Carbon Dioxide Emissions Reduction Potential in Japan's Power Sector —
Estimating Carbon Emissions Avoided by a Fuel-Switch Scenario

Prepared by:

Masami Nakata, Junichiro Oda, Charles Heaps and David Von Hippel

For WWF-Japan

ANNEXES: WORKPAPERS AND BACKGROUND DATA USED IN PREPARING JAPAN LEAP DATASET AND SCENARIOS, AND SELECTED DETAILED RESULTS

October, 2003

[WWF COVER GRAPHIC?]

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Annex 1: Workpapers for Derivation of Costs, Resource Potential, and Energy Efficiency Cost and Performance

The workpapers in this Annex are printouts from the MS Excel workbook **LNG5_dvh.xls**. Subsections of this Annex correspond to worksheets in the workbook, and cover background data related to costs, capacities, output and/or performance of different supply- and demand-side resource options.

Annex 1.1: Assumptions as to Monetary Conversions

Data set for WWF Japan project
Back-up Calculations, Data Preparation, and Reference Citations

Prepared by: Masami Nakata and David Von Hippel
Date Last Modified: 9/10/2003

Monetary Conversions

Data from FXHistory: historical currency exchange rates http://www.oanda.com/convert/fxhistory, visited 9/10/03
Japanese Yen per Dollar

Year	Average	High	Low	Average, CPI adjusted (2000 yen)	USD per Yen
2000	107.8605	114.9	101.31	107.86	0.00927
2001	121.5555	132.06	113.52	122.66	0.00815
2002	125.2194	135.18	115.43	127.77	0.00783
2003 to date	118.6904	121.87	115.03	121.73	0.00821
Rate on 9/10/2003:		116.86			

Consumer Price Index (2000 = 100) from http://www.stat.go.jp/english/data/cpi/, file a002hh.xls

Year	Average, Calendar Year	
2000	100	
2001	99.1	
2002	98.0	
2003	97.5	(through August, 2003)'

Annex 1.2: LNG Capacity and Cost Data

Data set for WWF Japan project
Back-up Calculations, Data Preparation, and Reference Citations

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	6/16/2003

LNG Data of Year 2000

1. LNG import and NG consumption

	Natural Gas consumption	LNG import	World Total LNG
Billion m3	74.5	69.3	124.2

	Gas company	Electric Power Company	Others
Ratio [%]	29.5	69.4	1.1

2. Terminal

	# of terminals	# of tanks	tank size storage capacity [kL]
Gas company	9	39	3,356,000
Power company	6	38	3,200,000
Owned by both above	3	55	4,210,000
Others	5	30	2,477,200
Total	23	162	13,243,200
Under construction			4,175,000

3. Cost

LNG Terminal	Capital Cost [Byen]	# of Tank	Tank size Storage Capacity [kL]	Capital cost/tank [Billion yen]	Capital cost/kL [Yen]	
??	36.9	1	160000	36.9	230625	
??	114.5	4	360000	28.625	318056	
????	170	1	200000	170	850000	
??	50	2	177200	25	282167	
??	91.5	6	480000	15.25	190625	
?????	29	1	80000	29	362500	
???	78	4	320000	19.5	243750	
?????	70	4	320000	17.5	218750	
??LNG???	62.5	4	280000	15.625	223214	
?	24	1	85000	24	282353	
??	66	3	240000	22	275000	
??	23	1	35000	23	657143	
??	82	3	240000	27.33333333	341667	
Total/Weighted Average		35	2977200	24.41	270931	<-- Average except numbers marked yellow

4. LNG import and consumption
[1000 ton]

Year	1995	1996	1997	1998	1999	2000	
LNG Import	43687	46445	48349	49478	52112	54100	2,967,926
Municipal gas	12166	13679	13611	14100	14850	15989	
electricity generation	30857	32516	33656	35026	36392	37844	
industrial use	611	611	721	667	669	667	
LNG consumption	43634	46806	47988	49793	51911	54500	
LNG consumption (TJ)	2,567,777	2,632,622	2,632,622	2,731,644	2,847,837	2,989,870	

Note: Converted figure (TJ) for 2000 imports above is roughly consistent with LNG imports figure found in energy balance for 2000 (see, for example, "Detailed Balance" sheet in workbook JPN_dataset_02_11_27.XLS). This figure is not particularly consistent, however, with the figure in section 1 of this worksheet, which converts to 2,370,060 TJ/yr. Thus we use the figure for 2000 shown above to compute average capacity factor for the industry.

5. LNG throughput

	Tank size [kL]	Annual output [ton]	Year
Sodegaura Terminal	1610000	7400000	?
Ohgijima terminal	200000	650000	1998
	200000 x 2	1130000	2000
	200000 x 3	2200000	2003

Density of LNG:	26.5	lbs/cubic ft.
Density of Water:	65	lbs/cubic ft.
Implied SI density of LNG	0.407692	kg/liter or te/kl

Estimate of Ratio of throughput to tank size

Terminals	Year	Ratio
Sodegaura Terminal	???	11.27
Ohgijima terminal	1998	7.97
Ohgijima terminal	2000	6.93
Ohgijima terminal	2003	8.99
All Terminals in Japan	2000	10.09

6. Domestic Production and Imports in the Supply of Natural Gas (2000)
From Japan Agency for National Resources and Energy, The Energy and Resources Today,
Chapter "4-1.Trends in Natural Gas", from http://www.enecho.meti.go.jp/english/energy/lng/trends.html,
visited 6/12/03. [Units not given in source, but presumably million tonnes LNG].

Imports (percentage)	Domestic Production	Total Supply
54.1 (96.8%)	1.8 (3.2%)	55.9

Source [as cited in document above]: Compiled from "Japan's Imports and Exports",
"Statistics of Energy, Production, Supply and Demand"

7. Japan's LNG Import Sources (2000)
[From same document as 6., above]

(Unit: 10,000 tons LNG equivalent)

Indonesia	Malaysia	Brunei	Alaska	Australia	Qatar	Abu Dhabi	Oman	Total	Total for Asia Pacific Region
1,812	1,092	715	600	572	480	126	12	5,410	4,318

Source [as cited in document above]: Compiled from "Japan's Imports and Exports",

8. Source of data on composition of City Gas and on gas import statistics:
http://www.gas.or.jp/gasfacts_e/02_e.html

Consumption of raw materials

	Coal [illegible]	Coke [illegible]	Crude and heavy oil [illegible]	Naphtha [illegible]	LPG [illegible]	[illegible]	LNG [illegible]
1976	5,591	15	13	3,013	691	664	1,937
1981	4,769	45	0	1,086	1,737	681	3,783
1986	4,073	45	0	493	1,900	870	5,923
1991	1,577	5	0	347	2,452	1,000	8,887
1996	657	0	0	350	2,395	1,185	12,288
2001	0	0	0	81	1,910	1,481	15,084

Units in table above are as follows: coal, coke, LPG, LNG are 1000 tonnes, crude and heavy oil, naptha are in 1000 kl, domestic natural gas is in million cubic meters.

9. Estimate of Total Throughput Capacity for Japanese Regasification Terminals
From "PIPELINES AND THE LIQUID PIPELINES AND THE LIQUID
BULK SHIPPING MARKET BULK SHIPPING MARKET
Drs. Liliya Chernyavs'ka, DIEM, University of Genoa, Italy.
Course of Maritime and Port Economics, 20th March 2003
File http://www.enricomusso.it/GNL_1.pdf.
Presentation lists number of regasification terminals as "20 in Japan (total capacity 230 bcm/y)"
This is less than the 23 terminals listed above, but suggests that existing terminals operate at on the order of 30 percent of capacity. It is probable that the total throughput of the terminal is constrained by the amount of storage that is provided, so that the throughput of plants in Japan can be increased toward the total regasification capacity if more storage is added.

10. Following table from University of Houston Law Center, Institute for Law and Enterprise, "Introduction to LNG",
http://www.energy.uh.edu/LNG/documents/IELE_introduction_to_LNG.pdf, visited 6/12/03.
This indicates that the heating value of 1 ton LNG is 52 million Btu, or
54.86 GJ

Appendix 1: Conversion Table

Conversion Units	*Source: BP Statistical Review of U.S. Energy June 2002*					
Natural gas (NG) and LNG	**To:** 1 billion cubic meters NG	1 billion cubic feet NG	1 million tons oil equivalent	1 million tons LNG	1 trillion British thermal units (Btus)	1 million barrels oil equivalent (Boe)
From:	**Multiply by:**					
1 billion cubic meters NG	1	35.3	0.90	0.73	36	6.29
1 billion cubic feet NG	0.028	1	0.026	0.021	1.03	0.18
1 million tons oil equivalent	1.111	39.2	1	0.81	40.4	7.33
1 million tons LNG	1.38	48.7	1.23	1	52.0	8.68
1 trillion British thermal units (Btus)	0.028	0.98	0.025	0.02	1	0.17
1 million barrels oil equivalent (Boe)	0.16	5.61	0.14	0.12	5.8	1

For use in LEAP, assume current throughput capacity of 250 bcm per year (based on 9., above), but use a maximum capacity factor of 40% (by way of comparison, capacity of 250 bcm/yr implies a 34.7% capacity factor as of 2000).

From http://www.mycgiserver.com/~jossobri/energia.htm, visited 9/10/03
BP Statistical Review of World Energy June 2002
Gas: Prices

Japan LNG prices, CIF, $/MMBtu

1990	3.64
1991	3.99
1992	3.62
1993	3.52
1994	3.18
1995	3.46
1996	3.66
1997	3.91
1998	3.05
1999	3.14
2000	4.72
2001	4.64
2002	

from http://www.bp.com/files/16/natural_gas_1618.pdf
BP 2003 Statistical Review of World Energy
Page 10

Prices

US dollars per million Btu	LNG Japan cif	Natural gas European Union cif	UK (Heren NBP index)†	USA Henry Hub‡	Canada (Alberta)‡	Crude oil OECD countries cif
1984	–	3.76	–	–	–	5.00
1985	5.23	3.83	–	–	–	4.75
1986	4.10	3.65	–	–	–	2.57
1987	3.35	2.59	–	–	–	3.09
1988	3.34	2.36	–	–	–	2.56
1989	3.28	2.09	–	1.70	–	3.01
1990	3.64	2.82	–	1.64	1.05	3.82
1991	3.99	3.18	–	1.49	0.89	3.33
1992	3.62	2.76	–	1.77	0.98	3.19
1993	3.52	2.53	–	2.12	1.69	2.82
1994	3.18	2.24	–	1.92	1.45	2.70
1995	3.46	2.37	–	1.69	0.89	2.96
1996	3.66	2.43	1.85	2.76	1.12	3.54
1997	3.91	2.65	2.03	2.53	1.36	3.29
1998	3.05	2.26	1.92	2.08	1.42	2.16
1999	3.14	1.80	1.64	2.27	2.00	2.98
2000	4.72	3.25	2.68	4.23	3.75	4.83
2001	4.64	4.15	3.22	4.07	3.61	4.08
2002	4.27	3.47	2.58	3.33	2.57	4.17

†Source: Heren Energy Ltd.
‡Source: Natural Gas Week.
Note: cif = cost+insurance+freight (average prices).

Derivation of LNG Price Data for Incorporation in LEAP

Historical average import prices for LNG

	USD/MMBtu	Current Yen/GJ	Year 2000 Yen/GJ
2000	$ 4.72	482.56	482.56
2001	$ 4.64	534.61	539.47
2002	$ 4.27	506.81	517.16

No specific LNG price forecasts were immediately available, but as LNG prices are often linked to crude oil contracts in the types of contracts used (in the past, at least) in Japan, we make the assumption that growth rates in LNG prices will track those in crude oil prices.

Use IEA oil price growth rates for 2000 to 2020 to estimate future LNG prices.

LNG price growth IEA projections

	%/yr real growth
2000 - 2005	-5.59%
2005 - 2010	0.00%
2010 - 2015	0.00%
2015 - 2020	3.55%

Implied Japanese LNG Import Prices, 2000 Yen per GJ

2000	482.56
2001	539.47
2002	517.16
2005	435.14
2010	435.14
2015	435.14
2020	518.03

Derivation of LNG Import Terminal Cost Data for Incorporation in LEAP

As of about 1998, a small LNG terminal was to be built in Puerto Rico to service a gas-fired power plant. The rough estimate for the cost of that plant was $100 million, and the plant was to have a storage capacity of 2000000 bbl, or 158,839 kL

Using 2000 Yen to dollar conversion rates, this is approximately 67,905 Yen/kL

This is considerably lower than the average 270,931 Yen/kL for the Japanese installations shown above (section 3), but means that the latter figure is a plausible total capital cost for LNG receiving terminal installations.

Based on data in 2., above, total capacity in Japan is roughly 13,243,200 kL, with throughput of about 250 billion cubic meters of gas or 447,641,509 kL LNG.

This implies an average ratio of annual throughput to storage capacity of 33.80 .

Given the capital cost above per unit storage, a capital cost per unit throughput of 8,015 Yen/(kL/yr) is implied, or 19,660 Yen/(tonne/yr), or 358.37 Yen/(GJ/yr)

By way of comparison, in the PARES analysis we used a capital cost of 20.25 Yen/(m^3/yr), or 592.1053 Yen/(GJ/yr), based on an older US estimate of terminal costs.

For the WWF-Japan analysis, we will use 358.37 Yen/(GJ/yr), though this value could be lower if, as expected, much of the expansion of capacity is through just adding storage at existing terminals, not entire new terminals.

For O&M costs, we make the rough assumption that a terminal of average size, 575,791 kL of storage, or 19,462,674 kL/yr, or 435,302,174 GJ/yr throughput, would cost $20,000,000 per year to operate. This is based on an estimate, obtained in 1998 from an industry source, that an LNG terminal (in the US or similar) costs $10-12 million per year to operate, more or less independent of throughput. We use a higher value on the assumption that Japanese O&M costs will be somewhat higher. This value equates to a fixed O&M cost of 4.96 Y per GJ/yr of capacity.

Annex 1.3: Natural Gas Production

Data set for WWF Japan project
Back-up Calculations, Data Preparation, and Reference Citations

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	6/16/2003

NATURAL GAS PRODUCTION DATA

Data below from USDOE Energy Information Administration Web Site
http://www.eia.doe.gov/emeu/international/gas.html#Production, visited 6/16/03
Table F4 World Dry Natural Gas Production (Btu), 1980-2001
Table 2.4 World Dry Natural Gas Production, 1980-2001

Country		**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**
Japan, Dry Gas (Q Btu)		0.0854	0.0817	0.0796	0.0811	0.0829	0.0865	0.0818	0.0843
Japan (dry gas, Tcf)	JA	0.0776	0.0742	0.0723	0.0736	0.0753	0.0786	0.0743	0.0766
Btu/cubic foot implied		1101	1101	1101	1101	1101	1101	1101	1101

Gas production growth rate, 1990 to 2001 1.94% per year

Country		**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Japan, Dry Gas (Q Btu)		0.0815	0.0781	0.0793	0.0826	0.0839	0.0857	0.0884	0.0859
Japan (dry gas, Tcf)	JA	0.0741	0.0709	0.0720	0.0750	0.0762	0.0778	0.0803	0.0780
Btu/cubic foot implied		1101	1101	1101	1101	1101	1101	1101	1101

Country		**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Japan, Dry Gas (Q Btu)		0.0867	0.0886	0.0895	0.0887	0.0954	0.0979
Japan (dry gas, Tcf)	JA	0.0788	0.0805	0.0813	0.0805	0.0866	0.0890
Btu/cubic foot implied		1101	1101	1101	1101	1101	1101

Table 4.1 World Natural Gas Production, 2000
(Billion Cubic Feet)

Region/Country	**Gross Production**	**Vented, Flared**	**Reinjected**	**Marketed Production**	**Dry Gas Production**
Japan	87	0	0	87	87

Japan produces relatively little natural gas, but the rate of gas production increased by an average of about 2 percent annually during the 1990s (after staying relatively steady during the 1980s). For the purposes of the WWF project, assume that Gas production continues to grow at the 1990 through 2001 rate through 2020, and use the year 2000 production rate above, namely 86.6 billion cubic feet or 2.45 billion cubic meters. or 100.62 million GJ
Set year 2000 capacity at the same level as production, set maximum capacity factor at 100%, and grow future capacity at 2% annually for the BAU case (and probably all cases).

According to the Japan Country Analysis Brief, prepared by the US DOE EIA (http://www.eia.doe.gov/emeu/cabs/japan.html), "Japan has about 1.4 trillion cubic feet (Tcf) in proven natural gas reserves, with possibly more under the seabed surrounding Japan".

Annex 1.4: Coal Production and Import Cost Data

Data set for WWF Japan project
Back-up Calculations, Data Preparation, and Reference Citations

Prepared by: Masami Nakata and David Von Hippel
Date Last Modified: 9/10/2003

COAL PRODUCTION AND IMPORT PRICE DATA

Steam Coal Import Costs:
U.S. Dollars per Metric Ton (Average Unit Value, CIF)
http://www.eia.doe.gov/emeu/international/stmimp.html (as of 9/10/03)

Country	1994	1995	1996	1997	1998	1999	2000	2001
Japan	43.88	47.85	49.29	45.26	40.68	35.86	34.59	37.95

Table 16. Coal Supply, Disposition, and Prices
(Million Short Tons per Year, Unless Otherwise Noted)
http://www.eia.doe.gov/oiaf/aeo/aeotab_16.htm
Price projection for US coal purchased by US electric utilities: Average Growth rate of -0.50% /yr, 2001-2025
Price projection for US coal for export: Average Growth rate of -0.80% /yr, 2001-2025
Starting at $36.97/short ton in 2001
and $35.72 per short ton in 2000.
Conversion factor for above approximately 20.20 MMBtu/short ton, or 23.45 GJ/te

Table 5.5 World Coal Supply and Disposition, 2000
(Trillion Btu)
From file "Table55.xls", downloaded from http://www.eia.doe.gov/emeu/international/coal.html#PriceForecasts

Region/Cour	Production	Imports	Exports	Consumption
Japan	68	3,559	74	3,543

Table C6 Gross Heat Content of Coal, 1980-2001
From file "Tablec6.xls", downloaded from http://www.eia.doe.gov/emeu/international/coal.html#PriceForecasts
(Thousand Btu per Short Ton)

Country	FIPS CODE	1980	1981	1982	1983	1984	1985	1986	1987
Japan	JA	21,087	21,084	21,088	21,107	21,106	21,104	21,111	21,102

Country	FIPS CODE	1988	1989	1990	1991	1992	1993	1994	1995
Japan	JA	21,096	21,091	21,095	21,100	21,102	21,102	19,834	19,834

Country	FIPS CODE	1996	1997	1998	1999	2000	2001
Japan	JA	19,834	20,826	20,826	20,826	20,826	20,826

Coking Coal Import Costs
U.S. Dollars per Metric Ton (Average Unit Value, CIF)
http://www.eia.doe.gov/emeu/international/cokeimp.html

Country	1994	1995	1996	1997	1998	1999
Japan	51.91	55.03	56.39	55.19	50.98	42.95

Table 8.2 World Estimated Recoverable Coal
(Million Short Tons)
From file "Table82.xls", downloaded from http://www.eia.doe.gov/emeu/international/coal.html#PriceForecasts

Region/ Country	Recoverable Anthracite and Bituminous [1]	Recoverable Lignite and Subbituminous [1]	Total Recoverable Coal [1]
Japan	852	0	852

Table 5.1 World Coal Production, 2000
(Thousand Short Tons)
From file "Table51.xls", downloaded from http://www.eia.doe.gov/emeu/international/coal.html#PriceForecasts

Region/ Country	Primary			Secondary		
	Anthracite	Bituminous	Lignite	Metallurgical Coke	Anthracite and Bituminous Briquets	Lignite Briquets
Japan	54	3,223	0	42,451	55	0

Table 5.2 World Anthracite Coal Production, 1980-2001
Table 5.3 World Bituminous Coal Production, 1980-2001
Table 5.4 World Lignite Coal Production, 1980-2001
(Thousand Short Tons)
From files "Table52.xls", ""Table53.xls", and "Table54.xls", downloaded from http://www.eia.doe.gov/emeu/international/coal.html#PriceForecasts

Country	Coal type	1980	1981	1982	1983	1984	1985	1986	1987
Japan	Anthracite	491	437	482	699	669	665	636	481
Japan	Bituminous	21,962	20,728	19,635	18,912	18,732	18,351	14,624	14,037
Japan	Lignite	30	33	30	11	10	17	14	13

Country	Coal type	1988	1989	1990	1991	1992	1993	1994	1995
Japan	Anthracite	387	313	238	247	239	219	187	179
Japan	Bituminous	13,382	12,220	11,068	9,335	8,379	7,717	7,867	6,785
Japan	Lignite	14	0	0	0	0	0	0	0

Country	Coal type	1996	1997	1998	1999	2000	2001
Japan	Anthracite	183	87	65	69	54	58
Japan	Bituminous	6,614	4,289	4,011	3,998	3,223	3,467
Japan	Lignite	0	0	0	0	0	0

According to the Japan Country Analysis Brief, prepared by the US DOE EIA (http://www.eia.doe.gov/emeu/cabs/japan.html),
Japan "ceased [coal] production in January 2002 with the closure of its last operating coal mine at Kushiro, on the northern island of Hokkaido. Japan's coal mines had been heavily subsidized in recent years, since they were not costcompetitive with other producers."

COAL COST DATA

Following table from BP 2003 Statistical Review of World Energy, http://www.bp.com/files/16/coal_1622.pdf

Prices

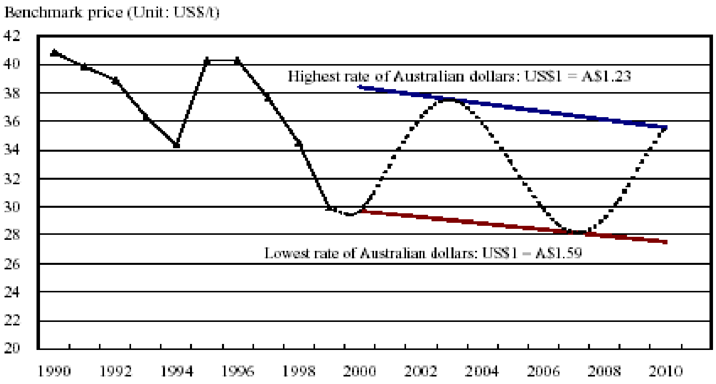
US dollars per tonne	Marker Price (basis Northwest Europe)*	Price of US coal receipts at steam-electric utility plants	Japan coking coal import cif price	Japan steam coal import cif price
1988	39.94	33.77	55.06	42.47
1989	42.08	33.21	58.68	46.86
1990	43.48	33.57	60.54	50.81
1991	42.80	33.10	60.45	50.30
1992	38.53	32.35	57.82	48.45
1993	33.68	31.51	55.26	45.71
1994	37.18	30.88	51.77	43.66
1995	44.50	29.78	54.47	47.58
1996	41.25	29.16	56.68	49.54
1997	38.92	28.83	55.51	45.53
1998	32.00	28.31	50.76	40.51
1999	28.79	27.35	42.83	35.74
2000	35.98	26.99	39.69	34.58
2001	39.29	27.68	41.33	37.96
2002	31.65	27.46	41.91	37.04

*Source of Marker Price: McCloskey Coal Information Service.
Note: cif = cost+insurance+freight (average prices).

From "Japan" section of IEA document Energy Prices and Taxes, 2nd Quarter, 2003, page 173, the
Net calorific value of Coking coal was 7221 kcal/kg, or 30.213 GJ/te.
From same document, the
Net calorific value of imported steam (and industrial, probably) coal was 5,905 kcal/kg, or 24.706 GJ/te.
The net calorific value of domestic coal was 5,524 kcal/kg, or 23.112 GJ/te.
The sulfur content of coal used in Japan is listed as 0.71%

From http://eneken.ieej.or.jp/en/data/pdf/159.pdf
An Analysis of Steaming Coal Price Trends
- Factors behind Price Fluctuations and Outlook -
Yoshimitsu MIMUROTO, Group Manager
Coal Research Group, International Cooperation Department [IEEJ--I believe]

Fig. 2-5 Australian Coal Export Price Outlook



PREPARATION OF COAL DATA FOR USE IN LEAP

Coal Reserves: 852 million short tons. Assume an average of 23.45 GJ/te for domestic coal
2000 Coal output: 3,277 thousand short tons or
68 Trillion Btu or 72.004 million GJ. Since almost all is bituminous coal,
for simplicity, categorize input at "domestic coal" and output as "bituminous coal"

We have no data at present on actual coal production capacity, but since production ceased in early 2002, production capacity for coal in Japan has little effect on our scenarios. Assume that production capacity in 2000 was 100 million GJ/yr. Constrain year 2001 production to 3,525 thousand tonnes or by setting a maximum capacity factor of 77.5% for 2001. Set the maximum capacity factor for 2002 and beyond at zero to force production to zero.

Assume an efficiency of 75% for domestic coal mines (on the high end of typical for underground mines).

Derivation of Coal Price Data for Incorporation in LEAP

Historical average import prices for coal by type

	USD/tonne (from BP, see above)		Current Yen/tonne		Year 2000 Yen/tonne	
	Coking Coal	Steam Coal	Coking Coal	Steam Coal	Coking Coal	Steam Coal
2000	$ 39.69	$ 34.58	4,280.98	3,729.81	4,280.98	3,729.81
2001	$ 41.33	$ 37.96	5,023.89	4,614.25	5,069.51	4,656.15
2002	$ 41.91	$ 37.04	5,247.94	4,638.13	5,355.04	4,732.78

Both an IEEJ projection for the price of Australian coal to 2010 (see above) and USDOE EIA projections for the price of US (domestic) coal to 2025 (see "Oil" sheet in this workbook) show a trend of decreasing coal prices.
Use USDOE EIA coall price growth rates for 2000 to 2020 to estimate future coal prices.

Coal price growth, USDOE EIA projections

	%/yr real growth
2000 - 2025	-0.71%

Implied Coal Import Prices, 2000 Yen per tonne

	Coking Coal	Steam Coal
2000	4,280.98	3,729.81
2001	5,069.51	4,656.15
2002	5,355.04	4,732.78
2020	4,706.50	4,159.59

Annex 1.5: Oil Production and Import Cost Data

Data set for WWF Japan project
Back-up Calculations, Data Preparation, and Reference Citations

Prepared by: Masami Nakata and David Von Hippel
Date Last Modified: 9/10/2003

OIL PRODUCTION AND IMPORT PRICE DATA

Annual Energy Outlook 2003 with Projections to 2025
Table 1. Summary of results [from http://www.eia.doe.gov/oiaf/aeo/tbl1.html, only part of table duplicated here]
[Prices are in 2001 dollars]

			2025				
Energy/ Economic Factors	2000	2001	Reference	Low Economic Growth	High Economic Growth	Low World Oil Price	High World Oil Price
World Oil Price (dollars per barrell)	28.35	22.01	26.57	24.85	28.09	19.04	33.05
Domestic Natural Gas at Wellhead (dollars per thousand cubic feet)	3.83	4.12	3.9	3.83	4.5	3.87	3.92
Domestic Coal at Minemouth (dollars per short ton)	17.18	17.59	14.36	13.99	14.93	14.17	14.59

http://www.eia.doe.gov/oiaf/aeo/aeotab_12.htm provides a table of crude oil and oil product price forecasts (reference case) by year for 2001 through 2025.

