

Modeling of Energy Sector in India



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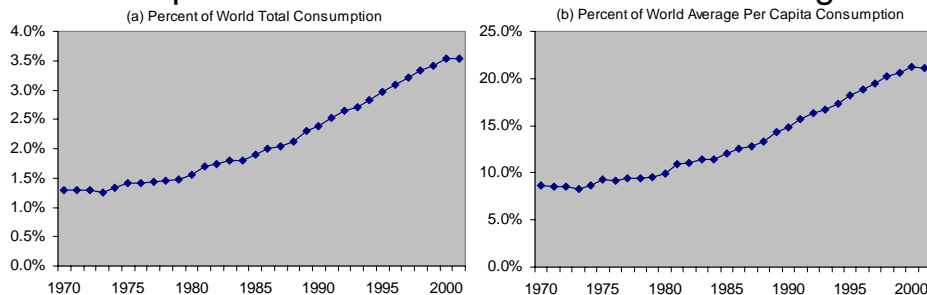


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Brief historical perspective



- Economic growth rising rapidly in recent years
 - Avg. 8.1% (2003/04-2005/06), Rapid growth of Services sector
- Energy consumption growth more than 5%pa
- Per capita levels much below the world average



High optimism for unprecedented economic growth and challenges for matching energy requirements

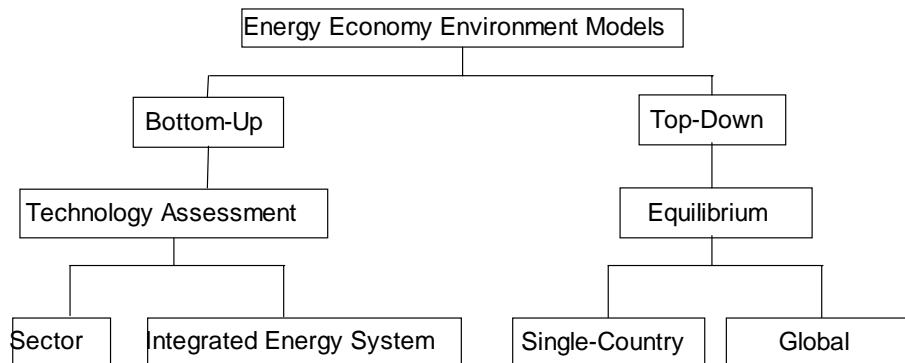
Policy environment



- Economic reforms (~ 15 years now)
 - Broad fiscal discipline and inflation control
- Electricity sector reforms
 - Restructuring of public sector utilities, deregulation
 - National Electricity Policy, Electricity Conservation Act
- Oil & Gas and Petroleum sector reforms
 - Dismantling of administered prices, Reforms in Exploration policy
 - Changes in tax structure for petroleum products
- Nuclear and renewables
 - Independent programmes of DAE and MNES resp., central and state government support
- International agreements
 - Very active in championing causes of international importance

Broadly conducive and getting better

Tools for energy sector policy analyses



Different models suit different needs...

Tools for energy sector policy analyses (contd.)



- Models are useful tools to aid policy articulation
- Top-down models combined with bottom-up models are capable of generating information of particular interest in this respect
- Current models reflect developing country dynamics inadequately, particularly the top-down models

What we need:

1. develop **models** that adequately represent the reality,
2. **modeling** to provide insights and identify optimal response actions for addressing the key policy Qs.

...a balanced development is required

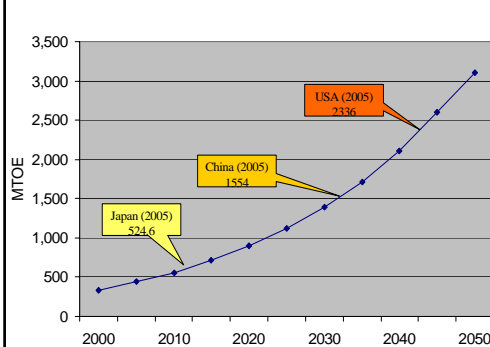
Development of Bottom-up Model



- State-of-the-art tool has been developed for analyzing a variety of policy options in energy sector
- Multi-sector, multi-period cost minimization linear programming model
- 5 End-Use sectors: Agriculture, Residential, Commercial, Industry and Transport
- Detailed modeling of technologies in Electricity, Refining and Transport

