Construction of an Energy Database for GTAP V4: Concordance with IEA Energy Statistics

Christophe Complainville and Dominique van der Mensbrugghe

OECD Development Centre
94 rue Chardon-Lagache
75016 Paris
France
Contact: Dominique.Mensbrugghe@oecd.org
Web: http://www.oecd.org/dev/cendev/index.htm

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Introduction

The purpose of this document is to describe adjustment procedures for the IEA energy balances in order to integrate this adjusted data into the GTAP v4 database. The adjustments include filling in gaps for missing data, and re-calibrating data in order to achieve domestic and global flow consistency. The output from these adjustments is a data set referred to as GTAP-E, and is intended to be incorporated into a special version of GTAP v4 using the GTAP FIT procedure.

IEA[1] Energy Balances

The IEA provides country energy balances for 130 countries[2] and 3 remaining regions[3] which is fully sufficient to match the actual GTAP regional breakdown (45 regions). In order to allow regional extension in the future for GTAP, we will construct the energy database using the IEA breakdown of 133 countries. This special version of the energy database will be referred to as GTAP-E.

The energy balances express basic supply and demand for all fuels in a common unit (toe[4]) which allow comparison of each fuel's contribution to both supply source and demand uses.

In the following paragraphs, we will describe the adjustments made to the IEA energy balance. The first set of adjustments concerns filling in missing data in the IEA energy balance sheet. The second set of adjustments aggregates IEA decompositions to match the composition of energy supply and demand of GTAP. The first adjustments are mainly used to fill in, where necessary, the sub-sectors of 'total industry' and 'other sectors' (agriculture, residential, commercial and public services). As shown in Table 1, these two sectors represent 22.8% and 26.5% of global energy demand respectively. However, the IEA data on both energy transformation (electricity production, refineries etc.) and transport, representing 31.6% and 17.3%, are fully reported for all countries. Even for the countries where total industrial use is not available by sub sectors, the adjustments will concern a small amount of total energy demand.

Table 1. **Global Energy Demand**
(*percent of total*)

	Coal	Oil	Gas	RefOil	Elec	Heat	Renew	Total
Energy Transformation	64.6	67.6	43.8	14.9	17.8	13.6	10.9	**31.6**
Industry	28.1	19.1	24.4	15.9	35.4	37.2	12.5	**22.8**
Transport	0.3	11.6	2.0	48.8	1.7	0.0	1.6	**17.3**
Agr, Srv, Rsdt	6.9	0.6	29.8	15.2	45.1	49.2	74.7	**26.5**
Non Energy use	0.1	1.0	0.0	5.2	0.0	0.0	0.2	**1.8**
Total (Mtoe)	**2,224**	**59**	**1,828**	**3,320**	**1,135**	**308**	**1,002**	**9,876**

Source: IEA energy balance, 1997.

I- Deriving GTAP-E from IEA

1 International Energy Agency
2 Former Soviet Union countries are available individually
3 Other Asia, other Africa and other Latin America
4 Tonnes of oil equivalent

The following paragraphs discuss the adjustments made for each main sector. Annex-A shows the IEA flow codes corresponding to the GTAP-E flows.

To simplify the presentation, *'Italic'* font is used for IEA flow codes while a normal font refers to GTAP-E flows.

Annex-B provides both the IEA energy balance and the derived GTAP-E energy balance for Canada.

1. Energy Transformation

a. Electricity and Heat Plants

This transformation sector includes electricity plants, combined heat and power plants and heat plants (including heat pumps and electric boilers) which are aggregated under 'ELY' in the GTAP-E energy balance. A negative figure in the IEA data represents inputs (e.g. *'PUBELEC'* consumes -21.2 Mtoe of coal) and are reported as positive figures in the GTAP-E energy balance (i.e. 21.0 Mtoe[5]).

