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M. Handri Imansyah
Center for Administrative Studies, Faculty of Social and Political Sciences, Universitas Indonesia, Depok; Indonesia

Titi Muswati Putranti
Center for Administrative Studies, Faculty of Social and Political Sciences, Universitas Indonesia, Depok; Indonesia

Dean Yuliandri Affandi
Center for Administrative Studies, Faculty of Social and Political Sciences, Universitas Indonesia, Depok; Indonesia

Nidaan Khafian
Center for Administrative Studies, Faculty of Social and Political Sciences, Universitas Indonesia, Depok; Indonesia

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The Key Sectors in CO2 Emission in Indonesia: Input Output Analysis

M. HANDRY IMANSYAH, TITI MUSWATI PUTRANTI, DEAN YULIANDRI AFFANDI, NIDAAN KHAFIAN, AND MARIA TAMBUNAN
Center for Administrative Studies, Faculty of Social and Political Sciences, Universitas Indonesia, Depok, Indonesia
puska.adm@ui.ac.id

Abstract. This research is intended to identify changes of key sectors in CO2 emission over the period of 1990-1995. This research uses input-output method for mapping of the biggest polluting industry. By identifying the highest output multiplier, CO2 emission and change of final demand can be known from each of sectors. The research results show that there is emission reduction in the fifteen key sectors over 1990-1995, but there is no significant change in the five key sectors that are still the highest polluters.

Keywords: CO2 emission, consumption of energy, input-output method

Abstrak. *Penelitian ini dimaksudkan untuk mengidentifikasi perubahan sektor kunci dalam emisi CO2 selama periode 1990-1995. Penelitian ini menggunakan metode input-output untuk pemetaan industri dengan polusi terbesar. Dengan mengidentifikasi pengganda output tertinggi, emisi CO2 dan perubahan permintaan akhir dapat diketahui dari masing-masing sektor. Hasil penelitian menunjukkan bahwa ada pengurangan emisi di lima belas sektor-sektor kunci selama 1990-1995, tetapi tidak ada perubahan yang signifikan dalam lima sektor kunci yang masih sebagai penghasil polusi terbesar.*

Kata kunci: *emisi CO2, konsumsi energi, metode input-output*

INTRODUCTION

Economic growth has positive correlation with carbon emission of a country. Sathaye, Monahan and Sanstad (1996), and Macho (2000) show that fast economic growth is always followed by increasing emission, particularly carbon (CO2) emission. According to the World Bank (2007), Indonesia is the third biggest emission producer after United States and China. Indonesia produces approximately 3.014 tons of CO2 (MtCO2e), 85% of which is caused by deforestation and damage in peat lands that contain carbon in massive number.

Increasing carbon emission in line with economic growth is triggered by fast-growing industrial activity. According to the Ministry of Environment (2006), industry sector was the highest energy consumers since 2001, followed by transportation sector. Manufacturing sectors contributed to 25% to Gross Domestic Product (GDP) in 2010. The consequences of this contribution are higher level of energy consumption and CO2 emission from industry sector, with average escalation of 146.87% in five years (1995-2000).

However, higher energy consumption is caused not only by higher economic growth, but also by low energy efficiency in Indonesia (Basri, 2009; Kusumawardhani, 2009). Based on Review of World Energy (2004), Indonesia requires more than 470 tons of energy to generate GDP of US$ 1 million and Thailand requires approximately 400 tons. Meanwhile, Japan needs only 92.3 tons and OECD countries around 200 tons.

Policy makers require comprehensive information on energy use and CO2 emission to make an appropriate policy, particularly in key sectors that show significant growth in Indonesia. Comprehensive information is needed for the key sectors in Indonesian economy, especially in context of CO2 emission from the sectors, if the sectors are driven to be the key sectors in acceleration of economic development. Should this happen, economic acceleration that relies on the key sectors would generate a higher CO2 emission as well. Therefore, review is important to identify whether or not the key sectors generate high CO2.

Many studies related to energy use and emission effects have been done using input-output analysis (Lee, Lin and Lewis, 2001; Casler and Rose, 1998; Matthews, Weber and Hendrickson, 2008; Hondo, Sakai and Tanno, 2002; Hikita, Shimpo and Shukla, 2007; Mukhopadhyay, 2002a). For example, Mukhopadhyay (2002a) studied on changes in the sources of CO2 emission in India and found that CO2 emission from fossil fuel and coal reaches 65%.

