**AUSTRALIAN GREENHOUSE GAS EMISSIONS: EXPERIMENTAL CONSUMPTION-BASED ESTIMATES VIA INPUT-OUTPUT ANALYSIS**

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[](http://www.google.com.au/imgres?q=Australian+emission+accounting&um=1&hl=en&sa=N&biw=853&bih=562&tbm=isch&tbnid=qqWDYn9dMPZnbM:&imgrefurl=http://www.smh.com.au/environment/climate-change/joint-emissions-plan-to-un-20110920-1kjn0.html&docid=OemjWEqpUMGB2M&imgurl=http://images.smh.com.au/2011/09/20/2638497/ipad-art-wide-joing-emissions-420x0.jpg&w=420&h=304&ei=0PjvTszzO8aaiAfQg6yuBw&zoom=1&iact=rc&dur=263&sig=104439259884651283588&page=14&tbnh=157&tbnw=209&start=88&ndsp=8&ved=1t:429,r:0,s:88&tx=100&ty=71)

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**1. INTRODUCTION**

This study attempts to construct an environmentally extended Input-Output (IO) table for Australian greenhouse gas (GHG) emissions[[2]](#footnote-3) induced by final demand at the industry group level. The work is part of a pilot project to produce GHG emissions accounts according to the System of Environmental-Economic Accounting (SEEA)[[3]](#footnote-4).

The paper outlines the methodology, presents some early results and identifies some of the practical challenges encountered. Another objective of this paper is to seek feedback from stakeholders in order to inform internal ABS consideration of its future work program for environmental statistics and future releases of these experimental data. It is not an official ABS release of data. In particular, the ABS has a project underway to review and improve the energy related columns and rows of the IO tables. These improvements once implemented would likely impact on the results presented here, particularly the industry dimension of emissions induced by final demand products.

Estimates of emissions induced by final demand (often referred to as consumption-based emissions) can be seen as complementing the National Greenhouse Accounts prepared by the Department of Climate Change and Energy Efficiency (DCCEE)[[4]](#footnote-5). They are designed to enable GHG emissions to be viewed from a consumption perspective and to answer some policy questions. The DCCEE produces the National Greenhouse Accounts to meet the Australian Government’s reporting obligations under the UN Framework Convention on Climate Change and under the Kyoto Protocol, and to fulfil accounting obligations in relation to the Government’s national emission reduction commitments. The National Greenhouse Accounts also provide emissions data associated with production processes in the Australian economy at national and state levels according to both the Intergovernmental Panel on Climate Change (IPCC) and based on Australian and New Zealand Standard Industrial Classification 06 (ANZSIC 06) systems.  Integral to the accounting framework developed by DCCEE is the design of policies to manage emissions at the point of production in a manner consistent with the National Greenhouse Accounts including policies such as the Carbon Price Mechanism and the Carbon Farming Initiative.

While the data compiled by the DCCEE are production based estimates, the environmentally extended IO model provides a different perspective by allocating production based emissions to final users. The resulting consumption-based emissions estimate the economy’s cumulative GHG emissions[[5]](#footnote-6) embodied in final products consumed, used in gross capital formation[[6]](#footnote-7) or exported.

A consumption-based emissions data set could be very informative for policy makers. Global efforts to reduce greenhouse gas emissions, such as the Kyoto Protocol, will prove less effective if they fail to account for the relocation of GHG-intensive production processes from countries which have emission restrictions, to non-restricted countries. In addition, free trade agreements and cross-border supply chains have resulted in increasing volumes of internationally traded goods and services. In order to comprehensively measure the GHG emissions directly attributable to a particular country, analysts must take a global perspective and consider the feedback effects and GHG emissions embodied in traded goods and services.

**2. LITERATURE REVIEW**

Previous international studies which have estimated final demand induced carbon emissions using IO tables include Cumberland (1966), Ayres and Kneese (1969), Bullard and Herendeen (1975), and Griffin (1976). A number of national statistical agencies and other official bodies in Europe including Carlsson, A. et al. (2006), Francis (2004), Rormose et al. (2009), Rormose (2010) and Federal Statistical Office of Germany (2011) and also Canada such as Gaston (2011) have produced data for consumption based emissions using IO model. Recent work by Edens et al. (2011) on Dutch GHG emissions account and IO analysis is perhaps the most comprehensive study to date. It utilises a greater level of disaggregation (60 industries) and a broader scope of emissions (the whole Intergovernmental Panel on Climate Change (IPCC) reporting scope). In addition, it also adjusts for the difference between the SEEA and IPCC framework on emissions accounting.

Within an Australian context, Common and Salma (1992) were pioneers in utilising the IO framework to allocate the emissions from the combustion process of primary fuel sources towards final demand. They contended that carbon generally enters the economy as primary fuels (that is, coal, crude oil, and natural gas) and is used either as intermediate inputs or as final products. Most primary fuels are transformed into other forms of energy before being used (for example, coal into electricity and crude oil into refined petroleum). This transformed energy is then used to produce downstream products (for example, electricity used in factories or petroleum used in transport). An economy’s carbon content can therefore be measured at final demand stage. Lenzen (1998) extended Common and Salma’s work by taking into account and ; taking a consumption perspective rather than a production perspective; singling out gross capital formation from final demand; and taking into account electricity price differentials.

The ABS produced experimental estimates of final demand driven GHG emissions for Australia in the Energy and Greenhouse Gas Emissions Accounts, Australia 1992–93 to 1997–98 ABS (2001) (cat. 4604.0) in 2001. While the work was well received, it has not been updated. This study builds on the ABS (2001) work, and more particularly, it utilises the extensive data base now available from the Australian Greenhouse Emissions Inventory developed and maintained by DCCEE.

**3. CONCEPTS AND METHODOLOGY**

The main data inputs for this study are the 2007-08 *National Greenhouse Inventory* *by Economic Sector* data and the 2007-08 suite of IO tables for Australia.

