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IEA OECD ETSAP news

ANNEX X: GLOBAL ENERGY SYSTEMS AND COMMON ANALYSES

The IEA G8+5 POW and the contribution of ETSAP

This issue of the ETSAP Newsletter focuses on the importance of global climate change, energy, and sustainable development, and the approaches taken to address these problems by several of the world's emerging leadership economies - the "Plus 5 of the G8+5 - Brazil, China, South Africa, Mexico, and India. The specific issues and the responses of the countries presented in this version of the newsletter address the issues highlighted in the G8 Gleneagles Communique:

- Serious linked changes of Climate Change, Energy and Sustainable Development require urgent action;
- Tackling climate change and promoting clean technologies, while pursuing energy security and sustainable development, will require a global concentrated effort over a sustained period to
  - ➢ Promote innovation, energy efficiency, conservation, and accelerate deployment of clean technologies, and
  - ➢ Work with developing countries to enhance private investment and transfer of said technologies;.
- More attention needs to be paid to adaptation due to the affects of climate change, and
- IEA/World Bank common initiatives should be developed.

ETSAP has been actively engaged with key institutions in the +5 for more than a decade. And with the International Energy Agency G8 Program of Work ETSAP is looking to respond by strengthening and expanding these ties. To this end ETSAP is looking to more fully engage key Plus-5 institutions in a coordinated initiative to enhance the ability of the Plus-5 to analyze, deliberate and engage in the various aspects of the IEA-G8 PoW as well as develop their own "post-Kyoto" analysis framework to enable their active engagement in the process. Channeling the skills, expertise, knowledge and experience embodied in such Plus-5 institutions, some of which are contributors to this Newsletter, towards these challenging goals could have substantial rewards. Besides those already noted, owing to the synergy with proper planning for the energy/environment system, such a framework can help to examine ways of achieving many aspects of the Millennium Development Goals as well. In addition, the proposed activity would also look to improve the development of energy and economic data from the key Plus-5 institutions to foster better characterization of these countries in the IEA Energy Technology Perspective, EIA SAGE, ETSAP TIAM and other global energy models.

Institutions in the Plus-Five Countries Familiar with or Building Capacity for the ETSAP Tools

Country	Institutions	Comment
Brazil	Ministry of Mines and Energy CEPEL Universidade Federal do Rio de Janerio	New capacity building initiative getting underway.
China	China Energy Research Institute Environmental Protection Department, Hong Kong GRIEP, Guangzhang Guangdong Energy Economic Research Centre Shanghai Academy of Environmental Sciences Tsinghua University China University of Mining and Technology	Various national and provincial (and city) models available.
India	Indian Institute of Management, Ahmedabad Reliance Industries Ltd. The Energy Research Institute	Various national and state level models available.
Mexico	Instituto Mexicano del Petróleo National University of Mexico	Various national models.
South Africa	Department of Minerals and Energy Energy Research Centre, University of Cape Town	National, regional and various localized models exist.

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Brazil Energy Plan 2030

1. Introduction

In this article we introduce one of the various scenarios presented by the National Energy Plan 2030, a quite comprehensive study which intends to design future paths for the Brazilian energy development. The National Energy Plan 2030 is today being discussed in Brazil and is to be released in January, by the Mines and Energy Ministry.

The Brazilian Government is about to release the National Energy Plan 2006-2030 (NEP2030). The Brazil NEP 2030 is a quite comprehensive study concerned about feasible paths for a sustainable development in the long term. Today, developing country economies usually face the prospect of high energy prices and require diversifying their energy mix, in many cases by moving away from fossil fuels to alternatives sources of energy. At the same time, access to reliable and reasonably-priced energy is a key element for achieving poverty reduction. Fortunately, these economies often also show an unexpected variety of energy sources options and Brazil has not been an exception to this rule. In this context, namely energy security, sustainable development, and high energy prices in the future, scenarios in the NEP2030 were considered.

The International Energy Outlook 2006 (IEO2006) projects strong growth for worldwide energy demand over the 27-year projection period from 2003 to 2030. Roughly, the World GDP is to grow at 3,0% annual average growth. In this connection, NPE 2030, among others existing scenarios, projects for Brazil to grow at 4,1 % from 2005 to 2030 while the world grows at 3,3%, in a comparable scenario.

Historically, Brazil has presented an intricate energy evolution, not always arising from economical difficulties. Basically, there has been a huge firewood substitution process as energy for residential demand and industrial charcoal burners since the 1970's. Apart from this, in the 1980's several energy intensive industries were built as well as an oil substitution policy by electricity in some industrials processes, because of the high oil price in international market, which explains the structural change observed in the elasticity from 1970 up to 2005.

The reference scenario has considered oil price in the range of US$ 50,00 up to 2030. Under of this scenario there are, obviously, some others assumptions about efficiency, energy substitution and industrial sector size reduction as well as a relevant increase of services sector participation in the economy.

Figure 1-1- Primary Energy Growth, GDP Growth and Energy Intensity

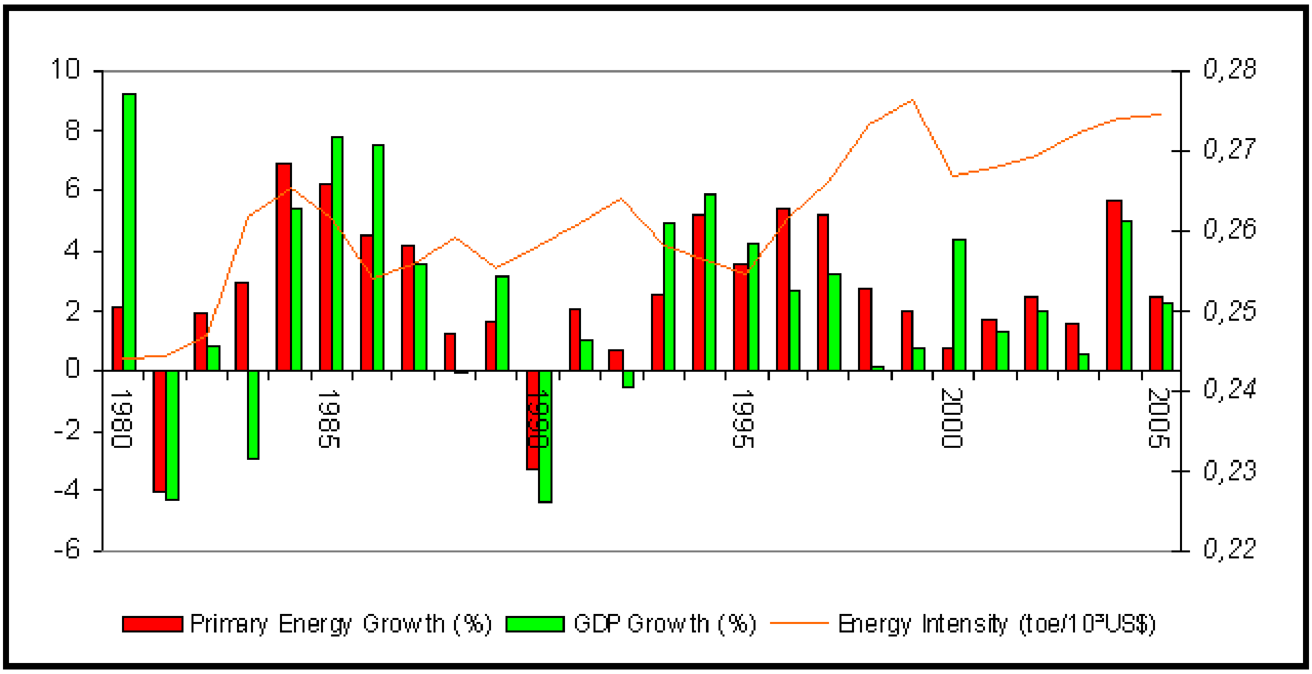


Table 1-1— Income elasticity of energy and electricity demand

Period	1971-1980	1981-1990	1991-2000	2001-2005
Energy Elasticity	0,54	0,82	1,21	1,29
Electricity Elasticity	1,39	3,53	1,62	1,15

