A Micro Environmental SAM for Australia[1]

Duy Nong[2], Sam Meng, Mahida Siriwardana, Judith McNeill, Trang Tran

Abstract

This paper presents an approach to building an Australian micro environmental social accounting matrix (E-SAM) with details of 24 energy sectors and corresponding emissions matrixes. The purpose behind this is to evaluate impacts of Australian climate change policies on the energy sectors and the environment. The work has developed a higher level of disaggregation regarding energy sectors than in the popular model, the MMRF-Green model, which has been used for Australian policy analyses for over 10 years. The paper provides a procedure used to construct the SAM, based on the initial industries in the ABS Input-Output (I-O) Tables 2008-09. From this SAM, the disaggregation procedure has been processed. We list the Australian data availability regarding our disaggregation and justify which database we have used. At the final stage, we extract the stationary and non-stationary emissions data from the National Greenhouse Gas Inventory (NGGI) at the most detailed level possible based on this data. Once the data from the NGGI is compatible with the I-O product details Table, we have constructed the stationary emissions and the activity emissions matrixes.

Key Words: Australia, E-SAM 2008-09, energy sectors, climate change policies, stationary emissions matrix, activity emissions matrix.

1. Introduction

Computable General Equilibrium (CGE) modelling is an important tool for assessing the effects of climate change policies. However, the approach requires intensive data collection and complex data base compilation before approaching any result. On the other hand, data base compilation is always a big challenge for any modeller. As a result, the more reliable and detailed literature in this field, the easier and quicker future modellers can employ it. This paper is therefore intended to exploit a detailed work of data base compilation with a hope to make a reliable reference.

[1] The authors would like to acknowledge funding from the Australian Research Council under ARC Linkage Project LP120200192.
[2] UNE Business School and Institute for Rural Futures, University of New England, Armidale, NSW, Australia.

In this paper, we describe a detailed approach to building a micro E-SAM for energy sectors and greenhouse gas (GHG) emissions data, based on Australian data. Particularly, we disaggregated the four energy industries of the original ABS I-O Tables into 24 sub-energy industries. The purpose behind this task is to evaluate impacts of Australian climate change policies on the energy sectors and the environment. 24 sub-energy industries were the result of our disaggregation due to a couple of reasons: (1) most of the industries were conveniently derived from the data available in the I-O product details Table. In this case, we selected only important sub-energy industries, presenting relatively large output from the I-O product details Table. (2) We also added other important sub-energy industries, which are not presented in the I-O product details Table. (3) As climate change policies may make a strong transition to a low carbon economy; a disaggregation of renewable energy industries becomes important. Accordingly, this ensures simulations would not miss any important energy industry for analysis, and would also capture necessary effects of the policy changes, i.e. transition to a particular renewable energy industry such as the solar-electricity generation industry.

The work indeed exploits a higher intensive disaggregation than the popular model, MMRF-Green model[3], which has been for Australian policy analyses for over 10 years[4]. Specifically, we disaggregated oil and gas extraction; petroleum products and electricity generation sectors into a more detailed level rather than in the MMRF-Green model. We also disaggregated the stationary and non-stationary emissions data and constructed emissions matrixes for environmental assessment purposes.

The initial process is to search for available and reliable data. At this stage, we presented the characteristics of the SAM, then the specific characteristics of data sources to make an appropriate database. For example, the characteristics and methods in the I-O Tables, the I-O product details Table and the Australian System of National Accounts (ASNA) are discussed to show how to make a suitable database.

Subsequently, we have provided the procedure to make the SAM, based on the initial industries in the I-O Tables 2008-09. From this SAM, the disaggregation procedure has been processed. Essentially, it was based on the most consistent statistics available; the RAS method has been an alternative after considering all data available. We list the Australian data

[3] MMRF-Green model includes two commodities of "coal mining" sector, two commodities of "oil and gas extraction" sector, five commodities of "petroleum products" sector and six commodities of "electricity generation" sectors.

[4] This model was intensively applied by the Australian Treasury (2011) in order to estimate the effects of carbon price in Australia. It was also significantly applied by organisations and economists for Australian policy analyses in Australia and states (Adams, 2007; Hoque et al., 2010; and Dwyer et al., 2012).

available regarding our disaggregation and justify which database we have used. For example, the sub-energy commodities disaggregation has been based essentially on the information in the I-O product details Table and energy supply statistics published by ABARE. We have used industry information, assumptions based on current technology and information from the NGGI for the sub-energy industries disaggregation.

At the final stage, we have extracted the stationary and non-stationary emissions data from the NGGI at the most detailed level possible based on this data. Once the data from the NGGI was compatible with the I-O product details Table, we constructed the stationary emissions and the activity emissions matrixes. Emissions of some particular emissions allocations have been assisted by using product component information. For example, emissions from use of refrigeration were considered as emissions of Halocarbons and Sulphur Hexafluoride.

The paper is organised as follows: Section 2 describes the characteristics of a SAM and database to construct it. Section 3 shows how to construct the SAM, keeping the 111 initial industries. For this stage, the I-O Tables 2008-09 and ASNA 2010-11 bulletins are adequate. Section 4 highlights the procedure to divide the four initial energy industries into 24 sub-energy industries. In this Section, the I-O product details Table 2008-09 is used for the energy industries subdivision. In Section 5, we highlight the process to create emissions matrixes, based on the data in the NGGI 2009. Section 6 provides the conclusing remarks.

2. A SAM and database requirement

A SAM describes all transactions and transfers in the economy, with intermediate goods and the primary factors of production (i.e. labour, capital and land) used for production. These factor endowments are contributed by institutions (households, firms, foreigners and government) that, in turn, receive factor payments as value-added. Apart from the value-added, institutions get income from other sources, such as transfers from the government and foreigners. The income is spent as the consumption expenditure on goods and services, capital goods and for payment of taxes. Reserves are saved for future. The total supply in the economy has to be matched by the demand made by the institutions and capital formation, i.e. purchase of investment goods. In addition, an economic activity also contains financial flows among institutions. A SAM is a comprehensive accounting framework within which the full circular flow of income from production to factor incomes, household income to household consumption, and back to production is captured. All the transactions in the economy are presented in the form of a SAM. Each *row* of the SAM indicates receipts of an account while the *column* presents the expenditure. The total of *each row k* equals the total of *each column k*.

Table 1: The general structure of Australian SAM

Classification		Production activities							Factors of production			Income account					Financial account					Capital account					Total
	Items	Industry	Non-margin comm (dom)	Non-margin Comm (imp)	Margin comm	Taxes on domestic products	Taxes on imported products	Taxes on production	Labour	Capital	Land	HH	NF-C	FC	G	Fo	HH	NF-C	FC	G	Fo	HH	NF-C	FC	G	Fo	
Production activities	Industry	A										E										J				
	Non-margin Comm (dom)																									
	Non-margin Comm (imp)																									
	Margin comm																									
	Taxes on domestic products																									
	Taxes on imported products																									
	Taxes on production																									
Factors of production	Labour	B										F														
	Capital																									
	Land																									
Income account	Households (HH)	C							D			G														
	Non-financial corp (NF-C)																									
	Financial corp (FC)																									
	Government (G)																									
	Foreigners (Fo)																									
Financial account	HH																I									
	NF-C																									
	FC																									
	G																									
	Fo																									
Capital account	HH											H										K				
	NF-C																									
	FC																									
	G																									
	Fo																									
Total																										

Table 1 is an example of the general structure of a SAM. The classifications associated with corresponding items are presented in *column* and *row* directions. Within the large matrix of the SAM, there are some sub-matrixes, i.e. matrixes A, B, C, called the classification matrixes, which are the cross-matrixes among classifications. Each matrix A, B or C also contains sub-matrixes (referred as A1, A2, B1, B2, etc.), called the item matrixes, which are the cross-matrixes among items.

There are some cross-classification matrixes, which are not labeled with names. These matrixes indicate that there is no transaction involved between the classification in the column and classification in the row. At the outset, we briefly present the meaning of each classification matrix in Table 1.

Matrix A presents inter-industry transactions. It is based on the characteristics of the MMRF, MONASH or ORANI-G's TABLO. For example, *industry k* produces both margin and non-margin commodities; and the non-margin commodities are produced domestically only. This industry also uses intermediate domestic and imported commodities. Industries use the margin commodities as catalysts in order to use intermediate non-margin commodities for their production processes. For example, an industry might use the "transport margin" commodity in order to transport the "coal" commodity to its factory. In addition, matrix A also shows obligations of industries regarding tax payments for their consumption and production processes.

Matrix B refers to payments of industries regarding their uses of primary factors. In this study, the primary factors are labour, capital and land.

Matrix C indicates the income inflows of recipients regarding taxes on products, taxes on production and imported commodities. For example, taxes belong to government while imported commodity revenues belong to foreigners. On the other hand, matrix A shows the tax payments and a payment for buying imported commodities, while matrix C indicates the recipients of these payments.

Matrix D shows the income of recipients regarding their supplies of primary factors for production processes of industries. Likewise, matrix B describes the sources of the primary factors payments, whereas matrix D shows the recipients of these payments.

Matrix E describes the payments of institutions regarding their final consumption, which includes payments for non-margin and margin commodities and taxes on products subject to their purchases. In this matrix, the subsidy from government to production of industries is also presented.

Matrix F shows the payments of institutions to primary factors, if institutions involve any domestic production activities, i.e. from foreigners.

Matrix G provides inter-institution transactions within the income account. This involves the payments and receipts regarding interest, dividend, rent, insurance premiums, insurance claims and other transfers.

Matrix H indicates the savings of institutions after all expenditures. This is allocated in the capital account as "net saving and consumption of fixed capital".

Matrix I refers to inter-institution transactions within the financial account. These transactions contain the flows of financial assets, i.e. currency and deposits, bills of exchange, bonds, securities and loans.

Matrix J reflects the consumption by institutions of capital goods, including both domestic and imported capital goods. Similarly to normal commodities, the users of capital goods pay taxes on products based on their purchases.

Matrix K presents inter-institution transactions within the capital account. This shows the net lending and capital transfers from column institutions to row institutions.

In addition, a SAM can be regarded as a combination of the I-O Tables and the ASNA bulletin. The I-O Tables provide detailed information on the flows of goods and services and the structure of production costs. The symmetric I-O Tables are based on the USE matrix and SUPPLY matrix. The USE matrix gives the information regarding intermediate inputs into industries, final uses of institutions, trade and consumption of capital goods. The SUPPLY matrix gives information of output supply by industries. The I-O Tables do not show the interrelationship between value-added and final expenditures. However, the ASNA bulletin shows the flows among institutions in the economy regarding the income account, financial account and capital account.

Before turning to compilation, we briefly describe the characteristics of these two data base bulletins. The essential requirement would be an exact consistency between the I-O Tables bulletin and the ASNA bulletin; otherwise there would be a need to adjust the I-O Tables data to the ASNA database (Pang et al., 2006).