The study concludes that the main factor behind the increase CO2 emission is the level of changes in value added and in final demand over 1973-1974 and

Table 1. Tables of energy input-output made by Central Bureau of Statistics (1990-1995)

Indonesia Input-Uotput Table (Currency)

I	1	. . .	161	180	301	. . .	309	310	. . .	600	700
	:										
	161										
	190										
	Value Added										

EDEN Indonesia Input-Output Table (Currency)

II	1	. . .	76	180	301	. . .	309	310	. . .	600	700
Energy Sector	:										
	76										
	190										
	Value Added										

Energy Input Table (Currency)

III	1	. . .	76	180	301	. . .	309	310	. . .	600	700
			Goal								
	:		***Gasoline***								
	.		***Electricity***								
	22										

Energy Input Table (Physical)

IV	1	. . .	76	180	301	. . .	309	310	. . .	600	700
			Goal								
	:		***Gasoline***								
	.		***Electricity***								
	22										

V **The Energy For Non-Energy Purposes (Percentage)**

	1	. . .	76	180	301	. . .	309	310	. . .	600	700
			Goal								
	:		***Gasoline***								
	.		***Electricity***								
	22										

VI (VI=IV-V) **The Combination Energy (Percentage)**

	1	. . .	76	180	301	. . .	309	310	. . .	600	700
			Goal								
	:		***Gasoline***								
	.		***Electricity***								
	22										

VII **Energy Emissions (CO2, SO2)**

	1	. . .	76	180	301	. . .	309	310	. . .	600	700
			Goal								
	:		***Gasoline***								
	.		***Electricity***								
	22										

VIII **The Energy for Convertion/Tranformation (Percentage)**

	1	. . .	76	180	301	. . .	309	310	. . .	600	700
			Goal								
	:		***Gasoline***								
	.		***Electricity***								
	22										

IX (IX=IV-V-VIII) **Energy Balance**

	1	. . .	76	180	301	. . .	309	310	. . .	600	700
			Goal								
	:		***Gasoline***								
	.		***Electricity***								
	22										

1996-1997. Thus, it appears that change of value added (revenue) will affect CO2 emission, as well as final demand. Mukhopadhyay (2002b) finds that information is no longer dependent on production, but on energy. In other words, production and energy will rely on information. The results showed that it was quite interesting, showing that information sector has partially reduced energy consumption or saved energy in indirect ways.

Shukla (2007) argued that India is the fourth biggest producer of CO2 emission in the world, after United States, China and Russia. This condition relates closely to high population growth. Furthermore, economic growth targeted to be 8% annually in the next ten years after 2002 has directly and indirectly affected CO2 emission growth

in India. However, the increasing emission is hopefully coupled with better quality of life of the population. International Energy Agency (IEA) reported in 2010 that China produced higher emission than that of the United States in 2006. Over 1992-2007, emission growth in China is 166% and 70% of this percentage took place in the period of 2002-2007 when China's GDP growth reached the highest level. Sixty percents emission in China comes from the sector of construction industry and 12% from household sector

In China, urban population consumption pattern is not environmentally friendly, while 85% population of China live in many cities. Imposition of carbon tax is considered an attempt to control the consumption pattern. In addition, the Government of China has enacted many regulations that are related to international trading, in order to continuously maintain reduction of carbon emission and China's role as the biggest exporter of the world.

Brazil has a better capability of carbon reduction than that of other developing countries. This could be attributed to Brazil's low dependence on fossil fuel (Imoriand Guilhoto, 2008). Brazil used bio-energy and hydropower to reduce emission, and this is strikingly different from most countries of the world.

By contrast, South Africa as one of the biggest coal producers in the world uses coal to a maximum extent for household fuel, and this causes an increasing CO2 emission (Arndt 2011). Arnd uses Input Output Analysis to dissect carbon intensity in South Africa and determines the instrument of carbon pricing as an instrument of intervention.

