SLT Projection Questionnaire

Compiler's Guide

International Energy Agency

iea

This document provides information and instructions for data compilers regarding the International Energy Agency (IEA) *SLT Projection Questionnaire*. Please share with slt@iea.org any questions or comments you may have on this document or the underlying data compilation, as soon as they emerge.

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1. Introduction

Considering the complexities of the related socio-economic factors, energy policy and planning requires adopting a long-term perspective. Building energy infrastructure takes time and decisions made right now can shape the structure and outcomes of our choices for many decades. It takes a considerable amount of time for new energy technologies to develop and mature and reach their desired market share. Similarly, the use of energy has impacts on the ecosystem over a long period expanding from decades to centuries and it can take years for the effects of energy policy responses to be appreciated. Hence, long-term perspectives are essential in analysing and planning the energy system and its corresponding socio-economic and environmental impacts in order to accelerate energy transitions.

National projections will become more and more relevant within the evolving landscape of energy transitions. Governments and other data users benefit from these projections for planning and monitoring the progress towards national energy and climate targets, refining energy models and informing policy reviews and recommendations. The data submitted to the IEA in this questionnaire are the basis for an international compilation of national projections and are disseminated through the Energy Projections of IEA Countries – with Extended Transitions Indicators and Projections: Energy Policies of IEA Countries databases.

In an effort to keep the data collection pertinent to evolving policy priorities while minimizing the additional burden on data providers, IEA initiated a consultation with member countries in summer 2021, discussing opportunities for improving the Standing Group on Long-Term Co-operation (SLT) projections questionnaire for the upcoming cycles. Following constructive responses from data providers, this effort was broadly communicated with the country delegates in the SLT Committee held in December 2021, receiving much positive feedback.

Subsequent to the consensus among member countries on the value of enhancing the relevance of projections data collection and its visibility, IEA introduced during the 2021/22 cycle a pilot data collection with the new version of the questionnaire, to assess the impact of the updates, and collect relevant feedback from data providers. Based on further feedback from data compilers and users, the pilot was further refined for the upcoming cycles.

To ensure clarity to users, data compilers are requested to select the specific scenario category that best corresponds to the national scenario underlying the reported data; additionally, projections corresponding to different scenarios can be reported in different files. Please refer to *Section 4 – Guidelines for the completion of the questionnaire* for more details.

The projections refer to three years: 2030, 2040 and 2050. To support compilation, the IEA will prefill energy time series of balances for the last three historical years, based on previous country reporting.

The questionnaire also covers few additional items not yet collected in the annual questionnaires in order to compile data on fuel/technologies which are expected to gain importance in the energy systems. This includes: accounting of hydrogen and synthetic fuels; the ambient heat captured by heat pumps; and the emissions savings from carbon capture, utilization and storage (CCUS) across sectors.

The list of sheets and tables to be filled is presented in *Section 3 – Content of the questionnaire*.

2. Changes from last cycle

This section presents the changes of the questionnaire structure/content as well as amendments to this document compared to the previous submission cycles.

Amendments to guidelines for reporting newly introduced energy products

Following the launch of the pilot version of this questionnaire last cycle, the simplified energy balance of Table 1 was extended to allow for reporting of few additional energy products and flows that may become more relevant in future energy systems.

The guidelines for reporting under two of the newly introduced products: *"Memo: Hydrogen & Synthetic fuels"* and *"Memo: Heat pump"* have been amended to comprise additional clarifications including graphical representations to help further facilitate the reporting by the data compilers.

For details, please refer to *Section 4 – Guidelines for compiling the questionnaire – Table 1.*

Amendments to the import/export functionalities of the tool

Based on the feedback received from data compilers and to enhance the combability of the questionnaire with our data processing infrastructure, there has been slight amendments to the technicalities of importing and exporting the data using CSVs.

For details, please refer to *Section 4 – Guidelines for compiling the questionnaire – CSV import and export.*

3. Content of the questionnaire

This section describes the overall structure of the file, with focus on the sheets to be filled by data compilers: the scenario information and three statistical tables.

The file includes 12 worksheets with distinguish colour coding. When opening the file a sheet called the **"Start"** tab is visible. By clicking on the button on this sheet the remaining sheets are populated. The green tabs include the **"Intro"** sheet which provides general guidance on using the tool, the **"Data Import & Export"** sheet which provides functionalities to import and/or export data using CSVs as well as the **"2020"** sheet which is pre-filled by the IEA with the latest available historical data. The blue tabs correspond to the **"Energy Balance Time Series"** and **"Indicators"** sheets which are data visualization tools populated automatically providing a means to verify the submitted data.

The orange tabs are to be filled by the data compliers and include a **"Scenario"** sheet, **"Table 1"** sheets (for years 2030, 2040 and 2050), **"Table 2"** and **"Table 3"** sheets. This section includes visual representation of the above orange sheets. For details on how to report the data corresponding to each sheet please refer to *Section 4 – Guidelines for compiling the questionnaire*.

Please note that you can submit more than one file if you wish to share information corresponding to different scenario categories. In case of lack of updated projections, you can opt for copying previously submitted information in the statistical tables – please still ensure to provide the information on the underlying scenario.

List of data inputs to be filled by compilers

Scenario: Sheet to select the category of scenario and provide additional information

Table 1: Energy balances for 2030, 2040 and 2050.

Table 2: Supplementary data

Table 3: Emission savings from CCUS

Scenario sheet

A. Scenario selection	Main category	Sub category
The objective of this section is to assist in categorising the national scenario which is the basis of the projections data submitted in Tables 1, 2, 3.	Business as Usual	Please provide details in the table below

Instructions

Please indicate above which one of the following scenario categories correspond to the submitted projections data.

1. Business as Usual	Baseline scenarios (e.g. fixed with a specific base year for benchmarking)
2. Stated Policies	Scenarios taking into account measures which have been already adopted, together with pertinent policy proposals and announced commitments
3. Beyond Stated Policies (Aspirational)	Scenarios which set a pathway consistent with specific target(s) or other desired outcomes
a) Achieving national targets	Examples include net zero scenarios and Paris Agreement compliant (2 or 1.5 ºC temperature increase) scenarios
b) Achieving defined outcomes	Examples include SDG compliant scenarios, energy access and/or energy security related scenarios
4. Other	Scenarios which do not fall under any of the above general categories

Note: if multiple scenarios are available, please save this questionnaire / extract the corresponding csv, then change the scenario and report the data for the alternative scenario (s)

For more detailed instructions on scenario selection, please refer to the Compiler Guide.

B. Qualitative information
• **Source institution for modelling and collaborating institutions**
• **Short description of the methodology (and model used for the scenario)**
• **Main assumptions of the scenario: specific targets (e.g. net zero, SDGs, 1.5C); desired outcomes (e.g. energy access, energy security); other relevant information**
• **Frequency of projections update**
• **Please provide links to any documentation, reports, or website**
• **Any other comments if applicable**

Table 1 – Energy Balance (Mtoe)

		Coal / Oil shale	Peat	Oil	Natural gas	Nuclear	Hydro	Wind	Geothermal	Solar	Tide, Etc.
		A	B	C	D	E	F	G	H	I	J
Production (+)	A	-	-	-	-	-	-	-	-	-	-
Imports (+)	B	-	-	-	-						
Exports (–)	C	-	-	-	-						
International marine bunkers (–)	D	-	-	-	-						
International aviation bunkers (–)	E	-	-	-	-						
Stock changes (±)	F	-	-	-	-						
Total Energy Supply	G	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Transformation processes & Energy industry own use	H	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Electricity, CHP & heat plants (±)	I	-	-	-	-	-	-	-	-	-	-
Other transformation processes (±)	J	-	-	-	-						
Own use and Losses	K	-	-	-	-				-	-	-
Statistical differences (±)	L	**-**	**-**	**-**	**-**				**-**	**-**	**-**
Total Final Consumption	M	**-**	**-**	**-**	**-**				**-**	**-**	**-**
Industry (+)	N	-	-	-	-				-	-	-
Transport (+)	O	-	-	-	-						
of which: Road (+)	P	-	-	-	-						
Other (+)	Q	-	-	-	-				-	-	-
of which: Residential (+)	R	-	-	-	-				-	-	-
of which: Commercial and Public Services (+)	S	-	-	-	-				-	-	-
Non-energy use (+)	T	-	-	-	-						
of which: chemical/petrochemical (+)	U	-	-	-	-						
Elec. Gen. Exc. Pumped storage (TWh) (+)	V	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Heat generated (PJ) (+)	W	**-**	**-**	**-**	**-**	**-**			**-**	**-**	**-**
Memo: Electrical capacities (MW)	X	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Memo: Input to Hydrogen & Synthetic fuels production	Y	-	-	-	-						
Memo: Input to Heat pump	Z										

Table 1 – Energy Balance (Mtoe) (continued)

		Biofuels & renewable waste	Non-renewable waste	Electricity	Heat	Total	Memo: Offshore wind	Memo: Hydrogen & synthetic fuels	Memo: Heat pump
		K	L	M	N	O	P	Q	R
Production (+)	A					-			
Imports (+)	B					-			
Exports (–)	C					-			
International marine bunkers (–)	D					-			
International aviation bunkers (–)	E					-			
Stock changes (±)	F					-			
Total Energy Supply	G	-	-	-	-	-	-	-	-
Transformation processes & Energy industry own use	H	-	-	-	-	-	-	-	-
Electricity, CHP & heat plants (±)	I					-			
Other transformation processes (±)	J					-			
Own use and Losses	K					-			
Statistical differences (±)	L					-			
Total Final Consumption	M	-	-	-	-	-		-	-
Industry (+)	N					-			
Transport (+)	O					-			
of which: Road (+)	P					-			
Other (+)	Q					-			
of which: Residential (+)	R					-			
of which: Commercial and Public Services (+)	S					-			
Non-energy use (+)	T					-			
of which: chemical/petrochemical (+)	U					-			
Elec. Gen. Exc. Pumped storage (TWh) (+)	V					-			
Heat generated (PJ) (+)	W					-			
Memo: Electrical capacities (MW)	X					-			
Memo: Input to Hydrogen & synthetic fuels production	Y					-			
Memo: Input to heat pumps	Z					-			

Table 2 – Supplementary data

	Historical Data				Data submission This Cycle			Last Cycle Projections		
	2018	2019	2020	2021	2030	2040	2050	2030.LC	2040.LC	2050.LC
GDP Growth Rates (%)(1)	-	-	-	-				-	-	-
Population (Millions) (2)	-	-	-	-				-	-	-
GDP (Billion USD 2015) (1)(2)	-	-	-	-	-	-	-	-	-	-

(1) Refers to GDP in constant 2015 prices

(1) The annual growth rates (which refer to GDP in constant 2015 prices) should be calculated in the following way:

For 2020 report the GDP 2020/GDP 2019 annual rate.

For 2021 report the GDP 2021/GDP 2020 average annual rate.

For 2030 report the GDP 2030/GDP 2020 average annual rate.

For 2040 report the GDP 2040/GDP 2030 average annual rate.

For 2050 report the GDP 2050/GDP 2040 average annual rate.

(2) Before publication, the Secretariat will update the provisional 2021 GDP and population figures submitted with those published in OECD National Accounts.

