Working Paper
in Economics and
Development Studies

Department of Economics
Padjadjaran University

No. 200702

The Economy-wide Impact of Controlling Energy Consumption in Indonesia: An Analysis Using a Social Accounting Matrix Framework

Djoni Hartono
(University of Indonesia)

Budy Resosudarmo
(Australian National University)

January, 2007

Center for Economics and Development Studies,
Department of Economics, Padjadjaran University
Jalan Cimandiri no. 6, Bandung, Indonesia.
Phone/Fax: +62-22-4204510
http://www.lp3e-unpad.org

The Economy-wide Impact of Controlling Energy Consumption in Indonesia: An Analysis Using a Social Accounting Matrix Framework

Abstract

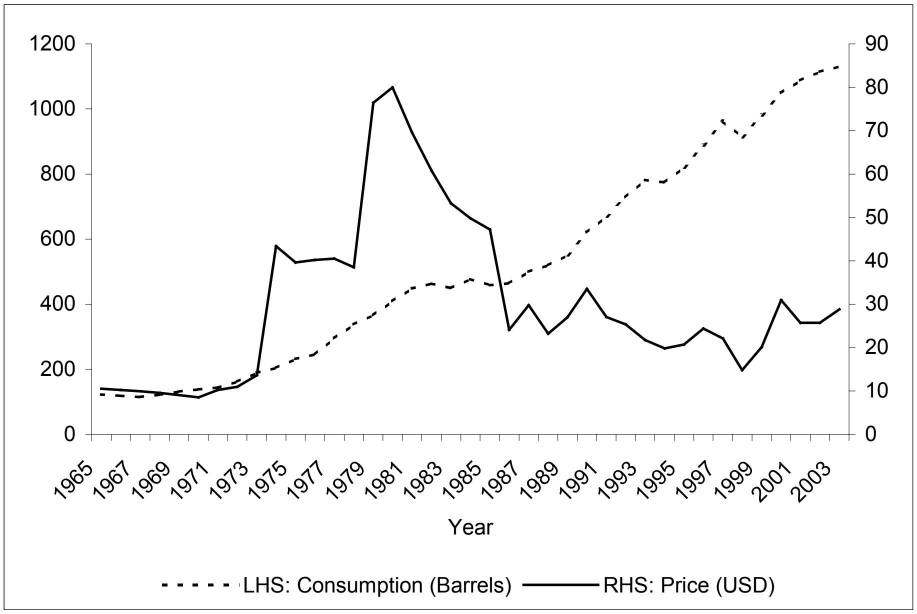
Escalating oil prices and the need to control carbon emissions sound the alarm for Indonesia to reduce or be more efficient in its energy use. To create an incentive for society to be more energy efficient, the government needs to reduce the current energy subsidy, which, in any case, has imposed a tremendous fiscal burden on the country. This paper aims to analyse the impact on the economy of energy policies aiming to reduce and to improve the efficiency of energy use, particularly on the income of various household groups. This paper will, first, construct a Social Accounting Matrix for Indonesia with detailed energy sectors and, second, utilise various multiplier analyses to observe and understand the impact of these energy policies.

Keywords: Energy economics, government policy, pricing policy, social accounting matrix

JEL Categories: Q43, Q48, E64, O21

1. Introduction

So far, oil has played an important role as Indonesia's main energy source. In the last 10 years, approximately 65.5 percent of Indonesia's total energy consumption has come from crude oil (Department of Energy and Mineral Resources, 2006). Furthermore, crude oil has long been an important source of government revenue. Nowadays, however, more and more people are questioning whether Indonesia can continue to depend on oil as its main source of energy and as one of its main sources of revenue. In the last 10 years or so, Indonesian oil production has not increased and no new significant oil reserve has been discovered, while domestic demand for oil has increased significantly. Figure 1 shows the increasing trend of domestic demand for oil in spite of the increase in price over the last 10 years or so. That Indonesia depends too much on oil is one of the energy related concerns.



Source: Center of Data and Information, Department of Energy and Mineral Resources (2005)

Figure 1. International Crude Oil Price and Indonesian Crude Oil Consumption

The second energy related concern is the government energy subsidy. The government so far controls the price of domestic oil products —fuel oils— such as gasoline, diesel oil and kerosene, so it is lower than the world price by providing a subsidy to Pertamina, the only oil processor and distributor of fuel oils in the country. The government also controls the price of electricity at lower than production cost by subsidising the national electricity company.

In recent years, the increasing demand for fuel oils has forced Indonesia to increase the amount of crude oil imported, while the world price of crude oil has increased. Demand for electricity has also increased. Hence, overall, the government spends a significant amount of its budget on energy subsidies (Table 1).

Table 1. Fuel and Electricity Subsidies, 1994–2004 (Billion Rupiah)

Fiscal Year	Fuel Subsidy	% of Fuel Subsidy to State Budget	Electricity Subsidy	% of Electricity Subsidy to State Budget
1994/1995[p]	686.80	1.10	0.00	0.00
1995/1996[p]	0.00	0.00	0.00	0.00
1996/1997[p]	1,416.10	1.72	0.00	0.00
1997/1998[p]	9,814.30	8.98	0.00	0.00
1998/1999[p]	28,606.60	16.57	1,929.90	1.12
1999/2000[1)p]	40,923.40	17.65	4,551.60	1.96
2000[2)p]	51,135.20	23.09	3,928.00	1.77
2001[p]	68,380.80	20.02	4,618.10	1.35
2002[p]	31,161.70	9.67	4,102.70	1.27
2003[p]	30,037.90	7.98	3,759.30	1.00
2004[3)]	69,024.50	15.82	3,309.50	0.76

Source: Agency for Research in Economic, Financial Policies, and International Cooperation, 2006

Notes:
p states budget calculation.
1) real budget until March 31, 2000.
2) phase April 1–December 31, 2000 (9 months).
3) estimates for the 2004 phase.

The third concern is energy intensity, which has not improved in the last decade. Energy Information Administration (EIA) in 2005 reported that, in the last two decades, energy intensity several East Asian countries, particularly China, have improved significantly, and developed countries around the world have been able to keep the energy intensity low, while Indonesia's energy intensity has worsened at a rate of 1.94 percent annually (EIA, 2005). This situation indicates, though not precisely, that there has been an increasing trend towards inefficiency in primary energy use in Indonesia during 1999–2003. Henceforth, there has been growing pressure on Indonesia to improve its efficiency in using primary energy.