IEA's gross electricity production appears as a positive quantity in column 'Elec' (e.g. *'PUBELEC'* produces 43.6 Mtoe of electricity), while in the GTAP-E energy balance it is reported as *'INDPROD'*.

b. Gas works

This is gas produced at gas works. The treatment is similar to that of electricity (i.e. quantity produced as a positive figure and inputs as negative). On the GTAP-E energy balance, the inputs (coal, oil and refined oil) appear under the row 'GAS' and the corresponding gas output has been put under production *'INDPROD'*.

c. Petroleum refineries

This is the use of primary energy for the manufacture of petroleum products and the corresponding output. The oil inputs are reported as a negative figure (e.g. -86.5 Mtoe) in the row *'TREFINER'* appears positive in row 'P_C' of the GTAP-E energy balance.

The production of petroleum products is shown in row *'INDPROD'* of GTAP-E.

d. Coal transformation

Coal transformation (i.e. hard coal to coke) includes losses and these are recorded as negative entries in the IEA energy balances (e.g. –0.343 Mtoe), while in GTAP-E, they are reported as coal own-use (row 'COL'- column 'COL').

In the IEA energy balances, this flow is positive for some countries[6] due to the net calorific values used. In this case, the flow is added to coal production for balancing supply-demand.

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5 This figure differs slightly from IEA due to adjusting total supply to demand (see section II).

6 Russia, Chinese Taipei, Germany, Hungary, Bulgaria, Greece, Egypt, Uruguay and Tanzania.

e. Liquefaction

Liquefaction includes diverse liquefaction processes, such as gas liquefaction into oil in Canada. The fuel input of such processes, shown in the IEA energy balance as negative figures (i.e. gas liquefaction into oil –2.2 Mtoe in Canada), is reported in row 'OIL' - column 'GAS' in GTAP-E[7].

The oil production, shown as positive figure under the row *'LIQUEFAC'* in the IEA, is reported in GTAP-E as production (*'INDPROD'*).

f. Other Transformation and Transfers

Other transformation covers backflows from the petrochemical sector as well as all other non-specified transformation. Transfers include inter-product transfers as well as products transferred.

To simplify, these flows have been aggregated with petroleum refineries. There is an exception to this rule concerning other transformation for renewables that is considered as own-use. For some countries, mainly non-OECD countries, other transformation of renewables can represent up to 75% of renewable total primary energy supply with an average of 11%.

g. Own-Use and Distribution and Transmission Losses

Own-use contains primary and secondary energy consumed by transformation industries for heating, pumping, traction and lighting purposes as well as energy used for oil and gas extraction. Distribution and transformation losses include losses in gas distribution, electricity transmission and coal transport. In the IEA, these two flows (*'OWNUSE'* and *'DISTLOSS'*) are shown as negative figures. In the GTAP-E, they are aggregated and shown as positive figures under Row_i – $Column_i$ ($i \in$ {COL, OIL, GAS, P_C, ELY, HEAT, RENEW})

2. Industrial Sector

As previously mentioned in the paper on 'Proposed Design for the GTAP Energy Data Base', for the 'Big-6' countries[8] which represent 73% of world energy demand, we use other sources to disaggregate IEA's total industry energy demand when incomplete.

In GTAP v4, there are 25 industrial sectors that are not individually available in the IEA energy balance. GTAP-E reports industry energy consumption for 13 industries consistent with the IEA aggregation. Annex C provides the correspondence between GTAP-E and GTAP industrial sectors. Among the 13 industries, 4 of them are aggregates of several GTAP industries (FPR, OME, TRN and TWL). The disaggregation of these 4 sectors into individual GTAP industries is done using GTAP FIT software.

IEA always reports total industry energy demand by fuels for all countries. However, at the sub-sector level (13 including non-specified) the data is not always complete.

In the case when the industry split is incomplete, the residual *'INONSPEC'*[9] includes not only other industries but also missing industries making the share far too high (e.g., 45% of refined oil is consumed by other industries in Venezuela).

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[7] Estonia produces petroleum products using coal. This transformation is reported in row 'P_C' - column 'GAS' in GTAP-E.

[8] US, Japan, EU, FSU, China and India

In order to fill the missing information, we simply split IEA non-specified industries energy demand *'INONSPEC'*, applying GTAP value shares to the missing sub-sectors.