Data from workbook mps.xls, downloaded from http://www.eia.doe.gov/emeu/international/petroleu.html#PriceForecasts. Workbook contains data from the International Energy Agency. Data shown below are from worksheet "Table 4".

END-USER PETROLEUM PRODUCT PRICES
AND
AVERAGE CRUDE OIL IMPORT COSTS

June 2003

INTERNATIONAL ENERGY AGENCY

PRODUCT FLOW — Total Crude Imports, Average Cost (dollars/bbl)

	Japan
1983	$ 30.47
1984	$ 29.35
1985	$ 27.90
1986	$ 16.08
1987	$ 17.99
1988	$ 15.47
1989	$ 16.91
1990	$ 22.64
1991	$ 20.14
1992	$ 19.30
1993	$ 17.47
1994	$ 16.48
1995	$ 18.02
1996	$ 20.55
1997	$ 20.55
1998	$ 13.68
1999	$ 17.38
2000	$ 28.72
2001	$ 25.01
2002	$ 24.96

Oil Price Data Used for LEAP WWF-JAPAN MODEL:
Actual annual average crude oil import costs from IEA source above (workbook mps.xls)

YEAR	USD/bbl
2000	$ 28.72
2001	$ 25.01
2002	$ 24.96

Below extracted from worksheet "T2" from workbook "oil_web.xls", from the MONTHLY OIL SURVEY by the International Energy Agency (March, 2003), as downloaded from http://www.eia.doe.gov/emeu/international/petroleu.html#PriceForecasts.

TABLE 2

Total OECD: Indigenous Production of Crude, NGL and Refinery Feedstocks[1]

Thousand metric tons

	2001	2002	2Q2002	3Q2002	4Q2002	1Q2003	Mar2003	%Change Current Month[2]	%Change Year to Date[3]
Japan	592	560	128	133	148	174	59	20.4	15.2

Table 3.2 World Output of Refined Petroleum Products, 2000
(Thousand Barrels per Day)
From file "Table32.xls", downloaded from http://www.eia.doe.gov/emeu/international/petroleu.html#PriceForecasts

Region/Country	Motor Gasoline	Jet Fuel	Kerosene	Distillate Fuel Oil	Residual Fuel Oil	Liquefied Petroleum Gases	Other	Total Output of Refined Petroleum Products	Refinery Fuel and Loss
Japan	974	180	480	1,224	649	156	682	4,346	246

Data below from
Table 2.3 World Natural Gas Plant Liquids Production, 1980-2001
(Thousand Barrels per Day)
Table F3 World Natural Gas Plant Liquids Production (Btu), 1980-2001
(Quadrillion (10^{15}) Btu)
From files "Table23.xls" and "Tablef3.xls", downloaded from http://www.eia.doe.gov/emeu/international/petroleu.html#PriceForecasts

Country	Units	1980	1981	1982	1983	1984	1985	1986	1987
Japan	Quad Btu	0.00159	0.00159	0.00159	0.00159	0.00064	0.00056	0.00054	0.00072
Japan	Thous BPD	1.00	1.00	1.00	1.00	0.40	0.35	0.34	0.46

Country	Units	1988	1989	1990	1991	1992	1993	1994	1995
Japan	Quad Btu	0.00058	0.00063	0.00060	0.00063	0.00063	0.00666	0.00639	0.00663
Japan	Thous BPD	0.37	0.40	0.38	0.40	0.40	4.22	4.05	4.20

Country	Units	1996	1997	1998	1999	2000	2001
Japan	Quad Btu	0.00633	0.00712	0.00853	0.00853	0.01267	0.01421
Japan	Thous BPD	4.00	4.51	5.40	5.40	8.00	9.00

Table G1 World Production of Crude Oil, Natural Gas Plant Liquids, and Other Liquids, 1980-2001
(Thousand Barrels per Day)
Table G2 World Production of Crude Oil, Natural Gas Plant Liquids, Other Liquids, and Refinery Processing Gain, 1980-2001
(Thousand Barrels per Day)
From files "Tableg1.xls" and "Tableg2.xls", downloaded from http://www.eia.doe.gov/emeu/international/petroleu.html#PriceForecasts

Country	Source	1980	1981	1982	1983	1984	1985	1986	1987
Japan	Table G1	11	8	11	12	10	15	15	14
Japan	Table G2	40	38	44	39	46	51	46	70

Country	Source	1988	1989	1990	1991	1992	1993	1994	1995
Japan	Table G1	14	13	14	18	20	19	18	18
Japan	Table G2	76	73	74	76	79	82	81	81

Country	Source	1996	1997	1998	1999	2000	2001
Japan	Table G1	18	17	17	16	18	17
Japan	Table G2	81	80	80	79	81	80

Implied Crude Oil and Natural Gas Liquids Output in Japan

		1980	1981	1982	1983	1984	1985	1986	1987
Natural Gas Liquids	Thous BPD	1.00	1.00	1.00	1.00	0.40	0.35	0.34	0.46
Crude Oil	Thous BPD	10.00	7.00	10.00	11.00	10.00	15.00	15.00	14.00
TOTAL	Thous BPD	11.00	8.00	11.00	12.00	10.40	15.35	15.34	14.46

		1988	1989	1990	1991	1992	1993	1994	1995
Natural Gas Liquids	Thous BPD	0.37	0.40	0.38	0.40	0.40	4.22	4.05	4.20
Crude Oil	Thous BPD	14.00	13.00	13.54	17.48	19.63	15.07	13.50	13.62
TOTAL	Thous BPD	14.37	13.40	13.92	17.88	20.03	19.29	17.55	17.82

		1996	1997	1998	1999	2000	2001
Natural Gas Liquids	Thous BPD	4.00	4.51	5.40	5.40	8.00	9.00
Crude Oil	Thous BPD	14.34	12.95	11.98	10.92	10.00	8.33
TOTAL	Thous BPD	18.34	17.46	17.38	16.32	18.00	17.33

World Crude Oil and Natural Gas Reserves, Most Recent Estimates
From file "reserves.xls", downloaded from http://www.eia.doe.gov/emeu/international/petroleu.html#Reserves

Region/Country	Crude Oil (Billion Barrels) *Oil & Gas Journal*[1] January 1, 2003	Crude Oil (Billion Barrels) *World Oil*[2] Year-End 2001	Natural Gas (Trillion Cubic Feet) *Oil & Gas Journal*[1] January 1, 2003	Natural Gas (Trillion Cubic Feet) *World Oil*[2] Year-End 2001
Japan	0.059	NA	1.400	NA

CALCULATION/DESIGNATION OF OIL PRODUCTION MODULE INPUTS TO LEAP

Domestic crude oil production supplies a negligible percentage of total Japanese oil needs. In recent years, the oil produced in Japan has in fact been approximately half natural gas liquids (NGL), based on the above USDOE statistics (which may or may not reflect Japanese statistics). As a simplification, we will call both natural gas liquids and crude oil "crude oil" for the sake of the WWF LEAP model, as both natural gas liquids and crude oil from domestic operations go into refining anyway, and as domestic supplies are a very small portion of refinery inputs.

So year 2000 crude oil (crude oil and NGL) output is: 18.00 thousand bbl/day, or, at 6.119 GJ/BOE
40,201,830 GJ
Assume that oil wells were operating at 90% of capacity (we have no direct data on pumping capacity in the Japanese oil industry at present), then capacity would be 44.67 million GJ/yr. Set maximum capacity factor equal to 90%. Over the last decade, Japanese crude oil and NGL output has increased and decreased modestly, with relatively little overall change. Assume that capacity and output will remain roughly constant through the planning period. Crude oil (which we assume includes NGL) reserves are as given above, namely:
58.500 million barrels.
Set the efficiency of crude oil extraction at 100%. This is not likely correct, but we do not at present have the data to estimate an accurate efficiency.

COMPILATION OF CRUDE OIL PRICE FORECASTS (FROM USDOE EIA)

Annual Energy Outlook 2003 with Projections to 2025
Table 15. Forecasts of world oil prices, 2000-2025
from http://www.eia.doe.gov/oiaf/aeo/tbl15.html

	2001 dollars per barrel					
Forecast	2000	2005	2010	2015	2020	2025
AEO2003						
Reference	28.35	23.27	23.99	24.72	25.48	26.57
High price	28.35	28.65	32.51	32.95	33.02	33.05
Low price	28.35	22.04	19.04	19.04	19.04	19.04
Altos	NA	22.64	23.4	25.58	27.9	31.61
GII	28.12	21.28	22.09	23.54	25.08	NA
IEA	28.63	21.47	21.47	21.47	25.56	27.61
PEL	28.63	21.21	18.46	17.47	NA	NA
PIRA	31	22.43	23.33	26.32	NA	NA
NRCan	22.28	22.28	22.28	22.28	22.28	NA
DBAB	28.01	19.04	19.04	18.94	19.34	19.18
EEA	28.87	20.98	20.47	19.98	19.5	NA

[Notes from original table]: Tables A1 and C1. AEO2002: AEO2002 National Energy Modeling System, run AEO2003.D102001B. GII (formerly DRI-WEFA): Global Insight, Oil Market Outlook: Long Term Focus (Spring-Summer 2002). Note: Prices shown here differ from those shown in Table 22. The source is a later edition of the Long-Term Focus that was developed in a nonintegrated run. Altos: Altos Partners, World Oil Model, e-mail from Tom Choi (October 9, 2002). Note: Price is WTI at Cushing. IEA: International Energy Agency, World Energy Outlook 2002 (September 2002). Note: Price is crude oil import price. PEL: Petroleum Economics, Ltd., World Long Term Oil and Energy Outlook (June 2002). Note: Brent price. PIRA: PIRA Energy Group, Retainer Client Seminar (October 2002). Note: Price is WTI at Cushing. NRCan: Natural Resources Canada, Canada’s Energy Outlook 1996-2020 (April 1997 and reaffirmed in August 2002). DBAB: Deutsche Banc Alex.Brown, World Oil Supply and Demand Estimates (September 2002). EEA: Energy and Environmental Analysis, Inc., EEA Compass Service (October 2002). Note: Price is U.S. refiner’s acquisition cost of crude oil. NA = not available.

Oil Refinery Capacity and Throughput Data

from http://www.mycgiserver.com/~jossobri/energia.htm, visited 9/10/03
BP Statistical Review of World Energy June 2002

Thousand barrels daily *

	Oil: Refinery throughputs	Oil: Refinery capacities	Implied Capacity Factor
1965		1917	
1966		2102	
1967		2214	
1968		2613	
1969		3029	
1970		3504	
1971		3904	
1972		4635	
1973		5140	
1974		5377	
1975		5567	
1976		5643	
1977		5643	
1978		5643	
1979		5643	
1980	4015	5643	71.2%
1981	3630	5643	64.3%
1982	3360	5643	59.5%
1983	3254	4724	68.9%
1984	3355	4724	71.0%
1985	3120	4724	66.0%
1986	2991	4619	64.8%
1987	2910	4461	65.2%
1988	2990	4324	69.1%
1989	3175	4324	73.4%
1990	3437	4324	79.5%
1991	3653	4505	81.1%
1992	3882	4636	83.7%
1993	3982	4802	82.9%
1994	4167	4862	85.7%
1995	4169	5006	83.3%
1996	4168	5006	83.3%
1997	4319	5056	85.4%
1998	4212	5088	82.8%
1999	4149	5109	81.2%
2000	4145	5029	82.4%
2001	4107	4811	85.4%

Derivation of Oil Price Data for Incorporation in LEAP

Historical average import prices for crude oil

	USD/bbl	Current Yen/bbl	Year 2000 Yen/bbl
2000	$ 28.72	3,097.75	3,097.75
2001	$ 25.01	3,040.10	3,067.71
2002	$ 24.96	3,125.48	3,189.26

Use IEA oil price growth rates for 2000 to 2020 to estimate future oil prices.

Oil price growth IEA projections

	%/yr real growth
2000 - 2005	-5.59%
2005 - 2010	0.00%
2010 - 2015	0.00%
2015 - 2020	3.55%

Implied Japanese Crude Import Prices, 2000 Yen per bbl

2000	3,097.75
2001	3,067.71
2002	3,189.26
2005	2,683.47
2010	2,683.47
2015	2,683.47
2020	3,194.66

Derivation of Oil Refining Cost and Capacity Data for Incorporation in LEAP

From http://eneken.ieej.or.jp/en/data/old/pdf/kaji0107.pdf, visited 9/12/03:
Crude Oil Procurement by Japanese Oil Companies
Shigeki KAJIWARA
Researcher of Oil Group [IEEJ, July 2001], includes the following table:

Fig. 5 Evaluation of Economics by Netback Values and Selection of Crude Oil Purchased

Netback value = Weighted average product price - Freight - Insurance - Refining cost

Latest product market conditions

Name of oil products	Price of oil products	Arabian Light	Iranian Light	
LPG	¥19,000 /KL	2.1%	2.9%	
Light naphtha	¥20,000 /KL	5.8%	6.2%	
Heavy naphtha	¥25,000 /KL	11.4%	12.9%	
Kerosene	¥26,000 /KL	19.8%	19.0%	
Automotive diesel oil	¥26,000 /KL	15.4%	14.8%	
Fuel oil	¥20,000 /KL	45.5%	44.2%	
Weighted average of oil product prices		¥22,661 /KL	¥22,644 /KL	
(Yen's exchange rate to U.S. dollar \110$)		$32.76 /bbl	$32.73 /bbl	...(1)
Freight		$1.20 /bbl	$1.20 /bbl	...(2)
Insurance		$0.02 /bbl	$0.02 /bbl	...(3)
Refining cost		$2.00 /bbl	$2.00 /bbl	...(4)
Netback value		$29.54 /bbl	$29.51 /bbl	...(5) = (1) - ((2)+(3)+(4))
OSP Price		$28.10 /bbl	$28.00 /bbl	
Margin		$1.44 /bbl	$1.51 /bbl	

Products yields for each crude (varies depending on process units of each company.)

According to this evaluation, the economic viability of Iranian Light is larger than that of Arabian Light by $0.07/bbl.

(Source: Prepared on the basis of various published materials.)

The above suggests that refinery O&M costs total $2 per bbl of crude oil input. It is unclear whether this figure includes refinery capital costs, but the assumption is that it does not.
Using a conversion factor of 6.12 GJ/bbl oil equivalent, this equates to a variable cost of 35.25 Yen/GJ oil input.

Based on a year 2000 refining capacity of 5029 thousand bbl/day (BP figures, see above),
Implied capacity is 11,231.94 Million GJ/yr of crude oil input. This is somewhat less than the 12,000 million GJ/yr included in the LEAP data set originally, possibly because the former may include all refining capacity, both active and "mothballed".
At present, refining is modeled so that the product slate automatically meets demand. This is unrealistic, but doesn't have a significant impact on the results of this modeling exercise (which focuses on changes in other fuels).

Annex 1.6: Energy Efficiency and Distributed Generation

Data set for WWF Japan project
Back-up Calculations, Data Preparation, and Reference Citations

Prepared by: Masami Nakata and David Von Hippel
Date Last Modified: 7/24/2003

Estimate of Electricity Savings Implied in the Study
WWF Scenario for Solving the Global Warming Problem, Index for 2010 and 2020
By Haruki Tsuchiya, Dr.

Data below from Table 9 (pages 33 to 37) of file wwfscenarioe_tsuchiya.pdf.

"Technologies and policies used in the WWF Scenario"
[Note--technologies without electricity savings are omitted]

		Reduction in CO_2 emissions (1000 te C)			Reduction in CO_2 emissions (Mte CO_2)	
Sector	Technology/Measure	by 2010	by 2020	Notes	by 2010	by 2020
Energy conversion	Improved Pole (Distribution) Transformers	1,320	2590	Replace 80,000 MVA by 2010, 157,500 MVA by 2020	4.84	9.50
Industrial	Inverter-controlled Motors (drives)	750	1520	Equivalent demand of 2000 MW by 2010, 4000 by 2020	2.75	5.57
	Improved Industrial Transformers	960	2060	Replace 58,000 MVA by 2010, 124,920 MVA by 2020	3.52	7.55
	High-efficiency motors	850	1700	Motors with 5% higher average efficiency account for 30,000 MW of demand in 2010, 60,000 MW in 2020	3.12	6.23
	High-efficiency Fluorescent Lighting	1,110	1,650	Equivalent demand of 8000 MW by 2010, 12000 by 2020	4.07	6.05
	High-efficiency LED Lighting	1,370	4130	Equivalent demand of 8000 MW by 2010, 12000 by 2021	5.02	15.14
	House renovation rather than replacement	460	690	100,000 houses/yr to 2010, 150,000 to 2020. Some of this savings is likely non-electric fuels.	1.69	2.53
	Industrial Subtotal without house rennovation	5040	11060		18.48	40.55
Transport	[Measures omitted here, as virtually all savings are for fuels other than electricity]				62.04	91.45
Commercial	Improved Commercial Transformers	230	430	Replace 14,000 MVA by 2010, 26,000 MVA by 2020	0.84	1.58
	Cogeneration	1,510	4,530	Gas-fired generation of 3000 MW covering equivalent of 80% of consumption (presumably by facilities where it is installed) by 2010, 9000 MW by 2020	5.54	16.61
	Non-filament street lights	140	340	Lamps with twice the performance of mercury vapor, equivalent to 200 MW by 2010, 500 MW by 2020.	0.51	1.25
	LED traffic lights	90	90	980,000 lights by 2010, all by 2020	0.33	0.33
	Convert incandescent lamps to LED	1,200	2390	Equivalent of 2000 MW incandescent lamps replaced by 2010, 4000 MW by 2020.	4.40	8.76
	Convert fluorescent lamps to LED	690	1380	Equivalent of 2000 MW fluorescent lamps replaced by 2010, 4000 MW by 2020.	2.53	5.06
	Replace emergency lights with LEDs	160	230	Replacement of 70% or 180 MW by 2010, 100% by 2020	0.59	0.84
	LCD Computer Monitors	800	1590	Replacement of 20 million units by 2010, 40 million by 2020 (20 W vs. 120 W)	2.93	5.83
	Improved insulation in rental offices	500	500	Will affect heating and cooling, so will have an impact on electricity and other fuels in an unspecified ratio.	1.83	1.83
	Reduction of standby energy use in electronic devices	130	260	1 million devices by 2010, 2 million by 2020.	0.48	0.95
	Digitization of printed materials	500	1500	1 million te paper production avoided by 2010, 3 million by 2020 [but what fraction is domestically produced?].	1.83	5.50
	Improved Vending Machines	770	1000	Power consumption reduced by 54% by 2010, 70% by 2020.	2.82	3.67

Conversion of Data Above to Electricity Savings Estimates

The study from which the data above were taken does not supply estimates for the electricity savings per measure. In order to apply the estimates above to the WWF "Power Switch Scenario" LEAP data set, a conversion of these savings to estimates for electricity savings is necessary.

Mr. Oda has suggested a method whereby a coefficient of 0.1875 kg C/kWh saved is used to back-calculate electricity savings from the figures above. Mr. Oda determined this figure by comparing calculated electricity savings from improved vending machines (an example provided in the study) with the CO_2 savings shown for those machines.

It appears that in some cases, the study from which these data were taken may have assumed that coal-fired power plants would be "backed off" (generation from them would be displaced) by savings from efficiency measures. By way of comparison, assuming a coal-fired power plant with an efficiency of 35%, and a CO_2 emission factor of 92.6 kg/GJ, (IPCC tier 2 factor) implies fuel input of 0.0103 GJ/kWh, and thus an emission coefficient of 0.95 kg CO2/kWh, or 0.260 kg C/kWh. This suggests that the value used to convert energy efficiency savings into carbon savings in the study assumed a mix of generation resources, which is reasonable. We make the assumption, lacking other information, that the conversion coefficient referenced above 0.1875 kg C/kWh, can be used to convert the carbon savings in the table shown above to electricity savings.

This calculation is applied below for each of the categories above with likely electricity sector impacts.

As the demand portion of the LEAP data set is currently structured on a per-household basis in the Residential (Household) sector, and on a per-meter-squared of floorspace basis in the Commercial sector, it is necessary to convert the savings numbers derived below to per-unit savings figures for 2010 and 2020. Each of the applicable measures is then set up as a "technology" under an "Efficiency Options" branch in the relevant sector, with "electricity" as the fuel (unless otherwise indicated below), and a **negative** intensity denoting that there is a net **savings** from implementing the technology. The cost for the technology (as estimated below) is then also set as a **negative** if there is an incremental cost to the technology (before accounting for fuel savings) so that there is a positive cost for achieving the energy savings (when applicable).

		Reduction in TWh or per-unit usage implied by CO_2 savings		All Savings likely Electricity (or units for per-unit savings)?	TWh Total with any electric savings calculated as below	
Sector	Technology/Measure	by 2010	by 2020		by 2010	by 2020
Energy Conversion	Improved Pole (Distribution) Transformers	7.04	13.81	Yes		
Industrial	Inverter-controlled Motors (drives)	4.00	8.11	Yes		
	Improved Industrial Transformers	5.12	10.99	Yes		
	High-efficiency motors	4.53	9.07	Yes		
	High-efficiency Fluorescent Lighting	5.92	8.80	Yes		
	High-efficiency LED Lighting	7.31	22.03	Yes		
	House renovation rather than replacement	2.45	3.68	No		
Industrial Total (Electric only)		26.88	58.99		27.07	59.27

Sector	Technology/Measure	Reduction in TWh or per-unit usage implied by CO_2 savings by 2010	by 2020	All Savings likely Electricity (or units for per-unit savings)?	TWh Total with any electric savings calculated as below by 2010	by 2020
Commercial	Improved Commercial Transformers	1.23	2.29	Yes		
	Improved Commercial Transformers	0.61	0.98	kWh/sq.m.		
	Cogeneration	8.05	24.16	No		
	Non-filament street lights	0.75	1.81	Yes		
	Non-filament street lights	0.37	0.77	kWh/sq.m.		
	LED traffic lights	0.48	0.48	Yes		
	LED traffic lights	0.24	0.20	kWh/sq.m.		
	Convert incandescent lamps to LED	6.40	12.75	Yes		
	Convert incandescent lamps to LED	3.21	5.43	kWh/sq.m.		
	Convert fluorescent lamps to LED	3.68	7.36	Yes		
	Convert fluorescent lamps to LED	1.84	3.13	kWh/sq.m.		
	Replace emergency lights with LEDs	0.85	1.23	Yes		
	Replace emergency lights with LEDs	0.43	0.52	kWh/sq.m.		
	LCD Computer Monitors	4.27	8.48	Yes		
	LCD Computer Monitors	2.14	3.61	kWh/sq.m.		
	Improved insulation in rental offices	2.67	2.67	No		
	Reduction of standby energy use in electronic devices	0.69	1.39	Yes		
	Reduction of standby energy use in electronic devices	0.35	0.59	kWh/sq.m.		
	Digitization of printed materials	2.67	8.00	No		
	Improved Vending Machines	4.11	5.33	Yes		
	Improved Vending Machines	2.06	2.27	kWh/sq.m.		
	Heat-recovery hot water boilers	0.37	0.75	No		
	Energy-saving elevators	0.59	1.17	Yes		
	Energy-saving elevators	0.29	0.50	kWh/sq.m.		
	Energy management systems for buildings	2.03	2.99	No		
Commercial Total (Electric only)		23.04	42.29		46.62	93.93
Square Meters Commercial Space (from LEAP)		2.00E+09	2.35E+09			
Implied Savings per square meter (electric only)		11.54	18.00	kWh/sq.m.		
Household	LCD Television (50 W) replacing CRT television (150 W)	2.93	5.87	Yes		
	LCD Television (50 W) replacing CRT television (150 W)	58.32	116.63	kWh/HH		
	LCD Computer Monitors	1.33	2.67	Yes		
	LCD Computer Monitors	26.51	53.02	kWh/HH		
	High-performance refrigerators	14.29	17.17	Yes		
	High-performance refrigerators	284.16	341.42	kWh/HH		
	Fuel-cell cogeneration	4.32	21.71	No		
	Reduction of standby energy use in electronic devices	8.27	12.43	Yes		
	Reduction of standby energy use in electronic devices	164.35	247.05	kWh/HH		
Household Total (Electric only)--TWh		26.83	38.13		30.83	58.13
Number of Households (from LEAP)		5.03E+07	5.03E+07			
Implied Savings per Household (electric only)		533.33	758.12	kWh/HH		
					Total of Industrial, Commercial, and Household	
Renewables	Photovoltaics	10.08	30.19			
	Wind Power	17.60	35.25		104.51	211.33

Calculations for Individual Measures (those not "all electric")

House renovation rather than replacement

Page 17 of the Tsuchiya document states that 5 te of carbon is released in the construction of a 100 sq.m. house (on a lifetime basis). Most (about 92%) of this total is claimed as a carbon savings when a house is rennovated rather than replaced. If the 5 te per house estimate includes all relevant energy (for example, embodied energy in wood and concrete) and materials (for example, carbon in the wood used in the structure) inputs to home construction, it is theoretically possible to determine the electricity saved through this measure **if** one knows the relevant proportions of the different types of inputs to home construction. This information is not, however, provided in the Tsuchiya paper.

An example of a roster of materials use in home construction (from the United States) is as follows:
Source: McStainability: Environmental Leadership for Building a Better World, Volume III, Number 3, 3rd Quarter, 2002, downloaded as http://www.mcstain.com/public/newsletters/McStainability-Vol_III-3.pdf.