The fourth concern is negative externalities to the environment, both at local and global levels. At the local level, environmental problems related to energy use are generally human health problems caused by emissions from vehicles and industrial activities. At the global level, the main concerns are global climate change and global warming due to increasing emissions of greenhouse gases. The energy sector, through its production and exploitation activities, is considered the main contributor of greenhouse gases. EIA in 2005 reported that CO_2 emission intensity of Indonesia has been worsening at a rate of 4.1% annually during 1998 – 2003.

By looking at the above mentioned problems, it is important for the Indonesian government to develop various programs to promote better and more efficient use of energy. Eliminating the fuel oil subsidy is the most common issue discussed as a way to encourage households to be more efficient in using energy (or to save energy). Another issue currently discussed is restricting energy use.

To help the government develop these programs, this paper aims to establish the economic impact of the improvement in efficiency of energy use, the cutting of the fuel oil subsidy, and the restrictions of energy use for households on the Indonesian economy, particularly on the income of various household groups.

2. Literature Reviews

There are many previous studies on the impact of energy efficiency on the economy. Generally, these studies can be classified into five main categories: (i) "rebound effect theory"; (ii) Input-Output (I-O) Model; (iii) decomposition approach; (iv) linear programming; (v) macroeconomic model; and (vi) general equilibrium model.

Works on the rebound effect theory typically prove that innovations improving the efficiency of energy use end up using more energy (Khazzom, 1980; Lovins, 1988;

Brookes, 1990, Binswanger, 2001). This phenomenon occurs since the money saved by using less energy will eventually be used to buy other goods and services (which in turn need energy to be produced). Furthermore, lower use of energy pulls the energy price down. Lower energy price results in higher income, which is followed by the rise in demand for goods and services. Producers anticipate the rise in demand by raising their level of production (which results in higher use of energy).

The I-O model implements an I-O multiplier matrix to predict the direct and indirect impacts of improvement in efficiency of energy use on the industrial outputs, and then uses the output changes to predict the impact on macroeconomics indicators and demographic variables (Ghebremedhin and Schreiner, 1983; Yanai and Hewings, 2004).

The decomposition technique decomposes productions of sectoral outputs into various inputs, energy and technology, then analyses the contribution of energy efficiency on the output changes (Newell et al., 1999; Koop, 2001). The linear programming approach typically minimises the cost of producing outputs to meet certain levels of demand under a certain energy policy regime (Pacudan and Guzman, 2002). Lastly, the macroeconomic model is a set of macroeconomic equations to represent an economy. This set of equations is then utilised to predict the impact of abolishing economic distortion, such as tax, to induce a more efficient use of energy (Khanna and Zilberman, 2001).

However, none of the approaches mentioned is able to determine the economy-wide impact of an energy policy. A general equilibrium model, such as that of Garbaccio, Ho and Jorgenson (2000), does, since decisions of all agents in the economy are modeled into a set of equations.

This paper uses a simple version of a general equilibrium model, namely the social accounting matrix framework, to predict the economy-wide impact of an energy policy. The two particular methods implemented are: (i) an accounting multiplier matrix with backward linkage to analyse the impacts of improvement in efficiency of energy use (or energy-saving), both with and without subsidies; and (ii) a constrained fixed price multiplier to analyse the impact of restrictions in energy use. All methodologies used in this study are based on the national data system, i.e. the Social Accounting Matrix (SAM) Indonesia 2000.

SAM is a traditional double accounting economic matrix in the form of a partition matrix that records all economic transactions between agents, especially between sectors in production blocks, sectors within institution blocks (including households), and sectors within production factors, in the economy (Pyatt and Round, 1979; Hartono and Resosudarmo, 1998).

SAM is a good database system because: (1) SAM summarises all transaction activities in an economy within a certain period of time, thus giving a general picture of an economy in one area; and (2) SAM photographs the socio-economy structure in an economy, and illustrates poverty and income distribution in that economy.

SAM is also an important analysing tool, because: (1) it properly describes economic policy impacts on a household's income, hence illustrating the economic policy impact on poverty and income distribution; and (2) the application is relatively simple; thus it can easily be applied to various countries.

To elucidate the better concept of SAM, we will start with the SAM framework. As previously explained, SAM is a matrix that represents the economic and social accounts of a country. These accounts are grouped into two: endogenous and exogenous accounts. The main endogenous accounts are divided into three blocks: production factor, institutional, and production activity blocks. Table 2 illustrates a simple SAM framework.

Table 2. SAM Framework

			EXPENDITURE				
			Endogenous Accounts			*Exogenous Account*	TOTAL
			Production Factors	Institutions	Production Activities		
RECEIPTS	*Endogenous Accounts*	Production Factors	$\boldsymbol{0}$	$\boldsymbol{0}$	$\boldsymbol{T_{13}}$	$\boldsymbol{Z_1}$	$\boldsymbol{y_1}$
		Institutions	$\boldsymbol{T_{21}}$	$\boldsymbol{T_{22}}$	$\boldsymbol{0}$	$\boldsymbol{Z_2}$	$\boldsymbol{y_2}$
		Production Activities	$\boldsymbol{0}$	$\boldsymbol{T_{32}}$	$\boldsymbol{T_{33}}$	$\boldsymbol{Z_3}$	$\boldsymbol{y_3}$
	Exogenous Account		$\boldsymbol{T_{41}}$	$\boldsymbol{T_{42}}$	$\boldsymbol{T_{43}}$	$\boldsymbol{Z_4}$	$\boldsymbol{z}$
	TOTAL		$\boldsymbol{y'_1}$	$\boldsymbol{y'_2}$	$\boldsymbol{y'_3}$	$\boldsymbol{z'}$	

The basic framework of a SAM is a 4x4 partition matrix. The row shows income, while the column shows expenditure. In Table 2, sub matrix $\boldsymbol{T_{ij}}$ (or $\boldsymbol{Z_i}$) shows the income of the account in row i from the account of column j. Vector $\boldsymbol{y_i}$ (or $\boldsymbol{z}$) shows the total incomes of all accounts, and vector $\boldsymbol{y'_j}$ (or $\boldsymbol{z'}$) shows the total expenditure account of all accounts. In addition, SAM requires that the vector $\boldsymbol{y_i}$ is the same as vector $\boldsymbol{y'_j}$, or in other words $\boldsymbol{y'_j}$ is a transpose of $\boldsymbol{y_i}$, for every $i = j$. The relations in Table 2 can be written as (Defourny dan Thorbecke, 1984):

$$\boldsymbol{y} = \boldsymbol{A}\,\boldsymbol{y} + \boldsymbol{x} \qquad [1]$$

where: $\boldsymbol{y}$ = vector of total income

$\boldsymbol{x}$ = vector whose members are $x_m = \Sigma_n z_{mn}$ *where* $z_{mn} \in \boldsymbol{Z_i}$

