne of CO_2*"
  - This cost only reflects the impact that carbon emissions will have and do not include any other environmental and social impacts
- These are close to the carbon tax imposed in Australia in 2012 - a fixed carbon tax of AU$ 23-25/tonne of CO_2 to be followed by an ETS

Adding the Cost of Carbon to Power Generation Costs (1)

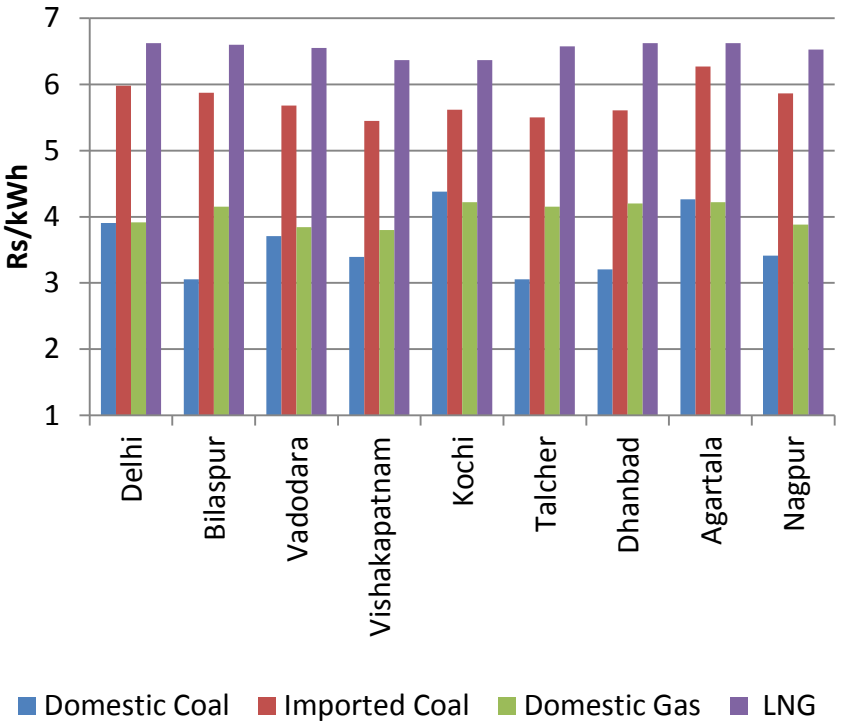
Total cost of power generation at a carbon price of US$ 30/tCO_2 (in Rs./kWh)



Plant Locations	Fuel Options			
	Domestic Coal	Imported Coal	Domestic Gas	LNG
Delhi	4.97	7.02	4.41	7.11
Bilaspur	4.11	6.91	4.65	7.09
Vadodara	4.76	6.72	4.34	7.04
Vishakapatnam	4.45	6.48	4.29	6.86
Kochi	5.44	6.65	4.72	6.86
Talcher	4.11	6.53	4.65	7.07
Dhanbad	4.26	6.64	4.70	7.11
Agartala	5.32	7.30	4.72	7.11
Nagpur	4.47	6.90	4.38	7.02

Adding the Cost of Carbon to Power Generation Costs (2)

Total cost of power generation at a carbon price of US$ 10/tCO_2 (in Rs./kWh)



Plant Locations	Fuel Options			
	Domestic Coal	Imported Coal	Domestic Gas	LNG
Delhi	3.91	5.98	3.92	6.62
Bilaspur	3.05	5.87	4.15	6.60
Vadodara	3.71	5.68	3.84	6.55
Vishakapatnam	3.39	5.45	3.80	6.37
Kochi	4.38	5.62	4.22	6.37
Talcher	3.05	5.50	4.15	6.58
Dhanbad	3.21	5.61	4.20	6.62
Agartala	4.26	6.27	4.22	6.62
Nagpur	3.41	5.87	3.88	6.53

Adding the Cost of Carbon to Power Generation Cost (3)

- When the costs of carbon are incorporated:
  - Domestic natural gas becomes competitive with domestic coal in most locations
  - The difference between imported coal and LNG reduces substantially and LNG even becomes competitive in distant locations (such as Agartala)

