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Japan's Long-Term Energy Demand and Supply Outlook
- A projection up to 2020 assuming environmental constraints and market liberalization -

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Purpose

Given the need to simultaneously secure a stable energy supply, preserve the environment, and achieve efficiency (i.e., market liberalization), the purpose of this study is to systematically and quantitatively describe realistic energy futures while paying due attention to changes in social and economic structures. This study assumes three cases: "**reference**," "**low growth**," and "**enhanced environmental measures**." In view of current economic and social situations and policies, the reference case presents a future under more realistic assumptions. On the other hand, the low-growth case assumes a prolonged structural recession and stagnant economy until 2010. The enhanced environmental measures case assumes, in addition to current policy measures, that energy conservation and increased use of new energy sources will be further promoted successfully (roughly the goal set by the government).

1. Assumptions for Economy and Society

Population peaks at 128 million in 2006, and gradually declines thereafter. In other words, aging will progress in a rate unprecedented in the world. Under the reference case, the economy's annual average growth rate will be 1.5% and 1.1% during the periods of 2000-2010 and 2010-2020, respectively. Under the low-growth case, the economic growth rate will be 0.5% and 0.9%, respectively.

Advances toward the service economy and the dissemination of information technology, coupled with a decline in materials exports to Asian countries, will transform the industrial structure from a material industry orientation to an assembly orientation.

It is assumed that Asian economies will lead the world economy, which is expected to grow steadily as a whole, by 2.8% during the period of 2000-2020. This figure corresponds to the approximate average of the long-term economic forecasts released by major institutions including the OECD.

The international oil market is assumed to remain relatively smooth until 2010, after which the market will gradually firm and bring real crude oil prices (CIF, 2001 prices) up from US$21/bbl in 2010 to US$25/bbl in 2020. CIF prices for coal and LNG are assumed to be lower than those for crude oil. All three cases share these assumptions for the world economy and primary energy prices.

2. Outlook for Primary Energy Supply and CO_2 emissions

Total primary energy supply under the reference case will grow by 0.3% and 0.2% per year on the average during the periods of 2000-2010 and 2010-2020, respectively. Such low growth is due to low economic growth and population decline. In addition, energy-GDP intensity, defined as the total primary energy supply per unit GDP, will decline by 1.2% and 0.9% during the same periods due to drastic industrial restructuring and accelerated energy conservation.

Oil's share of Japan's total energy sources will decline from 51.8% in 2000 to 48.4% in 2010 and 45.4% in 2020, which is still a major share. Natural gas will increase from 13.1% (2000) to 15.8% (2020), which is attributable to the growing demand for natural gas for power generation and final use. Lower coal demand by the material industries will be more than offset by coal-fired power generation, and its share will grow from 17.9% (2000) to 18.9% (2020). Though nuclear plant construction will lag behind the planned level, nuclear's share will increase from 12.4% (2000) to 14.8% (2020). Overall, energy sources will diversify somewhat but dependency on fossil fuels will still be extremely high (more than 80%).

On the other hand, the low-growth case predicts a minor decline in total primary energy supply: -0.3% and 0.0% for 2000-2010 and 2010-2020, respectively, a trend reflecting the stagnant economy up to 2010. Under the enhanced environmental measures case, efforts directed at energy conservation and promoting new energy sources will gradually progress and result in minor growth of 0.2% in total primary energy during the period of 2000-2010, and negative growth of 0.0% during the period of 2010-2020. Compared with the other two cases, clean energy sources such as new energy and natural gas will have the highest shares.

CO_2 emissions in 2010 will be 325 MtC (million tons carbon equivalent) in the reference case, 301 MtC in the low-growth case, and 310 MtC in the enhanced environmental measures case. All cases forecasted that future CO_2 emissions will exceed those in 1990 (287 MtC), indicating significant difficulties in achieving the emission reduction target. However, emissions in 2020 will fall short of those in 2010 in all cases. By sector, industrial sector emissions will fall short of those in 1990 in all cases. On the other hand, residential and commercial sector emissions will rise. Transport sector emissions will peak in 2000, and thereafter decline. In addition, increasing nuclear capacity by five units (equivalent to 6,500 MW) in 2010 would have a significant impact on emissions, which would be 7 MtC under those of the reference case. Likewise, if increasing nuclear capacity by seven units would make emissions 6.8 MtC lower than those of the reference case in 2020.