Table 1-2 – Sectorial GDP Share and evolution (%): Scenario Considered

Sector	2004	2030	Growth Average Rate (% a.a.)
Agriculture	9,7	9,5	3,9
Industrial	37,2	33,0	3,6
Services	53,1	57,5	4,3

2. Final Energy Consumption and Energy Supply up to 2030

Consistent with the last 30 years tendency, a strong growth is projected for final consumption demand for Brazil. By 2030, oil and derivatives lose theirs share, reaching 32,6% of the total consumption, while hydroelectricity will keep its share (in the range of 17%) along this time period. Following a long process started the 1970's, firewood was reduced share while sugarcane biomass, ethanol, biofuel and others renewables will increase their share remarkably into the energy matrix. The next table resumes the most important numbers.

Table 2-1/2 - Evolution of Final Energy Consumption Share by source(%)

FONTES	2005	2010	2015	2020	2025	2030
Natural Gas	6,8	9,1	9,7	10,3	11,3	10,8
Steam Coal	1,8	1,9	2,3	2,0	2,0	1,9
Firewood	8,2	6,7	5,1	4,6	4,1	3,7
Sugarcane biomass	10,8	11,0	13,3	14,6	14,5	14,3
Others Renewable primaries sources	2,2	4,0	5,7	6,4	7,2	7,9
Coke gas	0,7	1,4	1,4	1,2	1,0	1,0
Coke steam coal	3,3	4,0	4,8	4,5	4,1	3,6
Electricity	16,5	16,6	16,2	16,4	16,7	17,7
Charcoal	3,2	2,4	2,1	1,6	1,4	1,2
Ethanol	3,7	3,6	4,1	4,5	4,8	5,3
Others Secondary	0,1	0,1	0,1	0,1	0,1	0,1
Oil and Derivatives	42,7	39,3	35,3	33,8	32,9	32,6
Diesel	16,5	16,9	14,3	14,1	13,7	13,7
Heavy Fuel	3,4	2,5	2,1	2,0	1,8	1,7
Gasoline	7,0	6,3	6,1	5,5	5,9	6,4
LGP	3,6	3,4	3,3	3,4	3,3	3,2
NAFTA	3,7	2,9	2,3	2,0	1,7	1,4
KEROSENE	1,3	1,2	1,3	1,4	1,4	1,6
GAS	0,0	0,0	0,0	0,0	0,0	0,0
Other Oil Secondary	4,9	4,3	4,4	4,4	4,1	3,9
Non-Energy Products	2,3	1,8	1,4	1,2	1,0	0,9
TOTAL	100	100	100	100	100	100
TOTAL (Mtoe)	196	252	320	370	440	515

Figure 2-1- Evolution of Final Energy Consumption Share by source(%)

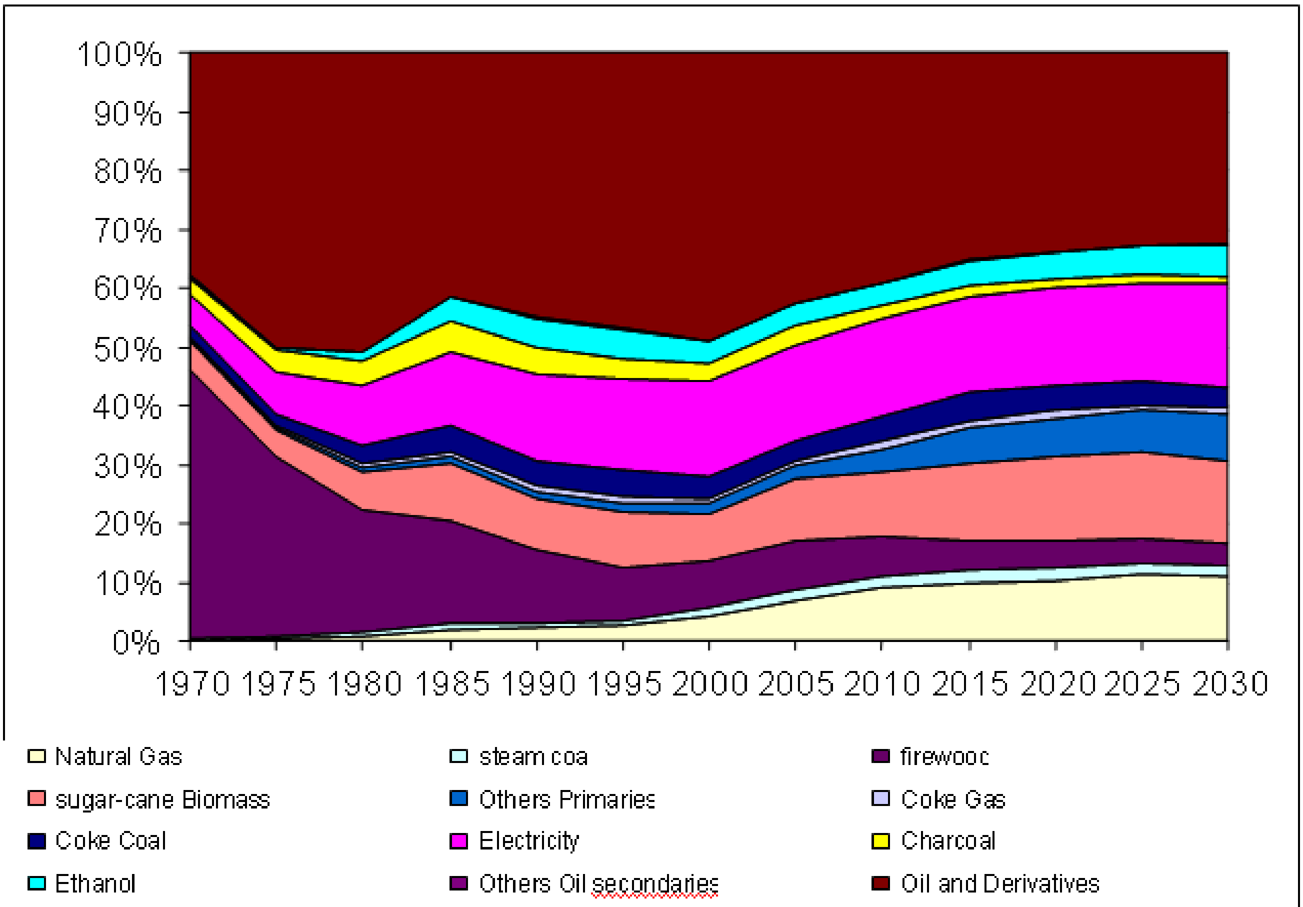


Table 2-3- Energy Supply Evolution, 1970, 1975, 1980, 1990, 1995, 2000 (ktoe)

