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Methodology for Estimation of Energy Physical Supply and Use Tables based on IEA's World Energy Balances

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This working paper develops a methodology for the estimation of Energy Physical Supply and Use Tables (E-PSUTs) based on the IEA's World Energy Balances (WEB). The tables are similar in nature to those proposed by the United Nations (UN) System of Environmental Economic Accounting (SEEA). However, unlike the SEEA system, the proposed methodology is able to fully exploit, and be consistent, with the information on fuel transformation processes available in the WEB, a significant improvement.

The E-PSUTs, by themselves, can be used to derive robust energy indicators in physical units. However, the final goal of the modelling strategy is to use the estimated E-PSUTs as a key input into a hybrid methodological approach, an Energy Multi-Factor Input-Output (MF-IO) model, which links global energy production and consumption in physical units with global production and consumption in monetary units, allowing the development of novel indicators to provide a richer understanding of the multiple links between global energy systems and the global economy and, contribute to ongoing discussions related to climate change.

Furthermore, complementary analyses can be undertaken by linking the MF-IO model with other relevant variables such as industry value added and employment data. Additionally it can be used to estimate energy-related CO_2 emissions indicators, allowing for improved estimates of "embodied" carbon emissions.

The document is a result of joint work between the IEA and the OECD.

Keywords: World Energy Balances, Physical Supply and Use Tables, Energy

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1. Introduction

This paper proposes a methodology to estimate Energy Physical Supply and Use Tables (E-PSUTs) based on the International Energy Agency's World Energy Balances (IEA, 2020)[2]. The estimated E-PSUTs are designed to be a key input into the generation of new hybrid energy indicators that associate physical energy production and consumption with monetary production and consumption of energy, goods, and services, taking into account the different fuel types and fuel production processes.

The tables are similar in nature to those proposed by the United Nations (UN) System of Environmental Economic Accounting (SEEA), (UN, 2016; UN, 2019). However, unlike the SEEA system, through use of the energy balances we are able to exploit available information on fuel transformation processes, a significant improvement, as it will be possible to measure the direct and indirect fuels types required to produce primary and secondary energy. Consequently, the E-PSUTs, estimated according to the proposed methodology, can be used to derive robust energy indicators in physical units.

Such indicators have an important value in their own right. However, the construction of E-PSUTs in this joint OECD/IEA exercise is only the first step in a broader project. In the **second stage**, the aim is to link the E-PSUTs with national input-output tables (IOTs), in a hybrid model, with both energy and monetary units, allowing for a richer understanding of the use of energy by non-energy industries and, reveal the links between energy used in production processes with the energy incorporated in final demand of goods and services (termed "lifecycle energy indicators").

In the **third stage**, the system is "internationalised" through links with OECD's Inter-Country Input-Output (ICIO)[3] tables, which provide a globally balanced view of inter-country inter-industry flows of intermediate and final goods and services. The development of E-PSUTs can thus be considered as a first step in the construction of a Multi-Factor Input-Output (MF-IO) data infrastructure (Guevara and Domingos, 2017). Such a framework allows for a fuller understanding of the multiple links between the energy system and the economy, and thus analysis of a number of important policy questions (see section 2.1).

In the **fourth stage,** this structure could be complemented by linking the MF-IO structure with other relevant variables such as value added and employment data. Another important example is energy-related CO_2, with the modelling structure allowing for improved estimates of "embodied" carbon emissions, e.g. per unit of value added and fuel type, in addition to emissions by industrial activity. This has important policy implications, allowing for the analysis of so-called carbon leakage i.e. the extent to which mitigation efforts in one region could be undermined by imports of embodied emissions for domestic final demand through internationally fragmented production processes.

However, even at this first stage, the work undertaken allows for the generation of a range of pertinent indicators, reflecting how these links vary across time and countries. For example, the evolution over time of a country's energy inputs (disaggregated by fuel type) per unit of value added at the industry level.

This allows for a much richer understanding of developments in factors such as sectoral energy intensity – i.e. to what extent are positive trends in a given sector undermined or reinforced by trends in upstream sectors, which are important sources of intermediate inputs (energy and non-energy). For example, does the use of more energy-efficient practices in a given sector involve the use of intermediate inputs from other sectors (materials and equipment) which are themselves more (or less) energy-intensive in production? A further report will summarise the results of this work in terms of indicators that highlight trends by country and industrial activity.

2. Estimating Energy Physical Supply and Use Tables (E-PSUTs)

This section details the methodology to estimate E-PSUTs from IEA's World Energy Balances (WEB). First, we highlight the main similarities and differences between the E-PSUTs proposed here and the approach presented by the UN SEEA Energy accounts; next, it presents the methodology used to estimate the EPSUTs based on IEA Energy Balances.

2.1. Comparing the structure of the E-PSUTs in the UN SEEA Energy accounts and on the MF-IO modelling approach

Section 3.4 of UN (2019) describes the transition from energy balances to the estimation of E-PSUTs according to SEEA principles. However, the UN approach does not fully align with our aim to preserve all the information in the WEB – rather, the UN makes adjustments to conform to the standards in the SEEA Energy accounts (SEEA-E).[4]

As with the SEEA-E, this work understands the importance of distinguishing between the main industries that produce energy, namely:

1. Mining and quarrying:
    a. ISIC Division 05—Mining of coal and lignite;
    b. ISIC Division 06—Extraction of crude petroleum and natural gas.
2. Energy production:
    a. ISIC Group 191—Manufacture of coke oven products;
    b. ISIC Group 192—Manufacture of refined petroleum products;
    c. ISIC Group 351—Electric power generation, transmission and distribution;
    d. ISIC Group 352—Manufacture of gas; distribution of gaseous fuels through mains;
    e. ISIC Group 353—Steam and air conditioning supply

As noted earlier, we exploit available information on fuel transformation processes, information that is not reflected in the SEEA accounts. Such information is important for the estimation of indicators (in physical terms) which take into account primary and secondary energy and information on the *energy required to produce energy*. In that sense, the focus of this work is more on fuels and fuel transformation processes than on the industry classification. The links between the (ISIC Rev.4) industry classification and fuel use categories are established when developing a full MF-IO hybrid model, i.e. considering both energy and monetary units, to be discussed in a future document.

