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An Analysis Based on the Environmental-Macroeconomic-Model MEMLI, 1990-2020

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Abstract:
This document contains an analysis of CO_2 emissions in Indonesia using the MEMLI model. MEMLI is a disaggregated economy-wide model integrating environmental variables with traditional macroeconomic modelling. Constructing the model and implementing it in the Indonesian central administration has been done through a cooperation between Statistics Norway and the State Ministry of Environment (LH) - assisted by the Central Bureau of Statistics (BPS) - in Indonesia. The project has been carried out under the auspices of a cooperation agreement between the Norwegian Ministry of Environment and the Indonesian State Ministry of Environment. Financial support has been provided by the Norwegian Ministry of Environment. This document is the third report from the project, constituting the end of the agreement period for 1994 and 1995.

Contents

1. Introduction

It is increasingly acknowledged that economic development and environment are intimately linked. All countries and regions experiencing economic growth have seen a rapid increase in the use of energy that impose strains on the environment. For Indonesia, the latest 10-15 years of significant increases in per capita GDP have been partly associated with a surge in industrial production that has also caused environmental problems. The relatively rapid growth of the population just adds to this problem.

Public policies directed at preventing a deterioration of the environment can take many forms. Judicial (direct) regulations have been used in many countries. However, the use of economic instruments for reducing pollution by changing market incentives (prices) has gained increased support. Direct regulation has its strengths in the case of large and few polluters and/or in the case where damages generated by even small quantities of polluting substance are considered intolerable. In other cases, indirect instruments policy may be more powerful and have less side-effects. One important example of this is "environmental taxes". By taxing activities generating negative external effects such as pollution, the polluting agents are induced to pollute less, either by reducing the utilisation of specific production factors (e.g. substitution of machinery and labour for energy), or by reducing the scale of the polluting activity. These green taxes may increase government revenues.

As environmental problems are usually closely connected to economic activities of firms or individuals, most "economic policies" actually affect the environment. Similarly, environmental policies have economic consequences as well. Consequently, any analysis concerning the welfare effects of changes in policy should consider not only the economic effects but also to the environmental factors related to the welfare. Deterioration of the environment, pollution and congestion have negative effects for both individuals and society as a whole and thus become obstacles to economic efficiency. Local air pollution has a direct negative welfare effect, but may increase 'traditional' economic variables such as GDP[1]. The negative effects may take time to appear as does the greenhouse effect. However all should be carefully considered in order to achieve sustainable development. Accordingly, a system that can produce environmental economic indicators serving as a warning of further environmental problems is really needed. This view is supported in the report titled "Our common future" of the World Commission on Environment and Development (UN,1987). The report [2] clearly recognises the need for analytical tools and models capable of analysing problems associated with economic development, energy use and environment in an integrated and comprehensive manner.

This report - and the model building project underlying it - is an attempt at meeting this demand in the Indonesian context. It is a co-project between the State Ministry of Environment (LH)-assisted by the Central Bureau of Statistics (CBS) in Indonesia - and the Norwegian Central Bureau of Statistics (Statistics Norway / SN)). The main purpose of this collaboration is to enable the central administration in Indonesia to carry out comprehensive analyses using a macroeconomic model that takes economic and environmental repercussions between sectors and institutions in the economy and changes in policy and economic development abroad into account.

The report summaries simulation results of various policy scenarios by using the **MEMLI** model (from the Indonesian acronym **M**odel **E**konomi **M**akro-**L**ingkungan **I**ndonesia) as the helping device. MEMLI is based on the 1985 Input-Output (IO) table and Social Accounting Matrix (SAM) of Indonesia. It represents a synthesis of traditional IO modelling, macroeconomic modelling and applied general equilibrium modelling. The model consists of 29 production sectors and 5 institutional sectors

[1] This shows the well-known limitation of GDP as a welfare measure, since e.g. an increase in medical expenditures due to illness caused by pollution will appear as an increase in GDP, not a decrease.
[2] The report is also frequently referred as the **Brundtland** report.

(urban/rural households, government, the corporate sector and the foreign sector). The model integrates elements of resource accounting, as it describes the use of electricity and fuels in physical units and calculates CO_2-emissions from combustion of oil products (fuels).

A macroeconomic model involving environmental variables such as MEMLI can be a powerful tool in analysing problems in environmental and economic policy. Given forecasts for variables not determined in the model (exogenous variables), the model calculates a trajectory for the (endogenous) variables. Thus, by the aid of the model, one can produce scenarios for the economic development and the corresponding development of environmental indicators. That may be interesting in its own right. Alternative scenarios can be worked out by changing the forecasts for certain policy parameters in the model. Changes in e.g. taxes will affect the whole development of the economy and will produce different trajectories for energy use and emissions.

The model can therefore be very useful for assessing important and interesting policy issues since it can provide policy-makers with a menu of policy actions and their corresponding outcomes. Thus it also restricts the range of possible outcomes. It is also possible to continuously improve the quality and usefulness of the model by changing the model specification- as a reflection of assumptions underlying model development - as well as by increasing the quality of data used - in the light of experience and new research results. Therefore, it can be thought as a continuously learning by doing process. In practical applications, the use of the model can increase the quality of the analyses and policy assessments of the State Ministry of Environment.

The report is organised as follows. Chapter 2 contains a short literature review, also containing theoretical concepts underlying the model development and the thinking behind use of macroeconomic models for government policy-making and planning. In chapter 3 an overview of environmental and economic policy issues in Indonesia is given. Chapter 4 describes briefly the main properties of the MEMLI model while chapter 5 describes the results from the simulations. There are two reference scenarios and two policy scenarios. Some concluding remarks of the discussions presented in Chapter 6.

The main conclusions of this report are: Depending on the future overall economic growth in Indonesia, emissions of CO_2 will increase sharply, although at a rate slightly less than GDP. According to the analysis presented here, there are significant possibilities for reducing CO_2 emissions by changing fuel prices. However, unless similar policies are undertaken by Indonesia's trading partners, there will be negative effects on traditional macroeconomic variables such as GDP.

2. Background for the analysis

This report contains an analysis of a possible development of the Indonesian economy in the period until 2020. By using the macroeconomic model MEMLI as a helping device, scenarios for economic variables as well as for the CO_2 emissions have been constructed. This is intended to help policy-makers and the public to see what are possible developments for these variables in the future under varying assumptions. The most ambitious aim, perhaps, is to make the policy-making process more rational, in the sense that one can obtain a common framework for discussing effects on the economy and environment of pursuing different economic and environmental policies. The model can provide such a framework. A scenario where more emphasis is put on environmental policy is outlined in Ch. 5.

This type of analysis mixes elements from different areas of research. It is connected to the literature of (macro-) economic planning. Important in the analysis is to describe the way the economy functions and what are the effects of different policies. The tool for our analysis is a disaggregated economic model for the Indonesian economy. The model relies heavily on data from the national accounts (including the calculation of input-output tables), the social accounting matrix (SAM) and other data sources (data for fuel use and greenhouse gas emissions by different agents in the economy). The model is described in some more detail below. See also Bowitz et. al. (1996) for a full documentation.

In (the simplistic version of the) the planning literature, the planner is seen as a benevolent maximiser of a social welfare function, given the functioning of the economy and factors external to the economy. The planner is also assumed to have an imagination of how the economy functions. This imagination may be in the form of a formal macroeconomic model, but knowledge outside the model is of course also relevant for the analysis. The planner is fixing the policy instruments in order to produce the best outcome under the given restrictions. In the planning process, different policies will be evaluated. The policy giving the highest welfare for the planner is chosen.

Important in this view of policy-making is the notion of a welfare function, comprising the evaluation of the different elements (for example a trade-off between economic growth and a clean environment). The planning process is multi-dimensional. The planner may be interested in the aggregate income of the country, the personal income distribution as well as the regional distribution. Environmental indicators such as emissions and water quality, indicators of health and well-being among the population are only a few indicators that will be highly relevant in evaluating the outcome of a policy analysis. For a thorough description, see e.g. Sen(1963).