FONTES	1970	1975	1980	1985	1990	1995	2000
Non-renewable source	**27858**	**47490**	**62387**	**63123**	**72298**	**89105**	**112376**
Oil and Derivatives	25251	43718	55393	49239	57749	70786	86743
Natural Gas	170	571	1092	2946	4337	5424	10256
Steam coal and Derivatives	2437	3201	5902	10021	9615	11984	13571
URÂNIO (U3O8)	0	0	0	916	598	911	1806
Renewable Source	**39088**	**43896**	**52373**	**67883**	**69702**	**73870**	**78239**
Hydroelectricity	10118	18400	32734	15499	20051	24866	29980
Firewood and Charcoal	31852	33154	31083	32925	28537	23266	23060
Sugar-Cane derivatives	3593	4161	9217	17877	18988	22814	20761
Others renewable	223	363	1010	1583	2126	2923	4439
TOTAL	**66945**	**91386**	**114761**	**131006**	**142000**	**162975**	**190615**

Source: (BEN, 2005)

Table 2-4- Some Important Energy Indicators

ESPECIFICAÇÃO	UNIDADE	1970	1975	1980	1985	1990	1995	2000	2005
Energy Supply	106 toe	66,9	91,4	114,8	131,0	142,0	163,0	190,6	218,7
GDP	109 US$ (05)	205,6	332,2	470,6	501,4	550,2	640,0	714,6	796,3
Population	106 hab	93,1	107,3	121,6	134,2	146,6	158,9	171,3	184,2
ES/GDP	toe/10^3 US$	0,326	0,275	0,244	0,261	0,258	0,255	0,267	0,275
EI/POP	toe/hab	0,719	0,852	0,944	0,976	0,969	1,026	1,113	1,187

Finally, the Energy Supply from 2005 to 2015 is expected to increase 65%, from 2015 to 2025, 34,3% and in the last period, from 2025 to 2030, 17%. The same scenario indicates a population growing to 238 million by 2030, meaning an extraordinary responsibility with the population welfare. It is important to remember the fundamental changes that have taken place in the Brazil energy matrix since 1970. In 1970, oil and derivatives had an 34% energy matrix share, most of this being imported. By 2030, likely, oil and derivatives will reach 31%, with a much lower importation percentage. The gas share, on the other hand, has been increased since 1990, and possible is going to achieve more than 15% share in this scenario by 2030. Last but not least, Brazil will be successful to keep its amazingly renewable share in the energy matrix, reaching 43,3%. Concerning electricity generation, most probably hydroelectricity is going to keep a important share (17,9%) but because of the rigorous environmental law framework in the Brazil, in the reality one of the most modern and strict of the world, some Nuclear generation will become necessary by 2030, increasing its share up to 2,9%.

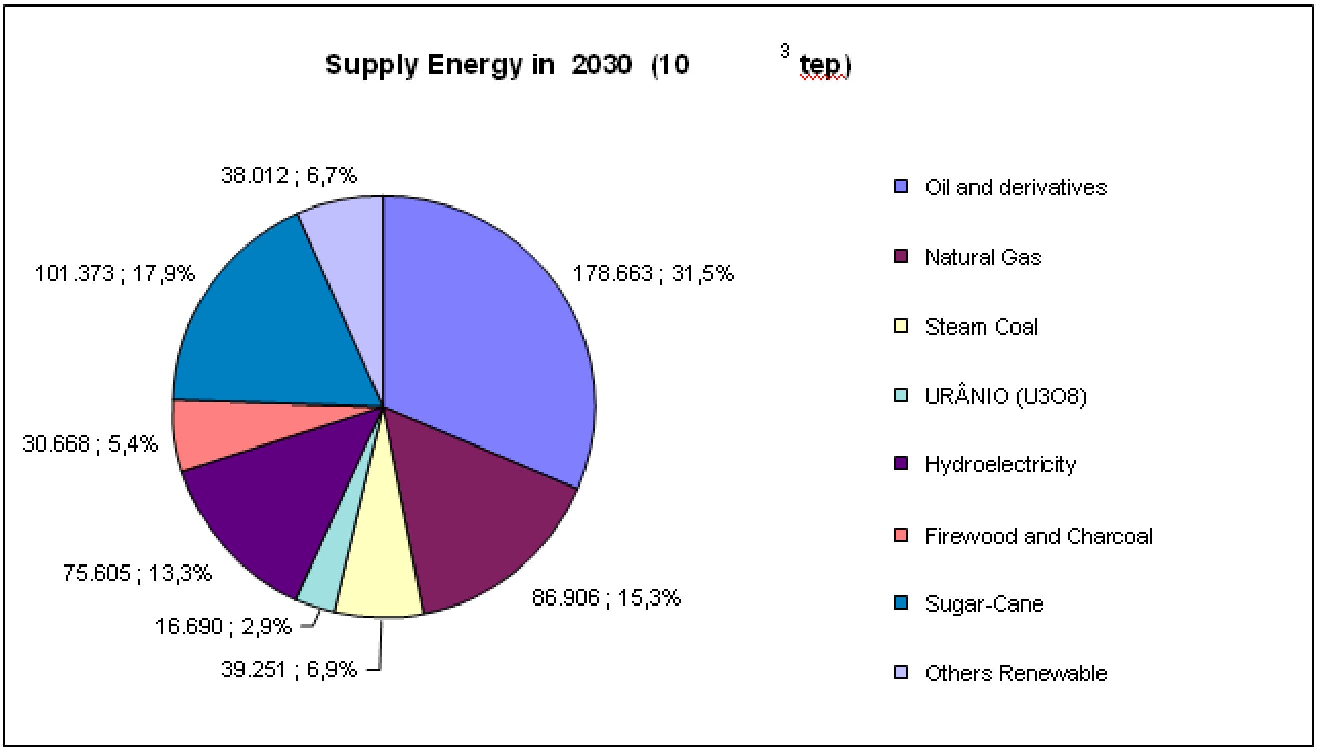
Table 2-5- Energy Supply Scenario, 2005*, 2010, 2015, 2020, 2025, 2030 (Mtoe)

FONTES	2005	2010	2015	2020	2025	2030
Non-renewable source	**121.350**	**161.180**	**212.319**	**241.581**	**274.152**	**321.510**
Oil and Derivatives	84.553	98.358	116.452	134.240	153.947	178.663
Natural Gas	20.526	37.678	53.513	59.023	73.939	86.906
Steam coal and Derivatives	13.721	18.549	28.238	29.944	34.138	39.251
URANIO (U3O8)	2.549	6.595	14.117	18.374	12.127	16.690
Renewable Source	**97.314**	**115.972**	**148.357**	**176.790**	**210.096**	**245.658**
Hydroelectricity	32.379	38.716	45.321	54.598	65.054	75.605
Firewood and Charcoal	28.468	28.130	28.650	28.047	29.540	30.668
Sugar-Cane derivatives	30.147	39.254	57.063	71.846	85.872	101.373
Others renewable	6.320	9.873	17.323	22.300	29.630	38.012
TOTAL	**218.663**	**277.152**	**360.676**	**418.371**	**484.247**	**567.168**

Table 2-6- annual average growth: Energy Supply Evolution (%)