The Australian Bureau of Statistics (ABS) normally publishes the I-O Tables with a three-year lag based on the information of the ASNA bulletin released in the previous year. For example, ABS published the I-O Tables 2008-09 in 2012 based on the ASNA bulletin released in 2011, called the ASNA 2010-11. Hence, use of the I-O Tables 2008-09 and the

ASNA 2010-11 bulletins will allow consistent results without any adjustment. Simply, we also use these databases for the compilation in this paper.

Most of these databases were collected from ABS; only the NGGI 2009 was gathered from the Department of Climate Change in 2013 or Department of Environment since 2014.

3. The SAM compilation procedure

In the I-O Tables, the SUPPLY matrix provides values of non-margin and margin commodities supplied by industries; and the USE matrix contains the uses of domestic and imported non-margin and margin commodities. Hence, in order to be consistent with the structure of the SAM in Table 1, the margin and non-margin commodities supplies need to be separated in the SUPPLY matrix[5]. Similarly, in the USE matrix, the commodities uses by industries and final users have to be separated by sources and by types of commodities (margin and non-margin commodities).

3.1. Separating margin and non-margin commodities supplies in the SUPPLY matrix

Table 2: The structure of the SUPPLY matrix

		Industry	Total Australian supply
		111 ↔	
Commodities	111 ↕	X1	
Total			

Table 2 is an example of the SUPPLY matrix, including margin and non-margin commodities. The margin commodities are actually the sub-commodities of the main commodities, named in the I-O Tables. For example, the "wholesale trade" commodity is the main commodity in the I-O Tables; it contains six sub-commodities, including one margin commodity (called "wholesaling services margin"). These sub-commodities are detailed in the I-O product details Table. Hence, from the I-O product details Table, we can know which industries and how much these industries supply this margin commodity. We subsequently obtain the SUPPLY matrix for all margin commodities, with the name of the main commodities. For example, the supply of the "wholesaling services margin" commodity

[5] This is only to make the SAM balance. We do not separate the non-margin and margin commodities in the SUPPLY matrix when using ORANI-G, MMRF and MONASH models because the supply sides in these models provide values of both non-margin and margin commodities. Only the uses of non-margin and margin commodities are separated from the demand side.

means the supply of the "wholesale trade" commodity; hence the commodities in the "SUPPLY matrix of margin commodities" are consistent with the "SUPPLY matrix of both margin and non-margin commodities".

The "SUPPLY matrix of non-margin commodities" is obtained by subtracting the "SUPPLY matrix of margin commodities" from the "SUPPLY matrix of both margin and non-margin commodities". So matrix X1 in Table 2 is separated into matrix X1.1 (the SUPPLY matrix of non-margin commodities) and matrix X1.2 (the SUPPLY matrix of margin commodities).

3.2. Separating the uses of margin commodities, non-margin commodities and indirect imports in the USE matrix

Table 3: The USE matrix with uses of margin, non-margin commodities and indirect imports

Sales by commodities	Purchases by industries	Industry	Households (final use)	Government (final use)	Gross fixed capital formation			Change in inventory	Export
					Private	Public enterprise	Government		
		111	1	1	1	1	1	1	1
Commodities	111	Y1	Y5	Y6	Y7	Y8	Y9	Y10	Y11
Taxes on domestic products	1				Y12	Y13	Y14		
Taxes on imported products					Y15	Y16	Y17		
Taxes on production	1	Y2							
Labour	1	Y3							
Capital	1	Y4							

Table 3 shows the general structure of the USE matrix at basic prices (A$ million). The USE matrix includes uses of both margin and non-margin commodities from domestic and imported markets. In addition, the USE matrix also presents the payments of industries regarding taxes and primary factors; and payments of institutions for their final purchases. This represents the uses of row commodities by column industries and institutions.

Table 4: The wholesaling services margin matrix

Sales by commodities / Purchases by industries		Industry	Households (final use)	Government (final use)	Gross fixed capital formation			Change in inventory	Export
					Private	Public enterprise	Government		
		111	1	1	1	1	1	1	1
Commodities	111								
Total	1	T1	T2	T3	T4	T5	T6	T7	T8

Table 4 shows how industries and final users use the "wholesaling services margin" commodity associated with other non-margin commodities. The row totals (T1, T2 … T8) represent the total usage of this margin commodity by institutions. Hence, the USE matrix without the use of the "wholesaling services margin" commodity is obtained by subtracting the total numbers (T1, T2 … T8) from the row of the "wholesale trade" commodity in the USE matrix. This is because the "wholesale trade" commodity is the main commodity and the "wholesaling services margin" commodity is one of its sub-commodities. Other margin commodities are applied in the same way. Subsequently, we obtain the "USE matrix of non-margin commodities". It means that the matrixes *Y1, Y5, Y6 ... Y11* in the "USE matrix of both non-margin and margin commodities" (in Table 3) become *Y'1, Y'5, Y'6 ... Y'11*[6] in the "USE matrix of non-margin commodities".

The "IMPORT matrix" of the I-O Tables represents the use of the imported non-margin commodities by each industry and final users, as the margin commodities are only produced domestically. This "IMPORT matrix" is the indirect imports allocated in each cell of the USE matrix.

The "domestic USE matrix of non-margin commodities" is simply achieved by deducting the "IMPORT matrix" from the "USE matrix of non-margin commodities". This activity includes the first row (commodities) in Table 3, for example, matrix Y'1 in Table 3 is divided into matrix Y'1.1 (the domestic USE matrix of non-margin commodities) and matrix Y'1.2 (the IMPORT matrix).

[6] We use these matrixes onwards instead of matrixes Y1, Y5, Y6 … Y11 as shown in Table 3.

3.3. The TAXES matrixes

Table 5: The taxes and subsidy matrixes in the I-O Tables

Sales by commodities	Purchases by industries	Industry	Households (final use)	Government (final use)	Gross fixed capital formation			Change in inventory	Export
					Private	Public enterprise	Government		
		111	1	1	1	1	1	1	1
Commodities	111	Z1	Z2		Z3	Z4	Z5	Z6	Z7

There are three kinds of taxes as shown in the I-O Tables; they are (1) goods and services taxes on products, (2) import duty on products, and (3) taxes on products not elsewhere identified. Taxes and subsidies on products have their own matrixes as shown in Table 5. The allocation in Table 5 means the column items pay taxes on products relative to their commodities consumption. In this case, the taxes on products payment is separated subject to domestic and imported commodities uses. We assume that the tax rate is the same for both domestic and imported commodities uses; however, only the imported commodities involve import duty on products.

Consequently, the taxes on domestic products matrix comes from the following formula:

Tax on domestic products matrix = (goods and services taxes on products matrix
+ taxes on products not else where identified matrix
+ subsidy matrix) * the domestic USE matrix of non-margin commodities matrix / (the IMPORT matrix + the domestic USE matrix of non-margin commodities matrix).

Then the tax on imported products matrix is identified as:

Tax on imported products matrix = (goods and services taxes on products matrix
+ taxes on products not else where identified matrix
+ subsidy matrix)
– taxes on domestic products matrix
+ import duty on products matrix.

As a result, the matrixes Z1, Z2 … Z7 in Table 5 would be an example of total taxes on products, the corresponding matrixes Z1.1, Z2.1 … Z7.1 represent "taxes on domestic products", whereas matrixes Z1.2, Z2.2 … Z7.2 indicate "taxes on imported products".

3.4. Dealing with undisclosed numbers in the I-O Tables

Before compiling the database, it is necessary to solve the problem of undisclosed (u.d) numbers in the I-O Tables. In the USE matrix, there are some undisclosed numbers; they are the final uses of the commodity 4901 and commodity 5101. In Table 6.1, from the total use of all commodities of the final users, it is easy to calculate the total final uses for both commodities 4901 and 5101 because other final uses of other commodities are known. Table 6.2 shows the uses of sub-commodities of commodity 4901 and commodity 5101 obtained from the I-O product details Table. The combination of both Table 6.1 and Table 6.2 results in the data in Table 6.3[7]. For example, the number 13907 equals 14349*21624/(21624+688); the number 442; 7717 and 246 are obtained in the same way. It is noted that the row total of commodity 4901 used is only the total of households and export columns; that is of 21624 (= 21744 – 113 – 4 – 11 + 8).

Table 6.1: The numbers provided in the USE matrix (A$ million)

USE	**Final Consumption Expenditure**		**Gross Fixed Capital Formation**			**Changes In Inventories**	**Exports**	**Final Uses**
Commodity id in I-O Tables	Households	Gov	Private	Public Enterprise	General Gov			
4901	u.d	u.d	u.d	u.d	u.d	u.d	u.d	**21,744**
5101	u.d	u.d	u.d	u.d	u.d	u.d	u.d	**688**
Total 4901 + 5101	14,349	0	113	4	11	-8	7,963	
Total intermediate use	**623,929**	**220,597**	**266,261**	**22,896**	**42,579**	**-2,993**	**277,349**	

Table 6.2: Sub-commodities id of commodity 4901 and commodity 5101 (A$ million)

Main comm id	USE	**Final Consumption Expenditure**		**Gross Fixed Capital Formation**			**Changes In**	**Exports**
	Sub-comm id	Households	Gov	Private	Public Enterprise	General Gov	**Inventories**	
4901	49000020	0	0	0	0	0	0	u.d
	49000030	u.d	0	0	0	0	0	u.d
	49000040	u.d	0	0	0	0	0	u.d
	49000050	149	0	113	4	11	-8	49
5101	51010010	u.d	0	0	0	0	0	u.d
	51020010	u.d	0	0	0	0	0	u.d
	51021980	0	0	0	0	0	0	0

[7] The method applied follows (Pang et al., 2006). That is, the number is allocated proportionally based on the row totals and column totals.

Table 6.3: The combination of Tables 6.1 and 6.2 (A$ million)

USE Commid	Final Consumption Expenditure		Gross Fixed Capital Formation			Changes In Inventories	Exports	Final Uses
	Households	Government	Private	Public Enterprise	General Government			
4901	13,907	0	113	4	11	-8	7,717	21,744
5101	442	0	0	0	0	0	246	688

Similarly, these u.d numbers occur in the same situation in the IMPORT matrix; however, they only occur in the households column for both commodity 4901 and commodity 5101. As a result, when there are total final use of A$7,432 million for the commodity 4901 row and A$10 million for the commodity 5101 row; and there is a total households column value of A$7,442 million for both these commodities. Obviously, each component value (A$7,432 million and A$10 million) is allocated into each commodity. There is no u.d number in the SUPPLY matrix, MARGIN matrixes and TAXES matrixes.

The different year I-O Tables databases have different confidential cells. Hence, we generally recommend making reference to the I-O product details Table in advance. This Table provides very detailed information regarding sub-commodities of a commodity in the I-O Tables. If they are not available to obtain the intended results, the next step is to find the information from the particular industries or base estimations on the I-O Tables released in previous years and apply the RAS method[8].