But evaluation of the damage to the environment due to pollution is not quantified in money terms in this approach. This is based on the view that to quantify environment damage in money terms is very difficult and to a considerable extent arbitrary. E.g. to calculate an environment-corrected GDP ("green" GDP), where the money value of various environment damages have been deducted, has been the subject of a rather heated debate. Using a green GDP does not say anything about effects of hypothetical changes in environmental policies, even if the damage to the environment has been given a "correct" value, cf. e.g. Aaheim and Nyborg (1995). Indeed, these effects of policy are really what we are interested in. Environmental policy may reduce environmental damage, but may induce other effects of the economy as well, and these effects may be considerable. They can only be analysed by using some form of (formal or informal) economic model of the entire economy.

When it comes to measuring observed environmental changes, this is clearly an accounting task, and elements of this is incorporated in the present analysis. Assessing effects on the emissions of CO_2 from various policies is an integral part of our analysis. But valuing such changes in money terms on a macro level is a very different undertaking. That could, in some circumstances, give results that are more confusing than illuminating.

When the costs of environmental control policies become large, it is even more important to secure cost efficiency of the measures introduced. There is nothing in general that prevents administrative direct environmental regulations to be as cost effective as economic incentives, but economic theory provides arguments in favour of indirect economically oriented control policies in order to obtain cost efficiency. Once more, this emphasise the need for analytical tools capable of treating economic development and emissions to air within a consistent modelling framework. More precisely, our model should be able to produce meaningful answers to questions of the following type: What tax rates are necessary in order to achieve the goals announced with respect to air pollution?

In this report, the macroeconomic model will be used in the following way. First, two reference simulations (scenarios) for the period until 2020 are constructed. They are based on exogenous assumptions of variables that are truly exogenous to the economy. As the model does not cover the full behaviour of the agents in economy, we have to impose exogenous trajectories for variables that are endogenous in the economy, but exogenous in the model (model-exogenous but economy-endogenous). These scenarios are designed to be a "business as usual" scenarios regarding economic and environmental policies. We assume no other measures to combat emissions of CO_2 than those already imposed. In two alternative scenarios, policies are changed in order to measure the economic (in a narrow sense) costs of more environmental-friendly policies, cf. chapter 5.

3. Environmental policy issues in Indonesia

3.1 General aspects

The focus of this report is on the close links that exist between the economic development and air pollution problems. Most important in this respect is the use of energy. Use of fossil fuels like oil and natural gas is the main contributor to air pollution problems, spanning from high concentration levels locally damaging people's health and spoiling the environment of the cities, to global problems like the emission of the most important greenhouse gas: Carbon dioxide (CO_2).

Recent events, like the UN-conference on environment and development (UNCED) in Rio de Janeiro, seem to indicate that one of the main environmental problems of today is related to the man-made enhancement of the greenhouse effect, mainly caused by emission of so-called greenhouse gases, among which carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chloro-fluoro-carbons - CFCs for short - are important.

Another relatively recent global environmental problem is the reduction of the ozone layer in the stratosphere in the region from approximately 15 to 60 km above the Earth's surface. While the depletion of the ozone layer is most pronounced over the Antarctic region due to the local meteorological conditions near the South Pole, it has now been established that the total ozone column at lower latitudes is decreasing at a rate of approximately 4 per cent per decade. Reductions in the ozone layer leads to increased exposure to harmful ultra violet light, causing potential disastrous damage to both plants and animals.

In many countries, the environmental focus has been on emissions of sulphur dioxide (SO_2) and particulate matter. High concentration levels of SO_2 and particulate matter cause respiratory diseases. Also, acid precipitation has increased as a result of local SO_2 emissions. Furthermore, local SO_2 emissions contribute to increases in the corrosion rates of many common materials.

The main man-made (anthropogenic) sources of sulphur emissions are large point sources, e.g. large manufacturing firms. Furthermore, a significant fraction of the SO_2 emissions is due to other processes than burning of fossil fuels. In particular metal production, manufacturing of industrial chemicals, pulp and paper production and production of mineral products are activities with large SO_2 emissions.

Lately, concern about increased emissions of a growing number of a number of local air pollutants has directed the attention to new sources of pollution. While SO_2 is mainly emitted from large point sources, NO_x, CO, and particulate matter are primarily emitted from smaller, more diffusive sources like single dwellings, cars, etc. New control policies, additional to the direct regulation approach used to control SO_2 emissions, are therefore required. In many cases, arguments can be made for extended use of economically oriented control policies, either in the form of tradable emission permits or taxation of emissions. The overall effects of economic instruments of course depend on how the economy functions, i.e. how the economic agents respond to for instance changes in relative prices. Thus, the environmental and economic impacts of economic instruments can most properly be studied by use of economic models in which economic incentives are pursued by the individual agents. To the extent that the price changes induced by the control policy affects more than one sector of the economy, one should use a general, as opposed to partial, economic model, describing the interactions and repercussions between all economic sectors.

Local, regional and global air pollution problems are of course intimately connected. For instance, measures to control the emission of CO_2 will automatically reduce the emissions of local and regional air pollutants like SO_2, NO_x, CO and particulate matter. This is so because the only economically viable means of reducing CO_2 emissions in the foreseeable future, is to reduce the combustion of fossil fuels - an important source for all air pollutants. Furthermore, changes in the use of fossil fuels will affect the demand for electricity, and more generally, the size and structure of economic growth. Policies directed against climate change will thus have implications for economic development through the effects it will have on energy use. There are also other links between the economic development and the state of the environment. Climate change and the destruction of the stratospheric ozone layer will of course have economic impacts. However, while potentially large, these effects are at present extremely difficult to quantify with any precision. Part of the difficulty is that any benefits stemming from the control measures implemented today only will materialise in the future. A better understanding exists of the more immediate economic damage and costs caused by regional and local air pollution, for instance through forest damage, damage to lakes and to human health.

A reduction in emissions of local and regional air pollutants like SO_2, NO_x, particulate matter, etc., are more or less guaranteed when CO_2 emissions are reduced. The opposite is not the case, since local and regional pollutants can be cleaned from the exhaust gases without much affecting the CO_2 emissions. Thus, there exists an asymmetry in the linkage between reductions in CO_2 and other pollutants. This makes it rational to first consider the problem of designing and analysing policies directed against future CO_2 emissions, and only later determine what actions, if any, should be taken to reduce local and regional air pollution. This is the reason why we focus on the greenhouse problem and emissions of CO_2 in our study.

3.2 On energy and environment in Indonesia

3.2.1 Historical development

Indonesia's domestic demand for energy has grown rapidly over the past 25 years, averaging nearly 7% per annum. However, the energy intensity of GDP is still relatively low. With 3% of the world's population, Indonesia consumes only about 0.3% of total energy. Commercial energy consumption per capita in Indonesia is still very low and is 0.272 ton of oil equivalent (toe) compared to Canada (10.009 toe), United States (7.822 toe) and United Arab Emirates (10.874 toe) in 1990. The World Bank estimates that the rapid rise of the consumption of commercial energy in developing countries will dominate energy markets world-wide in 2030 (World Bank, 1995).

In 1988, consumption of commercial energy in industrial countries was mostly in electricity generation, but in eight developing countries (Brazil, China, India, Indonesia, Malaysia, Pakistan, Philippines, and Thailand) consumption was mainly in industry. This growing industrial activity generates most of the serious environmental problems in relation to energy use such as emissions of particulate matter (dust and smoke), sulphur dioxide, nitrogen oxides, unburned hydrocarbons, carbon monoxide, the use of leaded fuels, and the indoor air pollution.