FONTES	2005/1980	2010/2005	2015/2005	2020/2005	2025/2005	2030 / 2005
Non-renewable source	2,7%	5,8%	5,8%	4,7%	4,2%	4,0%
Oil and Derivatives	1,7%	3,1%	3,3%	3,1%	3,0%	3,0%
Natural Gas	12,5%	12,9%	10,1%	7,3%	6,6%	5,9%
Steam coal and Derivatives	3,4%	6,2%	7,5%	5,3%	4,7%	4,3%
URANIO (U3O8)		20,9%	18,7%	14,1%	8,1%	7,8%
Renewable Source		3,6%	4,3%	4,1%	3,9%	3,8%
Hydroelectricity	0,0%	3,6%	3,4%	3,5%	3,6%	3,5%
Firewood and Charcoal	-0,4%	-0,2%	0,1%	-0,1%	0,2%	0,3%
Sugar-Cane derivatives	4,9%	5,4%	6,6%	6,0%	5,4%	5,0%
Others renewable	7,6%	9,3%	10,6%	8,8%	8,0%	7,4%
TOTAL	2,6%	4,9%	5,1%	4,4%	4,1%	3,9%

Figure 2-2- annual average growth: Energy Supply Evolution (%)



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South Africa ERC Modeling Activities: Recent and Current Projects

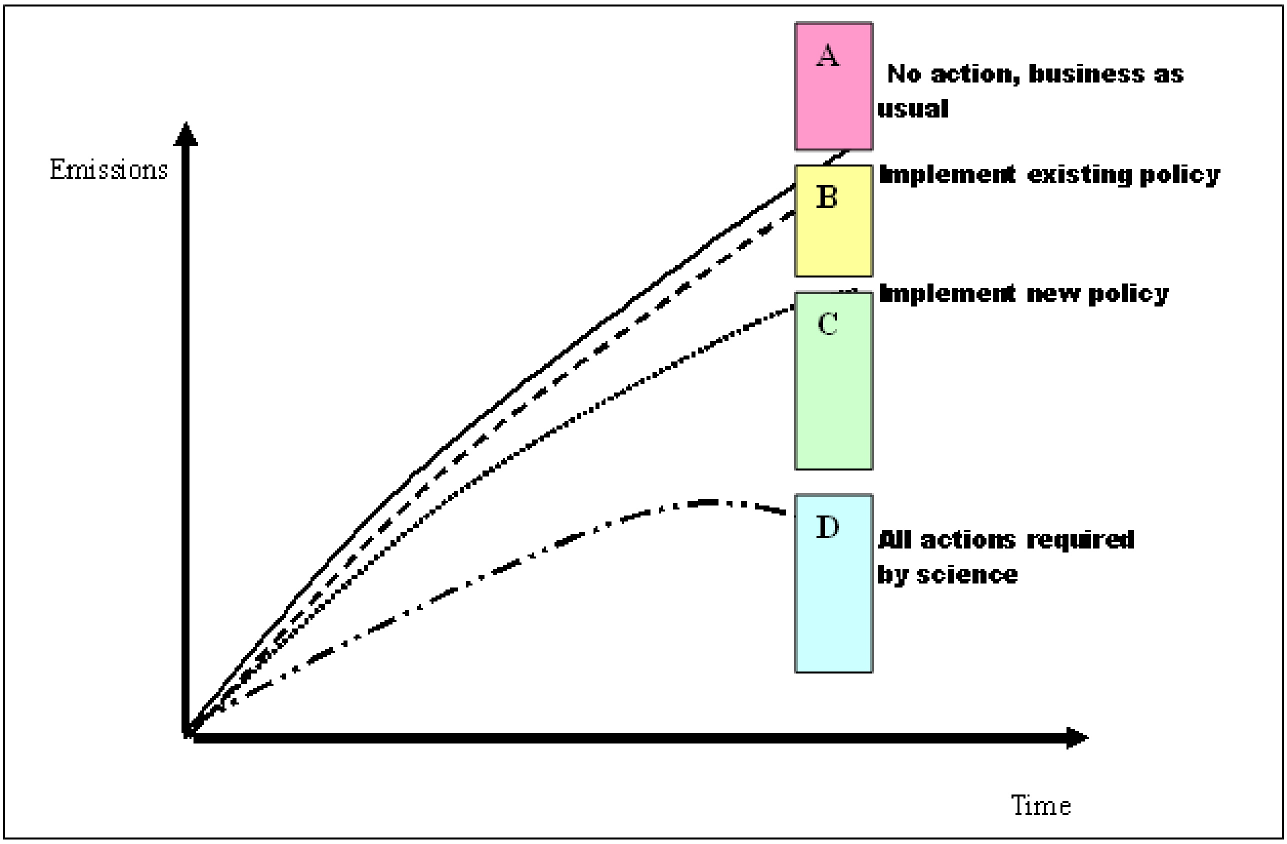
Energy modeling at the Energy Research Centre (ERC) is aimed at assisting local industry and government identify and assess technology and policy options. The focus is on modeling aspects unique to developing nations, where little expertise exists elsewhere. In addition to model-development ERC provides capacity building for model users within government and utilities as well as training for students. The modeling is not done in isolation. There is close collaboration with other research groups at the ERC and other energy research groups around the world (PESD – Stanford, IER-Stuttgart, and KTH Sweden for example) from whom we draw useful knowledge and experience exchange. The group is an active participant in energy model development forums (ETSAP, COMMEND) and co-hosted the International Energy Workshop and ETSAP workshop held in Cape Town in 2006.

Currently the main research areas are national integrated energy planning, utility planning support and the energisation of low-income households. Other research interests and services include city and municipal planning, and regional (SADC) energy supply.

National Modeling

The South African government is committed to Integrated Energy Planning. The first Integrated Energy Plan (IEP), a joint effort between government, the Energy Research Centre (ERC) at the University of Cape Town and ESKOM (the largest electricity supplier) was produced in 2002. The IEP addresses policy questions related to energy such as security of supply, environmental concerns and implications for economic growth. The first IEP modeled two main scenarios, a Baseline or 'business as usual" scenario and Siyaphambili where policies were used to diversify primary energy supply away from coal, there was an increase in energy efficiency and demand side management. South Africa currently relies on coal for 70% of its primary energy. The IEP showed significant potential for reduction in final energy demand through improved energy efficiency, improvement in public transport, and switching from solid fuels to gas. A national MARKAL and LEAP model of South Africa were developed for the first IEP, and have been used for several studies since, such as a Policies and Measures study which looked at increasing the share of renewable energy in the energy supply mix. The model is updated by the ERC every second year, the latest update is funded by the British Foreign Commonwealth Office. Unfortunately some of the data with which the model is populated is taken from studies which have not been updated since the early 1990s.