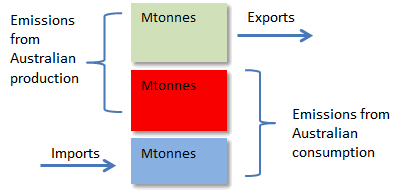
* 1. **Consumption-based emissions concepts**

Consumption-based emissions consist of the cumulative emissions resulting from domestic final demands. Production-based emissions consist of direct emissions incurred during domestic production[[7]](#footnote-8). The formulas below and Figure 1 both illustrate this relationship.

Or alternatively,

s

***Figure 1: Production and consumption approaches to GHG measurement[[8]](#footnote-9)***



* 1. **Improvements**

This paper improves on previous ABS work in five areas.

* + 1. The scope of the emissions has been extended from combustion-process-only to include GHG emissions under the Kyoto framework comprising all IPCC energy sectors (including stationary energy and transport); industrial processes; solvent and other product use; agriculture; waste; and land use, land use change and forestry (LULUCF).[[9]](#footnote-10)
    2. It uses the Australian Greenhouse Emissions Inventory[[10]](#footnote-11) as the primary data source. The previous study used an indirect approach that involved the application of emissions intensity factors to energy use data.
    3. The transport and electricity activity based data has been reallocated to an industry basis.[[11]](#footnote-12)
    4. In linking the emissions data, which consists of 40 sectors, with the Australian IO matrix by 111 Input-Output Industry Group (IOIG)[[12]](#footnote-13), this study adopts a two-stage four-factor dissection technique[[13]](#footnote-14).
    5. The emissions data from the *National Greenhouse Inventory* *by Economic Sector* is adjusted to SEEA concepts. Such transformation shifts the territorial-based dataset towards a resident-based dataset, which enables compatibility between the emissions data and the economic data in the IO tables.
  1. **SEEA adjustments**

In order to represent the emission information on a SEEA basis, several adjustments to the Kyoto accounting data are required.

* + 1. The first adjustment is the travellers abroad adjustment based on the Tourism

Satellite Account[[14]](#footnote-15) where the direct emissions related to road transport activities by residents abroad are added and the emissions related to non-residents within Australian territory are subtracted. Due to the net effect, the result is marginal for the reference year.

* + 1. International bunkering[[15]](#footnote-16) and [[16]](#footnote-17)emissions from burning of biomass are added. The data are taken from the UNFCCC memo items data from the DCCEE.
    2. The “Carbon Dioxide Equivalent Emissions sink” associated with afforestation and reforestation (-23081.08 kilotonne for the year 2007-08) in the Kyoto data is reversed. Air emissions accounting does not allow for carbon offsets. SEEA stipulates that capture or embodiment of gases by plants or other sinks should not be included in the air emissions account.
    3. The electricity emissions data are reallocated from an activity-basis to a standard industry classification basis. For example, the self-generated electricity by an enterprise in the manufacturing industry is included in the manufacturing industry, not the electricity-generation industry. This ensures compatibility with the IO table. This reallocation is facilitated by the ABS Energy, Water and Environment Management Survey (EWE) survey[[17]](#footnote-18). The difference between the EWES energy consumption and the activity based energy consumption data are transformed into emission estimates via weighted emission conversion factors. Heterogeneous electricity production processes are incorporated when calculating the industry emissions estimate. For example, the emissions from the burning of bagasse (residue of sugar cane production) are associated with the sugar cane industry.

As a result, the total SEEA adjustments comprise 19 megatonne (Mt) from burning of biomass, 12 Mt -e from international bunkering activity and 23 Mt -e from adding back afforestation and reforestation offsets. All up, the total Kyoto domestic emissions 583 Mt are adjusted upward by 54 Mt -e, (a 9% increase). This results in total SEEA production-based emissions at 636 Mt representing the direct emissions as a result of Australian economic activity.

* 1. **Dissection of the input data**

When matching different levels of disaggregation between the direct emissions intensity data and the IO table, there are two schools of thought. Machado (2000) contends that the finer IO data needs to be collapsed to match the environmental data while Lenzen et al. (2004) postulates that the energy data should be dissected further so as to match the IO data. This study adopts the latter approach requiring the splitting of data using indicators as it avoids the aggregation error[[18]](#footnote-19) as a result of grouping industries with disparate emission intensities. It retains the full information of IO industrial linkage while the emissions information can be augmented by the knowledge of particular engineering processes and reasonable assumptions.

1. A concordance table is constructed between the DCCEE industries (predominantly based on ANSZIG 06) with the IOIG industries[[19]](#footnote-20). The matched emissions data are dissected according to a four-factor dissection technique. The first factor is the actual emissions figures from the IPCC emission categories, which can be found through the DCCEE AGEIS reporting interface[[20]](#footnote-21). This dataset is used to reallocate the emissions data for the Agriculture industries and the Cement, Lime, Plaster and Concrete Product Manufacturing industries[[21]](#footnote-22). A concordance table is created to link the most detailed categories and the agriculture IOIG industries[[22]](#footnote-23).
2. The residuals resulting from the first stage of the reallocation are then dissected based on a second-stage allocation ratio. This ratio is based on the direct energy consumption ratio combined with the weighted emissions conversion factor and industry total domestic output[[23]](#footnote-24). The direct energy consumption weighting is obtained from the IO Table 9 - Direct Requirement Coefficients (Indirect Allocation of Imports[[24]](#footnote-25)) table (Cat. 5209.0.55.001) by dividing the total use from each energy industry by the total intermediate use figures[[25]](#footnote-26). For example, the direct energy consumption intensity ratio for the Sheep, Grains, Beef and Dairy Cattle industry (IOIG 0601) should be the sum of Coal Mining (IOIG 0601), Oil and Gas Extraction (IOIG 0701), Petroleum and Coal Production (IOIG 1701), and Gas Supply (IOIG 2701) divided by the total intermediate use.

The weighted emissions conversion factor is derived from the National Greenhouse Accounts (NGA) Factors[[26]](#footnote-27) and the Bureau of Resources and Energy Economics (BREE) - Table A - Australian energy supply and consumption - energy units. This information is used to obtain the weighted average emission conversion factor for the relevant energy inputs.

The total industry domestic output can be obtained from the Australian Supply Table - Supply by Product Group by Industry. These three parameters are combined to compute the reallocation ratios, which are used as a secondary reallocation measure.

