US-Japan Energy Cooperation
To Help Achieve Sustainable Development In Asia

ENERGY OUTLOOK FOR ASIA

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As preparation for developing recommendations to increase Japanese-US cooperation and leadership in the energy field that can contribute to achieving sustainable development in Asia, this paper reviews the long-term energy outlook for Asia, excluding Japan. The purpose of this review is to provide a basic understanding of the major trends and possible energy developments as a framework for deciding on what issues we should focus our efforts.

Since the Asian energy outlook mirrors that of the world, this discussion will start with a short review of global energy developments which were covered more fully in my presentation "Long-tem Global Energy Outlook" presented at the November15-16, 1999 US-Japan Energy Policy Dialogue. In order to utilize a consistent set of data, the basic forecasts are taken from a five-year study conducted jointly by the International Institute for Applied Systems Analysis [IIASA] and the World Energy Council [WEC]. This study entails three cases and six scenarios that are presented in *Global Energy Perspectives*, published October 1998 by Cambridge University Press. Although more recent forecasts might alter some of the projections, the range of possibilities indicated by the scenarios provides a useful basis for focusing on the trends and developments that are likely to occur.

Whenever using such forecast, we need to keep in mind that the direction and relative developments associated with various assumptions are more important than the absolute numbers. In addition the long-term portion of the projections are clearly less reliable than the nearer term. Nevertheless, the 2100 outlook is helpful in indicating where near term events can take us. Typically, even major policy decisions will take twenty to fifty years to have a major impact on energy structures. With these caveats, the implications of the forecasts can help us assess if we should attempt to modify the outcomes through policy, technology and investment decisions.

The IIASA's three cases were designed to indicate potential outcomes over a range of economic growth, supply availability and environmental conditions. Case A is a high growth case that explores the implications of differing oil and gas reserve assumptions and the pace of technological changes through three scenarios. Case B is a single

"middle course" scenario incorporating more modest GDP growth and technological change. Case C is the most challenging; it is optimistic about technology and geopolitics and assumes unprecedented international cooperation focused explicitly on environmental protection and equity.

Summary of the Three Cases
Global

	Case A High growth	**Case B Middle**	**Case C Ecologically Driven**
GDP growth, % per year			
1990-2000	2.7	2.3	2.2
2000-2020	2.7	2.2	2.2
2020-2050	2.6	2.0	2.1
2050-2100	2.3	2.0	2.2
Global Primary Energy Intensity Improvement (% per year)			
1990-2050	0.9	0.8	1.4
2050-2100	1.0	0.8	1.4
Primary Energy Demand (Gtoe)			
1990	9	9	9
2000	11	10	10
2020	15	13	11
2050	25	20	14
2100	45	35	21
Net Carbon Emissions (GtC)			
1990	6	6	6
2000	7	7	6
2020	8-10	8	6
2050	9-15	10	5
2100	6-20	11	2
Environmental Taxes	No	No	Yes
CO2 Emission constraint	No	No	Yes

Observations on the three global cases

Long-term global primary energy needs in case A grow to 45 Gtoe in 2100, an increase of 1.9 percent per annum for the next fifty years and 1.5 percent per annum for the last half of the century. Primary energy needs in Case B are 20-25 percent below Case A, principally due to lower GDP growth rates. Primary energy needs in Case C are 45-55 percent below Case A, as lower economic growth, energy intensity improvements and demand restraints reduce requirements. Case C is the only case that reduces CO2

emissions below the 1990 level, having implemented environmental tax and CO2 emission constraints.

Next Twenty Years

Through the year 2020, most forecasts provided by others, such as the IEA (International Energy Agency), DRI (Standard & Poor's DRI), PEL (Petroleum Economics, Ltd.), and PIRQA (PIRA Group), are remarkably similar to the Case A results. Major trends are as follows:

- The Developing world GDP grows faster than that in the Industrialized countries.
- Worldwide primary energy grows 2.1% a year (2000-2020) versus 1.7 % a year over the 1980-2000 period.
- Developing countries total consumption of primary energy surpasses that in the industrialized countries by 2020, reflecting faster economic growth.
- Energy intensity starts a downward trend in the developing world, and the historical trend of modest improvements continues in the industrialized world.
- Primary fuel patterns remain similar to past trends with the exception that natural gas demand accelerates.
- Nuclear grows slowly, less than 1% a year.
- Carbon emissions continue to rise with developing country emissions equaling industrialized by 2010.
- Electricity production grows at 2.5% a year outpacing primary energy growth of 2.1% a year, with growth in the developing world about three times that in the industrialized world.
- Oil and gas reserves remain plentiful and oil prices are expected to remain close to current levels.