In the present methodology, the structure of fuels and fuel transformation processes from the WEB (IEA 2020) are fully considered. However, the way they are presented and treated differs from the WEB to adjust to the structure of the E-PSUTs. Fuels that are primary energy appear first in the list, followed by fuels that can be either primary or secondary energy, and then those identified as secondary energy – see Table 2.1. Concerning the primary energy transformation processes, some primary industries present in the E-PSUT (with codes "xxx_PRIMARY") do not appear directly in the WEB and were created to reconcile and link the structure of these two databases.

Table 2.2 presents first the transformation processes that essentially produce primary energy, followed by those that can produce either type of energy, Annex A presents which fuels are produced by each transformation process, identifying if the fuel produced is primary or secondary. The above ISIC Rev.4 energy producing sectors (05, 06, 191, 192, 351, 352 and 353) do not appear on the demand side (Table 2.3), which only includes the sectors that use energy. Consistent with the treatment in IEA's WEB, sectors that eventually produce energy, but for which the primary focus of their production is on non-energy goods are, however, considered on the demand side.

With a view to eventual integration into a MF-IO hybrid model, the E-PSUTs proposed here, will:

1. Avoid the problem of relative prices, i.e., different consumers paying different prices for the same fuel. This is one of the advantages of working with hybrid energy models. For a detailed explanation see Miller and Blair (2019, chapter 9) and Wyckoff et al. (1990);
2. Respect the energy conservation principle, i.e., the conservation of embodied energy establishes that the energy embodied in the output of an industry is equal to the energy embodied in its intermediate inputs plus its direct energy inputs;
3. Ensure a consistent interconnection between the energy and non-energy industries, including industries that generate energy although it is not their primary focus of production; and,
4. Allow for the breakdown of the use of energy in the final demand of energy and non-energy industries by different types of fuels and by direct and indirect energy use.

Table 2.1. Fuels from the WEB used in the E-PSUTs

Code	Description	Code	Description
HARDCOAL	Hard coal (if no detail)	NATGAS_S	Natural gas secondary
BROWN	Brown coal (if no detail)	NONCRUDE_S	Other hydrocarbons secondary
ANTCOAL	Anthracite	HEAT_S	Heat secondary
COKCOAL	Coking coal	PATFUEL	Patent fuel
BITCOAL	Other bituminous coal	OVENCOKE	Coke oven coke
SUBCOAL	Sub-bituminous coal	GASCOKE	Gas coke
LIGNITE	Lignite	COALTAR	Coal tar
PEAT	Peat	BKB	Brown coal briquettes
OILSHALE	Oil shale and oil sands	GASWKSGS	Gas works gas
CRNGFEED	Crude/NGL/feedstocks (if no detail)	COKEOVGS	Coke oven gas
CRUDEOIL	Crude oil	BLFURGS	Blast furnace gas
NGL	Natural gas liquids	OGASES	Other recovered gases
ADDITIVE	Additives/blending components	PEATPROD	Peat products
NUCLEAR	Nuclear	REFFEEDS	Refinery feedstocks
HYDRO	Hydro	REFINGAS	Refinery gas
INDWASTE	Industrial waste	ETHANE	Ethane
MUNWASTER	Municipal waste (renewable)	LPG	Liquefied petroleum gases (LPG)
MUNWASTEN	Municipal waste (non-renewable)	NONBIOGASO	Motor gasoline excl. biofuels
PRIMSBIO	Primary solid biofuels	AVGAS	Aviation gasoline
BIOGASES	Biogases	JETGAS	Gasoline type jet fuel
BIOGASOL	Biogasoline	NONBIOJETK	Kerosene type jet fuel excl. biofuels
BIODIESEL	Biodiesels	OTHKERO	Other kerosene
BIOJETKERO	Bio jet kerosene	NONBIODIES	Gas/diesel oil excl. biofuels
OBIOLIQ	Other liquid biofuels	RESFUEL	Fuel oil
RENEWNS	Non-specified primary biofuels and waste	NAPHTHA	Naphtha
GEOTHERM	Geothermal	WHITESP	White spirit and industrial spirit
SOLARPV	Solar photovoltaics	LUBRIC	Lubricants
SOLARTH	Solar thermal	BITUMEN	Bitumen
TIDE	Tide, wave and ocean	PARWAX	Paraffin waxes
WIND	Wind	PETCOKE	Petroleum coke
OTHER	Other sources	ONONSPEC	Other oil products
NATGAS_P	Natural gas primary	CHARCOAL	Charcoal
NONCRUDE_P	Other hydrocarbons primary	ELECTR	Electricity
HEAT_P	Heat primary		

Source: Authors' elaboration based on IEA (2020).

Table 2.2. Fuel transformation processes

Code	Description	Code	Description
MINES_PRIMARY	Coal mines primary	MAINHEAT	Main activity producer heat plants
OILGASEX_PRIMARY	Oil and gas extraction primary	AUTOHEAT	Autoproducer heat plants
NUCLEAR_PRIMARY	Nuclear primary	THEAT	Heat pumps
HYDRO_PRIMARY	Hydro primary	TBOILER	Electric boilers
WASTE_PRIMARY	Waste primary	TELE	Chemical heat for electricity production
BIOGAS_PRIMARY	Biogases primary	TBLASTFUR	Blast furnaces
BIOLIQ_PRIMARY	Bioliquides primary	TGASWKS	Gas works
BIOMASS_PRIMARY	Biomass primary	TCOKEOVS	Coke ovens
BIONS_PRIMARY	Biosolid primary	TPATFUEL	Patent fuel plants
GEOTHERMAL_PRIMARY	Geothermal primary	TBKB	BKB/peat briquette plants
REN_ELE_PRIMARY	Renewable electricity primary	TREFINER	Oil refineries
REN_HEAT_PRIMARY	Renewable heat primary	TPETCHEM	Petrochemical plants
NONCRUDE_PRIMARY	Other hydrocarbons primary	TCOALLIQ	Coal liquefaction plants
OTHER_PRIMARY	Other primary	TGTL	Gas-to-liquids (GTL) plants
MAINELEC	Main activity producer electricity plants	TBLENDGAS	For blended natural gas
AUTOELEC	Autoproducer electricity plants	TCHARCOAL	Charcoal production plants
MAINCHP	Main activity producer CHP* plants	TNONSPEC	Non-specified (transformation)§
AUTOCHP	Autoproducer CHP* plants		

Notes:
* CHP - combined heat and power
§ Includes the transformation of natural gas for hydrogen manufacture and other non-specified transformation.
Source: Authors' elaboration based on IEA (2020).