$\boldsymbol{A}$ = matrix whose members are $a_{mn} = t_{mn}/y_n$ where $t_{mn} \in T_{ij}$ and $y_n \in \boldsymbol{y'_j}$

3. Methodology

3.1. Accounting Multiplier Matrix to Simulate an Improvement in Energy Efficiency

An accounting multiplier matrix in a SAM framework is very important since it captures overall impacts of changes in a particular sector on other sectors within the economy, and is thus also used to explain the impacts of changes in exogenous accounts on endogenous accounts. The accounting multiplier matrix, which is a standard inversion of the $(I-\boldsymbol{A})$ matrix, can be derived from the basic SAM framework and written as (Defourny dan Thorbecke, 1984):

$$\boldsymbol{y} = \boldsymbol{A}\,\boldsymbol{y} + \boldsymbol{x} \Leftrightarrow \boldsymbol{y} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\,\boldsymbol{x} \Leftrightarrow \boldsymbol{y} = \boldsymbol{M}_a\,\boldsymbol{x} \qquad [2]$$

The $\boldsymbol{M}_a = (\boldsymbol{I} - \boldsymbol{A})^{-1}$ is known as a multiplier matrix account, which shows global impacts of changes in a particular economic sector on other sectors.

To analyse the impact of the improvement in efficiency of energy consumption on income among household groups, it is necessary to modify equation [2]. This can be done by changing all $a_{ej} \in \boldsymbol{A}$ to become $a_{ej}^{*} \in \boldsymbol{A}^{*}$, where $a_{ej}^{*} < a_{ej}$ and e is the index of energy sectors. The benefits of this energy efficiency improvement then distributes to production factors.

We observe the impact of improvement in the efficiency of energy use on the performance of the economy and society's welfare by looking at:

$$\nabla \boldsymbol{y} = \boldsymbol{y}^{*} - \boldsymbol{y} \qquad [3]$$

where $\boldsymbol{y}^{*} = (\boldsymbol{I} - \boldsymbol{A}^{*})^{-1}\,\boldsymbol{x}$.

3.2. Constrained Fixed Price Multiplier to Simulate a Restriction on Energy Use

The Constrained Fixed Price Multiplier method is used to discover the impact of changes in outputs of constrained endogenous accounts on non-constrained endogenous accounts. To illustrate this, we modify the SAM framework in Table 2 by differentiating the endogenous account into constrained and non-constrained endogenous accounts, as depicted in Table 3 (Lewis and Thorbecke, 1992; Resosudarmo and Thorbecke, 1996).

Table 3. The SAM with Constrained and Non-constrained Accounts

				Endogenous			**Exogenous**		**TOTAL**
				Non-constrained	Constrained	**Sum**	Transaction	**Sum**	
Endogenous	Non-constrained	1	Factor	T_{NC}	T_Q	n_{NC}	X_{NC}	x_{NC}	y_{NC}
		2a	Institution						
	Constrained	3	Sector	T_R	T_C	n_C	X_C	x_C	y_C
Exogenous		2b	Government	L_{NC}	L_C	L	U	u	y_E
		4	Other						
TOTAL				y_{NC}'	y_C'		y_E'		

Mathematically, Table 3 can be formulated as:

$$\left[\frac{y_{NC}}{y_C}\right] = \left[\frac{n_{NC}}{n_C}\right] + \left[\frac{x_{NC}}{x_C}\right] = \left[\begin{array}{c|c} \frac{A_{NC}}{R} & \frac{Q}{A_C} \end{array}\right]\left[\frac{y_{NC}}{y_C}\right] + \left[\frac{x_{NC}}{x_C}\right] \quad [4]$$

By elabourating equation [4] into 2 equations and rearranging those equations (Resosudarmo and Thorbecke, 1996), we arrive at:

$$\left[\frac{y_{NC}}{x_C}\right] = \left[\begin{array}{c|c} \frac{(I - A_{NC})}{R} & \frac{0}{I} \end{array}\right]^{-1}\left[\begin{array}{c|c} \frac{I}{0} & \frac{Q}{(I - A_C)} \end{array}\right]\left[\frac{x_{NC}}{y_C}\right] \quad [5]$$

$\left[\begin{array}{c|c} \frac{(I - A_{NC})}{R} & \frac{0}{I} \end{array}\right]^{-1}\left[\begin{array}{c|c} \frac{I}{0} & \frac{Q}{(I - A_C)} \end{array}\right]$ is the constrained fixed price multiplier matrix. This matrix reflects the impact of changes in exogenous sectors (x_{NC}) and constrained endogenous sectors (y_C) on non-constrained endogenous sectors (y_{NC}) and exogenous accounts (x_C).

Suppose the government forces some sectors to reduce their energy consumption by controlling the amount of their outputs. We simulate this by changing $\boldsymbol{y}_c \in \boldsymbol{y}_C$ into $\boldsymbol{y}_c^*$ $\in \boldsymbol{y}_C^*$ where $\boldsymbol{y}_c^* < \boldsymbol{y}_c$. We observe the impact of this reduction in energy consumption policy by looking at

$$\nabla \boldsymbol{y}_{NC} = \boldsymbol{y}^*_{NC} - \boldsymbol{y}_{NC} \qquad [6]$$

where $\left[\frac{y^*_{NC}}{x^*_C}\right] = \left[\begin{array}{c|c} (I - A_{NC}) & 0 \\ \hline R & I \end{array}\right]^{-1} \left[\begin{array}{c|c} I & Q \\ \hline 0 & (I - A_C) \end{array}\right] \left[\frac{x_{NC}}{y^*_C}\right]$.

4. Sources of Data

The Indonesian Energy SAM data used in this study are based on the Indonesian SAM data 2000. The Indonesian Energy SAM contains comprehensive data of energy sectors. The 33 production sectors can be seen in Table 4. The energy sector discussed in this study only covers: (1) fuel oil sectors (BBM), which are: gasoline*,* automotive diesel oil*,* industrial diesel oil and kerosene; (2) the gas fuel sector (BBG), i.e. refinery gas and urban gas, where BBG referred to here is from refinery or oil production and is not a liquid natural gas; and (3) the electricity sector.