3.5. Matrixes compilation procedure

Table 7: Matrix A of SAM in Table 1

Classification	Item	Dimension	Production activities					
			Industry	Non-margin Commodity (domestic)	Non-margin Commodity (imported)	Margin commodity	Taxes on products	Taxes on production
			111	111	111	111	111	1
Production activities	Industry	111		A1		A2		
	Non-margin commodity (domestic)	111	A3					
	Non-margin commodity (imported)	111	A4					
	Margins	111	A5					
	Taxes on domestic products	111	A6					
	Taxes on imported products	111	A7					
	Taxes on production	1	A8					

[8] See, for example, United Nations, Handbook of National Accounting, Studies in Methods, ST/ESA/STAT/SER.F/74, Sales No. F.99 SV11.4, Chapter IX.

The classification matrix (matrix A) is presented in Table 7. This Table also shows the item matrixes (i.e. matrixes A1, A2), which are sub-matrixes of matrix A. The column and row dimensions respectively indicate the number of columns and rows. For example, matrix A1 includes 111 columns and 111 rows while matrix A8 has 111 columns and 1 row.

Matrix A1 indicates the revenues of industries in producing and supplying their non-margin commodities while **matrix A2** represents the revenues of industries from producing their margin commodities. As a result, the features in Table 2 could be compatible with these matrixes. However, Table 2 and Table 7 show the opposite direction between industry and commodity; therefore, matrix X1.1 and matrix X1.2 from the SUPPLY matrix in Table 2 will be transposed columns to rows and then allocated in matrixes A1 and A2 in Table 7.

The payments of industries related to intermediate uses of commodities are presented in **matrixes A3, A4 and A5** in Table 7. Matrixes Y'1.1 and Y'1.2 in Table 3 show the uses of industries regarding domestic and imported non-margin commodities, respectively. Hence, these two matrixes are respectively allocated in matrixes A3 and A4 in Table 7. The sum of all margin matrixes, an example of wholesaling services margin matrix shown in Table 4, has been allocated in matrix A5 in Table 7.

Matrixes A6 and A7 in Table 7 shows the payments of taxes on products by industries regarding the uses of domestic and imported commodities. Recall matrix Z1 in Table 5 also indicates the payments of taxes on products by industries for their uses of commodities; hence, matrix Z1.1 and Z1.2 are definitely compatible with matrixes A6 and A7.

Similarly, **matrix A8** indicates the payments of industries for taxes on production and this matrix is the same as matrix Y2 in Table 3. Hence, matrix Y2 in Table 3 will be allocated in matrix A7 in Table 7 as the payment of industries for taxes on production.

Table 8: Matrix B of SAM in Table 1

Classification			Production activities						
Item			Industry	Non-margin Commodity (domestic)	Non-margin Commodity (imported)	Margin commodities	Taxes on domestic products	Taxes on imported products	Taxes on production
		Dimension	111	111	111	111	111		1
Factors of production	Labour	1	B1						
	Capital	1	B2						
	Land	1	B3						

Matrixes B1, B2 and B3 in Table 8 shows the payments of industries for their uses of primary factors. As shown in Table 3, matrix Y3 represents payments of industries for labour used in their production processes. Consequently, matrix Y3 will be allocated to matrix B1 in

Table 8. Similarly, matrix Y4 in Table 3 represents payments of industries for capital and is placed in matrix B2 in Table 8. However, capital in the USE matrix (in Table 3) involves cost of land or land rent. Land used by industries mostly occurs for agricultural purposes, which are owned by households. Specifically, in this USE matrix, there are two primary factors such as labour and capital, whereas there are three factors of production in SAM in Table 1 (or in Table 8). Therefore, in order to be consistent with SAM in Table 1, it is necessary to separate capital uses in the USE matrix (in Table 3) into capital uses and land uses.

We have used the information in GTAP-E version 8.1, base year 2007; the capital value is US$266,745.82 million (254,315.7 + 12,430.12), while the land value is US$4,465.524 million. Hence, the values of land and capital in this paper were based on the ratios computed using these numbers. For example, total capital (including land value) in the USE matrix is A$536,909 million; the value of land therefore equals A$8,840.265 million (= 4,465.524/(266,745.82 + 4,465.524)*536,909) and the value of capital is A$528,068.735 million (= 266,745.82/(266,745.82 + 4,465.524)*536,909). Simply, the value A$536,909 million corresponds to matrix Y4 in Table 3; and the separation values A$528,068.735 million and A$8,840.265 million are called matrix Y4.1 and matrix Y4.2, respectively. Hence, matrix Y4.1 and matrix Y4.2 are respectively allocated to matrixes, which are payments from industries to capital and land (matrixes B2 and B3 in Table 8).

Table 9: Matrix C of SAM in Table 1

Classification	Item	Dimension	Production activities						
			Industry	Non-margin Comm (domestic)	Non-margin Comm (imported)	Margins	Taxes on domestic products	Taxes on imported products	Taxes on production
			111	111	111	111	111		1
Income account	Households	1							
	Non-financial corporation	1							
	Financial corporation	1							
	Government	1					C2	C3	C4
	Foreigners	1			C1				

In Table 9, **matrix C1** represents the receipts of foreigners regarding their commodities supplied to the Australian market. In the external account of the ASNA bulletin, there is one flow, which reports the receipts of foreigners regarding their exports to Australia. Hence, this amount will be allocated to matrix C1 in Table 9 as foreigners' receipts for commodities exported to Australia.

Matrixes C2, C3 and C4 shows the receipts of government regarding taxes on domestic products, imported products and production. From the income account of the ASNA bulletin,

the government receives "taxes on production and imports of goods and services"; in another way, they are taxes on production and products. The government also supports industries' production activities through subsidies, reducing taxes on production. It means the government receives taxes on production, which equals taxes on production paid by industries (in matrix A8 in Table 7) plus government's subsidies to industries (from the ASNA bulletin). These receipts are placed in matrix C4 in Table 9. The residual from deducting the amount allocated to matrix C4 from "taxes on production and imports of goods and services" above will be an income to government for taxes on products. This amount is in turn distributed to matrixes C2 and C3, based on the ratio between domestic usage and imports from the "domestic USE matrix of non-margin commodities" and "IMPORT matrix".

Table 10: Matrix D of SAM in Table 1

Classification	Item		Factors of production		
			Labour	Capital	Land
		Dimension	1	1	1
Income account	Households	1	D1	D3	D7
	Non-financial corporation	1		D4	
	Financial corporation	1		D5	
	Government	1		D6	
	Foreigner	1	D2		

Matrix B indicates the primary factors payments by industries. By contrast, matrix D represents the recipients of these payments as shown in the income account. For example, matrixes D1 and D2 show the receipts of households and foreigners for their supplies of labour, respectively.

The sub-matrixes D1 to D7 of matrix D are derived from the ASNA bulletin. The total of "gross operating surplus and gross mixed income" in the income account of the ASNA bulletin indicates the receipts of capital payment outflows. Therefore, they are correspondingly allocated to **matrixes D3 to D6** in Table 10. However, capital value receipts by households are divided into capital value and land value; therefore, the value in matrix D3 will be divided into land value receipt and capital value receipt. It means A$8,840.265 million (the total value in matrix B3) is now reallocated to **matrix D7** in Table 10. The actual value in **matrix D3** is obtained by subtracting A$8,840.265 million from the "gross operating surplus and gross mixed income" received by households.

Similarly, in the income account and external account of the ASNA bulletin, there are receipt values of households and foreigners regarding "compensation to employees"; they are the receipts of households and foreigners for their labour supplies. Therefore, they are allocated respectively as outflows from the labour item in the factors of production classification to

households and foreigners in the income account classification (**matrixes D1 and D2** in Table 10).

Table 11: Matrix E of SAM in Table 1

Classification	Items	Dimension	Income account				
			Households	Non-financial corporation	Financial corporation	Government	Foreigners
			1	1	1	1	1
Production activities	Industry	111					
	Commodity (domestic)	111	E1			E2	E3
	Commodity (imported)	111	E4			E5	E6
	Margins	111	E7			E8	E9
	Tax on domestic products	111	E10				E11
	Tax on imported products	111	E12				E13
	Tax on production	1				E14	

Matrixes E1 to E6 in Table 11 indicate the payments of institutions regarding their final uses of non-margin commodities, which relate to the activities in the USE matrix (matrixes Y'5, Y'6 and Y'11) as shown in Table 3. They show the payments of institutions towards final consumption of commodities. In Section 3.2 (page 8), there are the "domestic USE matrix of non-margin commodities" and the "IMPORT matrix". This action traced out matrixes Y'1.1 and Y'1.2 from matrix Y'1 in Table 3. Similarly, matrixes Y'5 was also divided into matrixes Y'5.1 and Y5.2; matrix Y'6 to matrixes Y'6.1 and Y6.2; and matrix Y'11 to matrixes Y'11.1 and Y'11.2.

Hence, matrixes Y'5.1 and Y'5.2 are respectively allocated to matrixes E1 and E4 in Table 11 as the payments of households towards their final uses of non-margin commodities. Matrixes Y'6.1 and Y'6.2 are placed in matrixes E2 and E5, respectively; this shows the payments of government for its uses of non-margin commodities. Matrixes Y'11.1 and Y'11.2 show the payments of foreigners for uses of Australian commodities, it therefore is respectively allocated to matrix E3 and E6 in Table 11.

Matrixes E7, E8 and E9 are extracted from "total margins matrix" with corresponding items.

Matrixes E10 to E13 show the payments of households and foreigners for taxes on products regarding their purchases of domestic and imported commodities. From Table 5, the matrixes Z2.1, Z2.2, Z7.1 and Z7.2 respectively indicate the payments for taxes on products by households and foreigners for Australia's government. They are consistent with matrixes E10 to E13 in Table 11. Hence, matrixes Z2.1, Z2.2, Z7.1 and Z7.2 in Table 5 will be respectively allocated to matrixes E10, E12, E11 and E13 in Table 11.

Matrix E14 indicates the subsidy transfers from government to industries in order to support industry production. In Section 2 (page 3), it was also mentioned that in the income account of ASNA bulletin, the government provides subsidies to the production of industries. Hence, for the time being, the subsidy transfers, indicated in the income account, from government to industries are allocated in matrix E14 in Table 11.

Table 12: Matrix F of SAM in Table 1

Classification Items		Dimension	Income account				
			Households	Non-financial corporation	Financial corporation	Government	Foreigners
			1	1	1	1	1
Factors of production	Labour	1					F1
	Capital	1					
	Land	1					

Matrix F in Table 12 indicates the payments by institutions to factors of production regarding the production processes within Australia; these payments were partly expended by industries as shown in matrix B. Hence, in matrix F there is only one item, foreigners, who could pay for factors of production if they participate in production within Australia. In fact, in the external account in the ASNA bulletin, there is a payment from foreigners to labour, called "compensation of employee"; it therefore is allocated into **matrix F1** in Table 12.