Table 2.3. Final demand elements

Code	Description	Code	Description
MINING	Mining and quarrying	PIPELINE	Pipeline transport
CONSTRUC	Construction	WORLDMAR	World marine bunkers
IRONSTL	Iron and steel	DOMESNAV	Domestic navigation
CHEMICAL	Chemical and petrochemical	TRNONSPE	Non-specified (transport)
NONFERR	Non-ferrous metals	RESIDENT	Residential
NONMET	Non-metallic minerals	COMMPUB	Commercial and public services
TRANSEQ	Transport equipment	AGRICULT	Agriculture/forestry
MACHINE	Machinery	FISHING	Fishing
FOODPRO	Food and tobacco	ONONSPECFD	Final consumption not elsewhere specified
PAPERPRO	Paper, pulp and printing	NONENUSE	Non-energy use
WOODPRO	Wood and wood products	MARBUNK	International marine bunkers
TEXTILES	Textile and leather	AVBUNK	International aviation bunkers
INONSPEC	Industry not elsewhere specified	EXPORTS	Exports
WORLDAV	World aviation bunkers	STOCKCHA	Stock changes
DOMESAIR	Domestic aviation	TRANSFER	Transfers
ROAD	Road transport	STATDIFF	Statistical differences
RAIL	Rail transport	DLFD	Distribution losses in final demand

Source: Authors' elaboration based on IEA (2020).

2.2. Estimating the E-PSUTs from IEA's World Energy Balances

This section details the methodology to estimate the E-PSUTs from IEA's World Energy Balances, focussing on how energy is used to produce energy and not which industries produce energy. Part of this section draws from the works of IEA (2020), UN (2019 and 2017), Heun, Owen, and Brockway (2018), and Miller and Blair (2009).

Figure 2.1 shows, in a schematic way, the processes to transform information in the IEA World Energy Balances to the E-PSUTs. The elements from the energy balance are marked as "Engy Bal" while the elements of the E-PSUTs can be recognized as they are represented by the matrices show in Figure 2.3 to Figure 2.6. Negative values from the energy balance which need to be transformed into positive values, for reasons that will be discussed below, are represented by first going through a box showing "* - 1", where they are transformed into positive numbers through a multiplication by -1.

We first present the overall structure of the IEA's World Energy Balances and then explain in detail the estimation procedure as they appear in each flow presented in Figure 2.1.

The IEA energy balances, Figure 2.2, can be divided into four major accounts:

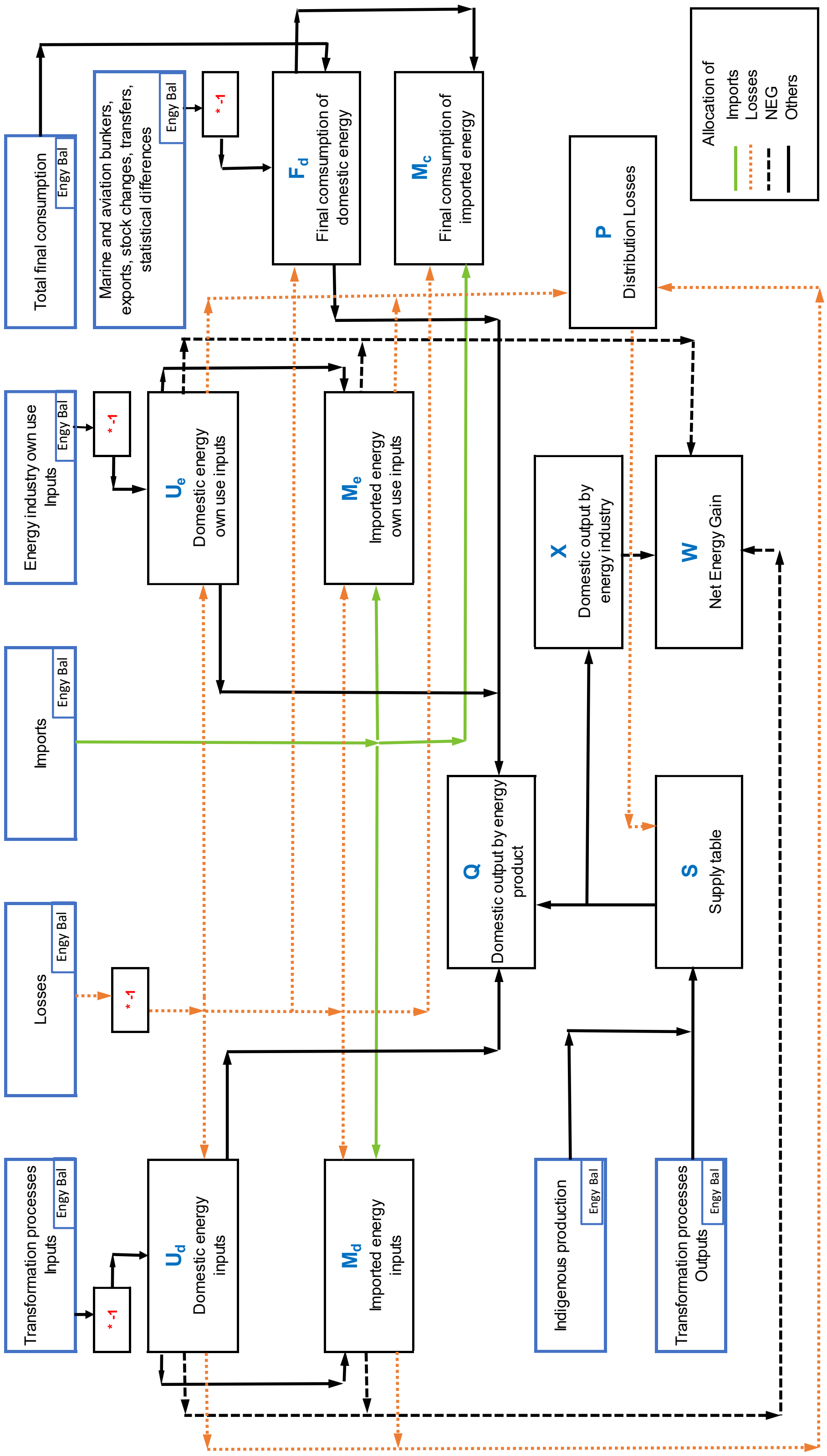
1. TES, total energy supply;
2. TIC, total intermediate consumption;
3. TFS, total final supply; and
4. TFC, total final consumption.