Figure 1 A range of future emission scenarios for the LTMS project



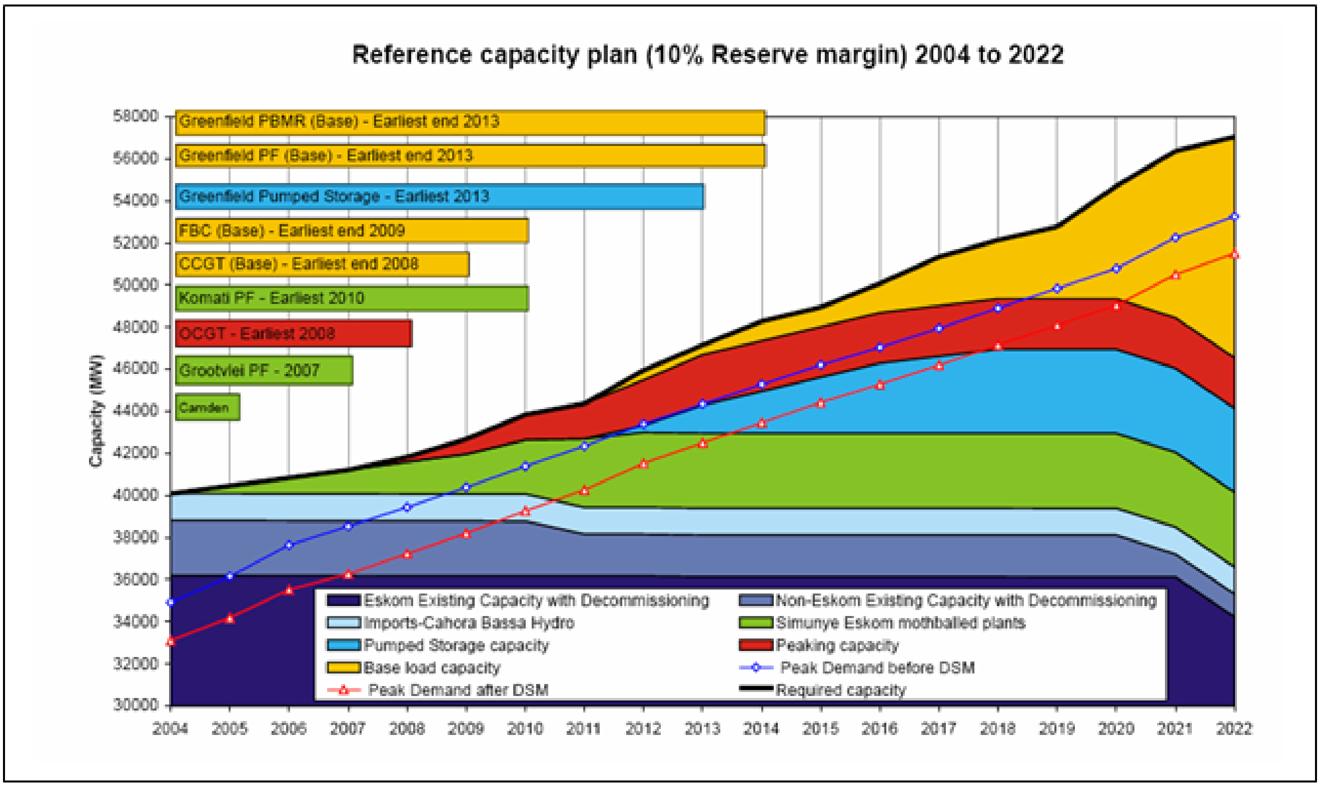
Currently we are using the model in a study being completed for the Department of Environmental Affairs and Tourism. This study investigates long term mitigation strategies for South Africa. The aim of the study is to enable South Africa to participate in post 2012 negotiations with some knowledge of how commitments to mitigate climate change might affect the economy and social development. The study includes energy and non-energy emissions although the MARKAL model includes only energy related emissions. The study also looks at the social impact of policies using a SAM and CGE model.

Electric Utility Planning

The first National Integrated Resource Plan (NIRP) for expansion of electricity generation capacity was developed in 2001 by Eskom Resources and Strategy Group under the guidance of the NER. The first NIRP was based on Eskom's Strategic Electricity Plan (ISEP8). The aim of the NIRP is to "optimize the supply-side and demand-side resources mix while ensuring reliable and secure electrical supply, and keeping the electricity price to consumers as low as possible" (NER,2002), the NIRP is the guiding policy document for the power sector. In 2004 NERSA released the second NIRP. This was a collaborative piece of work between ERC, ESKOM (ISEP) and NERSA.

After the recent blackouts in Western Cape which occurred due to extended outages at power stations in the Western Cape, insufficient transmission capacity and outages on transmission lines, between this area and the north of the country where the large coal fired stations are situated, ESKOM commissioned a study to integrate transmission and generation capacity expansion planning for South Africa. The Energy Research Centre is developing a multi region electricity supply model for ESKOM using TIMES which incorporates supply and generation capacity between 27 nodes in South Africa. Efforts have so far focused on finding a suitable multi-regional representation of the national grid, linking ESKOM's databases to the TIMES model database and developing a suitable representation of the reliability of generation and transmission units within the TIMES framework.

Figure 2 Capacity Outlook for NIRP2 Reference Plan

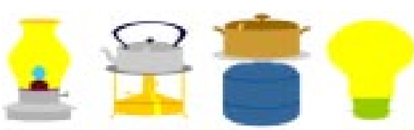


Holistic energy Model

In developing countries there is always need to focus effort on supply of clean and safe fuel to the poor. Currently roughly 70% of households in South Africa are electrified and the intention is to electrify the remainder over the coming years. The Holistic Energy Model is an attempt to use modeling to better understand and simulate the behavior of low income energy consumers and producers, including the drivers and conditions under which energy transitions occur. This would ultimately lead to the development of tools for energizing consumers and producers to meet financial, social, environmental and economic goals.

The holistic energy model relies on data from ESKOM's load research programme. Through the load research programme, household electricity consumption is monitored and socio economic data is collected for low income households in rural and urban areas. It has included the collection of household energy use before and during the introduction of the Free basic electricity tariff. The free basic electricity tariff allows households access to 50kWh's of electricity per month at no cost.

The final outcome of this project is a planning tool to be used by ESKOM, local municipalities and government. The chosen platform for this tool is IAEA's MESSAGE because of it's very low licensing costs.



Education and Training

The Department of Minerals and Energy in South Africa has been developing the modelling capacity of its staff with the aim of being able to produce the Integrated Energy Plans required by government in house. DME staff have received training in both MARKAL and LEAP from the ERC and should now be in a position to develop and run models. ERC will be training additional staff in LEAP on the latest SA LEAP model developed by the ERC in February 2007.
In addition, an energy modelling course was taught as part of the ERC Masters programme to post-graduate students.

Regional energy supply

The availability of low cost large supplies of energy are likely to be enhanced by regional integration. This is important as it provides options for reduced cost energisation, industrialization and improve environmental performance. A TIMES models was developed for the Southern African Development Community (SADC) as part of a Masters project. This model could be used to quantify the potential for regional integration and its effects in terms of costs and environmental impacts.

Following the initial TIMES SADC modelling it was decided to develop a LEAP SADC model, which will be available to all wishing to use it. This

City and municipal modelling

The role of energy in cities is critical due to high population, industry and transport densities. There are related aspects which would gain much from sensible analysis, including: Municipal planning, Waste management, Built environment "lock in", and the role of interventions such as CDM and DSM.

Figure 3 Map of Southern African Developing Countries

In this area ERC has developed a LEAP model for the City of Cape Town which has been used to analyse and test policies for sustainable development.