Table 13: Matrix G of SAM in Table 1

Classification Item		Dimension	Income account				
			Households	Non-financial corporation	Financial corporation	Government	Foreigners
			1	1	1	1	1
Income account	Households	1	G1	G6	G11	G16	G21
	Non-financial corporation	1	G2	G7	G12	G17	G22
	Financial corporation	1	G3	G8	G13	G18	G23
	Government	1	G4	G9	G14	G19	G24
	Foreigners	1	G5	G10	G15	G20	G25

In Table 13, **matrixes G1 to G25** indicate the inter-institution transactions in the income account. The ASNA bulletin reveals nine flows in the income account. The allocation of these flows among institutions will follow the assumptions and steps in the paper published by Pang et al. (2006). The total receipts and payments of each institution in the income account is the sum of all flows. The sums of all flows are allocated into matrixes G1 to G25.

Table 14: Matrix H of SAM in Table 1

Classification Items		Dimension	Income account: Households	Non-financial corporation	Financial corporation	Government	Foreigners
			1	1	1	1	1
Capital account	Households	1	H1				
	Non-financial corporation	1		H2			
	Financial corporation	1			H3		
	Government	1				H4	
	Foreigners	1					H5

Matrixes H1 to H5 in Table 14 show the residuals of institutions after all expenditures; such residuals are called "net saving and consumption of fixed capital". On the other hand, in the income account classification in Table 1, all of income (matrixes C, D and G) and the final consumption expenditure and transfers (matrixes E, F and G) of institutions were allocated. At this stage, the unequal amounts between gross disposal income and final consumption, called "net saving plus consumption of fixed capital" in the ASNA bulletin, will be reserves in the capital account. Therefore, these amounts will be allocated as outflows from the income account to capital account (matrixes H1, H2, H3, H4 and H5 in Table 14).

Table 15: Matrix I of SAM in Table 1

Classification Items		Dimension	Financial account: Households	Non-financial corporation	Financial corporation	Government	Foreigners
			1	1	1	1	1
Financial account	Households	1	I1	I6	I11	I16	I21
	Non-financial corporation	1	I2	I7	I12	I17	I22
	Financial corporation	1	I3	I8	I13	I18	I23
	Government	1	I4	I9	I14	I19	I24
	Foreigners	1	I5	I10	I15	I20	I25

Matrixes I1 to I25 in Table 15 reveal inter-institution transactions in the financial account. They show the buying and selling of financial assets by each institution with other institutions; there are 11 financial assets in the ASNA. Purchases (acquisition of financial assets) and sales (incurrence of financial assets) are bilaterally allocated between items. The allocation of flows in the financial account also follows the work of Pang et al. (2006). When there are both negative and positive row totals and column totals for some flows, a value number is added in every cell of the matrix in order to eliminate negative values of any row and column totals. Then at the final procedure, this value is subtracted again from each cell of the matrix.

Table 16: Matrix J of SAM in Table 1

Classification Items		Dimension	Capital account				
			Households	Non-financial corporation	Financial corporation	Government	Foreigners
			1	1	1	1	1
Production activities	Industry	111					
	Commodity (domestic)	111	J1	J4	J7	J10	
	Commodity (imported)	111	J2	J5	J8	J11	
	Margins	111	J3	J6	J9	J12	
	Tax on domestic products	111	J13	J14	J15	J16	
	Tax on imported products	111	J17	J18	J19	J20	
	Tax on production	1					

Matrixes J1 to J20 in Table 16 indicate the expenditure on fixed assets by institutions. The capital goods are similar to normal commodities; hence institutions can purchase domestic goods or imported goods and institutions also pay for margins and taxes on products.

In Table 3, matrixes Y7, Y8 and Y9 also show the purchases by institutions regarding capital goods, and matrixes Y12 to Y17 show the payments of institutions for taxes on products regarding these purchases. Hence, matrixes Y7, Y8 and Y9[9], and Y12 to Y17 in Table 3 may be compatible with matrixes J1 to J20 in Table 16. However, there are three institutions (private, public enterprise and general government) as shown in Table 3, while there are four institutions (households, non-financial corporation, financial corporation and general government) in Table 16. Hence, there is a need to combine data in the USE matrix of the I-O Tables with information in the ASNA bulletin in order to separate gross fixed capital formation (GFCF) expenditures to required institutions in matrix J in Table 16.

Table 17 (a, b and c) shows the change of GFCF expenditures from the I-O Tables to total fixed capital expenditures with required institutions based on the ASNA bulletin. In Table 17 (a), all of the numbers are derived from the "USE matrix without margins and indirect imports", "IMPORT matrix" and "total USE margins matrix". In Table 17 (b), the government expenditures column is taken from Table 17 (a), whereas the GFCF expenditures row totals are collected from the ASNA bulletin. The transfers from private and public enterprises to households, non-financial and financial corporations are shown in Table 17 (b). In addition, the transposition of changes in inventories to each institution of households, non-financial corporation, financial corporation and government follows Pang et al. (2006). In

[9] These matrixes are separated into three matrixes: the "domestic USE matrix of non-margin commodities", the "IMPORT matrix" and the "total margins matrix". They are similar to matrix Y1, Y5, Y6 and Y11 above.

Table 17 (c), the column totals of changes in inventories are derived from Table 17 (a), whereas the row totals are taken from the ASNA bulletin. Because there is a presence of both positive and negative numbers in row and column totals, so a value of A$1,000 million was added to each cell of the table before applying Pang et al.'s method. The shaded area in that table is the concluding result after applying Pang et al.'s method and deducting a value of A$1,000 million in each cell.

Table 17: Allocation of investment expenditure, 2008-09 (A$ million)

(a) Data from the USE, IMPORT and total USE margins matrixes in the I-O Tables

	Gross Fixed Capital Formation			Changes In
	Private	Public Enterprise	Government	Inventories
Total Intermediate Use	**266,261(a1)**	**22,896 (b1)**	**42,579**	**- 2,994**
Commodities (domestic)	204,536 (a2)	20,801 (b2)	34,173	-537
Commodities (import)	43,307 (a3)	1,436 (b3)	6,476	- 2,188
Margin	18,418 (a4)	659 (b4)	1,931	-269
Compensation of employees	0	0	0	0
Gross operating surplus & mixed income	0	0	0	0
Taxes less subsidies on products	17,714 (a5)	208 (b5)	1,454	- 64
Other taxes less subsidies on production	0	0	0	0
Complementary imports	0	0	0	0
Competing imports	0	0	0	0
Total supply in Australian economy	**283,975 (a)**	**23,104 (b)**	**44,033**	**- 3,058**

(b) A combination of the I-O Tables and ASNA bulletin regarding fixed capital expenditures

	Households	Non-financial	Financial	Government
Fixed capital expenditures				
Commodities (production)	**=c*(a1+b1)/(a+b)**	**=d*(a1+b1)/(a+b)**	**=e*(a1+b1)/(a+b)**	**42,579**
Commodities (domestic)	**=c*(a2+b2)/(a+b)**	**=d*(a2+b2)/(a+b)**	**=e*(a2+b2)/(a+b)**	34,173
Commodities (import)	**=c*(a3+b3)/(a+b)**	**=d*(a3+b3)/(a+b)**	**=e*(a3+b3)/(a+b)**	6,476
Margin	**=c*(a4+b4)/(a+b)**	**=d*(a4+b4)/(a+b)**	**=e*(a4+b4)/(a+b)**	1,931
Taxes less subsidies on products	**=c*(a5+b5)/(a+b)**	**=d*(a5+b5)/(a+b)**	**=e*(a5+b5)/(a+b)**	1,454
…				
Total Gross Fixed Capital Formation	**111,646 (c)**	**186,272 (d)**	**9,161 (e)**	**44,033**

(c) Allocation of changes in inventories of the institutions.

	Households	Non-financial	Financial	Government	Total changes in inventories
Change in inventories					
Domestic comodities (production)	**-185**	**-2,386**	**369**	**-792**	**-2,994**
Commodities (domestic)	82	-764	295	-151	-537
Commodities (import)	-434	-877	-322	-556	-2,188
Margin	166	-746	396	-85	-269
Taxes less subsidies on products	230	-732	472	-35	-64
…					
Total change in inventories	**45**	**-3,118**	**842**	**-827**	**-3,058**

The sum of each corresponding cell in Table 17 (b) and (c) are the total investment expenditure. The following steps will indicate how to separate these total numbers into matrixes with corresponding dimensions in Table 16.

- **Step 1**: There are GFCF expenditures by private, public corporations and general government on each commodity reported in the separated matrixes[10]. They are GFCF expenditures on domestic and imported non-margin and margins commodities, and taxes on domestic and imported products. In these separated matrixes, they are the total GFCF expenditures, *sum of all industries*, by these three institutions. The subdivision from these three institutions to the four required institutions, as shown in Table 17 (b and c), is shown in Table 17 (d) with an example of non-margin commodities. The numbers t1, t2, k1, k2, A1 and A2 on the left hand side of Table 17 (d) are extracted from the "domestic USE matrix of non-margin commodities", whereas the numbers X2, Y2 and Z2 are the sum of numbers in *domestic commodity row* in Table 17 (b and c). P2 is a sum of X2, Y2 and Z2. The method in Table 17 (d) is also applied for imported non-margin commodities, margin commodities, and taxes on domestic and imported products when transferring GFCF expenditures by the three institutions to the four required institutions.

Table 17 (d): Transferring GFCF expenditures on domestic non-margin commodities from three institutions to the four required institutions

	Pri	Pub	Gov	HH	Non-Financial	Financial	Gov
…	…	…	…	…	…	…	…
Commodity 5	t1	k1	A1	= (t1+k1)*X2/P2	= (t1+k1)*Y2/P2	= (t1+k1)*Z2/P2	A1
Commodity 6	t2	k2	A2	= (t2+k2)*X2/P2	= (t2+k2)*Y2/P2	= (t2+k2)*Z2/P2	A2
…	…	…	…	…	…	…	…
Total				X2	Y2	Z2	

Where Pri: private institution; Pub: public corporation; Gov: government; HH: households.

[10] The separated matrixes are the "domestic USE matrix of non-margin commodities", "IMPORT matrix", "total margins matrix", "tax on domestic products matrix" and "tax on imported products matrix".

In the ASNA bulletin, there are three tables provided the GFCF expenditures by private, public corporations and general government in each industry. They are the total GFCF expenditures, *sum of all commodities*, by these three institutions in each industry. Specifically, these three tables are Table 52 (Private GFCF), Table 53 (General government GFCF) and Table 54 (Public corporations GFCF).