"Trends [source quoted in McStainability article], defines some of the primary materials used to build a 2,082 square foot home as follows:
- 13,837 board feet of framing lumber
- 11,550 square feet of sheathing
- 3,011 square feet of exterior siding material
- 3,061 square feet of insulation
- 5,550 square feet of interior wall material
- 2,117 square feet of interior ceiling material
- 2,841 square feet of roof material
- 2,082 square feet of flooring material
- 226 linear feet of ducting
- 16.92 tons of concrete
- 18 windows"

Assuming that sheathing is 1.2 cm thick on average, the lumber and sheathing implied above by themselves imply 45.29 cubic meters of wood needed.
Further assuming that the home described above is roughly 2 times as large as an average Japanese dwelling, and that the wood used has a density of about 0.5 tonnes/cubic meter, an average wood use per dwelling in Japan would be 11.32 tonnes. Since wood is about half carbon, this comes out relatively close to the 5 tonnes C per household quoted above (though it is unknown whether the .
5 tonnes C is calculated in the same way at all).
For the purposes of the "Power Switch" analysis, the carbon in the wood itself, however, is not part of the calculus.
We therefore attempt to estimate the reduction in electricity use through reduction in concrete production and wood production. http://www.lifewater.ca/Appendix_J.htm suggests a total of
355 kg cement per cubic meter concrete for a 1:2:4 mixture of cement/sand/gravel.
Data provided in http://hypertextbook.com/facts/1999/KatrinaJones.shtml suggests that
2.3 tonnes/cubic meter is an average density for concrete, which would suggest that the average
Japanese house would require input of about 1.19 tonne of cement.
Avoiding housing starts would therefore avoid 118,708 tonnes of cement output through 2010, and 178,061 tonnes of cement output from 2011 through 2020.
These reductions can be used **directly in the LEAP data set as reductions in the activity in the "ceramics" manufacturing subsector**. Note that the reduction is modest, however, about 0.1-0.2% of production.

M.P. Hekkert and E. Worrell, Technology Characterization for Natural Organic Materials: Input Data for Western European MARKAL (Dept. of Science and Technology, Utrecht University, March, 1997, Report # 98002) includes coefficients for electricity use per tonne of wood at
0.77 GJ electricity/tonne for lumber,
0.34 GJ electricity/tonne for particle board,
0.3 GJ electricity/tonne for plywood, and
0.84 GJ electricity/tonne for oriented strand board.
Using a rough rule-of-thumb weighted average of 0.6 GJ electricity/tonne for all lumber products implies a reduction of
6.79 GJ of electricity per house rennovated instead of built new, or about
679.34 TJ electricity reduction annually through 2010 due to avoided wood products manufacture, and
1,019.01 TJ electricity reduction annually from 2011 through 2020 due to avoided wood products manufacture.
In this case, as Japan is a substantial importer of finished lumber, some of these savings will occur outside Japan.
These figures equate to 0.19 TWh savings annually through 2010, and
0.28 TWh savings annually from 2011 on.
Assume, however, that these savings are phased in, reaching 0.19 TWh/yr by 2006.

Commercial Cogeneration

If all of the carbon savings ascribed to commercial cogeneration in the Tsuchiya report were to come from avoided electricity generation, the average number of hours of annual operation for cogeneration systems installed would be equal to the total TWh savings divided by the installed capacity.

For 2010 this would be 2,684 hours, and
for 2020 this would be the same 2,684 hours.

These figures represent a capacity factor of 30.6% . This figure seems plausible for commercial cogeneration systems, but is in fact probably more likely to be **low** than high, since buyers of cogeneration systems have a strong incentive to operate them as much as possible in order to amortize the significant first cost of the systems. If the savings figures cited in the Tsuchiya report account for the additional gas required to generate the required electricity, which ideally they would, an additional calculation is required.

Assuming that the incremental efficiency of generating electricity via cogeneration is 80% , and that the cogeneration systems use natural gas (or the equivalent) with an emission factor of 55.781 kg CO_2 per GJ gas used, or 15.21 kG C/GJ gas used, then gas use would reduce the amount of carbon reduction per TWh generated by 68,459 tonnes. From the original data in the Tsuchiya report, total net carbon reduction per unit cogeneration capacity is 503,333 kg C/MW.

The coefficient for net carbon emissions from gas-fired cogeneration can be translated to 0.0548 kg C/kWh, and if the carbon emissions avoided by the cogenerated power (before accounting for gas use are the same as noted above, namely 0.1875 kg C/kWh, then the net emission factor would be 0.1327 kg C/kWh, and the implied annual operating hours would be 3,792 for an annual average capacity factor of 43.3% . This seems more reasonable than the figure initially calculated above for commercial cogeneration.

This capacity factor implies cogen output of 11.38 34.13 TWh/yr in 2010 and 2020, respectively

To express this in LEAP, set up a "Cogeneration" branch under "Commercial", and add a "gas-fired cogen" technology under the branch. This technology will have "electricity" as a co-product, and will consume and produce fuel in 2010 and 2020 in the following quantities: 5.70 14.53 kWh electricity generated/sq.m. floorspace, and 25.65 65.38 MJ gas consumed/sq.m. floorspace.

Electricity generation is set as a second branch under cogeneration, and its energy intensity is set up as a function of gas consumption, the incremental efficiency of cogeneration (80%), and a factor of -1 to indicate production of electricity rather than consumption.

In this approach, heat from cogeneration is not accounted for directly, but since only an incremental heat rate is used, the additional fuel needed (above that used for space heat, space cooling, and water heat in other commercial branches) is accounted for by the added gas use.

Improved Insulation in Rental Offices

Insulation in rental offices saves heating and cooling fuels, including electricity. There is no direct way to determine what fraction of the carbon savings identified above for this measure come from electricity savings, and which come from savings of other heating and cooling fuels. From the LEAP data set, approximately

29.5% of all commercial cooling and heating will be provided by electricity in 2010, and
32.8% of all commercial cooling and heating will be provided by electricity in 2010.

Using the very rough assumption that saving a unit of electricity saves about 2 times as much carbon as saving a unit of some other fuel used for heating and cooling (largely oil and gas), the implied electricity (only) savings from this measure would be:

1.21 TWh in 2010, or 0.61 kWh/sq.m., and
1.32 TWh in 2020, or 0.66 kWh/sq.m..

Digitization of Printed Materials

This measure will in theory reduce the need for paper, thereby reducing the energy needed to manufacture paper. There will likely be some additional electricity needed to run electronic machines, but it is difficult to determine, without detailed study, how much extra electricity will in fact be required. At present, we will assume:
1) that all of the paper avoided would have been manufactured domestically (probably not a good assumption) and 2) that marginal the electricity requirements for digitization are negliqible relative to the energy savings from avoided paper production. In addition to the energy requirements of manufacturing paper, the digitization process also avoids the manufacture of inks and the energy required for printing--this factor likely countervails some of the possible overstatement in electricity benefits from the assumptions above.

The 1 million te reduction in paper production represents about 3% of Japanese paper production in 2010 (production from the LEAP data set), and the 3 million te saved in 2020 represents about 7.5% of production then.

Heat-recovery Hot Water Boilers

This measure is unlikely to result in significant electricity savings, as little electricity seems to be used in Japan for hot water heating. Using this measure would involve getting more information about the per-unit savings (and costs) of heat-recovery boiler.

Energy Management Systems for Buildings

This measure applies to cooling, heating, and lighting. Although it probably does not apply proportionately to all of these end uses, we make the simplifying assumption that it does. For 2010, the notes in the Tsuchiya document suggest that savings are 6 percent of all energy use in those end-uses in commercial buildings. We will assume that the savings are proportionate across fuels as well (in fact, savings in lighting are likely to be proportionately greater than in the other end-uses, so the savings are probably greater for electricity than for other fuels).

In the LEAP demand data set, there is no separate lighting end-use. We assume that lighting is approximately 50% of the "Motive energy and other" end-use category used in the LEAP data set.

From the LEAP BAU case, year 2010 electricty use is 183.10 TWh for commercial lighting, heating, and cooling, and year 2020 electricity use for these uses is 209.05 TWh.

Based on the notes in Table 9 of the Tsuchiya document, 6% of energy in these end-uses is saved in 2010, which suggests savings of 10.99 TWh. For 2020, the statement that "the system will be applied to 15% of the energy for business use" in the Tsuchiya document is difficult to interpret.

We therefore estimate 2020 savings by increasing them by the ratio of 2010 and 2020 carbon savings from this measure, providing an estimated year 2020 savings of 16.19 TWh.

Averaged over all building area in the commercial sector, these savings are the equivalent of: 5.50 kWh/sq.m. annually for 2010, and 6.89 kWh/sq.m. annually for 2020.

Fuel Cell Cogeneration

Here again it is slightly unclear how to calculate TWh generated based on estimates of carbon savings, because fuel cell cogeneration avoids central station generation, consumes gas, and displaces space heat and water heating requirements normally fueled by gas or other fuels. Starting with an estimate that each residential system has a generating capacity of 2 kW (in the range of sizes that have been discussed for household systems) and operates 1000 hours per year, the total output of the 2 million systems that the Tsuchiya document suggests for 2010 would be 4.00 TWh electric. A fuel cell with an average efficiency in the range of 40 to 60 percent would thus produce on the order of 2000 kWh of heat, which, if used to heat water, would satisfy most of the hot water demand of a small household. This assumption therefore seems reasonable. In fact, fuel-cell cogeneration systems can be designed with auxiliary burners so that the ratio of thermal output to electrical output can be much greater, so that demands for space heating can be satisfied.

Ideally, fuel-cell cogeneration would be modeled in LEAP so as to explicitly "back off" heating or water heating fuels. In this case, we will use a somewhat simpler approach that is similar to that used for cogeneration in the commercial sector. We will create a "residential cogeneration" branch, and under it include technologies for gas consumption and electricity production by cogeneration systems. We will assume that the electricity produced by fuel cell cogeneration systems is produced at a 90% incremental efficiency. This means that 0.9 of the fuel used for fuel cell cogeneration either produces electricity or displaces fuel that would have been used to heat water or air. Based on the number of systems assumed implemented in the Tsuchiya report, the saturation of the systems will be 3.98% in 2010, and 19.9% in 2020. Each of these systems will produce 2000 kWh of electricity per year (entered as a "negative consumption" in LEAP), and will use 8000 MJ of gas.

Improved Pole (Distribution) Transformers

Improved distribution transformers will reduce overall transmission and distribution losses. The effect of investing in improved transformers will be modeled by reducing the fractional electric T&D losses in LEAP. As the savings implied in the Tsuchiya report for this measure is an absolute figure, and T&D losses as a fraction of demand is a relative figure, it is necessary to compute the fractional losses from the figures above, namely 7.04 TWh in 2010 and 13.81 TWh in 2020 once the total savings from demand-side measures have been incorporated into the LEAP demand model (and demand is thus reduced).

With demand in the PSE (Tsuchiya-report-based) scenario of approximately 1100 TWh (not changing much over time), these factors equate to about 0.64% of demand in 2010 and 1.26% of demand in 2020. We thus reduce transmission and distribution losses by these fractions for the PSE scenario.

Photovoltaics

The capacities for PVs and the estimated PV output calculated above imply average annual capacity factors of 11.51% in 2010 and a practically identical 11.49% in 2020. These capacity factors seem a bit low, but are perhaps not unreasonable for sometimes cloudy Japan. The estimate seems similar to the a historical (1999) value as calculated from NEDO data: 214 GWh produced from capacity of 200 MW, which yields an average 12.2% capacity factor.

What is not clear from the Tsuchiya report is what fraction of these PV installation are assumed to be installed on customer premises (and thus contribute to avoided T&D losses, as well as avoided T&D investments (although the use of PV systems on homes and businesses will also require some T&D investments, notably for network interfaces and special meters). Given the considerable population density in Japan, we assume that approximately 75% of the systems are installed on the "demand side". Of these, we assume that 45% are installed on residential buildings, 30% are installed on Commercial buildings, and 25% are installed on industrial buildings. This distribution, relative to the distribution of electricity demand, is somewhat more weighted toward residential and away from industrial installations. Assuming that

	10,000	30,000	MW of PV are installed overall
in 2010 and 2020, respectively, this means that in	2010	2020	
	3,375	10,125	MW of PV are installed on residences,
or an average of	0.067	0.201	kW per household, and
	2,250	6,750	MW of PV are installed on commercial
buildings, or about	0.00113	0.00287	kW per square meter of floor space (on
average), and	1,875	5,625	MW of PV are installed on industrial
buildings, with an additional	2,500	7,500	MW of PV are installed for utility use.

Emission Factors for Demand-side Cogeneration

In order to fairly account for net emissions savings, it is necessary to provide emission factors for demand-side cogeneration used in the Power Switch scenario. The TED database with LEAP currently lacks useful emission factors for gas-engine or fuel-cell cogeneration. The report:
Onsite Sycom Energy Corporation,
The Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector,
prepared for the USDOE EIA, January, 2000, lists a range of NOx emission factors for gas engine-driven, gas combustion turbine, and fuel cell cogeneration as follows (p. 61):

Gas engine-driven	2.2 - 28	lb/MWh
Gas combustion turbine	0.3 - 4	lb/MWh
Fuel cell cogeneration:	< 0.02	lb/MWh

We assume that CO_2 emissions for each of these devices will be proportional to the carbon content of the fuel (natural gas), and that SOx emissions will be similarly related to the fuel sulfur content (and thus negligible). We assume that new Japanese engine and turbine cogen systems would have NO_x emission factors at the low end of the ranges above (except fuel cells, where emissions are negligible, but we assume the maximum of the cited range). The emission factors used in LEAP for these devices are therefore (using efficiencies near the middle of the range given in the Onsite report):

	Efficiency	NOx, kg/GJ fuel input
Gas engine-driven	35%	0.0972
Gas combustion turbine	35%	0.0133
Fuel cell cogeneration:	55%	0.0014

As the LEAP dataset does not distinguish between Gas engine-driven and gas combustion turbine systems, we use the average of the two emission factors above as a composite figure.

Annex 1.7: Derivation of Cost Data for Energy Efficiency and Distributed Generation Measures

Data set for WWF Japan project
Back-up Calculations, Data Preparation, and Reference Citations

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/4/2003

Derivation of Cost Data for Energy Efficiency Measures:

Note: Unless otherwise specified below, it is assumed that average Japanese capital and/or O&M costs for energy efficiency measures are approximately 1.5 times costs for similar measures in the United States.

Improved Pole (Distribution) Transformers

Incremental cost in the United States of improved distribution transformers is assumed to be the same as that calculated for industrial transformers, namely $1.81 per kVA of transformer capacity.
This estimate based on data from Tables 5.4, 5.7, and 5.8 of
Supplement to the "Determination Analysis" (ORNL-6847) and Analysis of the NEMA Efficiency Standard for Distribution Transformers, by P. R. Barnes, S. Das, B. W. McConnell, and J. W. Van Dyke.
Report No. ORNL-6925, dated September 1997, and received as ORNL6925.pdf from
Jan Berry of ORNL, 10/24/01. (These data are presented and summarized in the "Transformer_data" worksheet in the workbook IntWest_CI_Ind_Transformers_rel_bc.xls, prepared by D. Von Hippel).
The designation "TP-1" refers to a USEPA EnergyStar program standard for transformers.
kVA = thousand volt-amps, a measure of transformer capacity.

Estimated incremental Japanese capital costs for these transformers is thus 292.84 Yen/kVA
The Tsuchiya report, in estimating carbon savings potential for these devices, assumes the replacement of 80000 MVA of transformers by 2010, and 157500 MVA by 2020.
Assume that the purchase of these transformers will be distributed as follows:

Capital costs annualized using a 3% /yr real discount rate, with a unit lifetime of 30 years,
implying an annual recovery factor of 0.05102 per year.

Year	Efficient Transformers Purchased Annually	Total Efficient Transformers Purchased	Total Incremental Capital Cost (Thousand Yen)	Incremental Annual Cap. Cost
2003				
2004	8,000	8,000	2,342,729	119.52
2005	12,000	20,000	3,514,093	298.81
2006	12,000	32,000	3,514,093	478.10
2007	12,000	44,000	3,514,093	657.38
2008	12,000	56,000	3,514,093	836.67
2009	12,000	68,000	3,514,093	1,015.96
2010	12,000	80,000	3,514,093	1,195.24
2011	8,000	88,000	2,342,729	1,314.77
2012	8,000	96,000	2,342,729	1,434.29
2013	8,000	104,000	2,342,729	1,553.82
2014	8,000	112,000	2,342,729	1,673.34
2015	8,000	120,000	2,342,729	1,792.86
2016	7,500	127,500	2,196,308	1,904.92
2017	7,500	135,000	2,196,308	2,016.97
2018	7,500	142,500	2,196,308	2,129.03
2019	7,500	150,000	2,196,308	2,241.08
2020	7,500	157,500	2,196,308	2,353.13

The stream of values in the incremental capital cost column are entered as Module Costs for Electricity Transmission and Distribution in LEAP for the PSE scenario.

Improved (for example, Amorphous) Commercial Transformers
Using technology cost and performance information from the ORNL report described above, David Von Hippel estimated a levelized cost of saved energy for improved transformers in commercial/institutional applications of $ 0.0172 per kWh savings. This includes some program-related costs (costs to a sponsor of a program to provide incentives or other inducements to adopt the technology). This estimate was prepared for the Western Regional Air Partnership (WRAP) in 2001 and 2002.
(levelized cost calculation shown in WRAP workbook Int_West_eco_res_3-8 with cost tables_cosmetic_mod.xls).
Adjusting this figure upward to reflect (probably) higher Japanese costs, and coverting to Yen yields an estimate of 2.79 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Improved (for example, Amorphous) Industrial Transformers
Using technology cost and performance information from the ORNL report described above, David Von Hippel estimated a levelized cost of saved energy for improved transformers in commercial/institutional applications of $ 0.0220 per kWh savings. This includes some program-related costs (costs to a sponsor of a program to provide incentives or other inducements to adopt the technology). This estimate was prepared for the Western Regional Air Partnership (WRAP) in 2001 and 2002.
(levelized cost calculation shown in WRAP workbook Int_West_eco_res_3-8 with cost tables_cosmetic_mod.xls).
Adjusting this figure upward to reflect (probably) higher Japanese costs, and coverting to Yen yields an estimate of 3.56 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Industrial Inverter-controlled Motors (drives)
Using technology cost, performance, and application information from a report prepared for the US Department of Energy by XENERGY, Inc., and from other sources (as referenced in the workbook IntWest_Ind_motor_systems_rel_bc.xls) David Von Hippel estimated levelized costs of saved energy for improved drive systems and other modifications to pump, air compressor, and fan motor systems used in industry. The weighted average costs of these improvements was $ 0.0110 per kWh savings. This includes some program-related costs (costs to a sponsor of a program to provide incentives or other inducements to adopt the technology). This estimate was prepared for the Western Regional Air Partnership (WRAP) in 2001 and 2002
(levelized cost calculation shown in WRAP workbook Int_West_eco_res_3-8 with cost tables_cosmetic_mod.xls).
Adjusting this figure upward to reflect (probably) higher Japanese costs, and coverting to Yen yields an estimate of 1.79 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Industrial High-Efficiency Motors
As for motor drives/systems, Using technology cost, performance, and application information from a report prepared for the US DOE by XENERGY, Inc., and from other sources (as referenced in the workbook IntWest_Ind_motor_systems_rel_bc.xls) David Von Hippel and colleagues estimated levelized costs of saved energy for premium versus standard efficiency motors used in industry. The weighted average costs of these improvements was $ 0.0137 per kWh savings. This includes some program-related costs (costs to a sponsor of a program to provide incentives or other inducements to adopt the technology). This estimate was prepared for the Western Regional Air Partnership (WRAP) in 2001 and 2002
(levelized cost calculation shown in WRAP workbook Int_West_eco_res_3-8 with cost tables_cosmetic_mod.xls).
Adjusting this figure upward to reflect (probably) higher Japanese costs, and coverting to Yen yields an estimate of 2.21 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Industrial High-efficiency Fluorescent Lighting
We assume that the cost of these measures is similar to that estimated for "Comml/Instit. Lighting, Efficient Fluorescent" measure, evaluated as a part of work done by David Von Hippel and colleagues for the Western Regional Air Partnership (WRAP) in 2001 and 2002
(levelized cost calculation shown in WRAP workbook Int_West_eco_res_3-8 with cost tables_cosmetic_mod.xls).
These improvements were estimated to cost $ 0.0117 per kWh savings. This includes some program-related costs to a sponsor of a program to provide incentives or other inducements to adopt the technology).
Adjusting this figure upward to reflect (probably) higher Japanese costs, and coverting to Yen yields an estimate of 1.89 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Industrial High-efficiency LED Lighting
We don't have available a compiled source of cost data for this measure, so we assume that the cost of these measures is similar to that estimated for "Comml/Instit. Lighting, Advanced Measures" evaluated as a part of work done by David Von Hippel and colleagues for the Western Regional Air Partnership (WRAP) in 2001 and 2002 (levelized cost calculation shown in WRAP workbook Int_West_eco_res_3-8 with cost tables_cosmetic_mod.xls).
These improvements were estimated to cost $ 0.0266 per kWh savings. This includes some program-related costs to a sponsor of a program to provide incentives or other inducements to adopt the technology).
This cost estimate is derived from data in
EMERGING ENERGY-SAVING TECHNOLOGIES AND PRACTICES FOR THE BUILDINGS SECTOR, Prepared by Steven Nadel, Leo Rainer, Michael Shepard, Margaret Suozzo, Jennifer Thorue. Prepared for the Association of State Energy Research and Technology Transfer Institutions California Institute for Energy Efficiency, Electric Power Research Institute, Energy Center of Wisconsin, Iowa Energy Center, Massachusetts Division of Energy Resources, Missouri Environmental Improvement and Energy Resources Authority, New York State Energy Research and Development Authority, U.S. Department of Energy, and Washington State University Energy Program. December, 1998. The cost estimate is based on a "bundle" of a number of different technologies.
In fact, the ultimate net costs of LED lamps replacing incandescent (where and when ultimately possible) may be much lower than this due to the considerable savings in O&M costs from avoided replacement of bulbs by using the much longer-lived LED lamps.
Adjusting the figure for these technologies upward to reflect (probably) higher Japanese costs, and coverting to Yen yields an estimate of 4.30 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Industrial sector savings from House renovation rather than replacement
The electricity savings ascribed directly to the industrial sector for "house renovation rather than replacement" are fairly modest, and are specified based on the avoided electricity for manufacturing wood products that would be used in a new home (see "Energy_Efficiency" sheet in this workbook). We have no direct information on what the net cost of this measure might be, but they seem as likely to be negative (due, for example, to reduced construction costs and reduced need for the imported and domestic roundwood needed to make lumber products) as they are to be positive. We therefore assume a net cost of 0 Yen per kWh saved for this measure.
This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Industrial Photovoltaic Installations

Industrial Installations of distributed photovoltaic power systems seem likely to be fairly large in scale, but somewhat smaller in scale and with more "custom" requirements for installation than utility PV systems. Accordingly, we assume that the cost for industrial PV systems will be approximately 10% higher than for utility-scale systems. Our assumptions for the costs of utility scale systems is 870,000 Yen/kW in 2000, falling to 300,000 in 2010 and to 150,000 in 2020.
Therefore the costs of industrial-scale PV systems are assumed to be 957,000 Yen/kW in 2000, falling to 330,000 in 2010 and to 165,000 in 2020.
Entering these costs in the LEAP demand program as "costs per device", where the "device" is one MW of capacity is made somewhat complex by the facts A) that "costs per device" are interpreted as annual costs by LEAP, and B) the annual costs of the total MW installed will change as the stock of PV systems grows and the costs change.

The following calculation is therefore required.

Interest rate for recovering capital costs in PV systems: 6% per year (assumption--somewhat higher than the 5% annually used for utility sector investments), with a system life of 20 years
MW PVs installed in 2010: 1875, and MW PVs installed in 2020: 5625

Year	MW Installed	Incremental MW Installed	Annualized Capital Costs of New Units (Yen/kW-yr)	Total Annualized Capital Costs for PVs Installed (Yen)	Average Annualized Capital Costs for PVs Installed (Yen/kW-yr)
2000	-		83,436		
2001	188	188	75,009	1.406E+10	75,009
2002	375	188	67,433	2.671E+10	71,221
2003	563	188	60,622	3.807E+10	67,688
2004	750	188	54,499	4.829E+10	64,391
2005	938	188	48,995	5.748E+10	61,312
2006	1,125	188	44,047	6.574E+10	58,434
2007	1,313	188	39,598	7.316E+10	55,743
2008	1,500	188	35,599	7.984E+10	53,225
2009	1,688	188	32,003	8.584E+10	50,867
2010	1,875	188	28,771	9.123E+10	48,658
2011	2,250	375	26,844	1.013E+11	45,022
2012	2,625	375	25,047	1.107E+11	42,168
2013	3,000	375	23,369	1.195E+11	39,818
2014	3,375	375	21,804	1.276E+11	37,817
2015	3,750	375	20,344	1.353E+11	36,070
2016	4,125	375	18,982	1.424E+11	34,516
2017	4,500	375	17,711	1.49E+11	33,116
2018	4,875	375	16,525	1.552E+11	31,839
2019	5,250	375	15,418	1.61E+11	30,666
2020	5,625	375	14,385	1.664E+11	29,581

Values from this final column are entered into LEAP to provide future annualized costs for installed PV systems.

Commercial Sector Cogeneration

In LEAP, the electricity output of added cogeneration systems in the commercial sector is expressed in TWh of net demand reduction in each year. As a consequence, the most useful expression of cogeneration costs is net amortized capital costs plus net non-fuel O&M costs per kWh of cogen power generated. To estimate this quantity, start with an estimate of net cogeneration capital costs of $ 1,200 per kW in 2000, and $800 per kW in 2020 (in the United States). These costs are estimates based roughly on the costs quoted for a range of different sizes and types of cogeneration systems (from 30 kW micro-turbines to 3000 kW internal combustion systems) applicable for the commercial sector and as described in Onsite Sycom Energy Corporation, The Market and Technical Potential for Combined Heat and Power in the Industrial Sector, and The Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector, both prepared for the USDOE EIA, January, 2000. For most technologies, these reports project declining costs through the year 2020.
Based roughly on the same documents, we assume average non-fuel O&M costs of $0.012 per kWh.
Using an interest rate of 6.50% (somewhat higher than the 5% used for utility sector investments to reflect the probably higher costs of borrowing in the commercial sector), and a system lifetime of 20 years, factoring in higher costs in Japan and monetary conversion to Yen, and using the annual capacity factor described in the "Energy_Efficiency" worksheet in this workbook, yields an average power cost of 6.59 Yen/kWh in 2000, and 5.04 Yen/kWh in 2020.

