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NRMP-IEA Input-Output Working Paper No. 15

Projecting Energy Scenarios for Indonesia

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Preface

NRMP-IEA Technological Scenarios

The Natural Resources Management Project (NRMP) assisted by USAID in association with the Institute for Economic Analysis (IEA) at New York University is carrying out a modelling exercise to project the economic, employment and environmental consequences of different development paths for the Indonesian economy. The purpose is to provide advice to the Indonesian National Planning Agency (BAPPENAS) to assist in the development of the next five-year plan (Repelita VI) and the next Long-Term Development Plan. The first stage of this work has already been completed with the support of the Environmental Programming Support Services Project of CIDA.

The analysis, of which the present paper is a component, will provide advice on the trade-offs and complementarities between the growth of income and employment on the one hand, and the levels of natural resource depletion and degradation of the natural environment on the other. For instance, it is important for policy makers to know how the development of the pulp and cement industries over the next 20 years is likely to affect air and water pollution and how costly or cost-saving it will be to adopt cleaner technologies than are being used now.

The analytical framework includes a dynamic input-output model covering all economic activities. The model is dynamic in two senses. First, it incorporates a representation of investment in which levels of sectoral investment depend on expected growth of output, the technology in use and levels of capacity utilisation. Secondly, the model is dynamic in that it explicitly incorporates projections of changes in technology for a range of sectors in the economy, including agricultural sectors, forestry, energy sectors and key manufacturing sectors.

Technological scenarios are developed for each of these sectors using detailed information about likely technological and institutional changes obtained from technical experts. They include expected changes in intermediate inputs, notably energy and raw materials, capital stocks and human resources of different skill types as well as expected changes in natural resource usage and environmental degradation associated with current and alternative future technologies.

This paper is one of a series of working papers prepared by NRMP and IEA researchers in collaboration with industry experts. The papers will form a vital part of the data base for the numerical computations. In addition, they will be valuable as stand-alone analyses of technological futures for a range of important industries in Indonesia.

It should be noted, however, that some of these working papers (especially those on manufacturing sectors) were prepared under severe time limits and should not be taken to represent the last word on technological change in the industries in question.

1. Introduction: the input-output framework[1]

This paper provides analysis of energy consumption, energy savings and electricity generation technologies for the NRMP-IEA dynamic input-output model. The model generates projections of demands for various types of energy and the atmospheric emissions associated with them to the year 2020.

Currently, the principal sources of energy in Indonesia are oil-fired power plants, diesel generators and hydroelectricity as well as petroleum products for transport and industrial use. The economy has been very heavily dependent on oil but the government has, since the mid-1980s, had a policy of diversification of energy sources in order to diminish dependence on oil.

Very large changes in the energy mix will occur in Indonesia over the next 10-20 years. There are two key trends:

- the electrification of households and industry replacing non-electric forms of energy and diesel generation; and
- massive substitution of coal and gas and to a lesser extent geothermal energy for oil in electricity generation.

In estimating demands for various types of energy we will distinguish between electric and non-electric energy. The former include electricity from oil, coal and gas-fired power plants, hydroelectric power and geothermal power. The development of nuclear power is not considered as an option because there remain serious doubts about the economic and environmental viability of a nuclear power program. The principal forms of non-electric energy are refined petroleum, biomass, coal and natural gas.

Demand for energy will derive from various types of energy consumers: households, manufacturing industry, commercial and service sectors, transportation and government and community services. In this paper we focus on households, manufacturing industry and transportation.

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1 In preparing this paper, I have benefited greatly from discussions with Dr Nengah Sudja of PLN, Dr Peter Jezek of the Directorate General of Electricity and New Energy, Mr Robert Dry of the US Embassy and Dr Glenn-Marie Lange of the IEA. However, I take full responsibility for all views and analysis in the paper.

Households: demand for energy will depend on household income and the share of household expenditure on each type of energy, in particular:

- electricity
- refined petroleum
- coal
- natural gas
- biomass.

These in turn will be influenced by the fuel efficiency of the appliances that use energy. Since biomass is mostly a non-commercial form of energy it does not appear explicitly in the input-output model.

Industry: demand for each type of energy will depend on the per unit input of each type of energy and the output of each industry. The former will depend on the technologies used, which will determine the types of fuel used, as well as measures taken to achieve fuel efficiencies. Industrial energy requirements, including expected energy savings due to technological changes in a number of manufacturing sectors, are discussed in Duchin and Lange (1992) and various case studies (see *NRMP-IEA Input-Output Working Papers* Numbers 10-14 and 16).