The GTAP value shares 'GTAPsh' for missing sub-sectors are calculated using the value (at market price) of purchase of fuel '*f*' by sector '*i*' over its total (Equation 1a). For example, in Venezuela, the GTAP value share of non-metal mineral industry 'NMM' represents 21.7% of total missing industry for refined oil and other industries 'OMF' 0.01% (see Table 2).

(Eq. 1a) $$GTAPsh_{f,m,reg} = \frac{VDFM_{f,m,reg} + VIFM_{f,m,reg}}{\sum_{m} VDFM_{f,m,reg} + VIFM_{f,m,reg}}$$

(Eq. 1b) $$IEA_{f,m,r} = GTAPsh_{f,m,reg} \times INONSPEC_{f,r}$$

with : *VDFM* and *VIFM* value of purchases of domestic and imported commodities
'*reg*' 45 regions from GTAP
'*m*' missing industries in the IEA energy balance
'*r*' country from IEA (r ∈ reg)
'*f*' fuels

Table 2. **Industry Energy Demand Breakdown**

(Case of incomplete IEA breakdown)

Refined Oil in Venezuela

	IEA (000 toe)	**GTAP Value Share**	**Adjusted**[1] (000 toe)
I_S	66	.	66
CRP	1,412	.	1,412
NFM	4	.	4
NMM	?	21.7	268
TRN	?	7.7	95
OME	?	8.4	103
OMN	?	3.6	44
FPR	?	19.4	241
PPP		?	4.6
57			
LUM	?	4.0	49
CNS	?	24.5	303
TWL	?	6.2	77
OMF	1,237	0[2]	0
TOTIND	**2,720**	**100**	**2.720**

Note: 1. Energy demand for missing industries is computed using GTAP value shares.
2. non-specified industries shares in GTAP is 0.01 % for venezuela.

It should be noted that even if the methodology described appears to be too systematic, it is only a small share of world energy industry demand that is distributed among the missing industries averaging from 3% to 15% with the exception of renewables at 49% (see Table 3). However, when

[9] If the IEA industrial data is complete, the *'INONSPEC'* corresponds to GTAP's 'OMF' sector. However, in the case of incomplete IEA data, it will include energy use by the not-reported sectors.

there is no sub-sector breakdown of total industry energy demand, the adjustment required can account for up to 100% for some individual countries.

Table 3 indicates that the world share of missing industries for coal represents 8.5 % of total industrial demand for coal. This is then distributed among the industries shown below with iron and steel industries 'I_S' accounting for 11.2%.

Table 3. **Global Adjustment of Industrial Sectors Fuel Demand**
(*in percent*)

	Coal	Oil	Gas	RefOil	Elec	Heat	Renew
INONSPEC (share of 'TOTIND')							
	10.7	**3.2**	**16.6**	**17.4**	**17.0**	**12.0**	**51.0**
of which :							
Oth. Ind.	**2.2**	**0.1**	**2.2**	**2.6**	**5.0**	**0.8**	**2.2**
Missing Ind.	**8.5**	**3.1**	**14.4**	**14.8**	**12.0**	**11.2**	**48.8**
Distribution pattern of missing industries :							
I_S	11.2	4.1	4.6	3.9	4.6	16.1	27.0
CRP	6.3	45.3	35.3	7.8	5.1	4.6	12.3
NFM	8.6	27.4	2.1	3.2	5.7	12.4	7.6
NMM	19.5	1.6	5.4	10.5	6.8	5.9	17.5
TRN	8.1	0.2	3.8	14.1	9.0	7.2	2.1
OME	4.9	9.3	9.6	7.4	11.5	9.4	3.9
OMN	5.0	0.7	4.1	7.4	7.6	21.5	1.9
FPR	24.2	7.8	13.7	12.0	9.8	5.2	7.3
PPP	6.2	0.4	2.3	3.7	5.6	5.2	5.0
LUM	2.1	0.3	4.6	6.3	14.5	5.5	0.6
CNS	2.8	2.4	8.4	18.9	7.9	2.8	1.7
TWL	1.1	0.4	6.1	4.9	12.0	4.3	13.1
TOTIND (Mtoe)	**625.6**	**11.3**	**446.8**	**528.1**	**401.7**	**114.5**	**125.3**

Among the 'Big-6', currently only the United States has been adjusted using national sources (see Table 4). We expect to receive data for both India and FSU since the reported IEA dissaggregation of sub-sectors is relatively poor.