3. Outlook for Final Energy Consumption

Final energy consumption under the reference case will grow 0.2% per year during the period of 2000-2010, and 0.1% per year during the period of 2010-2020. In terms of energy conservation, currently considered measures (the Keidanren Voluntary Action Plan, the Top Runner standards scheme, and the like) will make substantial progress.

By sector, the commercial and the industrial sectors show contrasting trends: the former's demand will continue to grow whereas the latter's demand will decrease. Industrial sector energy demand to 2020 will level off as a result of the 0.3% annual decrease during the period of 2000-2010, and the 0.2% annual increase during the 2010-2020 period.   Presumably, the increase in production will be set off by the progress to be made through energy conservation measures such as the Keidanren Voluntary Action Plan, as well as by the shift towards high-value-added industrial structure (increased share for assembly industries).   Consequently, there will be considerable electrification (meaning a trend where a larger proportion of primary energy will be used for power production).

Energy consumption growth in both the residential and the commercial sub-sectors (these two compose the residential and commercial sector) will remain stronger than in other sectors.   In particular, due to the trend toward the service economy, increasing commercial floor space, and other factors, commercial sub-sector energy consumption will grow by 1.7% per year during the period of 2000-2010, and 0.9% in 2010-2020.   Accelerated use of information technologies will increase demand for lighting and space cooling, and accelerate trends towards electrification and gasification (a trend where a larger proportion of primary energy will be used for end-use gas). Reflecting such factors as the accelerated use of information technologies, and the higher density of electric home appliances with more sophisticated functions, the residential sub-sector's energy consumption will also increase.   However, owing to the energy conservation effects of the Top Runner standards scheme and slower growth in the number of households, the sub-sector's energy demand will be quite modest, 0.9% and 0.2% during the periods of 2000-2010 and 2010-2020, respectively.

Transport sector energy consumption will decrease after years of growth due to the improvement in mileage and transport efficiency.   Passenger sub-sector energy consumption will show a modest 0.1% per year growth for 2000-2010, and thereafter a 0.5% decline for 2010-2020. Causes for such trends are: the saturation of automobile ownership; the shift of motor vehicle stock towards smaller cars in line with the rising environmental consciousness and the increased number of aged and female drivers; and increased mileage due to the implementation of Top Runner standards.   The freight sub-sector's energy consumption will decline by 0.4% and 0.7% per year during the periods of 2000-2010 and 2010-2020, respectively, due to improved truck mileage, the shift towards smaller vehicles for small-cargo delivery, and improvement in transport efficiency.

In terms of energy source, the shares of electricity and gas in total final energy consumption will continue increasing due to the shift towards the high-value-added economy and the residential and commercial sector's increased energy demand.

4. Summary and Implications

We have thus far delineated outlooks for the future based on certain assumptions for the socioeconomic structure, rate of progress in energy conservation and new energy technologies, energy price trends, and the delays in implementing nuclear power plant siting plans.

To summarize:
(1)   Growth in energy demand will be extremely low, due to:
- Low economic growth
- Population decline
- Energy conservation measures such as the Keidanren Voluntary Action Plan and Top Runner standards scheme
(2)   Attainment of CO_2 emissions target for Japan will be fairly difficult, even under a stagnant economy.
(3)   The energy mix will further diversify, but the high dependency on fossil fuels will continue (more than 80%).

- **The Best Fossil Fuel Mix**

Currently **oil** accounts for the largest share of entire fossil consumption and this will remain unchanged.   Reliance on Middle East oil could increase.   Given that possibility, it is important to continue securing self-developed crude oil and enhancing cooperation with Middle Eastern countries, and the government has a major role (in diplomacy and funding).   In addition, oil demand is expected to grow in Asia, and solidarity among Asian countries will have desirable impacts.

Coal should not be excluded from the fuel mix simply because of its large environmental burden. Since coal has the advantages of stable supply and low cost, its effective and efficient utilization should be promoted.   This is important not only for Japan but also for all of Asia with its abundant coal resources, and Japan as a technology-savvy nation can play a pivotal role in this arena.

Utilization of **gas** is expected to grow most rapidly among fossil fuels (in terms of relative share in total primary energy supply, it will increase from 13% in 2000 to 16% in 2020; the government-set target for gas share is 20% in 2020).   To realize this expectation, the economic efficiency of gas should be improved in such respects as reduced LNG import costs based on Japan's bargaining power, transition to a flexible supply system, and reduced domestic sales costs through further streamlining.   Since gas has been competing against oil, its prices have been linked to crude oil prices.   However, coal will emerge as an important competitor for gas in the future.