Over the next twenty years there will be acceleration in the development of networks and in the transportation of fuels between countries. Electricity grids and natural gas pipeline networks multiply. Oil transportation flows grow by 80% between 1995 and 2020 owing to demand in developing countries. Similarly, LNG shipments will expand.

New fuels will start to be evident as natural gas is converted to liquids, hydrogen becomes used as a transportation fuel, solar and biomass become more economic. Technically there remains a possibility that inherently safe and smaller nuclear power plants (100 to 300 megawatts installed capacity) may be developed.

Post 2020

After the year 2020, there is a slow steady shift away from oil and gas that becomes most pronounced in the last half of the century. This shift in relative shares is least pronounced in the scenario that assumes abundant oil and gas reserves, and is most pronounced in the scenarios assuming rapid technological change and/or environmental constraints.

Case C, which incorporates environmental constraints, also indicates a rapid movement away from coal after 2020. Even in the Case A and B scenarios that continue to rely on coal for a substantial portion of primary energy demand, little of this coal is used directly. Instead it is converted to high quality energy forms such as electricity, liquids and gas demanded by the higher income consumer in the second half of the 21st century.

In the long term there will be an increased reliance on renewables and nuclear in all cases with its share increasing from 20 % today to roughly 40 to 70 percent of primary energy by 2100.

Most interesting is the IIASA's conclusion that "despite the divergence in primary energy structures, the pattern of final energy use is remarkably consistent across scenarios, showing a continuing trend toward energy reaching the consumer in ever more flexible, more convenient, and cleaner forms". This is seen in Figure 3 attached. Increasingly, energy will be delivered by dedicated transport systems, such as pipelines and networks ultimately requiring more sophisticated systems and higher-quality energy carriers.

With increased trade similar end-use patters will emerge across regions with fundamentally different primary energy structures. Also, throughout the world energy intensities will continue to decline owing to a shift in the sources of GDP growth and from technological change.

Implications of Global Outlook

Even with the wide range of assumptions used in the IIASA's three cases, there are a number of implications that are evident across all scenarios.

–World energy markets will become even more interdependent.

–Technology transfers will become essential to meet environmental requirements and demand needs.

–Research and development programs will need to be encouraged to meet growing requirements for renewables and /or nuclear.

–Construction and maintenance standards for networks, pipelines and transportation carriers will become more critical.

–Growth in CO_2 emissions can be slowed and leveled off, but not reduced, without a political and economic commitment to shift resources to the developing world.

Asian Energy Outlook

Since we are focusing on developing energy related recommendations to encourage sustainable development, this discussion will examine the Asian projections excluding Japan. The projections represent the data from the same IIASA cases as shown for the global data. In order to illustrate the complexity of policy making in this area as well as the variability between sub-regions, charts have been attached for Case A1 (high growth, abundant oil and gas} and Case B (middle growth, continuing reliance on coal). These charts display shifts in energy structure over time for Centrally Planned Asia (dominated by China), South Asia (dominated by India), and Other Pacific Asia (includes South

Korea, Taiwan, Singapore, Malaysia and the Philippines). Over the next century, taken together, these areas experience the same trends as discussed above for the world as a whole. However, the trends will be even more dramatic as this area will in fact be driving the world markets.

Summary of Three Cases
Asia, Excluding Japan

	Case A High Growth	**Case B Middle**	**Case C Ecologically Driven**
GDP Growth, % per year			
1990-2000	6.8	5.3	6.4
2000-2020	5.4	4.0	5.0
2020-2050	4.0	3.5	3.7
2050-2100	2.8	3.0	2.8
Primary Energy Demand, Gtoe			
1990	1.8	1.8	1.8
2000	2.6	2.5	2.4
2020	4.7	3.7	3.6
2050	8.7	6.9	5.5
2100	17.5	14.0	9.2
Net Carbon Emissions, GtC			
1990	1.1	1.1	1.1
2000	1.7-1.8	1.6	1.6
2020	2.7-3.1	2.5	1.7
2050	3.3-5.3	3.3	1.7
2100	0.8-8.0	5.4	0.2
Environmental taxes	No	No	Yes
CO_2 Emission constraint	No	No	Yes