Table 3 – Emission savings from CCUS[1]

	Historical Data				Data submission This Cycle			Last Cycle Projections		
Mass of CO_2 captured ($ktCO_2$)	2018	2019	2020	2021	2030	2040	2050	2030.LC	2040.LC	2050.LC
Total	-	-	-	-	-	-	-	-	-	-
Natural gas processing								-	-	-
Manufacturing								-	-	-
Electricity and heat generation								-	-	-
Hydrogen and synthetic fuel production								-	-	-
Other								-	-	-

[1] CCUS refers to carbon capture, utilization and storage

4. Guidelines for compiling the questionnaire

This section provides general guidelines for completing the questionnaire, from the scenario selection, to the new CSV import and export functionalities that can be used.

Scenario categorisation

It is important to clearly communicate the purpose and context of the scenarios to avoid misinterpretation. The objective of this section is to assist data compilers in categorising the national scenario(s) which are the basis of the projections data submitted in the SLT questionnaire into one of the general categories described below. Understanding the category of the scenarios and their underlying methodology is of great value and facilitates the comparison and analysis of the submitted projections data.

Note that completion of the **"Scenario"** sheet is a requirement to ensure that data included in statistical tables are interpreted correctly; this information will be assessed during the questionnaire validation process.

To assist data compilers in categorising the national scenario used for each of the submissions, the **"Scenario"** sheet includes a menu and a few qualitative questions. It will be important to i) select a scenario category and ii) include key information on assumptions and methodologies, as well as links to available reference documentation, following the questions listed in the same sheet.

This section briefly introduces the typical scenario categories used across institutions for long-term energy planning, which correspond to the options to choose from in the **"Scenario"** sheet of the questionnaire.

1. **Business as usual scenarios:**

The Business as Usual scenario category aims to capture scenarios that include only government policies which have been already adopted, and therefore project how the national energy landscape may evolve if the existing structures in energy supply and demand remain unchanged.

Scenarios with the Business as Usual category provide a baseline to compare alternative scenarios and a starting point for the understanding and analysis of the energy system by assuming a general continuation of historical trends into the future. The assumption is that the structure of the system remains unchanged or responds in pre-determined forms.

Examples include the European Commission's EU Reference Scenario 2020, the IEA Current Policies Scenario, the EIA's Annual Energy Outlook Reference Case and Canada's Energy Future Current Policies Scenario.

2. **Stated policies scenarios:**

The Stated Policy Scenario category aims to capture scenarios that take into account national climate and/or energy-related policies and measures which have been already adopted by the government, together with pertinent policy proposals, announced commitments and plans which have been announced but are yet to be formally adopted.

A cautious view of the extent and timing to which policy proposals are projected to be implemented and objectives achieved are key in defining this type of scenarios. The aim of scenarios in this category is to provide a sense of where today's policy ambitions seem likely to drive the energy landscape.

In other words, this scenario type is a policy-based forecast, not a hypothetical scenario which is based on optimizing policy for a desired outcome.

It is typical to set out the gap in between the outcome of these types of scenario and targets such as efforts to limit global temperature increase to 1.5 Cº, or wider Paris Agreement objectives. Examples include the IEA Stated Policies Scenario (STEPS) and the EU's With Additional Measures (WAM) scenarios.

3. **Beyond stated policies (Aspirational) scenarios:**

Scenarios within this category set an energy pathway consistent with specific target(s) or other particular desired outcomes. By this means, they demonstrate what should be achieved across sectors and by various actors and by when, for the targets or outcomes to be achieved.

Examples include the European Commission's REG and MIX and the IEA Net Zero Emissions by 2050 (NZE) and Sustainable Development (SDS) scenarios.

The Aspirational scenarios may be divided into the following sub-categories:

a) **Achieving national targets scenarios:**

This type of scenarios could set out a pathway for the national (or regional) energy sector to achieve a specific target. For example a net zero scenario could set out a pathway for the national energy sector to achieve net zero emissions by a certain year. Or a Paris Agreement compliant scenario demonstrates a pathway consistent with the goal of limiting the global increase in temperature to 2 or 1.5°C (with a certain probability). Additionally, scenarios consistent with achieving certain sustainable development goals fall within this category.

b) **Achieving defined outcomes scenarios:**

This category of scenarios is consistent with defined outcomes rather than targets. Examples include scenarios consistent with achieving affordability of energy sources or long/short-term energy security purposes. Some scenarios could have multiple desired outcomes.

4. **Other**

Scenarios which do not fall under any of the above general categories can be reported under this option. A short description of the methodology and model used and any underlying assumptions would be in this case essential to help with the clarity of the submitted projections data.

Energy balance concepts

The energy balance is a presentation of the basic supply and demand data for all fuels in a manner which shows the main fuels together but separately distinguished and expressed in a common energy unit. The format of the IEA energy balance is based on the International Recommendations on Energy Statistics (IRES)[2], which is a comprehensive framework on the scope of energy statistics including classifications, units and methodologies.

Energy data are generally collected independently across different commodities. Energy statistics are the simplest format to present all the data together, assembling the individual balances of all products, each expressed in its own physical unit (e.g. TJ for natural gas, kt for coal, etc). These are called commodity balances. However, energy products can be converted into one another through a number of transformation processes. Therefore, it is very useful to also develop one comprehensive national energy balance, to understand how products are transformed into one another, and to highlight the various relationships among them.

By presenting all the data in a common energy unit, the energy balance allows users to see the total amount of energy used and the relative contribution of each different source, for the whole economy and for each individual consumption sector; to compute the different fuel transformation efficiencies and to develop various indicators. The energy balance is a natural starting point to study the evolution of the domestic energy market, forecast energy demand, monitor impacts of energy policies and assess potential areas for action. The energy balance can also be used as a high-level check on the data accuracy, as large statistical differences in energy units, apparent energy gains or large losses in transformation processes, or large unexplained variations in shares or in high-level indicators may all indicate underlying data problems.

Table 1 is a simplified version of the IEA energy balance. An example of how to complete this table can be found by clicking the button "Sample latest historical year Energy Balance" included on the **"Intro"** sheet. This will direct you to a table which contains a simplified energy balance for the latest historical year. The data in this table have been prefilled by IEA based on the data submitted through the annual questionnaires, and can be used as a guide for filling Table 1 for projections.

This section outlines a general guide for completing the energy balances tables. Please refer to the IEA World Energy Balances documentation file for more details on the methodology for developing an energy balance based on fuel statistics.

[2] The report on International Recommendations on Energy Statistics (IRES) is available at https://unstats.un.org/unsd/energystats/methodology/ires/.

Table 1

Columns

Column A: "Coal" includes: All coal and coal products both primary and derived, such as anthracite, coking coal, other bituminous coal, sub-bituminous coal, lignite, oil shale (primary product – however, note that the secondary product shale oil should be included under oil), patent fuel, coke oven coke (including semi-coke), gas coke, coal tar, brown coal briquettes as well as coke oven gas, gas works gas, blast furnace gas and other recovered gases. Note that peat should not be included in this column.

Column B: "Peat" includes peat burned for energy. Peat used for non-energy purposes should not be included.

Column C: "Oil" includes:

1. Crude oil, refinery feedstocks, natural gas liquids, and additives as well as non-crude hydrocarbons (tar sands, shale oils, etc.) and Orimulsion. **Imports and exports** of liquefied synthetic fuels should also be shown here.

2. Oil products including liquefied petroleum gas and refinery gas. Synthesised liquid hydrocarbons from other sources (e.g. hydrogen produced from natural gas, coal liquefaction) are transferred into the "Oil" column from the appropriate cells. For example, liquefied coal would be shown as coal consumed (and therefore negative) in *Cell JA* of Table 1 and as secondary oil production (and therefore positive) in *Cell JC*. Similarly hydrogen or other synthetic fuels produced from natural gas, would be shown as natural gas consumed in *Cell JD* and as secondary oil production in *Cell JC*.

Column D: "Natural gas" includes natural gas (excluding natural gas liquids) and import and exports of gaseous synthetic fuels including Hydrogen.

Column E: **"Nuclear "**. Please refer to the *Units and Conversion* section below.

Column F: "Hydro". Please refer to the *Units and Conversion* section below. Note that only natural flow hydro generation should be included**.** The electricity losses associated with pumped storage electricity should be included in the quantities given in *Cell KM* "electricity-own use and losses".

Column G: "Wind". Please refer to the *Units and Conversion* section below.

Column H: "Geothermal". Please refer to the *Units and Conversion* section below.

Column I: "Solar". Please refer to the *Units and Conversion* section below.

Column J: "Tide, etc.". Please refer to the *Units and Conversion* section below.

Column K: "Biofuels and renewable waste" includes solid biofuels, liquid biofuels, biogases and the renewable fraction of municipal waste. This includes primary solid biofuels, biogases, biogasoline, biodiesels, bio jet kerosene, other liquid biofuels, charcoal and renewable fraction of municipal waste produced by households, industry, hospitals and the tertiary sector that are collected by local authorities for incineration at specific installations.

Column L: "Non-renewable waste" includes industrial waste of non-renewable origin consisting of solid and liquid products (e.g. tyres) combusted directly, usually in specialised plants, to produce heat and/or power and the non-renewable fraction of municipal waste produced by households, industry, hospitals and the tertiary sector that are collected by local authorities for incineration at specific installations.

Column M: "Electricity" shows trade and final consumption in electricity (which is counted at the same heat value as electricity in final consumption i.e., 1 TWh = 0.086 Mtoe).

If hydrogen or synthetic fuels are produced through power to gas processes by consumption of electricity, and due to the current absence of these products in the main structure of the energy balance, the final consumption of these fuels can be reported under electricity, while accounting for the conversion losses. For example assuming a 3 Mtoe input of natural gas, 2/3 efficiency for electricity generation and 50% efficiency for the power to gas process, -3 should be reported in *Cell ID*, while 2 should be reported in *Cell IM*, -1 in *Cell KM* and 1 in *Cell RM* (assuming hydrogen consumption in household heating).

Column N: "Heat" permits the reporting of (a) the generation and consumption of heat for sale and (b) heat extracted from ambient air and water by heat pumps. The generation of heat for sale is reported as a transformation sector activity and the corresponding inputs should be included in the row **"Electricity, CHP & heat plants"**. Heat consumed at the point of production which is generated from fuels reported elsewhere in the balance, is not reported since this would be double-counting.

The ambient heat input to **large-scale** commercial heat pumps should be reported under this column and row **"Production".**

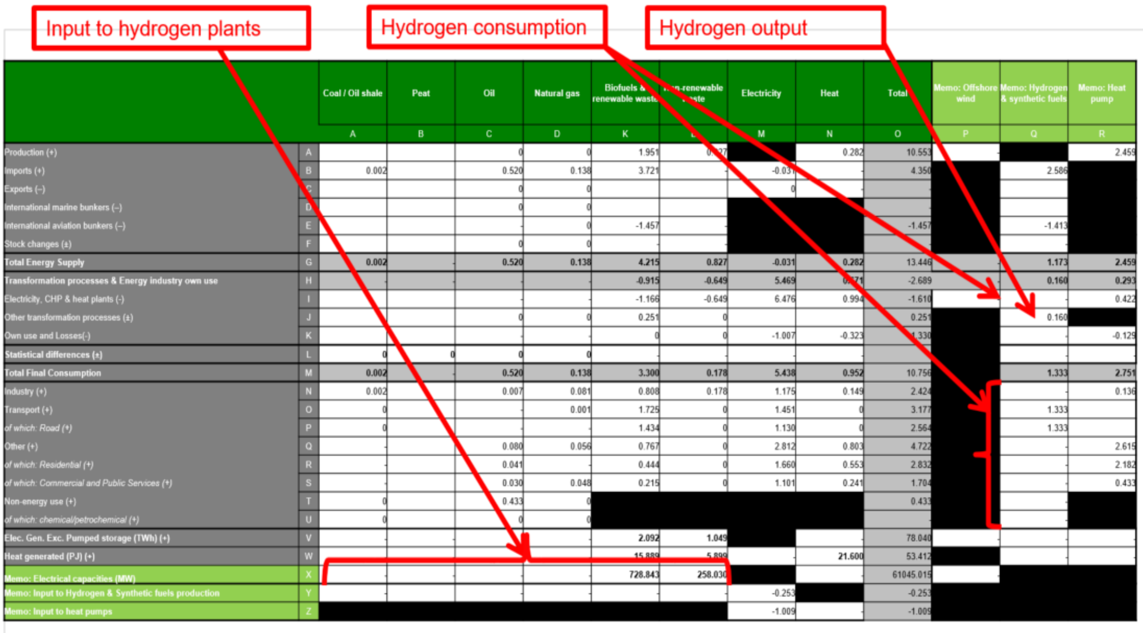
Column O: "Total" is the sum of columns (A) to (N). This column shows total energy supply (excluding international marine and aviation bunkers) and total final consumption.