In the past, Indonesia has relied heavily on the development and use of its petroleum resources for power generation, transport and industrial sector needs, as well as a major source of foreign exchange. As a result of the rapid growth of domestic demand, combined with a gradual depletion of reserves, it now appears likely that the country will become a net oil importer as early as the year 2000. World crude oil and gas reserves are still abundant since their annual consumption as a percentage of reserves in 1988 was 2.2 (for crude oil) and 1.5 (for gas), compared to 2.7 and 2.1 in 1970. The world's proven reserves of oil and gas in 1950 stood at 30 billion toe (btoe) and in 1990 more than 250 btoe while the total world consumption over the forty year period was 100 btoe. Estimates of "ultimately recoverable" fossil fuel reserves world-wide are more than 600 times the present annual rate of extraction, which all tell that the reserves are probably sufficient to meet world energy demands for the next century and perhaps longer.

In developing countries, the largest sources of energy is biomass and the next largest sources are coal, oil, and gas (they are called hydrocarbon energy or fossil fuel). Hydrocarbon energy consumption in Indonesia is about 92% of total energy consumption. Proven reserves of coal rose from 450 btoe (in 1950) to 570 btoe (in 1990) and reserves of natural gas have expanded more than fivefold since 1965 (amount to more than 100 btoe in 1990 which is almost as much as the world's proven oil reserves). Since 1978, Indonesia's exports of liquefied natural gas (LNG) have expanded significantly, but these still only account for about 8% of total exports. The use of biomass fuels (firewood, charcoal, agricultural residues) generates smoke containing significant amounts of several important pollutants, including particulates, carbon monoxide, hydrocarbons and nitrogen oxides. Indoor air pollution from such open cookstoves is a risk factor for chronic lung disease for adults and acute respiratory disease for young children. In Indonesia, it is estimated that about 88% of the rural households cook with wood or charcoal, frequently indoors, in stoves without flues and in poorly ventilated kitchens. Given the country's tropical climate, most houses are likely to have relatively high ventilation rates, which tend to reduce indoor pollutant concentrations. In Jakarta households, most kitchens (83%) had ventilation but more than a quarter (28%) of homemakers suffered from respiratory disease.

The growing consumption and production of energy is associated with an increasing environmental impact especially the use of fuels in transport and industry in urban areas. The local impacts of power generation are small since most plants are located in rural areas and their local effects are expected to be limited by appropriate abatement technology. Also environmental impact of energy production such as effluents from coal mines, power plants, geothermal plants are also manageable and should be addressed through the AMDAL process.

Besides local effects, air pollution may also have regional effects. SO_2 and NO_x emissions, carried by winds far beyond the point of origin, result in acid rain, which pollution impacts are on human health, animal and vegetation. Given the expected rapid growth in energy consumption, the possibility of acid rain in the longer term exists. The last effect is the increased concern about Indonesia's potential role in global warming. At several places in Jakarta such as Bandengan, Pasar Baru, and Terminal P.Gadung, the pollution has already been above ambient standard for NO_x and TSP which are 0.05 PPM and 269 µgr/m3 respectively (Djoko Heru Martono). Hence, in stead of reserve concern, environmental concern of the energy development strategy has probably been more important.

The recent rapid economic growth in Indonesia has been accompanied by a significant increase in the use of energy, although not as fast as the GDP increase. While GDP increased by some 50 per cent from 1985 to 1992, total energy consumption (excl. biomass) increased by 40 per cent (sources: National accounts and UN-Energy (1992)). The increase in energy use was particularly rapid in the production sectors of iron and steel, where energy use more than doubled these years. Particularly slow increases took place in the household sector. According to the data, the household sector's energy consumption only increased by 12 per cent or some 1 ½ per cent per annum on average in this period.

In 1992, electricity constituted about 9 per cent of aggregate energy use (excl. biomass) in Indonesia. Nearly 60 per cent of total energy use was combustion of heating oils. Final use of natural gas - dominantly in industry - constituted approximately 30 per cent, while coal constituted less than 2 per cent of total use of energy in Indonesia.

The structure of the electricity sector is very important. This is an area where the outcome in most countries is heavily dependent upon government policies and less on pure market forces. In Indonesia, hydroelectric power has constituted 20-25 per cent of electricity supply.

Geothermal electricity, natural gas and fuel have constituted the rest of the primary energy input into the power generating sector. With a continued growth in energy and more specifically- electricity - demand, coal, natural gas or oil may be a cheaper way than hydroelectric power to expand the electricity capacity. In addition, in the populated areas in Indonesia, the potential for further expansion of the hydroelectric system is practically exhausted. Thus, although electricity is a «clean» energy source, electricity use may induce as large increases in CO_2 emissions than direct use of fossil fuels.

In 1992 CO_2 emissions from combustion of petroleum products in Indonesia was 98 mill. tons, according to calculations based on UN-Energy (1992). The emissions of CO_2 differ significantly between industries. This is partly because the industries are of different size, but also because the sectors differ very much with respect to energy intensity. Table 3.1 below shows CO_2 emissions in 1992 by main economic sector.

Table 3. 1. CO_2 emissions by sector, 1992 (kilotons)

Sector	*Emissions*	*Emissions per unit value added*
Primary sectors	590	0.03
Industry	20800	1.37
Electricity	6600	19.9
Other sectors	53760	0.9
Households	16600	
Total	**98350**	

The primary sectors (agriculture, fishery, forestry, logging) use little energy, both absolutely and especially per unit of value added. The CO_2 intensity is only 2 per cent of the intensity in manufacturing. Also within the manufacturing sector, there are large differences. On average, the service sector is less energy intensive than manufacturing.

3.2.2 Renewable and nuclear energy resources

More efficient use of fossil fuels and a switch from coal to fuels lower in carbon could substantially reduce emissions of carbon dioxide per unit of output. Beyond that, the options would be nuclear energy or renewable energy (primarily solar energy, biomass, geothermal energy, hydropower, and wind). The costs of nuclear stations have risen for a variety of reasons: long lead times and delays in seeking approval, meeting environmental safeguards, and constructing the plants; the costs and risks of disposing of radioactive wastes; and the prospective costs of decommissioning plants. The environmental problems associated with radioactive wastes have not been fully resolved and, as a result, costs have soared and world-wide construction has slowed dramatically.

Nuclear power has the environmental advantage of emitting no greenhouse gases (GHG). In light of nuclear power's status as a major backstop option to reduce GHG. the Government of Indonesia recently commissioned a major study to explore the feasibility of a first nuclear power plant on Java for commissioning in 2005 or soon thereafter. Simply based on generic comparisons, it is expected that the cost of nuclear power will be at least 50% higher than those of coal based generation. On this basis, the nuclear option does not appear to be competitive with coal fired generation, unless there is a willingness to pay a premium equivalent to about $37-64/ton of carbon abatement.

Fossil fuels still have lower costs than nuclear power, except perhaps at low discount rates. But, developments in other renewable energy - solar, wind, geothermal, and biomass - have led to remarkable cost reductions in these technologies. Indonesia is rich in biomass, geothermal, wind and solar resources. For large scale power generation, biomass, solar and nuclear technologies constitute the most likely candidates as backstop technologies. The development and implementation of these backstop options deserve to be considered as an insurance for the contingency that GHG emission growth may have to be stopped in the future. Based on long term expectations of technology development, it is possible that power from these sources could be supplied at a premium of about 20% above current electricity costs.

For non-electric uses of gaseous and liquid fuels, the main backstop technologies are biomass- derived fuels, ethanol or methanol, hydrogen (via electrolysis) using solar or nuclear power as the energy source, or further electrification of the energy markets. As these non-electric options are much more costly, their active consideration in Indonesia should be postponed until technology improvements have made them more economical. Hence, renewable energy is an abundant resource that can be harnessed.