While the TIC and the TFS accounts do not appear explicitly in the WEB, they can be easily derived, as shown in Figure 2.2.

In the TES and TIC accounts, the signs indicate if the items in these accounts contribute positively or negatively to the availability of the energy products in the economy. For example, in TES, production and imports contribute positively to the availability of energy in the economy, while exports, international bunkers and stock changes contribute negatively; overall, it is expected that the TES in the economy is positive (the sign in the column of Total). In the TIC, for the item transformation process, the outputs of the energy industries appear as positive and the inputs as negative, the other items are negative; overall, it is expected that the TIC in the economy appears as a negative number, showing the net, output less input, energy consumed in the transformation and distribution process.

The TFS is obtained by deducting from the TES the energy used in the TIC, as the energy used in TIC appears as negative i.e. TFS = TES + TIC. The result in TFS shows, by energy product, how much energy is available for final consumption in the economy (TFC), the energy consumed in the TFC appears as positive numbers.

Figure 2.1. Going from IEA world energy balances to E-PSUTs



Source: Authors' elaboration.

Figure 2.2. Structure of IEA Energy Balances

IEA ENERGY BALANCE		Energy Products	Total	
TES Total Energy Supply	Production	+	+ (Positive)	
	Imports	+		
	Exports	-		
	International marine bunkers	-		
	International aviation bunkers	-		
	Stock changes	-		
TIC Total Intermediate Consumption	Transfers	-	- (Negative)	
	Statistical differences	-		
	Transformation processes	-		
	Output	+		
	Input	-		
	Energy industry own use	-		
	Losses	-		
TFS Total Final Supply	TES	+	+ (Positive)	TFS = TFC
	TIC	-	TFS = TES + TIC	
TFC Total Final Consumption	Industry	+	+ (Positive)	
	Transport	+		
	Other	+		
	Non-energy use	+		

Source: Authors' elaboration based on IEA (2020).

The main idea behind the proposed E-PSUTs is to represent, in the best way possible, the fuel production process (energy industry) and the use of energy in the national economy, with a focus on the fuel type and the fuel transformation process presented in the WEB, as well as the information on the components of final consumption.

The integrated system proposed for the E-PSUTs is presented in Figure 2.3 to Figure 2.6, and the matrix notation is presented in Table 2.4. Each figure presents two sets of information, the first one shows a description of each account while the second one shows the matrix notation.

The Energy Physical *Supply Tables* (EPSTs) structure is presented in Figure 2.3, the columns show the producing industries and the rows show the fuels produced. Thus the supply table (S) shows for each national fuel production process, which fuels are produced and in what quantity, i.e., a given fuel type can be produced by more than one fuel production process, and a fuel production process can produce more than one type of fuel. Note that the values are presented as energy less distribution losses, given that the distribution losses are subtracted from the total energy produced and are presented in the column Losses of the supply table. The columns show which industries produce a given fuel and the amount of distribution losses of the fuel in consideration, also note that these values of distribution losses refer only to national fuels as there are also distribution losses associated with imported inputs.

The Energy Physical *Use Tables* (EPUTs) structure is presented in Figure 2.4. The columns show the consumption of energy by the domestic energy producing industries, and by final users of energy; while the rows separate the energy consumed by its origin, domestic and imported, and by type of use: a) to produce energy; b) energy industry own use; c) distribution losses; and d) net energy gain.

To produce the different fuels, the fuel production process can use domestic (U_d) and imported (M_{dt}) fuels. The fuel can either be used: a) as energy which is consumed by the producing industry for its own operations (industry own use, U_e and M_{et}), e.g., electricity which is used to power machinery in the industry; or b) as an input in the production process (U_d and M_{dt}),, e.g., coal which is used in the generation of power.

By producing energy, the producing industries can have a surplus of energy, when the total energy produced (useable energy) is greater than the total input of energy, or a deficit of energy, when the useable energy produced is less than the energy consumed. These surpluses or deficits appear as net energy gain (W) in the E-PUTs.

The rows of distribution losses ($P_{dt}, P_{et}, P_{it}, P_{eit}$) show the distribution losses associated with the fuels used in the energy transformation processes. When the distribution losses cannot be associated with production they are allocated to the final demand (P_{ct}, P_{ict}) , by using the column "Distribution losses in final demand" (DLFD).

The final demand elements refers to the consumption of energy products by end users of energy, which can be energy domestically produced (F_d) or imported energy (M_{ct}).

The row and column of totals in the E-PUTs shows the total production of energy by industry and product, and the total final consumption of energy.

The Energy Physical *Import Tables* (EPIMPs) structure is presented in Figure 2.5, it actually expands into a matrix the information presented in the rows of imported energy in the EPUTs by the different type of fuels used.

The Energy Physical *Distribution Losses Tables* (EPDLs) structure is presented in Figure 2.6, and similar to the EPIMPs table, it expands the information presented in the rows of distribution losses in the EPUTs by the different type of fuels used.