Table 4 . **United States Industry Energy Demand**
(*percent of total industry energy demand*)

	Coal	Gas	RefOil	Elec
I_S	51.6	9.0	13.8	7.9
CRP	11.9	41.5	66.6	19.3
NFM	0.9	4.1	0.6	10.4
NMM	11.0	7.0	1.2	4.6
TRN	1.2	2.5	0.8	4.9
OME	0.4	6.8	0.8	12.5
OMN	2.7	2.7	3.5	5.1
FPR	6.4	10.2	1.8	7.5
PPP	12.0	10.1	6.9	10.5
LUM	0.0	0.8	1.0	2.5
CNS	0.0	0.1	0.9	0.9
TWL	1.6	2.3	1.1	5.2
OMF	0.4	2.9	1.0	8.8

Source : '1994 Manufacturing Energy Consumption Survey', EIA.

3. Transport Sector

For road and non-road energy demand, the data provided by the IEA were fully reported and did not need any further adjustment. International marine bunkers, reported separately by IEA, have been added to non-road.

4. Other Sectors

Other sectors represent 19.8% of world energy demand and consist of agriculture 'AGR', residential 'DWE', commercial-public services 'SER', and non-specified consumption '*ONONSPEC*' (e.g. military use not shown in the transport sector).

It is difficult to make distinction among the components in many cases, while the total *'TOTOTHER'* is more reliable and accurate. Furthermore, for some countries the reporting agency is not able to distinguish energy consumption in 'SER' from 'DWE', nor can they distinguish agriculture from residential.

When the IEA database has all four sub-sectors we aggregate '*ONONSPEC*' and 'DWE' (see Table 5, Case 1).

Table 5 . **Other Sectors Adjustment**

	Case 1	**Case 2**	**Case 3**	**Case 4**	**Case 5**[1]
Reported IEA data :					
AGR	IEA_{agr}	IEA_{agr}	0	one	0
SER	IEA_{ser}	0	IEA_{ser}	or more	0
DWE	IEA_{dwe}	IEA_{dwe}	IEA_{dwe}	missing	IEA_{dwe}
OTH	IEA_{oth}	0	0	IEA_{oth}	0
Adjusted :					
AGR	IEA_{agr}	IEA_{agr}	½ . IEA_{dwe}	IEA_{n}	$GTAP_{agr}$*IEA_{dwe}
SER	IEA_{ser}+IEA_{oth}	½ . IEA_{dwe}	IEA_{ser}	or	$GTAP_{ser}$*IEA_{dwe}
DWE	IEA_{dwe}	½ . IEA_{dwe}	½ . IEA_{dwe}	$GTAP_{m}$*IEA_{oth}	$GTAP_{dwe}$*IEA_{dwe}

1- Renewables are not adjusted.

If *'ONONSPEC'* is zero, and IEA reports data only for 'AGR' and 'DWE' we assume that 'DWE' includes 'SER' and therefore we split 'DWE' equally between the two (Case 2). In the same way, if IEA reports data only for 'SER' and 'DWE' we assume that 'DWE' includes 'AGR' and therefore we split 'DWE' equally between the two (Case 3).

In all the other cases, when the IEA does not report one or more of the three sub-sectors, and instead reports under *'ONONSPEC'*, then we use the GTAP value shares to distribute *'ONONSPEC'* (Eq. 2a and 2b) among the missing sub-sectors (Case 4). In the case when IEA reports 'DWE' only, we split it among the three sub-sectors using GTAP shares (Case 5).

