Harmonisation of the Australian Energy Hybrid Accounts with the Input-Output Tables

Khanh Vy Hoang and Ben Loughton
Australian Bureau of Statistics

Abstract

Environmental-economic accounts record the transactions in monetary terms between economic units that may be considered environmental and deliver necessary extensions to System of National Accounts (SNA). The environmental-economic accounts produced, to the extent that it is conceptually possible, should align with the SNA accounts to allow for coherent analysis of the contribution of energy to the economy, the impact of the economy on the energy resources, and the efficiency of the use of energy resources within the economy.

One of the sets of environmental-economic accounts produced by the Australian Bureau of Statistics is the Energy Hybrid Accounts comprising physical and monetary supply and use tables, energy asset tables and a hybrid energy use table. This paper outlines the recent work by the ABS towards integrating Energy Hybrid Accounts with existing SNA accounts i.e. the Input-Output tables. The Energy Hybrid Accounts are compiled based on the System of Environmental-Economic Accounting (SEEA). Thus, in theory, the harmonisation of these accounts should be relatively straightforward. However, in practice, some challenges exist. The paper will examine the conceptual and methodological issues in energy resources accounting and describe in detail the source data and the valuation methods used by the ABS. The practical challenges of the harmonisation process and the long-term plan to align other sets of environmental-economic accounts with the Input-Output tables are also discussed.

1. Introduction

There is a growing interest in integrating the value of the environment[1] into core economic indicators such as Gross Domestic Product (GDP), to allow for coherent analysis of the interactions of the environment and the economy. The satellite environmental-economic accounts ('environmental accounts') have not yet been explicitly harmonised with official national accounts statistics, either at regional or national levels. The reason for this deficiency is because there remain many unresolved issues in the measurement of even basic environmental inputs in current environmental accounting frameworks (UN 2014a).

1.1 Developments in environmental-economic accounts

The importance of the environment for economic development was highlighted by Meadows et al. (1972) and Ayres and Kneese (1969), which provided the impetus for the economics community to analyse these issues by including non-renewable resources in macroeconomic models[2]. Weitzman (1976) provided the seminal contribution where he established (under certain assumptions) a welfare measure of Gross domestic product (GDP) in which national income equals the return to wealth. These articles kicked off a "green accounting literature" which analyses the relationship between concepts such as wealth, income, and welfare in macroeconomic models including the role of natural resources (Heal and Kriström 2005).

While the green accounting literature offered a promising way forward, the approach was not integrated into the measurement of GDP, since it was established "at a very high level of abstraction without searching any longer for any relationship to actual national accounting measurements" (Vanoli 2005). Instead, national statistical offices (NSOs), which compile GDP for their respective countries, followed a more empirical approach. The initial attempts to integrate environmental and natural resources into the national accounts occurred during the 1970s and 1980s with early work in the Netherlands (Hueting 1980), France (Commission interministérielle du patrimoine naturel 1986) and Norway (Alfsen et al. 1987).

These developments gradually progressed[3], and in the 1990s, the United Nations Statistical Commission released the 1993 Handbook of National Accounting: Integrated Environmental and Economic Accounting (UN 1993). The most prominent addition to the national accounting literature on this topic in recent times is a framework known as the System of Environmental-Economic Accounting Central Framework (SEEA CF) (UN 2014a)[4]. The SEEA CF provides a framework for understanding the role of environmental assets and ecosystems services in economic activity and how they can be valued. It focusses on individual resources such as land, minerals, timber and water resources that contribute to economic activities.

[1] Ecosystems are defined as "a dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit. Examples are terrestrial ecosystems (e.g., forests and wetlands) and marine ecosystems." (UN 2014b, 2.21)
[2] For example see Solow 1974.
[3] For a summary see Ahmad et al. 1989.
[4] The SEEA was produced jointly by the United Nations, European Union, Food and Agriculture Organization, OECD, and World Bank.

1.2 Aims of this paper

The Australian Bureau of Statistics (ABS) produces a set of environmental accounts based on the SEEA, which includes the Energy Hybrid Accounts (‘energy accounts'). The energy accounts, to the extent that it is conceptually possible, should align with the SNA accounts to allow for coherent analysis of the contribution of energy to the economy. The Input-Output (IO) tables produced by the ABS provide a framework for the organisation of national accounts statistics from a production perspective. In the IO tables, the supply and use of products, of which energy products is a subset, is presented within a product by industry matrix.