Figure 2.3. Structure of Energy Physical Supply Tables – EPSTs

Definitions

IEA EPST	National Energy Producing Industries	Total Net Energy	Losses	Total Including Losses
Energy Products by National Industries	Supply Table	Domestic output by product	Losses on domestic production	Domestic output including losses
Total	Domestic output by industry	Total domestic production of energy	Total losses on domestic production	Total domestic prod including losses

Matrix notation

IEA EPST	National Energy Producing Industries	Total Net Energy	Losses	Total Including Losses
Energy Products by National Industries	S	Q	P_f	Q_P
Total	X'	X_T	P_{ft}	X_{TP}

Source: Authors' elaboration

Figure 2.4. Structure of Energy Physical Use Tables – EPUTs

Definitions

IEA EPUT	National Energy Producing Industries	Final Demand	Total
Domestically Produced Energy	Domestically produced energy used in the transformation processes	Final consumption of domestically produced energy	Domestic output used in the transformation process and in the final consumption
Domestically Produced Energy Industry Own Use	Energy industry own use from domestic sources	Zero	Domestic output for energy industry own use
Imported Energy	Imported energy on domestic production	Imported energy on consumption	Imported energy on production and FD
	Imported energy on industry own use	Zero	Imported energy on industry on use
Distribution Losses	Losses on dom prod	Losses on dom cons	Total losses on dom prod and consumption
	Losses on industry own use	Zero	Total losses on industry own use
	Losses on imp dom prod	Losses on imp cons	Total losses on imp dom prod and cons
	Losses on imp own use	Zero	Loss on imp industry own use
Net Energy Gain	Net Energy Gain	Zero	Total net energy gain
Total	Domestic output by industry	Final consumption of energy	Total domestic production of energy

Matrix notation

IEA EPUT	National Energy Producing Industries	Final Demand	Total
Domestically Produced Energy	U_d	F_d	Q_d
Domestically Produced Energy Industry Own Use	U_e	Zero	Q_e
Imported Energy	M_{dt}	M_{ct}	M_{dtt}
	M_{et}	Zero	M_{ett}
Distribution Losses	P_{dt}	P_{dct}	P_{dtt}
	P_{et}	Zero	P_{ett}
	P_{it}	P_{ict}	P_{itt}
	P_{eit}	Zero	P_{eitt}
Net Energy Gain	W	Zero	W_T
Total	X'	F_{TT}	X_T

Source: Authors' elaboration.

Figure 2.5. Structure of Energy Physical Import Tables – EPIMPs

Definitions

IEA EPIMP	National Energy Producing Industries	Final Demand	Total
Imported Energy	Imported energy used on the transformation processes	Imported energy on final consumption	Imported energy used in the transformation process and in the final consumption
Imported Energy on Energy Industry Own Use	Imported energy used on energy industry own use	Zero	Imported energy industry own use
Total	Imported energy by producing industry	Final consumption of imported energy	Total imported energy

Matrix notation

IEA EPIMP	National Energy Producing Industries	Final Demand	Total
Imported Energy	M_d	M_c	M_{df}
Imported Energy on Energy Industry Own Use	M_e	Zero	M_{ef}
Total	M_{dt}	M_{ct}	M_{tt}

Source: Authors' elaboration

Figure 2.6. Structure of Energy Physical Distribution Losses Tables – EPDLs

Definitions

IEA EPDL	National Energy Producing Industries	Final Demand	Total
Distribution Losses on Domestically Produced Energy	Distribution losses on the transformation processes	Distribution losses on the final consumption	Losses in the transformation process and in the final consumption
Distribution Losses on Energy Industry Own Use	Distribution losses on domestic energy industry own use	Zero	Losses on energy industry own use
Distribution Losses on Imports for Domestic Production	Distribution losses on imported energy used in the transformation processes	Distribution losses on imported energy used in final consumption	Losses on imports in the transformation process and in final consumption
Distribution Losses on Imports for Energy Industry Own Use	Distribution losses on imported energy for industry own use	Zero	Losses on imports for energy industry own use
Total	Distribution losses by producing industry	Distribution losses on final consumption	Total distribution losses

Matrix notation

IEA EPDL	National Energy Producing Industries	Final Demand	Total
Distribution Losses on Domestically Produced Energy	P_d	P_{dc}	P_{df}
Distribution Losses on Energy Industry Own Use	P_e	Zero	P_{ef}
Distribution Losses on Imports for Domestic Production	P_i	P_{ic}	P_{if}
Distribution Losses on Imports for Energy Industry Own Use	P_{ei}	Zero	P_{eif}
Total	P_t	P_{ct}	P_{tt}

Source: Authors' elaboration.

Table 2.4. Matrices and Dimensions

Variable	Dimension	Description
m		Number of energy products
n		Number of energy industries
k		Number of final demand elements
F_d	$m \times k$	Final consumption of domestically produced energy
F_{TT}	$1 \times k$	Total consumption of energy by the final demand
M_c	$m \times k$	Imported energy on final consumption
M_{ct}	$1 \times k$	Imported energy used in final consumption
M_d	$m \times n$	Imported energy used in the transformation processes
M_{df}	$m \times 1$	Imported energy used in the transformation process and in the final consumption, by type of product
M_{dt}	$1 \times n$	Imported energy used on domestic production
M_{dtt}	1×1	Total imported energy used in the transformation process and in final consumption
M_e	$m \times n$	Imported energy on industry own use by energy product and industry
M_{ef}	$m \times 1$	Imported energy on industry own use by product
M_{et}	$1 \times n$	Imported energy on industry own use by industry
M_{ett}	1×1	Total imported energy on industry own use
M_{tt}	1×1	Total imported energy
P_{ct}	$1 \times k$	Losses on domestic energy used in final consumption
P_d	$m \times n$	Losses on energy used in the transformation processes
P_{dc}	$m \times k$	Losses on the final consumption by type of product
P_{dct}	$1 \times k$	Losses on the final consumption
P_{df}	$m \times 1$	Losses in the transformation process and in the final consumption
P_{dt}	$1 \times n$	Losses on domestic production
P_{dtt}	1×1	Total losses on energy used in the transformation process and in final consumption
P_e	$m \times n$	Losses on domestic energy industry own use
P_{ef}	$m \times 1$	Losses on energy industry own use
P_{ei}	$m \times n$	Losses on imported energy for industry own use
P_{eif}	$m \times 1$	Losses on imports for energy industry own use
P_{eit}	$1 \times n$	Losses on imports used on industry own use
P_{eitt}	1×1	Total losses on imported energy used on industry own use
P_{et}	$1 \times n$	Losses on industry own use
P_{ett}	1×1	Total energy losses on industry own use
P_f	$m \times 1$	Losses on domestic production
P_{ft}	1×1	Total losses on domestic production
P_i	$m \times n$	Losses on imported energy used in the transformation processes
P_{ic}	$m \times k$	Losses on imported energy used in final consumption by type of product
P_{ict}	$1 \times k$	Losses on imported energy used in final consumption