(Eq. 2a) sub-sector available: $IEA^{adj}_{f,n,r} = IEA_{f,n,r}$

(Eq. 2b) sub-sector non-available: $IEA^{adj}_{f,m,r} = GTAPsh_{f,m,reg} \times ONONSPEC_{f,r}$

with : '*reg*' 45 regions from GTAP
'*m*' missing sub-sectors in the IEA energy balance
'*n*' reported sub-sectors in the IEA energy balance
'*r*' country from IEA (r ∈ reg)
'*f*' fuels
$GTAPsh_{f,m,reg}$ GTAP value shares

As shown in Table 6, the adjustment made for 'other sectors' do not significantly modify the shares of the 3 sub-sectors. In most cases *'ONONSPEC'* has been added-up with 'SER' (Case 1, Table 5).

Table 6. **Global Adjustment for Other Sectors**
(*percent*)

	Coal	Oil	Gas	RefOil	Elec	Heat	Renew
IEA data :							
AGR	9.9	52.1	2.1	22.9	6.2	6.1	1.0
SER	12.4	4.0	22.1	19.4	37.6	7.6	0.3
DWE	72.9	16.0	59.4	47.8	50.7	71.9	91.4
ONONSPEC	4.8	27.9	16.4	9.9	5.5	14.5	7.3
Adjusted data :							
AGR	10.4	50.8	4.0	26.5	6.7	6.9	2.4
SER	19.3	41.3	40.5	28.9	42.9	22.3	6.7
DWE	70.3	7.9	55.6	44.5	50.5	70.8	91.0
TOTOTHER (Mtoe)	**153.3**	**0.4**	**544.3**	**503.6**	**512.2**	**151.4**	**748.6**

5. Non-Energy Use

This includes the use of petroleum products such as lubricants, white spirit etc., or coal such as carbon blacks, and graphite electrodes.

If the reported total non-energy use *'NONENUSE'*, reported by IEA, does not equal the sum of its three reported components (industry, transport and other sectors), then the difference ($NEnU^{IEA}_{f,nse,r}$) is split across the three components using their energy demand shares (Eq. 3).

(Eq. 3) $$NEnU^{adj}_{f,s,r} = NEnU^{IEA}_{f,s,r} + NEnU^{IEA}_{f,nse,r} \times \frac{EnD_s}{\sum_s EnD_s}$$

with : '*f*' fuels
'*s*' 3 main sectors in the IEA: Industry, Transport and Other
'*r*' country from IEA
'*nse*' not specified elsewhere

6. Stock Changes

These reflect the annual change in stock levels held by producers, importers, energy transformation industries and large consumers. The stock changes are not reported separately in GTAP-E database and have to be aggregated with other flows. To simplify, we split stock changes ($StCh_{f,r}$) over production, imports and electricity consumption using their corresponding weights (see Eq. 4). For

some countries with negligible production, the adjustment would be mainly made to imports[10], and hence affecting the world trade balance (e.g. In Philippines' case, where imports represent 98.5% of the sum of production plus imports, the adjusted imports comprise mainly of all the stock changes which represent 23% of production plus imports).

(Eq. 4a) $$PROD^{Adj}_{f,r} = PROD_{f,r} + StCh_{f,r} \times \frac{PROD_{f,r}}{PROD_{f,r} + IMP_{f,r} + ELY}_{f,r}$$

(Eq. 4b) $$IMP^{Adj}_{f,r} = IMP_{f,r} + StCh_{f,r} \times \frac{IMP_{f,r}}{PROD_{f,r} + IMP_{f,r} + ELY}_{f,r}$$

(Eq. 4c) $$ELY^{Adj}_{f,r} = ELY_{f,r} - StCh_{f,r} \times \frac{ELY_{f,r}}{PROD_{f,r} + IMP_{f,r} + ELY}_{f,r}$$

with : '*f*' fuels
'*r*' country from IEA

II- Adjusting GTAP-E

1. Trade Balance

As described above, we modified imports by adding to it a portion of stock changes. In addition, the trade reported by IEA is not balanced at the world level. The difference between imports and exports ranges from 1 to 8% (see Table 7). Since world trade needs to be balanced, we take the IEA average of world imports and exports and re-scale each country's imports/exports to the trade average (see Eq. 5).