Column P: "Memo: Offshore wind" is a memo category outside the current main structure of the energy balance. This product is a subcomponent of the **"Wind"** element. The Total wind production (including both onshore and offshore) is still to be reported under the product "**Wind**"*.* Please refer to the *Units and Conversion* section below.

Column Q: "Memo: Hydrogen & synthetic fuels" is a memo category outside the current main structure of the energy balance. This memo product has been added to allow reporting the data corresponding to hydrogen and synthetic fuels in a more visible manner. However, the reporting under this Memo category should not impact the existing means of reporting hydrogen and synthetic fuels supply and consumption as part of the main energy balance. Refer to *Column C (Oil)*, *Column D (Natural gas)* and *Column M (Electricity)* for details on how to report these products in the main structure of the energy balance.

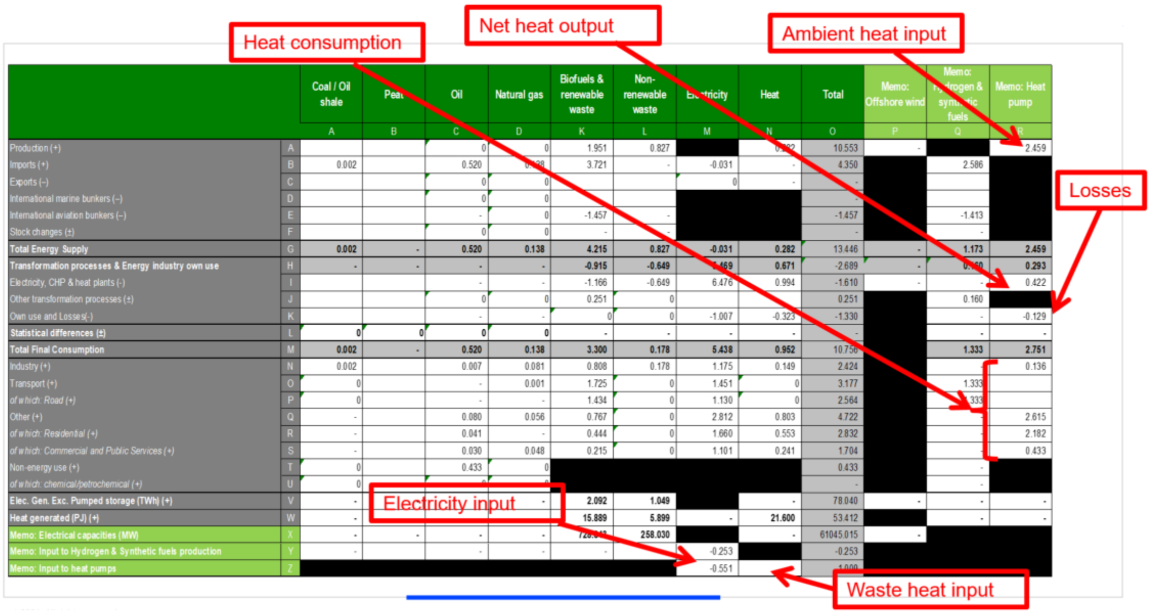
For general guidance on reporting under this memo category, please refer to the snapshot provided below. Production of hydrogen and synthetic fuels should be reported under the category **"Other transformation processes"**. The consumption of hydrogen and synthetic fuels should be reported under the corresponding sectors. This could be inputs to electricity and/or heat plants or final consumption sectors including non-energy use. The input figures should be reported as negative numbers. The fuel or electricity inputs should be reported under the corresponding column in *Row Y (Memo: Input to Hydrogen & synthetic fuels production)*. Refer to *Row Y* under section *ROWS* below for more details.

The addition of this memo item outside the balance provides a mean to enhance the granularity for reporting supply and demand of these energy carriers without a risk of double counting or breaking the balance, until a harmonized methodology for reporting is adopted in international energy statistics.



Column R: "Memo: Heat pumps" is a memo category outside the current main structure of the energy balance. The addition of this memo item allows the reporting of ambient heat input data corresponding to all types of heat pumps and not only large-scale units used for selling heat which are currently reported in the main balance. The reporting under this Memo category should not impact the existing means of reporting data corresponding to heat pumps as part of the main energy balance. Refer to *Row A (Production)*, *Row K (Own use and losses)*, *Row I (Electricity, CHP and heat plants) and ROW W (Heat generated)* for details on how to report heat pumps as part of the main structure of the energy balance.

For general guidance on reporting under this memo category, please refer to the snapshot provided below. The ambient heat extracted from the environment should be reported under **"Production"**. The net heat output (gross output - ambient heat), which in case of no losses, equals the electricity and waste heat input should be reported under the item **"Other transformation processes"**. The consumption of heat from the heat pumps should be reported under the specific sector(s). The electricity and non-ambient heat (e.g. recovered heat) inputs should be reported under the corresponding columns in *Row Z (Memo: Input to heat pumps)* as negative numbers. Refer to *Row Z* under section *ROWS* below for more details.



Rows

Row A: "Production" shows only production of primary energy, i.e. hard coal and lignite, oil shale, peat, biofuels and renewable waste (see definition above), non-renewable waste, crude oil and NGL, natural gas, and electricity and heat from nuclear, hydro, tidal, wave, geothermal, wind and solar plants. Note that:

(a) Where synthetic liquid or gas hydrocarbons are produced directly as a result of "in place extraction" they should be regarded as primary fuels and included under production. For example, oil from tar sands and shale should be shown in *Column C (oil)*.

(b) Production of natural gas should exclude gas reinjected, vented or flared but should include gas subsequently used in the gas extraction and drying processes as well as for transportation of the gas by pipeline.

(c) Heat from large-scale only (heat pumps which sell heat to third parties) that is extracted from the ambient air is included in the heat column under this category.

Row B/C: "Imports (+)" and "Exports (-)" show trade both in primary and secondary forms of energy. Note in particular that LPG traded should be placed in *Column C (oil)*. Nuclear fuel trade is not shown in the balance. Trade in electricity is counted at the same heat value as in final consumption (1 TWh = 0.086 Mtoe). For countries trading across common borders, actual import and export figures should be given instead of a net trade balance.

Row D: "International marine bunkers" includes those quantities of fuel delivered to ships of all flags that are engaged in international navigation. The international navigation may take place at sea, on inland lakes and waterways, and in coastal waters. The domestic/international split is determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship. Consumption by ships engaged in domestic navigation is not covered here but should be included in *Row O* under the transport sector.

Row E: "International aviation bunkers" includes deliveries of aviation fuels to aircraft for international aviation. Fuels used by airlines for their road vehicles are excluded. The domestic/international split should be determined on the basis of departure and landing locations and not by the nationality of the airline. Consumption by aircraft engaged in domestic aviation are not covered here but should be included in *Row O* under the transport sector.

Row F: "Stock changes" show additions to stocks as negative, and lowering of stock levels as positive. For the projection years, stock changes are conventionally zero. However, countries may report the data if available. The reporting of this category is optional and not part of the mandatory reporting for projection years.

Row G: "Total energy supply" (TES) is made up of production (*Row A*), imports (*Row B*, positive), exports (*Row C*, negative), international marine bunkers (*Row D*, negative), international aviation bunkers (*Row E*, negative) and stock changes (*Row F* either positive or negative).

Note that when no stock change data is submitted (optional reporting), the TES is still populated with the assumption of a zero value for the stock change figure.

Row H: "Transformation processes and energy industry own use" shows the total of the energy transformation processes (*Rows I* and *J*) and energy used by energy-producing industries and losses in energy distribution, transmission and transport (*Row K*).

Row I: "Electricity, CHP and heat plants" *Cells IA* to *IL* in this table should contain inputs of each fuel for the production of electricity and heat as negative entries. This row includes both main activity producer (formerly known as public) [3] and autoproducer [4] plants. However, for autoproducers all fuel inputs to electricity production are taken into account, while only the part of fuel inputs to heat sold is shown. Note that fuel inputs for the production of heat consumed within the autoproducer's establishment are not included here but are included with figures for the final consumption of fuels in the appropriate consuming sector.

Outputs of electricity appear as a positive number in *Cell IM* and the heat that is sold to outside users appears as a positive number in *Cell IN*. Transformation losses are shown as negative numbers in the **"Total"** column, *Cell IO*.

Note that Gross electricity produced should contain total electricity generation in Mtoe calculated on the basis of 1 TWh = 0.086 Mtoe. Gross generation from hydro plants should not include that generated by pumped storage. The energy absorbed for pumped storage should be accounted for under **"Own use and losses"**, *Row K*. Refer to *Column F* (Hydro) above for more details.

[3] Main activity producers generate electricity and/or heat for sale to third parties, *as their primary activity*. They may be privately or publicly owned. Note that the sale need not take place through the public grid.

[4] Autoproducer undertakings generate electricity and/or heat, wholly or partly for their own use as an activity which *supports* their primary activity. They may be privately or publicly owned.

Note that if electricity is being used to produce heat in heat pumps or electric boilers, the electricity inputs should be reported in *Cell IM*. Similarly the corresponding net heat output (gross output - ambient heat in case of the heat pumps) should be reported in *Cell IN*.

Row J: "Other transformation processes" includes conversion losses in gas manufacture, oil refineries, coke ovens and blast furnaces, liquefaction, and other non-specified transformation.

Hydrogen or other synthetic fuels produced from hydrocarbons (e.g. natural gas), would be shown as secondary oil production in *Cell JC*. Refer to *Column C (Oil)* above for more details.

Row K: "Own use and losses" contains the primary and secondary energy consumed by transformation industries for heating, pumping, traction and lighting purposes. These are shown as negative numbers. Included here are, for example, coal mines' own use of energy, power plants' own consumption (which includes net electricity consumed for pumped storage), and energy used for oil and gas extraction. Also includes losses in gas distribution, electricity transmission and coal transport. Note the following:

(a) Fuels used for pipeline transport should be included in the transport sector.

(b) The electricity generation losses appear in the electricity, CHP and heat plants.

(c) If hydrogen or synthetic fuels are produced through power to gas process by consumption of electricity, and due to the current absence of these products in the main structure of the energy balance, the conversion losses should be accounted under **"Own use and losses".** Refer to *Column M (Electricity)* above for more details.