Commercial Sector Non-filament Street Lights

Lacking independent estimates for these costs, we assume that they will be similar to the cost of "Advanced Commercial Measures" used as the basis for the "Industrial LED lighting" cost assumption derived above. This is likely to be an over-estimate, as O&M savings for this measure is likely to be considerable, given that non-filament street lights should have much longer lifetimes than standard street lights. We use an estimate of 4.30 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Commercial Sector LED Traffic Lights

In an assessment of LED Traffic and Walk/Don't Walk lights carried out as a part of a DSM Assessment project for the Energy Trust of Oregon [USA], David Von Hippel and co-workers found that the Cost of Saved Energy for these measures was, in fact, an average $0.0264 cost savings per kWh saved due to avoided O&M costs. This estimate was derived using information from several sources, and is documented in the workbook ETO_CI_LED_Traffic.xls. In Japan, O&M savings are likely to be highly significant as well. In order to err on the side of under-estimating these savings, we convert this estimate to yen without using a mark-up for Japanese costs. The net cost (note that it is a negative value, denoting savings) of this measure is thus (2.85) Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Commercial Sector Convert incandescent lamps to LED and Convert fluorescent lamps to LED

For these measures, we use the same estimate as for "non-filament street lamps", above. Again, this is likely to be an overestimate of the net costs of these measures due to substantial O&M savings. We use an estimate of 4.30 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Commercial Replace emergency lights with LEDs

In an assessment of LED Exit signs carried out as a part of a DSM Assessment project for the Energy Trust of Oregon [USA], David Von Hippel and co-workers found that the Cost of Saved Energy for these measures was, in fact, an average $0.0237 cost savings per kWh saved due to avoided O&M costs. This estimate was derived using information from several sources, and is documented in the workbook ETO_CI_Lighting.xls. In Japan, O&M savings are likely to be highly significant as well. In order to err on the side of under-estimating these savings, we convert this estimate to yen without using a mark-up for Japanese costs. The net cost (note that it is a negative value, denoting savings) of this measure is thus (2.56) Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Commercial Sector LCD Computer Monitors

Starting with the assumption of 20000000 monitors replaced by 2010 from the Tsuchiya report, and a total savings of 4.27 TWh in 2010 (estimated based on data in the Tsuchiya report), the annual savings per monitor is 213.33 kWh/yr. Assuming an incremental cost for LCD over CRT monitors of $100 a lifetime of 5 years, and an interest rate of 6.50% /yr, the implied cost of saved energy for this measure would be $ 0.113 per kWh saved. Marking this up for higher Japanese prices, and converting to Yen, yields an estimate of 18.25 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Note that the assumed base incremental cost shown here is somewhat (though not substantially) lower than the prevailing incremental cost in 2003, but is in fact likely to be high as a weighted average for costs over the 2003 to 2020 time period.

Commercial Sector Improved insulation in rental offices

We assume that the cost of these measures is similar to that estimated for "Comml/Instit. Building Envelope--ASHRAE Stds." measure, evaluated as a part of work done by David Von Hippel and colleagues for the Western Regional Air Partnership (WRAP) in 2001 and 2002 (levelized cost calculation shown in WRAP workbook OR_ID_eco_res_d-18_rev with cost tables.xls). These improvements were estimated to cost $ 0.0592 per kWh savings. This includes some program-related costs to a sponsor of a program to provide incentives or other inducements to adopt the technology). This figure is for a US Northwest climate, which is not dissimilar to that found in Japan. Adjusting this figure upward to reflect (probably) higher Japanese costs, and coverting to Yen yields an estimate of 9.58 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Commercial Sector Reduction of standby energy use in electronic devices
Starting with the assumption of 1000000 units of office electronics to which reduction in standby mode energy use is applied by 2010 (from the Tsuchiya report), and
a total savings of 0.69 TWh in 2010 (estimated based on data in the Tsuchiya report), the
annual savings per unit is 693.33 kWh/yr. Assuming an incremental cost for no-standby energy use versus
standard equipment of $25 a lifetime of 5 years, and an interest rate of 6.50% /yr, the implied
cost of saved energy for this measure would be $ 0.009 per kWh saved. Marking this up for higher Japanese prices,
and converting to Yen, yields an estimate of 1.40 Yen per kWh saved. This value is entered into
LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Commercial Sector: Improved Vending Machines
In an assessment of vending machine and icemaker improvements carried out as a part of a DSM Assessment project for the Energy Trust of Oregon [USA], David Von Hippel and co-workers found that the Cost of Saved Energy for these measures was, in fact, an average $0.0125 per kWh saved.
This estimate was derived using information from several sources, and is documented in the workbook ETO_CI_Refrig.xls.
We convert this estimate to yen using a mark-up for Japanese costs.
The net cost of this measure is thus 2.02 Yen per kWh saved. This value is entered into
LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Commercial Sector: Energy-saving elevators
Starting with the assumption of 100000 energy-efficient elevators installed by 2010 (from the Tsuchiya report), and
a total savings of 0.59 TWh in 2010 (estimated based on data in the Tsuchiya report), the
annual savings per unit is 5,866.67 kWh/yr. Assuming an incremental cost for no-standby energy use versus
standard equipment of $3,000 a lifetime of 20 years, and an interest rate of 6.50% /yr, the implied
cost of saved energy for this measure would be $ 0.046 per kWh saved. Marking this up for higher Japanese prices,
and converting to Yen, yields an estimate of 7.51 Yen per kWh saved. This value is entered into
LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost). Please note that the incremental equipment cost noted here is little more than a guess, and should be confirmed or refined based on conversations with elevator vendors (for example, Hitachi in Japan).

Commercial Sector: Energy Management Systems for Buildings
Costs and savings from Energy Management Systems (EMS) for building vary widely by building type and by particular installation. Costs figures for general application to a range of buildings are difficult to obtain.
In a case study of EMS installations for a chain of stores in California (see http://www.consumerenergycenter.org/enhancedautomation/case_studies/CS5_Staples.pdf),
a total building area of 2600000 square feet, or 74,188 square meters, cost
$320,000 to install, for a cost of $4.31 per square meter.
Unfortunately, no energy savings figures were included in this case study, and the goal of the project seems to have been peak reduction more than energy savings.
A brief and informal review of other case studies and manufacturers' literature on EMS suggests that these systems have simple paybacks on the order of two to four years in most US applications. Assuming an average
US Commercial electricity price of $0.06 per kWh, this implies total net costs for EMS systems
of on the order of $0.12 to $0.24 per annual kWh saved, or, assuming EMS
lifetimes of 10 years (which seems minimal), cost per lifetime kWh saved, assuming
an interest rate of 6.50% annually, would be $0.017 to $0.033 per kWh.
Taking an average of these values, marking up for higher Japanese costs, and converting to Yen yields
an estimate of 4.05 Yen per kWh saved. This value is entered into
LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Commercial Sector Solar Water Heat
In an assessment of Commercial solar water heat carried out as a part of a DSM Assessment project for the Energy Trust of Oregon [USA], David Von Hippel and co-workers found that the Cost of Saved Energy
for these measures was an average $0.1110 per kWh of electricity saved if a solar water heater replaced an electric unit. This estimate was derived using information from several sources, and is documented in the workbook ETO_CI_Water_Heat.xls. We convert this estimate to yen using a mark-up for Japanese costs.
The cost of this measure is thus 17.96 Yen per kWh saved. This value is entered into
LEAP as a negative cost per kWh (of solar energy used) relative to the BAU scenario (that is, as an incremental cost).
It is entered as a negative cost because the solar energy used in the PSE scenario is greater than that in the BAU scenario, thus BAU solar use - PSE solar use is a negative number, and a negative "cost of saved energy" (actually a cost of used energy) is required.

Commercial Photovoltaic Installations

Commercial Installations of distributed photovoltaic power systems seem likely to vary in scale, but somewhat smaller in scale and with more "custom" requirements for installation than utility PV systems. Accordingly, we assume that the cost for commercial PV systems will be approximately 25% higher than for utility-scale systems. Our assumptions for the costs of utility scale systems is 870,000 Yen/kW in 2000, falling to 300,000 in 2010 and to 150,000 in 2020.

Therefore the costs of commercial-scale PV systems are assumed to be 1,087,500 Yen/kW in 2000, falling to 375,000 in 2010 and to 187,500 in 2020.

Entering these costs in the LEAP demand program as "costs per device", where the "device" is one MW of capacity is made somewhat complex by the facts A) that "costs per device" are interpreted as annual costs by LEAP, and B) the annual costs of the total MW installed will change as the stock of PV systems grows and the costs change.

The following calculation is therefore required.

Interest rate for recovering capital costs in PV systems: 6.5% per year (assumption as for other commercial sector investments), with a system life of 20 years

MW PVs installed in 2010: 2250, and MW PVs installed in 2020: 6750

Year	MW Installed	Incremental MW Installed	Annualized Capital Costs of New Units (Yen/kW-yr)	Total Annualized Capital Costs for PVs Installed (Yen)	Average Annualized Capital Costs for PVs Installed (Yen/kW-yr)
2000	-		98,698		
2001	225	225	88,729	1.996E+10	88,729
2002	450	225	79,768	3.791E+10	84,248
2003	675	225	71,711	5.405E+10	80,069
2004	900	225	64,468	6.855E+10	76,169
2005	1,125	225	57,957	8.159E+10	72,527
2006	1,350	225	52,104	9.332E+10	69,123
2007	1,575	225	46,841	1.039E+11	65,940
2008	1,800	225	42,110	1.133E+11	62,961
2009	2,025	225	37,857	1.218E+11	60,172
2010	2,250	225	34,034	1.295E+11	57,558
2011	2,700	450	31,755	1.438E+11	53,257
2012	3,150	450	29,628	1.571E+11	49,882
2013	3,600	450	27,644	1.696E+11	47,102
2014	4,050	450	25,793	1.812E+11	44,734
2015	4,500	450	24,065	1.92E+11	42,667
2016	4,950	450	22,454	2.021E+11	40,830
2017	5,400	450	20,950	2.115E+11	39,173
2018	5,850	450	19,547	2.203E+11	37,664
2019	6,300	450	18,238	2.285E+11	36,276
2020	6,750	450	17,017	2.362E+11	34,992

Values from this final column are entered into LEAP to provide future annualized costs for installed PV systems.

Residential Sector: LCD Television (50 W) replacing CRT television (150 W)

Starting with the assumption of 20000000 LCD Televisions replacing CRT televisions by by 2010 (from the Tsuchiya report), and a total savings of 2.93 TWh in 2010 (estimated based on data in the Tsuchiya report), the annual savings per unit is 146.67 kWh/yr. Assuming an incremental cost for LCD televisions versus standard equipment of $100, a lifetime of 7 years, and a consumer interest rate of 7.00% /yr, the implied cost of saved energy for this measure would be $ 0.127 per kWh saved. Marking this up for higher Japanese prrices, and converting to Yen, yields an estimate of 20.47 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Note that the estimate of incremental cost used here is a rough assumption, and is designed to take into account the rapidly falling prices for LCD TVs that has been the trend in recent years.

The cost of this measure is actually likely to be higher than the value shown in the early years of the analysis period, but lower in the later years of the analysis period. Further, it is quite possible that new display technologies now being developed will push energy savings for these types of TV improvements higher, and prices lower.

Residential Sector: LCD Computer Monitors

Starting with the assumption of 12000000 monitors on home computer systems replaced by 2010 from the Tsuchiya report, and a total savings of 1.33 TWh in 2010 (estimated based on data in the Tsuchiya report), the annual savings per monitor is 111.11 kWh/yr. Assuming an incremental cost for LCD over CRT monitors of $100 a lifetime of 5 years, and an interest rate of 7.00% /yr, the implied cost of saved energy for this measure would be $ 0.220 per kWh saved. Marking this up for higher Japanese prices, and converting to Yen, yields an estimate of 35.51 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).
Note that the assumed base incremental cost shown here is somewhat (though not substantially) lower than the prevailing incremental cost in 2003, but is in fact likely to be high as a weighted average for costs over the 2003 to 2020 time period.

Residential Sector: High-performance Refrigerators

The US-based Consortium For Energy Efficiency, in its Super-Efficient Home Appliances Initiative, lists as an example refrigerator improvements savings an average of $16 per year per unit, at an average incremental retail cost of $106 . Assuming that the savings noted in the CEE example (see http://www.cee1.org/resid/seha/refrig/refrig-main.php3) are estimated at average (2002) US residential retail electricity prices of $0.08 per kWh, inferred savings are 200 kWh per year relative to refrigerators meeting new US standards, and with a lifetime of 12 years, and an interest rate of 7.00% a cost of saved energy of $ 0.067 per kWh saved is estimated. Marking this up for higher Japanese prices, and converting to Yen, yields an estimate of 10.80 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Residential Sector: Reduction of Standby Energy use in Electronic Devices

Starting with the assumption of 20 Watts per household of office electronics standby energy reduction by 2010 (from the Tsuchiya report), and 5.03E+07 households by 2010 (from original LEAP dataset), plus a total savings of 8.27 TWh in 2010 (estimated based on data in the Tsuchiya report), the annual savings per household is 164.35 kWh/yr, which implies an that the standby energy use reduction applies to 8,217 hours per year, or essentially 24 hours per day. Assuming that the cost of the modificaitons required the appliances used in the home to make these savings possible have a total incremental cost of $25 relative to what the cost would be to manufacture standard equipment, along with a lifetime of 5 years, and an interest rate of 7.00% per year, the cost of saved energy for this measure would be $ 0.037 per kWh saved. Marking this up for higher Japanese prices, and converting to Yen, yields an estimate of 6.00 Yen per kWh saved. This value is entered into LEAP as a cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Residential Sector: Fuel Cell Cogeneration http://fuelcells.si.edu/future/furmain.htm (3-5 years to $1000/kW)

The development of fuel cells for a number of applications, ranging from cell phones to power systems, is proceeding rapidly. Several anecdotal reviews of residential fuel cell technology (see, for example, http://fuelcells.si.edu/future/furmain.htm), suggest that residential fuel cell systems will cost on the order of $1000/kW within three to five years.

NEDO data from http://www.nedo.go.jp/nedata/12fy/01/g/0001g007.htm, shows significantly higher costs, however (see "Costs" worksheet in WWFJapan_workbook_9.xls). We assume that the cost for residential-scale (one to several kW electric) PEFC-type fuel cell systems will be approximately 450,000 Yen/kW in 2000, (see quote below from "Fuel Cell Today") falling to 200,000 in 2010 and to 100,000 in 2020.

Entering these costs in the LEAP demand program as "costs per device", where the "device" is one MW of capacity is made somewhat complex by the facts A) that "costs per device" are interpreted as annual costs by LEAP, and B) the annual costs of the total MW installed will change as the stock of fuel cell systems grows and the costs change.

The NEDO source cited above gives average non-fuel O&M costs of 1.14 Yen/kWh, or 2280 Yen per 2 kW system per year.

The following calculation is required.

Interest rate for recovering capital costs in fuel cell systems: 7.0% per year (assumption as for other commercial sector investments), with a system life of 15 years

MW fuel cell units installed in 2010: 4000, and MW fuel cell units installed in 2020: 20000

Year	MW Installed	Incremental MW Installed	Annualized Capital Costs of New Units (Yen/kW-yr)	Total Annualized Capital Costs for Fuel Cells Installed (Yen)	Average Annualized Capital Costs plus O&M for Fuel Cells Installed (Yen/unit-yr)
2000	-		49,408		101,095
2001	400	400	45,559	1.822E+10	93,398
2002	800	400	42,010	3.503E+10	89,850
2003	1,200	400	38,738	5.052E+10	86,485
2004	1,600	400	35,721	6.481E+10	83,294
2005	2,000	400	32,938	7.799E+10	80,267
2006	2,400	400	30,373	9.014E+10	77,393
2007	2,800	400	28,007	1.013E+11	74,665
2008	3,200	400	25,825	1.117E+11	72,073
2009	3,600	400	23,814	1.212E+11	69,610
2010	4,000	400	21,959	1.3E+11	67,269
2011	5,600	1,600	20,488	1.628E+11	60,408
2012	7,200	1,600	19,116	1.933E+11	55,987
2013	8,800	1,600	17,836	2.219E+11	52,708
2014	10,400	1,600	16,642	2.485E+11	50,070
2015	12,000	1,600	15,527	2.734E+11	47,839
2016	13,600	1,600	14,487	2.965E+11	45,888
2017	15,200	1,600	13,517	3.182E+11	44,143
2018	16,800	1,600	12,612	3.383E+11	42,559
2019	18,400	1,600	11,767	3.572E+11	41,103
2020	20,000	1,600	10,979	3.747E+11	39,754

Values from this final column are entered into LEAP to provide future annualized costs for installed fuel cell systems.

Following from http://www.fuelcelltoday.com/FuelCellToday/FCTFiles/FCTArticleFiles/Article_640_SmallStatSurvey0703.pdf, page 3 (visited 9/24/03).

"In Japan, it is notable that companies such as Ishikawajima-Harima Heavy Industries (IHI), Nippon Oil, Osaka Gas, and Sanyo are the biggest names looking at mass production of small stationary fuel cells and aim to bring 1kW units to market by 2005 for around US$4,200."

Residential Photovoltaic Installations

Residential Installations of distributed photovoltaic power systems seem likely to vary less in scale, but be significantly smaller and with more "custom" requirements for installation than utility, industrial, or residential PV systems. Accordingly, we assume that the cost for commercial PV systems will be approximately 35% higher than for utility-scale systems. Our assumptions for the costs of utility scale systems is 870,000 Yen/kW in 2000, falling to 300,000 in 2010 and to 150,000 in 2020.

Therefore the costs of residential-scale PV systems are assumed to be 1,174,500 Yen/kW in 2000, falling to 405,000 in 2010 and to 202,500 in 2020.

Entering these costs in the LEAP demand program as "costs per device", where the "device" is one MW of capacity is made somewhat complex by the facts A) that "costs per device" are interpreted as annual costs by LEAP, and B) the annual costs of the total MW installed will change as the stock of PV systems grows and the costs change.

The following calculation is therefore required.

Interest rate for recovering capital costs in PV systems: 7.0% per year (assumption as for other residential sector investments), with a system life of 20 years

MW PVs installed in 2010: 3375, and MW PVs installed in 2020: 10125

Year	MW Installed	Incremental MW Installed	Annualized Capital Costs of New Units (Yen/kW-yr)	Total Annualized Capital Costs for PVs Installed (Yen)	Average Annualized Capital Costs for PVs Installed (Yen/kW-yr)
2000	-		106,593		
2001	338	338	95,828	3.234E+10	95,828
2002	675	338	86,149	6.142E+10	90,988
2003	1,013	338	77,448	8.756E+10	86,475
2004	1,350	338	69,626	1.111E+11	82,263
2005	1,688	338	62,594	1.322E+11	78,329
2006	2,025	338	56,272	1.512E+11	74,653
2007	2,363	338	50,588	1.682E+11	71,215
2008	2,700	338	45,479	1.836E+11	67,998
2009	3,038	338	40,886	1.974E+11	64,986
2010	3,375	338	36,756	2.098E+11	62,163
2011	4,050	675	34,295	2.329E+11	57,518
2012	4,725	675	31,998	2.545E+11	53,872
2013	5,400	675	29,855	2.747E+11	50,870
2014	6,075	675	27,856	2.935E+11	48,313
2015	6,750	675	25,991	3.11E+11	46,081
2016	7,425	675	24,250	3.274E+11	44,096
2017	8,100	675	22,626	3.427E+11	42,307
2018	8,775	675	21,111	3.569E+11	40,677
2019	9,450	675	19,697	3.702E+11	39,178
2020	10,125	675	18,378	3.826E+11	37,791

Values from this final column are entered into LEAP to provide future annualized costs for installed PV systems.

Residential Sector: Solar Water Heat

We assume an average Japanese installed retail cost of $3,000 per household for a solar water heater with annual average usable hot water output of about 2000 kWh per year (that is, hot water output that would displace about that quantity of other fuels annually), with a lifetime of 20 years, and an interest rate of 7.00% a cost of saved energy of $ 0.142 per kWh saved is estimated.

and converting to Yen, yields an estimate of 15.27 Yen per kWh saved. This value is entered into LEAP as a negative cost per kWh relative to the BAU scenario (that is, as an incremental cost).

Annex 1.8: Biomass Resources in Japan

Data set for WWF Japan project
Back-up Calculations, Data Preparation, and Reference Citations

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/9/2003

Data on Biomass Resources in Japan from Various Sources

FROM
http://www.fao.org/docrep/T4470E/t4470e0n.htm#ii. biomass resource and its energy value
A potential renewable energy resource development and
utilization of biomass energy
Wang Mengjie & Ding Suzhen
Chinese Academy of Agricultural Engineering Research & Planning Beijing, P.R. China.

Paper No.9408

Table 1. Annual Biomass Energy Yield from Residue in Different Areas in the World in 1987 unit: EJ (1018 J)

Area	Maize Straw	Wheat Straw	Rice Straw	Bagasse	Manure	Forest Residue	Firewood Forest	Total
Japan	0	0.02	0.24	0.01	0.3	0.41	0	0.98

FROM
http://www.co2e.com/news/story.asp?StoryID=1048

18/03/2003: Biomass holds promise for clean energy: Yomiuri Shimbun

Includes a quote from a "Kyoto University Researcher" that 77 million tonnes of biomass go unused in Japan annually.

Assuming that 77 million tonnes of biomass is available, and an energy content of 15.5 GJ per tonne (assumes air-dry, ~15% moisture), this is 1193.5 PJ. Converted to electricity, and assuming an electricity conversion efficiency of 30%, this is 99,458 GWh, or about 11.35 average GW of power if all resources were used.

FROM
wastes-affluence-paper.pdf,
Effects of affluence and population density on waste generation and disposal of municipal solid wastes
Ko Matsunaga and Nickolas J. Themelis
Earth Engineering Center, Columbia University, New York
Dated 9/2002
Includes estimates of total MSW produced in Japan in the late 1990s, and its disposition.
"The rate of MSW generation in Japan (principally residential and commercial wastes) in fiscal 1999 totaled 53.7 million tons."

For LEAP data set, used 53.7 million tonnes/yr, with no change in yield over time.

Annex 1.9: Nuclear Fuel Costs

Data set for WWF Japan project
Back-up Calculations, Data Preparation, and Reference Citations

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/9/2003

Data on Nuclear Fuel Costs

NUCLEAR FUEL
Based on a nuclear fuel cost c $260 per kg Uranium (*Note 9*), and an assumed average
fuel burnup rate of 43,000 kW-days thermal per kg of U consumed (US DOE *Source below*), an average
nuclear fuel cost of 7.55 Yen per GJ thermal energy produced (in 2000 Yen)
This value is significantly lower, however, than the 1.3 Yen per kWh (or
119.17 Yen per thermal GJ) included in the original data set. We will use the value from
the original data set, as it probably is a more comprehensive and Japan-specific accounting of costs.

US Department of Energy, Energy Information Administration (USDOE/EIA, 1996), Nuclear Power Generation and Fuel Cycle Report, 1996. Report No. DOE/EIA-0436(96), October, 1996. Estimated US contract prices for fabricated BWR fuel.

Annex 1.10: Potential of Renewable Energy Resources

Data set for WWF Japan project
Back-up Calculations, Data Preparation, and Reference Citations

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/9/2003

Data on Renewable Resources in Japan from ISEP Study

Source: Renewable energy potential in 2010 in Japan
Institute of Sustainable Energy Policies, March 2003
As compiled in "ISEP Scenario" sheet of WWFJapan_Workbook_09.xls.

	MW	PJ
Wind	26107	109
Solar (PV)	87970	311.5
Biomass (Gas)	1973	
Biomass (Solid)	2226	104.8
Hydro	11715	
Geothermal	2016.5	318.7

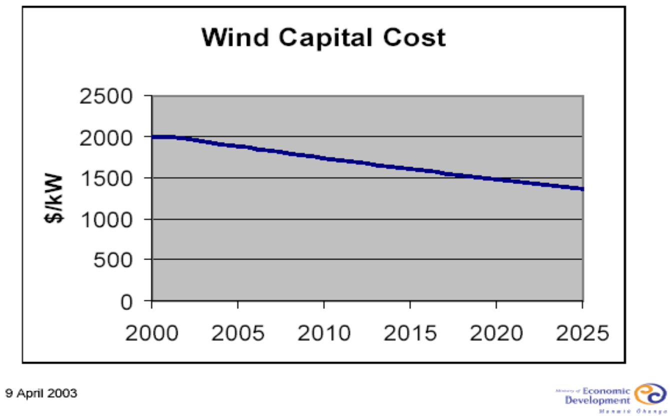
For LEAP, we enter the Wind and PV figures in PJ as above, except that as wind output is given in electricity terms, we convert to wind energy input terms using an efficiency of 33% as used in the LEAP data set. Total annual resource is thus 330.303 PJ

For Hydro, we assume that value shown is for remaining (not total) capacity, and use an average annual capacity factor of 45% (current for large hydro in Japan is above 50%) to calculate PJ potential as 166.25

For Geothermal, use the MW figure above, and assume a 10% efficiency and a 70% capacity factor to give an estimated annual output of 12,365 GWhe per year, or a thermal resource of 44.51 PJ.

For Solar, 87970 MW at a capacity factor of 12% implies output of 92474 GWhe per year, or 333 PJ, which is close to the 311.5 PJ shown above. Assuming an average efficiency of 15%, this implies a total solar resource (at least for PV applications) of 2077 PJ

http://www.med.govt.nz/ers/electric/misc-presentations/roger-fairclough-20030409/#P90_2976 (visited 9/12/03) provides the following estimate of future wind power capital costs (presumably in New Zealand, which is the subject of the presentation):



This largely linear curve suggests a growth rate in the costs of wind generation of about -2% per year. Though the starting (year 2000) cost for wind generation in Japan, as derived from various documents, is a much higher 300000 Yen/kW, we will use this growth rate as an estimate for the price trend of wind generation. Prices of wind power could easily fall much more rapidly in Japan.