Continued …

Table 2.4 Matrices and Dimensions (Continued)

Variable	Dimension	Description
P_{if}	$m \times 1$	Losses on imports in the transformation process and in final consumption
P_{it}	$1 \times n$	Losses on imports used in the domestic production
P_{itt}	1×1	Total losses on imported energy used in the transformation process and in final consumption
P_t	$n \times 1$	Total losses by producing industry
P_{tt}	1×1	Total distribution losses
Q	$m \times 1$	Domestic energy produced, by type of product
Q_d	$m \times 1$	Domestic output used in the transformation process and in the final consumption, by type of product
Q_e	$m \times 1$	Domestic output for energy industry own use, by type of product
Q_p	$m \times 1$	Domestic energy produced, by type of product, including losses
S	$m \times n$	Supply table
U_d	$m \times n$	Domestically produced energy used in the transformation processes
U_e	$m \times n$	Energy industry own use from domestic sources
W	$1 \times n$	Net energy gain
W_T	1×1	Total net energy gain
X	$n \times 1$	Domestic output by industry
X_T	1×1	Total domestic production of energy
X_{TP}	1×1	Total domestic production of energy including losses

Taking into consideration the above overview of the WEBs and E-PSUTs, we turn now to the methodology used to estimate the E-PSUTs from WEBs (Figure 2.1). The allocation of values from the WEBs to the E-PSUTs requires the following steps:

1. Transformation process:
    a. Positive values are considered as energy output and are allocated to the Supply table (S) according to the fuel transformation process and fuel type;
    b. The negative values in the transformation process are multiplied by -1 to be considered as positive values, and allocated as fuels inputs in the fuels production process in matrix U_d.

2. Energy industry own use:
   a. The following energy own industries are directly associated with the fuel transformation process and are considered as only one fuel transformation process:
      i. MAINELEC = MAINELEC + EPUMPST
      ii. TBLASTFUR = TBLASTFUR + EBLASTFUR
      iii. TGASWKS = TGASWKS + EGASWKS
      iv. TCOKEOVS = TCOKEOVS + ECOKEOVS
      v. TPATFUEL = TPATFUEL + EPATFUEL
      vi. TBKB = TBKB + EBKB
      vii. TREFINER = TREFINER + EREFINER
      viii. TCOALLIQ = TCOALLIQ + ECOALLIQ
      ix. TGTL = TGTL + EGTL
      x. TCHARCOAL = TCHARCOAL + ECHARCOAL
   b. The values of EPWPLT are allocated to the following fuel production processes according the share of each process in the sum of the energy they produce: MAINELEC, AUTOELEC, MAINCHP, AUTOCHP, MAINHEAT and AUTOHEAT;
   c. The values of ENONSPEC are split proportionally between all the energy transformation/production processes that use the same fuels as the ones used by ENONSPEC;
   d. The following energy industry own use are considered individually as being fuels production processes:
      i. MINES_PRIMARY = MINES_PRIMARY + EMINES
      ii. OILGASEX_PRIMARY = OILGASEX_PRIMARY + EOILGASEX
      iii. BIOGAS_PRIMARY = BIOGAS_PRIMARY + EBIOGAS
      iv. NUCLEAR_PRIMARY = NUCLEAR_PRIMARY + ENUC;
   e. ELNG is added to distribution losses and it is treated as such;
   f. The values are multiplied by -1 to become positive numbers;
   g. The values are allocated as inputs in the fuel production process in matrix U_e.
3. Total final consumption:
   a. The values are allocated to the final consumption matrix (F_d).
4. Marine and aviation bunkers, exports, stock changes, transfers, statistical differences
   a. The values are multiplied by -1;
   b. The values are allocated to the final consumption matrix (F_d).

5. Imports and distribution losses:
    a. As the products of energy used in the TIC and TFC accounts of the energy balance includes imports and distribution losses, they need to be explicitly adjusted in these accounts and allocated, respectively, to the import matrices (M_d, M_e, M_c) and to the industry distribution losses matrices (P_i, P_{ei}). When the distribution losses cannot be associated with production, they are allocated to final consumption (P_{ic}).
6. Imports:
    a. The allocation of imported fuel to the imported matrices assumes that the share of imports in a given consumed fuel is the same in all the end users of this fuel and is given by the share of this imported fuel in the total use of this fuel;
    b. The imported values allocated to the import matrices (M_d, M_e, M_c) are subtracted from the energy previously allocated to the domestic matrices (U_d, U_e, F_d);
    c. For the allocation of imports to the final demand components, a specific approach is required for stock changes, transfers and statistical differences. The imported values are allocated to stock changes only if there is an increase in the stocks; the values are allocated to transfers and statistical differences only if the subtraction of imports from the consumption of a fuel generates negative values in the consumption of this fuel.
7. Distribution losses:
    a. The values of distribution losses are multiplied by -1;
    b. The procedure to estimate the distribution losses (P_d, P_e, P_i, P_{ei}) is to estimate the energy lost from the use of this energy, either domestic or imported, in the matrices of intermediate use (U_d, U_e, M_d, M_e);
    c. The allocation of the distribution losses assumes that the share of distribution losses in a given consumed fuel is the same in all the end users of this fuel and is given by the share of this distribution losses in the total use of this fuel;
    d. In the cases where the value of the distribution losses are greater than the total value of a fuel used in the energy transformation process, there is an adjustment, so that the inputted energy values remains greater or equal to zero, and the difference of the distribution losses for this fuel is allocated to final demand (P_{dc}, P_{ic}).