Gregg and Robert (2005) mention that Indonesia ranks the 21st among other countries in the world as CO2 emitter. It is necessary to emphasize that the rank might go even higher as a higher population growth requires more energy to meet higher standard of living. Imansyah (2008) uses structural decomposition analysis from the analysis of input-output table, in which production structure is affected by price through monetary crisis and it undergoes structural change as consequences. Capital and manpower intensities are highly susceptible to crisis. In addition, the study found that technology used is affected by price change arising from monetary crisis. Thus, price change will affect technology that is used for energy, and energy price will have important roles in reducing energy use. For instance, energy use decreases substantially during monetary crisis, hence lower CO2 emission.

RESEARCH METHODS

Input-output analysis will be used to identify the key sectors, through the highest output multiplier by sector. Output multiplier analysis is intended to identify the impacts of final demand change of particular sector on all existing sectors in each change unit of multiplier type. Final demand increase in sector j will cause not only increase of production output of sector j, but also increase of other sectors' output in economy. Increase of other sectors' output is created by direct and indirect effects of final demand increase of sector j (Miller and Blair, 2009). Thus, the formula of total output (production) multiplier is as follows:

Output Multiplier type I $$O_j = \sum_{i=1}^{n} b_j$$

Output Multiplier type II $$O_j * = \sum_{i=1}^{n} b_j *$$

where:

$\mathbf{O}_j$ and $\mathbf{O}_j$* : output multiplier of sector j in open and closed I-O

$\mathbf{b}_{ij}$: Leontief inverse matrix

$\mathbf{b}_{ij}$* is Leontief inverse matrix in the model of closed I-O, where one column is added for share of household consumption and one row for share of wage and salary per sector (to endogenize consumption variables)

i = row 1, 2 …….. n

As the highest output multiplier is known so, in case of demand change, the impact can be identified on CO2 emission in sectors that form parts of the key sectors.

The data of table of energy input-output, which are used, are 1990 and 1995 tables of energy input-output made by Central Bureau of Statistics. The path for making Indonesia Table of Energy Input-Output is developed by the Central Bureau and as follows.

RESULT AND DISCUSSION

Output multiplier analysis is very useful to identify sector policies and mitigation of green-house gases though reduction of CO2 emission. The analysis in this paper will examine the main sectors that have high output multiplier and high CO2 emission that will cause increasing green-house gases effect if the key sectors are developed to achieve high output growth.

Generally, development strategy focuses on the key sectors that have high outputs. However, the key sectors are not exactly known if these sectors generate high emission and identification, of course, is needed. Economic development strategy should consider the concept of green economy that are: pro growth, pro poor, pro job, and pro environment.

In 1990, the key sectors based on output multipliers were dairy products, plastic products, iron and steel, wooden furniture, and iron and steel products. Based on multiplier, the total volume of CO2 emission from the 15 key sectors is 12,072.78 thousand tons or 35.81% of total emission generated by all production sector (BPS, 1990).

In 1995, the key sectors based on output multipliers

Table 2. Key Sector based on *Multiplier Output* and CO2 Emission ('000 ton) Year 1990

No.	Sector	*Type I*	*Type II*	CO2 Emission
1	*Dairy products*	6.16	8.10	18.88
2	*Plastic products*	5.93	7.79	20.39
3	*Iron and steel*	5.22	6.87	493.74
4	*Wooden furniture*	4.22	5.55	1,210.86
5	*Iron and steel products*	4.05	5.32	317.77
6	*Coke and other coal products*	4.05	5.32	2.63
7	*Cement*	4.01	5.27	997.14
8	*Animal feeds*	3.39	4.45	19.72
9	*Other foods*	3.33	4.37	615.51
10	*Spinning and weaving*	3.32	4.36	662.31
11	*Rubber products*	3.25	4.27	119.47
12	*Tobacco*	3.19	4.19	65.65
13	*Soap, detergent and toiletries*	3.16	4.16	27.62
14	*Thermal power*	3.09	4.06	6,461.18
15	*Air transport*	3.03	3.98	1,039.92
	Total			12,072.78
	Presentage to total CO2 Emission for all sectors			35.81%

Table 3. Key Sector based on *Multiplier* Output dan CO2 Emission ('000 ton) Year 1995