Row L: "Statistical differences". In principle, the figure for total requirements should equal the sum of deliveries to final consumption and use for transformation and consumption within the energy sector plus losses. However, in practice this is rarely the case and the difference is shown as **"Statistical differences"**. This arises because the data for the individual components of supply are often derived from different data sources by the national administrations. Furthermore, the inclusion of changes in some large consumers' stocks in the supply part of the balance introduces distortions which also contribute to the statistical difference.

Row M: "Total Final Consumption" (TFC) is the sum of consumption by the different end-use sectors and also includes non-energy use. Backflows from the petrochemical industry are not included in final consumption. TFC can be derived from both formulas below:

TFC = industry + transport + other + non-energy use, and

TFC = TES + transformation processes and energy industry own use + statistical differences.

Row N: "Industry" sector should cover all activity in mining, manufacturing and construction except for fuel production and transformation sectors. The industry's use of energy for owns transport should be included under the **"Transport"** category. The use of coke oven and blast furnace gas by the iron and steel industry appears in the form of coal and coal product consumption and not as gas. Feedstocks to the chemical/petrochemical industry should not be included in this category. Refer to *ROW T (Non-energy use)* below for more details.

Row O: "Transport" sector includes all fuels for transport regardless of sector, except international marine bunkers and international aviation bunkers. Fuels used for pipeline transport should be included here.

Row P: "Of which: Road" sub-sector includes all fuels for road transport regardless of sector. This includes fuels used in road vehicles as well as agricultural and industrial highway use. This category excludes military consumption and diesel oil for use in tractors that are not for highway use.

Row Q: "Other" covers the sum of consumption in residential, commercial/public services, agriculture/forestry, fishing and military use.

Row R: "Of which: Residential" includes consumption by households, excluding fuels used for transport.

Row S: "Of which: Commercial and public services" includes consumption corresponding to commercial and public services.

Row T: "Non-energy use" includes coal, oil and gas that are not used for energy purposes, such as bitumen, lubricants, waxes, white spirit and that part of petroleum coke which cannot be used for energy purposes. Non-energy use of peat and biomass should not be included here. The use of petrochemical feedstocks in the chemical/petrochemical industry should be included here and not under industry.

Note that natural gas used for ammonia production, which converts to hydrogen during the process, should be reported under this category.

Row U: "Of which chemical/petrochemical" covers the use of petrochemical feedstocks in the chemical/petrochemical industry.

Row V: "Electricity generated excluding pumped storage" shows total quantities of gross electricity generated in TWh by all electricity and CHP plants. Electricity generated from pumped storage should not be included. Refer to *Row I* above for more details.

Row W: "Heat generated (PJ)" shows quantities of heat produced for sale by CHP and heat plants. Heat produced in electric boilers should be reported under the product **"Electricity"** and heat produced by heat pumps should be reported under the product **"Heat"**.

Row X: "Memo: Electrical capacities (MW)" represents the net maximum capacity which is the maximum active power that can be supplied, continuously, with all plant running, at the point of outlet (i.e. after taking the power supplies for the station auxiliaries and allowing for the losses in those transformers considered integral to the station). Please refer to the Annual electricity data questionnaire instructions[5] for more details.

Row Y: "Memo: Input to Hydrogen & synthetic fuels production" is a memo category outside the current main structure of the energy balance. This memo flow has been added to allow reporting the data corresponding to fuel/electricity inputs for hydrogen and

[5] https://iea.blob.core.windows.net/assets/92c8e9d6-b8b1-4ecc-a0da-f3c00f5f0f42/Electricity_HeatQuestionnaire_Instructions.pdf.

synthetic fuels production in a more visible manner. However, the reporting under this Memo category should not impact the existing means of reporting inputs to hydrogen and synthetic fuels production as part of the main energy balance. Refer to *Column A (Coal/Oil shale)*, *Column D (Natural gas)* and *Column M (Electricity)* for details on how to report these inputs in the main structure of the energy balance.

For reporting under this memo category, the input for the production of synthetic fuels should be reported under the respective column as negative numbers. For example, the coal input should be reported in *Cell ZA*. If hydrogen production is from natural gas reforming, then the input should be reported in *Cell ZD*. Similarly, for power to gas processes (e.g. electrolysers), the electricity input should be reported under the product **"Electricity"** *in Cell ZM*. The production and consumption of hydrogen and synthetic fuels should be reported under the *Column Q (Memo: Hydrogen & synthetic fuels)*. For details refer to *Column Q* above.

The addition of this memo item outside the balance provides a mean to enhance the granularity for reporting supply and demand of these energy carriers without a risk of double counting or breaking the balance, until a harmonized methodology for reporting is adopted in international energy statistics

Row Z: "Memo: Input to heat pump" is a memo category outside the current main structure of the energy balance. The addition of this memo item allows the reporting of input data corresponding to all types of heat pumps. The reporting under this Memo category should not impact the existing means of reporting the input corresponding to heat pumps as part of the main energy balance. Refer to *Row A (Production)* and *Row I (Electricity, CHP and Heat Plants)* for details on how to report heat pumps inputs as part of the main structure of the energy balance.

For reporting under this memo category, the electricity used to generate heat in all types of heat pumps, including the small-scale residential ones which are not used for commercial purposes, should be reported under *Column M* (*Electricity)*. Moreover, any non-ambient heat (e.g. recovered heat) used as an input to heat pumps; should be reported under *Column N (heat).* The ambient heat input, the net heat output and consumption of heat produced from the heat pumps should be reported under the memo product **"Memo: Heat pumps"**. For more details please refer to *Column R* above.

Units and conversions

This section outlines the units and conversion factors which should be used when completing the energy balance (Table 1). The full methodological details on how to complete Table 1 is detailed in the section "Table 1- Energy Balances" above.

The energy balances should be completed in millions of tonnes (metric tons) of oil equivalent (Mtoe). 1 Mtoe = 41.868 Petajoules (10 Petacalories). In converting fuels to Mtoe for the purpose of the energy balances and other tables, respondents should use the factors outlined below.

Oil

The same default net calorific values used to convert oil products in reporting through the Oil annual questionnaire should be used for conversion. These figures are region-specific and are expressed in kJ/kg as shown below:

Default NCVs (kJ/kg)			
Product	**Europe**	**America**	**Asia Oceania**
Refinery gas	49 500	48 100	48 100
Ethane	49 500	49 400	49 400
LPG	46 000	47 300	47 700
Aviation gasoline	44 000	44 800	44 600
Motor gasoline	44 000	44 800	44 600
Jet gasoline	43 000	44 800	44 600
Jet kerosene	43 000	44 600	44 500
Other kerosene	43 000	43 800	42 900
Naphtha	44 000	45 000	43 200
Gas/diesel oil	42 600	42 600	42 600
Fuel oil	40 000	40 200	42 600
Petroleum coke	32 000	32 000	33 800
White spirit	43 600	43 000	43 000
Lubricants	42 000	42 000	42 900
Bitumen	39 000	40 000	38 800
Other oil products	40 000	40 000	40 000

Crude oil (including NGL, refinery feedstocks, additives and "other hydrocarbons") production, imports and direct use should be converted using the specific net calorific value of the crude oil(s), NGL, feedstocks, additives and "other hydrocarbons" for the country concerned. The NCVs used should be the same as those reported on the Annual Oil Questionnaire. If you are unable to get a copy of what was submitted, please contact slt@iea.org.

Coal

Coal has separate net calorific values for production, imports, exports, inputs to electricity/heat generation and coal used in coke ovens, blast furnaces and industry.

The net calorific values used for the various coals and coal products that make up production, trade and consumption should be the same as those given in the Coal (solid fossil fuels and manufactured gases) Annual Questionnaire. If you are unable to get a copy of what was submitted, please contact slt@iea.org. As data for gas derived from coal are usually provided in TJ, the problem of specific net calorific values does not arise.

Note that the data for the coal gases in Mtoe should be derived from net heat values. To calculate the net heat content of a gas from its gross heat content, multiply the gross heat content by the appropriate following factor.

Gas works gas	0.9
Coke oven gas	0.9
Blast furnace gas	1.0
Other recovered gases	1.0

Natural gas

Gas data provided in joules should be converted as follows: 1 Mtoe = 41 868 TJ.

Data should be converted from 1000 m^3 to Terajoules using the country-specific factors given in the Natural Gas Annual Questionnaire. [The average net heat value of 1000 m^3 of gas = 0.034 Terajoules.]

To calculate the net heat content of natural gas from its gross heat content, the gross heat content should be multiplied by 0.9.

Nuclear

The primary energy value ascribed to nuclear electricity is calculated from the gross generation by assuming that only 33% of the primary energy content appears as electricity. The calculation to be carried out is the following: Gross electricity generation in TWh x 0.086 / 0.33 = primary energy equivalent in Mtoe.

Heat sold by nuclear power plants should be shown as an output in the heat column (positive number in *Cell IN*), with an identical input in the nuclear column (negative number in *Cell IE).*

Hydro

The primary energy value ascribed to hydroelectricity is the energy content of the gross electricity generation from the natural flow of the water course: Gross generation from hydroelectric plants, excluding that from pumped storage plants: Gross electricity generation in TWh x 0.086 = primary energy equivalent in Mtoe.

Wind

The primary energy value ascribed to electricity produced from wind is taken to be the physical energy content of the gross generation: Gross electricity generation in TWh x 0.086 = primary energy equivalent in Mtoe.

Geothermal

If information on geothermal heat inputs to electricity generation is not available, then the primary energy value ascribed to geothermal electricity is calculated from the gross generation by assuming that only 10% of the primary energy content appears as electricity. The calculation to be carried out is the following: Gross electricity generation in TWh x 0.086 / 0.10 = primary energy equivalent in Mtoe.

For heat production, the indigenous production of geothermal is the difference between the enthalpy of the fluid produced in the production borehole and that of the fluid eventually disposed of (reinjection borehole). Heat sold by geothermal plants should be shown as an output in the heat column (positive number in *Cell IN*), with the input in the geothermal column (negative number in *Cell IH*). If the actual geothermal plant efficiency is not known, then the primary equivalent is calculated assuming an efficiency of 50%. The calculation to be carried out is the following: Heat production in TJ x 0.00002388 / 0.50 = primary energy equivalent in Mtoe.

Solar

Solar includes both solar photovoltaic electricity generation and solar thermal electricity and heat generation.

The primary energy value ascribed to electricity produced from solar photovoltaic is taken to be the physical energy content of the gross generation: Gross electricity generation in TWh x 0.086 = primary energy equivalent in Mtoe.

The primary energy equivalent for solar thermal energy is the heat available to the heat transfer medium, i.e. the incident solar energy less the optical, collectors and other eventual losses. It should be reported as indigenous production. The quantity of heat consumed should be entered in the relevant final sectors.

For electricity produced from solar thermal heat, unless the actual efficiency is known, the primary equivalent is calculated assuming an efficiency of 33%. The calculation to be carried out is the following: Gross electricity generation in TWh x 0.086 / 0.33 = primary energy equivalent in Mtoe. For heat produced in a solar thermal plant, the primary equivalent is equal to the heat consumed, i.e. 1 TJ = 0.00002388 Mtoe.

Tide/Wave/Ocean Energy, etc.

The primary energy value ascribed to electricity produced from tide, wave, ocean and other non-thermal sources is taken to be the physical energy content of the gross generation: Gross electricity generation in TWh x 0.086 = primary energy equivalent in Mtoe.