8. Matrices of totals by domestic and imported fuel (Q_d, Q_e, M_{dt}, M_{et}, Q):
   a. By using the information on the consumption of domestic energy and imported energy it possible to obtain the fuel totals that are domestically produced and imported:
      i. The sum over each row of U_d plus the sum over each row of F_d will give Q_d;
      ii. The sum over each row of U_e will give Q_e;
      iii. The sum over each row of M_d plus the sum over each row of M_c will give M_{df};
      iv. The sum over each row of M_e will give M_{ef};
      v. The sum of Q_d and M_{df} will give Q.
9. Supply table (S):
   a. The production of domestic fuels obtained from the outputs of the transformation process (item 1.a) is allocated to the supply table;
   b. The indigenous production (INDPROD) in the WEB is allocated to the supply table according to the distribution table presented in Annex A;
   c. The values for NATGAS, NONCRUDE and HEAT from item (a) are allocated as secondary energy (NATGAS_S, NONCRUDE_S and HEAT_S), while the values from item (b) are allocated as primary energy (NATGAS_P, NONCRUDE_P and HEAT_P);
   d. The values in the supply table are adjusted to reflect the net supplied energy, i.e., energy net of distribution losses;
   e. The distribution losses on the domestically produced energy are allocated to the column distribution losses in the supply table (P_f).
10. Domestic output by fuel processing process (X):
    a. The sum over each column of the supply table (S) will give the domestic output of the fuel production processes (X).
11. Net energy gain (W):
    a. The estimated net energy gain (W) is obtained by subtracting from the domestic output of the fuel processing processes (X) the values of the intermediate inputs used in production (U_d, U_e, M_{dt}, U_{et}, P_{dt}, P_{et}, P_{it}, P_{eit}).

2.3. Example of an EPSUT

Based on Figure 2.3 and Figure 2.4, this section presents an example of an Energy Physical *Supply* (EPST) and the *Use* (EPUT) Table.

The Energy Physical Supply Table (EPST) shows the amount of fuels produced by each industry. In the example, the economy has five fuel industries (*Mines primary, Oil and gas primary, Electricity primary, Oil refineries, and Electricity Plants*) and six energy goods (*Coal, Crude oil and gas, Diesel, Other Fuels, Hydro and nuclear electricity, and Electricity and heat*). *Oil refineries* produces two types of fuels (*Diesel* and *Other fuels*), while the other five industries produce only one kind of fuel each. Four of the fuels considered are produced by only one industry, while other fuels are produced by *Oil refineries*. The only fuel which shows distribution losses is *Electricity and heat*, the losses on this domestic produced fuel are 20 units of energy, meaning that the fuel available for consumption is 360 units (net output) and the total output is 380 units.

In the Energy Physical Use Table (EPUT), the fuels produced can be consumed by the fuel industries to produce energy, used by the non-energy industries to produce goods and services, used by households and for the transportation of goods and services, or exported. The fuels used to produce energy are referred to as *intermediate inputs*, while the fuels used for other purposes are referred as *final fuel consumption*, and are considered in the final demand for energy. For example, *coal* can be used: a) to generate energy in the *Mines primary*, as own energy use; b) used in *electricity plants* as fuel to produce energy (*intermediate inputs*); c) used in the *iron and steel industry* to produce iron and steel (*final fuel consumption*); d) or exported.

Besides the fuels produced domestically, imported fuels can also be used in the production of energy or directly used by the final consumers. This is shown in the row of Imports.

The distribution losses incurred in transformation process are shown in the row of Distribution losses.

Electricity primary, which produces *hydro and nuclear electricity*, uses no energy inputs, and all of its production is allocated to *Electricity plants*, which then distributes this energy to the consumers.

Electricity plants, which produces *Electricity and heat* uses domestic and imported inputs in its production. Also, note that besides *hydro and nuclear electricity*, which is directly allocated to this industry, *coal*, and *crude oil and gas*, are the most important inputs. In this example, *Electricity plants* uses 309 units of coal and 215 units of *crude oil and gas* from domestic origin. The total energy consumed by *Electricity plants* is 881 units, 838 units used as fuel to produce energy, zero units used as own energy, 30 units of imported energy, and 13 units of distribution losses. It produces 360 units to supply the needs of the economy, showing a net use of 521 units of energy in the production process. These differences in energy requirements for production are reflected in the net energy gain account, where the numbers show the balance of energy required to produce usable energy. The net energy gain will be positive for industries which produces primary energy (*coal, oil*, *nuclear*, *hydro*, *wind*, *solar*, etc.), and usually negative for other industries.

In the case of the *Oil refineries industry*, 939 units of energy are used to produce 850 units; 459 units used as fuel to produce energy, 56 units used as own energy, 420 units of imported energy, and 4 units of distribution losses.

A link can be made between the Net Energy Gain (NEG) and the final fuel consumption. In the example, the net energy gain is 1104 units while the total domestic energy, including the foreign intermediate inputs, used by final demand is 1579 units. The difference of 475 units refers to the imported energy and distribution losses associated with production of the national energy industries and embodied in the final demand energy, i.e.:

NEG = FD of domestic energy – Intermediate imported energy – Distribution losses

Figure 2.7. Energy physical supply and use tables, an example

ENERGY PHYSICAL SUPPLY TABLE

		NATIONAL INDUSTRY					TOTAL Net Energy	Distribution Losses	TOTAL Including Losses
		Mines primary	Oil and gas primary	Electricity primary	Oil refineries	Electricity plants			
ENERGY PRODUCTS MADE BY NATIONAL INDUSTRIES	Coal	350	0	0	0	0	**350**	0	**350**
	Crude oil and gas	0	1,150	0	0	0	**1,150**	0	**1,150**
	Diesel	0	0	0	230	0	**230**	0	**230**
	Other Fuels	0	0	0	620	0	**620**	0	**620**
	Hydro & Nuclear electricity	0	0	270	0	0	**270**	0	**270**
	Electricity and Heat	0	0	0	0	360	**360**	20	**380**
TOTAL		**350**	**1,150**	**270**	**850**	**360**	**2,980**	20	**3,000**