The ***i*** is the number of the iteration for dissection whenever there is one DCCEE industry matching with more than one IOIG industries and ***j*** is the number of IOIG industry that are matched with one DCCEE industry in any particular iteration of dissection.

In addition to the four-factor dissection technique, there are allocations based on the idiosyncratic characteristics of the industries. For instance, the direct emissions for Electricity Supply is entirely allocated towards the 2601 Electricity Generation with no direct emissions assigned to 2605 Electricity Transmission, Distribution, On Selling and Electricity Market Operation. Another example is the emissions due to the industrial process for Cement, Lime, Plaster and Concrete Product Manufacturing is entirely assigned to the 2003 Cement, Lime and Ready-Mixed Concrete Manufacturing.

**3.5 Input-Output Model**

This paper follows the standard approach of IO analysis by applying the domestic direct emission intensity vector to the Leontief inverse and direct requirement matrix of final demand.

The Australian IO Table 8 - Industry by Industry Flow Table (Indirect Allocation of Imports) (Cat. 5209.0.55.001) is employed to incorporate the embodied emissions from imports. This method treats imports as though they were produced by Australian industries (referred to as indirect allocation of imports). It does this by grossing up inputs by the amount of imports based on the characteristic of that industry's products. This treatment flows through to the derived IO tables 9 - Direct Requirement Coefficients (Indirect Allocation of Imports) and 10 - Total Requirement Coefficients (Indirect Allocation of Imports) (Cat. 5209.0.55.001).

The simplest environmental extension of the IO model is through a pre-multiplication of the monetary IO table by a vector of “emissions intensity” coefficients. This study embraces the same basic IO model from the ABS (2001). The underlying monetary input-output tables have an indirect allocation of competing imports, and the theoretical model is developed accordingly. The model is represented by the following identities of IO variables:

Denote Supply as **S**, Use as **U**, Intermediate Consumption as **Z**, Household final consumption as **H**, Government final consumption as **G**, Gross capital formation as **K,** and Exports as **X.**

(3.1)

(3.3)

(3.4) Denote as the direct requirement coefficients matrix with indirect allocation

of imports at basic prices, and using the same terms as 3.1 to 3.3 above, the

following equations are can be derived:

(3.5) In a steady condition, balance of system requires

When coefficient matrix and final demand[[27]](#footnote-28) vector are given, the solution for Gross Output is available as follows (in the case that is square matrix):

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(3.7)Similarly, emissions induced by final demand can be calculated using the model in 3.6. This is the traditional-method model, and emissions produced induced by final demand can be calculated as follows:

Let be a diagonalised[[28]](#footnote-29) matrix of industry direct emission intensities or emissions coefficients, which is defined as where is the vector of domestic direct emissions (The SEEA production-based emissions by 111 IOIG industries) produced and is the vector of total domestic output from the industry. Then:

The inherent assumption of the indirect allocation method is that the imports share the same technology of production with the same or similar domestically produced goods and services. Denote the direct emission intensity of imports as

is the cumulative emissions intensity which represents the globally induced emissions per dollar of total outputs including competing imports.

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The resulting matrix will be an industry by final demand category emissions matrix. Household direct emissions need to be added to the total emissions induced by final use to derive the total consumption based emissions. Direct emissions by households cannot be derived within the standard IO model as it is neither captured by the intermediate production matrix nor the domestic emissions intensity. Therefore the household direct emissions due to the combustion process of petroleum products needs to be manually adjusted.

Exported energy products such as coal, gas, crude oil and petroleum only have induced emissions up to the point when the products are exported. The potential emissions as a result of the combustion of the energy products in another country are not captured by this model. This is consistent with the economic resident principle.

On the supply side, the cumulative emissions induced in order to produce the imports is computed by assigning the cumulative emission intensity towards the total competing imports by industry, which can be found at the IO Table 8 - Industry by Industry Flow Table (Indirect Allocation of Imports).

Among the many assumptions that are inherent in the IO model, two assumptions in particular are relevant to the results of this study.

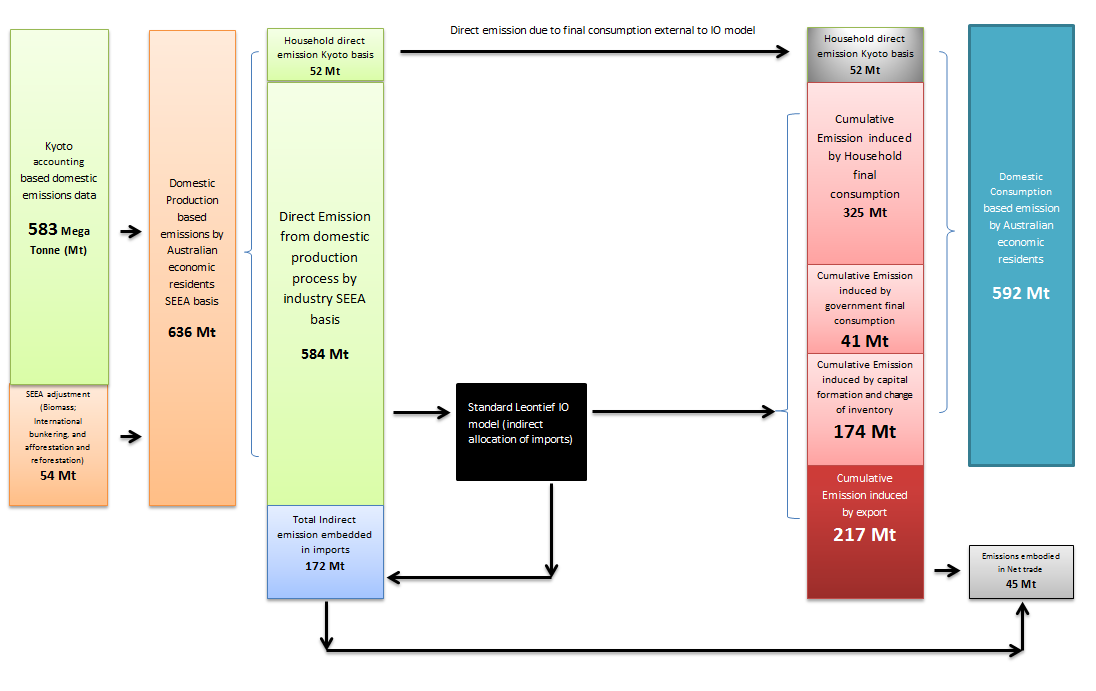
1. All electricity users are assumed to be paying the same average price. In the real world, this is not likely to be true. Heavy users of electricity are likely to negotiate more favourable prices. This could distort the attribution of GHG emissions to final demand categories by type of product, but should not affect the total induced emissions estimate. In future work, physical flow of electricity could be linked to the monetary IO table to overcome such problems.
2. Imports are assumed to share the same technology of production with the same or similar domestically produced goods and services. This assumption may be unsatisfactory where imports are produced using energy sources or practices that are more or less GHG intensive than in Australia. In future work, a more sophisticated multi-regional IO model could be used to take into account the production technologies of key trading partners.