In any case, having various fossil fuel mix options is important because Japan can increase pricing power for competing fuels and therefore enhance energy supply stability.

- **Liberalization, Supply Stability, and Environmental Preservation**

In the midst of globalization and increasing structural reform pressure on the Japanese economy, the liberalization of energy markets is necessary and unavoidable.

To begin with, the market mechanism tends to seek economic rationality for the relatively short term, but energy matters require a long-term view. For this reason, some aspects of the market mechanism do not perfectly fit into Japan's energy situations (and if a market has defects, speculation will be accelerated, benefiting only a few and harming many).

Should stability or efficiency be considered more important?   We have to contemplate a system suitable for each country.   An extreme ideology regarding the market mechanism as a general panacea is no solution.   How should one reconcile efficiency with environmental constraints and energy supply stability?   There should be a Japanese way of solving the problem (Japan differs from resource-rich America in that the market mechanism might be a tool for the "haves").

Especially in need of investigation is the question of nuclear power's role in the midst of liberalization.   Nuclear power has played an important role in reducing oil dependency and increasing energy security.   This role will remain in future and become all the more important (nuclear power is a vital means of achieving energy security and solving global environmental problems at the same time).

It is difficult for the market mechanism to properly incorporate social costs for environmental preservation and securing a stable energy supply.   The ways in which such costs are incorporated should be clarified, along with the associated burden-sharing mechanism among the government, suppliers, and populace.

Promoting nuclear power development makes it necessary to assure transparency and safety while endeavoring to further improve its economic efficiency.   Further, nuclear must be given a suitable role in national energy policy, and it is necessary to show how the government and the private sector can cooperate, including how they should share the burden.

- **Global Perspective for Tackling Environmental Problems and Stabilizing Energy Supply**

Japan's domestic policy measures have limitations in overcoming environmental obstacles. Energy demand is expected to glow globally, particularly in Asia. Technology transfer and other measures could reduce the environmental burden much more.

Assuming a global perspective is not equivalent to the simple-minded view that Japan should take responsibility for developing countries.   International cooperation can be viewed as major business opportunities made available by environmental constraints.   Japan is on the cutting

edge in energy conservation and environmental technology.   It is important for resource-poor Japan to support its economy with its inexhaustible supply of technology.

Many new technologies require vast amounts of money and a long time to penetrate the market, and the private sector alone would not be able to bear the burden. Therefore cooperation between the government and the private sector is essential.

In addition, cooperation among Asian countries as a whole may lead to enhanced bargaining power, joint energy resource development, and a cooperative response to energy security, thereby benefiting not only Japan, but also the region as a whole.

- **Kyoto Protocol**

The Kyoto Protocol is not the only measure of global warming, and we should not misunderstand the essence of the issue.   However, we cannot breach our commitments.   If we stick to the idea that commitments made under the Kyoto Protocol should be attained only though domestic measures, it will be dangerous and unrealistic.

To begin with, economic realities do not guarantee that numerical targets will be attained mainly through domestic policies.   In addition to flexibility mechanisms under the protocol, the government should prepare measures that have a long-term view and that look ahead to the second commitment period.

5.   Nature of This Projection

While maintaining logical and quantitative consistency, this projection presents calculation results obtained with certain assumptions.   Given various future uncertainties, projected figures are sensitive to assumptions.   To give readers supplementary information, we have conducted a sensitivity analysis on parameters for "economic growth," "energy technology" and "enhanced nuclear development."   It is hoped that this projection will serve as a reference for considering and discussing future energy demand.

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List of Assumptions

Socioeconomic Indicators

Population   Peaks at 128 million in 2006, thereafter declines (medium variant by the National Institute of Population and Social Security Research)

GDP growth rate   Recovers to 2% mark after structural adjustment (by 2010)
                FY 2000 to FY 2010: 1.5% per year
                FY 2010 to FY 2020: 1.1% per year

Industrial structure   Shift from materials industries to assembly industries will progress
                Crude steel production: -11 million tons (FY 2010: 96 million tons)
                Ethylene production: -0.9 million tons (FY 2010: 6.7 million tons)
                Cement production: -9.8 million tons (FY 2010: 70.3 million tons)
                Paperboard production:+420 million tons (FY 2010: 36 million tons)
                Machinery production index: 2.0% growth per year
                             (2010: 138, 1990=100)