Table 4. Production Sector Classification

Sector Classification	Sector Classification
Food Crops	Kerosene
Estate Crops	Fuel Oil
Livestock	Other Chemical Industry
Forestry and Hunting	Electricity
Fishery	Urban Gas
Coal Mining	Clean Water
Crude Oil	Construction
Natural Gas	Trade and Storage
Other Mining	Restaurant
Food Processing	Hotel
Textile and Leather	Land Transportation
Wood Processing	Air-Water Transportation and Communication
Paper and Metal Product	Bank and Insurance
Gasoline	Real Estate
Automotive Diesel Oil	Public Services
Industrial Diesel Oil	Personal Services
Refinery Gas	

The Indonesian Energy SAM data 2000 in this study comprises 23 production factors: Agricultural Paid Rural worker, Agricultural Paid Urban worker, Agricultural Unpaid Rural worker, Agricultural Unpaid Urban worker, Manual Paid Rural worker, Manual Paid Urban worker, Manual Unpaid Rural worker, Manual Unpaid Urban worker, Clerical Paid Rural worker, Clerical Paid Urban worker, Clerical Unpaid Rural worker, Clerical Unpaid Urban worker, Professional Paid Rural worker, Professional Paid Urban worker, Professional Unpaid Rural worker, Professional Unpaid Urban worker, Land, House, Rural Asset, Urban Asset, Domestic Private Capital, Government Asset and Foreign Capital. It consists of 10 households: Agricultural Employee, Small Scale Farmer, Medium Scale Farmer, Large Scale Farmer, Rural Low Income, Rural Non Labour, Rural High Income, Urban Low Income, Urban Non Labour and Urban High Income and 2 other institutions: Company and Government. Capital account, indirect taxes, subsidies, and foreign transaction account are also included in the SAM.

The SAM illustrates the sectors and households that consume the highest amount of energy (Table 5).

Table 5. Household and Other Economy Sectors with High Energy Consumption

Household group	Sector
The highest gasoline consumers (in rank)	
Urban High Income	Land Transportation
Urban Low Income	Trade and Storage
Rural High Income	Food, Drinking and Tobacco
The highest automotive diesel oil consumers (in rank)	
Urban High Income	Paper and Metal Product
Rural High Income	Construction
Urban Low Income	Land Transportation
The highest industrial diesel oil consumers (in rank) *	
	Construction
	Textile and Leather
	Food, Drinking and Tobacco
The highest refinery gas consumers (in rank)	
Urban High Income	Other Chemical Industry
Urban Low Income	Trade and Storage
Rural High Income	Paper and Metal Product
The highest kerosene consumers (in rank)	
Rural Low Income	Paper and Metal Product
Urban Low Income	Textile and Leather
Rural High Income	Personal Service
The highest electricity consumers (in rank)	
Urban High Income	Trade and Storage
Urban Low Income	Paper and Metal Product
Rural High Income	Textile and Leather
The highest urban gas consumer (in rank)	
Urban High Income	Trade and Storage
Rural High Income	Textile and Leather
Urban Low Income	Paper and Metal Product

Source: the writer's calculation result using MATS software

Note:
* it is assumed that households do not use industrial diesel oil as their energy source.

5. Scenarios

The scenarios simulated are categorised into two groups. Group A consists of 6 scenarios simulating the impact of improvement in the efficiency of energy use, and Group B consists of 4 scenarios simulating the impact of energy restriction policies. The scenarios are as follows.

Scenario A1: This scenario simulates a situation in which all industrial sectors are able to improve the efficiency of their energy consumption by 15 %.

Scenario A2: This scenario simulates a situation in which all household groups are able to improve the efficiency of their energy consumption by 10 %.

Scenario A3: This scenario combines Scenarios A1 and A2; i.e. a situation in which all industrial sectors and all household groups are able to improve the efficiency of their energy consumption by 15% and 10%, respectively.

Scenario A4: This scenario simulates a condition in which the government reduces its total energy subsidy by 20% and all industrial sectors are able to improve the efficiency of their energy consumption by 20%.

Scenario A5: This scenario simulates a condition in which the government reduces its total energy subsidy by 20% and all household groups are able to improve the efficiency of their energy consumption by 15%.

Scenario A6: This scenario combines Scenarios A4 and A5.

Since mid 2006, the government has required owners of restaurants, pubs and coffee shops to close by 1am. No public buses operate and most street lights are turned off by 1am. In fact, apart from police stations, most electric appliances in public offices should be shut down by 1am. Hotels are also required to reduce their electricity use significantly by 1am. Hence, the scenarios in group B assume that activities within the relevant sector are restricted so that fuel oil consumption declines by 5%. **Scenario B1** concerns the restaurant sector; **Scenario B2** the hotel sector; **Scenario B3** the public service sector and **Scenario B4** the restaurant, hotel, and public service sectors.

6. Results and Discussions

In this part, we elabourate and analyse the results from the application of the two methods. There are three main issues to discuss: (i) the improvement in efficiency of energy use **without** subsidy cuts; (ii) the improvement in efficiency of energy use **with** subsidy cuts; (iii) the restrictions in energy usage.

Table 6 displays the changes in income of various household groups due to the improvement in efficiency of energy use without subsidy cuts. The estimates from **Scenario A1** show that all households enjoy an improvement in their level of income if all industry sectors use one of the following types of energy efficiently: gasoline, automotive diesel oil, refinery gas, electricity, or urban gas; and particularly when all industry sectors use automotive diesel oil or electricity efficiently. Nevertheless, there are household groups that suffer from income decline when all industry sectors use automotive diesel oil or kerosene efficiently. The results also show that urban high-income (UrbHigh) households enjoy the greatest benefit if all industry sectors use automotive diesel oil or kerosene efficiently. Meanwhile, the large-scale farmer (LarFarm) households and the rural low-income (RurLow) households suffer the greatest loss in their income when all industry sectors use kerosene efficiently.