Annex 1.11: Data on Retail Gas Prices

Data set for WWF Japan project
Back-up Calculations, Data Preparation, and Reference Citations

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	8/1/2003

Data on Retail Gas Prices in Japan and Elsewhere from USDOE EIA

From http://www.eia.doe.gov/emeu/international/ngasprih.html
Natural Gas Prices for Households

U.S. Dollars per 10^7 Kilocalories (Gross Calorific Value)

Country	1994	1995	1996	1997	1998	1999	2000	2001	2002
OECD1	345.4	361.9	367.2	362.7	359.2	351.7	340.9	386.4	
OECD Europe2	411.7	441.1	437.8	423.4	423	399	328.2		
OECD Europe2	411.7	441.1	437.8	423.4	423	399	328.2		
Argentina								235.27	237.85
Australia	312.2	317.9	332.8	332.3					
Austria	405.7	459.4	468.3	431.1	415.3	393.4	348.4	368.5	379.3
Barbados							813.61	813.61	
Belgium	435.6	487.3	451.8	413.5	409.8	383.1	407.7		
Bolivia							281.54	281.54	
Canada	175.6	162.2	169.7	170.6	169.8	212.4	199.4	294.1	
Chile							542.34	533.13	
Chinese Taipei (Taiwan)	416.37	425.86	410.97	431.18	372.21	354.59	379.68	372.53	
Colombia							232.27	210.6	
Cuba							161.66	198.36	
Czech Republic	111.4	125.5	131.6	128.7	177.3	185.1	214.1	233	274.8
Denmark	636.9	691.5	739.2	677.6	645.2	654.6	735.1	709.2	720.1
Finland	131.2	178.1	181.5	170.4	169	156.3	159.5	221.1	201.6
France	459.8	500.4	470.3	426.5	435	384.5	347.5	402.7	435
Germany	436.2	476.6	439.2	416.4	404.8	382.2	373.4		
Greece					405.9	342.3	297.2	308.7	
Hungary	104.5	137.2	136.3	165.6	202.5	185	166.3	183.2	215.4
Indonesia					10				
Ireland	441.4	473.2	472.6	447.2	420.2	435.3	345.8	353	376.2
Italy	666.4	667.5	733.1	698.6	690.7	639			
Japan	1,307.90	1,410.70	1,294.10	1,287.80	1,068.40	1,196.40	1,294.10	1,168.20	
Kazakhstan			48.63	44.35	51.06	43.2	39.02	40.65	
Luxembourg	261.6	298.1	319.4	296.9	274.4	244.6	275.6	300.2	272.7
Netherlands	365.9	406.4	400.2	393.2	393.3	369.3	359.4	401.4	457.1
New Zealand	297.2	363.4	415.9	437.7	380.2	379.3	322.5	296.6	341.6
Poland	159.5	208.7	236.1	227.7	248.3	244.3	247.5	304	
Portugal									654.4
Romania	20.35	19.75	18.69	30.25	41.02	52.44	60.08	76.93	
Russia	1.53								
Slovak Republic (Slovakia)	72.3	81.3	80.1	75.3	73.3	77.9	108.6	115.4	125.9
Spain	541.1	609.9	613.8	548	533.2	481.1	491.4	507.9	496.9
Switzerland	448.3	537.8	505.7	437.7	439.6	412.2	411.3	490.5	494.9
Turkey	207.8	210.6	209.3	238.5	217.9	225.8	259.6	242.2	
United Kingdom	308.9	328.8	325.7	338.2	330.6	321	292.8	286.5	317
United States	246.5	244.3	264.3	266.8	262.2	257.2	298.4	375.3	326.5
Venezuela	44.48	37.35	15.83	36.34	86.15	96.57	113.19		

from http://www.eia.doe.gov/emeu/international/ngasprii.html
Natural Gas Prices for Industry

U.S. Dollars per 10 ^{7} Kilocalories (Gross Calorific Value)

Country	1994	1995	1996	1997	1998	1999	2000	2001	2002
OECD1	131.4	130.1	143.6	147.6	133.5	129.5	168.5	182.6	
OECD Europe2	150.9	166.4	164.2	159.3	150.5	134.6	157.4		
Argentina							139.87	144.72	
Australia	127.2	132.4	144.9	135.8					
Austria	151.9	171.8	172	164.5	154.7	144.7			
Barbados							739.6	739.6	
Belgium	124.4	141.6	132.6	131.4					
Bolivia							47.91	44.61	
Brazil	239.3	142.96	132.26	123.29	114.48				
Canada	78.5	69.8	71.1	72.5	70.6	79.4	89.8	108.8	
Chile							185.87	218.75	
Chinese Taipei (Taiwan)	282.16	291.81	281.6	307.46	264.54	248.3	297.81	288.63	
Colombia							159.71	144.78	
Cuba							121.22	121.22	
Czech Republic	137.2	157.5	164.1	152.2	159.8	142.8	147.6	155.9	173.6
Finland	107.5	146	148.8	143.7	138.5	128.1	130.7	126	126.9
France	141.8	161	161.9	152.7	145.5	135.4	167.8	187.1	171.9
Germany	184.7	207	201.7	189.8	177.7	161.6	187.9		
Greece				184.4	152.4	160.7	216.1	205.2	
Hungary	111.9	105.6	105.8	145	144.8	134.9	124.9	158.5	188.7
Indonesia				97.21	79.37				
Ireland	296.7	318	317.6	300.6	171.5	164.9	114.2	143.5	183.8
Italy	157.5	173.7	197.9	191.9	171.3				
Japan	466.2	490.4	423.1	463.3	356	385.8	452.7	406.4	
Kazakhstan			45.2	38.52	34.9	24.82	26.59	29.75	
Mexico	79.7	61.6	89.3	99.3	81.4	88.3	150	163.4	n.a.
Netherlands	125.9	158.8	153	142.8	132.9	116.8	166.5	175.6	164.5
New Zealand	180.4	203	217.2	222	209.3	217.4	176.2	162.7	187.4
Poland	115.4	129.7	138.4	130.6	132	121.8	133	173.3	
Portugal									248
Romania					64.92				
Russia	24.05								
Slovak Republic (Slovakia)	113.7	127.7	124.4	118.6	124.7	106.8	101.8	106.6	132.9
South Africa	140.43	142.56	131.11	136.38	152.86	182.89	237.06	212.85	
Spain	135.6	159.1	168.8	155.8	137.8	131.5	175.4	176	165.5
Switzerland	267.7	296.9	272.8	237.5	238.8	215	222.9	296.4	281.1
Thailand					83.42	82.51	108.7		
Trinidad and Tobago							30.31		
Turkey	140.6	157.6	187.8	199.3	172.3	162.3	175.2	200.1	215.4
United Kingdom	141.6	127.1	92	101.8	108.7	102.9	104.6	133.6	
United States	113.8	100.8	129.2	136.2	119	118.7	171.3	191.5	151.2
Venezuela	29.95	8	3.39	7.07	20.64	27.84	25.63		

Annex 2: Workpapers for Derivation of Factors Related to the Incorporation of Cogenerated Heat and District Heat in the Japan LEAP Dataset

The workpapers in this Annex are printouts from the MS Excel workbook **dist_heat_module_calcs.xls**. Subsections of this Annex correspond to worksheets in the workbook, and cover background data and calculations related to the inclusion of consideration of cogenerated heat and district heat in the Japan LEAP data and scenarios.

Annex 2.1: Cogeneration Heat Consumption in Japan

BACKGROUND CALCULATIONS FOR PREPARATION OF COGEN HEAT DEMAND ESTIMATES FOR USE IN THE JAPAN WWF LEAP DATA SET

Prepared by:	David Von Hippel
Date Last Modified:	7/17/2003

Input data

[Data below from Japan Cogeneration Information Center (energy) and The Cogeneration in Japan (Cogeneration Research Society of Japan) (capacity data), as Translated by Masami Nakata] in WWF_Japan_workbook_4.XLS, "Cogeneration" sheet.

		1999			
Cogeneration from Gas (GWh)		8,515			
Total Cogeneration (GWh)		20,115			
Implied Diesel Cogeneration (GWh)		11,600			
Total Cogeneration Capacity (MW)		5,131	(does not include black liquor/waste wood)		
Implied Overall Capacity Factor (All Cogeneration)		44.7%			
Residential/Commercial (MW)	Gas Turbine	230.438	269.2		
	Gas Engine	300.996	344.655		
	Diesel Engine	493.405	533.838		
Total Residential/Commercial (MW)		1,025	1,148		
Industrial (MW)	Gas Turbine	2,354	2465.983		
	Gas Engine	186	204.559		
	Diesel Engine	1,566	1699.521		
Total Industrial (MW)		4,106	4,370		
Total Gas Capacity (MW)		3,072	3,284		
Total Diesel Capacity (MW)		2,060	2,233		
Implied Gas Cogen Capacity Factor		31.6%			
Implied Diesel Cogen Capacity Factor		64.3%			
Assume that Industrial Cogen Capacity Factors					
are on average	33%	higher than capacity			
factors for residential/commercial cogen (rough assumption)					
Then the overall industrial capacity factor is		47.1%	(Determined iteratively		
And total generation (check) is		20,122	or	100.0%	of 1999 total output
So the overal residential/commercial capacity factor is		35.4%			
If the ratio of the gas to diesel cogen factors in each sector are the same, that is				0.4922	, then
Industrial Gas Cogen Output Implied is		5,589	GWh		
Industrial Diesel Cogen Output Implied is		11,354	GWh		
Residential/Commerial Gas Cogen Output Implied is		1,049	GWh		
Residential/Commerial Diesel Cogen Output Implied is		2,131	GWh		
Assuming that gas turbine and gas engine capacity factors are not significantly different:					
Industrial Gas Engine Output (GWh)		410			
Industrial Gas Turbine Output (GWh)		5,179			
Residential/Commercial Gas Engine Output (GWh)		594			
Residential/Commercial Gas Turbin Output (GWh)		455			

Assuming the efficiencies of power generation and heat production now used in the WWF-Japan LEAP model, namely:

	Electricity Generation Efficiency	Heat Production Efficiency
Gas Engine Cogeneration	40%	40%
Gas Turbine Cogeneration	32%	40%
Diesel Engine Cogeneration	43%	40%

Implies that heat output is as follows:		1999	2000
	GWh (heat)	TJ (heat)	TJ (heat)
Industrial Diesel Cogen	10,562	38,023	41,257
Industrial Gas Engine Output	410	1,477	1,620.29
Industrial Gas Turbine Output	5,178.65	18,643	19,532.78
Total Industrial	16,151	58,143	62,410
Residential/Commercial Diesel Cogen	1,982	7,135	7,720
Residential/Commercial Gas Engine Output	594	2,138	2,449
Residential/Commercial Gas Turbine Output	568	2,046	2,391
Total Residential/Commercial	3,144	11,320	12,559

Assume that industrial cogenerated heat is distributed into five industrial subsectors as below.
Activity and fuel use in these subsectors per unit activity in 2000, based on the LEAP dataset are
as follows: Units: GJ except as noted

	Activity	Unit	Kerosene	Diesel	Residual Fuel Oil	Petroleum Coke	LPG	Municipal gas	Biomass unspecified	Electricity	Bituminous coal
Paper	31.76	million te	0.162	0.002	3.606	0.128	0.076	0.951	3.152	4.076	1.763

			Bituminous coal	Anthracite coal	Metalurgical Coke	Kerosene	Diesel	Residual Fuel Oil	Petroleum Coke	LPG	Municipal gas	Biomass unspecified	Electricity	Naphtha	Natural Gas
Chemicals	7.57	million te	4.626	0.395	0.224	1.901	0.01	11.912	3.19	13.795	9.939	0.145	31.201	209.369	1.979

	[Fuel Units 1000 GJ]		Bituminous coal	Metalurgical Coke	Kerosene	Diesel	Residual Fuel Oil	Petroleum Coke	LPG	Municipal gas	Electricity	Gasoline	Naphtha	Natural Gas
Other Manufacturing	92.1	(unspecified)	32.573	168.979	2,052.96	1,029.03	987.08	452.258	2,029.84	479.933	2,780.54	86.039	250.036	56.396

	[Fuel Units 1000 GJ]		Residual Fuel Oil	Municipal gas	Electricity
Food Products	99.2	(unspecified)	803.447	516.149	1,012.45

	[Fuel Units 1000 GJ]		Kerosene	Residual Fuel Oil	Petroleum Coke	LPG	Municipal gas	Biomass unspecified	Electricity	Coal bituminous
Textile and Fiber	70.7	(unspecified)	6.741	1,091.83	14.612	88.844	115.974	29.684	398.667	15.198

Calculation of Total non-electric fuel use (used as a guide to distribution of cogen heat by subsector)

Subsector	Activity (2000)	Unit	Total non-electric intensity (GJ/unit)	Total non-electric TJ	Fraction of non-electric TJ	Implied Cogen Heat (TJ)	Implied Energy Intensity (GJ/unit)	Implied Energy Intensity (Gcal/unit)
Paper	31.76	million te	9.84	312,518	19.46%	12,142	0.382	0.091
Chemicals	7.57	million te	48.116	364,238	22.68%	14,152	1.869	0.447
Other Manufacturing	92.1	(unspecified)	7,625,126	702,274	43.72%	27,286	296,261	70,808
Food Products	99.2	(unspecified)	1,319,596	130,904	8.15%	5,086	51,271	12,254
Textile and Fiber	70.7	(unspecified)	1,362,887	96,356	6.00%	3,744	52,953	12,656
Total of Above				1,606,291	100.00%	62,410		

Note that heat produced from cogeneration using "black liquor" and wood wastes as fuels are not included in the estimates above. At present, power generation using black liquor and wood wastes is not treated as cogeneration in the transformation module of LEAP, so, though it is likely that most of the systems using these fuels are in fact cogeneration systems for the paper (and other wood products) industries, the heat produced by and consumed from these systems simply does not show up in the energy consumption or production statistics.

We assume that all of the cogenerated heat described above as being in the "commercial and residential" sectors is in fact consumed in the commercial (services) sector.
In the commercial sector, we assume that space heating and water heating consume roughly equal quantities of cogenerated heat (these end uses use similar quantities of fuel per square meter in 2020, though it is not clear why), and further, assume that cogenerated heat simply adds to the overall intensity for these end-uses, thus the fraction of all fuel use accounted for by each individual fuel declines so that the absolute use of that fuel stays the same (in the BAU case) when cogenerated heat is added to the list of fuels.

So for the year 2000:
Energy intensity, hot water supply, Commercial (from LEAP data set): 60.79 Mcal/sq.m. without cogen heat
Energy intensity, space heat supply, Commercial (from LEAP data set): 60.03 Mcal/sq.m. without cogen heat
If cogen heat is apportioned proportionately to these end-uses, it means that 50.3% of cogen heat is used for hot water supply, with the remainder used for space heat.
If total commercial sector cogen heat in the year 2000 is (as above) 12,559 TJ, or ####### Tcal,
and total year 2000 commercial floorspace is 1654 million square meters, the implication is that
heat from cogen adds 0.91 Mcal/sq.m. to the total hot water supply energy intensity, and
0.90 Mcal/sq.m. to the total space heat energy intensity, and

In the BAU case, production of cogenerated heat (from diesel and gas-fired cogeneration rises as follows:
(Terajoules)

	2000	2005	2010	2015	2020
Heat from Cogen (TJ)	78.5	95.9	105.2	110.4	115.7
Index relative to 2000	1.00	1.22	1.34	1.41	1.47
Following data from LEAP data set					
Commercial million sq. meters	1,654.00	1,804.00	1,996.00	2,172.50	2,349.00
Hot water intensity (Mcal/sq.m.)	60.79	58.58	49.73	46	42.27
Space heat intensity (Mcal/sq.m.)	60.03	55.04	49.73	46	42.27

Assuming that the commercial sector continues to use a proportional share of cogenerated heat output,
total cogen heat consumption in these end-uses per square meter (Mcal) in the commercial sector will be:

	2000	2005	2010	2015	2020
Water Heating	0.91	1.02	1.01	0.98	0.95
Space Heating	0.90	1.01	1.00	0.97	0.94
Revised total Intensities:					
Water Heating	61.70	59.60	50.74	46.98	43.22
Space Heating	60.93	56.05	50.73	46.97	43.21

	Fuel Shares for Hot Water Supply, 2000		Fuel Shares for Hot Water Supply, 2005		Fuel Shares for Hot Water Supply, 2010		Fuel Shares for Hot Water Supply, 2015		Fuel Shares for Hot Water Supply, 2020	
Fuel	Original	Revised	Original	Revised	Original	Revised	Original	Revised	Original	Revised
LPG	10.91	10.75	11.47	11.27	11.6	11.38	11.39	11.16	11.18	10.94
Municipal Gas	28.21	27.79	31.03	30.48	33.9	33.24	35.61	34.89	37.32	36.53
Kerosene	11.14	10.98	9.5	9.33	8.28	8.12	7.5	7.35	6.72	6.58
Diesel	0.39	0.38	0.4	0.39	0.41	0.40	0.435	0.43	0.46	0.45
Residual Fuel Oil	42.74	42.11	40.1	39.39	37.31	36.59	36.065	35.34	34.82	34.08
Solar Heat	0.24	0.24	0.26	0.26	0.3	0.29	0.315	0.31	0.33	0.32
Geothermal Heat	1.2	1.18	1.28	1.26	1.36	1.33	1.345	1.32	1.33	1.30
Heat	5.13	5.05	5.96	5.85	6.84	6.71	7.34	7.19	7.84	7.67
Natural Gas	0.04	0.04	0	-	0	-	0	-	0	-
Heat from Cogen	0	1.48	0	1.80	0	1.97		2.06		2.17
Total	100	100.00	100.00	100.03	100.00	100.04	100.00	100.04	100.00	100.05

	Fuel Shares for Space Heating, 2000		Fuel Shares for Space Heating, 2005		Fuel Shares for Space Heating, 2010		Fuel Shares for Space Heating, 2015		Space Heating, 2020	
Fuel	Original	Revised	Original	Revised	Original	Revised	Original	Revised	Original	Revised
Electricity	7.67	7.56	9.5	9.34	10.5	10.29	11	10.78	11.5	11.25
LPG	3.27	3.22	3.72	3.66	4.06	3.98	4.37	4.28	4.68	4.58
Municipal Gas	8.22	8.10	9.78	9.62	11.44	11.22	13.13	12.86	14.82	14.50
Kerosene	16.59	16.34	14.63	14.38	13.32	13.06	12.18	11.93	11.04	10.80
Diesel	0.58	0.57	0.62	0.61	0.67	0.66	0.715	0.70	0.76	0.74
Residual Fuel Oil	63.66	62.72	61.75	60.71	60.01	58.83	58.605	57.41	57.2	55.97
Natural Gas	0.01	0.01	0	-		-	0	-	0	-
Heat from Cogen	0	1.48	0	1.72		2.00		2.08		2.19
Total	100.00	100.00	100.00	100.03	100.00	100.04	100.00	100.04	100.00	100.05

For industrial sector cogeneration, assume that cogeneration heat use in the industrial subsectors listed above
will grow at the same rate as overall cogeneration heat output (BAU scenario) and that in the future the total cogenerated
heat will be distributed among industrial subsector in the same fractions as base-year cogenerated heat (see above).
This assumption is probably not too accurate, as some subsectors show increasing activity, while others are
expected to decline, but it is a reasonable starting assumption, and will yield a total overall cogenerated
heat demand consistent with BAU heat output.

			Future Activities			
Subsector	Activity (2000)	Unit	2005	2010	2015	2020
Paper	31.76	million te	33.1	35.3	37.8	40.3
Chemicals	7.57	million te	7.6	7.8	8	8.2
Other Manufacturing	92.1	(unspecified)	81.8	74.6	68.3	62
Food Products	99.2	(unspecified)	101.5	103.8	103.1	102.5
Textile and Fiber	70.7	(unspecified)	70.9	71	69.4	67.7
Total Industrial Cogen Heat Use	62,410	TJ	76,243	83,637	87,771	91,985
Cogen Heat Use by Subsector						
Paper	12,142	TJ	14,834	16,272	17,077	17,896
Chemicals	14,152	TJ	17,289	18,965	19,903	20,858
Other Manufacturing	27,286	TJ	33,334	36,566	38,374	40,216
Food Products	5,086	TJ	6,213	6,816	7,153	7,496
Textile and Fiber	3,744	TJ	4,574	5,017	5,265	5,518
Total of above	62,410		76,243	83,637	87,771	91,985
Cogen Heat Intenstity by Subsector						
Paper	0.091	Gcal/te	0.1071	0.1102	0.1080	0.1061
Chemicals	0.447	Gcal/te	0.5437	0.5811	0.5946	0.6080
Other Manufacturing	70,808	Gcal/unit	97,395	117,152	134,283	155,030
Food Products	12,254	Gcal/unit	14,631	15,694	16,582	17,479
Textile and Fiber	12,656	Gcal/unit	15,418	16,889	18,132	19,480

POWER SWITCH WITH ENERGY EFFICIENCY (PSE) CASE

In the PSE case, production of cogenerated heat (from diesel and gas-fired cogeneration rises as follows: (Terajoules)

	2000	2005	2010	2015	2020
Heat from Cogen (TJ)	78.48	121.32	167.04	216	257.4
Index relative to 2000	1.00	1.55	2.13	2.75	3.28

In order to model the substitution of additional cogenerated heat for other space- and water-heating fuels in the commercial sector, we recalculate the energy intensity of the overall use of these end-uses, then recalculate the fuel shares for the PSE case. We assume that the average boiler or furnace efficiency for fossil fuels used in these end-uses is 80% , thus the use of a GJ of cogenerated heat displaces more than one GJ of fossil fuel. We also assume that the fraction of solar heat use in the commercial sector increases as shown in the tables below, but that the increase in solar heat use has no impact on the overall energy intensity. Assuming, as in the BAU Case that the commercial sector continues to use a proportional share of cogenerated heat output, total cogen heat consumption in these end-uses per square meter (Mcal) in the commercial sector will be:

	2000	2005	2010	2015	2020
Water Heating	0.91	1.29	1.61	1.91	2.11
Space Heating	0.90	1.28	1.59	1.89	2.08
and total energy intensities for these end uses will be:					
Water Heating	61.70	59.53	50.59	46.74	42.93
Space Heating	60.93	55.98	50.58	46.73	42.92

Assume that the fraction of water heat provided by district heat ("Heat") and geothermal heat in the services sector does not change. Then fuel shares are as follows:

	Fuel Shares for Hot Water Supply, 2000		Fuel Shares for Hot Water Supply, 2005		Fuel Shares for Hot Water Supply, 2010		Fuel Shares for Hot Water Supply, 2015		Fuel Shares for Hot Water Supply, 2020	
Fuel	BAU	PSE	BAU	PSE	BAU	PSE	BAU	PSE	BAU	PSE
LPG	10.75	10.75	11.27	11.19	11.38	11.06	11.16	10.56	10.94	10.02
Municipal Gas	27.79	27.79	30.48	30.26	33.24	32.34	34.89	33.03	36.53	33.45
Kerosene	10.98	10.98	9.33	9.27	8.12	7.90	7.35	6.96	6.58	6.02
Diesel	0.38	0.38	0.39	0.39	0.40	0.39	0.43	0.40	0.45	0.41
Residual Fuel Oil	42.11	42.11	39.39	39.11	36.59	35.59	35.34	33.45	34.08	31.21
Solar Heat	0.24	0.24	0.26	0.50	0.29	1.50	0.31	3.00	0.32	5.00
Geothermal Heat	1.18	1.18	1.26	1.26	1.33	1.33	1.32	1.32	1.30	1.30
Heat	5.05	5.05	5.85	5.85	6.71	6.71	7.19	7.19	7.67	7.67
Natural Gas	0.04	0.04	-	-	-	-	-	-	-	-
Heat from Cogen	1.48	1.48	1.80	2.17	1.97	3.18	2.06	4.09	2.17	4.91
Total	100	100.00	100.03	100.00	100.04	100.00	100.04	100.00	100.05	100.00

	Fuel Shares for Space Heating, 2000		Fuel Shares for Space Heating, 2005		Fuel Shares for Space Heating, 2010		Fuel Shares for Space Heating, 2015		Fuel Shares for Space Heating,	
Fuel	BAU	PSE	BAU	PSE	BAU	PSE	BAU	PSE	BAU	PSE
Electricity	7.56	7.56	9.34	9.28	10.29	10.17	10.78	10.56	11.25	10.94
LPG	3.22	3.22	3.66	3.64	3.98	3.93	4.28	4.19	4.58	4.45
Municipal Gas	8.10	8.10	9.62	9.56	11.22	11.08	12.86	12.60	14.50	14.10
Kerosene	16.34	16.34	14.38	14.30	13.06	12.90	11.93	11.69	10.80	10.50
Diesel	0.57	0.57	0.61	0.61	0.66	0.65	0.70	0.69	0.74	0.72
Residual Fuel Oil	62.72	62.72	60.71	60.34	58.83	58.12	57.41	56.24	55.97	54.43
Natural Gas	0.01	0.01	-	-	-	-	-	-	-	-
Heat from Cogen	1.48	1.48	1.72	2.28	2.00	3.14	2.08	4.04	2.19	4.85
Total	100.00	100.00	100.03	100.00	100.04	100.00	100.04	100.00	100.05	100.00

For the Industrial Sector in the PSE scenario:

	2000		2005	2010	2015	2020
Total Industrial Cogen Heat Use	62,410	TJ	96,453	132,801	171,726	204,640

Cogen Heat Use by Subsector			2005	2010	2015	2020
Paper	12,142	TJ	18,766	25,838	33,411	39,815
Chemicals	14,152	TJ	21,871	30,114	38,940	46,404
Other Manufacturing	27,286	TJ	42,169	58,061	75,079	89,469
Food Products	5,086	TJ	7,860	10,823	13,995	16,677
Textile and Fiber	3,744	TJ	5,786	7,966	10,301	12,276

Assume that in each subsector, Cogen Heat displaces residual oil use. This is unlikely to be strictly the case, but residual oil use is significant in each of the above subsectors, and probably fuels the older equipment that cogen is more likely to displace. BAU values for residual oil use in each subsector are as follows:

BAU Residual Oil Use by Subsector	2000		2005	2010	2015	2020
Paper	114,500	TJ	115,800	120,100	124,800	129,000
Chemicals	90,200	TJ	99,800	113,300	128,600	145,900
Other Manufacturing	90,900	TJ	84,700	80,800	77,200	73,000
Food Products	79,700	TJ	76,000	72,500	67,200	62,200
Textile and Fiber	77,200	TJ	85,200	93,200	98,500	103,600

Assume that cogen heat displaces heat from boilers with efficiencies of 80%. Then the net residual oil use in each subsector is:

PSE Net Residual Oil Use by Subsector	2000		2005	2010	2015	2020
Paper	114,500	TJ	111,868	110,535	108,466	107,082
Chemicals	90,200	TJ	95,217	102,152	109,563	120,355
Other Manufacturing	90,900	TJ	75,864	59,305	40,495	23,747
Food Products	79,700	TJ	74,353	68,493	60,358	53,019
Textile and Fiber	77,200	TJ	83,988	90,251	93,464	96,842

The above imply the following intensities for cogen heat and residual fuel oil use:

Cogen Heat Intenstity by Subsector (PSE scenario)

	2000		2005	2010	2015	2020
Paper	0.091	Gcal/te	0.136	0.175	0.211	0.236
Chemicals	0.447	Gcal/te	0.688	0.923	1.163	1.353
Other Manufacturing	70,808	Gcal/unit	123,212	186,018	262,728	344,897
Food Products	12,254	Gcal/unit	18,509	24,920	32,442	38,887
Textile and Fiber	12,656	Gcal/unit	19,504	26,817	35,476	43,338

Residual Oil Intenstity by Subsector (PSE scenario)

	2000		2005	2010	2015	2020
Paper	0.862	Gcal/te	0.808	0.748	0.686	0.635
Chemicals	2.848	Gcal/te	2.994	3.130	3.273	3.508
Other Manufacturing	235,892	Gcal/unit	221,663	190,004	141,705	91,542
Food Products	192,024	Gcal/unit	175,082	157,710	139,922	123,628
Textile and Fiber	260,979	Gcal/unit	283,125	303,809	321,879	341,888