**4. RESULTS**

Due to the experimental nature of this study, only aggregated results are presented here for key industries. Investigations are continuing to further review the results. The data are presented here as part of the review process.

Figure 2 shows the indirect emissions embedded in imports totalling 172 Mt is derived from the IO model through the indirect allocation of imports with the assumption that imports share the same technology requirement as domestic products of the same or similar types. The SEEA Production based emissions plus the embedded emissions in imports (172 Mt) give rise to the total emissions supply of 809 Mt. On the use side, the total supply is allocated towards households (377 Mt including the direct emissions from households), government final consumption expenditure (41 Mt), capital formation and change of inventories (174 Mt) and exports (217 Mt). The total consumption based emissions by Australian economic residents is 592 Mt, which is 45 Mt lower than the production based emissions. This is due to the 45 Mt of emissions embedded in net trade balance.

Figure 2: GHG Emissions flow supply and use 2007-2008



|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table 1: Greenhouse Gas Emissions Induced by Final Demand, (Mt**  **-e) 2007-2008** | | | | | | |
|  | **Household final consumption** | **Government final consumption** | **Gross capital formation** | **Total domestic use** | **Exports** | **Total uses** |
| Agriculture, forestry and fishing | 15 | 0 | 16 | 31 | 31 | 62 |
| Mining | 1 | 0 | 6 | 7 | 58 | 65 |
| Manufacturing |  |  |  |  |  |  |
| *Food, beverages and tobacco* | *57* | 0 | 2 | 59 | 31 | 90 |
| *Textile, wood, paper and printing* | *7* | 0 | 1 | 8 | 4 | 11 |
| *Petroleum, coal and chemical products* | *15* | 2 | 8 | 25 | 9 | 33 |
| *Non-metallic mineral products* | *1* | 0 | 1 | 2 | 1 | 2 |
| *Metal products* | *1* | 0 | 5 | 6 | 45 | 51 |
| *Machinery and equipment* | *20* | 0 | 34 | 54 | 7 | 60 |
| Total manufacturing | 100 | 2 | 52 | 153 | 96 | 249 |
| Electricity, gas, water and waste services | 80 | 0 | 18 | 99 | 0 | 100 |
| Construction | 1 | 1 | 66 | 68 | 0 | 69 |
| Transport | 22 | 2 | 1 | 26 | 18 | 44 |
| Commercial and other services | 106 | 35 | 15 | 156 | 13 | 169 |
| **Total indirect emissions by industries** | **325** | **41** | **174** | **540** | **217** | **757** |
| Direct Emissions by households | 52 |  |  | 52 |  | 52 |
| **Total direct and indirect emissions Australia** | **377** | **41** | **174** | **592** | **217** | **809** |
| Note: Figures are for direct and indirect emissions | | | | | | |

Table 1 above displays the direct and indirect emissions induced by final demand category. This table also shows that of the 809 Mt of GHG emissions induced by the Australian economy, 592 Mt of GHG emissions are induced to satisfy domestic expenditure while 217 Mt emissions are induced by exports. Approximately 90% of total induced emissions from the mining category and 40% of total induced emissions from the manufacturing category are induced by exports. Household expenditure constitutes just under 50% of the total induced emissions mainly through ‘Food, beverages and tobacco’, ‘Electricity, gas, water and waste services’ and ‘Commercial and other services’.

Figure 3 presents the comparison between the total SEEA production-based emissions (636 Mt) and the total consumption-based emissions (592 Mt) by Australian residents. The difference between the two methods of analysis is the emissions embodied in the net trade balance.

Figure 4 presents the induced emissions from total final demand satisfied by industry producing the final demand products. The largest contributors are manufacturing and commercial and other services industries products. Key industries such as retail and whole sale trade and the services industries products have large cumulative intensities due to the upstream emissions from electricity generation and transport.

It is worth noting that emissions induced by final demand are only associated with the final consumption expenditure by households, governments and gross capital formation. It takes into account the embodied emissions from the intermediate inputs, however, excludes the emissions associated with the industry output which is consumed by other industries as intermediate inputs. A typical example is electricity industry where the induced emissions by final demand is much smaller than the total produced emissions as most of the industry outputs go into other industries as intermediate consumption, which is accounted for as part of the induced emissions by other industries. For the same reason, transport has relatively smaller induced emissions than it produces. The direct emissions by households are the emissions due to the transport activities, combustion of gas for heating and petrol use for lawn mowers etc.

Figure 5 is a breakdown of emissions induced by final demand for manufacturing products. Whilst domestic demand is the major driver of the induced emissions across different manufacturing industries, metal products have a rather large export proportion. Such observations are consistent with Australia’s export profile.

Figures 6, 7 and 8 show the induced emissions for household final consumption expenditure, exports and gross capital formation (including change in inventories). Figure 6 suggests that for household final consumption the highest induced emissions are from Commercial and services products (106 Mt); Electricity, gas, water and waste services (80 Mt); and Food, beverages and tobacco manufacturing products (57 Mt). For Australia’s exports, the highest induced emissions are Mining products (58 Mt); Metal products manufacturing (45 Mt); Agriculture, forestry and fishing products (31 Mt); and Food, beverages and tobacco manufacturing products (31 Mt). The highest induced emissions products are in relation to gross capital formation are Construction (66 Mt); and Machinery and equipment manufacturing products (34 Mt).