Table 6. Income Changes of Various Household Groups Based on the Improvement in Efficiency of Energy Use without Subsidy Cuts
(Billion Rupiah, %)

Household Group	Gasoline	Automotive Diesel Oil	Industrial Diesel Oil	Refinery Gas	Kerosene	Electricity	Urban Gas
Scenario A1							
AGMPL	38.95 *0.054%*	59.78 *0.083%*	9.41 *0.013%*	9.50 *0.013%*	-10.15 *-0.014%*	62.20 *0.087%*	2.22 *0.003%*
SMLFARM	69.21 *0.068%*	100.22 *0.098%*	15.06 *0.015%*	16.50 *0.016%*	-21.27 *-0.021%*	108.76 *0.107%*	3.83 *0.004%*
MEDFARM	37.51 *0.073%*	60.67 *0.118%*	9.78 *0.019%*	8.81 *0.017%*	-6.50 *-0.013%*	53.03 *0.103%*	1.88 *0.004%*
LARFARM	19.35 *0.035%*	12.45 *0.023%*	-3.55 *-0.006%*	5.81 *0.011%*	-35.40 *-0.065%*	36.32 *0.066%*	1.47 *0.003%*
RURLOW	64.00 *0.056%*	48.88 *0.043%*	6.35 *0.006%*	18.64 *0.016%*	-73.11 *-0.065%*	148.25 *0.131%*	5.45 *0.005%*
RURNLAB	36.75 *0.072%*	51.85 *0.101%*	9.20 *0.018%*	7.75 *0.015%*	-12.63 *-0.025%*	47.11 *0.092%*	1.71 *0.003%*
RURHIGH	92.63 *0.089%*	159.09 *0.153%*	30.02 *0.029%*	20.15 *0.019%*	16.52 *0.016%*	131.25 *0.126%*	4.27 *0.004%*
URBLOW	118.68 *0.066%*	94.59 *0.052%*	6.77 *0.004%*	29.99 *0.017%*	-83.11 *-0.046%*	240.93 *0.133%*	9.63 *0.005%*
URBNLAB	50.18 *0.069%*	60.07 *0.083%*	7.33 *0.010%*	13.73 *0.019%*	-16.82 *-0.023%*	113.09 *0.156%*	4.07 *0.006%*
URBHIGH	177.03 *0.095%*	301.44 *0.161%*	53.35 *0.029%*	44.01 *0.024%*	42.15 *0.023%*	340.51 *0.182%*	11.02 *0.006%*
Scenario A2							
AGMPL	11.23 *0.016%*	1.97 *0.003%*	*	3.01 *0.004%*	-2.71 *-0.004%*	25.70 *0.036%*	0.33 *0.000%*
SMLFARM	22.53 *0.022%*	4.31 *0.004%*	*	5.79 *0.006%*	-3.07 *-0.003%*	51.66 *0.051%*	0.61 *0.001%*
MEDFARM	11.79 *0.023%*	2.29 *0.004%*	*	3.01 *0.006%*	-1.55 *-0.003%*	25.59 *0.050%*	0.30 *0.001%*
LARFARM	7.24 *0.013%*	0.28 *0.001%*	*	2.22 *0.004%*	-7.14 *-0.013%*	19.59 *0.036%*	0.24 *0.000%*
RURLOW	-1.16 *-0.001%*	-4.38 *-0.004%*	*	1.17 *0.001%*	-22.94 *-0.020%*	18.16 *0.016%*	0.27 *0.000%*
RURNLAB	5.41 *0.011%*	0.26 *0.001%*	*	1.65 *0.003%*	-5.30 *-0.010%*	15.31 *0.030%*	0.19 *0.000%*
RURHIGH	19.21 *0.019%*	4.05 *0.004%*	*	4.82 *0.005%*	-1.95 *-0.002%*	34.49 *0.033%*	0.41 *0.000%*
URBLOW	-9.52 *-0.005%*	-10.26 *-0.006%*	*	0.62 *0.000%*	-45.76 *-0.025%*	13.38 *0.007%*	0.28 *0.000%*
URBNLAB	2.64 *0.004%*	-1.50 *-0.002%*	*	1.46 *0.002%*	-11.92 *-0.016%*	13.25 *0.018%*	0.19 *0.000%*
URBHIGH	26.56 *0.014%*	4.59 *0.002%*	*	7.23 *0.004%*	-9.18 *-0.005%*	51.89 *0.028%*	0.64 *0.000%*
Scenario A3							
AGMPL	52.06 *0.073%*	63.80 *0.089%*	*	12.52 *0.017%*	-5.78 *-0.008%*	88.80 *0.124%*	2.54 *0.004%*
SMLFARM	94.97 *0.093%*	108.05 *0.106%*	*	22.35 *0.022%*	-12.33 *-0.012%*	161.97 *0.159%*	4.46 *0.004%*
MEDFARM	51.11	64.95	*	11.85	-1.28	79.50	2.19

	0.099%	*0.126%*		*0.023%*	*-0.002%*	*0.154%*	*0.004%*
LARFARM	28.76 *0.052%*	15.11 *0.028%*	*	8.07 *0.015%*	-34.40 *-0.063%*	57.06 *0.104%*	1.72 *0.003%*
RURLOW	66.75 *0.059%*	48.78 *0.043%*	*	19.86 *0.018%*	-81.31 *-0.072%*	168.36 *0.149%*	5.72 *0.005%*
RURNLAB	43.96 *0.086%*	54.08 *0.106%*	*	9.43 *0.018%*	-11.14 *-0.022%*	63.32 *0.124%*	1.91 *0.004%*
RURHIGH	115.67 *0.111%*	167.34 *0.161%*	*	25.02 *0.024%*	28.96 *0.028%*	167.74 *0.162%*	4.68 *0.005%*
URBLOW	116.24 *0.064%*	92.10 *0.051%*	*	30.72 *0.017%*	-102.14 *-0.056%*	257.91 *0.143%*	9.92 *0.005%*
URBNLAB	55.55 *0.077%*	61.56 *0.085%*	*	15.23 *0.021%*	-18.46 *-0.025%*	127.70 *0.176%*	4.27 *0.006%*
URBHIGH	210.64 *0.113%*	313.76 *0.168%*	*	51.35 *0.027%*	59.43 *0.032%*	396.00 *0.212%*	11.67 *0.006%*

Source: Writer's calculation

Notes:

- Assumed that households do not consume industrial diesel oil, therefore calculation was not performed
- 0.000% is a smaller value from 0.001

With higher efficiency in automotive diesel oil use by all industry sectors, urban workers receive higher income benefits than workers in rural areas (around 57% of the rise in income goes to urban workers). The same occurs in the case of electricity use, where 60% of urban workers enjoy a rise in income. In general, the rise in payments to factor owners due to higher efficiency and higher government expenditures (thanks to the subsidy cut) can counterbalance the negative impact of the decline in outputs of the gasoline, automotive diesel oil, refinery gas, electricity, and urban gas sectors. Nonetheless, this is not the case when all industry sectors are efficient in using kerosene, where almost all households' income fall.

The estimates from **Scenario A2** show that all households receive a higher income when they use one of the following types of energy efficiently: refinery gas, electricity, and urban gas, especially when all households use electricity efficiently (which will raise household income the most). Nonetheless, there are some groups of households whose income fall when all households use gasoline and automotive diesel oil efficiently. Furthermore, all households' income falls when they all use kerosene efficiently. The results also show that urban low-income (UrbLow) households receive the greatest negative impact when all households use kerosene efficiently. Conversely, small-scale farmer (SmlFarm) households receive the greatest positive impact when all households use electricity efficiently.