ENERGY PHYSICAL USE TABLE

		NATIONAL ENERGY INDUSTRIES					Final Demand			TOTAL
		Mines primary	Oil and gas primary	Electricity primary	Oil refineries	Electricity plants	Industries	Households and Transport	Exports	
DOMESTIC ENERGY	Coal	0	0	0	0	309	10	0	30	349
	Crude oil and gas	0	0	0	450	215	210	125	96	1,096
	Diesel	0	0	0	5	4	35	125	55	224
	Other Fuels	0	0	0	4	20	135	305	125	589
	Hydro & Nuclear electricity	0	0	0	0	270	0	0	0	270
	Electricity and Heat	0	0	0	0	20	196	130	2	348
OWN ENERGY	Coal	1	0	0	0	0	0	0	0	1
	Crude oil and gas	0	34	0	20	0	0	0	0	54
	Diesel	2	4	0	0	0	0	0	0	6
	Other Fuels	0	1	0	30	0	0	0	0	31
	Hydro & Nuclear electricity	0	0	0	0	0	0	0	0	0
	Electricity and Heat	2	4	0	6	0	0	0	0	12
IMPORTS	Imports	1	4	0	420	30	36	65	45	601
DIST. LOSSES	Distribution losses	1	2	0	4	13	0	0	0	20
NET ENERGY GAIN	NEG	343	1,101	270	-89	-521				1,104
TOTAL		**350**	**1,150**	**270**	**850**	**360**	**622**	**750**	**353**	

Source: Authors' elaboration

3. Final Comments

This paper presented the methodology used for the estimation of EPSUTs based on IEA's WEB. The estimated EPSUTs should be viewed as an important step to study and better understand the interconnections of energy production with the world economy and the emissions associated with fuel combustion.

A first set of indicators, based on the EPSUTs, will explore the distinction between primary versus secondary energy, and the requirements of energy to produce energy. A further step of these indicators would be to estimate direct versus indirect energy through a link to national input-output models, so-called "lifecycle energy indicators".

More complex indicators, can be obtained by combining the EPSUTs with the ICIO tables estimated by OECD, in an Energy MF-IO hybrid model. Such indicators associate energy use with monetary production and consumption of goods and services around the world. Based on these indicators, it will be possible to measure the importance of countries for energy production and consumption in the world. A natural extension of these energy indicators would be to obtain improved estimates of embodied carbon indicators, by fuel type, using the relevant emission factors estimated by IEA.

The estimation and use of EPSUTs and related indicators can also contribute to data quality assurance, highlighting to countries included in the IEA-WEB database the importance of supplying a consistent set of energy data to IEA. Despite the efforts of IEA to assure the consistency of the WEB, this database sometimes suffers from lack of information, or a high level of data aggregation submitted to IEA by some countries.

The development of novel energy-use indicators, providing a richer understanding of the multiple links between global energy systems and the global economy has the potential to make an important contribution to ongoing discussions related to climate change, notably through OECD's International Programme for Action on Climate (IPAC) initiative.

Endnotes

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[2] https://www.iea.org/reports/world-energy-balances-overview

[3] http://oe.cd/icio

[4] The territorial and residential principal, as presented in the System of National Accounts (SNA), will be dealt in the MF-IO hybrid model.

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Annex A. Appendix

Figure A.1. Map of fuel production processes to fuels production

	INDUSTRIES \ FUELS	PRIMARY																														
		HARDCOAL	BROWN	ANTCOAL	COKCOAL	BITCOAL	SUBCOAL	LIGNITE	PEAT	OILSHALE	CRNGFEED	CRUDEOIL	NGL	ADDITIVE	NUCLEAR	HYDRO	INDWASTE	MUNWASTER	MUNWASTEN	PRIMSBIO	BIOGASES	BIOGASOL	BIODIESEL	BIOJETKERO	OBIOLIQ	RENEWNS	GEOTHERM	SOLARPV	SOLARTH	TIDE	WIND	OTHER
PRIMARY	MINES_PRIMARY	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	OILGASEX_PRIMARY	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	NUCLEAR_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	HYDRO_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	WASTE_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	BIOGAS_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	BIOLIQ_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
PRIMARY	BIOMASS_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	BIONS_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
PRIMARY	GEOTHERMAL_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
PRIMARY	REN_ELE_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0
PRIMARY	REN_HEAT_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
PRIMARY	NONCRUDE_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	OTHER_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PRIMARY & SECONDARY	MAINELEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	AUTOELEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	MAINCHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	AUTOCHP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	MAINHEAT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	AUTOHEAT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	THEAT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TBOILER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TELE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TBLASTFUR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TGASWKS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TCOKEOVS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TPATFUEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TBKB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TREFINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TPETCHEM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TCOALLIQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TGTL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TBLENDGAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TCHARCOAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TNONSPEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	INDUSTRIES \ FUELS	PRIM & SECOND						SECONDARY																													
		NATGAS_P	NONCRUDE_P	HEAT_P	NATGAS_S	NONCRUDE_S	HEAT_S	PATFUEL	OVENCOKE	GASCOKE	COALTAR	BKB	GASWKSGS	COKEOVGS	BLFURGS	OGASES	PEATPROD	REFFEEDS	REFINGAS	ETHANE	LPG	NONBIOGASO	AVGAS	JETGAS	NONBIOJETK	OTHKERO	NONBIODIES	RESFUEL	NAPHTHA	WHITESP	LUBRIC	BITUMEN	PARWAX	PETCOKE	ONONSPEC	CHARCOAL	ELECTR
PRIMARY	MINES_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	OILGASEX_PRIMARY	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	NUCLEAR_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	HYDRO_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	WASTE_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	BIOGAS_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	BIOLIQ_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	BIOMASS_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	BIONS_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	GEOTHERMAL_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	REN_ELE_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	REN_HEAT_PRIMARY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	NONCRUDE_PRIMARY	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY	OTHER_PRIMARY	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	MAINELEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PRIMARY & SECONDARY	AUTOELEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PRIMARY & SECONDARY	MAINCHP	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PRIMARY & SECONDARY	AUTOCHP	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PRIMARY & SECONDARY	MAINHEAT	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	AUTOHEAT	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	THEAT	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TBOILER	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TELE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PRIMARY & SECONDARY	TBLASTFUR	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TGASWKS	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TCOKEOVS	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TPATFUEL	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TBKB	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TREFINER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
PRIMARY & SECONDARY	TPETCHEM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TCOALLIQ	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TGTL	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TBLENDGAS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMARY & SECONDARY	TCHARCOAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
PRIMARY & SECONDARY	TNONSPEC	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1 Primary energy

1 Secondary energy