Each year the earth's surface receives from the sun about ten times as much energy as is stored in the whole of the world's fossil fuel and uranium reserves. This energy is equivalent of 15,000 times the world's primary energy demand and can be captured in solar-thermal systems (producing heat for electric power generation and for domestic and commercial uses) or with photovoltaic systems (producing electric power directly from sunlight). Both types of scheme have been considered for the production of hydrogen, which could be used as a transport, domestic, or industrial fuel. Solar energy can also be stored by growing plants and, in the form of biomass, may be used as a feedstock for the production of commercial fuels and electric power. In addition, solar schemes suffer very little from three problems of hydroelectric schemes- the inundation of arable or forested lands, ecological side effects, and displacement of people.

However, in Indonesia solar photovoltaic electrical supply is expensive compared to diesel power and its economic viability is limited to remote communities where the cost of diesel is high and loads are small. The Indonesian Government is currently assessing the feasibility of photovoltaic systems for rural electrification, and about 10,000 photovoltaic systems have already been installed. The capacities of the systems are still 72 kW in Jawa Barat, 48 kW in Lombok Tengah and 157.2 kW for 3145 unit in a numbers of villages in 14 provinces. But in the United States, the costs of all commercial forms of renewable energy have declined remarkably over the past two decades and the costs of solar energy may well fall further. In the high-solar-insolation areas of the US, the costs of electric power from solar energy seem likely to become competitive with those of nuclear power within the next ten years and probably with those of fossil fuels over the long term (in 2020). Consequently, the commercial development of renewables may thus be more justified on non-environmental grounds than e.g. in the US because Indonesia has more high-solar-insolation areas.

Wind energy conversion systems are competitive with diesel-based generation in areas with average wind speeds above 4 m/sec. This type of areas exist in parts of Eastern Indonesia (e.g., East and West Nusa Tenggara), but the potential demand loads are relatively small due to the low population densities. Hence, biomass, solar, and wind energy still do not constitute an alternative to fossil fuels in a large scale.

3.2.3 The potential for energy conservation

Unlike efficiency of production and distribution, energy efficiency among the users of energy has not been concerned. The potential for improved efficiency in the transport sector (35-40% of petroleum consumption) has never been studied. A survey of improvements in the industrial establishments identified a conservation potential of about 23% for all forms of energy used in various industrial processes. The Indonesian government initiated an Industrial Energy Conservation Program under which ONEBA (an energy conservation company) was established. However, its effectiveness is constrained by a number of factors, including a lack of clear institutional objectives and other difficulties.

A major obstacle to the improvement in energy efficiency is that the engineering, architectural, construction, operation and maintenance communities appear to lack both the requisite knowledge of energy efficient technology and the incentives to use this technology. The recent elimination of energy price subsidies have moved the incentives in the right direction. The introduction of pollution-based fuel taxes would provide additional incentives and, at the same time, help to reduce urban vehicle emissions.

3.2.4 Demand side management (DSM) in the electricity sector

The potential for DSM in the use of electricity could, over the longer term, reduce electricity requirements by about 20% on average. The achievement of the actual savings will depend on a variety of factors, including the regulatory framework, the pricing of energy resources and the capacity of public and private institutions to support an effective of DSM activities. Examples of possibly significant savings exist throughout Indonesia. New commercial buildings in Jakarta tend to use flat glass curtain walls, without insulation or exterior sun shading and unitary air-cooled chilling systems.

The trend appears to be towards the adoption of architecture that has been developed in industrialised countries with a temperate climate, with little application of the more traditional and energy-efficient tropical architecture with its sun-shaded exteriors. An indication of the potential savings is suggested by a detailed assessment of potential energy savings in a single 15- story building complex, which concluded that electricity use could be reduced by about 40% through the use of energy efficient building design, centralised water-cooled air conditioning and improved lighting.

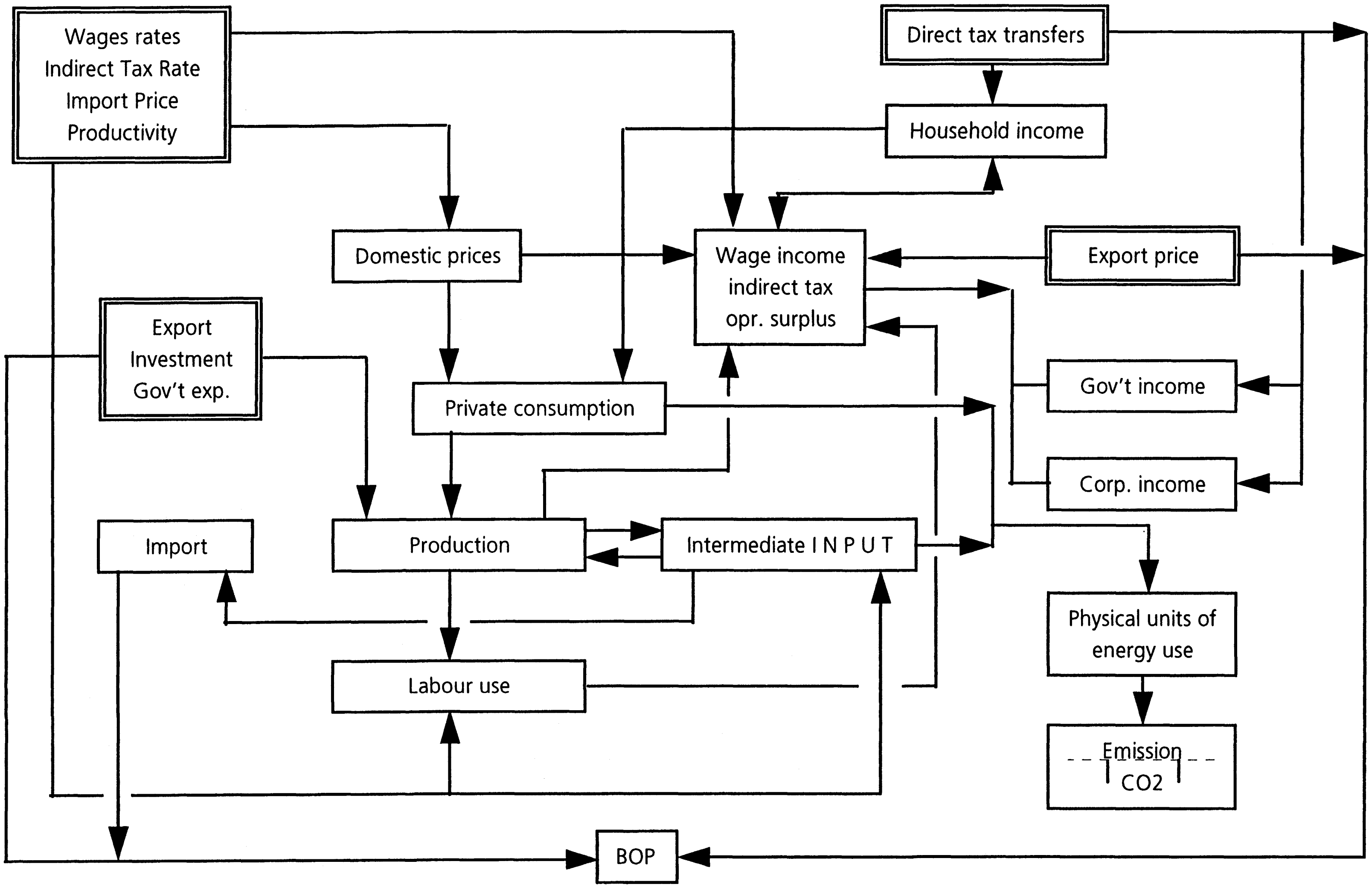
4. Description of the Model

In the last few years, increased concern for the environment has lead to several national and international integrated environment-economy assessments based on macroeconomic modelling. The starting point has typically been the question of what impacts an increase in the prices of fossil fuels will have on future greenhouse gas emissions and economic growth, either on a global scale or on a national/state scale. A recent survey of works in this field is given in Dean et al. (1992). While most of the studies are exclusively concerned with CO_2 emissions from combustion of fossil fuels, some works have included analysis of other air pollutants, e.g., regional or local pollutants such as Sulphur dioxide (SO_2), Nitrogen oxides (NO_x), Carbon monoxide (CO) and particulate matter.