A Comparison

Plant Locations	Fuel Options					
	Imported Coal			LNG		
	Without carbon cost	With carbon costs (at US$ 10)	With carbon costs (at US$ 30)	Without carbon cost	With carbon costs (at US$ 10)	With carbon costs (at US$ 30)
Delhi	5.47	5.98	7.02	6.38	6.62	7.11
Bilaspur	5.35	5.87	6.91	6.36	6.60	7.09
Vadodara	5.16	5.68	6.72	6.31	6.55	7.04
Vishakapatnam	4.93	5.45	6.48	6.12	6.55	6.86
Kochi	5.10	5.62	6.65	6.12	6.55	6.86
Talcher	4.98	5.50	6.53	6.33	6.58	7.07
Dhanbad	5.09	5.61	6.64	6.38	6.62	7.11
Agartala	5.75	6.27	7.30	6.38	6.62	7.11
Nagpur	5.35	5.87	6.90	6.28	6.53	7.02

Domestic Coal and Gas Availability and Projected Requirements

Domestic Fuel Availability in India - Coal

- Coal and gas shortages in the country are constraining the development of power sector in the country
- The reasons cited for shortages of coal are delay in obtaining clearances, bottlenecks in transport and evacuation facilities
- The total requirement for non-coking coal is projected to increase to 913.3 Mt (Million tonnes) by 2016-17 and further to 1268 Mt by 2021-22*
- Even if domestic production targets are met, the gap between requirement and domestic availability is projected to be 150 Mt in 2016-17 and 230 Mt in in 2021-22*

*Planning Commission, Working Group Report for the 12th Five Year Plan

Domestic Fuel Availability in India – Natural Gas

- Production of natural gas from domestic fields has declined – reduction in KG-D6 output which has decreased to nearly 16 mmscmd*
- Low prospects of addition to domestic gas production levels
- Actual production in 11th Five Year Plan was 83% of the targets, down from 89.5% achievement in the 10th Five Year Plan
- Advisory by Ministry of Power not to build gas based power plants till 2015-16

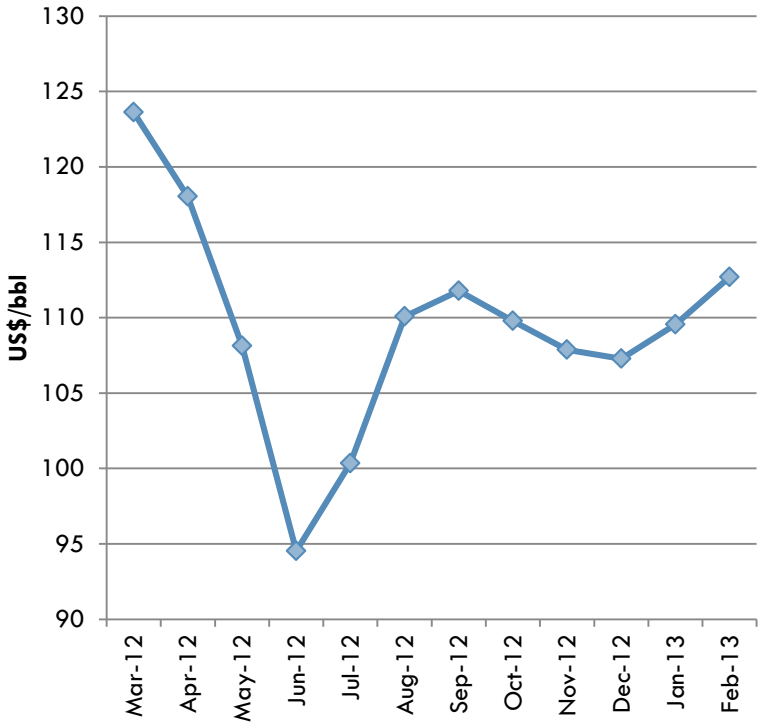
* Lok Sabha Standing Committee Report, April 2013

International Fuel Markets

Changing Trends in International Markets

- Need to examine the international fuel markets and their evolution in the near to medium term (5 to 10 years)
- Dependence on international markets is rising for both coal and gas
- Production of natural gas/shale oil and gas in North America – changing the flow of international energy trade
- Natural gas production in North America – likely to impact the fundamentals across Europe and Asia as well
- This will have implications on the price of energy sources in the international markets