Transportation: energy demand from the transportation sector depends on the size of the fleet, the types of engines used (petroleum, diesel or natural gas) and the fuel efficiency of the fleet.

Total atmospheric emissions associated with energy use from all sources in 2020 will depend on:

- total energy used;
- the emissions of pollutants for each unit of electric and non-electric energy generated using a given technology.
- the shares of electric and non-electric power;
- the technology used for non-electric energy use (eg. types of boilers, the fuel efficiency of motor vehicles, etc);
- the mix of fuels and technologies used to generate electricity.

These data requirements for the input-output model can be illustrated in the framework provided by the input-output table shown in the two panels of Table 1. In Panel 1, the

columns show fuel or energy used as intermediate inputs in the production of electricity and other fuel-using industries. There are also columns for the relevant final demand sectors -- private consumption, government consumption and exports. The electricity sector shows the intermediate input coefficients required to generate electricity in the given year averaged across the various technologies (power generation methods) that use each type of fuel.

In Panel 2, the electricity sector of Panel 1 is broken down by the types of electricity-generating technology. These are distinguished in the table by the fuels used, other intermediate inputs and capital requirements. At the bottom of Panel 2 are the per unit atmospheric emissions from each type of electricity generating technology.

It should be pointed out that the 'electricity' sector of the BPS input-output tables shows electricity generated by the state-owned electricity utility (PLN) only. In 1985 more than half of electricity supply in Indonesia was generated by private industry and businesses, mostly using diesel generators (details will be given later). This autogeneration or captive generation, as it is known, is reflected in the input-output tables by purchases from the 'petroleum refining' sector (in the case of diesel generators) [2] by auto-generating industries. Thus to the extent that electricity produced by PLN (or privately owned utilities) substitutes for captive generation, we need to reduce the per unit purchases by industry from the petroleum refining sector and increase their per unit purchases from the electricity sector. Some of these coefficient changes will be captured by the projected energy coefficients in the industry case studies being carried out as part of this study (see the *NRMP-IEA Input-Output Working Papers*).

In Table 1, therefore, the second panel shows both the technologies used to generate electricity in the electricity sector and in other industries (captive generation).

We deal with the data needs of Panel 1 first, focussing especially on private consumption, i.e. household energy use. Note that this paper does not develop atmospheric emission coefficients. These are discussed in Duchin and Lange (1992).

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2 It would also be reflected in the capital stock tables as purchases of generators from the 'other manufacturing' sector.

Table 1 Input-output structure of electricity production and energy use

Panel 1: Unit energy inputs into electricity production, industry and final demands

	Electricity	Other industry	Private cons'n	Govt cons'n	Exports
Energy sectors					
Coal	x	x	x	x	x
Natural gas	x				
Petroleum refining	x	x	x	x	x
LNG	x	x	x	x	x
Electricity	x	x	x	x	
Gas utilities		x	x	x	
Other intermediate, labour and capital inputs	x	x			

Panel 2: Unit intermediate input structure and emissions of various types of electricity generation

	Coal steam	Oil steam	Gas steam	Gas CC	Gas turbine	Diesel	Geoth	Hydro
Energy sectors								
Coal	x			x				
Natural gas			x	x	x			
Petrol refining		x				x		
LNG								
Electricity	x	x	x	x	x	x	x	x
Gas utilities								
Other intermediate and labour inputs	x	x	x	x	x	x	x	x
Capital stocks	x	x	x	x	x	x	x	x
Emissions								
CO2	x	x	x	x	x	x	x	
NOx	x	x	x	x		x		
SO2	x	x	x	x		x		

Note: an 'x' indicates a positive input from the row indicated.
CC -- combined cycle

2. Household energy use

Households accounted for around 20 per cent of national fuel consumption in 1990 if non-commercial fuels are not taken into account (Newjec 1993 Task 3, Table 3.5-4). In rural households the principal commercial fuel is kerosine which is used to supplement fuelwood and agricultural waste. As family incomes rise, households tend to switch from non-commercial fuels to commercial fuels, but the switch has been hastened in some areas by declining availability of fuelwood (Newjec 1993, Task 1). In future, it is expected that extensive electrification and the promotion of LPG and city gas in both urban and rural areas will decrease the shares of both kerosine and biomass in household consumption. At present, LPG is popular only among wealthier households because of the significant costs of investing in stoves and gas bottles that must precede its use. In addition, LPG is not available outside larger towns.