Figure 9 presents the cumulative emissions intensity for all industry groups The cumulative emissions intensity is the total induced emissions per dollar of final demand for products from that industry. Electricity, gas, water and waste services have the highest cumulative emission intensities.

**5. CONCLUSION**

This study uses the suit of IO tables for the Australian economy in conjunction with data for greenhouse gas emissions by industry supplied by the Department of Climate Change and Energy Efficiency to model a demand-side view of Australia’s greenhouse gas emissions. It uses the standard environmentally extended Leontief model to bridge the gap between the production and final demand sides of the economy. More importantly, it brings to account the global greenhouse gas implications of Australian consumption, regardless of whether that consumption is satisfied by domestic production or from imported products.

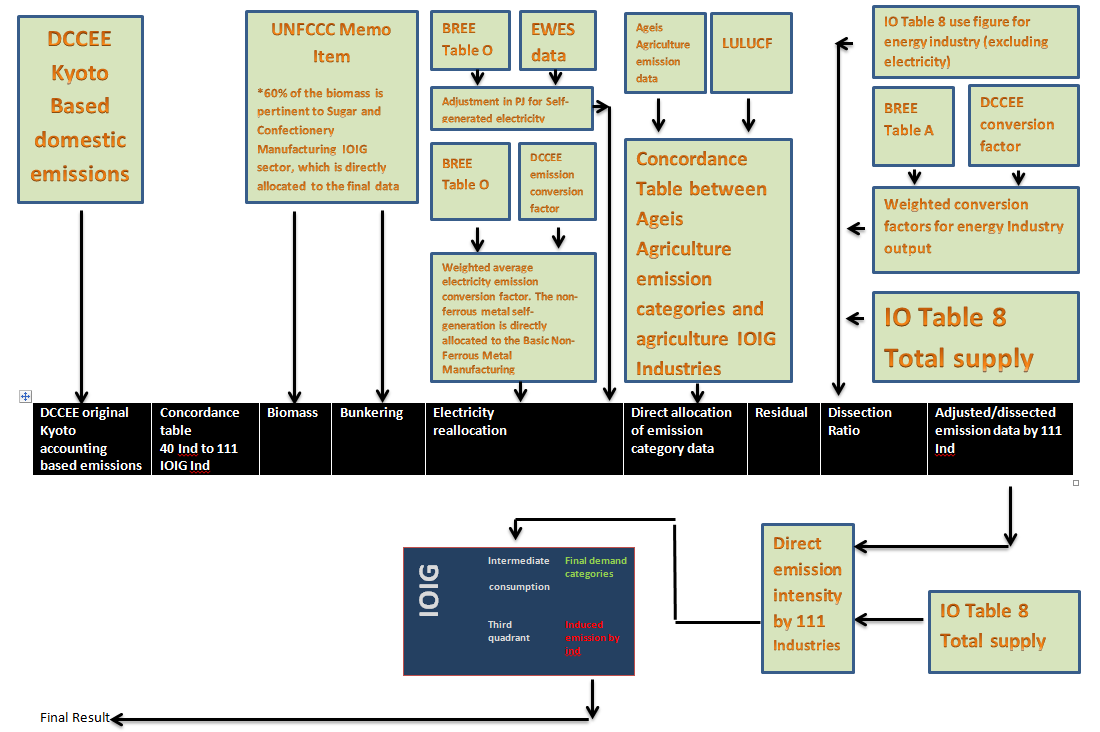
The strength of this study lies in the high level of disaggregation. The available emissions data was further dissected to a finer level to match the dimensions of the official IO tables. This is based on the four factor dissection technique to enable production based emissions data be allocated across the 111 IOIG industries in the IO tables. The results of the model largely avoid the aggregation error inherent in the alternative approach which is to build a smaller IO table to match the available data. Additionally, the source data is transformed to align with the SEEA framework.

The results of the model indicate that the total cumulative emissions 592 Mt[[29]](#footnote-31) are induced by Australian economic residents, including 377 Mt induced by household expenditure and 174 Mt induced by gross capital formation. The difference between production and consumption based emissions is not substantially different. Australia’s exports result in 217 Mt induced GHG emissions while Australia’s imports have 172 Mt embedded. The 45 Mt of emissions is embodied in net export out of the total 636 Mt of emissions by domestic production.

There are two important assumptions in the model that could affect the quality of the results. Firstly, the production function of imported products with respect to greenhouse gas emissions is assumed to be the same as for locally produced products of the same type. The likely impact of this assumption is an overstatement of emissions embodied in imports due to the high emission intensity owing to the over reliance of coal for electricity generation in Australia. Therefore it understates the net exported emissions. It is possible to mitigate the potential estimation bias by incorporating the global production functions and regional I-O models with further assistance from DCCEE. Secondly, all consumers of electricity are assumed to pay the same price per unit. These assumptions are not expected to be entirely valid, but no analysis of possible biases in the results has been undertaken for this study. More sophisticated models which take these factors into account are possibilities for future work.

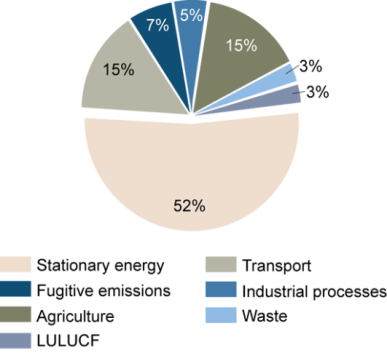
**APPENDIX**

**Appendix 1: Flow chart for adjustments and model**



**Appendix 2: GHG emission**

The GHG emissions by industry data is the input for the IO analysis. It encompasses , , and . Under the UNFCCC reporting guidelines, human-induced greenhouse emissions must be reported in six sectors: energy (including stationary energy and transport); industrial processes; solvent and other product use; agriculture; waste; and land use, land use change and forestry (LULUCF). According to the Greenhouse emissions by sector, Kyoto accounting, 2009, the energy sector (comprising stationary energy, transport and fugitive emissions from fuels) continues to be the dominant source of Australia’s GHG emissions accounting for 74% of net emissions, including those associated with land use, land-use change and forestry (LULUCF). Within this sector, stationary energy accounts for 52%, which comprises of electricity (37%) and fuel combustion (15%). LULUCF = land use, land-use change and forestry. (DCCEE, 2009)