Price of Indian basket of crude oil



Global Coal Markets (1)

- Coal continues to be a major source of energy – fastest growing source in absolute terms in 2011
- Europe has witnessed an increase in coal consumption – primarily driven by switching from natural gas to coal fired power generation, exports from USA to Europe
- In the immediate term, coal consumption in Europe is expected to increase
- As per the IEA – in the medium term – coal usage in OECD Europe will stagnate whereas that in OECD Asia/Oceania will rise marginally
- Coal demand in USA has declined substantially – due to decline in gas prices and ageing coal fired power plants
- Demand for coal is expected to remain strong, driven by high demand from non-OECD countries – particularly India and China
  - China – became a net importer of coal in 2009
  - This will increase the competition among importing countries

Global Coal Markets: Import Constraints for India

- Changes in policies and pricing mechanism in exporting countries
- Availability of coal exports in traditional export sources :
  - Australia already exporting 75% of production in 2011 (60% in 2006)
  - Indonesia – exporting more than 80% of its production
  - South Africa – exporting nearly 30% of its production
- Climate change implications on countries/regions
  - Carbon tax in Australia introduced in 2012-13 (AU$ 23/tonne of carbon)
- Changing policies in exporting nations
  - Increase in prices of coal in Indonesia and 'potential' ban of certain exports
  - Resource nationalism and sovereignty

	Share in global coal reserves	R/P ratio
	%	#
South Africa	3.5	118
Australia	8.9	184
Indonesia	0.6	17
China	13.3	33
India	7	103

Source: BP, 2012

Global Gas Markets

- 4 gas markets – North America, Europe, Asia and Australia
- Natural gas prices in Asian markets - largely linked to crude oil prices
- Production of shale gas in North America is altering the global gas markets
- USA no longer dependent on imported LNG and is expected to now become an exporter
- LNG which was to be exported to USA will now be available to Europe and Asia
  - At lower rates?
- Progressive delinking of oil and gas prices in Europe – move towards gas on gas competition and pricing
- Reports of gas contracts being renegotiated in these regions
- Likelihood of excess gas availability and softening of prices in Asia?

Conclusions

Conclusions

- The difference between cost of power generated using LNG and imported coal reduces if the carbon implications are taken into account
- If the **impact of increased shale gas availability** in North America spreads to Europe and then to Asia, the rise in LNG prices may only be moderate
- The **tax etc. on coal exports** from Australia and Indonesia are only likely to increase, making coal import costs higher
- The **climate change concerns** and the National Action Plan on Climate Change also warrant lowering emissions from power generation
- The huge demand for fuel makes it imperative that we abandon an '***either or approach***' and attempt to increase the availability of piped natural gas and LNG in addition to clean coal and domestic gas
- However, **tariff rationalisation** will be **a *sine qua non*** for such a multi fuel strategy

Suggestions – Policy Options

Infrastructure Requirements

- Infrastructure capacity needs be increased in order to meet the requirements
- Railways and port facilities need to be expanded for facilitating domestic coal production as well as imports
- Substantial infrastructure capacity addition is required to facilitate imports
  - Creation of LNG terminals
  - Construction of Natural Gas Pipelines
- Associated lag times and completion periods (e.g. Kochi terminal) need to be considered while planning for infrastructure

Coal

Transport infrastructure	• Evacuation infrastructure in terms of rail networks to transport mined coal to demand centres
Mining Technology	• Increasing the share of underground coal mining
Underground coal gasification	• In-situ gasification is one of the most important ways to reach coal at depths and to reduce the carbon impact
Washery capacity	• Domestic coal is high in ash content • Current washery capacity for coal is only 33 Mt for coking coal and 112 Mt for non-coking coal (2010-11, Coal Directory)
Import infrastructure	• Port facilities • Rail links for in-land hauling of coal

Natural Gas

Import infrastructure	• LNG terminals • Regasification facilities - FSRUs
Pipelines	• Cross country/trunk pipelines
Pricing	• Report of the Rangarajan Committee under consideration • Need to examine a mechanism where certainty is provided

THANK YOU