- **Step 2**: We computed the ratios of total GFCF expenditures by each of the three institutions in each of the separated matrixes to sum of total GFCF expenditures by each of the three institutions in all separated matrixes. These ratios are used to divide the values for each industry in Tables 52, 53 and 54 to GFCF expenditures on domestic and imported non-margin commodities; margin commodities, taxes on domestic products and taxes on imported products. For example, the total GFCF expenditures by private institution in the separated matrixes are A, B, C, D and E, respectively. The ratio of A to (A+B+C+D+E) will be multiplied by GFCF expenditures in Table 52. It indicates the GFCF expenditures on domestic non-margin commodities by private institution. This approach is applied through types of commodities and institutions.
- **Step 3**: As the number of industries in Tables 52, 53 and 54 are very limited, we matched these industries to the number of industries in the I-O Table, based on the name and the characteristics of industries provided in I-O product details Table.
- **Step 4**: We now had the GFCF expenditures by each of the three institutions on each industry. These GFCF expenditures are on domestic and imported non-margin commodities, margin commodities, taxes on domestic products and taxes on imported products. We in turn separated these GFCF expenditures by the three institutions to the four required institutions, based on the industries and institutions information. For example, the requirement is to transfer GFCF expenditures by private and public enterprises to households, non-financial and financial corporations. GFCF expenditures by private institution in "black coal" and "brown coal" industries cannot be transferred to households and financial corporations, they are entirely transferred to non-financial corporations.
- **Step 5**: From Step 1, we had GFCF expenditures by each of the four institutions, which are summed over all industries (the columns total). From Step 4, we got GFCF expenditures by each of the four institutions; which are summed over all commodities (the rows total). Consequently, based on the ratios of values in Step 4 to total value of all numbers in Step 4, we allocated the GFCF expenditures in Step 1 into each cross-cell between industry and commodity for each of the four institutions.

These matrixes in turn were placed in matrixes J1 to J20 in Table 16.

Table 18: Matrix K of SAM in Table 1

Classification / Items		Dimension	Capital account				
			Households	Non-financial corporation	Financial corporation	Government	Foreigners
			1	1	1	1	1
Capital account	Households	1		K3		K5	
	Non-financial corporation	1	K1			K6	
	Financial corporation	1					
	Government	1	K2	K4			
	Foreigners	1				K7	

Matrixes K1 to K7 are the inter-institution transactions in the capital account; each matrix indicates the net lending of the column institution to the row institution. The capital account in the ASNA bulletin clearly provides most of the bilateral flows.

4. Energy sectors disaggregation

All matrixes in Table 1 have been allocated and the next step is an explanation of the disaggregation from the four initial energy industries to 24 sub-energy industries. The energy industries are separated from the initial industries as follows:

- The coal mining industry into two industries: black coal (code: a1) and brown coal (a2) industries.
- The oil and gas extraction industry into five industries: crude oil (b1), condensate (b2), liquefied natural gas (b3), natural gas (b4) and other gas (b5) industries.
- The coal and petroleum product manufacturing industry into eight industries: automotive petrol (c1), kerosene (c2), fuel oil (c3), petroleum bitumen (c4), liquefied petroleum gas produced at refineries (c5), lubricants (c6), bituminous mixtures (c7), and other coal and petroleum products (c8).
- The electricity generation industry into nine industries: electricity generation from black coal (d1), brown coal (d2), oil (d3), gas (d4), hydro (d5), wind (d6), solar (d7), biogas (d8) and biomass (d9).

The disaggregation of the energy industries is initially based on the data available in the I-O product details Table 2008-09. Because it provides details of sub-commodities supplied by each industry; the uses of the sub-commodities by each industry; and the corresponding margins and tax payments from these uses.

4.1. The disaggregation procedure in the SUPPLY matrix

The SUPPLY matrix was used to conduct the disaggregation in the first instance because it will be the basis for disaggregation of other matrixes. In order to construct the disaggregation from the initial energy industries into sub-energy industries, we considered some critical characteristics of those industries. The disaggregation begins with row commodity disaggregation, based on the data provided by ABS in the I-O product details Table. For example, the row commodity disaggregation of the "coal mining" commodity into "black coal" and "brown coal" commodities are entirely based on the I-O product details Table. The actual numbers are shown in Table 19.

Table 19: Row commodity disaggregation in the SUPPLY matrix for "coal mining" commodity (A$ million)

Industry / Commodity	Black coal	Brown coal	Coal mining
Coal mining			57,407
Black coal			56,423
Brown coal			984

In the I-O product details Table, there are 21 sub-commodities of the "petroleum and coal product manufacturing" industry; however, the disaggregation in this study is only based on the commodities, which are supplied at more than A$500 million. As the total supply of the "petroleum and coal product manufacturing" commodity was A$31,233 million in 2008-09, the supply of A$500 million only accounted for 1.6%. Therefore, other supplies, which were less than A$500 million, have been regarded as negligible. Hence 14 sub-commodities, which contributed a value supply less than A$500 million, were regarded as "other petroleum and coal product n.e.c" commodity. The row commodity disaggregation is totally based on the I-O product details Table with 14 sub-commodities forming the "other petroleum and coal product n.e.c" commodity. The row commodity disaggregation of this industry is similar to the row commodity disaggregation of coal mining commodities as shown in Table 19.

The row commodity disaggregation of "oil and gas extraction" commodity is mainly based on the disaggregation by ABS in the I-O product details Table that has four sub-commodities. However, the initial "crude oil" commodity provided by ABS was separated into "crude oil" and "condensate" commodities because the production of "condensate" has played an important role. In 2008-09, the production of "crude oil" was A$11,971 million while there was A$4,132 million for "condensate" (ABS, 2010). The row commodity disaggregation of

"crude oil" commodity into "crude oil" and "condensate" commodities was based on the ratio of A$11,971 million per A$4,132 million.

Table 20: The row commodity disaggregation of "electricity generation" commodity in the SUPPLY matrix

Industry / Commodity	…	Basic chemical manufacturing	Electricity transmission, distribution, on selling and electricity market operation	…	Total Australian supply value
Electricity generation	X	X	X	X	X
From fossil fuels	X	M	X	X	X (P)
Black coal (d1)					A (P)
Brown coal (d2)					A (P)
Oil (d3)					A (P)
Gas (d4)		M			A (P)
From Hydro (d5)	X	X	X	X	X (P)
From other sources (n.e.c)	X		X	X	X (P)
Wind (d6)					A (P)
Solar (d7)					A (P
Biomass (d8)					A (P)
Biogas (d9)					A (P)

Note: X indicates the actual numbers provided in the I-O Tables 2008-09.

P indicates the total physical supply units published by ABARE.

A refers to the total Australian supply for each disaggregated commodity.

M refers to electricity generation from fossil fuels, provided in the I-O Tables 2008-09. It is in turn allocated in electricity generation from gas.

With respect to row commodity disaggregation of the "electricity generation" commodity, we make the main "electricity generation" commodity into nine sub-commodities as mentioned above and as listed in Table 20. However, in the I-O product details Table, ABS provides the disaggregation into three sub-commodities only. For example, there is electricity generation from fossil fuels, hydro-electricity and others; the cells with mark (X) in Table 20 indicate the real numbers provided by ABS. In this study, the electricity generation commodity from fossil fuels was divided into electricity generation from black coal (d1), brown coal (d2), oil (d3) and gas (d4). Electricity generation n.e.c was separated into electricity generation from wind (d6), solar (d7), biomass (d8) and biogas (d9).

A preferred way would be to obtain the value of each electricity commodity supplied by each industry. This means that every blank cell in Table 20 would be shown by the actual value number without any adjustment. However, this is impracticable as much data is simply not

available[11]. The best alternative way is to find the "total Australian supply value" for each electricity commodity (find A in Table 20), and then row commodity disaggregation for each industry could be based on the ratios of each (A) to (X) within a group. These values could be found by multiplying the physical supply units (marked as (P)) with its price. In this case, there is data of "Australian electricity generation by fuel type in physical units" for each state and territory and "the average price per physical electricity unit" in some states, which form the National Electricity Market[12]. However, the total value (A) could not be calculated in this way as prices have changed during a year and also there are variations depending on the types of customers such as private or business. Therefore, an appropriate alternative method is based on the physical electricity generation by fuel type (marked as (P)) in order to calculate "total Australian supply value" for each commodity. This means the "total Australian supply values" of sub-electricity commodities in the SUPPLY matrix are proportioned to these physical units relative to sum of all these physical units within a group. This method was used, based on some assumptions. An initial assumption is that all of electricity prices from all fossil fuels are the same; this is similar to the case of electricity generation from renewable sources, excluding hydro-electricity. Therefore, the "total Australian supply values" of electricity generation from fossil fuels are based on the physical electricity generation units from fossil fuels only; it is similar to the value of electricity supply from renewable sources. These physical units are obtained from Table O (Australian electricity generation by fuel type, physical units) released by BREE (BREE, 2013b).

Regarding the issue that some industries also produce electricity from fossil fuels, i.e. the "basic chemical manufacturing" industry, it is assumed that the industries only generate electricity by using gases, because the capital cost of coals and oil electricity power stations are quite expensive relative to gas electricity power stations (U.S. Energy Information Administration, 2013). Hence, in this example in Table 20, the value M, the electricity from fossil fuels generated by the "basic chemical manufacturing" industry, is the electricity generation from gas.

However, there is one case of the "electricity transmission, distribution, on-selling and electricity market operation" industry (code 2605) in case of supplying "electricity

[11] BREE only provides the electricity generation by fuel types in physical units and International Energy Agency (IEA) does not provide Australian electricity generation prices by fuel types as required by this study. For example, IEA releases data of electricity generation prices from some petroleum products, natural gas, steam coal and coking coal only. In addition, IEA does not provide the end use prices of electricity for required industries in this study.

[12] Queensland, New South Wales, South Australia, Victoria and Tasmania have joined the National Electricity Market and BREE also reports the average price of electricity per physical unit in these states and the Capital Territory. Only Western Australian and Northern Territory do not report the average price.

generation" commodity (code 2601) in the SUPPLY matrix. This industry actually makes profits by value adding in its processes of transmission, distribution and selling; it does not make profits from generating electricity and selling it. Therefore, for row electricity disaggregation of this industry, it is reasonable to base these matters on the ratios of the "total Australian supply values" of these sub-electricity commodities to "total Australian supply value" of the main electricity commodity, "electricity generation" commodity. We argue that this industry would be based on the electricity commodities available in order to make profit from its value added.

With respect to the column industry disaggregation, the essential assumptions are that each disaggregated industry will produce its own commodity. Other commodities will be proportionally produced according to the disaggregated industries' production levels because the production of these industries will represent the capacity of these industries, even in producing other commodities. This is illustrated in Table 21, ratio r1 and r2 are obtained from the "total Australian supply value".

Table 21: An example of column industry disaggregation in the SUPPLY matrix (A$ million)

Ratio		r1 = 56,423/57,407	r2 = 984/57,407			
Industry / Commodity	…	Black coal	Brown coal	Coal mining	…	Total Australian supply value
…		= r1*k	= r2*k	k		
Other agriculture		= r1*A	= r2*A	1.187 (A)		
Coal mining		56,423	984	57,407		57,407
Black coal		56,423		56,423		56,423
Brown coal			984	984		984
Electricity generation		= r1*B	= r2*B	15 (B)		
…		= r1*ks	= r2*ks	ks		

The separation of the SUPPLY matrix into two separated matrixes, the "SUPPLY matrix of non-margin" and "SUPPLY matrix of margin commodities", is carried out in the same way as performed in Section 3.1 (page 7).