The faster economic growth rates in Asia cause the area's GDP to rise from 7 percent of the world 's total in 1990 to 27-35 Percent in 2050 and to 35 – 40 percent in 2100. Over 55 percent of the world's population reside in the area today. By 2100 this share will have fallen slightly to 48 percent, reflecting slower population growth rates that may actually be falling faster than assumed in the projections. Despite the enormous change in this area's share of world economic activity, regional GDP per Capita will be only $1/5^{th}$ to $1/4^{th}$ of that in the OECD countries by 2100.

The area's primary energy demand will rise from 25 percent of global demand today to 35-40 percent in 2050 and to 40-45 percent by the end of the 21^{st} century. This trend will cause the focus of world energy trade to shift from the Atlantic to the Far East.

The intensity with which energy is consumed per unit of output continues to decline faster in this region than in the industrialized countries throughout the forecast. For at least the next twenty years the rate of improvement will be double that in the industrialized countries.

While the attached graphs indicate that energy structures will vary greatly between sub-regions, there are some broad trends across all case:

– Oil and gas consumption rises for the next thirty to seventy years before starting to decline.
– Coal consumption grows rapidly for the next 20-30 years even in the high growth case with abundant oil and gas reserves. In Case B (middle) coal consumption dominates energy demand throughout the century. As in the global forecast, coal is steadily converted from direct burning to cleaner, more convenient forms of energy.
– The region's heavy reliance on coal, and eventually on oil by the middle of the 21st Century causes the area's carbon emissions to contribute between 30-35 percent of the world's total CO2 emissions between 2020 and 2050.
– The region's large current dependence (15-35%) on noncommercial biomass will continue to diminish rapidly, but not disappear until around 2070.
– Nuclear and renewables will be evident throughout the area by 2020, will be substantial by 2050, and will meet over 50 percent of the total energy demand by the end of the century.
– The shift in the structure of final energy demand towards grids that reach the consumer with more flexible, convenient and cleaner forms of energy will be even more pronounced than in the industrialized countries. This reflects the very small level of energy moving through grids today.

China and India dominate the region from an economic and energy perspective. As the world's two most populous countries, their combined population of 2.2 billion represents over two- thirds of the region's population and over one -third of the world's population. Both these countries must become successful at achieving long term sustainable development for the region to obtain economic and political stability. While there has been considerable progress over the last half century, the task ahead is enormous. This paper will only attempt to provide a broad outline of the some of the more pressing energy issues facing these two countries in their efforts to achieve sustainable development. Many of the observations on China and India were obtained from United States Energy Information Administration briefing papers posted on the Internet at www.ela.doe.gov.. Comments will be grouped into the following subject areas: energy supply and demand, energy inefficiencies, environmental issues, and governmental regulations.

China Energy Issues

China's GDP per capita is currently less than 1/25th that experience by the OECD countries. It is clear that high economic growth rates will remain a top priority of the Chinese for many years to come. This will lead to energy demand growth rates that

should also be expected to exceed the industrialized worlds for many years. Currently, per capita energy is only 1/6th that in the OECD; the relatively high energy consumption rate relative to the GDP rates reflects inefficiencies that are partly related to the countries' primary and final energy structures.

China's primary energy and final energy structures are both dominated by solids, namely coal and biomass. This is unique and reflects the relatively low level of electricity production as well as the direct consumption of coal in the industrial sector and biomass by households. China's coal production equals 1/3d of the world's total and is expected to more than double by 2020. While small inefficient mines are currently being closed, projects exist to build mine mouth electric power plants. Projects to develop coal gasification and coalbed methane production are also in progress.

Oil meets only about 1/5th of total primary energy demands and other fuels such as natural gas and renewables, solar and wind, are negligible. China succeeded in being a net exporter of crude oil through 1995, primarily by suppressing demand. However since then oil consumption has been allowed to rise and imports are growing rapidly, reaching roughly 20% of total oil demand in 1998. Today all imports are delivered by tanker, mostly from the Middle East. In the future pipeline imports may materialize from concessions in Kazakhstan. Offshore concessions are also held in Venezuela, Sudan, Iraq and Peru.