Selected Publications

A model of household energy services in a low-income rural African village, Howells, M., Alfstad, T., Victor, D., Goldstein, G., and Remme U. 2005, Energy Policy, Volume 33, Issue 14, September 2005, Pages 1833-1851 and presented at the International Energy Workshop Vienna, July 2003

Beyond free electricity: The costs of electric cooking in poor households and a market-friendly alternative, Howells. M., Victor, D. G., Gaunt T., Elias, R., Alfstad T., In Press., Energy Policy, Article in Press.
Energy policies for sustainable development in South Africa: Options for the future. Energy Research Centre, 2006

Greenhouse gas reduction impacts of energy efficiency policies, Trikam A., Hughes A., and Howells, M., Proceedings of the 7th International Conference on GHG Control Technologies, Volume II – Part 1, 2005

Mapping out development pathways for climate friendly economic growth in a developing country, Howells, M., In Press , International Journal of Energy Technology and Policy., Special Issue: Modeling Technology Characterization.

National Integrated Resource Plan 2 (NIRP2), ERC, ESKOM, NER. National Electricity Regulator (NER), Pretoria 2004
Electricity supply industry modelling for multiple objectives under uncertainty, Heinrich, G., Howells, M., Basson, L., Petrie, J., Submitted to ENERGY March 2006 (in review)

Reinventing Kimberley: the Potential Contribution of Solar Energy, Collins, I., MSc Dissertation, University of Cape Town, 2006

Policies and scenarios for Cape Town's energy future: Options for sustainable city energy development, Winkler, H., Bourchers, M., Hughes, A., Visagie, E., Heinrich G., Journal of Energy in Southern Africa, Volume 17 No. 1, February, 2006.

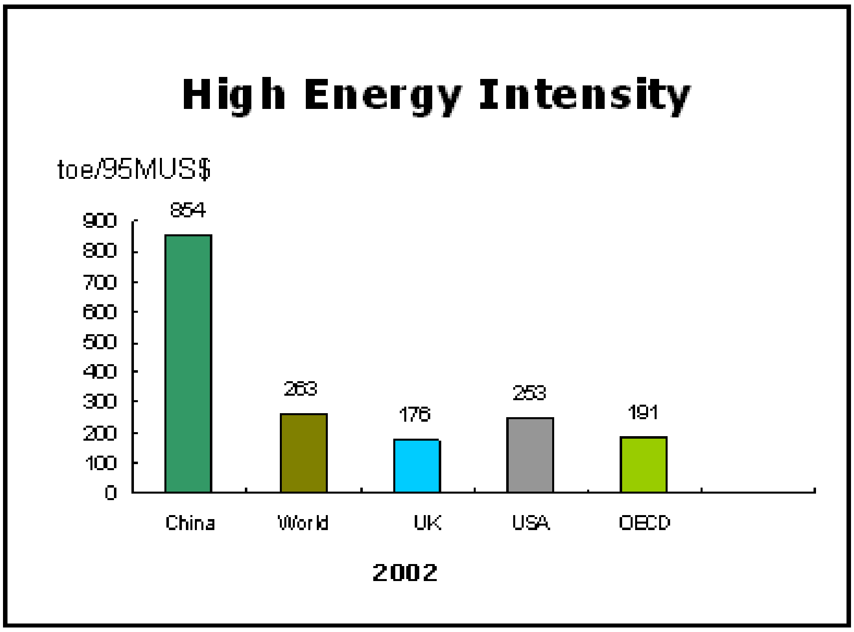
Development of a least cost energy supply model for the SADC region, Alfstadt, T., MSc Dissertation, University of Cape Town, 2005

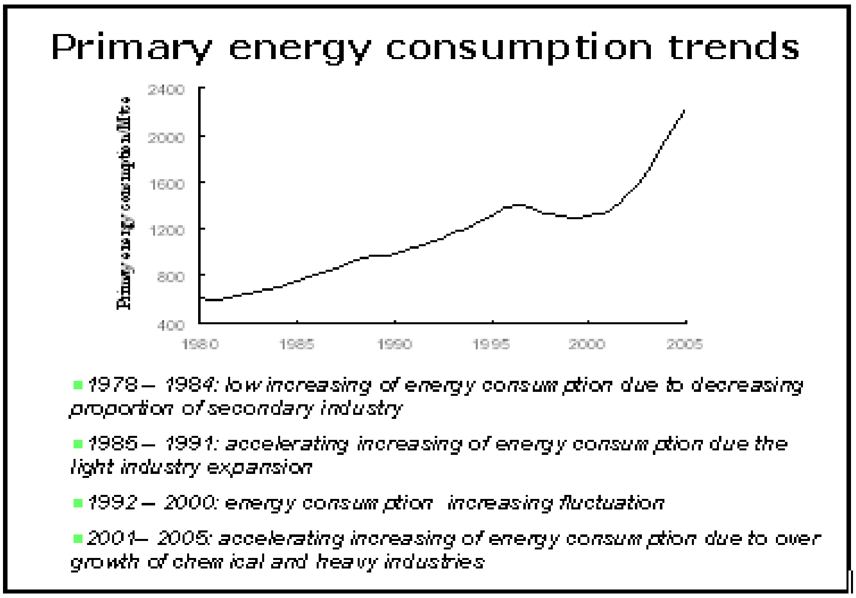
China: Proposal on future cooperation with ETSAP under G8+5

The Current Energy Situation

China's per capita GDP is less than one-fifth of the world average, and energy consumption is less than half of the world average – and less than a tenth of that of the USA. Yet China uses over 10 percent of the world's primary energy on an annual basis. China's energy intensity per dollar of GDP is is more than 3 times that of the US and the world

Due to rapid economic growth and industrial expansion, China's primary energy consumption has nearly doubled since 2000. GDP growth has averaged almost 10 percent over the last decade; primary energy (and electricity) use has been increasing at almost 15 percent per year since 2002. An increasing urbanization rate, increasing living floor area per capita, the growth of automobile use for transportation, and the expansion of heavy and other chemical industries to support infrastructure expansion and manufacturing growth has fuelled (and will continue to stimulate) increased energy use in China.





China produces nearly 95 percent of the energy she uses, yet oil imports are nearly double domestic production. China's reliance on coal – two thirds of primary energy use – is more than twice the world average.

Energy Challenges

Because energy inefficiency and high dependence on coal, China's emissions of CO_2 are the second highest in the world, and China is the world's largest emitter of SO_2. Only one third of China's cities meet (second grade) standards for air quality, and acid rain is a problem for 30 percent of the country. Environmental protection is an increasingly urgent priority.

The high energy intensity per unit of GDP in China - 3.2 times the world average - presents both a challenge and an opportunity. The specific energy consumption for most energy-intensive products is 20-50% higher than that of industrialized countries. Energy security is a problem as well. It is estimated that China will import 60 percent of its oil and 40 percent of natural gas by 2020.

Thus the three largest challenges for China on the energy front are:

- Energy Security;
- Energy Efficiency Improvement, and
- Environmental Protection.

MARKAL Modeling Activities

Effectively addressing China's energy challenges requires effective planning and analysis. MARKAL model development for China began in 1999, and since then the model has been updated to include more advanced technologies, the model has been linked with MACRO to study the impact of carbon emission reductions, and elastic demands have been introduced into the model. The model has been used to assess future energy development scenarios, sustainable energy strategies, and carbon mitigation costs. The main MARKAL modelling activities at Tsinghua University include:

- First China MARKAL model developed in 1999-2000;
- Model updated to include more advanced technologies (2001-2003);
- Energy service demand updated (2003-2005);
- Linked the model with MACRO to simulate the impact of carbon emission reduction on China (2001-2004);
- Introduced elastic demand into the model (2004);
- CCS included into the model to assess its potential role on China's future carbon emission reduction (2005-ongoing);
- Western China MARKAL model (2004-2006), and
- Beijing MARKAL modeling (2005-ongoing).