Table 7. **Energy World Trade**

	Coal	Oil	Gas	RefOil	Elec
IEA gap (%)	1.4	1.8	1.4	7.8	1.2
Adjusted World Trade (Mtoe)	322.7	1,750.4	406.2	631.8	34.8

[10] In this case, we are assuming no consumption from power plants.

(Eq. 5a) $$WTrade_f = \frac{EXP_f^{IEA} + IMP_f^{IEA}}{2}$$

(Eq. 5b) $$EXP_{f,r}^{Adj} = WTrade_f \times \frac{EXP_{f,r}^{IEA}}{\sum_r EXP_{f,r}^{IEA}}$$

(Eq. 5c) $$IMP_{f,r}^{Adj} = WTrade_f \times \frac{IMP_{f,r}^{IEA}}{\sum_r IMP_{f,r}^{IEA}}$$

with : '*f*' fuels
'*r*' country from IEA

2. Demand-Supply Adjustment

In the IEA energy balances, the difference between supply and demand is reported under statistical differences *'STATDIFF'*. Since we had to adjust the trade for each country, the equilibrium between supply and demand no longer holds. Furthermore, in GTAP-E we do not report this difference separately. To re-establish this equilibrium, we re-scale the components of the demand to match the supply (see Eq. 6). Once again the necessary adjustments were negligible.

(Eq. 6) $$Dem_{f,d,r}^{Adj} = Sup_{f,r} \times \frac{Dem_{f,d,r}}{\sum_d Dem_{f,d,r}}$$

with : '*f*' fuels
'*d*' sub-sectors of demand
'*r*' country from IEA

III- Improvement and Future Developments

In this version of GTAP-E, we have filled in the missing data of the IEA energy balances, however at the level of disaggregation of the IEA database, not at the 50-sector disaggregation of GTAP v4. Ideally, we should be able to provide a new version of GTAP-E, which will include the same number of sectors as in GTAP.

As proposed earlier, we will use national sources both for India and FSU to refine the breakdown of energy demand. For example, in the case of India, IEA's breakdown of industry energy demand only represents 44% of the reported total and the remaining 56% is allocated among the missing sectors using the method described above. Although this method has the advantage of being simple and straightforward, it can result in incorrect results. For the FSU, the IEA breakdown represents 78% of total industry energy demand.

The IEA data on agriculture is one sector only while GTAP reports 14 sectors for agriculture. Therefore, in order to disaggregate IEA's total agriculture energy demand into sub-sectors, we have to come-up with a method which takes into account the energy intensity differences among these sub-sectors.

Another flaw in the present GTAP-E database is that commercial and non-commercial road energy demands are not reported separately. In order to determine the household demand of energy used for transportation vehicles (non-commercial road), we would use other relevant sources.

Annex A .**IEA Flow Aggregation**

IEA Flow Codes	GTAP-E Flow Codes	Description
INDPROD	PROD	Indigenous production
IMPORTS	IMP	Imports
EXPORTS	EXP	Exports
BUNKERS	NONROAD	International marine bunkers
STOCKCHA	Split over PROD, IMP and ELY	Stock changes
Energy Transformation :		
TRANSFER	P_C	Transfers
STATDIFF	DIFF	Statistical differences
PUBELEC	ELY	Public electricity plants
AUTOELEC	ELY	Autoproducer electricity plants
PUBCHP	ELY	Public CHP plants
AUTOCHP	ELY	Autoproducer CHP plants
PUBHEAT	ELY	Public heat plants
AUTOHEAT	ELY	Autoproducer heat plants
THEAT	ELY	heat pumps
TBOILER	ELY	Electric boilers
TGASWKS	P_C	Gas Works
TREFINER	P_C	Petroleum refineries
COALTRAN	OWNUSE[11]	Coal transformation
LIQUEFAC	P_C	Liquefaction
TNONSPEC	P_C	Other transformation
OWNUSE	OWNUSE	Own use
DISTLOSS	OWNUSE	Distribution losses
Industry Consumption :		
IRONSTL	I_S	Iron and stel
CHEMICAL	CRP	Chemical and petrochemical
NONFERR	NFM	Non-ferrous metals
NONMET	NMM	Non-metallic minerals
TRANSEQ	TRN	Transport equipment
MACHINE	OME	Machinery
MINING	MIN	Mining and quarrying
FOODPRO	FPR	food and tobacco
PAPERPRO	PPP	Paper, pulp and printing
WOODPRO	LUM	Wood and wood products
CONSTRUC	CNS	Construction
TEXTILES	TWL	Textiles and leather
INONSPEC	OMF	Non-specified industry
Transport Consumption :		
INTLCIAV	NONROAD	International civil aviation
AIR	NONROAD	Air transport
ROAD	ROAD	Road
RAIL	NONROAD	Rail
PIPELINE	NONROAD	Pipeline transport
INLWATER	NONROAD	Internal navigation
TRNONSPEC	NONROAD	Non-specified transport
Other Sectorst Consumption :		
AGRICULT	AGR	Agriculture
COMMPUB	SER	Commercial and public services
RESIDENT	DWE	Residential
ONONSPEC	split over AGR, SER, DWE	Non-specified other
Non-Energy Use :		
NEINTREN	CRP	in industry/transf./energy
NETRANS	OTHTRP	in transport
NEOTHER	split over AGR, SER, DWE	in other sectors