At the broad aggregate level, IO data meets the standards of data reliability and consistency and aligns with published national accounts estimates. However, at the disaggregated level, particularly intermediate use by product, data is often modelled in the absence of detailed information. Thus, the energy accounts provide a framework to link physical information to core components of the IO tables. In theory, the harmonisation of these accounts should be relatively straightforward. However, applying integrated definitions and measurement boundaries and also consistent valuation concepts for the different products, are in practice, a challenging exercise.

Thus, the aims of this paper are to share the ABS experience on harmonising the energy accounts with the IO tables and to demonstrate some of the benefits of a hybrid approach to accounting. By reconciling the physical and monetary values, insights are gained into the strengths and potential weakness of the accounts and as a result, add value to both set of statistics. Section 2 presents the energy accounts produced by the ABS and describes in detail the data sources and valuation methods. Section 3 outlines the various practical and methodological issues encountered by the ABS in harmonising the two accounts. Some concluding remarks and the long-term plan to align other sets of environmental accounts with the core SNA accounts are provided in Section 4.

2. The Australian Environmental–Economic Accounts

The Australian Environmental-Economic Accounts (AEEA) represents the consolidated efforts by the ABS to develop and produce a set of environmental accounts. The ABS provides separate environmental accounts for water, energy, waste, land, and environmental assets as part of the national balance sheet. Table 2 (Appendix A) provides the catalogue of environmental accounts generated by the ABS. The environmental accounts are underpinned by the SEEA which is a satellite system to the SNA. The SEEA extends the boundaries of the national accounts to include environmental and energy resources that occur outside the economic asset and production boundaries. An important feature of the SEEA is that it links environmental information to the SNA, which provides the concepts and methods for official economic statistics produced internationally.

2.1 Energy Hybrid Account

One set of environmental accounts is the energy accounts, which encompass a set of supply and use tables showing how energy products are produced and used by the various industries/sectors that make up the economy. The energy products include brown coal, black coal, natural gas, liquefied petroleum gas, crude oil, refined products, electricity (including renewables) and uranium. Not all these products are separately identifiable in all published tables.

The energy accounts data are presented in physical terms, as well as, wherever possible, corresponding monetary terms. The principal data sources are the Australian Energy Statistics (AES) produced by the Department of Industry, Innovation and Science (DIIS), the ABS Energy, Water and Environment Management Survey (EWES) and the ABS Energy Indicators Survey (unpublished).

Table 1: Summary of main data sources used in the Energy Hybrid Account

Data Source Name	Year range	Description	Reference
Australian Energy Statistics (AES)	1973-74 to 2014-15	The AES is the official source of energy data for Australia. It forms the basis of Australia's international reporting obligations. It is updated annually and consists of detailed historical energy consumption, production and trade statistics.	DIIS (2016)
Energy, Water and Environment Survey	2011-12, 2014-15	The EWES collects data about the consumption of energy, in both monetary and physical terms, from businesses in the economy. The survey also collects data about their generation of electricity by fuel type.	ABS (2016)
Energy Indicators Survey (EIS)	2012-13 to 2013-14	The EIS collects data about the consumption of energy, in both monetary and physical terms, from businesses in the economy. Collecting data on fewer industries and products than the EWES, the survey serves as an indicator between benchmarks established by the more comprehensive survey.	Unpublished ABS data
National Greenhouse and Energy Reporting Scheme (NGERS)	2008-09 to 2014-15	The scheme is a single national framework for the reporting and disseminating of company information about greenhouse gas emissions, energy production, energy consumption and other information specified under NGER legislation.	NGER (2017)

The AES contains physical supply and use data by sector and product, and are used for Australia's official energy reporting obligations to the International Energy Agency. Not all of the physical energy data is compiled and published in a manner consistent with the SNA due to international reporting requirements and limitations in source data. For instance, as the energy data are collected on an 'activity basis', it is consequently compiled by energy type irrespective of the industry of origin (e.g. electricity generation attributed to the Electricity supply sector, even if produced by Mining or Manufacturing). Also, the consumption of energy is recorded by activity rather than the industry/sector of use. For example, the use of automotive fuel for transportation purposes is attributed to the Transport sector, even if the transportation is undertaken by Retail or Mining). Both the SNA and SEEA frameworks assign all economic activities, including the supply and use of energy products, to the industry performing them. This enables compilation of physical and monetary information, such as energy consumption per unit of industry output, on a comparable and consistent basis.