4.2. The disaggregation procedure in the USE matrix

The following steps describe disaggregation in the USE matrix. The disaggregation shown in the USE matrix is quite similar to the disaggregation in the SUPPLY matrix. With respect to row commodity disaggregation, most of the sub-energy commodities are based on the data in the I-O product details Table. Only the disaggregation from "crude oil" commodity to "crude oil" and "condensate" commodities is based on the ratio of the "total Australia supply value"

of these two commodities to the "total Australia supply value" of the "crude oil" commodity as shown in the SUPPLY matrix.

The disaggregation from the "fossil fuel-electricity generation" commodity to black coal, brown coal, oil and gas-electricity generation commodities and the disaggregation from the "electricity generation n.e.c" commodity to wind, solar, biomass and biogas-electricity generation commodities are based on the ratios of the "total Australia supply values" of these commodities to the sum of these "total Australia supply values" within a group, i.e. a group of fossil fuels-electricity generation. An example related to sub-fossil fuels-electricity generation row commodity disaggregation is shown in Table 22. We argue that uses of industries rely on the commodities available, which are shown in the SUPPLY matrix as the "total Australian supply values". The greater the availability of commodities, the more quantity will be used by each industry. Hence, we relied on the ratios obtained from using the "total Australian supply values" (in the SUPPLY matrix) to disaggregate the row commodity (in the USE matrix). In Table 22, each industry uses each kind of fossil fuel-electricity in proportion to its "total Australian supply values" in the SUPPLY matrix.

Table 22: An example of row commodity disaggregation in the USE matrix based on the ratios of "total Australian supply value" in the SUPPLY matrix (A$ million)

Industry / Commodity	…	Other agriculture	Aquaculture	Forestry and logging	…	Total industry use in USE matrix	Total Australian supply value in the SUPPY matrix
Fossil fuel – electricity	…	54	3	3	…	8,681	13,002
Black coal – electricity	…	= 54*r1	= 3*r1	= 3*r1	…	= 8,681*r1	7,430 *(r1 = 7,430/13,002)*
Brown coal – electricity	…	= 54*r2	= 3*r2	= 3*r2	…	= 8,681*r2	3,235 *(r2 = 3,235/13,002)*
Oil – electricity	…	= 54*r3	= 3*r3	= 3*r3	…	= 8,681*r3	229 *(r3 = 229/13,002)*
Gas – electricity	…	= 54*r4	= 3*r4	= 3*r4	…	= 8,681*r4	2,108 *(r4 = 2,108/13,002)*

Regarding column industry disaggregation, the initial assumption is based on the ratios of the "total Australian supply values" of sub-commodities to "total Australian supply values" of its main commodities in the SUPPLY matrix. It is because whenever one sub-industry produces large quantity of products, it will demand more inputs for its production. However, there are some specific adjustments, which depend on the particular characteristics of sub-energy commodities. Specifically, the sub-industries of the "coal mining" industry and the "oil and

gas extraction" industry will use their own commodities, which they readily produce. For example, the "black coal" industry will only use "black coal" commodity, while the "brown coal" industry will only use "brown coal" commodity. Similarly, the "liquefied natural gas" industry will use "liquefied natural gas" commodity, whereas the "natural gas" industry will use "natural gas" commodity. These group commodities are relatively perfect substitutes; in most cases, the energy inputs within a group can be substituted by each other with similar functions.

There is one adjustment from the sub-electricity generation industries, which use sub-energy commodities, depending on the main characteristics of these industries. For example, the "black coal-electricity generation" industry will use only "black coal" commodity in its production process, similarly with the "brown coal-electricity" and "gas-electricity" industries. However, the "oil-electricity generation" industry will use "fuel oil" commodity as its main input, the "other petroleum" commodities will be proportionally divided to each of "sub-electricity generation" industries. Another assumption in column disaggregation of "sub-electricity generation" industries is that each "sub-electricity generation" industry will use their own produced electricity because of its effectiveness and efficiency. It can reduce value added cost from using electricity from other sources, thereby minimising the cost of these industries. For example, "black coal-electricity generation" industry will only use electricity generated from black coal.

In the I-O Tables, the institutions use "electricity generation" commodity (code 2601) and "electricity distribution" commodity (code 2605) separately. It means the institutions use electricity and electricity services independently. However, that is just for statistical purposes at one time; in reality, whenever institutions use electricity, they have to use electricity services. The institutions use electricity from electricity suppliers, these suppliers also make profit from their services. It means that the electricity commodity and electricity services commodity are used together and the usage ratio between these two commodities is unchanged if the usage of a commodity changes. Hence, if we still keep "electricity generation" commodity and "electricity distribution" commodity separately as shown in the I-O Tables; when there is a shock in the model, it will affect the uses of commodity 2601 and commodity 2605 separately. Consequently, the usage ratio between these two commodities will change after the shock. Therefore, we constructed a database, which allows electricity suppliers to use electricity from generators. Then electricity suppliers will supply electricity and electricity services to households, industries and government. It keeps the usage ratio between "electricity generation" commodity and "electricity services" commodity unchanged.

The process is that in the USE matrix, all use values of the sub-electricity commodities (commodities d1 to d9) by each industry and each final user, except industries 2601 and 2605, are added to use value of commodity 2605 by each corresponding industry and final user, called vertical movement. These values are also added to use values of corresponding sub-electricity commodities (commodities d1 to d9) by industry 2605, called horizontal movement. The use values of sub-electricity commodities (commodities d1 to d9) by sub-electricity industries (industries d1 to d9) of industry 2601 are unchanged. It means that all values of sub-electricity commodities (commodities d1 to d9), used by industries and final users, except industries 2601 and 2605, will be zero. Total column values of these sub-electricity commodities will be added to commodity 2605. Total row values of these sub-electricity commodities, except values in industries 2601 and 2605, will be added to industries 2605 subject to these corresponding sub-electricity commodities.

Regarding the use of the "sub-petroleum and coal product manufacturing" industries towards the "sub-coal mining" commodities and "sub-oil and gas extraction" commodities, the case is more complex. It is because some "sub-energy' commodities are the main inputs of particular sub-industries in their production processes to make their own products, hence some do not follow the rule of proportion. For example, not every "sub-petroleum and coal product manufacturing" industries use black coal, brown coal and natural gas commodities in their production processes; hence, it is appropriate to find out which is the main input of each industry. One appropriate method is to base the analysis on the information from the Australian NGGI in 2009. This inventory provides the emissions from energy combustion of each fuel type for each industry. For example, it provides the energy combustion emissions from each fuel type for "petroleum refining", "brown coal briquette production", "coke production", "petroleum and coal product manufacturing n.e.c", and "lubricants and greases" industries, which are compatible with sub-industries of the "petroleum and coal product manufacturing" industry in the I-O Tables. Therefore, from these emissions, we are likely to know which energy inputs are used in each "sub-petroleum and coal product manufacturing" industry. Then, the ratios by using the "total Australian supply values" are applied to allocate energy uses for each "sub-petroleum and coal product manufacturing" industry. Specifically, if only industries c1 and c5 use "black coal" commodity, the ratios of the "total Australian supply values" of industries c1 and c5 to sum of the "total Australian supply values" of these two industries are used to allocate uses of "black coal" commodity to each industry c1 and c5. Other uses of commodities by "sub-petroleum and coal product manufacturing" industries will still follow the rule of production value proportion in the SUPPLY matrix. It is applied

even for their own "petroleum and coal product manufacturing" commodities since they are the main energy inputs for engines and machines.

4.3. The disaggregation procedure in the IMPORT matrix

The "IMPORT matrix" in the I-O Tables represents the uses of the main imported commodities by each main industry. For example, the "electricity generation" industry uses A$20 million of "coal mining" commodity. However, the I-O product details Table does not provide how much "black coal" commodity and "brown coal" commodity are used. It only provides the total use of black coal and brown coal commodities from all industries that are represents in the column totals.

We assume that the row commodity disaggregation is based on the ratios in the USE matrix; the proportional import commodity uses would have the same ratios as in the USE matrix. This assumption is reasonable when the uses of domestic and imported commodities have the same ratio within a group. The column industry disaggregation will follow the same rule as for the column disaggregation in the USE matrix. Below is an example of row commodity disaggregation shown in Table 23.

Table 23: An example of the row commodity disaggregation in the IMPORT matrix (A$ million)

Data in matrix	Industry / Commodity	Electricity generation
In the IMPORT matrix	**Coal mining (0601)**	**20**
	Black coal (A1)	= 20*2,003/2,910
	Brown coal (A2)	= 20*907/2,910
In the USE matrix	**Coal mining**	**2,910**
	Black coal (A1)	2,003
	Brown coal (A2)	907

4.4. The disaggregation procedure in the margin matrixes

There are many kinds of the margins, which are also imposed in each cell of the USE matrix. Each of them will have their own matrix and they are similar to the imposition of indirect import in the USE matrix. In the I-O product details Table, the margins have the same characteristics in order to do row commodity disaggregation as performed in the row disaggregation in the USE matrix. Hence all of the margins disaggregation will follow the rule of disaggregation as in the USE matrix. The total margins will sum up all of the margins.

The separated matrixes related to the USE matrixes were carried out in Section 3.2 (page 8). The disaggregation matrixes are currently performed in the same way. This procedure provides three different disaggregated matrixes: The disaggregated domestic USE matrix of non-margin commodities, the disaggregated IMPORT matrix and the disaggregated total margins matrix.

4.5. The disaggregation procedure in the TAXES matrixes

In the I-O product details Table, the TAXES matrixes have similar characteristics as was undertaken in the row commodity disaggregation in the USE matrix. Therefore, the disaggregation method will be the same as that employed in disaggregating the USE matrix.

4.6. The aggregation compilation in the I-O Tables

All previous disaggregation of matrixes are related to the disaggregating of the four energy industries and commodities into 24 industries and commodities. In this paper, we base analyses on 39 industries. Hence, another 107 initial industries and commodities (=111 – 4) will be aggregated into 15 industries. For example, construction industries, including private and public construction industries, are aggregated in construction sector. Services industries, including hospital, education, etc., are aggregated to services sector. We only keep the "electricity distribution" industry (code 2605) unchanged. The actual total numbers of this E-SAM is provided in Table A1 in Appendix A.

5. The stationary and activity emissions matrices

The NGGI database 2009 provides the emissions from fuel combustion, fugitive emissions from fuels, industrial processes, agricultural activities, waste and land use, land-use change and forestry under the Kyoto Protocol framework. The relationship between these emissions and the I-O Tables is that the USE matrix shows the uses of commodities, including energies and chemicals by industries whereas the SUPPY matrix represents the supplies of commodities by industries or the processes to supply outputs. Therefore, based on the characteristics of these two matrixes, the fuel combustion emissions and emissions from using Halocarbons and Sulphur Hexafluoride in industry processes are incorporated in the stationary emissions matrix (which are based on the USE matrix); while other mentioned emissions are located in the activity emissions matrix (which are based on the SUPPLY matrix).