The modelling basis for the analyses vary from extremely aggregated global economic models to more disaggregated national economic models. For Indonesia, there have been a number of modelling projects, of which some have integrated environmental and/or resource variables, see inter alia Lewis (1991), Duchin et al. (1992), SOW-VU (1990a,b), Thorbecke (1991), and Djajadiningrat et al. (1993). To some extent MEMLI synthesises properties of these models.

MEMLI is a model based on the 1985 input-output (IO) table and Social Accounting Matrix (SAM) of Indonesia. It represents a synthesis of traditional IO modelling, macroeconomic modelling and applied general equilibrium modelling. The model consists of 29 production sectors and 5 institutional sectors (urban/rural households, government, the corporate sector and the foreign sector). The model integrates elements of resource accounting, as it describes use of electricity end fuel in physical units and calculates emissions from combustion of CO_2. Demand for fuel depends on relative prices and income. A consistent set of equations describe the responses of households and firms when prices (e.g. as an effect of fuel taxes) and incomes change.

Chart 1: Flow-chart of the MEMLI



Note: - Full boxes are indicating model blocks which determine the endogenous variables.

- Double-line boxes are indicating exogenous variables.

The model contains a number of variables that must be forecasted by the model user (so-called exogenous variables). Given these, the model calculates the values for the endogenous variables. MEMLI is not a complete model, as some variables that are endogenous in the economy (wage rates, export volumes and real investment by sector are the most important) are exogenous in the model. The likely development for these variables must be given by the model user. The model also contains a large number of indirect tax variables and other policy instruments. In Bowitz et al. (1996) a full model documentation is given.

Chart 1 gives a graphical picture of the main structure of MEMLI.

The input-output table constitutes the core of the model. It describes from which sectors each sector's inputs come from, and to which final demand components outputs are delivered. The model distinguishes between 3 types of intermediate inputs; electricity, oil products (fuels) and other intermediate inputs. In the model version utilised in this analysis, the factor intensities in the production sectors are dependent on relative prices, while the rate of factor-neutral (autonomous) technical change must be assessed by the model user. Gross investment by sector must be given by the model user as well. Imports of each commodity is determined by sector-specific input-output coefficients for imports. Given import shares and final demand, intermediate inputs, gross production and imports are simultaneously determined.

For all final demand components, there are IO price equations, where the sectoral domestic and import prices are weighted together. Each sector's output price is assumed to depend fully on unit variable costs, which include the effects of factor prices and factor productivities. In this part of the model, there is also a detailed representation of net indirect taxes, that affect relative prices and the aggregate price level, but also government revenues. The development in the financial markets is not modelled explicitly, although a number of financial flow variables are present in the model. The exchange rate (Rupiah/US dollar) is exogenous.

Unlike many traditional input-output models, parts of final demand is endogenous (in this case - private consumption). This represents the integration of the IO tradition and the traditions of macroeconomic modelling and general equilibrium modelling. Private consumption is distinguished by rural and urban households. Each household group consumes 12 consumer categories. Exogenous population variables determine the absolute size of each group. Private per capita consumption of the different commodities and services in each class is determined by per capita income and relative prices. Electricity and fuels are specified as separate consumption categories. An increase in e.g. the relative price on fuels will induce households to consume less fuels and products that indirectly contain fuels (via the production process), and more of other goods and services.

Incomes and expenditures for the other institutional sectors are modelled consistently. The social accounting Matrix (SAM) constitutes the basis for this part of the model, but significant adjustments to this data source have been made. Household incomes (for each group) are determined by an income block. Household incomes consist mainly of wages, interest and operating surplus. Each group's wage income is derived from employment and exogenous wage rates. A fraction of operating surplus in the non-oil economy accrues to each household group. Household taxes are determined by group-specific average tax rates. Real disposable income is nominal after-tax income deflated by the consumer price index. Household consumption is then determined by exogenous saving rates (urban and rural).

Energy uses in physical units are calculated by using the intermediate inputs and private consumption of electricity and fuels as indicators. Finally, CO_2 emissions are calculated from the energy figures in physical units.

The model also contains a number of financial variables and calculates a number of sectoral balances. These are the current account, government saving and net lending, and household saving. The model for calculating various government revenue flows, such as custom duties, excise taxes and VAT is incorporated into the IO framework of the model.

Important exogenous variables are traditional fiscal policy instruments such as taxes and government consumption and investment. Various indirect taxes are represented in some detail. The model is suitable as a tool for analysing the overall impacts (economic and environmental) impacts of policies aimed at changing the relative prices on e.g. fuels, since it contains a relatively detailed and consistent description of household demand and factor demand in the production sectors. However, the model is not complete. There are a number of variables that are "endogenous in the economy but exogenous in the model". Inter alia this is the case with export quantities and prices, import shares and gross investment (capital formation) by sector, as well as wage rates. These variables must be given by the model user. Modelling these variables are possible directions for further development.

The model as it stands must be labelled as a 'demand-driven' macroeconomic input-output model, but including important elements from the general equilibrium modelling tradition. The supply of production factors (e.g. the available labour force) does however not constitute any formal limitation of the level of aggregate production. This means that in practical use, the model user must assure himself that the model-calculated employment, production and energy use can be realised within the limits of the available resources.

5. Results of Model Simulations

This chapter describes results of two reference scenarios and two policy simulations for the Indonesian economy using the MEMLI model. The aim of the reference scenarios is to point out possible developments in major macroeconomic and environmental variables. Forecasts for important variables are taken from reports and policy documents. We have relied much on World Bank (1994). A central property of the reference scenarios is "business as usual". This means that no particular policies are pursued to reduce fuel uses and thus emissions. Especially, it means that the domestic real price of fuel is not changed by means of taxes or subsidies. The two reference scenarios differ regarding foreign and domestic economic growth and can be labelled a high-growth and a low-growth scenario, respectively.

In the construction of scenarios for the Indonesian economy, we have done the following:

- Since the model's base year is 1985, a simulation that largely reproduces the observed development from 1985 to 1990 (or later, if data are available), has been made. The year 1990 has been chosen as the benchmark year for the simulation. Thus, even if the base year for the model is 1985, we can simulate as if actually the starting year for our analysis was 1990.

- We have made forecasts for important foreign variables such as market growth for Indonesia's trading partners. Export quantities are exogenous in the model, so assumptions on export growth for all commodities had to be made. The same applies to the world market prices on Indonesian import goods and the exchange rate. Assessments have also been made regarding the size of the urban and rural population. Policy variables such as direct and indirect tax rates have also been forecasted.

5.1 The reference scenarios

In order to get an impression of what are the prospects for emissions unless specific policy is implemented, we have constructed two reference scenarios (called scenario 1 and scenario 2). In scenario 1 economic growth for Indonesia's trading partners is high, resulting in strong growth in

Indonesian exports. In scenario 2 economic growth abroad is less rapid and also productivity increases in the domestic economy is assumed to be lower than in scenario 1. Most assumptions on exogenous variables are however the same in the two scenarios.