Biofuels and Renewable Wastes

Data that are provided in joules in the Renewables and Waste Annual Questionnaire should be converted as follows: 1 Mtoe = 41 868 TJ.

Data for charcoal and liquid biofuels (both reported in 1 000 tonnes) should be converted using an appropriate country-specific factor.

Non-Renewable Wastes

Data that are provided in joules in the Renewables and Waste Annual Questionnaire should be converted as follows: 1 Mtoe = 41 868 TJ.

Electricity

Electricity is converted as follows: 1 TWh = 0.086 Mtoe.

Heat

Heat is converted as follows: 1 Mtoe = 41 868 TJ.

Memo: Offshore Wind

As for the total Wind, the primary energy value ascribed to electricity produced from wind is taken to be the physical energy content of the gross generation: Gross electricity generation in TWh x 0.086 = primary energy equivalent in Mtoe.

Memo: Hydrogen & synthetic fuels

As hydrogen and other synthetic fuels produced through transformation and consumed across sectors are typically in their pure form rather than a mixture, their calorific values can be easily identified based on their respective chemical formula. For Hydrogen net calorific value of 120 MJ/kg should be used for the purpose of reporting. The net calorific values used for these fuels should be the same as those used when submitting the respective data in the Oil and Natural Gas Annual Questionnaires. If you are unable to get a copy of what was submitted, please contact slt@iea.org.

Memo: Heat pumps

Heat is converted as follows: 1 Mtoe = 41 868 TJ.

Table 2 – Supplementary data

This table includes macroeconomic data and is should be submitted for the provisional year (year 2020 for this cycle) and projection years. The included categories are detailed below:

"GDP growth rates (%)" represents the average annual growth rates of GDP. The annual growth rates refer to GDP in constant prices and should be calculated as detailed below:

- For historical and provisional year report the GDP $_{year}$/GDP $_{year-1}$ annual rate.
- For the projections years report the GDP $_{year}$/GDP $_{year-10}$ average annual rate. Note that this average should be calculated as a geometric mean. For instance the 2020 to 2030 period the average growth rates is calculated as:

$$Average\ annual\ GDP\ growth\ rate_{\ 2030/2020} = \left(\frac{GDP_{\ 2030}}{GDP_{\ 2020}}\right)^{\left(\frac{1}{10}\right)} - 1$$

"Population (millions)" represents the national population in millions.

"GDP (billion USD 2015)" represents GDP in constant 2015 prices.

Note: The Secretariat will update the GDP and population figures submitted with those published in OECD National Accounts prior to the publication of the database.

Table 3 – Emission savings from CCUS

Decarbonizing the energy system can only be achieved with a broad suite of technologies. Carbon capture, utilization and storage (CCUS) is considered one of the components of the future technology mix as it will allow reducing emissions across hard-to-abate sectors. Hence, CCUS has become a critical part of long-term strategies for achieving energy and climate targets.

This table should be used to report any emission savings associated with CCUS across the energy supply, transformation and consumption sectors. The data should be reported for latest three historical years, the provisional year as well as projections.

Data should be reported in kilo tonnes of CO_2 avoided ($ktCO_2$). The table includes the following categories:

"Total" represents the total emission savings through CCUS across the energy landscape.

"Natural gas processing" represents the emission savings through CCUS at natural gas processing plants.

"Manufacturing" represents the emission savings associated with CCUS across the manufacturing sectors, including ammonia production, Iron and steel and cement production.

"Electricity and heat generation" represents the emission savings associated with CCUS in power generation.

"Hydrogen and synthetic fuel production" represents the emission savings associated with CCUS in the production of blue hydrogen and other synthetic fuels.

"Other" represents the emission savings associated with CCUS in other areas of the energy supply, transformation and consumption not defined above.

CSV Import and Export

The data compliers have an option to import and export the data in CSV format. This could be a useful tool to automatize the data import and easily extract the data in a desired format. The details on how to use these functions are outlined below.

Note: **if multiple scenarios are available**, the user can save this questionnaire / extract the corresponding csv, then change the scenario and report the data for the alternative scenario (s). This scenario information will be included in the exported CSV file.

Importing projections data from CSVs

The data providers can load data from a CSV file to fill the tables for projections. The CSV import function is included on the **"Data Import & Export"** tab.

In order to import the data using this function, the CSVs prepared for import should include the data with code names which match the structure of the data included in the questionnaire. The table below lists the corresponding codes for all of the Flows, Products included in all three tables of the questionnaire.

FLOWS	
Table 1	
Long name	**Code**
Production (+)	INDPROD
Imports (+)	IMPORTS
Exports (–)	EXPORTS
International marine bunkers (–)	MARBUNK
International aviation bunkers (–)	AVBUNK
Stock changes (±)	STOCKCHA
Total energy supply	TES
Transformation processes & Energy industry own use	TRANENER
Electricity, CHP & heat plants (±)	ELECHEAT
Other transformation processes (±)	TRANOTH
Own use and Losses	OWNUSE
Statistical differences (±)	STATDIFF
Total Final Consumption	TFC
Industry (+)	TOTIND
Transport (+)	TOTTRANS
of which: Road (+)	ROAD

Other (+)	TOTOTHER
of which: Residential (+)	RESIDENT
of which: Commercial and Public Services (+)	COMMPUB
Non-energy use (+)	NONENUSE
of which: chemical/petrochemical (+)	NECHEM
Elec. Gen. Exc. Pumped storage (TWh) (+)	ELOUTPUT
Heat generated (PJ) (+)	HEATOUT
Memo: Electrical capacities (MW)	ELECAP
Memo: Input to Hydrogen & Synthetic fuels production	INH2PROD
Memo: Input to Heat pump	INHEATPUMP
Table 2	
Long name	**Code**
GDP Growth Rates (%)	GDPGR
Population (Millions)	POPULATION
GDP (billion USD 2015)	GDP
Table 3	
Long name	**Code**
Total	CCTOTAL
Natural gas processing	CCNGPROC
Manufacturing	CCMANUFACT
Electricity and heat generation	CCELECHEAT
Hydrogen and synthetic fuel production	CCH2PROD
Other	CCOTHER

PRODUCTS	
Table 1	
Long name	**Code**
Coal / Oil shale	COAL
Peat	PEAT
Oil	OIL
Natural gas	NATGAS

Nuclear	NUCLEAR
Hydro	HYDRO
Wind	WIND
Geothermal	GEOTHERM
Solar	SOLAR
Tide, Etc.	TIDEOTHER
Biofuels & renewable waste	COMRENEW
Non-renewable waste	NRENWASTE
Electricity	ELECTR
Heat	HEAT
Total	TOTAL
Memo: Offshore Wind	MWINDOFF
Memo: Hydrogen & Synthetic fuels	MH2SYNFUEL
Memo: Heat pump	MHEATPUMP
Table 2	
Long name	**Code**
N/A	TOTAL
Table 3	
Long name	**Code**
N/A	TOTAL

The table below lists the corresponding codes for the Scenarios:

SCENARIOS	
Long name	**Code**
Business as usual	BAU
Stated policies	STEPS
Aspirational – achieving national targets	ASPTARGET
Aspirational – achieving defined outcomes	ASPOUTCOME
Other	OTHER

The CSV file name used for importing data should be in the following format: *"Country_Scenario_SLT.csv", e.g. "AUSTRALIA_BAU_SLT.csv".*

In order to use CSV import function the steps listed below should be followed:

For importing the projections data corresponding to Table 1 and Table 3:

- On the **"Data Import & Export"** tab and in cell B10, indicate the import file path in the following format: *"C:/xxx/xxxx", e.g. "C:/Users/Dupont/Documents".*

- On the **"Data Import & Export"** tab and in cell B11, indicate the country name using capital letters.

- On the **"Data Import & Export"** tab and in cell B12, select the scenario category from the provided drop-down list.

- Prepare and place a CSV file including the projections data corresponding to Table 1 and Table 3 in the following format considering the codes as listed in the table above:

  "Country","Scenario","Product","Flow","2030","2040","2050"

  e.g. "AUSTRALIA","BAU","COAL","INDPROD","100","60","30"
  e.g. "AUSTRALIA","BAU","TOTAL","CCTOTAL","1200","800","1600"

- Click on the **"Import energy projections (Table 1 &3)"** button.

For importing the projections data corresponding to Table 2:

- On the **"Data Import & Export"** tab and in cell B10, indicate the import file path in the following format: *"C:/xxx/xxxx", e.g. "C:/Users/Dupont/Documents".*

- On the **"Data Import & Export"** tab and in cell B11, indicate the country name using capital letters.

- On the **"Data Import & Export"** tab and in cell B12, select the scenario category from the provided drop-down list.

- Prepare and place a CSV file including the projections data corresponding to Table 2 in the following format considering the codes as listed in the table above:

  "Country","Scenario","Product","Flow","2030","2040","2050"

  e.g. "AUSTRALIA","BAU","TOTAL","GDPGR","2","3","4"

- Click on the **"Import macro-economic projections (Table 2)"** button.

Following the above steps, the forecast data will be copied in the three data tables.

Exporting projections data in CSVs

Similarly, the data providers can export the data corresponding to the projections data in a CSV format. This includes the respective data included in all three tables. The CSV export function is included on the **"Data Import & Export"** tab. In order to use this function the steps listed below should be followed:

- On the **"Data Import & Export"** tab and in cell B14, indicate the export file path in the following format: *"C:/xxx/xxxx/", e.g. "C:/Users/Dupont/Documents/".*
- Click on the **"Export all projections"** button.

Following the above steps, a CSV which includes all the projections data includes in the three tables, will be saved in the indicated location, under the name *"Country_Scenario_SLT.csv", e.g. "AUSTRALIA_BAU_SLT.csv".*

5. Energy transitions indicators and graphs

A new functionality allows to populate various indicators and produce graphics based on the reported data, to support data validation and better tracking across historical and projection periods.

Accurate and up-to-date indicators are essential to assess how countries energy systems are evolving and to identify gaps and opportunities for policy decisions. No single indicator can fully capture the complexity of energy transitions; however, if taken together, a set of indicators can unpack the underlying drivers of energy supply and demand changes, and the energy sector's contribution to greenhouse gas (GHG) emissions.

This section describes the underlying methodology for deriving the transition indicators presented within the questionnaire on the **"Indicators"** sheet, to help with interpretation.

The indicators and their graphical representations are divided into three main categories including: i) Energy production and consumption; ii) GHG emissions from fuel combustion; iii) Electricity/heat generation and emissions; as detailed below. Please note that GHG emissions estimations are only provided as benchmark estimate and do not replace official national submissions.

By clicking on the respective links located on the top left hand side of the **"Indicators"** sheet, users can navigate through the page to view the corresponding tables and graphical representation included for each indicator.

Energy production and consumption

This section includes a set of transition indicators which correspond to energy supply and consumption including sectoral disaggregation.

The indicators listed below are taken directly from the data submitted in Table 1. However, the energy units have been all converted to units of joules in an effort to facilitate analysis and comparison with other sources.