With more efficient use of electricity by all households, rural workers receive more benefit as their income rises more than that of urban workers (around 62% of the rise in income goes to rural workers). Generally, the rise in payments to factor owners due to higher efficiency and the higher government expenditures (thanks to the subsidy cut) can counterbalance the negative impact of the decline in outputs of the refinery gas, electricity, and urban gas sectors. Nevertheless, it is not the case when all households use kerosene efficiently, where all households will suffer from income decline.

Finally, the estimates from **Scenario A3** show that all households receive higher income when all industry sectors and all households are use one of the following types of energy efficiently: premium, automotive diesel oil, refinery gas, electricity, or urban gas. However, there are some household groups whose income falls when all industry sectors and all households use kerosene efficiently. The results also show that urban high-income (UrbHigh) households receive the greatest positive impact when all industry sectors and all households use electricity efficiently. Meanwhile, large-scale farmer (LarFarm) and urban low-income (UrbLow) households suffer the most when all industry sectors and all households use kerosene efficiently, as income for these two groups fall.

With more efficient use of electricity by all industry sectors and all households, urban workers receive a greater rise in their income than rural workers (around 56% of the rise in income goes to urban workers). The rise in payments to factor owners due to higher efficiency and higher government expenditures (from the subsidy cut) are able to counterbalance the negative impact of the decline in outputs of the gasoline, automotive diesel oil, refinery gas, electricity, and urban gas sectors. This, however, is not the case when all industry sectors and all households use kerosene efficiently, where almost all households suffer from income decline.

Table 7 displays the income changes of various household groups resulting from the higher efficiency of energy use with a subsidy cut. The estimates in **Scenario A4** shows that the income of all households rises if all industry sectors use one of the following types of energy efficiently: gasoline, automotive diesel oil, industry diesel oil, refinery gas, kerosene, or electricity, where the improvement in efficiency occurs with a subsidy cut. With this cut, a greater increase in income will take place if all industry sectors use automotive diesel oil efficiently.

Table 7. Income Changes of Various Household groups based on the Improvement in Efficiency of Energy Use with the Subsidy Cut
(Billion Rupiah, %)

Household Group	Gasoline	Automotive Diesel Oil	Industrial Diesel Oil	Refinery Gas	Kerosene	Electricity
Scenario A4						
AGMPL	342.37 *0.478%*	563.33 *0.786%*	144.35 *0.202%*	353.07 *0.493%*	338.57 *0.473%*	173.64 *0.242%*
SMLFARM	557.28 *0.546%*	910.07 *0.892%*	231.79 *0.227%*	566.01 *0.555%*	535.95 *0.526%*	291.75 *0.286%*
MEDFARM	109.60 *0.213%*	197.66 *0.383%*	45.57 *0.088%*	73.64 *0.143%*	68.21 *0.132%*	92.95 *0.180%*
LARFARM	72.56 *0.132%*	117.47 *0.214%*	23.74 *0.043%*	52.17 *0.095%*	15.66 *0.029%*	66.85 *0.122%*
RURLOW	392.64 *0.346%*	600.55 *0.530%*	155.52 *0.137%*	374.10 *0.330%*	281.62 *0.248%*	298.21 *0.263%*
RURNLAB	97.07 *0.190%*	167.68 *0.328%*	39.89 *0.078%*	58.33 *0.114%*	46.36 *0.091%*	81.56 *0.159%*
RURHIGH	249.75 *0.241%*	459.86 *0.443%*	108.89 *0.105%*	157.59 *0.152%*	184.73 *0.178%*	220.01 *0.212%*
URBLOW	427.81	641.06	152.40	326.11	234.15	414.25

	0.237%	*0.354%*	*0.084%*	*0.180%*	*0.129%*	*0.229%*
URBNLAB	117.83 *0.163%*	194.68 *0.269%*	42.25 *0.058%*	64.36 *0.089%*	47.30 *0.065%*	171.54 *0.237%*
URBHIGH	439.15 *0.235%*	811.50 *0.434%*	185.34 *0.099%*	263.54 *0.141%*	320.91 *0.172%*	529.13 *0.283%*
Scenario A5						
AGMPL	293.03 *0.409%*	419.13 *0.585%*	*	343.56 *0.480%*	296.93 *0.415%*	125.79 *0.176%*
SMLFARM	474.69 *0.465%*	668.75 *0.656%*	*	550.41 *0.540%*	473.21 *0.464%*	218.48 *0.214%*
MEDFARM	63.68 *0.124%*	55.79 *0.108%*	*	65.11 *0.126%*	25.75 *0.050%*	57.27 *0.111%*
LARFARM	41.28 *0.075%*	23.94 *0.044%*	*	46.22 *0.084%*	-6.52 *-0.012%*	43.46 *0.079%*
RURLOW	275.97 *0.244%*	388.82 *0.343%*	*	348.18 *0.307%*	238.42 *0.210%*	120.26 *0.106%*
RURNLAB	42.56 *0.083%*	34.39 *0.067%*	*	49.17 *0.096%*	6.32 *0.012%*	38.24 *0.075%*
RURHIGH	126.05 *0.121%*	116.60 *0.112%*	*	135.19 *0.130%*	55.98 *0.054%*	89.00 *0.086%*
URBLOW	201.71 *0.112%*	245.86 *0.136%*	*	281.97 *0.156%*	83.58 *0.046%*	98.90 *0.055%*
URBNLAB	34.23 *0.047%*	14.56 *0.020%*	*	46.27 *0.064%*	-22.32 *-0.031%*	35.32 *0.049%*
URBHIGH	189.63 *0.101%*	164.19 *0.088%*	*	210.62 *0.113%*	60.06 *0.032%*	139.12 *0.074%*
Scenario A6						
AGMPL	366.84 *0.512%*	572.32 *0.799%*	*	358.11 *0.500%*	355.98 *0.497%*	215.29 *0.301%*
SMLFARM	604.07 *0.592%*	926.82 *0.909%*	*	575.63 *0.564%*	567.74 *0.557%*	374.44 *0.367%*
MEDFARM	134.59 *0.261%*	206.88 *0.401%*	*	78.67 *0.153%*	86.40 *0.168%*	134.33 *0.261%*
LARFARM	92.17 *0.168%*	124.83 *0.228%*	*	56.14 *0.102%*	29.61 *0.054%*	100.06 *0.182%*
RURLOW	406.69 *0.359%*	606.49 *0.535%*	*	376.96 *0.333%*	291.84 *0.258%*	332.02 *0.293%*
RURNLAB	112.47 *0.220%*	173.84 *0.340%*	*	61.32 *0.120%*	58.98 *0.115%*	107.56 *0.210%*
RURHIGH	294.02 *0.283%*	478.20 *0.461%*	*	165.90 *0.160%*	225.39 *0.217%*	278.51 *0.268%*
URBLOW	442.09 *0.244%*	648.36 *0.359%*	*	329.08 *0.182%*	246.45 *0.136%*	446.60 *0.247%*
URBNLAB	132.80 *0.183%*	201.18 *0.278%*	*	67.33 *0.093%*	60.58 *0.084%*	196.07 *0.271%*
URBHIGH	507.40 *0.272%*	840.94 *0.450%*	*	276.40 *0.148%*	387.27 *0.207%*	619.13 *0.331%*