Thus, the AES data must be reallocated onto an industry basis to compile the Energy Hybrid Account. This reallocation is based on data from the ABS Energy, Water and Environment Management Survey (ABS, 2014), the ABS Energy Indicators Survey (unpublished) and the Survey of Motor Vehicle Use (ABS, 2010). Where possible, unit record data from the EWES is matched with the National Greenhouse and Energy Reporting System (NGERS).

3. Harmonisation of the Energy Accounts and the Input-Output Tables

Over the past few years, the ABS has been working towards the alignment of ABS statistics compiled on the SEEA and SNA basis. The first phase involved harmonising the energy accounts with the IO tables as the energy accounts provide a way to link physical information to core components of the national accounts. A further aim is to minimise differences between data items purporting to measure the same quantity, irrespective of data sources and methodologies.

Naturally, the first step was aligning the supply and use of energy products in the IO tables with corresponding estimates from the energy account. For the most part, this should have been relatively straightforward as, although they are not identical, the SEEA and SNA treatments of these flows are complementary. In practice, a number of challenges exist. An area where they differ significantly is the treatment of goods and services produced by, and consumed as intermediate inputs within the one enterprise (hereafter referred to as "output for own intermediate use"). The linkages and challenges faced by the ABS in reconciling the two accounts are examined in this section.

3.1 Linkages

3.1.1 Output

Output consists of the production of goods and services for use as inputs into the production process of an industry, or as final demand. As the majority of these transactions take place between separate establishments, and at market prices, the output element is generally aligned by using the IO table values in both accounts. This choice is due to the IO table values being based on actual economic survey data while, prior to alignment, the energy account values were derived by applying suitable market price proxies to physical values. Where output is concerned, the main challenge is in the treatment of output for own intermediate use. This issue will be further discussed in the next section of this paper.

3.1.2 Intermediate use

Intermediate use consists of goods and services transformed or used up in the process of production. Unlike output, this element is aligned by using the energy account values on both accounts. This choice is made as, while the IO table values are more accurate at an industry level, they lack the product detail available in the energy account. In particular, the IO tables do not account for product substitution, such as the shift from petrol to diesel, and relative price differences between industries.

Nevertheless, it is important to note that compiling the energy account values for intermediate use is a challenge in and of itself. These values are derived by applying the observed value of relevant market transactions to physical energy use. This is an inherently difficult procedure as market prices for energy products can be volatile at lower levels, compounded by the absence of some monetary values corresponding to physical use. As noted, often the physical use information cover not only consumption arising from market transactions, but also output for own intermediate consumption, including energy losses. To the extent that these transactions are prevalent within an industry, not to mention the possibility of transfer pricing, the value of its market transactions will be distorted.

3.1.3 Changes in inventories

Changes in inventories consist of additions less withdrawals of goods held to be used as inputs into the production process, or as final demand. As with intermediate use, this element is aligned by using the energy account data in both accounts. This choice is made as the energy account values are derived by applying suitable market price proxies to physical values while, before alignment, the IO table values were highly modelled.

The use of the energy account values also bypasses the application of an inventory valuation adjustment (IVA). In compiling the IO tables, changes in inventories are adjusted to exclude holding gains or losses due to the effects of price changes. This adjustment, known as the IVA, is unnecessary in the energy account as the product’s unit price, both at the beginning and ending of the accounting period, is central to the valuation of this transaction.

3.1.4 Household final consumption expenditure

Household final consumption expenditure (HFCE) consists of final expenditure incurred by households on consumption goods and services. As with output, this element is aligned by using the IO table values in both accounts. The IO tables utilise data from the Household Expenditure Survey (HES) to capture household expenditure on all energy products. At present, the HES is only available every six years, so the accuracy of individual energy products, such as those related to petroleum and diesel consumption, would fall in the interim. Thus, to ensure ongoing relevance, the HFCE estimates in the IO tables are regularly confronted with the physical energy account and, where appropriate, adjusted to account for changes in expenditure patterns.

3.1.5 Imports and exports

In this context, exports of goods and services consist of goods and services from resident to non-residents, while imports consist of purchases of goods and services by resident from non-residents. As with output and HFCE, this element is aligned by using the IO table values in both accounts. This choice is due to the IO data being based on the Balance of Payments (BoP)[5] statistics while, prior to alignment, the energy account values were derived by applying suitable market price proxies to physical values.

[5] BoP statistics are based on International Merchandise Trade Statistics that, by SNA principles, are adjusted for coverage, timing and valuation differences.