Real crude oil prices
       Modestly increase after 2010 (see IEA and USDOE outlooks)
                   US$21/bbl (FY 2010)
                   US$25/bbl (FY 2020)

Energy Conservation

Currently considered energy conservation measures will progress

       Industrial sector: Reduced energy conservation by each category
                (Keidanren Voluntary Action)

       Residential and commercial sector: Improved appliance efficiency
                (Top Runner standard scheme)

       Transport sector: Improved car and truck mileage
                (Top Runner standard scheme)

Nuclear Generation Capacity

       Calculated from FY 2002 Electric Power Supply Plan (delays in realizing the plan are incorporated)

       End of March 2002:   45,910 MW (52 units)
                                      Electric Power Supply Plan
       FY 2010:   51,900 MW (five more units)   (about 12 more units)
       FY 2020:   61,500 MW (seven more units)   (about 7 more units)

New Energy Use

     FY 2010: 4 million kl oil equivalent (accounts for slightly less than 1% of the total primary energy supply)
    FY 2020: 5 million kl oil equivalent (same as above)
            PV: 2,540 MW (12 times the FY 1999 amount, 210 MW)
            Wind: 780 MW (9 times the FY 1999 amount, 80 MW)
            Waste: 1,750 MW (twice the FY 1999 amount, 900 MW)

Table 1. Outlook for Macro Economy (Reference Case)

(billion yen, 1995 prices)

	Actual		Forecast		Annual average growth rates (%)		
	1990FY	2000FY	2010FY	2020FY	2000 /1990	2010 /2000	2020 /2010
Gross domestic product (GDP)	469,781	535,690	624,248	696,995	1.3	1.5	1.1
Private demand	368,956	399,537	476,775	533,322	0.8	1.8	1.1
Private final consumption expenditures	248,840	290,139	342,530	375,913	1.5	1.7	0.9
Private residential investment	26,930	20,232	18,539	21,623	-2.8	-0.9	1.6
Private investment in plant equipment	90,711	89,300	114,694	134,924	-0.2	2.5	1.6
Public demand	93,876	125,049	128,918	131,188	2.9	0.3	0.2
Government final consumption expenditures	64,140	87,497	98,383	103,414	3.2	1.2	0.5
Government fixed capital formation	29,671	37,456	30,435	27,674	2.4	-2.1	-0.9
Net exports of goods and services	6,949	12,729	18,554	32,485	6.2	3.8	5.8
Exports of goods and services	39,302	59,825	76,169	95,476	4.3	2.4	2.3
Imports of goods and services	32,353	47,096	57,615	62,991	3.8	2.0	0.9
Consumer price index (1995=100)	92.9	99.9	106.7	112.6	0.7	0.7	0.5
Wholesale price index (1995=100)	108.6	96.8	97.3	98.5	-1.1	0.1	0.1
Foreign exchange rate (yen/US$)	141.5	110.5	130.0	130.0	-2.4	1.6	0.0
Crude oil price (US$/bbl)	22.8	28.4	25.6	37.1	2.2	-1.0	3.8
Manufacturing production index (1995=100)	105.9	104.7	119.0	133.0	-0.1	1.3	1.1
Crude steel production (1,000 tons)	111,710	106,901	95,917	90,431	-0.4	-1.1	-0.6
Ethylene production (1,000 tons)	5,966	7,566	6,679	6,678	2.4	-1.2	-0.0
Cement production (1,000 tons)	86,893	80,068	70,284	68,020	-0.8	-1.3	-0.3
Paper and paperboard production (1,000 tons)	28,538	31,742	35,955	39,863	1.1	1.3	1.0
Pulp production (1,000 tons)	11,509	11,266	11,789	12,443	-0.2	0.5	0.5
Electric machinery production index	106.3	113.3	138.3	161.3	0.6	2.0	1.6

Sources: Actual figures are from Cabinet Office, Preliminary Estimates for National Accounts, etc.
Projections are by the Institute of Energy Economics, Japan.