Source: Writer's calculation result

Notes:

- Assumed that households do not consume industrial diesel oil, so that the calculation was not performed.
- The calculation for urban gas is not performed because subsidy value=0

This scenario also shows that, with the subsidy cut, small-scale farmer (SmlFarm) households enjoy the highest increase in income when all industry sectors use automotive diesel oil efficiently, while large-scale farmer (LarFarm) households receive the lowest increase in income when all industry sectors use kerosene efficiently. Small-scale farmer (SmlFarm) households enjoy a considerable increase in their income since they receive subsidy-compensation funds. Generally, the increase in payments to factor owners can counterbalance the negative impact of the falling outputs in the gasoline, automotive diesel oil, industry diesel oil, refinery gas, kerosene, and electricity sectors.

Meanwhile, with the subsidy cut, the estimates in **Scenario A5** show that the income of all households rises if they use one of the following types of energy efficiently: gasoline, automotive diesel oil, refinery gas, or electricity. Nevertheless, there are some households whose income declines when all use kerosene efficiently.

It also shows that, with the subsidy cut, small-scale farmer (SmlFarm) households receive the highest increase in income when they all use automotive diesel oil efficiently. Conversely, large-scale farmer (LarFarm) and urban non-labour (UrbNlab) households suffer from a negative impact when all use kerosene efficiently. It is interesting that small-scale farmer (SmlFarm) households' income rises since they receive compensation funds for the poor. The increase in payments to labour can counterbalance the negative impact of falling outputs in the gasoline, automotive diesel oil, refinery gas, and electricity sectors.

Scenario A6 shows that, with the subsidy cut, all households' income rises if all industry sectors and all households use one of the following types of energy efficiently: gasoline, automotive diesel oil, refinery gas, kerosene, or electricity. Under this scenario, a relatively higher increase in income of all households takes place when all industry sectors and all households use automotive diesel oil efficiently.

With the subsidy cut, **Scenario A6** shows that small-scale farmer (SmlFarm) households receive the highest increase in income when all industry sectors and all households use automotive diesel oil efficiently, while large-scale farmer (LarFarm) households receive the lowest increase in income when all industry sectors and all households use kerosene efficiently. The higher increase in income received by small-scale farmer (SmlFarm) households is caused by the compensation funds. The rise in payments to factor owners counterbalances the negative impacts of the output declines in the gasoline, automotive diesel oil, refinery gas, kerosene, and electricity sectors.

Table 8 shows that with restrictions of energy use in the restaurant, hotel, or public service, or simultaneously in the three sectors (reflected by the 5% decline of fuel oil consumption in each sector), all households' income fall. Based on the table, simultaneous restrictions of energy use in the three sectors harms urban high-income (UrbHigh) households the most, while small-scale farmer (SmlFarm) households receive the least negative impact. Meanwhile, medium-scale farmer (MedFarm) households receive the least negative impact when restrictions are also imposed on the restaurant sector.

Table 8. Income Changes of Various Household groups Based on the Improvement in Efficiency of Energy Use

(Billion Rupiah, %)

Household Group	**Scenario B1**	**Scenario B2**	**Scenario B3**	**Scenario B4**
AGMPL	-20.74 *-0.029%*	-4.50 *-0.006%*	-70.67 *-0.099%*	-95.91 *-0.134%*
SMLFARM	-28.82	-6.02	-79.53	-114.38

	-0.028%	*-0.006%*	*-0.078%*	*-0.112%*
MEDFARM	-11.26 *-0.022%*	-3.27 *-0.006%*	-76.78 *-0.149%*	-91.31 *-0.177%*
LARFARM	-16.45 *-0.030%*	-6.38 *-0.012%*	-74.78 *-0.136%*	-97.60 *-0.178%*
RURLOW	-57.72 *-0.051%*	-9.77 *-0.009%*	-123.44 *-0.109%*	-190.93 *-0.168%*
RURNLAB	-13.19 *-0.026%*	-4.19 *-0.008%*	-103.67 *-0.203%*	-121.05 *-0.237%*
RURHIGH	-55.08 *-0.053%*	-13.09 *-0.013%*	-377.05 *-0.363%*	-445.23 *-0.429%*
URBLOW	-122.34 *-0.068%*	-27.59 *-0.015%*	-261.68 *-0.145%*	-411.61 *-0.228%*
URBNLAB	-62.96 *-0.087%*	-11.95 *-0.016%*	-155.56 *-0.215%*	-230.46 *-0.318%*
URBHIGH	-186.65 *-0.100%*	-35.80 *-0.019%*	-709.93 *-0.380%*	-932.38 *-0.499%*

Source: Writers' calculation

In general, the restriction of energy use in the hotel sector curbs the income of urban workers more than rural workers (around 84.15% of income decline is experienced by urban workers). A similar result occurs when the restriction is imposed on the restaurant sector, where 76.81% of urban workers suffer from income decline. Meanwhile, the restriction of energy in the public service sector causes urban workers' income to fall more than that of rural workers (urban workers shoulder around 66.13% of the income decline). A similar result also takes place when the restriction is imposed simultaneously on the three sectors, where urban workers' income falls by 68.85%.

Hence, energy restrictions imposed on particular economic sectors will only result in a negative impact on households. The least negative impact on households is when restrictions are imposed on the hotel sector, while the most negative impact is when restrictions are imposed on the public service sector.