Natural gas currently accounts for only 2% of total energy uses, but the combination of developments in western China and LNG imports for power in coastal areas could cause today's volumes to triple by 2010. Again, the concept of a Eurasian energy infrastructure is emerging, and major pipeline imports are under consideration from Siberia and Sakhalin Island. Within China gas distribution grids are starting to be built.

Final energy demand is slowly being meet by electricity with a total of 70 GW of new capacity under construction or approved. At the same time smaller less efficient coal – fired and diesel power plants are being decommissioned. Currently the average Chinese consumes less than 100 watts per hour of electricity.

China's impressive economic growth since the 1960s has been accompanied by a rapid increase in primary energy demand that would have been substantially higher in the absence of an impressive 2.7 percent a year improvement in final energy intensity. This is more than double the improvements seen globally. However, the level of energy consumed per unit of dollar output remains a factor of 10 higher than in the Pacific OECD countries. The basic problem remains the dominance of solid fuel in the primary and final energy mix. This implies low energy conversion and end-use efficiencies. Commercial energy grids are not available for at least a quarter of the population, and the final energy grids for electricity, gas and oil are still miniscule. Long- term projections incorporate further major improvements in energy efficiencies as there are continuing large shifts from noncommercial fuel to more liquids and grid-dependent forms of energy.

Severe environmental problems have accompanied the past rapid growth in the absolute level of energy consumption, and the challenges will continue to grow. Today seven of the ten most polluted cities in the world are in China. Acid rain falls on about 30% of China's total land area. Carbon emissions of about 800 million tons a year are largely associated (75%) with the industrial sector. Carbon emissions are forecast to continue to grow through the year 2050 and could surpass those in the United States by 2020. Water pollution also remains a severe problem throughout China, reflecting industrial, agricultural and sewerage wastes.

The conflict between growing energy consumption and pollution represents one of the major challenges to achieving sustainable development. The magnitude of the challenge is evident from the fact that despite obtaining very large energy intensity improvements over a sustained period, pollution problems have been exacerbated and are projected to continue to grow.

China's government has been actively working on energy and pollution issues for decades. However, the problems are interrelated and complex. The magnitude of energy needs is huge, dwarfing the availability of financial and managerial resources. Growing imports of oil and gas will be required for decades, placing severe strains on foreign exchange unless China can greatly expand its own exports. China remains a non-Annex I country and is focused on strategies to improve energy efficiencies, conservation, clean energy supply and reforestation. Reducing emissions is viewed as an auxiliary rather than a primary benefit. Major policy positions were enunciated with China Agenda 21 in 1994 and a 1996 campaign to close highly polluting township and village enterprises.

India Energy Issues

India's GDP per capita is less than $1/50^{th}$ that experience by the OECD countries or half the level in China. India's per capita primary energy consumption is also half that in China. Thus, India experiences similar basic inefficiencies in the use of energy as China. Growth in GDP is projected be almost double that in the industrialized world for many decades.

India's primary and final energy structures are also both dominated by coal and biomass. India is the world's third largest coal producer, and coal accounts for more than half of India's primary energy demand. Over 90% of production is mined by Coal India Ltd., which is a high cost producer with distribution problems. Coal use is projected to continue to grow throughout the next century. India's current emissions of carbon are less than one -third that of China, and are projected to increase more slowly than in China. About 70% of India's coal is consumed in electric power generation. Starting in 2001, washed coal will be mandatory.

Oil meets about 30% of total primary energy demand. While indigenous production is encouraged, imports are rising and will grow rapidly in the coming decades. Foreign firms were prohibited from exploration and production until 1997, but little interest was

generated in the 1999 liscencing round. Without new discoveries oil reserves will be essentially depleted over the next fifteen years.

Gas accounts for less than 4% of energy need today, and is projected to grow rapidly as infrastructure is being built and gas flaring is being reduced. Nevertheless, India will ultimately import most of its gas requirements either by pipeline or as LNG. In this regard, gas lines from Iran and Bangladesh are being considered. and LNG from Oman and Abu Dhabi will be used for electric power at Dabhol.

As of 1998 there was only 100,000 megawatts of installed capacity. Only 80% of the population have any electric service, and the per capita consumption amounts to only 50 watts per hour, half the rate in China. An additional 111,500 megawatts of capacity is planned by 2007. Distribution problems and transmission problems abound, reflecting subsidized rates and lack of metering.