The rate of urban electrification has increased rapidly over the last two decades. However, only about one third of villages have been supplied with electricity. According to PLN data residential sales accounted for 32 per cent of total electricity sales in 1990/91 (PLN, 1991, Table 54). Per capita electricity consumption is low by regional standards and only about 33 per cent of households -- 66 per cent in urban areas and 20 per cent in rural areas -- have been connected to electricity supplies (Sudja, 1992, p2).

Newjec (1993, Task 3) makes projections for household energy demand for the period 1990-2019 by regressing demands for electric and non-electric energy on GDP per capita using annual data for the period 1970-1990. In the Newjec analysis non-electric energy excludes non-commercial fuels (biomass). They obtain income elasticities of demand of 2.11 for electricity and 0.85 for other forms of energy. The elastic demand for electricity and the inelastic demand for non-electric energy is probably due to substitution of electricity for other forms of energy as incomes rise. Based on this analysis Newjec calculates future demand for household energy as in Table 2. Their projections, however, do not take into account the impact of energy conservation measures and the energy efficiency of new appliances.

Newjec uses a separate procedure to estimate that in 2019 non-commercial energy, used mainly by households, will be less than one percent (0.65 per cent) of total energy used, down from 36.92 per cent in 1990 (Newjec, 1993 Task 3 Table 3.5-19). However, even industrialised countries continue to rely to some extent on biomass, and its share is unlikely to fall as far as Newjec projects.

Table 2 Newjec's projected household energy demand (base case), 1990-2019 (in millions of boe and GWh)

	1980	1990	2000	2010	2019
Type of energy					
Electric					
. in boe	1.82	5.64	17.49	52.10	122.53
. in GWh	2910	9004	28178	83938	197408
Non-electric					
. in boe	47.83	52.53	92.54	155.63	229.93

Growth rates (% pa)	1980-1990	1990-2000	2000-2010	2010-2019
Electric	11.94	11.98	11.53	9.97
Non-electric	0.94	5.83	5.34	4.43

Notes: Figures for 1980 and 1990 are actual. The projections represent Newjec's 'base case' which lies between the NRMP-IEA high and moderate growth paths.
Source: Newjec (1993) Task No. 3 Tables 3.5-2, 3.5-4 and 3.5-5. The 1985 figure for electricity consumption is from PLN Statistics 1990/91, Table 36.

A USAID report on demand side management of the electricity supply in Indonesia considers energy savings in two end uses, refrigeration and lighting, which together are reported to account for around two-thirds of household electricity consumption (and three-quarters of peak household demand) (USAID, 1992, pIV.17).

Simple changes in construction of refrigerators built in Indonesia would improve their efficiency adding only a small amount to the cost of the appliance but decreasing electricity consumption by refrigerators by 20 per cent.

Use of compact fluorescent lamps instead of standard incandescent bulbs can save up to 75 per cent of the energy that would otherwise be used. Additional savings in energy could also be made by the use of more efficient air conditioners and television sets (USAID, 1992 pp IV.18-IV.19). Perhaps the greatest energy savings could come simply from proper maintenance of electrical appliances, including electrical water pumps.

Putting together these figures, we estimate that increased efficiency could reduce household electricity consumption by up to 25 per cent by the year 2020. This estimate, however, is a best case one; a more realistic estimate would see energy savings of only 10 per cent. Consequently, we adopt levels of household energy savings of 10 per cent in Scenario 1 and 25 per cent in Scenario 2.

The projections of Table 2 represent Newjec's 'base case'. Newjec's high and low growth cases correspond closely to the NRMP-IEA model's high and moderate growth paths (see Hamilton and Hulu, 1993). Projections of household electricity demand on the high and moderate growth paths including assumed levels of energy savings appear in Table 3.

Table 3 Projected household electricity demand under two energy-savings scenarios, 1990-2020 (in GWh)

	1990	2005	2020
Moderate growth path			
Scenario 1	9004	32797	208,426
Scenario 2	9004		149,657
High growth path			
Scenario 1	9004	46085	291,796
Scenario 2	9004		243,278

Source: Table 2 and NRMP-IEA estimates.

The estimates in Table 2 for non-electric energy demand by households are used as a base in the NRMP-IEA analysis but are adjusted to reflect energy savings. Projections of demand for petroleum products for transportation have been developed by Duchin and Lange (1992, Section 3B). It is very likely over the next ten years that the growth of coal briquettes and gas (LNG and town gas) will substitute for a large proportion of biomass and kerosine in households for cooking.