7. Conclusion

This paper has elaborated the calculation methods for energy efficiency and energy restrictions, and analysed energy issues related to efficiency and restrictions in energy use, and their impacts on the Indonesian economy. Nevertheless, there are some constraints concerning this study: (i) the method is relatively simple and does not address the price issue, while price is an important variable in energy issues in Indonesia, especially for fuel oil; (ii) the general equilibrium of the SAM in this model is static in nature, hence is less reliable for forecasting long-run trends; (iii) the SAM assumes fixed Leontief Technology, which implies that technologies are constant from the base year of the model until a particular period (usually five years);

Nonetheless, by carefully taking into account all weaknesses concerning the methods implemented, some of the important conclusions that can be drawn from this study are as follows:

- The calculation method of efficiency in energy use and the Indonesian Energy SAM are very important as these two factors enable us to know the precise impact of improvement in efficiency of energy use on households' income. It is also worth noting that only a few scholars and researchers have used the Energy SAM Table to discuss energy issues in Indonesia.
- In general, the economic impact of improvement in efficiency of energy use is relatively better than the impact of restrictions in energy use, i.e improvements in energy efficiency increases the income of most household groups, while energy restrictions decreases their income.
- In this situation where efficiency is reached without cutting government subsidies, household incomes will increase the most when all industry sectors and all households use electricity efficiently.

- In this situation where efficiency is reached with subsidy cuts, household incomes will increase the most when all industry sectors use automotive diesel oil efficiently and all households use refinery gas efficiently.
- The improvement in efficiency should be emphasised more in industrial sectors than in households, as the former will increase household income by a greater amount than the increase created by the improvement in household efficiency. Furthermore, the improvement in efficiency in industrial sectors should focus on industrial diesel oil, and would be the best if the government were to cut the subsidy.
- Specifically, based on the SAM utilized in this paper, the industrial sectors that are suggested to trial efficiency in energy consumption in order to result in a positive effect on household income are: (i) Pulp and Paper Industry, Construction and Land Transportation for automotive diesel oil; and (ii) Trade, Pulp and Paper Industry and Textile Industry for Electricity. The groups of households suggested to trial efficiency in their energy consumption to result in a positive impact on household income are: (i) Urban High, Rural High and Urban Low for automotive diesel oil; (ii) Urban High, Rural High and Urban Low for refinery gas and electricity.

References

Binswanger, M. (2001). "Technological Progress and Sustainable Development: What About the Rebound Effect?" Ecological Economics 36: 119-132.

Biro Pusat Statistik (2004). Sistem Neraca Sosial Ekonomi Indonesia 2000.

Brookes, L. (1990). "The Greenhouse Effect: The Fallacies in the Energy Efficiency

Solution." Energy Policy 18: 199-201.

Defourny, Jacques, and Erik Thorbecke (1984). Structural Path Analysis and Multiplier Decomposition within a Social Accounting Matrix Framework. Economic Journal 94: 111-136.

Departemen Keuangan, Nota Keuangan and RAPBN, beberapa terbitan.

Garbaccio, R. F., Mun S. Ho and Dale W. Jorgenson (2000). A Dynamic Economy-Energy-Environment Model of China. Kennedy School of Government, Harvard University, Cambridge.

Ghebremedhin, Tesfa.G and Schreiner, Dean. F (1983). An Input-Output Approach For Analysis of Energy and Economic Policies in Oklahoma, Department of Agriculture Economics, Southern University, Baton Rouge, LA and Oklahoma State University, Stillwater.

Hartono, Djoni. and B.P. Resosudarmo (1998). Eksistensi Matriks Pengganda dan Dekomposisi Matriks Pengganda Pyatt dan Round dari Sistem Neraca Sosial Ekonomi. Ekonomi dan Keuangan Indonesia. Vol XLVI, No. 4, hal. 473-496.

Khanna, Madhu and David Zilberman (2001). Adoption of Energy Efficient Technologies and Carbon Abatement: The Electricity Generating Sector in India. Energy Economics 23: 637–658.

Khazzoom, D. J. (1980). "Economic Implications of Mandated Efficiency Standards for Household Appliances." Energy Journal, 1(4): 21-39.

Koop, Gary (2001). Cross-Sectoral Patterns of Efficiency and Technical Change in Manufacturing, International Economic Review Vol.42 No.1, University of Glasgow.

Lewis, B., and Thorbecke, E. (1992). District-Level Economic Linkages in Kenya: Evidence Based on A Small Regional Social Accounting Matrix. World Development, 20(6): 881-897.

Lovins, A. B. (1988). “Energy Saving from More Efficient Applicances: Another View.” Energy Journal 10: 157-166.

Newell, R. G., A. B. Jaffe, and R. N. Stavins (1999). “The Induced Innovation Hypothesis and Energy-Saving Technological Change.” Quarterly Journal of Economics 114: 941-975.

Pacudan, Romeo and Elaine de Guzman (2002). Impact of Energy Efficiency Policy to Productive Efficiency of Electricity Distribution Industry in the Philippines. Energy Economics 24: 41–54.

Pusat Data dan Informasi Energi, Departemen Energi dan Sumber Daya Mineral (2005). Buku Statistika Energi 2005.

Pyatt, G. dan J. Round (1979). Accounting and Fixed Price Multipliers in a Social Accounting Matrix Framework. Economic Journal 89: 850–873.

Pyatt, G. dan J. Round (eds.) (1990). Social Accounting Matrices: A Basis for Planning, The World Bank, Washington D.C.

Resosudarmo, B. P. and E. Thorbecke (1996). The Impact of Environmental Policies on Households Incomes for Different Socio-Economic Classes: The Case of Air Pollutants in Indonesia. Ecological Economics 17(1996): 83-94.

Resosudarmo, B. P. and E. Thorbecke (1998). Reducing the Number of Pesticide Related Illnesses: The Impact on Household Incomes in Indonesia. Bulletin of Indonesian Economic Studies Vol 34 No 2, pp. 3–57.

Resosudarmo, B.P. (2002). Indonesia’s Clean Air Program. Bulletin of Indonesian Economic Studies, 38 (3), 343-365.

Sadoulet, E. and de Janvry, A (1995). Quantitative Development Policy Analysis, Johns

Hopkins University Press, Baltimore. Chapter 10, p: 273-301.

Searle, S. R (1982). Matrix Algebra Useful for Statistics. John Wiley and Sons. New York.

Thorbecke, E. (1985). The Social Accounting Matrix and Consistency Type Planning Models. In G. Pyatt and J.I. Round, eds. Social Accounting Matrices: A Basis for Planning, pp. 207-256. Washington, D.C., World Bank.

Thorbecke, E. (1992). Adjustment and Equity in Indonesia. Paris: OECD Publications.

Yanai, Moshe and Hewings, Geoffrey. J.D (2004). Economic Impact of Repowering the Midwest: Energy Efficiency Impacts for The Midwest, Working Report No.2, University Illnois and Federal Reserve Bank of Chicago.