- **Production by source (TJ)**
- **Total Energy Supply (TES) by source (TJ)**
- **Total Final Energy Consumption (TFEC) by fuel (TJ)**
- **Total consumption by sector (TJ)**
- **Industry energy consumption by source (TJ)**
- **Transport energy consumption by source (TJ)**
- **Road transport energy consumption by source (TJ)**
- **Other sectors energy consumption by source (TJ)**
- **Residential energy consumption by source (TJ)**
- **Commercial and public services energy consumption by source (TJ)**
- **Non-energy use by source (TJ)**
- **Electricity consumption by sector (EJ)**
- **Heat consumption by sector (EJ)**
- **Total input to electricity, CHP & heat plants (TJ)**

The following listed indicators are derived from the data submitted in Table 1 and Table 2 as detailed below:

- **Energy intensity of the economy (MJ per USD):**

Similar to the Sustainable Development Goal (SDG) 7.3.1 indicator, this indicator is measured in terms of primary energy supply and GDP as a proxy for energy efficiency. Note that due the availability of the data submitted in the questionnaire, the GDP used for deriving this indicator is represented in constant terms at exchange rates. However, the official SDG 7.3.1 indicator is measured in constant terms at purchasing power parities[6].

This indicator is calculated as:

$$Energy\ Intensity = \frac{TES}{GDP}$$

Where:
TES: Total energy supply (reported in Table 1)
GDP: Gross Domestic Product (extrapolated based on the average annual growth rate reported in Table 2 and the latest available absolute figure available from the OECD National accounts).

- **Final Consumption per GDP (MJ per USD)**

This indicator is calculated as:

$$Final\ consumption\ per\ GDP = \frac{TFC}{GDP}$$

Where:
TFC: Total Final Consumption (reported in Table 1)
GDP: Gross Domestic Product (extrapolated based on the average annual growth rate reported in Table 2 and the latest available absolute figure available from the OECD National accounts).

- **Energy supply per capita (GJ per Capita)**

This indicator is calculated as:

$$Energy\ supply\ per\ capita = \frac{TES}{Population}$$

Where:
TES: Total energy supply (reported in Table 1)
$Population$: National population (reported in Table 2)

- **Final consumption per capita (GJ per Capita)**

This indicator is calculated as:

$$Final\ consumption\ per\ capita = \frac{TFC}{Population}$$

[6] For more information on the methodology, please refer to the official SDG 7.3.1 metadata available at: https://unstats.un.org/sdgs/metadata/files/Metadata-07-03-01.pdf.

Where:
TFC: Total Final Consumption (reported in Table 1)
$Population$: National population (reported in Table 2)

- **Other non-specified energy consumption by source (TJ)**

This indicator represents the final energy consumption excluding industry, transport, residential and commercial and public services sectors. In other words it includes the energy consumption corresponding to agriculture/forestry, fishing and final consumption not elsewhere specified.

The indicator is derived as

$$\begin{aligned} Other\ non-specified\ energy\ consumption\ _p \\ &= Other\ sectors\ energy\ consumption\ _p \\ &- \big(Residential\ energy\ consumption\ _p \\ &+ Commerical\ and\ public\ services\ energy\ consumption\ _p\big) \end{aligned}$$

Where:

$Other\ sectors\ energy\ consumption\ _p$*:* Final consumption of all end-use sectors besides Industry and transport of energy product *p* (reported in Table 1)

$Residential\ energy\ consumption\ _p$*:* Residential consumption of energy product *p* (reported in Table 1)

$Commerical\ and\ public\ services\ energy\ consumption\ _p$: Commercial and public services consumption of energy product *p* (reported in Table 1)

- **Energy self-sufficiency (%)**

Self-sufficiency is an indicator representing the portion of the total energy demand which is met by the Indigenous production and can be used as a proxy to understand the country's dependence on energy imports.

This indicator is calculated as

$$Self\ sufficiency_p = \frac{Prodution_p}{TES_p}$$

Where:

$Production_p$: Indigenous production of energy product *p. This includes "Oil", "Coal/Oil Shale and Peat", "Natural gas" and "Total"* (reported in Table 1)

TES_p: Total energy supply of energy product *p* (reported in Table 1)

- **Renewables energy share in total energy supply (%):**

This indicator represents the share of renewable sources in total energy supply and is calculated as

$$\%TES_{RES} = \frac{TES_{RES}}{TES_{TOTAL}}$$

Where:

TES_{Total}: Total energy supply of all energy products (reported in Table 1)
TEC_{RES}: Total energy supply of renewable energy sources which includes: hydro, wind, solar, geothermal, tide, etc. and biofuels and renewable waste (reported in Table 1)

- **Renewable energy share in the total final energy consumption (%) (SDG 7.2.1):**

The indicator is used to track SDG 7.2, which is to increase substantially the share of renewable energy in the global energy mix by 2030. The indicator is derived using the same methodology corresponding to the official SDG 7.2.1 indicator which is defines as the share of renewable energy in total final energy consumption.

The denominator is the total final energy consumption of all energy products (as defined in Table 1) while the numerator, the renewable energy consumption, is a series of calculations defined as: the direct consumption of renewable energy sources plus the final consumption of gross electricity and heat that is estimated to have come from renewable sources. This estimation allocates the amount of electricity and heat consumption to renewable sources based on the share of renewables in gross production in order to perform the calculation at the final energy level[7].

This indicator is calculated as

$$\%TFEC_{RES} = \frac{TFEC_{RES} + \left(TFEC_{ELE} \times \frac{ELE_{RES}}{ELE_{TOTAL}}\right) + \left(TFEC_{HEAT} \times \frac{HEAT_{RES}}{HEAT_{TOTAL}}\right)}{TFEC_{TOTAL}}$$

Where:

$TFEC_{TOTAL}$: Total final energy consumption is the sum of final energy consumption in the transport, industry, and other sectors (also equivalent to the total final consumption minus non-energy use)
$TFEC_{RES}$: Direct final energy consumption of renewable energy sources which include hydro, wind, solar, geothermal, tide, etc. and biofuels and renewable waste (reported in Table 1)
$TFEC_{ELE}$: Final consumption of gross electricity (reported in Table 1)
$TFEC_{HEAT}$: Final consumption of gross heat (reported in Table 1)
ELE: Gross electricity production (reported in Table 1)
$HEAT$: Gross heat production (reported in Table 1)

- **Fossil energy share in energy supply (%):**

This indicator represents the share of fossil fuels in total energy supply and is calculated as

$$\%TES_{FOS} = \frac{TES_{FOS}}{TES_{TOTAL}}$$

Where:

[7] For more information on the methodology, please refer to the official SDG 7.2.1 metadata available at: https://unstats.un.org/sdgs/metadata/files/Metadata-07-02-01.pdf.

TES_{Total}: Total energy supply of all energy products (reported in Table 1)
TEC_{FOS}: Total energy supply of fossil fuels which include coal/oil shale, peat, oil, natural gas and non-renewable waste (reported in Table 1)

- **Fossil energy share in final energy consumption (%):**

This indicator is calculated as

$$\%TFEC_{FOS} = \frac{TFEC_{FOS} + \left(TFEC_{ELE} \times \frac{ELE_{FOS}}{ELE_{TOTAL}}\right) + \left(TFEC_{HEAT} \times \frac{HEAT_{FOS}}{HEAT_{TOTAL}}\right)}{TFEC_{TOTAL}}$$

Where:
$TFEC_{TOTAL}$: Total final energy consumption is the sum of final energy consumption in the transport, industry, and other sectors (also equivalent to the total final consumption minus non-energy use)
$TFEC_{FOS}$: Direct final energy consumption of fossil fuels which include coal/oil shale, peat, oil, natural gas and non-renewable waste (reported in Table 1)
$TFEC_{ELE}$: Final consumption of gross electricity (reported in Table 1)
$TFEC_{HEAT}$: Final consumption of gross heat (reported in Table 1)
ELE: Gross electricity production (reported in Table 1)
$HEAT$: Gross heat production (reported in Table 1)

Greenhouse gas (GHG) emissions from fuel combustion

This section includes a set of transition indicators which include estimated GHG emissions and respective indicators.

The included historical GHG emissions from fuel combustion are taken directly from the IEA global database of greenhouse gas emissions from energy. These estimates are obtained following harmonised definitions and comparable methodologies across countries. They do not represent an official source for national submissions, as national administrations should use the best available country specific information to complete their emissions reporting.

The estimated emission figures for projection years are derived based on the submitted total energy supply data by fuel category in the questionnaire. More details are provided in the following sections.

The following listed indicators are derived from the data submitted in Table 1 and Table 2 as detailed below:

- **CO_2 and GHG emissions from fuel combustion by source (Mt CO_2 and Mt CO_{2eq})**

CO_2 from fuel combustion presents total CO_2 emissions from fuel combustion. This includes CO_2 emissions from fuel combustion in *IPCC Source/Sink Category 1 A Fuel Combustion Activities* and those, which may be reallocated to *IPCC Source/Sink Category 2 Industrial Processes and Product Use* under the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Similarly GHG from fuel combustion presents total greenhouse gas emissions from fuel combustion including CO_2, CH_4 and N_2O corresponding to the same IPCC categories.

Note that according to the *2006 IPCC Guidelines*, CO_2 emissions from combustion of biofuels and renewable waste are not included in the emission estimates from energy; while, the associated non-CO_2 (CH_4 and N_2O) emissions are taken into account. However, the GHG estimates included in this tool, exclude the non-CO_2 emissions from combustion of renewable sources, which in the case of the IEA member countries correspond to a minor percentage of total emissions from fuel combustion.

For the historical years the estimates are demand-based estimates from the IEA global database of greenhouse gas emissions from energy, where The IEA uses the (Tier 1) methodology to estimate GHG emissions from fuel combustion based on the *2006 IPCC Guidelines*. For more details on the underlying methodology please refer to the respective database documentation file.

However for the projection years and due to the absence of demand side data, the indicators are derived based on the submitted total energy supply data by fuel category in the questionnaire, and the respective average fuels-specific carbon intensities for the latest three historical years as detailed below:

$$CO_2 \text{ or } GHG \text{ Emissions from fuel combustion by source} = \sum_p TES_p \times EF_{p,y} \quad (1)$$

Where:

$Emissions$: Total GHG emissions (expressed in Mt CO_{2eq}) or CO_2 only emissions (expressed in Mt CO_2)
EF_p: Emission factors of fossil energy product *p* expressed in CO_2 / TJ or in CO_{2eq} / TJ
However, given that the fossil energy products *"Oil", "Coal/Oil Shale and Peat"* and *"Other"* reported in the questionnaire aggregate different products with various emission factors, an average emission factor based on the average mix of products from the last 3 years is calculated, according to the following formula:

$$EF_{p,y} = \frac{1}{3}\sum_{i}\left[\left(\frac{Emissions_{p,y-1}}{TES_{p,y-1}}\right) + \left(\frac{Emissions_{p,y-2}}{TES_{p,y-2}}\right) + \left(\frac{Emissions_{p,y-3}}{TES_{p,y-3}}\right)\right]$$

Where:
$EF_{p,y}$: Average emission factors for product *p* (applied in the calculation (1) for projection years)
p: Aggregate product *"Oil", "Coal/Oil Shale and Peat"* and *"Other".* Note that "*Natural gas*" product refers to one single standard emission factor in the *2006 IPCC Guidelines*.
$Emissions_{p,y-1/y-2/y-3}$: Total GHG (or CO_2 only) demand based emission estimates of the aggregated fuel *p* from the latest three historical years.
$TES_{p,y-1/y-2/y-3}$: Total energy supply of aggregated fuel *p* from the latest three historical years

- **CO_2 and GHG emissions from fuel combustion by final consumption sectors (Mt CO_2 and Mt CO_{2eq})**

Similar to the total CO_2 (GHG) from fuel combustion as outlined above, the sectoral emissions include emissions corresponding to *IPCC Source/Sink Category 1 A Fuel Combustion Activities* and those, which may be reallocated to *IPCC Source/Sink Category 2 Industrial Processes and Product Use* under the *2006 IPCC Guidelines*.