India's Energy System modeled in an integrated framework

Commercial Energy Demand in Base case



Imports under Base case

Fuel	2000	2030	2050
Oil	72	375	965
Natural Gas	0	121	366
Coal	8	452	1,190
Total	80	948	2,521

Imports under Combined Options Scenario

Fuel	2000	2030	2050
Oil	72	247	553
Natural Gas	0	123	393
Coal	8	296	754
Total	80	666	1,701

Primary energy demand increases 4x by 2030 & 9x by 2050
 Energy intensity declines rapidly
 Significant increase in energy imports in all scenarios

Scenarios summary (2050)



	2000	Base	Equal	Manufacturing	Forced Hydro	Forced Hydro + Nuclear	Forced Hydro + Nuclear + Renewables	Increased Rail Share	Fuel Efficiency - High improvement	Forced AFVs	Fuel Efficiency	Combined Options
GDP (1993\$)	382	7,454	7,454	7,454	7,454	7,454	7,454	7,454	7,454	7,454	7,454	7,454
Agriculture	91	404	404	404	404	404	404	404	404	404	404	404
Manufacturing	104	1,257	3,946	2,432	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257
Services	187	5,793	3,105	4,619	5,793	5,793	5,793	5,793	5,793	5,793	5,793	5,793
Primary Energy (mtoe)	332	3,103	4,133	5,458	3,128	3,170	3,165	3,062	2,878	3,043	2,974	2,774
Crude Oil	105	965	1,280	1,683	965	965	965	860	678	821	774	553
Natural Gas	25	441	633	880	489	489	472	472	472	494	472	482
Coal	181	1,675	2,199	2,875	1,577	1,251	1,229	1,231	1,229	1,229	1,229	1,240
Hydro	17	17	17	17	92	92	92	92	92	92	92	92
Nuclear	3	3	3	3	3	371	371	371	371	371	371	371
Commercial Renewables	1	1	1	1	1	1	36	36	36	36	36	36
Commercial Energy Indicators												
Primary Energy (kqpc/cap)	325	1,963	2,614	3,453	1,978	2,005	2,002	1,937	1,821	1,925	1,881	1,755
Oil Consumption (kqpc/cap)	103	610	809	1,064	610	610	610	544	429	519	490	350
Energy Intensity (kqpc/000\$)	0.87	0.42	0.55	0.73	0.42	0.43	0.42	0.41	0.39	0.41	0.40	0.37
CO2 Emissions (MtCO2)	922	11,636	15,555	20,583	11,143	9,356	8,978	8,656	8,072	8,806	8,376	7,856
Total Vehicle Stock (Mn)	46	439	458	482	439	439	439	393	439	439	439	393
No of Cars per 1000 persons	5	59	59	59	59	59	59	53	59	59	59	53
Installed Capacity (GW)	102	1,186	1,468	1,832	1,345	1,345	1,397	1,400	1,397	1,397	1,397	1,400
Coal	61	775	971	1,224	685	413	393	393	393	393	393	402
Petcoke	0	10	10	10	10	10	10	10	10	10	10	3
Natural gas	10	371	457	568	405	405	310	310	310	310	310	310
Hydro	25	25	25	25	240	240	240	240	240	240	240	240
Nuclear	3	3	3	3	3	275	275	275	275	275	275	275
Renewables	2	2	2	2	2	2	169	169	169	169	169	169

Flexibility to study a variety of scenarios

Status of energy modeling in India



- Good but dispersed modeling capabilities
- Good general databases, weak model relevant databases
- Largely scientist/analysts driven policy modeling agenda
- Short-term and fragmented policy perspectives
- Personalized and not institutionalized effort

What is needed:

- Detailed national models
- Global and Long-term modeling perspective
- Funding and forums

Forward path with ETSAP



- Review India components in global models
- Participation in global/regional modeling projects
- Informal exchange of ideas/data with network participants



Thank You