Note:The sub-totals (TPES, TFC, TOTIND, TOTTRANS, TOTOTHER and NONENUSE) available in IEA energy balance are not shown.

[11] OWNUSE corresponds to the diagonal in the input-output table.

Annex B1 . **1995 IEA Energy Balance, Canada.**

(*thousands of toe*)

	Coal	Oil	RefOil	Gas	ElecPrim	Elec	Renew
INDPROD	**40,807**	**113,208**	**0**	**131,892**	**54,282**	**0**	**10,440**
IMPORTS	**6,956**	**30,351**	**6,821**	**557**	**0**	**638**	**0**
EXPORTS	**-23,589**	**-60,516**	**-12,414**	**-65,219**	**0**	**-3,736**	**0**
BUNKERS	0	0	-614	0	0	0	0
STOCKCHA	1,217	783	546	917	0	0	0
TPES	**25,392**	**83,826**	**-5,661**	**68,147**	**54,282**	**-3,098**	**10,440**
TRANSFER	0	-1,052	2,604	0	0	0	0
STATDIFF	522	1,738	-311	-2,139	0	0	0
PUBELEC	-21,221	-283	-1,620	-1,707	-51,485	43,612	0
AUTOELEC	-69	0	-158	-1,230	-2,734	3,812	-318
PUBCHP	0	0	-52	-1,478	-62	271	0
AUTOCHP	0	0	0	0	0	0	0
PUBHEAT	0	0	0	0	0	0	0
AUTOHEAT	0	0	0	0	0	0	0
THEAT	0	0	0	0	0	0	0
TBOILER	0	0	0	0	0	0	0
TGASWKS	0	0	0	0	0	0	0
TREFINER	0	-86,535	86,135	0	0	0	0
COALTRAN	-343	0	0	0	0	0	0
LIQUEFAC	0	2,349	0	-2,203	0	0	0
TNONSPEC	0	0	0	-282	0	0	0
OWNUSE	-125	-43	-7,069	-8,018	0	-3,556	0
DISTLOSS	0	0	0	0	0	-2,194	0
TFC	**4,156**	**0**	**73,869**	**51,090**	**0**	**38,847**	**10,123**
TOTIND	**3,845**	**0**	**14,089**	**22,571**	**0**	**16,300**	**8,202**
IRONSTL	2,733	0	204	1,675	0	745	0
CHEMICAL	0	0	8,042	7,119	0	1,658	0
NONFERR	282	0	288	579	0	4,008	0
NONMET	556	0	252	311	0	0	0
TRANSEQ	0	0	0	0	0	0	0
MACHINE	0	0	0	0	0	0	0
MINING	132	0	1,913	2,440	0	1,666	0
FOODPRO	0	0	0	0	0	0	0
PAPERPRO	36	0	1,335	2,641	0	4,869	8,202
WOODPRO	0	0	181	0	0	0	0
CONSTRUC	0	0	783	0	0	0	0
TEXTILES	0	0	0	0	0	0	0
INONSPEC	106	0	1,091	7,807	0	3,355	0
TOTTRANS	**0**	**0**	**43,810**	**5,172**	**0**	**333**	**0**
INTLCIAV	0	0	861	0	0	0	0
DOMESAIR	0	0	3,531	0	0	0	0
ROAD	0	0	35,878	167	0	0	0
RAIL	0	0	1,862	0	0	71	0
PIPELINE	0	0	32	5,005	0	262	0
INLWATER	0	0	1,646	0	0	0	0
TRNONSPE	0	0	0	0	0	0	0
TOTOTHER	**38**	**0**	**10,896**	**23,347**	**0**	**22,214**	**1,921**
AGRICULT	0	0	2,511	492	0	815	0
COMMPUB	1	0	4,975	9,306	0	10,091	0
RESIDENT	37	0	3,410	13,549	0	11,308	1,921
ONONSPEC	0	0	0	0	0	0	0
NONENUSE	**273**	**0**	**5,074**	**0**	**0**	**0**	**0**
NEINTREN	273	0	3,715	0	0	0	0
NETRANS	0	0	143	0	0	0	0
NEOTHER	0	0	1,216	0	0	0	0
ELOUTPUT(GWh)	**83,300**	**0**	**10,497**	**21,765**	**431,805**	**0**	**4,077**