*Source: DCCEE, National Inventory by Economic Sector 2009*

**Appendix 3: Concordance DCCEE Industry Classification and IOIG classification**

The industry classification used for input-output tables - Input-Output Industry Group (IOIG) - is based on the Australian and New Zealand Standard Industrial Classification 06 (ANZSIC 06).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DCCEE Industry Classification** | | | **Corresponding Input-Output Industries** | |
| **Level 02** | **Level 03** | **Level 04** | **IOIG** | **IOIG Descriptor** |
| Div. A Agriculture, Forestry and Fishing |  |  | 0101  0102  0103  0201  0301  0401  0501 | Sheep, Grains, Beef and Dairy Cattle  Poultry and Other Livestock  Other Agriculture  Aquaculture  Forestry and Logging  Fishing, hunting and trapping  Agriculture, Forestry and Fishing Support Services |
| Div. B Mining | 06 Coal Mining |  | 0601 | Coal mining |
| 07 Oil and Gas Extraction |  | 0701 | Oil and gas extraction |
| 08-10 Metal Ore and Non-Metallic Mineral Mining and Quarrying |  | 0801  0802  0901  1001 | Iron Ore Mining  Non Ferrous Metal Ore Mining  Non Metallic Mineral Mining  Exploration and Mining Support Services |
| Div. C Manufacturing | 11-12 Food, Beverages and Tobacco Product Manufacturing |  | 1101  1102  1103  1104  1105  1106  1107  1108  1109  1201  1202  1203  1204 | Meat and Meat product Manufacturing  Processed Seafood Manufacturing  Dairy Product Manufacturing  Fruit and Vegetable Product Manufacturing  Oils and Fats Manufacturing  Grain Mill and Cereal Product Manufacturing  Bakery Product Manufacturing  Sugar and Confectionery Manufacturing  Other Food Product Manufacturing  Soft Drinks, Cordials and Syrup Manufacturing  Beer Manufacturing  Wine, Spirits and Tobacco  Cigarette and Tobacco Product Manufacturing |
| 13 Textile, Leather, Clothing and Footwear Manufacturing |  | 1301  1302  1303  1304  1305  1306 | Textile Manufacturing  Tanned Leather, Dressed Fur and Leather Product Manufacturing  Textile Product Manufacturing  Knitted Product Manufacturing  Clothing Manufacturing  Footwear Manufacturing |
| 14-16 Wood and Paper Manufacturing and Printing Services |  | 1401  1402  1501  1502  1601 | Sawmill Product Manufacturing  Other Wood Product Manufacturing  Pulp, Paper and Paperboard Manufacturing  Paper Stationery and Other Converted Paper Product Manufacturing  Printing (including the reproduction of recorded media) |
| 17 Petroleum and Coal Product Manufacturing | 1701 Petroleum Refining and Petroleum Fuel Manufacturing | 1701 | Petroleum and Coal Product Manufacturing |
| 1709 Other Petroleum and Coal Product Manufacturing |  |  |
| 18-19 Basic Chemical and Chemical, Polymer and Rubber Product Manufacturing |  | 1801  1802  1803  1804  1901  1902 | Human Pharmaceutical and Medicinal Product Manufacturing  Veterinary Pharmaceutical and Medicinal Product Manufacturing  Basic Chemical Manufacturing  Cleaning Compounds and Toiletry Preparation Manufacturing  Polymer Product Manufacturing  Natural Rubber Product Manufacturing |
| 20 Non-Metallic Mineral Product Manufacturing | 201 Glass and Glass Product Manufacturing | 2001 | Glass and Glass Product Manufacturing |
| 202 Ceramic Product Manufacturing | 2002 | Ceramic Product Manufacturing |
| 203 Cement, Lime, Plaster and Concrete Product Manufacturing | 2003  2004 | Cement, Lime and Ready-Mixed Concrete Manufacturing  Plaster and Concrete Product Manufacturing |
| 209 Other Non-Metallic Mineral Product Manufacturing | 2005 | Other Non-Metallic Mineral Product Manufacturing |
| 21-22 Metal Product Manufacturing | 211-212 Basic Ferrous Metal Manufacturing | 2101 | Iron and Steel Manufacturing |
| 213-214 Basic Non-Ferrous Metal Manufacturing | 2102 | Basic Non-Ferrous Metal Manufacturing |
| 22 Fabricated Metal Product Manufacturing | 2201  2202  2203  2204 | Forged Iron and Steel Product Manufacturing  Structural Metal Product Manufacturing  Metal Containers and Other Sheet Metal Product manufacturing  Other Fabricated Metal Product manufacturing |
| 24 Machinery and Equipment Manufacturing |  | 2301  2302  2303  2304  2401  2403  2404  2405 | Motor Vehicles and Parts; Other Transport Equipment manufacturing  Ships and Boat Manufacturing  Railway Rolling Stock Manufacturing  Aircraft Manufacturing  Professional, Scientific, Computer and Electronic Equipment Manufacturing  Electrical Equipment Manufacturing  Domestic Appliance Manufacturing  Specialised and other Machinery and Equipment Manufacturing |
| 25 Furniture and Other Manufacturing |  | 2501  2502 | Furniture Manufacturing  Other Manufactured Products |
| Div. D Electricity, Gas and Water Supply | 26-27 Electricity and Gas Supply | 26 Electricity Supply | 2601  2605 | Electricity Generation  Electricity Transmission, Distribution, On Selling and Electricity Market Operation |
| 27 Gas Supply | 2701 | Gas Supply |
| 28 Water Supply, Sewerage and Drainage |  | 2801  2901 | Water Supply, Sewerage and Drainage Services  Waste Collection, Treatment and Disposal Services |
| Div. E Construction |  |  | 3001  3002  3101  3201 | Residential Building Construction  Non-Residential Building Construction  Heavy and Civil Engineering Construction  Construction Services |
| Residential | Residential (non-transport)  Residential (transport) |  |  |  |
| Div. F-H, J-Q Commercial Services | Div. F,G Wholesale and Retail Trade |  | 3301  3901 | Wholesale Trade  Retail Trade |
| Div. H,P,Q Accommodation, Food Services, Education and Health Services |  | 4401  4501 | Accommodation  Food and Beverage Services |
| Div. J Information Media and Telecommunications |  | 5401  5501  5601  5701  5801  6001 | Publishing (except Internet and Music Publishing)  Motion Picture and Sound Recording  Broadcasting (except Internet)  Internet Publishing and Broadcasting and Services Providers, Websearch Portals and Data Processing Services  Telecommunication Services  Library and Other Information Services |
| Div. K,L Finance, Insurance, Rental, Hiring and Real Estate |  | 6201  6301  6401  6601  6701  6702 | Finance  Insurance and Superannuation Funds  Auxiliary Finance and Insurance Services  Rental and Hiring Services (except Real Estate)  Ownership of Dwellings  Non-Residential Property Operators and Real Estate Services |
| Div. M Professional, Scientific and Technical Services |  | 6901  7001 | Professional, Scientific and Technical Services  Computer Systems Design and Related Services |
| Div. N,O Administration, Public Administration and Services |  | 7201  7501  7601  7701  8001  8401  8601  8901  9101  9201  9401  9402  9501  9502 | Building Cleaning, Pest Control, Administrative and Other Support Services  Public Administration and Regulatory Services  Defence  Public Order and Safety  Education and Training  Health Care Services  Residential Care and Social Assistance Services  Heritage, Creative and Performing Arts  Sports and Recreation  Gambling  Automotive Repair and Maintenance  Other Repair and Maintenance  Personal Services  Other Services |
| Div. I Transport, Postal and Warehousing | 46 Road Transport |  | 4601 | Road Transport |
| 47 Railway Transport |  | 4701 | Rail Transport |
| 48 Domestic Water Transport |  | 4801 | Water, Pipeline and Other Transport |
| 49 Domestic Air and Space Transport |  | 4901 | Air and Space Transport |
| 50-53 Other Transport, Services and Storage |  | 5101  5201 | Postal and Courier Pick-up and Delivery Service  Transport Support services and storage |