For the historical years the estimates are demand-based estimates from the IEA global database of greenhouse gas emissions from energy, where The IEA uses the (Tier 1) methodology to estimate GHG emissions from fuel combustion based on the *2006 IPCC Guidelines* and the sectoral consumption data.

However for the projection years, the indicators are derived based on the submitted sectoral consumption data by fuel category in the questionnaire, and the respective sectoral average carbon intensities for the latest three historical.

$$Emissions_i = \sum_{p} FC_{i,p} * EF_{p,y} \ (1)$$

Where:
$FC_{i,p}$: Final consumption of fossil energy product *p* in sector *i* (from Table 1).
$EF_{p,y}$: Average emission factors for product *p* (applied in the calculation (1) from year *y* onwards)

$$EF_{p,y} = \frac{1}{3}\sum_{p}\left[\left(\frac{Emissions_{p,y-1}}{FC_{p,y-1}}\right) + \left(\frac{Emissions_{p,y-2}}{FC_{p,y-2}}\right) + \left(\frac{Emissions_{p,y-3}}{FC_{p,y-3}}\right)\right]$$

Where:

p: Aggregate product *"Oil", "Coal/Oil Shale and Peat"* and *"Other".* Note that "*Natural gas*" product refers to one single standard emission factor in the *2006 IPCC Guidelines*.
$Emissions_{p,y-1/y-2/y-3}$: Sectoral GHG (or CO_2 only) demand based emission estimates of the aggregated fuel *p* from the latest three historical years.
$FC_{p,y-1/y-2/y-3}$: Final sectoral consumption of aggregated fuel *p* from the latest three historical years

- **CO_2 and GHG emissions from fuel combustion per capita (tonnes CO_2/Cap and tonnes CO_{2eq} / Cap)**

This indicator is calculated as

$$Emissions\ per\ capita = \frac{Emissions}{Population}$$

Where:

$Emissions$: Total GHG (expressed in Mt CO_{2eq}) or CO_2 emissions (expressed in Mt CO_2) from fuel combustion (estimated per above methodology)
$Population$: National population in millions (reported in Table 2)

- **CO_2 and GHG emissions from fuel combustion per GDP (kg CO_2/USD and kg CO_{2eq}/USD)**

This indicator is calculated as

$$Emissions\ per\ GDP = \frac{Emissions}{GDP}$$

Where:

$Emissions$: Total GHG (expressed in Mt CO_{2eq}) or CO_2 emissions (expressed in Mt CO_2) from fuel combustion (estimated per above methodology)
GDP: Gross Domestic Product in billion USD 2015 (extrapolated based on the average annual growth rate reported in Table 2 and the latest available absolute figure available from the OECD National accounts).

- **CO_2 and GHG emissions per energy consumption (tonnes CO_2/TJ and tonnes CO_{2eq}/TJ)**

$$Emission\ intensity\ of\ the\ energy\ mix = \frac{Emissions}{TES_{Total}}$$

Where:

$Emissions$: Total GHG (expressed in Mt CO_{2eq}) or CO_2 emissions (expressed in Mt CO_2) from fuel combustion (estimated per above methodology)
TES_{Total}: Total energy supply of all energy products (reported in Table 1)

- **CO_2 emissions and drivers indices and LMDI decomposition**

Decomposition of CO_2 emissions from fuel combustion into four driving factors (Kaya decomposition), can be represented as below. However, it should be noted that there are important caveats in the use of the Kaya identity. Most important, the four terms on the right-hand side of equation should be considered neither as fundamental driving forces in themselves, nor as generally independent from each other.

$$C = P \times \frac{GDP}{P} \times \frac{TES}{GDP} \times \frac{C}{TES}$$

Where:

C: Total CO_2 emissions form fuel combustion

P: National population (reported in Table 2)

$\frac{GDP}{P}$: GDP/population

$\frac{TES}{GDP}$: Total energy supply per GDP (energy intensity of the economy)

$\frac{C}{TES}$: Emissions intensity of the energy mix

The kaya identity expresses, for a given time, CO_2 emissions as the product of population, per capita economic output (GDP/P), energy intensity of the economy (TES/GDP) and carbon intensity of the energy mix (C/TES). For the purpose of this analysis the driving forces are represented as Indices (2020=100). Because of possible non-linear interactions between terms, the sum of the percentage changes of the four factors, e.g. $(P_y-P_x)/P_x$, will not generally add up to the percentage change of CO_2 emissions $(C_y-C_x)/C_x$. However, relative changes of CO_2 emissions in time can be obtained from relative changes of the four factors as follows:

$$\frac{C_y}{C_x} = \frac{p_y}{p_x} \times \frac{(\frac{GDP}{P})_y}{(\frac{GDP}{P})_x} \times \frac{(\frac{TES}{GDP})_y}{(\frac{TES}{GDP})_x} \times \frac{(\frac{C}{TES})_y}{(\frac{C}{TES})_x}$$

Where:

x and y represent two different years.

The effect of each coefficient is then expressed in unit of CO_2 emissions (Mt CO_2) by applying the logarithmic mean divisia (LMDI) method proposed by Ang (2004)[8]. Using this method, the change in total CO_2 emissions from fuel combustion (ΔC_{Total}) between year t and a base year 0, can be computed as the sum of the changes in each of the individual factors as follows:

$$\Delta C_{Total} = \Delta C_p + \Delta C_{GDP/P} + \Delta C_{TES/GDP} + \Delta C_{C/TES}$$

The effect of the variation of each coefficient on the total emission is then calculated by applying the LMDI formula:

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[8] B. W. Ang, Decomposition analysis for policymaking in energy: which is the preferred method ? Energy Policy, 32 (9) (2004), pp. 1131–1139

$$\Delta C = \sum_i w_{i,t} \ln\left(\frac{A_{i,t}}{A_{i,0}}\right)$$

with $w_{i,t} = L(Emissions_{i,0}, Emissions_{i,t})$

Where:

$A_{i,t}$: level of coefficient *i* at time *t*

$$L(X_1, X_2) = \frac{X_2 - X_1}{\ln\left(\frac{X_2}{X_1}\right)}) \; if X_1 \neq X_2 \; and \; L(X_1, X_1) = X_1$$

In this decomposition, each effect can therefore be calculated as

$$\Delta C_p = L(C^t, C^0)\ln(\frac{p^t}{p^0})$$

$$\Delta C_{GDP/P} = L(C^t, C^0)\ln(\frac{(\frac{GDP}{P})^t}{(\frac{GDP}{P})^0})$$

$$\Delta C_{TES/GDP} = L(C^t, C^0)\ln(\frac{(\frac{TES}{GDP})^t}{(\frac{TES}{GDP})^0})$$

$$\Delta C_{C/TES} = L(C^t, C^0)\ln(\frac{(\frac{C}{TES})^t}{(\frac{C}{TES})^0})$$

Electricity/heat generation and emissions

This section includes a set of transition indicators which correspond to electricity and heat generation and corresponding GHG emissions.

The two indicators listed below are taken directly from the data submitted in Table 1.

- **Electricity output by source (TWh)**
- **Heat output by source (PJ)**

The following listed indicators are derived from the data submitted in Table 1 as detailed below:

- **Share of Renewable sources in electricity and heat generation (%)**

The below two indicators, represent the share of renewable sources in electricity and heat generation respectively and are calculated as

$$Renewable\ share_{ELE} = \frac{ELE_{RES}}{ELE_{TOTAL}} \text{ and } Renewable\ share_{HEAT} = \frac{HEAT_{RES}}{HEAT_{TOTAL}}$$

Where:
ELE_{TOTAL}: Total electricity generation excluding pumped storage (reported in Table 1)
ELE_{RES}: Electricity generation from renewable energy sources (reported in Table 1)
$HEAT_{TOTAL}$: Total heat generation (reported in Table 1)
$HEAT_{RES}$: Heat generation from renewable energy sources (reported in Table 1)
RES: Renewable Energy Sources, which include: "*Hydro*", "*Wind*", "*Geothermal*", "*Solar*", "*Tide, Etc.*" and "*Biofuels & renewable waste*".

- **Share of low-carbon sources in electricity and heat generation (%)**

The below two indicators, represent the share of low-carbon sources in electricity and heat generation respectively and are calculated as

$$Low\ carbon\ share_{ELE} = \frac{ELE_{Low\ carbon}}{ELE_{TOTAL}} \text{ and } Low\ carbon\ share_{HEAT} = \frac{HEAT_{Low\ carbon}}{HEAT_{TOTAL}}$$

Where:
ELE_{TOTAL}: Total electricity generation excluding pumped storage (reported in Table 1)
$ELE_{LowCarbon}$: Electricity generation from low-carbon energy sources (reported in Table 1)
$HEAT_{TOTAL}$: Total heat generation (reported in Table 1)
$HEAT_{LowCarbon}$: Heat generation from low-carbon energy sources (reported in Table 1)
$Low\ carbon$: Low-carbon energy sources, which include all renewables sources as defined above plus "*Nuclear*"

- **Electricity and heat generation CO_2 and GHG emissions from fuel combustion (Mt CO_2 and Mt CO_{2eq})**

Similar to the total and sectoral CO_2 (GHG) from fuel combustion as outlined above, the electricity and heat generation emissions include emissions corresponding to *IPCC Source/Sink Category 1 A Fuel Combustion Activities* and those, which may be reallocated to *IPCC Source/Sink Category 2 Industrial Processes and Product Use* under the *2006 IPCC Guidelines*.

For the historical years the estimates are demand-based estimates from the IEA global database of greenhouse gas emissions from energy, where The IEA uses the (Tier 1) methodology to estimate GHG emissions from fuel combustion based on the *2006 IPCC Guidelines* and the inputs to the power generation plants.

However for the projection years and due to the absence of demand side data, the indicators are derived based on the submitted input to generation plants data by fuel category in the questionnaire, and the respective power generation average carbon intensities for the latest three historical.

$$Emissions \quad = \sum_{p} C_p * EF_{p,y} \ (1)$$

Where:
C_p: Inputs of electricity, CHP and heat plants from aggregated fossil product *p* (from Table 1)
$EF_{p,y}$: Average power generation emission factors for product *p* (applied in the calculation (1) for projection years)

$$EF_{p,y} = \frac{1}{3}\sum_{p}\left[\left(\frac{Emissions_{p,y-1}}{C_{p,y-1}}\right) + \left(\frac{Emissions_{p,y-2}}{C_{p,y-2}}\right) + \left(\frac{Emissions_{p,y-3}}{C_{p,y-3}}\right)\right]$$

Where:
p: Aggregate product *"Oil", "Coal/Oil Shale and Peat"* and *"Other".* Note that "*Natural gas*" product refers to one single standard emission factor in the *2006 IPCC Guidelines*.
$Emissions_{p,y-1/y-2/y-3}$: Power generation GHG (or CO_2 only) demand based emission estimates of the aggregated fuel *p* from the latest three historical years.
$C_{p,y-1/y-2/y-3}$: Inputs of electricity, CHP and heat plants from aggregated fossil product *p* from the latest three historical years

- **Intensity of electricity and heat generation (ton/MJ)**

This indicator is derived from the fuel combustion emissions associated with electricity and heat generation and the electricity and heat output from the plants. The indicator is calculated as below for the historical and projection years respectively.