With respect to emissions applied to the activity emissions matrix, because fugitive emissions are emissions of gases or vapours from pressurized sources due to leaks and other unintended or irregular releases of gases, they essentially come from activities in the "coal mining"

industry and the "oil and gas extraction" industry. According to the initial disaggregation in the I-O Tables of these industries, the fugitive emissions are accordingly allocated to these disaggregated industries, based on the sources as shown in Table A2 (a) in Appendix A. For example, oil fugitive emissions have to be incorporated in the "oil disaggregation" industry whereas the gas fugitive emissions are allocated to the "gases disaggregation" industries. Furthermore, the emissions of gas during distribution are the responsibility of the "gas supply" industry rather than the "oil and gas extraction" industry. This is because most activities of the "oil and gas extraction" industry include gases exploitation and transmission to a distribution center, storage facility or large volume customer, which operate with large diameter pipelines. The "gas supply" industry uses smaller pipelines to transport gases to institutions. On the other hand, the "gas supply" industry acts as a distributor. Accordingly, these fugitive emissions are proportionally allocated in the activity emissions matrix corresponding to the main commodities supplied by these respective industries; these ratios come from the supply of these industries in the SUPPLY matrix. For example, fugitive emissions from "coal mining" industry is proportionally allocated to inner-cross cells of black coal and brown coal items.

The emissions from industrial processes, agricultural activities and waste are allocated in the activity emissions matrix associated with all commodities supplied by related industries. This means they are totally incorporated into the industry columns. However, as the Department of Environment provides a NGGI in a very general way, which has considerably fewer industries than industries in the I-O Tables, the detailed links from industries in the NGGI and industries in the I-O Tables are presented in Table A2 (b, c and d) in Appendix A[13]. The emissions from land use, land-use change and forest are allocated in the "agriculture" industries based on the production level in the SUPPLY matrix.

Regarding the incorporation of emissions in the stationary emissions matrix, the fuel combustion emissions show the emissions of industries by using and combusting energies. The compatible industries between the NGGI and the I-O Tables are presented in Table A2 (e) in Appendix A[14]. Furthermore, the compatible energy commodities used in the NGGI and the I-O Tables are shown in Table A3 in Appendix A. These emissions from fuel combustion are proportionally allocated in the stationary emissions matrix corresponding to the uses of industries towards the energy commodities, with the ratios based on the use ratios in the USE matrix.

[13] The category in Table A2 (c) could be collected in more detailed levels from NGGI.
[14] The fuel types (black coal, oil, gas, etc.) in Table A2 (e) are available from NGGI.

The incorporation of emissions from consuming Halocarbons and Sulphur Hexafluoride is applied in a different way. Whenever the industries use refrigeration or air conditioning as part of production processes to supply their main goods and services, the gases in this equipment might usually be released. For example, air conditioning is commonly required in transportation in vehicles and some are equipped with refrigerators; so the emissions in this section are attributed to those industries, which use transportation services. It is similar to emissions from using fire extinguishers, metered dose inhalers, electricity equipment, and foam blowing. These emissions were allocated to the stationary emissions matrix according to the rows of these commodities, based on the use ratios relative to total uses in the USE matrix. In addition, in the I-O product details Table, "domestic appliance manufacturing" industry (code 2404) provides some products such as "domestic refrigerators and freezers", "domestic room air conditioners and coolers (excluding fans)", and "specialised machinery and equipment manufacturing" industry (code 2405), and "other manufactured product" industry (code 2502), which produces "refrigeration cabinets, cool-rooms, beverage dispensing (cooling)" commodity. These emissions from the use of domestic refrigeration and air conditioning are attributed to final household users, subject to commodity item 2404. The emissions from commercial refrigeration come from industries, which use the "refrigeration cabinets, cool-rooms and beverage dispending" commodity produced by industries 2405 and 2502. In this case, the use values of industries towards this commodity were taken from the I-O product details Table, and were used proportionally to allocate the emissions to the industries that use this commodity. Finally, the emissions from using commercial air conditioning come from industries, which use the "domestic room air conditioners and cooler" commodity supplied by industry 2404. The use values of this commodity were also taken from the I-O product details Table, and then the emissions were allocated to the stationary emissions matrix regarding the industries using commodity item 2404.

This stationary emissions matrix includes emissions from the uses of both domestic and imported commodities. Hence, in order to obtain the domestic stationary emissions matrix and imports stationary emissions matrix, we based these on the emissions intensities between domestic and imports from GTAP-E (database released in 2007). The original database 2007 of GTAP-E only includes CO_2 emissions. In this study, non-CO_2 emissions were incorporated in this database thereby getting CO_2 equivalent (CO_2e) emissions. From these CO_2e emissions, we calculated the emissions intensities for domestic usage and imports usage. The emissions intensity for domestic usage was used to calculate emissions for the domestic stationary emissions matrix. The emissions regarding the imports usage are simply obtained by subtracting the domestic stationary emissions matrix from the stationary emissions matrix.

Emissions from households consumption regarding domestic and imported commodities are calculated in the same way.

The output emissions intensity was calculated from data in the SUPPLY matrix and the activity emissions matrix. These intensities enable the study to obtain the scale of emissions fluctuations when experiencing shocks in the economy.

6. Conclusion

The CGE modelling framework has been a very powerful tool for economists and policy-makers in matters of assessing macroeconomic issues related to policy reform. By constructing the various models associated with the different databases (i.e. a SAM), the users can estimate the potential effects of a policy change, or multi-policy changes, on the economy. In recent years, Australia has experienced much debate on climate change policies and the abolition of the carbon pricing mechanism and its replacement policy (the Direct Action Plan) are still controversial among the Parties and in the public domain. Energy industries will certainly receive more attention, as they are the highest polluting emitters. They are also the suppliers for many other industries; hence, the effects on these up-stream industries will be very important indicators to other industries and indeed for the whole economy.

In this paper, we detailed a comprehensive procedure to compile an E-SAM for Australia. The purpose behind this task is to assess as accurately as possible the impacts of climate change policies on Australian energy supply and the environment. This procedure also helps new modellers to develop the construction of their own SAM. During the construction period, there are some challenges in any SAM compilation, and these mostly occur because of data limitations. We initially searched the published information relating to industries or the facts from the scientific knowledge to fill gaps in the data. The final step was to apply mathematical methods to allocate the data. This helps us obtain the most reliable result in constructing this E-SAM.

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Appendix A

Table A1: The general structure numbers of SAM 2008-09 based on ASNA bulletin 2010-11 as shown in Table 1 (A$ million).

Classification	Items	Dimension	Production activities							Factors of production		
			Industry	Non-margin Commodity (domestic)	Non-margin commodity (imported)	Margins	Taxes on domestic products	Taxes on imported products	Taxes on production	Labor	Capital	Land
			39	39	39	39	39	39	1	1	1	1
Production activities	Industry	39		2,220,823		238,980						
	Non-margin commodity (domestic)	39	1,036,367									
	Non-margin commodity (imported)	39	153,283									
	Margins	39	88,940									
	Taxes on domestic products	39	8,355									
	Taxes on imported products	39	3,984									
	Taxes on production	1	35,868									
Factors of production	Labor	1	596,098									
	Capital	1	528,069									
	Land	1	8,840									
Income account	Households (HH)	1								594,598	175,292	8,840
	Non-financial corp (NF-C)	1									266,949	
	Financial corp (FC)	1									59,520	
	Government (G)	1					63,239	20,104	53,496		26,308	
	Foreigner (Fo)	1			277,218					3,217		
Financial account	HH	1										
	NF-C	1										
	FC	1										
	G	1										
	Fo	1										
Capital account	HH	1										
	NF-C	1										
	FC	1										
	G	1										
	Fo	1										
	Non-flow items		0	0	0	0		0	0	0	0	0
	Total		**2,459,803**	**2,220,823**	**277,218**	**238,980**	**63,239**	**20,104**	**53,496**	**597,815**	**528,069**	**8,840**

Table A1: (continued)

Classification	Items	Dimension	Income account					Financial account				
			HH	NF-C	FC	G	Fo	HH	NF-C	FC	G	Fo
			1	1	1	1	1	1	1	1	1	1
Production activities	Industry	39										
	Commodity (domestic)	39	452,244			215,992	256,248					
	Commodity (imported)	39	64,189			2,902	7,813					
	Margins	39	106,496			1,703	21,101					
	Taxes on domestic products	39	38,259				-592					
	Taxes on imported products	39	14,026									
	Taxes on production	1				17,628						
Factors of production	Labor	1					1,717					
	Capital	1										
	Land	1										
Income account	Households (HH)	1	4,278	29,485	111,999	143,274	1,463					
	Non-financial corp (NF-C)	1	12,218	4,003	11,587	837	14,452					
	Financial corp (FC)	1	94,931	36,144	41,242	2,314	18,517					
	Government (G)	1	136,938	60,782	22,921	-	3,188					
	Foreigner (Fo)	1	2,093	41,000	34,033	6,439	9,369					
Financial account	HH	1						-1,124	-420	116,005	6,589	10,751
	NF-C	1						9,052	11,611	22,912	10,744	16,181
	FC	1						42,033	63,175	12,678	14,379	22,434
	G	1						8,248	13,534	-17,285	15,845	9,459
	Fo	1						10,490	59,199	6,991	22,744	175
Capital account	HH	1	142,558									
	NF-C	1		138,633								
	FC	1			30,884							
	G	1				-4,113						
	Fo	1					40,090					
	Non-flow items		0	0	0	0	1	63,100	-76,600	13,400	-40,500	40,600
	Total		**1,069,230**	**310,047**	**252,667**	**386,976**	**373,367**	**131,800**	**70,500**	**154,700**	**29,800**	**99,600**

Table A1: (continued)

Classification	Items	Dimension	Capital account						Total
			HH	NF-C	FC	G	Fo	Non-flow items	
			1	1	1	1	1		
Production activities	Industry	39						0	**2,459,803**
	Commodity (domestic)	39	82,009	135,924	7,018	34,022		0	**2,220,823**
	Commodity (imported)	39	15,834	26,264	1,013	5,920		0	**277,218**
	Margins	39	7,102	10,826	965	1,846		0	**238,980**
	Taxes on domestic products	39	6,014	9,040	898	1,265		0	**63,239**
	Taxes on imported products	39	732	1,099	109	154		0	**20,104**
	Taxes on production	1						0	**53,496**
Factors of production	Labor	1						0	**597,815**
	Capital	1						0	**528,069**
	Land	1						0	**8,840**
Income account	Households (HH)	1						-	**1,069,230**
	Non-financial corp (NF-C)	1						-	**310,047**
	Financial corp (FC)	1						-	**252,667**
	Government (G)	1						-	**386,976**
	Foreigner (Fo)	1						-2	**373,367**
Financial account	HH	1						0	**131,800**
	NF-C	1						0	**70,500**
	FC	1						0	**154,700**
	G	1						0	**29,800**
	Fo	1						0	**99,600**
Capital account	HH	1		202		2,132		0	**144,892**
	NF-C	1	373			4,616		0	**143,622**
	FC	1						0	**30,884**
	G	1	161	1,449				0	**-2,503**
	Fo	1				367		0	**40,457**
	Non-flow items		32,667	-41,183	20,881	-52,824	40,457		
	Total		**144,892**	**143,622**	**30,884**	**-2,503**	**40,457**		**9,659,036**