Table 2. Outlook for Total Primary Energy Supply (Reference Case)

$(10^{10}$ kcal=1,000 TOE)

	Actual		Forecast		Annual average growth rates (%)		
	1990FY	2000FY	2010FY	2020FY	2000 /1990	2010 /2000	2020 /2010
Coal	80,752 (16.6)	100,223 (17.9)	107,786 (18.7)	110,871 (18.9)	2.2	0.7	0.3
Oil	283,559 (58.3)	289,205 (51.8)	278,652 (48.4)	265,943 (45.4)	0.2	-0.4	-0.5
Natural gas	49,284 (10.1)	73,398 (13.1)	85,618 (14.9)	92,747 (15.8)	4.1	1.6	0.8
Hydro	20,512 (4.2)	19,253 (3.4)	19,314 (3.4)	19,360 (3.3)	-0.6	0.0	0.0
Nuclear	45,511 (9.4)	69,241 (12.4)	75,444 (13.1)	86,818 (14.8)	4.3	0.9	1.4
Geothermal	465 (0.1)	964 (0.2)	1,023 (0.2)	1,059 (0.2)	7.6	0.6	0.4
New energy	6,226 (1.3)	6,491 (1.2)	7,909 (1.4)	9,498 (1.6)	0.4	2.0	1.8
Total	486,310 (100.0)	558,651 (100.0)	575,747 (100.0)	586,296 (100.0)	1.4	0.3	0.2
Real GDP (billions of dollars, 1995 prices)	469,781	535,690	624,248	696,995	1.3	1.5	1.1
Energy input per unit real GDP (1990=100)	100.0	100.7	89.1	81.3	0.1	-1.2	-0.9
CO2 emissions (MtC)	287	316	325	323	1.0	0.3	-0.1
(FY1990=100)	100	110	113	112			

Sources: Resources and Energy Administration, ed., with the cooperation of IEEJ, Comprehensive Energy Statistics, etc.

Note 1: Numbers in parenthesis () indicate percentage share.

Note 2: "New energy" consists of photovoltaic, wind, black liquor, etc.

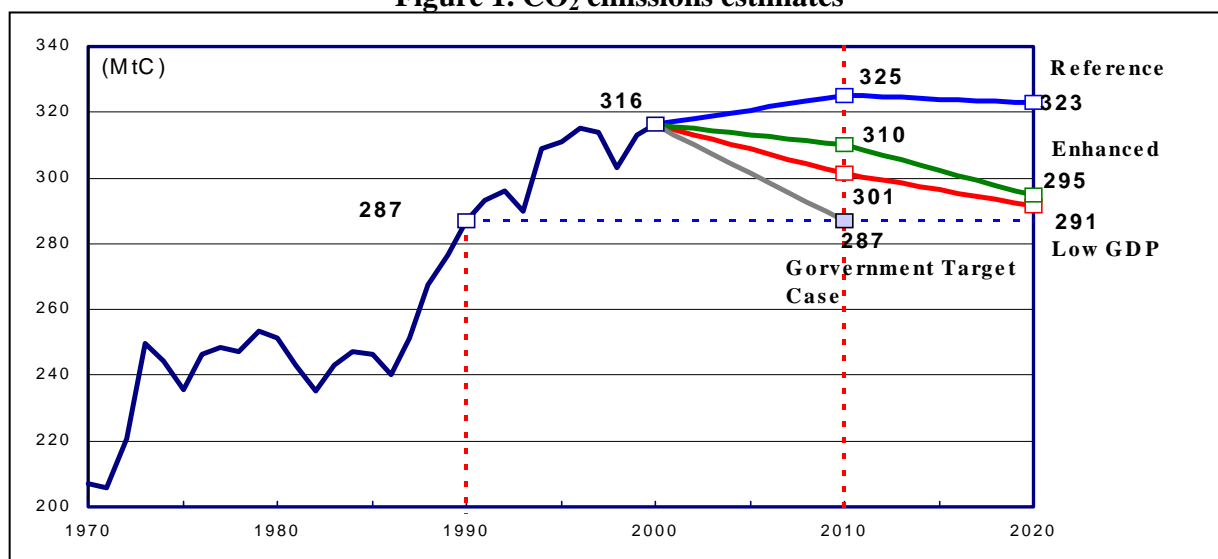**Figure 1. CO$_2$ emissions estimates**

Table 3. Outlook for Final Energy Consumption (Reference Case)

(1010 kcal=1,000 TOE)