5.1.1 Scenario 1 - the high-growth scenario

Basic assumptions used in scenario 1 are:

- Price increases on internationally traded goods of 3 per cent annually.
- 5 per cent annual depreciation of the Rupiah against US dollar.
- 5 per cent annual decrease in labour requirement per unit output
- 0.5 to 1 per cent annual decreases in energy requirement per unit output
- 6-7 % annual growth in gross investment (capital formation)
- 12-13 % annual growth in exports of non oil products
- 1-2 % annual growth rates in import shares
- a peak in the level of oil production from year 2000, but not for natural gas
- 7 % annual growth in government consumption
- Increases in wages and salaries by 12.5 %, except for government sector 4.5 %
- Decreases of custom duty rates to 0 % by year 2020 except for primary sector products which is reduced by 50 %. All are due to the implementation of AFTA and APEC
- Annual increases in output per man-hour per sector:
- Primary sectors 3%, Manufacturing 6%, Services 4%

The main results of scenario 1 are shown in **Table 5.1.1.a.** In both reference scenarios, population is assumed to continue growing, but at a slightly declining rate. The present differences between the growth in urban and rural populations are assumed to persist. While 29 per cent of the population was classified as living in urban areas in 1990, the number will be about 42 per cent in 2020, according to population forecasts taken from World Bank (1994). As the consumption pattern differs quite significantly between urban and rural households, this development is important for the overall growth in consumption of various commodities in the future.

From 1985 to 1990, GDP increased by 6.7 per cent annually on the average. The growth then increases to 8 % afterwards in scenario 1. Annual growth in GDP per person employed is 4-4,5% per year in scenario 1, and is largely a result of the assumptions on output per man-hour in the different sectors. Both real investment, private and public consumption increase less than GDP, while exports and imports have annual growth rates significantly larger than GDP growth rates. Domestic consumer price inflation in the scenario is around 6 % annually.

CO_2 emissions are also increasing, but with a slightly lower growth rate than GDP. Still, CO_2 emissions increase 9-fold from 1990 to 2020 under our assumptions. The highest growth is CO_2 emissions are in household consumption, which increase from 8 to 10 % annually during the period. This is because energy consumption is assumed to have a high income elasticity. Another factor contributing to this is the increasing urbanisation.

MEMLI distinguishes between rural and urban households. Urban households have a higher per capita income, and consume a larger fraction of their incomes on energy-intensive products, than rural households. The budget share for food is considerably higher in rural households than in rural households. Even with constant budget shares, an increase in the fraction of the population living in cities will contribute to increased use of energy-intensive products. And in addition, energy-intensive products have a larger income elasticity than less energy-intensive products. In the model, there are such effects included, although the actual magnitudes of the effects are uncertain. An increase in per capita incomes both in rural and urban households imply increased budget shares for energy-intensive goods in both household classes. The energy-intensive goods are fuels (for heating and private cars) as well as consumption of transport services (land, water and air transport). **Table 5.1.1b** shows average annual growth rates for private consumption of different goods and services.

The macro figures indicate an increase in the fuel use (higher than GDP growth). However emissions per unit of GDP is actually decreasing since the growth of CO_2 emissions is lower than that of GDP. Increased energy efficiency are taken account of by the energy/output coefficients for each sector and the demand effect by the fact that transport and other energy-intensive products have a relatively high income elasticity (cf. appendix 1 in Bowitz et al. (1996)). In the reference simulation we have assumed 1 per cent annual increases in energy efficiency in the primary sectors and the manufacturing sectors. For services we have assumed 0.5 per cent annual increases. We also have assumed that the fuel input fraction of output in the production of electricity, is unchanged. That might imply that increases in electricity production beyond today's levels, partly will have to be covered by other energy sources than fuels. These are hydro, thermal or nuclear. If it is not possible to supply electricity without increasing the oil input share in the electricity sector, the reference simulation presented here will under-estimate the fossil-fuel use and consequently the future CO_2 emissions.

The sectoral composition of the economy depends very much on the domestic demand, in which private consumption is the larger part, cf. above. **Table 5.1.1.c** summaries the average annual changes in sectoral value added of scenario 1. It can be seen that the value added growth of Manufacturing and Services are higher than that of other sectors. The lowest sectoral value added growth is in the petroleum sector. It is due to the often made assumption that the potential for future growth in oil extraction will soon be exhausted. The primary sectors have relatively low growth partly because we have assumed lower-than-average productivity growth, but also because low income elasticity of demand for primary sector products (mainly food). The picture is the opposite for private services (which here include the transport sector), having a high income elasticity. The assumed export development is also important for the sectoral development. We have assumed somewhat stronger growth in manufacturing exports than in non-manufacturing exports (exports from primary sectors are assumed to grow by only 2 per cent per year). There seems to be a widely held view that prospects for large increases in Indonesia's petroleum production are modest.

Table 5.1.1.a Average Annual Changes of Concerned Variables (%) Scenario 1

Variable Concerned	*1985-1990[1)]*	*1990-2000*	*2000-2010*	*2010-2020*
A. Macroeconomic Aggregates				
1. GDP	6.7	8.1	8.2	8.0
2. Employment	2.7	4.6	4.5	4.2
3 Investment	10.8	7.2	6.3	7.1
4.Prices:				
a. Gov't. consumption	9.6	5.7	6.2	6.2
b. Private consumption	7.8	6.2	7.0	7.2
B. Consumption				
1. Government	4.7	7.0	7.0	7.0
2. Household	5.8	8.7	8.4	7.7
C. External Condition				
1. Exports	9.4	8.9	10.1	10.1
2. Imports	6.7	9.8	9.9	10.5
D. CO_2 Emissions By Sectors				
1. Primary	2.4	6.8	7.2	6.2
2. Transport & Manft.	2.6	7.6	7.6	7.0
3. Other Sectors	6.4	7.2	7.2	7.2
4. Household	8.0	8.3	9.6	7.6
5. Total	5.5	7.7	8..0	7.2

1) The growth rate 1985-1990 was based on 1983 price

Table 5.1.1.b Average Annual Changes of private consumption of different goods and services (%) Scenario 1

Consumption goods category	*1985-90*	*1990-2000*	*2000-2010*	*2010-2020*
Food, beverages etc.	5.6	8.0	7.8	7.6
Energy (fuel+electricity)	7.9	8.1	9.8	7.8
Manufactured goods	4.2	9.7	8.3	7.6
Transport services	6.7	9.8	9.1	7.8
Other services	6.2	9.6	8.9	7.9
Total	5.8	8.7	8.4	7.7

Table 5.1.1.c Average Annual Changes of Value Added by-sectors in the reference scenario (%) Scenario 1

Sector	*1985-90*	*1990-2000*	*2000-2010*	*2010-2020*
Primary sectors	5.2	7.8	7.9	7.4
Manufacturing	9.6	10.3	9.8	9.3
Mining excl. oil	5.5	9.1	6.3	6.8
Petroleum prod	4.3	3.8	4.1	3.2
Private services	7.2	9.3	9.1	8.8
Governm. services	4.7	7.0	7.0	7.0

5.1.2 Scenario 2 - the low-growth scenario

The growth perspectives of scenario 1 may seem too strong. To show a possible development with lower growth in the Indonesian economy, scenario 2 - the low-growth scenario has been constructed. Many assumptions are identical to assumptions in scenario 1. The main differences compared to scenario 1 are:

- The percentage annual increases in output per man-hour in the production sectors are one half of what they are in scenario 1
- Investment growth is reduced by 1 % per year, as capital requirements are lower with lower overall growth
- Growth in exports of non-oil goods is reduced by 2-3 per cent per year
- In order to maintain government finances, growth in government consumption is reduced to 5 % per year
- Increases in wages and salaries are lower than in scenario 1, accommodating lower productivity growth. In scenario 2 average annual wage growth is 9.5 % in all sectors, except for government sector, where growth is 2.0 %

Table 5.1.2.a summarises changes in aggregate macroeconomic and environmental variables in scenario 2. The average annual GDP growth is some 2 % lower than in scenario 1. Private consumption growth is slightly higher than GDP growth in most of the simulation period, as was the case in scenario 1. As a consequence of the lower GDP growth, the growth in CO_2 emissions is also significantly reduced, compared to scenario 1. The highest growth is still CO_2 emission from the households which increases from 6 % to 7 % annually during the period.