3.1.6 Other elements (margins and taxes less subsidies on products)

The remaining elements: margins and taxes less subsidies on products are aligned by using the IO data in both accounts. In this context, margins consist of any trade or transport margins on goods purchased, while taxes less subsidies on products include any taxes less subsidies that become payable on the production, sale or delivery of goods and services. In this instance, the choice is clear as, due to its focus on tangible flows, neither element are compiled in the energy account.

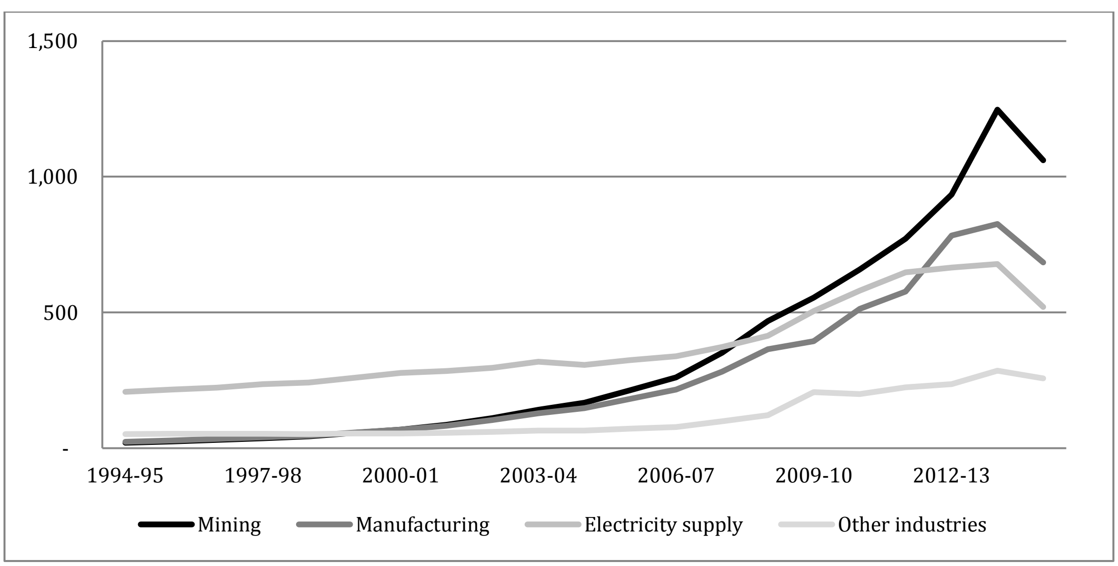
3.2 Challenges

3.2.1 Recording of output for own intermediate use

Many enterprises are vertically integrated and hence, do not separately report on non-market transactions involving the supply of inputs from one part of the enterprise supply chain to another. This is commonly the case with enterprises operating in the Mining industry, which generate their own electricity using own mined resources. This is known as "output for own intermediate use", referring to any good or services produced and consumed within the same enterprise. In an information perfect world, when part of an enterprise produces and supplies significant quantities of potentially saleable goods, this activity would be separately captured by establishing a reporting entity (separated from the enterprise) which is classified to the industry to which those goods are primary. In practice, this rarely happens due to the difficulty of collecting this information and due to the overall insignificance, at least in monetary terms, of these activities.

In an Australian context, this is a particular challenge where electricity generation is concerned. The significance of electricity produced as output for own intermediate use is significant and, in physical terms, increasing in prevalence. To illustrate these trends, Figure 1 contains experimental monetary estimates of electricity generated as output for own intermediate use by certain Australian industries.

Figure 1: Electricity output for own intermediate use ($ million), experimental, 1994-95 to 2014-15



Regardless of how it is produced, as electricity is a form of energy, the flows associated with its production and use are always recorded within the SEEA framework (UN 2014, para 1.43). In the SNA framework, however, output for own intermediate use of this variety does not necessarily have to be recorded unless there is an analytical need to do so. Thus, while the core SNA accounts do not need to differentiate between the different types of production by a unit (only that the net value of the production), such distinctions add to the analytic value of the IO tables. If statistics compiled on a SEEA and SNA basis are not aligned, this activity would be recorded on a physical basis in the energy account without corresponding monetary transactions in the IO tables.

The main challenge is identifying and recording these activities when and if they become significant. Brown coal is the sole exception, as supply and use values for the product are explicitly included in both accounts. In the case of electricity, output for own intermediate use will be fully aligned in the 2015-16 IO tables. A stylised illustration of how electricity output for own intermediate use is recorded in the basic structure of supply and use tables is provided in Table 3 (Appendix B).