As in China, environmental problems abound, but the magnitude is less. New Dehli is the only city in the World Health Organization's list of most polluted cities. The most serious problems relate to vehicular emissions, untreated industrial smoke and untreated water effluence. India's carbon emissions are less than one-third the level in China, and are expected to grow more slowly than in China. India, like China, remains a non-Annex I country, preferring to place a higher priority on economic development. But, there is recognition that carbon emissions could be reduced with improvements to thermal efficiencies in coal fired electric power generation, which is responsible for half of total carbon emissions. In many cases, the levels of pollution reflect lack of enforcement rather than the absence of laws.

India's government has recognized that a number of institutional and economic reforms are necessary to encourage sustainable development. With population growth rates just starting to diminish, the problems associated with meeting energy needs and reducing pollution have been exacerbated. There is a potential that India could overtake China as the world's most populous country in the next twenty years. In almost every sector, institutional reforms have been identified as critical. As stated by the IIASA's report "there must be a shift from subsidies and flat rates to segmented market pricing, losses and leakage must be reduced, and efficiencies must be improved. Such shifts must be politically acceptable and must not leave the poor behind."

Implications of Asian Outlook

Even with the wide range of assumptions used in the IIASA's three cases, there are a number of implications that are evident across all scenarios for the Asian region as a whole as well as for China and India specifically.

– World energy markets will become even more interdependent. Asian becomes more dependent upon the Middle East, the Caspian, and Russia. As energy trade between and across nations grows, there will be a need for greater cooperation. Also, the

arguments for treating energy security as an international, rather than a national, issue will intensify.

– Technology transfers will become essential to meet environmental requirements and demand needs. This will involve technology for conversion such as coal to gas and liquids, gas to liquids, biomass to liquids, and for technologies to improve energy efficiencies faster.

– Research and development programs will need to be encouraged to meet the growing requirements for renewables and /or nuclear. This will be especially critical if the world abandons and major form of energy, such as nuclear, for political reasons.

– Institutional reforms will be needed to encourage economic development of the energy sector.

– The volume of oil and gas trade in the region will increase more rapidly than energy consumption. The enforcement of construction and maintenance standards for networks, pipelines and transportation carriers will become more critical.

– Energy infrastructure in power plants, networks, pipelines and terminals will require massive investments.

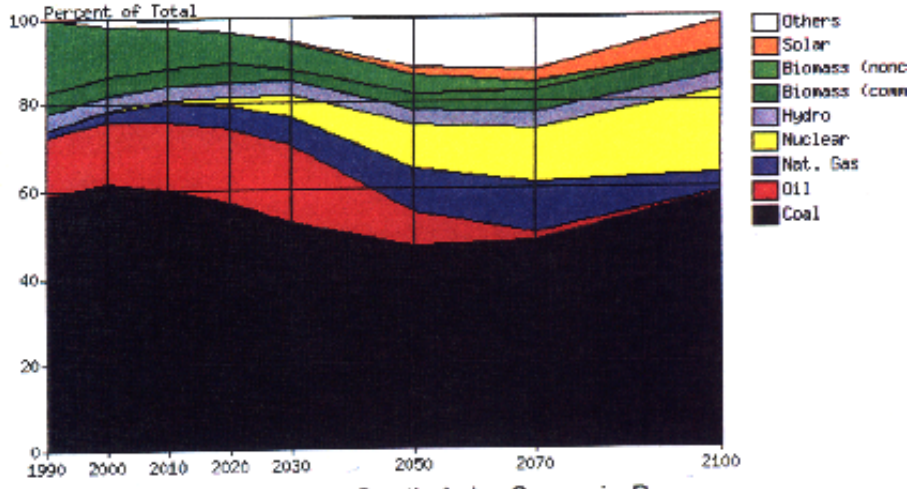
– Growth in CO2 emissions in the region can be slowed and leveled off, but not reduced, without a political and economic commitment by the OECD countries to shift resources to this region.