Owing to China's heavy dependency on abundantly available domestic coal reserves, an area of critical importance for the growing energy demands of China is the potential role to be played by Carbon Capture and Storage (CCS), which continues to be the focus of ongoing studies.

Future MARKAL modelling activities and continued cooperation with ETSAP is anticipated including:

- contribution to the development of modelling tools with emphasis on adaptation of the models to developing countries;
- national/regional model improvements, including capacity building, incorporation of CO2 from industry and other GHGs, and regionalization of the national model, and
- involvement into global model development and improvement, including bringing an improved developing country perspective to the process.

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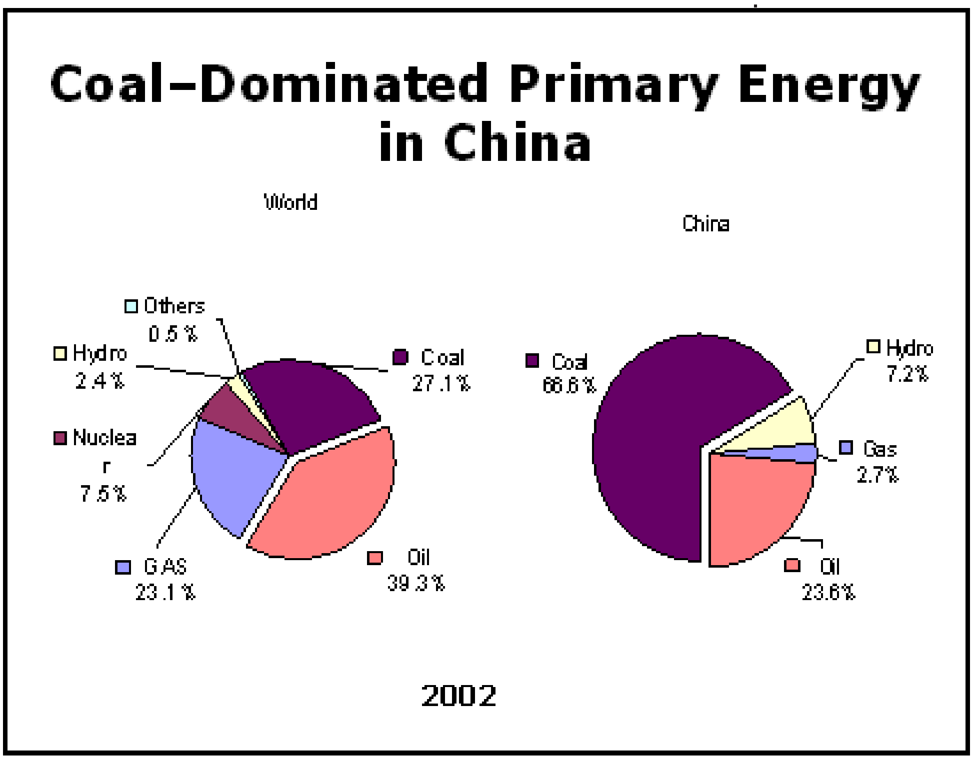
The Networks of Experties in Energy Technology (NEET) Initiative

The Networks of Expertise in Energy Technology (NEET) Initiative is the International Energy Agency's (IEA) response to the 2005 Gleneagles Plan of Action to:

"Raise the profile of existing research networks and encourage broader participation where appropriate; and, seek ways to improve the current arrangements of collaboration between developed and developing country participants in existing networks."

To know more on the progress of the NEET Initiative in the "Plus-Five" countries please visit the website http://www.iea.org/neet and contact Alexandra Niez, NEET Project Manager at Alexandra.niez@iea.org

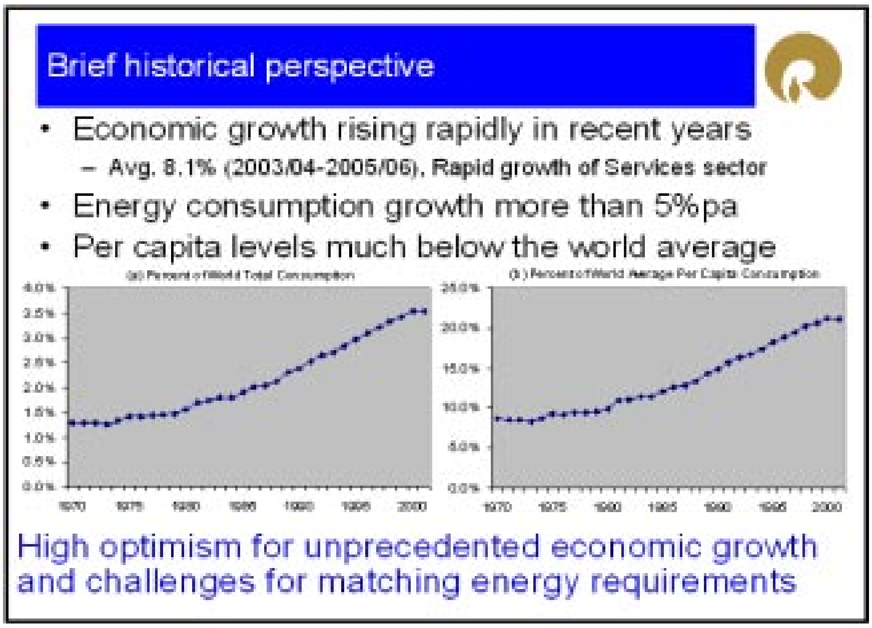


Modeling of the Energy Sector in India

Historical Perspective

Economic growth has been rising rapidly in India – an average of over 8 percent in recent years. Energy use has grown more than 5 percent per year. Still, per capita energy use remains far below the world average.

Economic growth is expected to continue at high levels, along with energy use. A dynamic policy environment, including economic reforms, deregulation of electricity and petroleum prices, the Electricity Conservation Act, and changes in the tax structure for petroleum products have been and continue to be conducive to economic development. Nevertheless the pressures on energy system growth and an increasing reliance on imports is anticipated as India's energy consumption begins to catch up with current levels of economies.



Tools for energy sector policy analyses

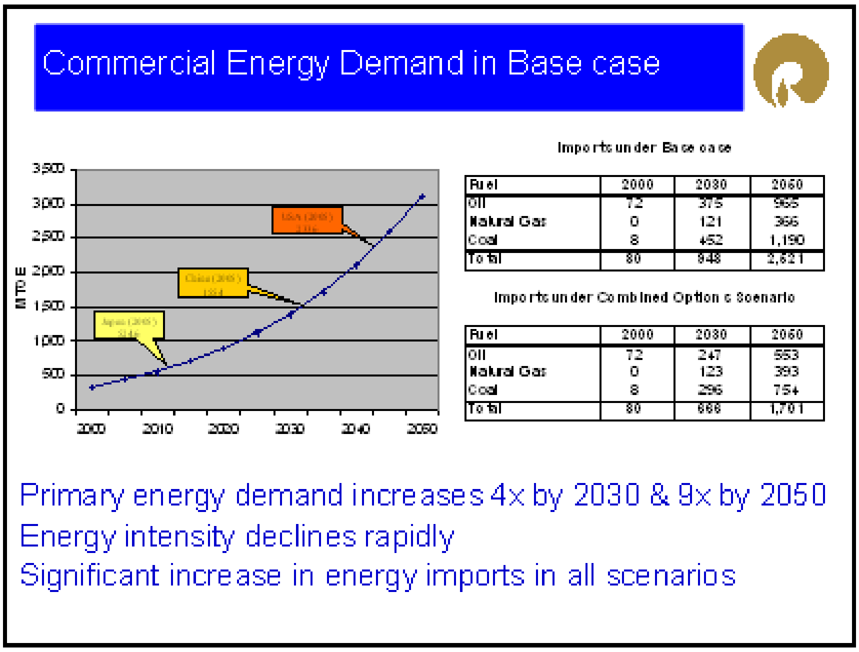
It is recognized that adequate assessment of energy policy options requires models which can be useful tools to aid policy articulation, and that top-down models combined with bottom-up models are capable of generating information of particular interest in this respect.