Besides electricity, there are other products, such as natural gas, for which output for own intermediate use might be significant. These instances are generally identified by relatively low unit prices, but can only be confirmed by conducting case studies e.g. while the NGERS data provides insight into electricity generation for own intermediate use, it could only be measured by the collection of specific data items in the ABS economic surveys.

3.2.2 Valuation of production for own use

The SEEA and SNA [6] frameworks share a common approach to the valuation of transactions. Accordingly, the valuation basis for converting physical data into monetary estimates, in order of preference, is as follows:

- Observed value of market transactions.
- Observed value of similar market transactions (or “proxy”).
- Costs of production.

Where electricity output for own intermediate use is concerned, while the choice of valuation basis is not clear-cut, the first option is clearly not feasible as there are no observed values associated with output for own intermediate use. Neither of the remaining options is perfect but, given the existence of a wealth of unit pricing data, the second option has been adopted. Due to differences in the production function, this approach admittedly causes certain distortions, but these presumably net out – more or less – at the industry and product level.

The primary issue with this approach is that unit prices derived from survey data are compromised, to the extent that an industry supplies its own energy inputs. For each industry, the unit prices for certain products are compiled by dividing the monetary purchases of each by their physical consumption, which assumes that output for own intermediate use is relatively uncommon. As output for own intermediate use becomes more prevalent, the year-on-year unit price changes become more difficult to interpret.

[6] Refer to SEEA (UN 2014, para 2.143-149) and SNA (UN 2009, para 6.124-125).

The ABS is conducting research into this matter, including the possibility of a cost of production approach – and not only for electricity, but any other product for which output for own intermediate use is prevalent. An example of this is the valuation of brown coal where the ABS has been able to determine the cost based non market domestic price, specific to brown coal.

3.2.3 Treatment of transmission and distribution losses

A significant amount of electricity use (which includes electricity transmission and distribution losses) is currently recorded on a physical basis in the energy accounts. Currently no monetary values associated with electricity transmission and distribution losses are recorded in the IO tables or energy accounts. The SNA and SEEA both recommend these flows should be valued at market prices. Indeed, the SEEA explicitly states that "losses should be recorded if there is a preference on the part of the economic unit to retain the physical quantities that return to the environment" (UN 2014, para 3.102).

Similar to output for own intermediate use, this issue is caused by the absence of transmission and distribution losses from the unit price calculation. The omission of these non-monetary transactions suppresses the unit price, as it implicitly valuing the losses at zero and belies the economic nature of the transactions. Given the nature of the inconsistency, not to mention its significance, the ABS is conducting further research into this matter.

3.2.4 Household consumption of own produced goods

The energy accounts follow SEEA and SNA principles[7] where the recording of 'backyard' production by households is concerned. Thus, at least in theory, household production is assigned to the industry that would typically produce the product and identified separately within the IO tables to maintain consistency. For example, wood extraction by households is considered part of the output of the Agriculture industry. Similarly, solar energy extracted within households to produce electricity is assigned to the Electricity supply industry, while solar energy obtained to produce hot water is allocated to the Water supply industry. Although certain adjustments are made in the IO tables to account for backyard production, such as fruit, vegetable, and meat production, no such adjustments are yet made to account for the supply and use of solar energy.

This omission may cause inconsistency between the monetary and physical dimensions of the energy account. However, the impact is likely an insignificant issue at present. The ambiguity stems from the lack of clarity about whether electricity suppliers report the value of feed-in tariffs[8] on ABS economic surveys. To the extent that they are reported, the inconsistency between the monetary and physical values is reduced. Regardless, any differences are likely insignificant as, in physical terms, households supplied just over 2% of Australian electricity in 2014-15[9].

[7] The SEEA (UN 2014) states that "if households extract or produce energy, the energy extraction or production should be recorded as part of the product output of the industry that would otherwise have produced the energy. At the same time a corresponding private consumption of energy products should be recorded for the households".
[8] Feed in tariffs are payments received by households for electricity fed back into the grid.
[9] Sourced from ABS Energy Accounts, 2014-15.

4. Conclusion and future direction

This example of aligning the energy accounts with the IO tables demonstrates that it is in the integration of information that holds great potential. If the delineation of measurement boundaries and the relationships between stocks and flows are carefully articulated, most relevant information can be placed in an integrated context. In this way, comprehensive information sets encompassing both the environment and the economy can be created. As the Australian experience shows, harmonisation is possible, meaningful and in the reconciliation process can add value to both sets of accounts.