Table 5.1.2.b summarises changes in private consumption of scenario 2. The pattern of average growth rates is very similar to the pattern in scenario 1, although the growth rates are smaller than in scenario 1.

Table 5.1.2.c summarises the changes in sectoral value added of scenario 2. As in scenario 1, the value added growth of Manufacturing and Services is higher than that of other sectors, while the petroleum sector has the slowest growth.

Table 5.1.2.a Average Annual Changes of Concerned Variables (%) Scenario 2

Variable Concerned	*1985-1990*[1)]	*1990-2000*	*2000-2010*	*2010-2020*
A. Macroeconomic Aggregates				
1. GDP	6.7	6.6	5.9	6.7
2. Employment	2.8	4.7	4.0	4.9
3. Investment	10.8	6.2	5.4	6.1
4.Prices:				
a. Gov't. Consumption	9.6	5.6	5.9	6.0
b. Private Consumption	7.8	6.2	6.6	6.8
B. Consumption				
1. Government	4.7	5.2	5.0	5.0
2. Household	5.8	7.1	5.9	6.7
C. External Condition				
1. Export	9.4	7.4	7.1	8.1
2. Import	6.7	7.9	7.2	8.0
D. CO_2 Emissions By Sectors				
1. Primary	2.4	5.1	4.7	5.5
2. Transport & Manufct.	2.6	6.0	5.4	6.0
3. Other Sectors	6.4	5.8	5.4	5.9
4. Household	8.0	6.0	6.9	7.0
5. Total	5.5	6.0	5.7	6.2

[1)] The growth rate 1985-1990 was based on 1983 price.

Table 5.1.2.b Average Annual Changes in private consumption of different goods and services (%) Scenario 2

Consumption goods category	*1985-90*	*1990-2000*	*2000-2010*	*2010-2020*
Food, beverages etc.	5.6	6.5	5.5	6.6
Energy (fuel+electricity)	7.9	5.9	7.0	7.1
Manufactured goods	4.2	8.1	5.7	6.4
Transport services	6.7	8.1	6.6	6.8
Other services	6.2	7.8	6.2	6.7
Total	5.8	7.1	5.9	6.7

Table 5.1.2.c Average Annual Changes of Value Added by-sectors in the reference scenario (%) Scenario 2

Sector	*1985-90*	*1990-2000*	*2000-2010*	*2010-2020*
Primary sectors	5.2	6.3	5.5	6.5
Manufacturing	9.6	8.6	7.3	8.1
Mining excl. oil	5.5	8.2	5.2	5.4
Petroleum prod	4.3	3.6	3.7	3.6
Private services	7.2	7.5	6.4	7.1
Governm. services	4.7	5.2	5.0	5.0

In both scenarios the CO_2 emissions increase slightly less than GDP. Production in CO_2-intensive sectors increase more than GDP, but the assumed increased energy efficiency counteracts this. Being about 90 mill. tons in 1990, CO_2 emissions increase to some 830 mill tonnes in 2020 in scenario 1 and

520 mill. tonnes in scenario 2. A development along these lines may not be desirable. Policies to limit emissions may have to be considered. What would be the effects of such policies ? That is the topic of the next section.

5.2 Results from policy simulations

In order to analyse the effects of possible policy changes in Indonesia, we report results from two partial policies. In the first we analyse environmental and macroeconomic effects of increasing domestic fuel prices by means of taxes[3] on domestic use of fuels. This reduces fuel use and emissions and increases government saving. One possibility for the government is to reduce other taxes, in order to keep government saving unchanged. The partial effects of this policy is also analysed. Finally, we consider the possible effects of a combination of these policies.

5.2.1. Increased fuel taxes to curb CO_2 emissions

In this section, we will look at the effects of increasing fuel taxes in order to limit the use of fossil fuels and thus CO_2 emissions. This will directly raise prices of fuel products. Consumer prices will rise and consumer demand for these products will decline. Input prices in the production of other goods will also increase. This will induce firms to substitute non-energy inputs (materials and labour) for energy. Also electricity prices will rise, because a large fraction of electricity is produced by fossil fuels. Production costs will rise, and will rise most for energy-intensive products. According to the model, this will be passed through to product prices, which in its turn again will induce substitution in private consumption. Export volumes, export prices, import shares and wage rates are exogenous in the model. To make the analysis more realistic, we have assumed that these variables also change when fuel taxes increase. We assume that wage-earners are partially compensated for the increase in consumer prices.

In the policy experiment presented here we have increased fuel taxes from its present level of zero, to 20 % of the price excl. the fuel tax. That amounts to a fuel tax of approximately 10 US dollar per tonne CO_2 (1996 prices). With this fuel tax and with an assumed overall increase in wage rates of 3 per cent in the long run, the final increase in the consumer price index is 4 %. Thus we have assumed less than full pass-through of increased consumer prices onto wages. One reason for this may be that the profitability in the firms has been reduced, since their competitive position vis-à-vis foreign firms, has deteriorated. In addition to increased wages, we have reduced exogenous exports for manufacturing products by 3 per cent and an increase in export prices of the same magnitude. Increased domestic costs is according to our analysis passed through onto export prices as well, giving lower foreign demand towards Indonesian goods. Higher domestic costs because of the fuel tax is assumed to increase import shares for manufacturing products by 2 %. In order to obtain a reasonable time path of the response, these changes in exogenous variables have been imposed gradually from 1995 to 2003, remaining constant from then on.

In **Table 5.2.1** the effects of imposing the fuel tax is shown. Next, an expansionary fiscal policy equal in absolute value to the size of the fuel tax is shown. The partial effect of that policy is shown in **Table 5.2.2**. The combined effects of policy 1 and policy 2 are shown in **Table 5.2.3**. The policy changes are imposed from 1996 to 2020. The effects are measured as differences from the reference simulation.

[3] An increase in the price of the domestic deliveries from the government oil company will have similar effects.

Table 5.2.1 Policy 1. Macroeconomic effects of imposing a fuel tax of 10 US dollar per ton CO_2. (% difference from reference simulation unless otherwise stated).

Variables	*1996*	*2000*	*2010*	*2020*
Price of fuel consumption	16.5	17.1	17.5	17.6
Fuel consumption	-15.2	-15.0	-14.7	-14.3
Average consumer prices	2.0	3.2	4.0	4.0
Private consumption	-2.2	-1.6	-2.5	-2.5
GDP	-1.1	-0.8	-1.7	-1.9
Exports	0.2	0.1	-1.2	-1.6
-non-petr. exports	-0.5	-1.1	-2.3	-2.3
Imports	-0.8	-0.3	-0.8	-1.0
Employment	-1.3	-0.4	-1.3	-1.3
CO_2 emissions	-5.1	-9.4	-12.3	-12.4
Gov't. saving1)	0.5	0.5	0.4	0.1
Current account 1)	0.1	0.2	0.0	0.1

1) Per centage points of GDP

An increase in the overall price level together with less than full compensating increase in nominal wages will reduce the real income of the households. This gives lower private consumption. Lower exports of non-oil products and higher import shares, are also important factors in producing a lower GDP. Petroleum exports increase due to lower domestic demand and production determined from the supply side.

The fuel tax rises domestic prices, most on fuel products. As the effects feeds through the economy, also other prices rise. Production costs in sectors using energy directly and indirectly rises. The shift in relative factor prices induces factor substitution in the firms and shifts in the households purchases of the different consumption goods. Increased fuel prices motivate a reduction of fuel consumption and consumption of transport services. Consumption of less energy-intensive goods declines less than average consumption. The factor substitution takes time, as changes in energy intensity must follow investment in new equipment in the production sectors. That is the reason why CO_2 declines by 5 % in the first year while the decline is more than 12 per cent in 2020. The economy becomes more labour-intensive. Although GDP declines, factor substitution makes employment decline less than GDP. The increased government revenues from the fuel tax is the reason why government saving has improved. The current account changes little, since reduced export volumes are linked to increased export prices. Neither does imports change much; lower domestic demand is a factor contributing to lower imports, while the assumed increases in sector-specific import shares is an impulse to higher imports.