**Appendix 4: Concordance DCCEE Industry Classification and IOIG classification**

|  |  |  |
| --- | --- | --- |
|  | **IOIG Descriptor** | **IPCC emission category** |
| 0101 | Sheep, Grains, Beef and Dairy Cattle | Sheep |
|  |  | Dairy Cattle |
|  |  | Non-Dairy Cattle |
|  |  | Sheep |
|  |  | Cattle |
|  |  | Irrigated |
| 0102 | Poultry and Other Livestock | Poultry |
|  |  | Horses |
|  |  | Swine |
|  |  | Other Livestock |
|  |  | Buffalo |
|  |  | Goats |
|  |  | Camels and Llamas |
|  |  | Mules and Asses |
|  |  | Horses |
|  |  | Swine |
|  |  | Other Livestock |
|  |  | Buffalo |
|  |  | Goats |
|  |  | Camels and Llamas |
|  |  | Mules and Asses |
| 0103 | Other Agriculture | Agricultural Soils |
|  |  | Prescribed Burning of Savannas |
|  |  | Field Burning of Agricultural Residues |
| 0201 | Aquaculture |  |
| 0301 | Forestry and Logging | Afforestation and reforestation offsets |

The detailed emission data by IPCC emission categories obtained from the AGEIS reporting interface enables the attribution of the emission data towards the IOIG agricultural industries which results in the below table (the results have been blacked out as the detailed industry data is not published in this study):

|  |  |  |
| --- | --- | --- |
|  |  | **Direct Allocation of Emission Category** |
| **IOIG** | **IOIG Descriptor** |  |
| 0101 | Sheep, Grains, Beef and Dairy Cattle | X\* |
| 0102 | Poultry and Other Livestock | Y |
| 0103 | Other Agriculture | Z |
| 0201 | Aquaculture | A |
| 0301 | Forestry and Logging | B |
| 0401 | Fishing, hunting and trapping | C |
| 0501 | Agriculture, Forestry and Fishing Support Services | D |
|  | | |

The table below presents the complete method of dissection for agricultural emissions data. Agriculture is linked with seven IOIG sectors, which are: 0101 Sheep, Grains, Beef and Dairy Cattle; 0102 Poultry and Other Livestock; 0103 Other Agriculture; 0201 Aquaculture; 0301 Forestry and Logging; 0401 Fishing, hunting and trapping; 0501 Agriculture, Forestry and Fishing Support Services.

The residual is the difference between the original figures with the total of the direct allocation of emission category figures. The corresponding secondary allocation ratios are assigned to the residual to derive the dissected residual. The dissected residual figures plus the direct allocation give the adjusted direct emission.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **by K ton** |  |  |  | **Direct Allocation of Emission Category** | **Residual** | **Dissected**  **Residual** | **Adjusted Direct**  **Emission** |
| **Level 02** | **-e**  **(2007-08)** | **IOIG** | **IOIG Descriptor** |  |  |  |  |
| Div. A Agriculture, Forestry and Fishing | 127298.09 | 0101 | Sheep, Grains, Beef and Dairy Cattle | 113,693.87 | 6,214.96 | 1701.8548 | 115395.72 |
| 0102 | Poultry and Other Livestock | 2110.5 | 279.22488 | 2389.7249 |
| 0103 | Other Agriculture | 28,359.84 | 2106.8278 | 30466.668 |
| 0201 | Aquaculture | 0 | 369.30271 | 369.30271 |
| 0301 | Forestry and Logging |  | 613.99392 | 613.99392 |
| 0401 | Fishing, hunting and trapping | 0 | 431.97475 | 431.97475 |
| 0501 | Agriculture, Forestry and Fishing Support Services | 0 | 711.78441 | 711.78441 |

The total directly allocated agriculture data make up 144 mega tonnes out of the total 150 mega tonnes for the agriculture total SEEA based emissions. The residual 6 mega tonnes is predominantly the energy emission, such as the emissions due to the operation of the agricultural equipment etc. The residue will then be reallocated based on the dissection ratios.