Possible Subjects for Japanese-US Cooperation

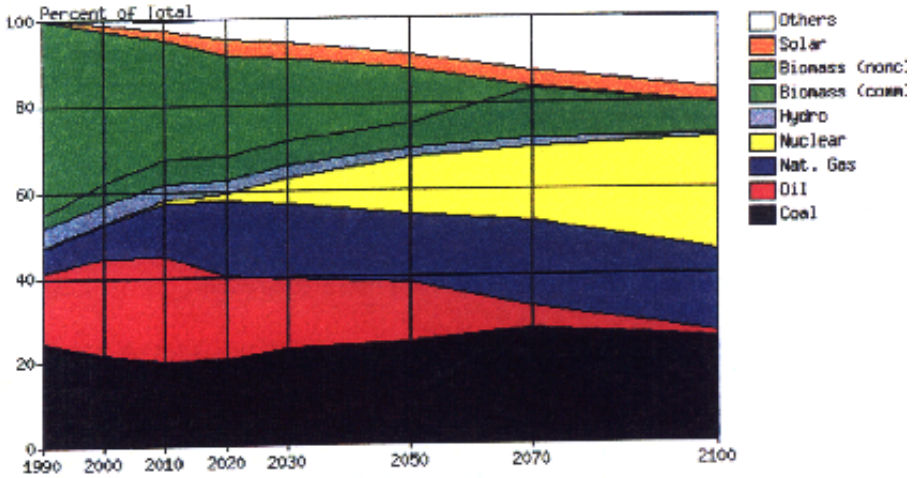
The complexity of energy issues related to achieving sustainable development in Asia could swap us given the difficulty of the issues. Clearly the pace of economic growth and political uncertainties surrounding government policies will both play key roles in the ultimate outcomes. The challenge for us will be to find areas for Japanese-US cooperation, which have the greatest likelihood of being heard and making an impact. Later today we will be focusing on specific recommendations for Japanese-US cooperation. Some of you have been contacted for suggestions. Below is a list of several areas that I feel would be worth considering.

1) Energy security with rising imports from outside the region
2) Technology and policies to improve energy efficiencies faster
3) Technologies and policies to reduce pollution and minimize “stranded assets”
4) Development and support of alternative energy sources
5) Development and support of conversion technologies
6) Institutional reforms to foster energy markets
7) Creation, monitoring and enforcement of construction and maintenance standards
8) Regional /international cooperation on some/or all of above.

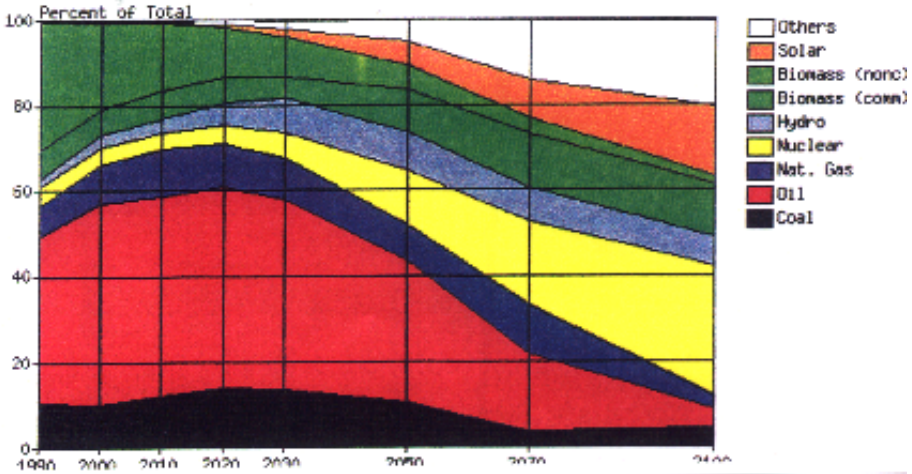
Total primary energy consumption Centrally planned Asia, Scenario B