It is also recognized that current models reflect developing country dynamics inadequately, particularly the top-down models.

What is needed is a balanced development of models that adequately represent the reality of the system, conduct modeling studies to provide insights and identify optimal response actions for addressing the key policy questions, and the development of a bottom-up model with sufficient technological detail to address specific options.

Development of the Bottom-up Model

A state-of-the-art modeling tool for India has been developed for analyzing a variety of policy options in the energy sector. The model is a multi-sector, multi-period cost minimization linear programming model with 5 end-use sectors [residential, commercial, agriculture, industry, and transport, with detailed modeling of technologies in electricity, refining, and transportation. The model is capable of generating a wide variety of future scenarios [see below].



The Forward Path with ETSAP

Future work with ETSAP will include the review of India components in global models, participation in global/ regional modeling projects, and informal exchange of ideas and data with network participants.

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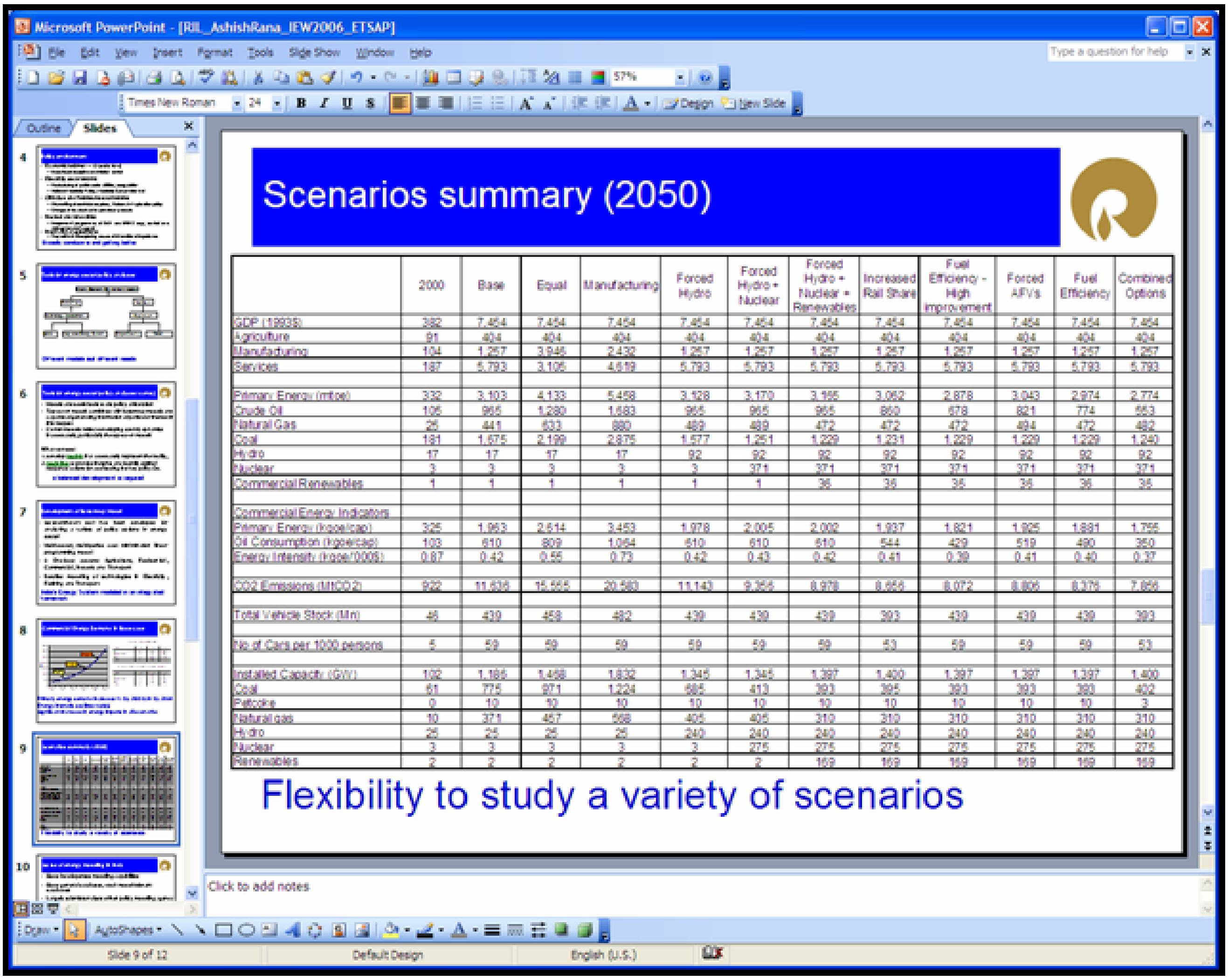

	2000	Base	Equal	Manufacturing	Forced Hydro	Forced Hydro + Nuclear	Forced Hydro + Nuclear + Renewables	Increased Rail Share	Fuel Efficiency - High improvement	Forced AFV's	Fuel Efficiency	Combined Options
GDP (1993$)	382	7,454	7,454	7,454	7,454	7,454	7,454	7,454	7,454	7,454	7,454	7,454
Agriculture	91	404	404	404	404	404	404	404	404	404	404	404
Manufacturing	104	1,257	3,946	2,432	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257
Services	187	5,793	3,105	4,619	5,793	5,793	5,793	5,793	5,793	5,793	5,793	5,793
Primary Energy (mtoe)	332	3,103	4,133	5,458	3,128	3,170	3,165	3,062	2,878	3,043	2,974	2,774
Crude Oil	105	965	1,280	1,683	965	965	965	860	678	821	774	553
Natural Gas	25	441	633	880	489	489	472	472	472	494	472	482
Coal	181	1,675	2,199	2,875	1,577	1,251	1,229	1,231	1,229	1,229	1,229	1,240
Hydro	17	17	17	17	92	92	92	92	92	92	92	92
Nuclear	3	3	3	3	3	371	371	371	371	371	371	371
Commercial Renewables	1	1	1	1	1	1	36	36	36	36	36	36
Commercial Energy Indicators												
Primary Energy (kgoe/cap)	325	1,963	2,614	3,453	1,978	2,005	2,002	1,937	1,821	1,925	1,881	1,755
Oil Consumption (kgoe/cap)	103	610	809	1,064	610	610	610	544	429	519	490	350
Energy Intensity (kgoe/000$)	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	15,565	20,580	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	395	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