Annex 2.2: Heat Production From Supply-side Cogeneration, Power Switch Scenario

WWF-Japan9: Outputs: processes
Scenario: Power Switch with Energy Efficiency, Fuel: Heat from Cogen
Units: thousand gigawatt-hour
(First Iteration), 7/23 2 PM

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Existing Coal Fired	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Coal Fired Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fluidized Bed Combustion Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IGCC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Oil Fired	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Oil Fired	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen Diesel Engine	10.7	11.9	12.6	13.4	14.2	15.1	16	17	18	19	20.1	20.3	20.6	20.8	21.1	21.4	21.6	21.9	22.2	22.5	22.8
Combustion Turbine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Large Hydro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Pumped storage hydro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Pump Storage Hydro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Nuclear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Nuclear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Combined Cycle NG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen Natural Gas Turbine	9.4	12	12.8	13.5	14.4	15.2	16.2	17.2	18.7	20.2	21.6	23.4	25.2	26.9	28.5	30.1	31.7	33.2	34.7	36.1	37.5
Cogen Natural Gas Engine	1.5	1.9	2.1	2.2	2.3	2.5	2.6	2.8	3	3.2	3.5	3.8	4.1	4.3	4.6	4.8	5.1	5.3	5.6	5.8	6
Fuel Cells	0.1	0.3	0.5	0.6	0.7	0.9	0.9	1	1.1	1.1	1.1	1.7	2.2	2.7	3.2	3.6	3.9	4.3	4.6	4.8	5.1
MCFC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Photovoltaics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Industry Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Digestor gas	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Black Liquor and Wood Wastes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micro Gas Turbine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	21.8	26.2	28	29.8	31.7	33.7	35.8	38.1	40.8	43.6	46.4	49.3	52.1	54.8	57.5	60	62.4	64.8	67.1	69.3	71.5

Annex 2.3: Demand for Cogenerated Heat in the Commercial and Industrial Sectors, Power Switch Scenario

WWF-Japan9: Net final energy demand in final energy units: demand
Scenario: Power Switch with Energy Efficiency, Fuel: Heat from Cogen
Units: thousand gigawatt-hour
(First Iteration), 7/23 2 PM

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Commercial	3.5	3.6	3.8	4	4.1	4.3	4.4	4.5	4.5	4.6	4.7	4.7	4.8	4.8	4.9	4.9	5	5	5.1	5.1	5.1
Industry	17.3	18.1	18.9	19.7	20.4	21.2	21.5	21.9	22.3	22.6	23	23.2	23.4	23.7	23.9	24.1	24.3	24.5	24.8	25	25.2
Total	20.8	21.8	22.7	23.7	24.6	25.4	25.9	26.4	26.8	27.2	27.6	27.9	28.2	28.5	28.7	29	29.3	29.5	29.8	30.1	30.3
Ratio: Total supply to demand, first iteration	1.05	1.2	1.23	1.26	1.29	1.33	1.38	1.44	1.52	1.6	1.68	1.77	1.85	1.92	2	2.07	2.13	2.2	2.25	2.3	2.36

Annex 2.4: Industrial Residual Fuel Oil Demand Results, BAU Scenario (Used to Estimate Impact of Cogenerated Heat on Residual Oil Use)

WWF-Japan9: Net final energy demand in final energy units: manufacturing industry
Scenario: BAU_modified Scenario IEEJ, Fuel: Residual Fuel Oil
Units: million gigajoule

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Paper	114.5	114.8	115.1	115.3	115.6	115.8	116.7	117.6	118.4	119.3	120.1	121	122	122.9	123.8	124.8	125.6	126.5	127.4	128.2	129
Chemicals	90.2	92	93.9	95.9	97.8	99.8	102.4	105	107.7	110.5	113.3	116.2	119.2	122.3	125.4	128.6	131.9	135.3	138.7	142.3	145.9
Ceramic	98.9	97.5	96.1	94.7	93.3	92	91.1	90.3	89.4	88.6	87.7	86.9	86.1	85.3	84.5	83.7	82.9	82.1	81.3	80.6	79.8
Steel	66.8	65.7	64.7	63.6	62.6	61.6	60.9	60.2	59.6	58.9	58.3	57.6	57	56.3	55.7	55.1	54.5	53.9	53.3	52.7	52.1
Other Manufacturing	90.9	89.7	88.5	87.3	86	84.7	84	83.2	82.4	81.6	80.8	80.1	79.4	78.7	78	77.2	76.4	75.6	74.8	73.9	73
Food Products	79.7	79	78.2	77.5	76.7	76	75.3	74.6	73.9	73.2	72.5	71.4	70.3	69.2	68.2	67.2	66.1	65.2	64.2	63.2	62.2
Textiles & Fiber	77.2	78.8	80.4	82	83.6	85.2	86.8	88.4	90	91.6	93.2	94.3	95.4	96.4	97.5	98.5	99.6	100.6	101.6	102.6	103.6
Non ferrous Metals	26.1	25.1	24.2	23.3	22.4	21.6	20.9	20.2	19.6	19	18.4	17.8	17.2	16.7	16.1	15.6	15.1	14.6	14.1	13.7	13.2
Metal Finishing	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0
Total	644.6	642.9	641.3	639.7	638.2	636.8	638.2	639.6	641	642.6	644.2	645.3	646.6	647.9	649.3	650.7	652.2	653.8	655.4	657.1	658.9

Annex 2.5: District Heating Module Calculations

BACKGROUND CALCULATIONS FOR PREPARATION OF A DISTRICT HEAT MODULE FOR THE JAPAN WWF LEAP DATA SET

Prepared by:	David Von Hippel
Date Last Modified:	5/16/2003

<u>Input data</u>

[Data below from EDMC Year 2000 Energy Balance, as Translated by Masami Nakata]

Category	Value	Units	Conversion Factor (TJ/Unit)	Converted Values (TJ)	Fraction of total fuel input as:
<u>District Heat Consumption</u>					
Residential Sector	1	PJ	1000	1,000	
Services Sector	21	PJ	1000	21,000	
<u>District Heat Inputs</u>					
Bituminous Coal	27	1000 t	26	702	3.12%
Kerosene	12	1000 kl	37.3	448	1.99%
Fuel Oil C	23	1000 kl	41	943	4.20%
Other Oil Products	2	1000 t	42.3	85	0.38%
LPG	7	1000 t	50.2	351	1.56%
Municipal Gas	16	PJ	1000	16,000	71.20%
Electricity	1095	GWh	3.6	3,942	17.54%
Implied Fuel Input (less Electricity)				18,529	82.46%
Implied Fuel Input (with Electricity)				22,471	100.00%
Heat Output	25	PJ	1000	25,000	

Year 2000 Heat Consumption in Current LEAP Dataset 21,600 TJ (in Services Sector Only)
Assume, based on the above that there is an additional 1,000 TJ used in the Residential Sector
Assume that this is used only for water heating, as in the Services sector, although it could be used for space heating as well. Given these assumtions, total heat demand covered by district heating is 22,600 TJ
If the total output estimate of 25,000 shown above (from EDMC balance) is correct, this implies heat transmission and distribution losses equal to 9.6% of output, which seems reasonable.
This value is entered as the losses rate for a new "Transmission and Distribution District Heat" Module.
The fuel input shown above, however, does not account for the full amount of fuel needed to supply 25 PJ of heat.
Further, the fraction of inputs as electricity seems quite high if electricity is used as an auxiliary fuel (that is, to run lights, pumps, instruments and the like). It is possible that electricity is sometimes used as a "boiler fuel", perhaps in times of low steam demand when it would be inefficient to turn on a fossil-fueled boiler? In any case, pending receipt of additional information, assume that electricity is one of the input fuels (rather than an auxiliarly fuel).

Year 2000 District Heat Consumption Per Household = 1,000 TJ for 47.2 Million Households
(from LEAP data set) = 21.19 MJ/HH

The data above suggest a heat production efficiency of greater than 100%, which does not seem reasonable.
Assume an average boiler efficiency of 85% for district heating in use as of 2000.

No capacity data for district heat is entered in LEAP at present.

Other Changes Made to LEAP dataset on 5/19/03
A major input to district heat is municipal gas. The existing municipal gas module had "natural gas" as an output, as well as an input, to municipal gas production. I changed this so that the output is "municipal gas".

Added fuel "Heat from Cogen", and changed Cogeneration processes in Electricity Module so that they produce that fuel (instead of "Heat").

Changed order of municipal gas and refining modules so that refining module is lower in the list so as to produce inputs to municipal gas production.

Annex 3: Selected Detailed LEAP Results

The results in this Annex are printouts from the MS Excel workbook **results_9-24.xls**. Subsections of this Annex correspond to worksheets in the workbook, and cover annual cost and other results exported from LEAP to Excel.

Annex 3.1: Power Switch with Energy Efficiency Scenario Cost Results

Results Data Compilation for WWF Japan Project
Raw LEAP Results and Summary Graphs and Tables

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/24/2003

COST RESULTS FOR PSE SCENARIO

WWF-Japan11: Costs
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Demand	0	147	286	420	550	679	817	953	1085	1213	1336	1513	1675	1822	1958	2086	2212	2341	2475	2616	2756
Transformation	3729	4170	4440	4706	4980	5251	5514	5774	6032	6288	6598	6742	6903	7034	7200	7321	7447	7609	7730	7889	8008
Resources	7197	7562	7733	7383	7030	6675	6688	6700	6720	6739	6748	6768	6786	6803	6820	6836	7077	7320	7566	7813	8062
Total	10926	11880	12459	12508	12561	12606	13019	13426	13837	14240	14682	15023	15364	15660	15977	16243	16736	17270	17771	18318	18826

WWF-Japan11: Costs: demand
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Residential	0	85	164	241	316	389	472	553	631	706	777	891	993	1085	1168	1246	1324	1404	1488	1571	1644	17145
Commercial	0	40	79	117	155	193	233	272	311	351	390	430	468	504	539	573	607	640	676	715	761	8053
Industry	0	22	43	62	80	97	113	128	143	157	169	193	214	233	251	267	282	296	312	330	351	3740
Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	147	286	420	550	679	817	953	1085	1213	1336	1513	1675	1822	1958	2086	2212	2341	2475	2616	2756	28939

WWF-Japan11: Costs: residential
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Space heating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cooling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot water supply	0	6	12	18	24	30	47	65	83	101	120	147	173	200	227	254	281	307	334	361	388	3175
Cooking	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Motive energy & Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity Saving Technologies	0	30	60	90	121	152	184	216	248	280	313	329	346	362	378	395	411	427	444	460	477	5722
Cogeneration and Distributed Generation	0	49	93	133	171	207	241	272	300	324	344	415	474	523	563	598	632	669	710	750	780	8249
Total	0	85	164	241	316	389	472	553	631	706	777	891	993	1085	1168	1246	1324	1404	1488	1571	1644	17145

WWF-Japan11: Costs: electricity saving technologies
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
LCD Television replacing CRT television	0	5.7	11.5	17.3	23.2	29.2	35.3	41.4	47.5	53.8	60	66.1	72.1	78.1	84.1	90.1	96.1	102.1	108.1	114.1	120.1	1256
LCD Computer Monitors	0	4.5	9	13.7	18.3	23.1	27.8	32.6	37.5	42.4	47.4	52.1	56.8	61.6	66.3	71	75.8	80.5	85.2	90	94.7	990
High performance refrigerators	0	14.8	29.8	44.9	60.3	75.9	91.5	107.4	123.3	139.5	155.8	158.9	162.1	165.2	168.4	171.5	174.6	177.8	180.9	184.1	187.2	2574
Electronic device standby energy reduction	0	4.7	9.5	14.3	19.2	24.2	29.1	34.2	39.3	44.4	49.6	52.1	54.6	57.1	59.6	62.1	64.6	67.1	69.6	72.1	74.6	902
Total	0	29.7	59.8	90.2	121.1	152.4	183.8	215.6	247.7	280.1	312.8	329.2	345.5	361.9	378.3	394.7	411	427.4	443.8	460.2	476.5	5722

WWF-Japan11: Costs: commercial
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Cooling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water Supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cooking	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Motive Energy and Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity Saving Technologies	0	16	33	51	69	88	107	128	149	171	194	208	223	238	253	269	285	301	318	335	353	3788
Cogeneration and distributed PVs	0	24	46	67	87	106	125	144	162	180	196	221	245	267	286	305	322	339	358	380	408	4265
Total	0	40	79	117	155	193	233	272	311	351	390	430	468	504	539	573	607	640	676	715	761	8053

WWF-Japan11: Costs: electricity saving technologies
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Improved Commercial Transformers	0	0	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	5	6	6	6	68
Nonfilament street lights	0	0	1	1	1	1	2	2	2	3	3	4	4	4	5	5	6	6	7	7	8	73
LED traffic lights	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-21
Convert incandescent lamps to LED	0	2	5	7	10	13	15	18	21	24	28	30	33	35	38	40	43	46	49	52	55	563
Convert fluorescent lamps to LED	0	1	3	4	6	7	9	10	12	14	16	17	19	20	22	23	25	27	28	30	32	323
Replace emergency lights with LEDs	0	0	0	-1	-1	-1	-1	-1	-2	-2	-2	-2	-2	-3	-3	-3	-3	-3	-3	-3	-3	-38
LCD Computer Monitors	0	7	13	20	28	35	43	51	60	69	78	85	92	99	106	114	122	130	138	146	155	1591
Reduction of electronic devices standby energy	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	17
Improved Vending Machines	0	1	1	2	3	4	5	6	6	7	8	9	9	9	9	10	10	10	10	11	11	140
Energy saving elevators	0	0	1	1	2	2	2	3	3	4	4	5	5	6	6	6	7	7	8	8	9	90
Improved Insulation in Rental Offices	0	1	2	3	4	5	7	8	9	10	12	12	12	13	13	13	14	14	14	15	15	195
Energy Management Systems for Buildings	0	4	8	12	16	20	25	29	34	39	45	46	48	50	52	55	57	59	61	63	66	788
Total	0	16	33	51	69	88	107	128	149	171	194	208	223	238	253	269	285	301	318	335	353	3788

WWF-Japan11: Costs: cogeneration and distributed pvs
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Cogeneration engine or turbine	0.0	6.3	12.6	19.0	25.4	31.9	38.6	45.4	52.2	59.2	66.2	76.7	87.3	98.0	108.6	119.3	129.9	140.5	151.1	161.6	172.0	1602
Distributed Photovoltaics	0.0	17.4	33.1	47.5	61.1	73.9	86.5	98.5	109.9	120.4	129.8	144.6	157.6	168.6	177.8	185.4	192.0	198.7	206.7	218.3	235.9	2664
Total	0.0	23.6	45.7	66.5	86.5	105.8	125.1	143.9	162.1	179.5	196.0	221.4	244.9	266.6	286.4	304.7	321.9	339.2	357.8	379.9	407.9	4265

WWF-Japan11: Costs: industry
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Manufacturing Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture_forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fishing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity Saving Technologies	0	8	16	23	31	39	47	55	62	70	78	89	99	110	121	132	142	153	164	174	185	1798
Distributed Photovoltaics	0	15	27	38	48	58	66	74	80	86	91	104	115	123	130	135	140	144	148	155	166	1943
Total	0	22	43	62	80	97	113	128	143	157	169	193	214	233	251	267	282	296	312	330	351	3740

WWF-Japan11: Costs: electricity saving technologies
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Inverter controlled Motor drives	0.0	0.7	1.4	2.1	2.9	3.6	4.3	5.0	5.7	6.4	7.2	7.9	8.6	9.4	10.1	10.8	11.6	12.3	13.0	13.8	14.5	151
Improved Industrial Transformers	0.0	1.8	3.6	5.5	7.3	9.1	10.9	12.8	14.6	16.4	18.2	20.3	22.4	24.5	26.6	28.7	30.8	32.9	34.9	37.0	39.1	397
Motors high efficiency	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	210
Fluorescent Lighting High efficiency	0.0	1.1	2.2	3.4	4.5	5.6	6.7	7.8	9.0	10.1	11.2	11.7	12.3	12.8	13.4	13.9	14.5	15.0	15.5	16.1	16.6	203
LED Lighting High efficiency	0.0	3.1	6.3	9.4	12.6	15.7	18.9	22.0	25.1	28.3	31.4	37.8	44.1	50.4	56.8	63.1	69.4	75.7	82.1	88.4	94.7	835
House renovation rather than replacement	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Total	0.0	7.8	15.6	23.4	31.2	39.0	46.8	54.6	62.4	70.2	78.0	88.7	99.4	110.1	120.8	131.5	142.2	152.9	163.6	174.3	185.0	1798

WWF-Japan11: Costs: transformation
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Transmission & Distribution Electricity	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	23
Electricity Generation	3381	3817	4086	4352	4614	4873	5135	5393	5651	5906	6161	6304	6440	6570	6696	6816	6941	7063	7183	7302	7421	122105
Oil Refining	305	311	311	311	312	312	313	313	314	315	316	317	318	318	319	320	321	322	323	323	324	6637
LNG Imports	43	43	43	43	54	66	66	66	66	66	121	121	144	144	183	183	183	222	222	261	261	2601
Total	3729	4170	4440	4706	4980	5251	5514	5774	6032	6288	6598	6742	6903	7034	7200	7321	7447	7609	7730	7889	8008	131365

WWF-Japan11: Costs: processes
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Existing Coal Fired	374	365	357	349	341	333	325	316	308	300	292	275	258	241	225	208	191	174	157	140	123	5652
New Coal Fired Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fluidized Bed Combustion Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IGCC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Oil Fired	286	278	270	262	255	248	241	234	228	221	215	209	202	196	190	185	179	174	169	164	159	4564
New Oil Fired	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen Diesel Engine	17	26	35	45	56	67	79	92	105	120	135	139	143	147	151	155	159	163	168	172	176	2347
Combustion Turbine	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	116
Large Hydro	395	406	416	426	436	446	456	466	476	486	496	496	496	496	496	496	496	496	496	496	496	9868
Existing Pumped storage hydro	457	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	457
New Pump Storage Hydro	0	117	235	352	469	587	704	822	939	1056	1174	1174	1174	1174	1174	1174	1174	1174	1174	1174	1174	18191
Existing Nuclear	1106	1718	1711	1704	1696	1688	1684	1679	1674	1669	1663	1628	1592	1556	1520	1484	1449	1414	1378	1343	1307	32661
New Nuclear	0	42	84	126	168	210	252	294	336	378	420	440	461	482	502	523	543	564	584	605	626	7638
Existing Natural Gas	666	657	648	639	630	621	612	603	594	585	576	562	548	534	521	507	493	479	465	452	438	11827
New Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geothermal	9	9	10	10	11	11	12	12	13	13	14	14	14	14	13	13	13	13	13	13	13	255
Combined Cycle NG	0	8	16	23	31	39	47	55	62	70	78	109	140	172	203	234	260	287	313	340	366	2853
Cogen Natural Gas Turbine	16	24	33	43	53	64	75	87	100	114	129	132	136	140	144	148	152	156	160	165	169	2240
Cogen Natural Gas Engine	7	10	13	16	19	22	26	30	34	38	43	44	45	47	48	49	50	52	53	54	56	756
Fuel Cells	0	7	14	20	26	32	38	44	49	54	59	87	115	142	168	194	219	243	268	292	316	2386
MCFC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0	23	45	67	88	109	130	150	170	189	208	274	339	403	465	526	586	645	702	759	814	6693
Photovoltaics	0	51	97	139	177	212	242	270	294	316	335	378	417	451	482	511	537	561	585	609	633	7298
MSW	10	32	54	76	98	120	142	164	186	208	229	235	241	246	252	257	263	268	274	280	285	3919
Industry Waste	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	27
Digestor gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Black Liquor and Wood Wastes	32	33	33	33	33	34	34	34	34	35	35	35	35	35	35	35	35	35	35	35	35	719
Micro Gas Turbine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Other Biomass	0	5	10	15	20	25	30	36	42	48	54	65	77	89	100	112	135	159	182	205	229	1635
Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3381	3817	4086	4352	4614	4873	5135	5393	5651	5906	6161	6304	6440	6570	6696	6816	6941	7063	7183	7302	7421	122105

WWF-Japan11: Costs: resources
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Primary	5629	5817	6044	5769	5492	5215	5215	5214	5221	5227	5224	5207	5190	5173	5156	5139	5287	5437	5587	5737	5888	113868
Secondary	1568	1745	1689	1614	1538	1460	1473	1486	1499	1512	1524	1561	1596	1630	1664	1697	1790	1884	1979	2076	2174	35157
Total	7197	7562	7733	7383	7030	6675	6688	6700	6720	6739	6748	6768	6786	6803	6820	6836	7077	7320	7566	7813	8062	149025

WWF-Japan11: Costs: primary
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Nuclear	416	404	405	406	406	407	410	412	414	416	418	411	404	397	390	383	376	369	362	355	348	8310
Crude Oil	4660	4770	4970	4709	4448	4185	4195	4204	4223	4240	4247	4258	4268	4277	4286	4295	4468	4642	4816	4990	5165	94316
Coking Coal	242	262	275	272	268	265	262	260	258	256	254	252	250	248	246	244	242	240	238	235	233	5301
Coal (bituminous)	311	382	394	382	370	359	348	337	326	315	305	286	268	251	234	217	202	186	171	156	142	5941
Total	5629	5817	6044	5769	5492	5215	5215	5214	5221	5227	5224	5207	5190	5173	5156	5139	5287	5437	5587	5737	5888	113868

WWF-Japan11: Costs: secondary
Scenario: Power Switch with Energy Efficiency, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Residual Fuel Oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Refinery Feedstocks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum Coke	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil (unspecified)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphtha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Municipal Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metalurgical Coke	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LNG	1568	1745	1689	1614	1538	1460	1473	1486	1499	1512	1524	1561	1596	1630	1664	1697	1790	1884	1979	2076	2174	35157
Kerosene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jet Kerosene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat from Cogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gasoline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Oil A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diesel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke oven gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnace gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1568	1745	1689	1614	1538	1460	1473	1486	1499	1512	1524	1561	1596	1630	1664	1697	1790	1884	1979	2076	2174	35157

Annex 3.2: Business as Usual Scenario Cost Results

Results Data Compilation for WWF Japan Project
Raw LEAP Results and Summary Graphs and Tables

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/24/2003

COST RESULTS FOR BAU SCENARIO

WWF-Japan11: Costs
Scenario: BAU_modified Scenario IEEJ, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Demand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transformation	3729	4281	4662	5039	5433	5824	6197	6606	6974	7380	7744	7977	8170	8362	8554	8785	8976	9167	9359	9550	9742	152510
Resources	7197	7595	7797	7477	7153	6825	6873	6920	6976	7030	7075	7118	7161	7203	7244	7284	7559	7835	8113	8393	8675	155504
Total	10926	11876	12459	12517	12586	12649	13070	13526	13951	14410	14819	15095	15331	15565	15798	16069	16535	17002	17472	17943	18417	308014

WWF-Japan11: Costs: demand
Scenario: BAU_modified Scenario IEEJ, Cost: All Costs
Units: japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

WWF-Japan11: Costs: transformation
Scenario: BAU_modified Scenario IEEJ, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Electricity Generation	3381	3928	4309	4686	5060	5431	5803	6172	6540	6905	7268	7460	7651	7842	8032	8222	8411	8601	8790	8980	9170	142640
Oil Refining	305	311	311	311	311	311	312	313	314	315	316	318	320	322	324	325	327	329	331	332	334	6692
LNG Imports	43	43	43	43	62	82	82	121	121	160	160	199	199	199	199	238	238	238	238	238	238	3178
Total	3729	4281	4662	5039	5433	5824	6197	6606	6974	7380	7744	7977	8170	8362	8554	8785	8976	9167	9359	9550	9742	152510

WWF-Japan11: Costs: processes
Scenario: BAU_modified Scenario IEEJ, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Existing Coal Fired	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	7846
New Coal Fired Plants	0	66	131	197	262	328	393	459	525	590	656	728	800	873	945	1017	1090	1162	1234	1307	1379	14141
Fluidized Bed Combust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IGCC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Oil Fired	286	278	270	262	255	248	241	234	228	221	215	213	211	209	207	205	203	201	199	197	195	4774
New Oil Fired	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen Diesel Engine	17	20	24	27	31	34	38	41	45	49	53	56	59	61	64	67	70	73	76	79	82	1064
Combustion Turbine	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	116
Large Hydro	395	406	416	426	436	446	456	466	476	486	496	496	496	496	496	496	496	496	496	496	496	9868
Existing Pumped storag	457	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	457
New Pump Storage Hy	0	117	235	352	469	587	704	822	939	1056	1174	1174	1174	1174	1174	1174	1174	1174	1174	1174	1174	18191
Existing Nuclear	1106	1721	1716	1710	1705	1700	1698	1697	1695	1693	1691	1688	1685	1682	1680	1677	1674	1671	1668	1665	1662	34883
New Nuclear	0	61	123	184	246	307	368	430	491	553	614	701	787	873	960	1046	1133	1219	1306	1392	1478	14271
Existing Natural Gas	666	666	666	666	666	666	666	666	666	666	666	666	666	666	666	666	666	666	666	666	666	13982
New Natural Gas	0	80	160	240	320	400	480	560	640	720	800	818	836	854	872	890	908	926	944	962	980	13393
Geothermal	9	9	10	10	11	11	12	12	13	13	14	14	14	14	13	13	13	13	13	13	13	255
Combined Cycle NG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cogen Natural Gas Tur	16	19	22	25	29	32	35	39	43	46	50	53	55	58	61	64	66	69	72	75	78	1006
Cogen Natural Gas Eng	7	8	9	10	11	12	14	15	16	17	18	19	20	21	22	22	23	24	25	26	27	366
Fuel Cells	0	1	1	1	2	2	2	3	3	4	4	5	6	6	7	8	9	10	11	12	13	108
MCFC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0	7	13	19	25	31	37	42	48	53	58	62	65	69	72	75	78	82	85	88	91	1097
Photovoltaics	0	43	81	116	148	176	202	225	245	263	279	286	292	298	302	307	311	315	319	323	326	4856
MSW	10	16	21	26	31	37	42	47	53	58	63	66	69	72	75	78	81	84	87	90	93	1202
Industry Waste	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	27
Digestor gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Black Liquor and Wood	32	33	33	33	33	34	34	34	34	35	35	35	35	35	35	35	35	35	35	35	35	719
Micro Gas Turbine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Other Biomass	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	16
Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3381	3928	4309	4686	5060	5431	5803	6172	6540	6905	7268	7460	7651	7842	8032	8222	8411	8601	8790	8980	9170	142640

WWF-Japan11: Costs: resources
Scenario: BAU_modified Scenario IEEJ, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Primary	5629	5833	6075	5815	5553	5291	5309	5325	5350	5374	5387	5419	5451	5482	5512	5542	5738	5936	6134	6333	6533	119020
Secondary	1568	1762	1722	1663	1600	1534	1564	1595	1626	1657	1688	1699	1710	1721	1732	1743	1821	1900	1979	2060	2142	36484
Total	7197	7595	7797	7477	7153	6825	6873	6920	6976	7030	7075	7118	7161	7203	7244	7284	7559	7835	8113	8393	8675	155504

WWF-Japan11: Costs: primary
Scenario: BAU_modified Scenario IEEJ, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Nuclear	416	406	408	411	413	416	420	425	429	434	438	444	450	456	461	467	472	478	483	488	494	9308
Crude Oil	4660	4768	4967	4705	4442	4178	4190	4201	4221	4239	4248	4274	4299	4324	4349	4373	4564	4757	4950	5145	5341	95196
Coking Coal	242	262	275	272	268	265	262	260	258	256	254	252	250	248	246	244	242	239	237	235	233	5300
Coal (bituminous)	311	397	424	427	430	433	436	439	442	445	447	450	452	454	456	458	460	462	463	465	466	9217
Total	5629	5833	6075	5815	5553	5291	5309	5325	5350	5374	5387	5419	5451	5482	5512	5542	5738	5936	6134	6333	6533	119020

WWF-Japan11: Costs: secondary
Scenario: BAU_modified Scenario IEEJ, Cost: All Costs
Units: billion japanese yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Residual Fuel Oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Refinery Feedstocks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum Coke	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil (unspecified)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphtha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Municipal Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metalurgical Coke	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LNG	1568	1762	1722	1663	1600	1534	1564	1595	1626	1657	1688	1699	1710	1721	1732	1743	1821	1900	1979	2060	2142	36484
Kerosene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jet Kerosene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat from Cogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gasoline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Oil A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diesel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke oven gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnace gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1568	1762	1722	1663	1600	1534	1564	1595	1626	1657	1688	1699	1710	1721	1732	1743	1821	1900	1979	2060	2142	36484

Annex 3.3: Correction for Costs of Solar Commercial Water Heat

Results Data Compilation for WWF Japan Project
Raw LEAP Results and Summary Graphs and Tables

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/24/2003

CORRECTION FOR COSTS OF SOLAR COMMERCIAL WATER HEAT

As of 9/25/03, there is an error in the LEAP program affecting the results of the costs of demand-side changes using the structure used to model the introduction of solar water heat in the commercial sector. The following data and calculations are used to estimate the net costs of introducing solar water heat in the commercial sector in the PSE scenario correctly.