		Actual		Forecast		Annual average growth rates (%)		
		1990FY	2000FY	2010FY	2020FY	2000 /1990	2010 /2000	2020 /2010
Sectors								
	Industry	160,787	178,091	172,627	176,065	1.0	-0.3	0.2
		(49.8)	(47.4)	(45.1)	(45.4)			
	Residential and commercial	78,925	99,745	113,238	119,164	2.4	1.3	0.5
		(24.4)	(26.5)	(29.6)	(30.7)			
	Residential	42,913	53,392	58,638	59,666	2.2	0.9	0.2
		(13.3)	(14.2)	(15.3)	(15.4)			
	Commercial	36,011	46,352	54,600	59,499	2.6	1.7	0.9
		(11.2)	(12.3)	(14.3)	(15.4)			
	Transport	74,386	90,740	89,988	85,292	2.0	-0.1	-0.5
		(23.0)	(24.1)	(23.5)	(22.0)			
	Passenger	44,303	58,079	58,609	55,945	2.7	0.1	-0.5
		(13.7)	(15.5)	(15.3)	(14.4)			
	Freight	30,083	32,661	31,379	29,347	0.8	-0.4	-0.7
		(9.3)	(8.7)	(8.2)	(7.6)			
	Non-energy	8,772	7,164	7,093	7,022	-2.0	-0.1	-0.1
		(2.7)	(1.9)	(1.9)	(1.8)			
Energy sources								
	Coal, etc.	41,907	41,360	37,651	35,669	-0.1	-0.9	-0.5
		(13.0)	(11.0)	(9.8)	(9.2)			
	Oil	195,507	221,914	215,832	209,260	1.3	-0.3	-0.3
		(60.6)	(59.1)	(56.4)	(54.0)			
	Gas	15,256	24,658	28,965	32,349	4.9	1.6	1.1
		(4.7)	(6.6)	(7.6)	(8.3)			
	Electricity	65,076	83,227	95,375	104,445	2.5	1.4	0.9
		(20.2)	(22.2)	(24.9)	(27.0)			
	New energy	4,324	3,869	3,926	4,246	-1.1	0.1	0.8
		(1.3)	(1.0)	(1.0)	(1.1)			
	Others	781	713	636	640	-0.9	-1.1	0.1
		(0.2)	(0.2)	(0.2)	(0.2)			
Total		322,870	375,740	382,945	387,543	1.5	0.2	0.1
		(100.0)	(100.0)	(100.0)	(100.0)			

Sources: Resources and Energy Administration, ed., with the cooperation of the Institute of Energy Economics, Comprehensive Energy Statistics, etc. Forecast figures are by the Institute of Energy Economics.

Note 1: Figures in parenthesis () indicate percentage share.

Note 2: Figures for "coal, etc." include coke, coke oven gas, blast furnace gas, and briquettes.

Note 3: Figures for gas include automobile fuel demand for natural gas.

Note 4: Figures for "new energy" include black liquor and solar thermal.

Note 5: Figures for "others" include natural gas and geothermal.

Table 4.   Comparison of Cases

	Case	Actual 2000	Forecast 2010	Forecast 2020	Rate of Divergence from Reference 2010	Rate of Divergence from Reference 2020	Annual Growth Rate(%) 2000 /1990	Annual Growth Rate(%) 2010 /2000	Annual Growth Rate(%) 2020 /2010
CO2 emissions	Reference	316	325	323	-	-	1.0	0.3	-0.1
(MtC)	Low GDP		301	291	-7.3	-9.7		-0.5	-0.3
	Enhanced		310	295	-4.6	-8.7		-0.2	-0.5
	Adding Nuclear		318	316	-2.2	-2.1		0.1	-0.1
Primary Energy	Reference	559	576	586	-	-	1.4	0.3	0.2
(MTOE)	Low GDP		542	542	-5.8	-7.5		-0.3	0.0
	Enhanced		567	565	-1.5	-3.6		0.2	-0.0
Final Energy Demand	Reference	376	383	388	-	-	1.5	0.2	0.1
(MTOE)	Low GDP		360	358	-6.0	-7.7		-0.4	-0.1
	Enhanced		380	378	-0.8	-2.4		0.1	-0.0
Oil Demand	Reference	243	233	223	-	-	1.1	-0.4	-0.4
(Million KL)	Low GDP		219	204	-6.0	-8.3		-1.0	-0.7
	Enhanced		221	201	-5.1	-9.6		-0.9	-0.9
Electric Power Demand	Reference	838	953	1,038	-	-	2.4	1.3	0.9
(Billion kWh)	Low GDP		885	947	-7.1	-8.7		0.6	0.7
	Enhanced		937	991	-1.7	-4.5		1.1	0.6
Town Gas Demand	Reference	250	328	379	-	-	5.0	2.7	1.4
(100 Million m3)	Low GDP		304	345	-7.3	-8.9		2.0	1.3
	Enhanced		358	435	9.0	14.8		3.6	2.0