The ABS intends to extend this reconciliation process to other environmental accounts. For instance, the ABS also produces the water accounts, which includes a monetary supply and use tables for the water supplied by the water supply industry. Similarly to the harmonisation of the energy account, bringing together of the physical and monetary information allows comparisons to be made between the volumes and values of water used within the economy.

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APPENDIX A: Environmental accounts produced by the ABS

Table 2: Availability of ABS environmental accounts and national balance sheets

Account type		Year First published	Frequency or status	Reference years for which accounts are available: Physical stock	Monetary stock	Physical flow	Monetary flow
NATIONAL BALANCE SHEET							
	Land Minerals Energy Timber	1995	Annual from 1995	1988-89 to 2015-16	1988-89 to 2015-16		
	Fish	2012	Experimental		2000-01, 2005-06 to 2009-10		
FISH		1999	Occasional	1996-97		1996-97	
ENERGY		1996	Annual from 2011	1988-89 to 2014-15	1988-89 to 2014-15	1993-94 to 1996-97, 2002-03 to 2014-15	2004-05, 2009-10 to 2014-15
MINERALS		1998	Occasional	1985 to 1996		1992-93, 1993-94	
WATER		2000	Annual from 2010			1993-94 to 1996-97, 2000-01, 2004-05, 2008-09 to 2014-15	2003-04, 2004-05, 2008-09 to 2014-15
LAND COVER AND LAND USE VALUES (BY STATE)(a)		2011	Annual from 2011	2011 to 2014	2012 to 2014	2013, 2014	2013, 2014
ENVIRONMENTAL TAXES		2013	Annual from 2013				2001-03 to 2014-15
ENVIRONMENTAL EXPENDITURES (b)		2013	Experimental				2009-10, 2010-11
WASTE		2012	Occasional			2009-10 2010-11	2009-10 2010-11
GHG EMISSIONS - EMBEDDED IN FINAL DEMAND (c)		2012	Experimental			2008-09 2009-10	

(a) Land cover, use and value accounts are intended to be released for each jurisdiction on a rotating schedule, pending data availability.
(b) Relates to functional accounts for the respective environmental transfers.
(c) Relates to Greenhouse gas emissions.
Source: Australian Bureau of Statistics, AEEA

APPENDIX B: Supply and Use Framework

Supply and use tables are presented as two tables: a supply table showing the supply of products by industry of origin, and a use table showing the intermediate use of products by industry and also final use by type of expenditure. The complete use table also includes primary inputs to production (i.e. compensation of employees, gross operating surplus and other taxes less subsidies on production) which is excluded from here for simplicity.

Table 3 provides an example of how electricity output for own intermediate use is recorded in a basic supply and use table. To recognise this activity, the electricity product must be split into two separate components. The first represents monetary transactions associated with the supply and use of electricity within the economy. This component is produced solely by the Electricity supply industry, and consumed as intermediate inputs (by industries A and B) and final consumption. The second component represents electricity produced as output for own intermediate consumption. Unlike the first component, as it is produced and solely consumed within each industry, the supply and use of this component is identical and thus, by definition, balanced automatically.

Table 3: Stylised Supply and Use Framework

SUPPLY OF PRODUCTS, at purchasers' prices								
	Output of industries at basic prices			Imports	Total supply at basic prices	Margins (a)	Taxes less subsidies on products (a)	Total supply at purchasers' prices
	(1)			(2)	(3)=(1)+(2)	(4)	(5)	(6) = (3)+(4)+(5)
	Industry A	Industry B	Electricity supply					
Product A	100			50	150	-	-	150
Product B		300		50	250	-	-	350
Electricity (monetary)			400		200	-	-	400
Electricity (own intermediate use)	25	25	50		100	-	-	100
Total supply	**125**	**225**	**250**	**100**	**1,000**	**-**	**-**	**1,000**

USE OF PRODUCTS, at purchasers' prices								
	Intermediate use by industries at purchasers' price				Final expenditure	Exports	Changes in inventories	Total use at purchasers' price
	Industry A	Industry B	Electricity supply	**Total**				
Product A			100	100	-	25	25	150
Product B		50	50	100	150	50	50	350
Electricity (monetary)	50	50		100	300	-	-	400
Electricity (own intermediate use)	25	25	50	100	-	-	-	100
Total intermediate use	**75**	**125**	**200**	**400**	**450**	**75**	**75**	**1,000**

(a) For simplicity, nil values are shown for margins and taxes less subsidies on products.