WWF-Japan11: Net final energy demand in final energy units: hot water supply
Scenario: BAU_modified Scenario IEEJ, Fuel: Solar
Units: gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Solar Heat	285	293	301	309	317	325	330	334	337	340	342	347	353	358	363	368	370	373	375	376	378

WWF-Japan11: Net final energy demand in final energy units: hot water supply
Scenario: Power Switch with Energy Efficiency, Fuel: Solar
Units: gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Solar Heat	285	350	417	485	554	625	866	1102	1330	1550	1762	2119	2476	2833	3188	3543	4014	4482	4947	5408	5864

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Net Solar Heat Demand in PSE Scenario	0	58	116	176	237	299	537	768	993	1211	1420	1771	2123	2475	2825	3175	3644	4110	4573	5032	5486

In the "Commercial Water Heat" section of worksheet "EE_Cost_Est" of LNG5_dvh.XLS, the "Cost of Saved Energy" from commercial water heat is estimated at 17.96 Yen per kWh of net solar energy used (or, effectively, per kWh of heat output). The net cost of commercial water heat improvements in the PSE scenario by year is thus:

Cost in billion Yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Solar Heat	-	1	2	3	4	5	10	14	18	22	26	32	38	44	51	57	65	74	82	90	99

Annex 3.4: Cost Comparisons: Differences Between Power Switch and BAU Scenarios

Results Data Compilation for WWF Japan Project
Raw LEAP Results and Summary Graphs and Tables

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/24/2003

COST RESULTS: DIFFERENCES BETWEEN BAU AND PSE SCENARIO
(EXPRESSED AS PSE MINUS BAU)

Net Present Value calculated using a discount rate of 3% per year.
(Discounting done as if payments are made at the beginning of each year)
Units: billion japanese yen

OVERALL SUMMARY

CATEGORY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL	NPV
Demand	0	148	288	423	555	684	827	966	1103	1235	1361	1545	1713	1867	2009	2143	2278	2414	2557	2706	2855	29676	19991
Transformation	0	-111	-222	-334	-453	-572	-683	-833	-943	-1091	-1145	-1234	-1267	-1328	-1355	-1463	-1529	-1558	-1629	-1661	-1734	-21144	-14479
Resources	0	-33	-64	-94	-123	-150	-185	-220	-256	-292	-327	-350	-375	-399	-424	-449	-482	-515	-548	-580	-613	-6479	-4380
Total	0	4	2	-5	-21	-38	-41	-87	-96	-148	-111	-40	71	140	230	231	267	341	381	465	508	2053	1132

DEMAND COSTS

CATEGORY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL	NPV
Residential	0	85	164	241	316	389	472	553	631	706	777	891	993	1085	1168	1246	1324	1404	1488	1571	1644	17145	11540
Commercial	0	41	81	120	160	199	242	286	329	372	415	461	506	549	590	630	672	714	758	805	859	8790	5916
Industry	0	22	43	62	80	97	113	128	143	157	169	193	214	233	251	267	282	296	312	330	351	3740	2535
Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	148	288	423	555	684	827	966	1103	1235	1361	1545	1713	1867	2009	2143	2278	2414	2557	2706	2855	29676	19991

TRANSFORMATION COSTS

CATEGORY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL	NPV
Transmission & Distribution Electricity	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.4	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.4	23	15
Electricity Generation	0	-111	-222	-334	-446	-557	-668	-779	-889	-999	-1107	-1156	-1211	-1272	-1336	-1405	-1470	-1538	-1607	-1678	-1749	-20535	-14035
Oil Refining	0.0	0.1	0.2	0.2	0.3	0.4	0.2	0.1	0.0	-0.1	-0.2	-1.2	-2.2	-3.3	-4.3	-5.3	-6.3	-7.1	-8.0	-9.0	-9.9	-55	-33
LNG Imports	0.0	0.0	0.0	0.0	-7.8	-15.6	-15.6	-54.6	-54.6	-93.6	-39.0	-78.0	-54.6	-54.6	-15.6	-54.6	-54.6	-15.6	-15.6	23.4	23.4	-577	-425
Total	0	-111	-222	-334	-453	-572	-683	-833	-943	-1091	-1145	-1234	-1267	-1328	-1355	-1463	-1529	-1558	-1629	-1661	-1733	-21144	-14479

ELECTRICITY GENERATION COSTS

CATEGORY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL	NPV
Existing Coal Fired	0.0	-8.2	-16.3	-24.5	-32.7	-40.9	-49.0	-57.2	-65.4	-73.6	-81.7	-98.6	-115.4	-132.3	-149.1	-166.0	-182.8	-199.6	-216.5	-233.3	-250.2	-2193	-1447
New Coal Fired Plants	0	-66	-131	-197	-262	-328	-393	-459	-525	-590	-656	-728	-800	-873	-945	-1017	-1090	-1162	-1234	-1307	-1379	-14141	-9515
Fluidized Bed Combustion Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
IGCC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Existing Oil Fired	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-4.3	-8.4	-12.4	-16.2	-19.9	-23.3	-26.7	-29.9	-33.0	-35.9	-210	-128
New Oil Fired	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Cogen Diesel Engine	0.0	5.6	11.6	18.2	25.3	33.0	41.3	50.3	60.0	70.4	81.7	82.9	84.0	85.4	86.6	87.9	89.2	90.5	91.9	93.2	94.6	1284	882
Combustion Turbine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Large Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Existing Pumped storage hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
New Pump Storage Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Existing Nuclear	0.0	-2.3	-4.5	-6.9	-9.3	-11.8	-14.7	-17.9	-21.1	-24.5	-28.0	-60.7	-93.6	-126.4	-159.4	-192.3	-224.7	-257.1	-289.6	-322.1	-354.7	-2222	-1385
New Nuclear	0.0	-19.4	-38.8	-58.3	-77.7	-97.1	-116.5	-135.9	-155.3	-174.8	-194.2	-260.1	-325.9	-391.8	-457.7	-523.5	-589.4	-655.3	-721.2	-787.0	-852.9	-6633	-4301
Existing Natural Gas	0.0	-9.0	-18.0	-27.0	-36.1	-45.1	-54.1	-63.1	-72.0	-81.0	-90.0	-103.8	-117.7	-131.5	-145.3	-159.1	-172.9	-186.7	-200.5	-214.3	-228.1	-2155	-1436
New Natural Gas	0.0	-80.0	-160.0	-240.0	-320.1	-400.1	-480.1	-560.1	-640.1	-720.1	-800.2	-818.2	-836.2	-854.2	-872.2	-890.2	-908.2	-926.2	-944.2	-962.2	-980.3	-13393	-9267
Geothermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Combined Cycle NG	0.0	7.8	15.6	23.4	31.2	39.0	46.8	54.6	62.4	70.2	78.0	109.2	140.4	171.6	202.8	234.0	260.4	286.8	313.2	339.6	366.0	2853	1844
Cogen Natural Gas Turbine	0.0	5.3	11.2	17.5	24.3	31.7	39.7	48.3	57.7	67.7	78.5	79.6	80.8	82.1	83.3	84.5	85.7	87.0	88.3	89.6	91.0	1234	848
Cogen Natural Gas Engine	0.0	1.7	3.6	5.5	7.7	10.0	12.5	15.3	18.2	21.3	24.8	25.1	25.5	26.0	26.3	26.7	27.1	27.5	27.9	28.3	28.7	390	268
Fuel Cells	0.0	6.6	13.0	19.2	24.9	30.5	35.8	40.8	45.6	50.3	54.6	82.5	109.4	135.5	161.0	185.8	209.9	233.7	257.0	279.9	302.5	2279	1468
MCFC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Wind	0.0	16.3	32.4	48.1	63.5	78.6	93.4	108.0	122.1	136.1	149.8	212.4	273.8	334.1	393.1	450.9	507.7	563.3	617.7	671.1	723.5	5596	3618
Photovoltaics	0.0	8.5	16.3	23.3	29.6	35.4	40.4	45.0	49.2	52.8	55.9	92.4	124.9	153.9	180.0	203.6	225.6	246.3	266.4	286.4	307.0	2443	1581
MSW	0.0	16.6	33.3	49.9	66.5	83.1	99.7	116.4	133.0	149.6	166.2	168.8	171.4	173.9	176.4	179.0	181.5	184.1	186.6	189.1	191.7	2717	1886
Industry Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Digestor gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Black Liquor and Wood Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Micro Gas Turbine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Other Biomass	0.0	4.8	9.7	14.5	19.3	24.1	29.9	35.6	41.4	47.1	52.9	64.5	76.0	87.6	99.1	110.7	133.9	157.2	180.4	203.6	226.9	1619	1050
Others	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Total	0	-111	-222	-334	-446	-557	-668	-779	-889	-999	-1107	-1156	-1211	-1272	-1336	-1405	-1470	-1538	-1607	-1678	-1749	-20535	-14035

RESOURCE COSTS

CATEGORY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL	NPV
Primary	0.0	-15.5	-30.8	-45.9	-61.0	-76.0	-93.9	-111.6	-129.0	-146.2	-163.0	-212.0	-260.7	-308.8	-356.3	-403.0	-450.7	-498.8	-547.3	-596.2	-645.5	-5152	-3352
Secondary	0.0	-17.4	-33.6	-48.4	-61.9	-73.7	-91.0	-108.7	-126.9	-145.3	-164.3	-138.2	-114.1	-90.6	-67.8	-45.8	-31.1	-15.9	-0.3	15.8	32.1	-1327	-1028
Total	0.0	-32.8	-64.4	-94.3	-122.9	-149.8	-184.9	-220.3	-255.8	-291.5	-327.3	-350.4	-374.8	-399.4	-424.1	-448.8	-481.7	-514.6	-547.5	-580.4	-613.3	-6479	-4380

PRIMARY RESOURCE COSTS

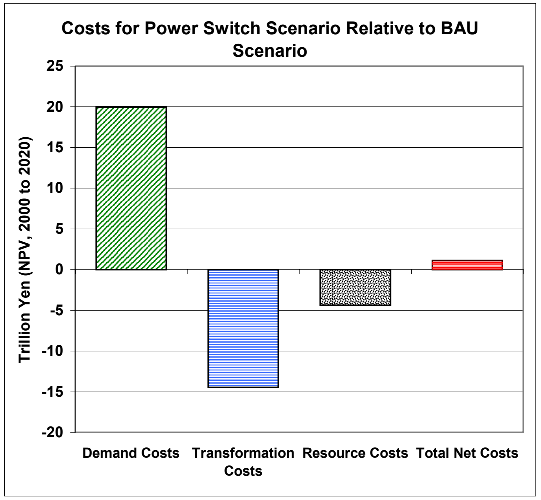
CATEGORY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL	NPV
Nuclear	0.0	-1.8	-3.4	-5.1	-6.9	-8.7	-10.7	-12.9	-15.1	-17.4	-19.8	-32.7	-45.6	-58.4	-71.3	-84.0	-96.3	-108.7	-120.9	-133.1	-145.3	-998	-632
Crude Oil	0.0	1.3	3.0	4.3	5.5	6.4	4.9	3.4	2.0	0.6	-0.6	-16.0	-31.6	-47.1	-62.7	-78.2	-95.8	-114.4	-134.1	-154.7	-176.3	-880	-524
Coking Coal	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	2	1
Coal (bituminous)	0.0	-15.0	-30.4	-45.1	-59.6	-73.9	-88.2	-102.1	-116.0	-129.5	-142.8	-163.6	-183.7	-203.3	-222.4	-240.9	-258.6	-275.7	-292.3	-308.5	-323.9	-3276	-2197
Total	0.0	-15.5	-30.8	-45.9	-61.0	-76.0	-93.9	-111.6	-129.0	-146.2	-163.0	-212.0	-260.7	-308.8	-356.3	-403.0	-450.7	-498.8	-547.3	-596.2	-645.5	-5152	-3352

SECONDARY RESOURCE COSTS

CATEGORY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL	NPV
Residual Fuel Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Refinery Feedstocks	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Petroleum Coke	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Oil (unspecified)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Naphtha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Municipal Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Methanol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Metalurgical Coke	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
LPG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
LNG	0.0	-17.4	-33.6	-48.4	-61.9	-73.7	-91.0	-108.7	-126.9	-145.3	-164.3	-138.2	-114.1	-90.6	-67.8	-45.8	-31.1	-15.9	-0.3	15.8	32.1	-1327	-1028
Kerosene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Jet Kerosene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Heat from Cogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Fuel Oil A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Diesel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Coke oven gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Blast Furnace gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Total	0.0	-17.4	-33.6	-48.4	-61.9	-73.7	-91.0	-108.7	-126.9	-145.3	-164.3	-138.2	-114.1	-90.6	-67.8	-45.8	-31.1	-15.9	-0.3	15.8	32.1	-1327	-1028

Summary for Graphic

PSE minus BAU	Trillion Yen NPV
Demand Costs	20
Transformation Costs	-14
Resource Costs	-4
Total Net Costs	1



Annex 3.5: Summary Cost Comparison Based on LEAP Report

Results Data Compilation for WWF Japan Project
Raw LEAP Results and Summary Graphs and Tables

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/24/2003

COST-BENEFIT SUMMARY RESULTS FROM LEAP

Cumulative Costs and Benefits Compared to BAU_modified Scenario IEEJ Scenario: 2000-2020
(Trillion 2000 Japanese Yen, discounted at 3.0%)

Energy Sector Category	Power Switch with Energy Efficiency	PSE Corrected for Solar Error	PSE Corrected for Solar Error, with Env. Costs
Demand			
Residential	11.54	11.54	11.54
Commercial	5.44	5.92	5.92
Industry	2.54	2.54	2.54
Transport	0	0	-
Transformation			
Transmission & Distribution Electricity	0.02	0.02	0.02
Transmission and Distribution District Heat	0	0	-
District Heat Production	0	0	-
Electricity Generation	-14.04	-14.04	(14.04)
Municipal Gas	0	0	-
Oil Refining	-0.03	-0.03	(0.03)
Coke	0	0	-
LNG Imports	-0.43	-0.43	(0.43)
Coal Mining	0	0	-
Natural Gas Extraction	0	0	-
Crude Oil Extraction	0	0	-
Resources			
Production	0	0	-
Imports	-4.38	-4.38	(4.38)
Exports	0	0	-
Environmental Externalities	0	0	(1.33)
Net Costs	0.66	1.13	(0.20)
GHG Savings (Mill. Tonnes C Eq.)	539.47	539.47	
Discounted GHG Savings (Mill. Tonnes C Eq.)	363.24	363.24	
Cost of Saved Carbon (Japanese Yen/Tonne C Eq.)	1,812.75	3,116.19	

GHG Savings (Mill. Tonnes CO2 Eq.)	1978	1978	
Discounted GHG Savings (Mill. Tonnes CO2 Eq.)	1332	1332	
Cost of Saved Carbon (Japanese Yen/Tonne CO2 Eq.)	494	850	(with CO2 Discounted)
Cost of Saved Carbon (Japanese Yen/Tonne CO2 Eq.)	334	572	(with CO2 Not Discounted)

Annex 3.6: Comparison of Incremental Costs of Power Switch Scenario with Electricity Tariffs

Results Data Compilation for WWF Japan Project
Raw LEAP Results and Summary Graphs and Tables

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/24/2003

COMPARISON OF INCREMENTAL COST OF PSE SCENARIO

With a rough estimate of Japanese electricity prices for 2000-2002 of about $0.20 per kWh
(see, for example, http://www.eia.doe.gov/emeu/international/elecprih.html), or about 21.40 Yen/kWh,
and with the PSE electricity demand as described below, the total discounted retail cost of electricity consumed
is as calculated below.

WWF-Japan11: Net final energy demand in final energy units: demand
Scenario: Power Switch with Energy Efficiency, Fuel: Electricity
Units: thousand gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL	NPV
Residential	265.6	266.5	267.4	268.1	268.8	269.4	269.5	269.5	269.4	269.3	269.1	267.5	265.8	264.1	262.3	260.5	258.7	256.8	254.9	253	251	5547	
Commercial	254.8	256	257.1	258	258.8	259.5	260.8	262	263	263.8	264.4	264	263.4	262.7	261.7	260.6	259.3	257.8	256.1	254.3	252.3	5450	
Industry	426.2	423.9	421.9	419.9	417.8	415.6	415.1	414.6	414.1	413.5	412.9	412.1	411.3	410.5	409.6	408.7	407.8	406.9	405.9	404.9	403.9	8677	
Transport	22	22	22.1	22.1	22.1	22.1	22.2	22.4	22.5	22.6	22.7	22.8	22.9	23	23	23.1	23.2	23.2	23.3	23.3	23.3	476	
Total	968.5	968.5	968.4	968.1	967.5	966.6	967.7	968.5	969	969.2	969.2	966.4	963.4	960.2	956.7	953	949	944.8	940.3	935.5	930.5	20151	
Cost (billion Yen) at average tariff shown above	20726	20726	20724	20717	20705	20685	20709	20726	20737	20741	20741	20681	20617	20548	20473	20394	20309	20219	20122	20020	19913	431231	326644

Discounted incremental Cost of PSE scenario therefore is equivalent to 0.3% of total Japanese retail power costs,
or an increase in tariff of about about 0.07 Yen per kWh

Annex 3.7: Fuel Imports Results from LEAP for Power Switch and BAU Scenarios

Results Data Compilation for WWF Japan Project
Raw LEAP Results and Summary Graphs and Tables

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/24/2003

COMPARISON OF FUEL IMPORTS

WWF-Japan11: Imports: resources
Scenario: BAU_modified Scenario IEEJ, Fuel: All Fuels
Units: thousand gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Primary	4,521	4,567	4,601	4,613	4,624	4,635	4,661	4,687	4,718	4,748	4,771	4,808	4,844	4,880	4,915	4,949	4,982	5,016	5,048	5,080	5,111
Secondary	1,642	1,650	1,669	1,689	1,709	1,728	1,749	1,770	1,792	1,813	1,835	1,843	1,852	1,860	1,869	1,877	1,886	1,894	1,903	1,912	1,920
Total	6,163	6,217	6,271	6,302	6,333	6,363	6,411	6,458	6,510	6,561	6,606	6,651	6,696	6,740	6,783	6,826	6,868	6,910	6,951	6,991	7,031

WWF-Japan11: Primary requirements: resources
Scenario: BAU_modified Scenario IEEJ, Fuel: All Fuels
Units: thousand gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Primary	4,717	4,782	4,792	4,809	4,825	4,840	4,872	4,903	4,933	4,963	4,991	5,030	5,068	5,105	5,142	5,179	5,214	5,249	5,283	5,317	5,350
Secondary	1,707	1,718	1,738	1,758	1,779	1,799	1,821	1,843	1,866	1,888	1,910	1,919	1,928	1,937	1,946	1,955	1,964	1,973	1,982	1,991	2,000
Total	6,424	6,500	6,530	6,567	6,604	6,640	6,693	6,747	6,799	6,851	6,901	6,949	6,996	7,043	7,089	7,134	7,178	7,222	7,266	7,308	7,350
Imports as % of Requirements	95.9%	95.7%	96.0%	96.0%	95.9%	95.8%	95.8%	95.7%	95.8%	95.8%	95.7%	95.7%	95.7%	95.7%	95.7%	95.7%	95.7%	95.7%	95.7%	95.7%	95.7%

WWF-Japan11: Imports: resources
Scenario: Power Switch with Energy Efficiency, Fuel: All Fuels
Units: thousand gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Primary	4,521	4,542	4,552	4,539	4,525	4,511	4,510	4,508	4,511	4,513	4,508	4,472	4,436	4,400	4,363	4,326	4,292	4,257	4,222	4,188	4,153
Secondary	1,642	1,637	1,643	1,649	1,656	1,662	1,667	1,673	1,679	1,685	1,690	1,712	1,736	1,759	1,782	1,805	1,823	1,842	1,860	1,878	1,896
Total	6,163	6,179	6,195	6,188	6,181	6,172	6,177	6,181	6,190	6,198	6,199	6,185	6,172	6,158	6,145	6,131	6,115	6,099	6,082	6,065	6,048

WWF-Japan11: Primary requirements: resources
Scenario: Power Switch with Energy Efficiency, Fuel: All Fuels
Units: thousand gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Primary	4,717	4,766	4,762	4,764	4,765	4,765	4,780	4,794	4,807	4,819	4,829	4,814	4,798	4,781	4,765	4,748	4,736	4,724	4,712	4,699	4,686
Secondary	1,707	1,704	1,710	1,717	1,723	1,729	1,735	1,741	1,747	1,753	1,758	1,780	1,803	1,825	1,848	1,870	1,888	1,906	1,923	1,941	1,958
Total	6,424	6,470	6,472	6,481	6,488	6,494	6,515	6,535	6,554	6,571	6,588	6,594	6,600	6,607	6,612	6,617	6,624	6,630	6,635	6,640	6,644
Imports as % of Requirements	95.9%	95.5%	95.7%	95.5%	95.3%	95.0%	94.8%	94.6%	94.5%	94.3%	94.1%	93.8%	93.5%	93.2%	92.9%	92.6%	92.3%	92.0%	91.7%	91.3%	91.0%

WWF-Japan11: Imports: primary
Scenario: Power Switch with Energy Efficiency, Fuel: All Fuels
Units: thousand gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wood	1.2	1.1	1.1	1.0	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5
Wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nuclear	968.2	941.1	943.3	945.2	946.8	948.0	954.2	960.0	965.4	970.4	975.0	958.7	942.2	925.6	908.9	892.0	876.2	860.1	844.0	827.7	811.3
Natural Gas Liquid	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Natural Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Municipal Solid Waste (MSW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydro	49.9	53.2	53.4	53.6	53.8	53.9	54.1	54.2	54.3	54.3	54.3	54.0	53.7	53.3	53.0	52.6	52.3	51.9	51.6	51.2	50.8
Geothermal	23.2	27.0	27.2	27.4	27.5	27.7	27.8	27.9	28.0	28.1	28.1	27.7	27.2	26.8	26.3	25.8	25.4	25.0	24.5	24.0	23.6
Crude Oil	2,431.1	2,517.1	2,518.6	2,519.6	2,520.2	2,520.5	2,526.6	2,532.2	2,543.4	2,553.5	2,557.9	2,564.4	2,570.4	2,576.1	2,581.5	2,586.6	2,592.3	2,597.6	2,602.7	2,607.6	2,612.1
Coking Coal	475.0	434.0	431.3	428.6	425.9	423.2	422.7	422.2	421.7	421.2	420.7	420.3	419.8	419.3	418.9	418.4	418.0	417.5	417.1	416.7	416.2
Coal domestic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal (bituminous)	571.7	562.7	571.0	557.8	544.4	531.0	518.3	505.4	492.5	479.6	466.6	441.8	417.3	393.0	369.1	345.5	322.5	299.9	277.5	255.5	233.8
Coal (anthracite)	0.0	5.1	5.0	4.9	4.9	4.8	4.7	4.6	4.6	4.5	4.5	4.4	4.3	4.3	4.2	4.1	4.1	4.0	3.9	3.9	3.8
Biomass (unspecified)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	4,520.8	4,542.0	4,551.5	4,538.7	4,525.0	4,510.5	4,509.7	4,507.9	4,511.3	4,512.9	4,508.4	4,472.4	4,436.1	4,399.5	4,362.9	4,326.2	4,291.7	4,257.1	4,222.4	4,187.5	4,152.5