Thus, the total effect of introducing a partial fuel tax without Indonesia's trading partners doing the same, will depress the economy. But government revenues will increase. If the government wants to (and the current account allows it), it may reduce other taxes or increase other subsidies. It might for example reduce income taxes, or increase food subsidies, if the distributional impacts of a fuel tax is considered undesirable. Or the authorities may choose to increase government consumption or investment.

5.2.2. Reducing household taxes by 1 percentage point of pre-tax income

We here consider the possibility that the government can reduce taxes with the same amount as the increase in government saving stemming from the CO_2 tax. This is equivalent to a tax reduction for the two household groups of approximately 1 percentage point. The results of this partial tax change are shown in **Table 5.2.2.**

Table 5.2.2 Policy 2. Macroeconomic effects of a reduction of household taxes by 1 percentage point of pre-tax income (% difference from reference simulation unless otherwise stated).

Variables	*1996*	*2000*	*2010*	*2020*
Price of fuel consumption	-	-	-	-
Fuel consumption	2.8	2.8	2.2	2.1
Private consumption	2.0	2.0	1.9	1.9
GDP	1.0	1.0	1.0	0.9
Employment	1.3	1.3	1.3	1.3
CO_2 emissions	1.4	1.4	1.3	1.2
Gov't. saving 1)	-0.4	-0.5	-0.5	-0.5
Current account 1)	-0.2	-0.3	-0.3	-0.3

1) Per centage points of GDP

There is an expansionary effect on the economy of lowering taxes. Due to the multiplier effect, private consumption increases relatively more than the initial tax reduction. As government consumption, exports and investment are all exogenous in MEMLI, the proportional GDP increase is smaller than for private consumption. Employment increases more than does GDP. This is because increased private consumption is directed towards the relatively more labour-intensive sectors of the economy, inter alia agriculture. In each sector, employment increases pari passu with value added. The reduction in government saving is approximately equal in absolute value to the change brought about by increasing fuel taxes. The increase in GDP, however, is smaller than the GDP decrease produced by introducing the fuel tax.

The results of combining the two simulations are shown in **Table 5.2.3**. GDP is still reduced, but the reduction is smaller than when only fuel taxes were increased. Also the effects on employment and the current account is still negative. Consequently, in our analysis of Indonesia unilaterally imposing "green taxes", we do not find a "double dividend" where pollution is reduced while at the same time traditional macroeconomic variables like GDP increase at the same time. However, this is not the same as saying that it will not increase welfare.

Table 5.2.3 Policy 1 and Policy 2. Macroeconomic effects of the combination of a fuel tax and a reduction of household taxes by 1 percentage point of pre-tax income (% difference from reference simulation unless otherwise stated).

Variables	*1996*	*2000*	*2010*	*2020*
Private consumption	-0.2	0.4	-0.6	-0.6
GDP	-0.1	0.2	-0.7	-1.0
Employment	0.0	0.9	0.0	0.0
CO_2 emissions	-3.7	-8.0	-11.0	-11.2
Gov't. saving 1)	0.1	0.0	-0.1	-0.4
Current account 1)	-0.1	-0.1	-0.3	-0.3

1) Per centage points of GDP

6. Concluding remarks

This report has shown an example of the use of an integrated environmental macroeconomic model for Indonesia. Since the model is quite disaggregated and includes an input-output core, it produces a consistent set of activity levels and levels for factor uses (labour, electricity, fuels and other

The model has been used for two purposes. First it was used as a tool to generate two "business as usual" scenarios, and it produced forecasts for the development of macroeconomic aggregates such as GDP, exports imports and the like. There are two counteracting forces present in the model, regarding CO_2 emissions. A high income elasticity of energy-intensive goods will, other factors constant, imply that CO_2 emissions will increase more than overall economic activity. But the assumed continued increases in energy efficiency will counteract this effect. The net result in our analysis is that CO_2 emissions increase at a lower rate than GDP, but they will still increase several times until 2020, according to the two reference scenarios.

Until now, Indonesia has adopted a policy of having a domestic oil price far below the world market price. We analyse a change in policy, where domestic prices of fuels are increased by imposing a fuel tax (or abolishing the present lower-than world market-oil price), and at the same time reducing the overall tax level, so that the government budget balance remains unchanged. This is done in the two tentative policy simulations. The effect is to change relative prices to induce firms and consumers to use less fossil fuels and more of less energy-intensive products. Our results indicate that this would produce significant reductions in CO_2 emissions and of the average fuel intensity of the Indonesian economy. However, given that the fuel tax is a unilateral policy not undertaken by Indonesia's trading partners, there will be negative effects on traditional macroeconomic variables such as GDP and employment.

In an analysis of this kind, it will also be important to take account of specific sectoral knowledge, so that the model results can be modified in certain areas. This may be especially relevant regarding the possibilities for factor substitution within specific sectors, or the availability of natural resources required in the production process. Such resources are not specified explicitly in the model (forests, availability of water and land, ore content in mines and sizes of oil reservoirs etc.). For the oil sector this has been taken account of when making forecasts for production and exports, but this has not so far been possible for other resource-based sectors.

References

Aaheim, A. and K. Nyborg (1995): On the interpretation and applicability of a "Green National Product", *Review of Income and Wealth* **1**, 57-71.

Bowitz, E., N. Ø. Mæhle, V.S. Sasmitawidjaja and S.B. Widoyono (1995): MEMLI - An Environmental Model for Indonesia. Technical Documentation of Data Programs and Procedures, Documents 95/7, Statistics Norway.

Bowitz, E., Mæhle, N. Ø., Sasmitawidjaja, V. S. and S. B. Widoyono (1996): *MEMLI. The Indonesian model for environmental analysis. Technical Documentation*, Reports 96/1, Statistics Norway.

Dean, A. and P. Hoeller (1992) : Costs of reducing CO_2 emissions: Evidence from six global models, *OECD Economic Studies* **19**, 15-48.

Djajadiningrat, S.T., M. Bordt, I. G.N. Agang, H.H. Amir and S. Zulfikar (1992): An Overview of KLHs Model for Population, Environment and Development, Ministry of Environment (KLH).

Duchin, F. and G.-M. Lange (1992): Input-Output Modeling, Development and the Environment. Final Report to Intera Kanting for CIDA contract, Institute for Economic Analysis, New York University.

Lewis, J.D. (1991): A computable general equilibrium (CGE) model of Indonesia, Development Discussion Paper No. 378, Harvard Institute for International Development, Harvard University.

Sen, A. (1963): Neo-classical and neo-Keynesian theories of distribution, *The Economic Record* **39**, 45-53.

SOW-VU (1990a): Structural adjustment in Indonesia: A counter-factual assessment for the eighties, Research Report SOW-90-01, Center for World Food Studies, Amsterdam.

SOW-VU (1990b): Technical specification of the Indonesia model, Addendum to Research report SOW-90-01, Center for World Food Studies, Amsterdam.

Thorbecke, E. (1991): Adjustment, Growth and Income Distribution in Indonesia, *World Development* **19**, 11, 1595-1614.

UN-Energy (1994): *1992 Energy balances and Electricity Profiles,* New York: United Nations.

UN (1987): *Our Common Future. The World Commission on Environment and Development,* Oxford: Oxford University Press.

World Bank (1994): *Indonesia. Environment and Development,* Washington D. C.: The World Bank.

World Bank (1995) *Indonesia. Improving Efficiency and Equity Changes in the Public Sector's Role,* Washington D. C.: The World Bank.

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