To incorporate household energy savings, two scenarios are defined for fossil fuel consumption. S1 assumes the growth rates put forward by Newjec while S2 assumes 50 per cent savings in petroleum consumption due to more efficient vehicles and 25 per cent greater efficiencies in the burning of coal (see Duchin and Lange, 1992 for more discussion).

(mostly diesel generators) grew from approximately 2.0 GW in 1981-82 to around 8.6 GW in 1991-92 (Sudja 1992, p2).[3]

Since 1986 the Indonesian Government has followed a policy of diversification of energy sources in order to reduce dependence on oil. PLN has shifted away from oil towards coal, natural gas and geothermal energy. The share of oil in PLN power generation fell from around 81 per cent in 1981-82 to around 46 per cent in 1991-92 -- see Table 6. Note that another source (USAID 1992 Exhibit 2-2) puts the share of oil in 1990-91 at 40 per cent, of which 10 per cent was diesel.

Table 6 PLN's electricity production by type of power plant (TWh)

	1981-82	1983-84	1985-86	1987-88	1989-90	1991-92
Steam - oil	4.6	7.4	7.7	7.0	7.2	12.2
Steam - coal	-	-	2.1	6.3	9.3	11.6
Hydro	1.6	1.8	3.0	4.5	6.6	6.6
Diesel	1.4	1.7	2.0	2.8	3.2	3.8
Gas turbine	1.0	1.1	0.9	1.4	1.5	2.6
Geothermal	-	0.2	0.2	0.7	1.0	1.1
Total	8.6	12.2	15.9	22.7	28.8	37.9

Source: Sudja 1992, Figure 5.

It is apparent from Table 6 that most electricity generated by PLN in the early 1990s was from coal and oil-fired power plants. These are conventional power plants located mostly on Java.

It is estimated that in 1985 captive generation accounted for 57.4 per cent of total electricity generation of 29,216.2 GWh. By 1990, this had fallen to 42.6 per cent (Newjec 1993, Task 1, Table A1.1-3).

In 1988-89, captive power generation by private industry was 62 per cent dependent on diesel generators. Natural gas was used by a few industries that depend on natural gas as a feedstock, notably fertilisers, and comprised 7 per cent of captive generation capacity. Hydroelectric power accounted for 11 per cent and wood for 5 per cent (see USAID 1992

3 Note that, based on PLN data, a USAID report (1992, Exhibit 2-10) estimates captive generation at only 6.9 GW in 1990/91.

Exhibit 2-10). There are also many thousands of small diesel generators at the village level.

For the purposes of this analysis we require estimates of the shares of various fuels in total electricity generation, PLN and captive. Using 57.4 per cent as the estimate of the share of captive generation in total generation in 1985, we can derive estimates of fuel use for total electricity generation as in Table 7.

Table 7 Electricity generation by type of fuel used, 1985 (TWh)

	PLN	Captive	Total	Share of total (%)
Oil	7.7	0.4	8.1	21.7
Coal	2.1	0.0	2.1	5.6
Gas	0.9	1.5	2.4	6.4
Diesel	2.0	13.3	15.3	41.0
Hydro	3.0	2.4	5.4	14.5
Geothermal	0.2	2.8	3.0	8.0
Total	15.9	21.4	37.3	100.0

Sources: Column 1: PLN production for 1985-86 from Sudja (1992) Figure 5.
Column 2: Captive generation = 57.4 per cent of PLN plus captive, from Newjec (1993), Task 1, Table A1.1-3; shares (for 1988-89) by fuel used in captive generation from USAID (1992), Volume II, Exhibit 2-10.
Note: in the table, 'oil' refers to residual fuel oil.

Before estimating the shares of various fuels for electricity generation in the future we first need an estimate of the changing share of captive generation in total generation. Sudja and Pambudi (1992, Tables 4 and 5) forecast that the share of PLN and private utilities in industrial electricity consumption throughout Indonesia in 2003 will reach 90 per cent under their high scenario and 62 per cent under their low scenario, an average of 76 per cent. This is likely to be substantially higher by the year 2020. However, outside of Java and Bali there will probably be some continuing reliance on autogeneration for many years because of the costs of taking electricity to remote parts of the archipelago. In addition, the increased availability of efficient and cheap photovoltaics may result in the greater substitution of captive electric energy for non-electric energy. We estimate that in 2020 autogeneration will account for 15 per cent of total electricity generation and that it will be divided equally between diesel, hydro and solar power. Projected shares of PLN and private utility electricity, on the one hand, and captive electricity, on the other, are shown in Table 8. This table assumes that the government's private power program succeeds in

increasing the share of private utilities in total power generation.