WWF-Japan11: Imports: primary
Scenario: BAU_modified Scenario IEEJ, Fuel: All Fuels
Units: thousand gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wood	1.2	1.1	1.1	1.0	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5
Wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nuclear	968.2	945.2	951.3	957.2	962.8	968.3	979.3	990.1	1000.6	1011.0	1021.1	1034.8	1048.4	1061.8	1074.9	1087.9	1100.7	1113.3	1125.7	1138.0	1150.0
Natural Gas Liquid	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Natural Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Municipal Solid Waste (MSW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydro	49.9	52.9	52.9	52.9	52.8	52.7	52.7	52.7	52.7	52.7	52.7	52.2	51.7	51.2	50.7	50.2	49.7	49.2	48.8	48.3	47.8
Geothermal	23.2	26.9	27.0	27.1	27.2	27.2	27.3	27.4	27.4	27.5	27.5	27.0	26.5	26.0	25.5	25.0	24.5	24.0	23.5	23.0	22.5
Crude Oil	2431.1	2516.4	2517.1	2517.3	2517.2	2516.6	2523.6	2530.2	2542.2	2553.1	2558.3	2574.0	2589.4	2604.5	2619.3	2633.7	2647.9	2661.7	2675.2	2688.4	2701.3
Coking Coal	475.0	434.0	431.3	428.6	425.8	423.1	422.6	422.1	421.6	421.1	420.6	420.1	419.6	419.2	418.7	418.3	417.8	417.4	417.0	416.6	416.1
Coal domestic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal (bituminous)	571.7	584.8	615.1	623.6	632.1	640.3	649.6	658.8	667.8	676.7	685.4	694.2	702.8	711.4	719.9	728.2	736.4	744.5	752.5	760.4	768.2
Coal (anthracite)	0.0	5.1	5.1	5.0	4.9	4.8	4.8	4.7	4.7	4.6	4.6	4.5	4.5	4.4	4.4	4.4	4.3	4.3	4.2	4.2	4.1
Biomass (unspecified)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	4520.8	4567.2	4601.3	4613.2	4624.2	4634.5	4661.3	4687.2	4718.3	4747.8	4771.3	4808.0	4844.1	4879.6	4914.5	4948.8	4982.4	5015.5	5047.9	5079.8	5111.0

WWF-Japan11: Imports: secondary
Scenario: BAU_modified Scenario IEEJ, Fuel: All Fuels
Units: thousand gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Residual Fuel Oil	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1
Refinery Feedstocks	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum Coke	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2
Oil (unspecified)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Naphtha	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4
Municipal Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Methanol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metalurgical Coke	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LPG	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9
LNG	902.4	907.3	925.0	942.8	961.0	979.3	998.6	1018.1	1037.8	1057.7	1077.7	1084.6	1091.5	1098.4	1105.5	1112.5	1119.6	1126.8	1134.0	1141.2	1148.5
Kerosene	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7
Jet Kerosene	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7
Heat from Cogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gasoline	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9
Fuel Oil A	5.1	5.3	5.3	5.2	5.1	5.0	5.0	4.9	4.8	4.8	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diesel	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2
Coke oven gas	24.1	24.8	25.2	25.7	26.1	26.5	27.0	27.4	27.8	28.3	28.7	29.1	29.5	29.9	30.3	30.7	31.1	31.5	31.9	32.2	32.6
Blast Furnace gas	67.4	69.4	70.6	71.8	73.0	74.2	75.4	76.7	77.9	79.1	80.2	81.4	82.6	83.7	84.8	85.9	87.0	88.1	89.2	90.2	91.2
Biogas	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	1642.2	1650.1	1669.3	1688.8	1708.5	1728.4	1749.2	1770.3	1791.6	1813.0	1834.6	1843.1	1851.5	1860.1	1868.6	1877.2	1885.7	1894.3	1903.0	1911.6	1920.3

WWF-Japan11: Imports: secondary
Scenario: Power Switch with Energy Efficiency, Fuel: All Fuels
Units: thousand gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Residual Fuel Oil	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1
Refinery Feedstocks	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum Coke	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2
Oil (unspecified)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Naphtha	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4	286.4
Municipal Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	7.3	11.5	15.8	20.3	24.7	29.1	33.7	38.4	43.1
Methanol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metalurgical Coke	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LPG	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9	196.9
LNG	902.4	898.4	906.9	915.4	923.8	932.2	940.5	948.7	956.8	964.9	972.8	996.3	1018.7	1040.6	1062.2	1083.3	1100.5	1117.3	1133.8	1149.9	1165.7
Kerosene	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7
Jet Kerosene	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7
Heat from Cogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	3.0	4.5	6.1	7.4	8.7	10.1	11.4	12.7
Heat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gasoline	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9
Fuel Oil A	5.1	5.3	5.3	5.2	5.2	5.1	5.0	5.0	4.9	4.8	4.8	4.7	4.6	4.5	4.4	4.3	4.3	4.2	4.1	4.0	3.9
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diesel	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2
Coke oven gas	24.1	23.7	23.1	22.5	21.9	21.3	20.7	20.1	19.5	18.9	18.3	17.1	15.9	14.7	13.6	12.5	11.4	10.3	9.2	8.1	7.1
Blast Furnace gas	67.4	66.4	64.7	63.0	61.3	59.6	57.9	56.2	54.5	52.8	51.1	47.8	44.5	41.2	38.0	34.9	31.8	28.7	25.7	22.8	19.9
Biogas	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	1642.2	1637.1	1643.3	1649.4	1655.5	1661.5	1667.4	1673.2	1679.0	1684.6	1690.2	1712.2	1735.6	1758.8	1781.8	1804.6	1823.3	1841.7	1859.9	1877.9	1895.7

Annex 3.8: Electricity Generation Fuels Supply and Supply Diversity Results from LEAP, Power Switch and BAU Scenarios

Results Data Compilation for WWF Japan Project
Raw LEAP Results and Summary Graphs and Tables

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/24/2003

COMPARISON OF ELECTRIC FUEL SUPPLY AND SUPPLY DIVERSITY

WWF-Japan11: Inputs: processes
Scenario: Power Switch with Energy Efficiency
Units: thousand gigawatt-hour

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wind	0.6	2.7	4.5	6.3	8.1	9.9	11.7	13.5	15.2	17	18.8	25.1	31.3	37.5	43.7	49.8	55.8	61.9	67.9	73.8	79.6
Solar	1.7	5.8	8.9	12	15	18	21.1	24.1	27.1	30.1	33	40.6	48.1	55.6	63	70.3	77.6	84.9	92	99.2	106.2
Residual Fuel Oil	240.5	252.6	250.1	247.5	244.7	241.8	239	236.1	233	229.8	226.5	222.8	219	215.1	211.3	207.4	203.7	200	196.3	192.6	188.8
Refinery Feedstocks	9.4	9.9	9.8	9.7	9.6	9.5	9.4	9.2	9.1	9	8.9	8.7	8.6	8.4	8.2	8.1	7.9	7.8	7.6	7.5	7.3
Petroleum Coke	4.3	4.6	4.5	4.5	4.4	4.3	4.3	4.2	4.2	4.1	4.1	4	3.9	3.9	3.8	3.7	3.6	3.6	3.5	3.4	3.4
Nuclear	968.2	941.1	943.3	945.2	946.8	948	954.2	960	965.4	970.4	975	958.7	942.2	925.6	908.9	892	876.2	860.1	844	827.7	811.3
Natural Gas Liquid	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Natural Gas	637.9	628.2	629.6	630.8	632	633	634.5	635.9	637.2	638.4	639.5	657.7	675.5	692.9	710	726.7	739.4	751.7	763.7	775.3	786.6
Naphtha	8.7	9.1	9	8.9	8.8	8.7	8.6	8.5	8.4	8.2	8.1	8	7.8	7.7	7.6	7.4	7.3	7.1	7	6.9	6.7
Municipal Solid Waste (MSW)	25.7	35.3	43.3	51.2	59.2	67	74.9	82.8	90.5	98.2	105.9	107.5	109.2	110.8	112.4	113.9	115.5	117.1	118.6	120.1	121.5
Municipal Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metalurgical Coke	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LPG	5.6	5.9	5.9	5.8	5.7	5.7	5.6	5.5	5.4	5.4	5.3	5.2	5.1	5	4.9	4.8	4.7	4.6	4.5	4.5	4.4
Hydro	96	99.3	99.5	99.7	99.9	100	100.2	100.3	100.4	100.4	100.4	100.1	99.8	99.5	99.1	98.7	98.4	98.1	97.7	97.3	96.9
Geothermal	34.2	38	38.1	38.2	38.4	38.5	38.6	38.7	38.8	38.9	38.9	38.5	38	37.6	37.1	36.6	36.2	35.8	35.3	34.9	34.4
Fuel Oil A	5.1	5.3	5.3	5.2	5.2	5.1	5	5	4.9	4.8	4.8	4.7	4.6	4.5	4.4	4.3	4.3	4.2	4.1	4	3.9
Electricity	64.5	67	67.1	67.2	67.3	67.4	67.5	67.7	67.8	67.9	68	67.4	66.9	66.4	65.8	65.2	64.7	64.1	63.5	62.9	62.3
Diesel	29.1	32.6	34.5	36.5	38.5	40.7	42.9	45.3	47.8	50.5	53.2	53.8	54.4	55	55.6	56.1	56.7	57.2	57.8	58.3	58.8
Crude Oil	75.4	79.3	78.5	77.6	76.7	75.7	74.8	73.9	72.9	71.8	70.8	69.5	68.3	67.1	65.8	64.5	63.3	62.1	60.9	59.7	58.5
Coke oven gas	24.1	23.7	23.1	22.5	21.9	21.3	20.7	20.1	19.5	18.9	18.3	17.1	15.9	14.7	13.6	12.5	11.4	10.3	9.2	8.1	7.1
Coal (bituminous)	503.1	495.6	483	470.3	457.5	444.6	432.1	419.4	406.7	394	381.2	356.4	331.9	307.7	283.7	260.2	237.2	214.5	192.2	170.1	148.3
Coal (anthracite)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Blast Furnace gas	67.4	66.4	64.7	63	61.3	59.6	57.9	56.2	54.5	52.8	51.1	47.8	44.5	41.2	38	34.9	31.8	28.7	25.7	22.8	19.9
Biomass (unspecified)	41.4	43.7	45.3	46.8	48.4	49.9	51.7	53.4	55.2	56.9	58.5	61.3	64.1	66.9	69.6	72.3	77.9	83.5	89.1	94.5	99.9
Biogas	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	2844	2847	2849	2850	2850	2850	2856	2861	2865	2869	2871	2856	2840	2824	2807	2790	2774	2758	2741	2724	2707

Summary by Fuel Category																					
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wind	0.6	2.7	4.5	6.3	8.1	9.9	11.7	13.5	15.2	17	18.8	25.1	31.3	37.5	43.7	49.8	55.8	61.9	67.9	73.8	79.6
Solar	1.7	5.8	8.9	12	15	18	21.1	24.1	27.1	30.1	33	40.6	48.1	55.6	63	70.3	77.6	84.9	92	99.2	106.2
Petroleum Products	378.1	399.3	397.6	395.7	393.6	391.5	389.6	387.7	385.7	383.6	381.7	376.7	371.7	366.7	361.6	356.3	351.5	346.6	341.7	336.9	331.8
Coal Products	594.9	586	571.1	556.1	541	525.8	511	495.9	480.9	465.9	450.8	421.5	392.5	363.8	335.5	307.8	280.5	253.6	227.2	201.1	175.4
Nuclear	968.2	941.1	943.3	945.2	946.8	948	954.2	960	965.4	970.4	975	958.7	942.2	925.6	908.9	892	876.2	860.1	844	827.7	811.3
Biomass	41.6	43.9	45.5	47	48.6	50.1	51.9	53.6	55.4	57.1	58.7	61.5	64.3	67.1	69.8	72.5	78.1	83.7	89.3	94.7	100.1
Natural Gas	638.4	628.7	630.1	631.3	632.5	633.5	635	636.4	637.7	638.9	640	658.2	676	693.4	710.4	727.1	739.8	752.1	764.1	775.7	787
Geothermal	34.2	38	38.1	38.2	38.4	38.5	38.6	38.7	38.8	38.9	38.9	38.5	38	37.6	37.1	36.6	36.2	35.8	35.3	34.9	34.4
MSW	25.7	35.3	43.3	51.2	59.2	67	74.9	82.8	90.5	98.2	105.9	107.5	109.2	110.8	112.4	113.9	115.5	117.1	118.6	120.1	121.5
Hydro	96	99.3	99.5	99.7	99.9	100	100.2	100.3	100.4	100.4	100.4	100.1	99.8	99.5	99.1	98.7	98.4	98.1	97.7	97.3	96.9
Electricity	64.5	67	67.1	67.2	67.3	67.4	67.5	67.7	67.8	67.9	68	67.4	66.9	66.4	65.8	65.2	64.7	64.1	63.5	62.9	62.3
TOTAL	2844	2847	2849	2850	2850	2850	2856	2861	2865	2868	2871	2856	2840	2824	2807	2790	2774	2758	2741	2724	2707
Diversification Index	0.240	0.233	0.231	0.229	0.227	0.226	0.225	0.224	0.223	0.222	0.221	0.219	0.217	0.215	0.214	0.213	0.212	0.211	0.211	0.210	0.210

WWF-Japan11: Inputs: processes
Scenario: BAU_modified Scenario IEEJ
Units: thousand gigawatt-hour

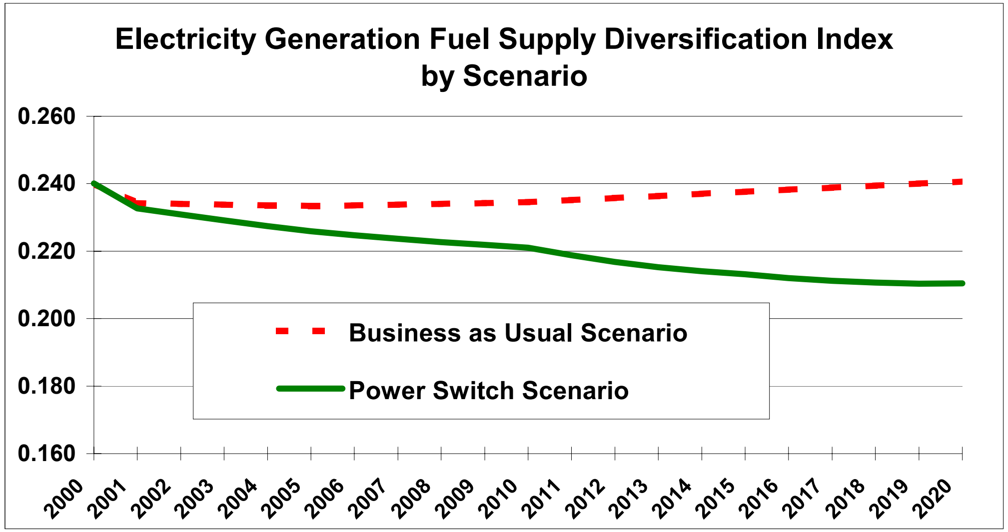
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wind	1	1	2	2	3	3	4	4	5	5	6	6	6	7	7	7	8	8	8	8	9
Solar	2	5	8	10	13	15	18	20	23	25	28	29	30	31	32	33	34	35	36	37	38
Residual Fuel Oil	241	252	249	246	242	239	236	233	229	226	223	223	223	223	223	223	223	223	223	222	222
Refinery Feedstocks	9	10	10	10	10	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Petroleum Coke	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Nuclear	968	945	951	957	963	968	979	990	1001	1011	1021	1035	1048	1062	1075	1088	1101	1113	1126	1138	1150
Natural Gas Liquid	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Natural Gas	638	638	650	662	674	687	700	714	728	742	756	758	760	762	764	766	767	769	772	774	776
Naphtha	9	9	9	9	9	9	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Municipal Solid Waste (MSW)	26	29	31	33	35	36	38	40	42	44	45	46	47	48	49	49	50	51	52	52	53
Municipal Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metalurgical Coke	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LPG	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Hydro	96	99	99	99	99	99	99	99	99	99	99	98	98	97	97	96	96	95	95	94	94
Geothermal	34	38	38	38	38	38	38	38	38	38	38	38	37	37	36	36	35	35	34	34	33
Fuel Oil A	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Electricity	65	68	69	69	70	71	72	73	74	75	76	76	77	77	78	78	78	79	79	80	80
Diesel	29	31	32	32	33	34	34	35	35	36	37	37	37	38	38	38	39	39	39	40	40
Crude Oil	75	79	78	77	76	75	74	73	72	71	70	70	70	70	70	70	70	70	70	70	70
Coke oven gas	24	25	25	26	26	27	27	27	28	28	29	29	30	30	30	31	31	32	32	32	33
Coal (bituminous)	503	518	527	536	545	554	563	572	581	590	599	608	616	625	633	642	650	658	666	673	681
Coal (anthracite)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blast Furnace gas	67	69	71	72	73	74	75	77	78	79	80	81	83	84	85	86	87	88	89	90	91
Biomass (unspecified)	41	42	43	43	43	43	43	44	44	44	44	44	44	44	43	43	43	43	43	42	42
Biogas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2844	2876	2907	2937	2967	2996	3034	3071	3108	3145	3181	3209	3237	3264	3291	3317	3343	3368	3393	3418	3442

Summary by Fuel Category

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wind	0.6	1.3	1.8	2.3	2.8	3.3	3.8	4.3	4.8	5.3	5.8	6.1	6.4	6.7	6.9	7.2	7.5	7.8	8.1	8.4	8.6
Solar	1.7	5.3	7.8	10.3	12.8	15.3	17.8	20.2	22.7	25.1	27.5	28.5	29.6	30.6	31.6	32.7	33.7	34.6	35.6	36.6	37.5
Petroleum Products	378.1	397.1	393.1	388.7	384.5	380.1	376.1	372.1	367.9	363.9	359.5	360.2	360.6	361.1	361.4	361.7	361.8	362	362.2	362.2	362.1
Coal Products	594.9	612.2	623.1	633.8	644.4	654.7	665.7	676.6	687.3	697.9	708.2	718.5	728.8	738.8	748.7	758.5	768.1	777.7	787.1	796.2	805.3
Nuclear	968.2	945.2	951.3	957.2	962.8	968.3	979.3	990.1	1001	1011	1021	1035	1048	1062	1075	1088	1101	1113	1126	1138	1150
Biomass	41.6	42.5	42.7	42.9	43.1	43.3	43.5	43.8	44	44.2	44.4	44.2	44	43.8	43.6	43.4	43.2	43	42.8	42.6	42.4
Natural Gas	638.4	638.9	650.6	662.5	674.7	687.1	700.6	714.3	728.3	742.4	756.9	758.6	760.4	762.2	764.1	766	767.9	769.9	772	774	776.1
Geothermal	34.2	37.9	37.9	38	38	38	38.1	38.2	38.2	38.3	38.3	37.8	37.3	36.8	36.3	35.8	35.3	34.8	34.3	33.8	33.3
MSW	25.7	29.1	31	32.8	34.6	36.4	38.2	39.9	41.7	43.5	45.2	46	46.9	47.7	48.5	49.3	50.1	50.9	51.6	52.4	53.1
Hydro	96	99.1	99	99	98.9	98.8	98.8	98.8	98.8	98.8	98.8	98.3	97.8	97.3	96.8	96.3	95.8	95.4	94.9	94.4	93.9
Electricity	64.5	67.7	68.5	69.4	70.2	71	72	73	73.9	74.8	75.8	76.2	76.7	77.1	77.6	78	78.4	78.8	79.2	79.6	80
	2844	2876	2907	2937	2967	2996	3034	3071	3108	3145	3182	3209	3237	3264	3290	3317	3343	3368	3394	3418	3442
Diversification Index	0.240	0.234	0.234	0.234	0.234	0.233	0.234	0.234	0.234	0.234	0.235	0.235	0.236	0.236	0.237	0.238	0.238	0.239	0.239	0.240	0.241

Summary of Diversification Index Results

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Business as Usual Scenario	0.240	0.234	0.234	0.234	0.234	0.233	0.234	0.234	0.234	0.234	0.235	0.235	0.236	0.236	0.237	0.238	0.238	0.239	0.239	0.240	0.241
Power Switch Scenario	0.240	0.233	0.231	0.229	0.227	0.226	0.225	0.224	0.223	0.222	0.221	0.219	0.217	0.215	0.214	0.213	0.212	0.211	0.211	0.210	0.210



Annex 3.9: Greenhouse Gas Emissions Results from LEAP, Power Switch and BAU Scenarios

Results Data Compilation for WWF Japan Project
Raw LEAP Results and Summary Graphs and Tables

Prepared by:	Masami Nakata and David Von Hippel
Date Last Modified:	9/24/2003

COMPARISON OFGHG EMISSIONS BY SCENARIO

WWF-Japan11: Global Warming Potential (CO2 equivalent)
Scenario: Power Switch with Energy Efficiency, Fuel: All Fuels, GWP: All GWPs
Units: billion kilogramme

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Demand	124.8	125	125.2	125.4	125.5	125.6	125	124.3	123.6	122.9	122.1	122	121.8	121.6	121.5	121.3	121.2	121.1	121	120.9	120.8	2583
Transformation	400.5	401.8	397.3	392.8	388.2	383.5	379	374.5	370	365.4	360.7	354.8	348.8	342.8	336.8	330.8	324.4	318	311.6	305.2	298.8	7486
Total	525.3	526.8	522.5	518.1	513.7	509.1	504	498.9	493.6	488.3	482.8	476.7	470.6	464.4	458.3	452.1	445.6	439.1	432.6	426.1	419.6	10068

2020 as % of 2000 PSE	79.9%
2020 as % of 2020 BAU	68.9%

WWF-Japan11: Global Warming Potential (CO2 equivalent)
Scenario: BAU_modified Scenario IEEJ, Fuel: All Fuels, GWP: All GWPs
Units: billion kilogramme

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Demand	124.8	125.2	125.5	125.8	126.1	126.4	126.3	126.2	126.1	125.8	125.6	125.7	125.8	126	126	126.1	126.1	126.1	126.1	126.1	126	2644
Transformation	400.5	410.6	415	419.3	423.6	427.8	432.5	437.3	442	446.7	451.4	454.8	458.2	461.5	464.8	468	471.2	474.4	477.4	480.5	483.4	9401
Total	525.3	535.8	540.5	545.1	549.7	554.2	558.9	563.5	568	572.5	576.9	580.5	584	587.5	590.9	594.1	597.4	600.5	603.5	606.5	609.4	12045

Difference of total GWP emissions: BAU minus PSE

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Demand	0	0.2	0.3	0.4	0.6	0.8	1.3	1.9	2.5	2.9	3.5	3.7	4	4.4	4.5	4.8	4.9	5	5.1	5.2	5.2	61.2
Transformation	0	8.8	17.7	26.5	35.4	44.3	53.5	62.8	72	81.3	90.7	100	109.4	118.7	128	137.2	146.8	156.4	165.8	175.3	184.6	1915
Total	0	9	18	27	36	45.1	54.9	64.6	74.4	84.2	94.1	103.8	113.4	123.1	132.6	142	151.8	161.4	170.9	180.4	189.8	1977

WWF-Japan11: Environment
Scenario: Power Switch with Energy Efficiency, Fuel: All Fuels, Effects: Carbon Dioxide Non Biogenic
Units: billion kilogramme

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Demand	124.5	124.7	124.9	125	125.2	125.3	124.7	124	123.3	122.6	121.8	121.6	121.5	121.3	121.2	121	120.9	120.8	120.7	120.6	120.5	2576
Transformation	398.3	399.5	395.1	390.6	386	381.3	376.9	372.4	367.8	363.2	358.6	352.6	346.7	340.7	334.8	328.8	322.4	316	309.6	303.2	296.9	7441
Total	522.8	524.2	520	515.6	511.1	506.6	501.5	496.4	491.1	485.8	480.4	474.3	468.2	462.1	455.9	449.8	443.3	436.8	430.3	423.8	417.4	10017

WWF-Japan11: Environment
Scenario: BAU_modified Scenario IEEJ, Fuel: All Fuels, Effects: Carbon Dioxide Non Biogenic
Units: billion kilogramme

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Demand	124.5	124.9	125.2	125.5	125.8	126.1	126	125.9	125.7	125.5	125.2	125.4	125.5	125.6	125.7	125.8	125.8	125.8	125.8	125.7	125.7	2637
Transformation	398.3	408.4	412.7	417	421.2	425.4	430.2	434.9	439.6	444.2	448.9	452.3	455.7	459	462.3	465.5	468.7	471.8	474.9	477.9	480.8	9350
Total	522.8	533.2	537.9	542.5	547	551.5	556.2	560.8	565.3	569.7	574.1	577.7	581.2	584.6	588	591.3	594.5	597.6	600.6	603.6	606.5	11987

Difference of total GWP emissions: BAU minus PSE

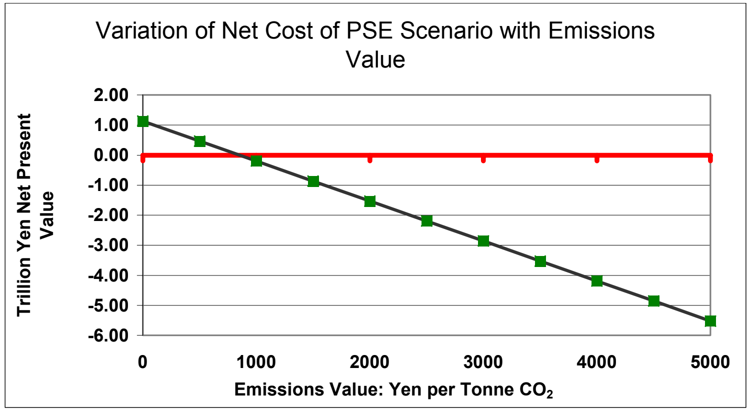
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
Demand	0	0.2	0.3	0.5	0.6	0.8	1.3	1.9	2.4	2.9	3.4	3.8	4	4.3	4.5	4.8	4.9	5	5.1	5.1	5.2	61
Transformation	0	8.9	17.6	26.4	35.2	44.1	53.3	62.5	71.8	81	90.3	99.7	109	118.3	127.5	136.7	146.3	155.8	165.3	174.7	183.9	1908
Total	0	9	17.9	26.9	35.9	44.9	54.7	64.4	74.2	83.9	93.7	103.4	113	122.5	132.1	141.5	151.2	160.8	170.3	179.8	189.1	1969

Value of Emissions at 1000 Yen per tonne CO2
Billion Japanese Yen

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL	NPV
BAU	525	536	541	545	550	554	559	564	568	573	577	581	584	588	591	594	597	601	604	607	609	12045	9037
PSE	525	527	523	518	514	509	504	499	494	488	483	477	471	464	458	452	446	439	433	426	420	10068	7706
BAU minus PSE	0	9	18	27	36	45	55	65	74	84	94	104	113	123	133	142	152	161	171	180	190	1977	1331

Sensitivity Analysis: Net Cost of PSE Scenario in trillion Yen after Environmental Adder of:

	Japanese Yen per tonne Carbon Dioxide										
	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000
(0.20)	1.13	0.47	(0.20)	(0.86)	(1.53)	(2.20)	(2.86)	(3.53)	(4.19)	(4.86)	(5.52)



Emissions Comparison

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Business as Usual Case	525.3	535.8	540.5	545.1	549.7	554.2	558.9	563.5	568	572.5	576.9	580.5	584	587.5	590.9	594.1	597.4	600.5	603.5	606.5	609.4
Power Switch Case	525.3	526.8	522.5	518.1	513.7	509.1	504	498.9	493.6	488.3	482.8	476.7	470.6	464.4	458.3	452.1	445.6	439.1	432.6	426.1	419.6