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   \*\* All co-authors are ABS officers. [↑](#footnote-ref-2)
2. The 3 key greenhouse gases are carbon dioxide (CO2), nitrous oxide (N2O) and methane (CH4). Carbon dioxide (CO2) equivalents are used to measure the emissions from various greenhouse gases based upon their global warming potential. The carbon dioxide equivalent for a gas is derived by multiplying the tonnes of the gas by the associated global warming potential. [↑](#footnote-ref-3)
3. SEEA is an international statistical standard for environmental-economic accounting. It integrates environmental information into a framework consistent with the economic data contained in the national accounts. The SEEA provides the conceptual basis describe the inter-relationship between the natural environment and the economy. [↑](#footnote-ref-4)
4. see [www.climatechange.gov.au](http://www.climatechange.gov.au) [↑](#footnote-ref-5)
5. The cumulative (also referred to as embodied and indirect) GHG emissions are the sum of emissions along the whole supply chain of the goods and services entering household and government consumption, gross capital formation, export, and inventory change. It conceptualises the induced emissions (including direct emissions from production processes plus the embodied emissions in inputs) induced by final demand. Additionally, it incorporates the embodied emissions from imports. It includes all emissions induced by final demand and is not limited to the emissions from the indirect allocation of purchased electricity. It encompasses all scope 2 and 3 emissions under Kyoto. [↑](#footnote-ref-6)
6. The gross capital formation includes the gross fixed capital formation and changes in inventories. [↑](#footnote-ref-7)
7. Production-based emissions include the household direct emissions. [↑](#footnote-ref-8)
8. Diagram based on Swedish Environmental Protection Agency report 5992, 2010, The climate impact of Swedish consumption. [↑](#footnote-ref-9)
9. Please see Appendix 1 for further information on the IPCC GHG emissions categories under the Kyoto framework. [↑](#footnote-ref-10)
10. From 1 July 2008 a registered corporation above a threshold is required to report the amount of greenhouse gas emissions and energy produced or consumed by facilities under the operational control of its group members (which may include subsidiaries, joint ventures or partnerships) during a reporting year. [↑](#footnote-ref-11)
11. The reallocation for transport industry is done by DCCEE. The reallocation for electricity data was undertaken by the ABS. [↑](#footnote-ref-12)
12. See Appendix 2 [↑](#footnote-ref-13)
13. See Appendix 1 and section 3.4 for detailed elaboration. [↑](#footnote-ref-14)
14. Australian National Accounts: Tourism Satellite Account (cat. No. 5249.0) [↑](#footnote-ref-15)
15. The UNFCCC international bunkering memo item represents emissions incurred by outbound international transport regardless of the residency of the carrier. This is not strictly on the basis required by SEEA, but has been used here as a reasonable proxy for Australia. [↑](#footnote-ref-16)
16. Only the as opposed to the -e from Biomass burning is excluded from Kyoto. Therefore only the is added. [↑](#footnote-ref-17)
17. The Energy, Water and Environment Management survey (ABS cat. no. 4660.0) data is used to reallocate electricity emissions data, to align with SEEA-E industry principle. [↑](#footnote-ref-18)
18. Aggregation error in input-output analysis is well-documented. The environmentally extended input-output analysis further complicate the matters due to the nature of heterogeneous sectors with disparate environmental impacts such as electricity generation and electricity transmission which are normally combined as one industry. [↑](#footnote-ref-19)
19. See Appendix 3 [↑](#footnote-ref-20)
20. http://ageis.climatechange.gov.au/NGGI.aspx# [↑](#footnote-ref-21)
21. The actual emission figures from the IPCC emission categories are only used for agriculture and the Cement, Lime, Plaster and Concrete Product Manufacturing industries where the detailed actual data makes up the majority of the emission data by economic sectors. For instance, the total allocated emission figure make up more than 90% of the total emissions from agriculture emission. [↑](#footnote-ref-22)
22. See appendix 4 [↑](#footnote-ref-23)
23. The domestic output as opposed to the total supply including competing imports as outputs is selected as one of the dissection factor since it is the domestic emissions that need to be dissected. Conversely the direct energy consumption weighting is taken from the table 9 which incorporate imports through indirect allocation since both imported energy and domestic energy as intermediate inputs contribute to the domestic emissions. [↑](#footnote-ref-24)
24. The values in a particular column of this table represent the direct requirements of supply from the industry represented by the row, when the Australian output of the industry represented by the column increases by $100. It describes the allocation of goods and services, inclusive of imports, but excluding re-exports. Imports are indirectly allocated and are included in the intermediate use of industries and in final use categories without distinguishing the imports from the products with which they compete allowing the intermediate use matrix to fully reflect the input structures of industries. [↑](#footnote-ref-25)
25. 0601 Coal mining; 0701 Oil gas extraction; 1701 Petroleum and coal production and 2701 Gas supply

    Electricity is not considered for the dissection of direct emissions purpose as no emissions take place when electricity is consumed. This also avoids double counting of the emissions intensity ratio. [↑](#footnote-ref-26)
26. The National Greenhouse Accounts (NGA) Factors have been prepared by the Department of Climate Change and Energy Efficiency and are designed for use by companies and individuals to estimate greenhouse gas emissions. The NGA Factors are not published for the purposes of reporting under the National Greenhouse and Energy Reporting Act 2007 (the NGER Act). While drawing on the National Greenhouse and Energy Reporting (Measurement) Determination 2008, the methods described in the NGA Factors have a general application to the estimation of a broader range of greenhouse emissions inventories. [↑](#footnote-ref-27)
27. In the updated Australian IO framework the final demand category is termed as final use category. For the benefits of the non IO readers, this study use both terms interchangeably [↑](#footnote-ref-28)
28. That is the vector is transformed into a square matrix with the value of the vector on the diagonal. [↑](#footnote-ref-29)
29. The cumulative emissions take into account of the embodied emissions from the imports via the indirect allocation of the imports in the model. [↑](#footnote-ref-31)