Table 8 Shares of utilities and captive generation in total electricity generation, 1985-2020 (%)

	Utilities	Captive
1985	42.6	57.4
1990	57.4	42.6
2003	76.0	24.0
2020	85.0	15.0

Note: 'utilities' includes PLN and private power utilities.
Sources: 1985 and 1990 - Newjec (1993, Task 1, Table A1.1-3); 2003 - Sudja and Pambudi (1992, Table 4); 2020 - NRMP-IEA estimates.

We are now in a position to develop estimates of shares of fuel for electricity generation. Shares of fuels used in 2020 to generate electricity will depend on the availability of fuels, costs of fuels, the capital and operating costs of plants that use various fuels, environmental considerations and the emergence of new technologies. There are two key variables that can be influenced by government. Firstly, there are regulatory, institutional and pricing obstacles to the development of geothermal energy and the discovery and exploitation of natural gas fields, especially smaller fields that under current policies are considered uneconomic to explore or develop (World Bank, 1992). These influence the availability and cost of fuels.

Secondly, there are measures to promote cleaner technologies such as the new clean coal technologies. It is difficult to predict which technologies will be in operation in Indonesia in 30 years time, but it is reasonable to expect that the new clean coal technologies, such as coal gasification, will have reached a sufficiently advanced stage of development and commercial operation. However, the very large-scale investment in conventional coal-fired power stations in the 1990s and early years of the next century, and the 30-50 year life-span of these plants, will see conventional power stations continue to generate a substantial share of total electricity in 2020 and beyond. On this basis we define three scenarios for the generation of electricity, each reflected in different shares of fuels and technologies in 2020.

The three scenarios are:

Scenario 1 (PLN Scenario) This scenario takes PLN forecasts for fuel use to the year 2003 and projects them through to 2020 using a range of information. It includes our estimate

that captive generation will contribute 15 per cent of total electricity, equally divided between diesel, hydroelectric and solar power.

Scenario 2 (Gas Development Scenario) Under this scenario we assume a smaller share of coal and larger shares of gas and geothermal energy. This comes about through appropriate pricing policies developed by the Ministry of Mining and Energy. There is considerable scope for the development of small natural gas fields that under the current pricing policies are uneconomic for development. There are also large reservoirs of geothermal energy which are currently not being used because of the pricing and access policies of Pertamina.

Scenario 3 (Clean Coal Scenario) Under this scenario we assume that in addition to the greater shares of gas and geothermal energy of Scenario 2, some coal is burned using coal gasification methods in combined cycle power plants and all gas is burned in combined cycle power plants.

Building on the information of Tables 7 and 8, Table 9 shows projected shares of fuels and technologies used in 2020 under the three scenarios.

Table 9 Shares of fuels and technologies under different scenarios (%)

	1985	2020		
		S1	S2	S3
Coal				
Coal-fired steam	5.6	45.0	25.5	15.5
Coal - gasified, CC	-	-	-	10.0
Oil				
Oil-fired steam	21.7	-	-	-
Diesel turbine	41.0	5.0	5.0	5.0
Gas				
Gas steam	6.4	-	-	-
Gas CC	-	12.8	20.0	40.0
Gas turbine	-	12.7	20.0	-
Hydro	14.5	17.8	17.8	17.8
Geothermal	8.0	1.7	6.7	6.7
Solar	-	5.0	5.0	5.0
Total	100.0	100.0	100.0	100.0

Note: 'CC' means combined cycle. A dash means zero value.
Source: see text

The capital costs associated with each scenario depend on the capital costs of each type of power generating system and the share of each system in total power generation, as indicated in Table 9. A complete and consistent set of capital cost figures are not available. We have used as our basic source the estimates contained in Prijono (1991, Table II) and supplemented for other technologies from Newjec (1993, Task 5, Appendix 5.3) and our own estimates. These appear in Table 10. The estimates of Table 10 are combined with the changes in shares in Table 9 to calculate the changes in the unit capital costs associated with the future scenarios. These are reported in Table 11 below. It will be assumed that there are no changes in the labour requirements per unit of electricity generated under the three scenarios.