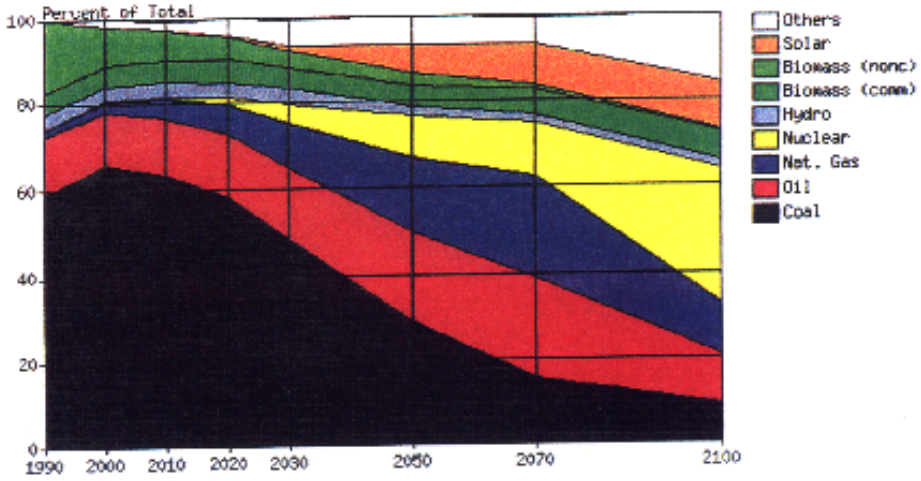
Total primary energy consumption South Asia, Scenario B



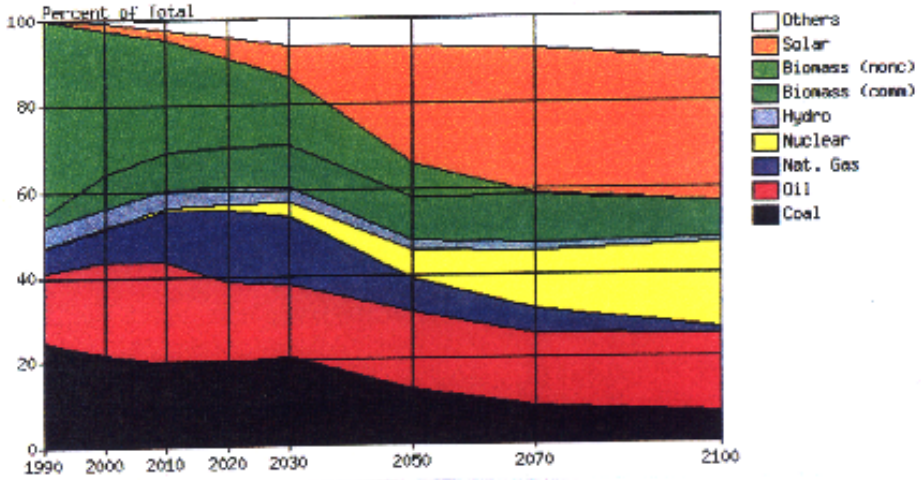
Total primary energy consumption Other Pacific Asia, Scenario B



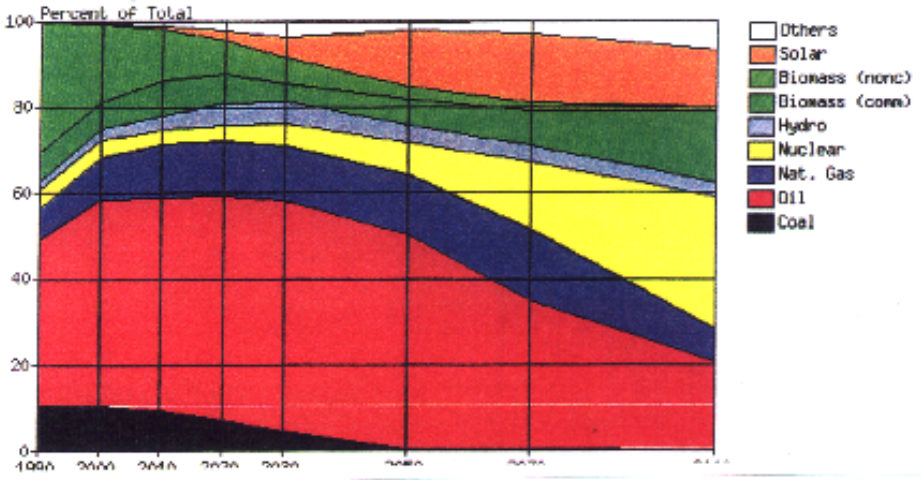
Total primary energy consumption Centrally planned Asia, Scenario A1



Total primary energy consumption South Asia, Scenario A1



Total primary energy consumption Other Pacific Asia, Scenario A1



Final World Energy by Form

Figure 3: World final energy by form, in percent, as solids, liquids, and grids. Overlapping shaded areas indicate variations across Cases A, B, and C.