No.	Sector	*Type I*	*Type II*	CO2 Emission
1	*Plastic products*	4.82	6.59	167.10
2	*Animal feeds*	4.58	6.25	60.57
3	*Iron and steel*	4.11	5.61	506.65
4	*Rubber products*	3.79	5.18	293.72
5	*Coke and other coal products*	3.51	4.80	4.18
6	*Other electrical machinery and apparatus*	3.39	4.62	252.02
7	*Iron and steel products*	3.31	4.52	1,484.43
8	*Air transport*	3.17	4.32	1,898.84
9	*Spinning and weaving*	3.12	4.27	1,605.21
10	*Wooden furniture*	3.12	4.26	1,325.90
11	*Fertilizer*	3.04	4.16	95.56
12	*Cement*	3.03	4.14	1,830.55
13	*Non-ferrous metal products*	3.00	4.10	153.45
14	*Dairy products*	2.94	4.02	151.02
15	*Tobacco*	2.94	4.01	187.76
	Total			10,016.94
	Percentage to total CO2 Emission for all sectors			15.41%

were plastic products, animal foods, iron and steel, rubber products, coke and other coal products. Based on multiplier, the total volume of CO2 emission from the 15 key sectors is 10,016.94 thousand tons, or lower emission if compared to CO2 emission from the 15 key sectors in 1990, 12,072.78 thousand tons. Thus, there is a decrease by 20.52% over the period of 1990-1995 (BPS, 1995). The 1995 condition is improving compared to that of the 1990 and it means that the key sectors generate only 15.41% of total emission of production sector, or 10,016.94 thousand tons based on multiplier of value added for the 15 key sectors.

One should consider the sectors that the driver of economic growth including in the level of CO2 emission. If the emission level is not high, the sectors then deserve to be the key sectors. This means that the sectors use more environmentally friendly technology. The growth of CO2 emission in the last five years from 1990-1995 is 92.82%, from 33,704.31 thousand tons to 64,987.37 thousand tons. However, the growth of the five sectors that generate the highest CO2 is highly varied. Thus, there is a more even distribution in 1995 in generating CO2 emission. However, the rank order of the five highest sectors does not change. The growth of CO2 emission in the five highest sectors has been quite varied over the period of time.

The civil engineering sector even has negative growth. This means that this sector uses more environmentally friendly technology, and the sector generates less CO2 emission amid soaring economic growth. Meanwhile,

thermal power plant sector shows significant growth or at 109.03%, higher than of the total growth reaching 92.82%. However, the five sectors that generate the highest CO2 emission show that the growth is far lower than that of the growth of CO2 emission from all sectors, which is 55.81% against 92.82%. This indicates that there is technological improvement as CO2 emission that is generated in the key sectors.

The highest growth is public administration, and the next sector that generates moderately high emission is gas sector. This is reasonable that gas began to be intensively used in 1995. A better living standard will create activities that generate higher CO2 emission. The sectors that generate the highest CO2 emission in 1990 are thermal power, civil engineering, road transport, buildings, and timber and wooden products. There is no significant change of ranking order of CO2 emission in 1990 compared to that in 1995.

Manufacturing sector also requires energy such as electricity and other sources for production, and it shows significant increase of CO2 emission, which is 171.25%, followed by 122.49% increase of CO2 emission from manufacture and construction industries in five years.

It important to note that Indonesia is classified as having the lowest efficiency of energy use in the world (Basri, 2009; Kusumawardhani, 2009), signifying that energy needed by Indonesia to achieve growth is higher than that of other countries (BP Statistical Review of World Energy 2004 and IMF World Monetary Outlook 2004). Data from Review of World Energy (2004) showed that Indonesia requires more than 470-tons energy to generate GDP of US$ 1 million, Thailand 400 tons while Japan needs only 92.3 tons, OECD countries approximately 200 tons.

This explains why Indonesia becomes a big producer of CO2 emission, since the sectors that show the highest real growth and forces behind economic growth are those with the highest CO2 emission, as shown in IO data (1995). This is shown by fast growth of 15 key sectors that previously generates 35% CO2 and currently 15%, which mean significant decrease in five-years.