Table 10 Capital costs per unit of energy output (cents/kWh) and thermal conversion efficiencies (%) for various technologies

	Capital cost (cents/kWh)	Feasible thermal conversion efficiency (per cent)
Coal		
Coal-fired steam	2.20	37
Coal - gasified, CC	2.00	45
Oil		
Oil-fired steam	2.26	37
Diesel turbine	1.20	37
Gas		
Gas steam	2.26	37
Gas CC	1.43	45
Gas turbine	1.30	37
Hydro	1.30	-
Geothermal	2.76	-
Solar	2.00	-

Sources: Capital cost estimates for coal-steam, oil-steam, gas-steam, gas CC and geothermal are from Prijono (1991, Table II); estimates for diesel, gas turbine and hydro are derived from figures on capital costs per kW of capacity in Newjec (1993, Task 5, Appendix 5.3); estimates for gasified CC coal and solar are NRMP-IEA approximations only.

Next we need to take account of changes in thermal conversion efficiency (TCE). According to UN estimates, thermal conversion efficiency in Indonesia in 1985 was 28 per cent. In future, we expect this figure to rise significantly due to both improved operating efficiency of power plants and to the switch to combined cycle generation (both natural gas and gasified coal). Whereas coal-fired steam power plants are typically estimated to have a TCE of 37 per cent, gas combined cycle plants are estimated to have a TCE of from 42 per cent to 50 per cent (eg. Sudja, 1992, Table 7, p15).

Duchin and Lange (1992, p27) estimate that to obtain similar improvements in thermal conversion efficiency as well as reductions in transmission and distribution losses, an additional 20 per cent of capital inputs per unit increase in capacity will be required. We assume that this capital outlay improves average TCE from 28 to 37 per cent and that changes in the composition of generating technology account for the rest of the improvement in TCE. Estimates of average thermal conversion efficiency under the three scenarios appear in Table 11.

Losses in transmission and distribution by PLN fell from 20.2 per cent of energy production in 1985 to 15.6 per cent in 1990/91 (PLN, 1991, Table 31, p33). Newjec (1993, Task 5, p3) expects these losses to fall to 9.9 per cent by 2004 and to stabilise at that level thereafter. Own use of electricity by PLN declined from 4.9 per cent in 1985 to 4.8 per cent in 1990/91. Newjec (1993, Task 5, p3) expects no change in this figure in the future. These changes are also reported in Table 11 below.

The first row of the middle panel of Table 11 shows the savings in fossil fuels per unit of electricity delivered that will occur as a result of increases in thermal conversion efficiency and reduced losses in transmission and distribution.

In the input-output framework, the principal inputs into electricity generation are coal, oil and gas, electricity (own use) and capital equipment and construction. The changes in input coefficients expected under each scenario are shown in the lower panel of Table 11.

Table 11 Parameters governing thermal conversion efficiency, losses in transmission and distribution and changing input requirements under different scenarios

	1985	2020 S1	2020 S2	2020 S3
Average thermal conversion efficiency (%)	28	37	39	43
Losses in transmission and distribution (%)	20	9.9	9.9	9.9
Own-use of electricity (% of total)	4.9	4.8	4.8	4.8

Percentage changes in input requirements due to projected increases in thermal conversion efficiency (TCE) and reduced losses in transmission and distribution (T&D) *

Inputs

Fossil fuels	-33	-36	-42
Own-use of electricity	-2	-2	-2
Capital requirements			
. to improve TCE & reduce T&D losses	+20	+20	+20
. due to shifts in technology	+7	+1	0
Total capital requirements	+27	+21	+20

Total changes to input coefficients for electricity production compared to 1985 **

Coal (# 7)	+438	+191	+164
Oil (# 18)	-95	-95	-95
Gas (# 9)	+167	+300	+263
Electricity (own-use) (# 20)	-2	-2	-2
Capital requirements	+27	+21	+20

* Calculated as follows for S1. In 1985 1 tonne of fossil fuels on average *delivered* 22.4 per cent of maximum potential energy (= 28 x 0.8). Under S1 this increases to 33.3 per cent in 2020 (37 x 0.901). This represents a 33 per cent reduction in the amount of fossil fuels required to deliver each unit of electricity.

** Percentage changes in coal, oil and gas coefficients are calculated using the percentage changes for fossil fuels in the middle panel of this table combined with the changes in shares of fossil fuels reported in Table 9. Thus the change in the coal coefficient under S1 is given by [(45.0 x 0.67) - 5.6]/5.6 = 438%.

Note: # indicates NRMP-IEA input-output sector number.

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