Table A2: Links between industries in I-O Tables and industries in NGGI regarding fugitive, industrial processes, agricultural activities and waste emissions.

a) Fugitive emissions

In I-O Tables code	Category	Gas	Gg (1,000 Tonnes)
	2. Fugitive Emissions From Fuels	CO2-e	40,211.89
	3.Solid Fuels	CO2-e	28,822.90
0601	4.Coal Mining	CO2-e	27,164.14
0601	4.Other	CO2-e	1,658.76
	3.Oil and Natural Gas	CO2-e	11,388.99
0701 (b1+b2)	4.Oil	CO2-e	377.65
0701 (b3+b4+b5)	4.Natural Gas	CO2-e	3,801.21
0701 (b3+b4+b5)	Production/ processing	CO2-e	67.64
2701	Distribution	CO2-e	3,014.90
0701 (b3+b4+b5)	Transmission	CO2-e	237.94
0701 (b3+b4+b5)	Exploration	CO2-e	480.73
	4.Venting and Flaring	CO2-e	7,210.13
	5.Venting	CO2-e	4,254.68
0701 (b3+b4+b5)	6.Gas	CO2-e	4,254.68
	5.Flaring	CO2-e	2,955.45
0701 (b3+b4+b5)	6.Gas	CO2-e	1,728.26
0701 (b1+b2)	6.Oil	CO2-e	1,227.18

b) Emissions from industrial processes

In I-O Tables code (industry)	Category	Gas	Gg (1,000 Tonnes)
2003	Mineral Products	CO2-e	6,535.57
1803	Chemical Industry	CO2-e	6,313.71
2101 + 2201	Iron and Steel Production	CO2-e	6,294.53
2102	Aluminium Production	CO2-e	3,444.14
1101=>1205	Food and Drink	CO2-e	161.4

c) Emissions from agricultural activities

In I-O Tables code (industry)	Category	Gas	Gg (1,000 Tonnes)
	Agriculture	CO2-e	83,860.13
	Enteric Fermentation	CO2-e	54,592.76
0101	Cattle	CO2-e	43,816.68
0102	Other Livestock	CO2-e	36.34
0102	Buffalo	CO2-e	7.04
0101	Sheep	CO2-e	10,496.83
0101	Goats	CO2-e	65.23
0102	Camels and Llamas	CO2-e	2.01
0102	Horses	CO2-e	97.65
0102	Mules and Asses	CO2-e	0.12
0102	Swine	CO2-e	70.84
	Manure Management	CO2-e	3,293.41
0101	Cattle	CO2-e	1,541.09
0102	Other Livestock	CO2-e	0.01
0102	Buffalo	CO2-e	0.01
0101	Sheep	CO2-e	2.78
0101	Goats	CO2-e	0.03
0102	Camels and Llamas	CO2-e	0
0102	Horses	CO2-e	0.15
0102	Mules and Asses	CO2-e	0
0102	Swine	CO2-e	1,154.11
0102	Poultry	CO2-e	595.22
0101	Rice Cultivation	CO2-e	46.28
	Agricultural Soils	CO2-e	14,271.60
	Direct Soil Emissions	CO2-e	4,875.86
0103	Synthetic Fertilisers	CO2-e	2,698.65
	Animal Waste Applied to Soils	CO2-e	661.29
	Manure	CO2-e	661.29
0101	Cattle	CO2-e	401.03
0102	Poultry	CO2-e	169.62
0102	Swine	CO2-e	90.64
0103	Nitrogen Fixing Crops	CO2-e	611.31
0103	Crop Residue	CO2-e	845.96
0103	Cultivation of Histosols	CO2-e	15.59
	Other Direct Emissions	CO2-e	43.05
0103	Sewage sludge applied to	CO2-e	43.05
	Animal Production	CO2-e	3,631.74
	Nitrogen Excretion on Pasture	CO2-e	3,631.74
	Urine	CO2-e	2,426.47
0102	Buffalo	CO2-e	0.33
0102	Camels and Llamas	CO2-e	0.11
0101	Cattle	CO2-e	1,662.65
0101	Goats	CO2-e	6.02
0102	Horses	CO2-e	14.12
0102	Mules and asses	CO2-e	0.01
0102	Other	CO2-e	2.19

0101	Sheep	CO2-e	741.04
	Faeces	CO2-e	1,205.27
0102	Buffalo	CO2-e	0.17
0102	Camels and Llamas	CO2-e	0.06
0101	Cattle	CO2-e	876.34
0101	Goats	CO2-e	3.07
0102	Horses	CO2-e	7.21
0102	Mules and asses	CO2-e	0.01
0102	Other	CO2-e	1.12
0102	Poultry	CO2-e	4.66
0101	Sheep	CO2-e	312.64
	Indirect	CO2-e	5,764.00
	Atmospheric Deposition	CO2-e	3,351.48
0103	Fertiliser	CO2-e	433
	Manure	CO2-e	2,042.03
0102	Buffalo	CO2-e	0.23
0102	Camels and Llamas	CO2-e	0.08
0101	Cattle	CO2-e	1,355.94
0101	Goats	CO2-e	4.24
0102	Horses	CO2-e	9.94
0102	Mules and asses	CO2-e	0.01
0102	Other	CO2-e	1.54
0102	Poultry	CO2-e	127.82
0101	Sheep	CO2-e	495.57
0102	Swine	CO2-e	46.65
0103	Other	CO2-e	876.44
	Nitrogen Leaching and Run-Off	CO2-e	2,412.52
0103	Fertiliser	CO2-e	744.35
	Manure	CO2-e	1,650.24
0102	Buffalo	CO2-e	0.3
0102	Camels and Llamas	CO2-e	0.1
0101	Cattle	CO2-e	1,154.00
0101	Goats	CO2-e	3
0102	Horses	CO2-e	6.99
0102	Mules and asses	CO2-e	0
0102	Other	CO2-e	1.57
0102	Poultry	CO2-e	30.9
0101	Sheep	CO2-e	439.1
0102	Swine	CO2-e	14.27
	Other	CO2-e	17.94
0103	Sewage sludge applied to	CO2-e	17.94
0101+0102+0103	Prescribed Burning of Savannas	CO2-e	11,342.10
0101+0102+0103	Field Burning of Agricultural	CO2-e	313.99

d) Emissions from waste

In I-O Tables	Category	Gas	Gg (1,000 Tonnes)
	Waste	Net	13,277.67
2901	Solid Waste Disposal on Land	Net	10,296.08
	Managed Waste Disposal on Land	Net	10,296.08
2801	Wastewater Handling	Net	2,880.43
	Industrial Wastewater	Net	1,196.88
	Domestic and Commercial Wastewater	Net	1,683.54
2901	Waste Incineration	Net	29.91
	Plastics and Other Non-Biogenic Wastes	Net	29.91
2901	Other	Net	71.25
	Biological Treatment of Solid Waste	Net	71.25

e) Emissions from fuels combustion

In I-O Tables code (industry)	Category	Fuel type	Gg (1,000 Tonnes)
	1.Energy		422,276.07
	2.Fuel Combustion	All Fuel	382,064.18
	3.Energy Industries	All Fuel	237,011.05
2601	4.Public Electricity and Heat Production	All Fuel	209,913.97
1701	4.Petroleum Refining	All Fuel	5,169.90
	4.Manufacture of Solid Fuels and Other Energy Industries	All Fuel	21,927.17
	5.Manufacture of Solid Fuels	All Fuel	1,136.24
1701	6.Brown Coal Briquette Production	All Fuel	63.91
1701	6.Coke Production	All Fuel	1,072.33
	5.Other Energy Industries	All Fuel	20,790.93
0601	6.Coal Mining	All Fuel	4,429.64
0701	6.Gas Production and Distribution	All Fuel	137.39
0701 (b4)	6.Natural Gas Transmission	All Fuel	934.58
0701	6.Oil and Gas Extraction	All Fuel	15,289.32
	3.Manufacturing Industries and Construction	All Fuel	39,318.92
2101+2201	4.Iron and Steel	All Fuel	3,434.56
2102	4.Non-Ferrous Metals	All Fuel	12,803.63
	4.Chemicals	All Fuel	5,231.57
1701	5.Petroleum and Coal Product Manufacturing (nec)	All Fuel	468.98
1803	5.Basic Chemical Manufacturing	All Fuel	4,762.59
1501+1502+1601	4.Pulp, Paper and Print	All Fuel	1,678.12
1101=>1205	4.Food Processing, Beverages and Tobacco	All Fuel	3,085.64
	4.Other	All Fuel	13,085.40
0801+0802+0901	5.Mining (Non-Energy)	All Fuel	4,099.09
	5.Non-Metallic Mineral Products	All Fuel	6,221.69
2003 + 2004	6.Cement, Lime, Plaster and Concrete Manufacturing	All Fuel	4,219.60
2002	6.Ceramic Manufacturing	All Fuel	1,150.42
2001	6.Glass and Glass Product Manufacturing	All Fuel	565.86
2005	6.Non-Metallic Mineral Product Manufacturing (nec)	All Fuel	285.83
	5.All Other Manufacturing	All Fuel	1,008.53
2301=> 2502	6.Machinery and Equipment	All Fuel	381.19

1401+1402+1801	6.Other Manufacturing	All Fuel	82.42
2202=>2204	6.Other Metal Manufacturing	All Fuel	139.48
1301=>1306	6.Textile, Clothing, Footwear and Leather	All Fuel	405.45
3001+3002+3101	5.Construction	All Fuel	1,756.09
	3.Transport	All Fuel	84,638.76
4901	4.Civil Aviation	All Fuel	6,002.75
4601	4.Road Transportation	All Fuel	72,923.28
4701	4.Railways	All Fuel	2,385.86
4801	4.Navigation	All Fuel	3,283.73
5101+5201	4.Other Transportation	All Fuel	43.15
	3.Other Sectors	All Fuel	19,674.07
1001, 2605 =>	4.Commercial / Institutional	All Fuel	4,537.75
Final households	4.Residential	All Fuel	9,219.52
0101=>0501	4.Agriculture, Forestry and Fishing	All Fuel	5,916.80
	3.Other (not elsewhere classified)	All Fuel	1,421.39
1701 (c6)	4. Lubricants and Greases	All Fuel	479.88
7601	4.Military mobile	All Fuel	941.51

Table A3: The compatible energy commodities between I-O Tables and NGGI

Compatible with fuel commodities in I-O Tables	Fuel names in National Greenhouse Gas Inventory
a1	Black Coal
a2	Brown coal
b1 + b2	Crude oil (natural gas liquid)
c3	Fuel Oil
c3	Automotive Diesel Oil
c2	Kerosene
c1	Petrol
c1	Aviation Gasoline
c5	Liquefied Petroleum Gas
c4 + c6	Other Oil
c6	Lubricants
c7 +c8	Petroleum Products nec
b3 + b4 + b5	Natural gas
b5	Town gas
1502	Solid Biomass
2901	Gas Biomass