Identification of these sectors is needed if Indonesia Government commits to implement of RAN (National Action Plan) GRK (Green House Gas) to obtain economy in both pro-growth and pro-green. Then, the main task of the government is to improve policy for manufacturing sector by encouraging environmentally friendly technology and efficient use of energy in order to reduce CO2 emission in the sectors with high CO2 emission in the key sectors.

However, there will be a dilemma when the reduction effort has to come in relation with the increasing growth of Indonesia economy. The foregoing table shows that the sectors with the highest contribution to GDP are also the sectors with the highest level of output multiplier and the highest carbon emission. For example, the sector of manufacture industry has given 25.37% contribution to total GDP in the second quarter of 2012, based on 2000 constant price (BPS, 2012). Sectors like cement industry, wood processing for furniture and textile industry have also high emission, which is approximately 40% of total 10,010 Mt CO2 from 15 key sectors.

If the government really want to reduce carbon emission from manufacturing sectors without having to slow down economic growth, the government and private sector will have to start instituting efficiency of fuel use in production methods and technology, as well as use of alternative fuel that is more environmentally friendly.

PT Semen Tonasa carries out its production activity by developing raw materials and alternative fuel for cement production. Cement manufacturing is an manufacturing with high level of emission, which produces raw materials for infrastructure construction, and of course its role is strategic in the country with ongoing economic growth. Therefore, it is interesting to take a closer look at the efforts made by PT. Semen Tonasa to reduce carbon emission and concurrently meet the demand of growing market.

PT. Semen Tonasa was founded in 1960. At the moment of the company establishment, the fuel that was used was Black Crude Oil (BCO). However, this fuel was considered inefficient and therefore no longer used and replaced by diesel fuel that was cheaper and easy to get. The problem of energy conservation did not stop and, in 1984, diesel fuel was replaced with coal. However, in the course of production process, coal was used in heating-up process and diesel fuel was still used for production process. As of 2007, PT. Semen Tonasa began to use rice hull as fuel and it has been effectively used since 2010.

In addition to use of rice hull as fuel, PT. Semen Tonasa used the hull of cashew nut as fuel, which was collected from plantation and home industry. Replacement of coal and rice hull with hull of cashew nut was considered more economical and environmentally friendly, and the hull of cashew nut is capable of generating calorie to a level that is enough to run production machinery. From that moment until 2012, PT. Semen Tonasa had set up the facility for gradual replacement of fuel by 30%.

CONCLUSION

Basically, emission from the 15 key sectors had shown significant decrease since 1990 until 1995, from 35% to 15%. The growth of CO2 emission over 1990-1995 is 92.82%. However, the growth of the five sectors with the highest CO2 emission is highly varied, based on sectors. There is a more even distribution in 1995 in relation to CO2 emission. However, the order of the five highest sectors remained unchanged.

Identification of these sectors is needed if Indonesia Government commits to implement of RAN (National Action Plan) GRK (Green House Gas) to obtain economy in both pro-growth and pro-green. Then, the main task of the government is to improve policy for manufacturing sector by encouraging environmentally friendly technology and efficient use of energy in order to reduce CO2 emission in the sectors with high CO2 emission in the key sectors.

The government should advisably cooperate with private parties in order to realize efficient use of fuel in production methods, technology and use of alternative fuel that is more environmentally friendly. There many policies has been issued in these matters, however, private sectors are still not interested to implement because the high energy subsidy to fuel fossil hampers private sectors to develop alternative fuel like bio-fuel from CPO or ethanol. The price of fossil fuel due to subsidy is lower than the price of alternative fuel like bio-fuel.

Efficiency of energy use is now relatively low in Indonesia, if compared to that of other countries that have relatively the same level of economic growth. To reduce emission without slowing down economic activity, the government needs to maximize its roles through regulatory mechanism and state budget, coupled with implementation regulation that is not open to many different interpretations and that is well coordinated. In addition, the government can copy policy as done by other developing countries such as India, China, Brazil and South Africa, and adjust to existing systems in Indonesia. The price policy of fossil fuel should consider by lifting price subsidy and the subsidy should be targeted to the appropriate target group. Without appropriate price policy in fossil fuel, current fiscal incentive is useless and CO2 emission can not be reduced substantially.

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