Source *Energy Balances of OECD countries, IEA.*

Annex B2. **GTAP-E Energy Balance, Canada**

	Coal	Oil	RefOil	Gas	Elec	Renew
INDPROD	41,847	116,177	89,247	132,805	47,695	10,440
IMPORTS	7,183	30,249	7,150	565	642	0
EXPORTS	-23,427	-61,051	-11,931	-64,773	-3,714	0
ELY	21,035	275	1,853	4,587	5,753	318
COL	462	0	0	0	0	0
OIL	0	42	0	2,290	0	0
GAS	0	0	0	8,333	0	0
P_C	0	85,059	7,161	293	0	0
HEAT	0	0	0	0	0	0
RENEW	0	0	0	0	0	0
I_S	2,700	0	206	1,741	763	0
CRP	19	0	8,146	7,398	1,659	0
NFM	278	0	292	601	4,020	0
NMM	549	0	255	323	355	0
TRN	28	0	341	583	670	0
OME	3	0	378	2,466	706	0
OMN	131	0	1,938	2,536	1,683	0
FPR	8	0	269	2,271	498	0
PPP	36	0	1,353	2,744	4,872	8,202
LUM	1	0	183	1,131	649	0
CNS	41	0	793	583	83	0
TWL	3	0	75	899	287	0
OMF	2	0	43	181	66	0
ROAD	0	0	36,345	174	0	0
NONROAD	0	0	8,657	5,201	333	0
AGR	0	0	2,544	511	816	640
SER	1	0	5,040	9,671	10,097	640
DWE	37	0	3,454	14,081	11,314	640
NEINTREN	270	0	3,763	0	0	0
NEOTHER	0	0	1,232	0	0	0
NETRANS	0	0	145	0	0	0

Annex C. **Code Equivalence**

IEA	GTAP-E	GTAP	
IRONSTL	I_S	I_S	Iron and steel industry
CHEMICAL	CRP	CRP	Chemical industry
NONFERR	NFM	NFM	Non-ferrous metals
NONMET	NMM	NMM	Non-metallic minerals
TRANSEQ	TRN	MVH, OTN	Transport equipment
MACHINE	OME	OME, FMP, ELE	Machinery
MINING	MIN	OMN	Mining
FOODPRO	FPR	OMT, VOL, MIL, PCR, SGR, OFD, B_T, CMT	Food and tobacco
PAPERPRO	PPP	PPP	Paper, pulp and print
WOODPRO	*LUM*	*LUM*	*Wood and wood products*
CONSTRUC	CNS	CNS	Construction
TEXTILES	TWL	TEX, WAP, LEA	Textile and leather
I*NONSPEC*	OMF	OMF	Other industries

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