For **historical** years:

$$Intensity_{Electricity\ \&\ heat} = \frac{\sum_p electricity\ and\ heat\ emissions_p}{Output_{Electricity\ \&\ heat}}$$

Where:
$Electricity\ and\ heat\ emissions_p$: Demand-based estimates from the IEA global database of greenhouse gas emissions from energy, for aggregated product *P*
$Output_{Electricity\ \&\ heat}$: Total output of electricity and heat plants from all sources

For **projection** years:

$$Intensity_{Electricity\ \&\ heat} = \frac{\sum_p (Input_{\ electricity,\ \ CHP\ \&\ heat\ plants})_p \times EF_p}{Output_{Electricity\&Heat}}\ (1)$$

Where:
$Input_{\ electricity,CHP\ \&\ heat\ plants,p}$: Input of aggregated product p in electricity, CHP & heat plant
$Output_{Electricity\ \&\ heat}$: Total output of electricity and heat plants from all sources
$EF_{p,y}$: Average emission factors for product *p* (applied in the calculation (1) for projection years)

$$EF_{p,y} = \frac{1}{3}\sum_i \left[\left(\frac{Emissions_{p,y-1}}{C_{p,y-1}}\right) + \left(\frac{Emissions_{p,y-2}}{C_{p,y-2}}\right) + \left(\frac{Emissions_{p,y-3}}{C_{p,y-3}}\right)\right]$$

Where:
p: Aggregate product *"Oil", "Coal/Oil Shale and Peat"* and *"Other".* Note that "*Natural gas*" product refers to one single standard emission factor in the *2006 IPCC Guidelines*.
$Emissions_{p,y-1/y-2/y-3}$: Electricity and heat generation GHG (or CO_2 only) demand based emission estimates of the aggregated fuel *p* from the latest three historical years.
$C_{p,y-1/y-2/y-3}$: Input of aggregated fuel *p* into electricity, CHP & heat plant from the latest three historical years

- **Electricity and heat emissions and drivers indices and LMDI decomposition**

Similar to the indicators derived for total emissions from fuel combustion, the following Kaya identity can be used to decompose the evolution of the emissions related to electricity and heat generation into four main factors. This decomposition expresses, for a given time, CO_2 emissions from electricity and heat generation as the product of the carbon intensity of the fossil fuel mix (CF), the reciprocal of fossil fuel based thermal electricity and heat generation efficiency ($1/EI$), the share of electricity from fossil fuels (FS) and total electricity and heat output (EH).

$$C = (CF)\ (EI)\ (FS)\ (EH)$$

Where

$C = Emissions_{Electricity\ \&\ heat}$: Emissions from electricity and heat generation

$CF = \sum_p \frac{Input_{\ electricity,\ \ CHP\ \&\ heat\ plants,p} \times EF_p}{Input_{\ electricity,CHP\ \&\ heat\ plants,p}}$: Carbon intensity of the fossil fuel mix

$EI = \sum_p \frac{Input_{\ electricity,CHP\ \&\ heat\ plants,p}}{Output_{Electricity\ \&\ heat,p}}$: The reciprocal of fossil fuel based electricity and heat generation efficiency

$FS = \frac{Output_{Electricity\ \&\ heat,fossil}}{Output_{Electricity\ \&\ heat}}$: Share of electricity and heat from fossil fuel and non-renewable waste

$EH = Output_{Electricity\&Heat}$: Total electricity and heat output

Similar to the Kaya identity expressed for total fuel combustion emissions, due to non-linear interactions between terms, if a simple decomposition is used, the sum of the percentage changes of the four factors may not perfectly match the percentage change of total CO_2

emissions. Hence, the (LMDI) method proposed by Ang (2004)[9] has been used. Using this method, the change in total CO_2 emissions from electricity and heat generation (ΔC_{Total}) between year t and a base year 0, can be computed as the sum of the changes in each of the individual factors as follows:

$$\Delta C_{Total} = \Delta C_{CF} + \Delta C_{EI} + \Delta C_{FS} + \Delta C_{EH}$$

The effect of the variation of each coefficient on the total emission is then calculated by applying the LMDI formula:

$$\Delta C = \sum_i w_{i,t} \ln\left(\frac{A_{i,t}}{A_{i,0}}\right)$$

with $w_{i,t} = L(Emissions_{i,0}, Emissions_{i,t})$

Where :

$A_{i,t}$: level of coefficient *i* at time *t*

$$L(X_1, X_2) = \frac{X_2 - X_1}{\ln\left(\frac{X_2}{X_1}\right)}) \; if X_1 \neq X_2 \; and \; L(X_1, X_1) = X_1$$

In this decomposition, each effect can therefore be calculated as

$$\Delta C_{CF} = L(C^t, C^0)\ln(\frac{CF^t}{CF^0})$$

$$\Delta C_{EI} = L(C^t, C^0)\ln(\frac{EI^t}{EI^0})$$

$$\Delta C_{FS} = L(C^t, C^0)\ln(\frac{FS^t}{FS^0})$$

$$\Delta C_{EH} = L(C^t, C^0)\ln(\frac{EH^t}{EH^0})$$

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[9] B. W. Ang, Decomposition analysis for policymaking in energy: which is the preferred method ? Energy Policy, 32 (9) (2004), pp. 1131–1139

6. Appendix

Conversion factors

General conversion factors for energy

To	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
terajoule (TJ)	1	2.3885×10^{2}	2.3885×10^{-5}	9.478×10^{2}	2.778×10^{-1}
gigacalorie (Gcal)	4.1868×10^{-3}	1	1.000×10^{-7}	3.968	1.163×10^{-3}
million tonnes of oil equivalent (Mtoe)	4.1868×10^{4}	1.000×10^{7}	1	3.968×10^{7}	1.163×10^{4}
million British thermal units (MBtu)	1.055×10^{-3}	2.520×10^{-1}	2.520×10^{-8}	1	2.931×10^{-4}
gigawatt hour (GWh)	3.600	8.598×10^{2}	8.598×10^{-5}	3.412×10^{3}	1

Conversion factors for mass

To	kg	t	lt	st	lb
From:	multiply by:				
kilogramme (kg)	1	1.000×10^{-3}	9.842×10^{-4}	1.102×10^{-3}	2.205
tonne (t)	1.000×10^{3}	1	9.842×10^{-1}	1.102	2.205×10^{3}
long ton (lt)	1.016×10^{3}	1.016	1	1.120	2.240×10^{3}
short ton (st)	9.072×10^{2}	9.072×10^{-1}	8.929×10^{-1}	1	2.000×10^{3}
pound (lb)	4.536×10^{-1}	4.536×10^{-4}	4.464×10^{-4}	5.000×10^{-4}	1

Conversion factors for volume

To	gal U.S.	gal U.K.	bbl	ft^3	l	m^3
From:	multiply by:					
U.S. gallon (gal U.S.)	1	8.327×10^{-1}	2.381×10^{-2}	1.337×10^{-1}	3.785	3.785×10^{-3}
U.K. gallon (gal U.K.)	1.201	1	2.859×10^{-2}	1.605×10^{-1}	4.546	4.546×10^{-3}
barrel (bbl)	4.200×10^{1}	3.497×10^{1}	1	5.615	1.590×10^{2}	1.590×10^{-1}
cubic foot (ft^3)	7.481	6.229	1.781×10^{-1}	1	2.832×10^{1}	2.832×10^{-2}

To	gal U.S.	gal U.K.	bbl	ft³	l	m³
litre (l)	$2.642x10^{-1}$	$2.200x10^{-1}$	$6.290x10^{-3}$	$3.531x10^{-2}$	1	$1.000x10^{-3}$
cubic metre (m^3)	$2.642x10^{2}$	$2.200x10^{2}$	6.290	$3.531x10^{1}$	$1.000x10^{3}$	1

Decimal prefixes

10^{1}	deca (da)	10^{-1}	deci (d)
10^{2}	hecto (h)	10^{-2}	centi (c)
10^{3}	kilo (k)	10^{-3}	milli (m)
10^{6}	mega (M)	10^{-6}	micro (µ)
10^{9}	giga (G)	10^{-9}	nano (n)
10^{12}	tera (T)	10^{-12}	pico (p)
10^{15}	peta (P)	10^{-15}	femto (f)
10^{18}	exa (E)	10^{-18}	atto (a)

Geographical notes

Country/Region	Short name	Definition
Australia	AUSTRALI	Excludes the overseas territories. Data are reported on a fiscal year basis. By convention data for the fiscal year that starts on 1 July Y-1 and ends on 30 June Y are labelled as year Y.
Austria	AUSTRIA	
Belgium	BELGIUM	
Canada	CANADA	
Denmark	DENMARK	Excludes Greenland and the Faroe Islands, except prior to 1990, where data on oil for Greenland were included with the Danish statistics.
Estonia	ESTONIA	Data start in 1990. Prior to that, they are included within Former Soviet Union.
Finland	FINLAND	
France	FRANCE	Includes Monaco and excludes the overseas collectivities: New Caledonia; French Polynesia; Saint Barthélemy; Saint Martin; Saint Pierre and Miquelon; and Wallis and Futuna. Energy data for the following overseas departments: Guadeloupe; French Guiana; Martinique; Mayotte; and Réunion are included for the years from 2011 onwards, and excluded for earlier years.
Germany	GERMANY	Includes the new federal states of Germany from 1970 onwards.
Greece	GREECE	
Hungary	HUNGARY	Data start in 1965.
Ireland	IRELAND	
Israel	ISRAEL	The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law. Data start in 1971. Israel is currently seeking accession to full IEA membership (Accession country), therefore it is included in the IEA and Accession/Association countries aggregate (IEA Family), for data starting in 1971 and for the entire time series.
Italy	ITALY	Includes San Marino and the Holy See.
Japan	JAPAN	Includes Okinawa. Starting 1990, data are reported on a fiscal year basis. By convention data for the fiscal year that starts on 1 April Y and ends on 31 March Y+1 are labelled as year Y.
Korea	KOREA	Data start in 1971.

Lithuania	LITHUANIA	Lithuania is currently seeking accession to full IEA membership (Accession country), therefore it is included in the IEA and Accession/Association countries aggregate (IEA family), for data starting in 1990 and for the entire time series. Data for Lithuania are available starting in 1990. Prior to that, they are included in Former Soviet Union.
Luxembourg	LUXEMBOU	
Mexico	MEXICO	Data start in 1971.
Netherlands	NETHLAND	Excludes Suriname, Aruba and the other former Netherland Antilles (Bonaire, Curaçao, Saba, Saint Eustatius and Sint Maarten).
New Zealand	NZ	
Norway	NORWAY	
Oman	OMAN	
Poland	POLAND	
Portugal	PORTUGAL	Includes the Azores and Madeira.
Slovak Republic	SLOVAKIA	Data start in 1971.
Slovenia	SLOVENIA	Data start in 1990. Prior to that, they are included within Former Yugoslavia.
Spain	SPAIN	Includes the Canary Islands.
Sweden	SWEDEN	
Switzerland	SWITLAND	Includes Liechtenstein for the oil data. Data for other fuels do not include Liechtenstein.
Republic of Türkiye	TURKEY	
United Kingdom	UK	Shipments of coal and oil to the Channel Islands and the Isle of Man from the United Kingdom are not classed as exports. Supplies of coal and oil to these islands are, therefore, included as part of UK supply. Exports of natural gas to the Isle of Man are included with the exports to Ireland. As of the 1st of February 2020, the United Kingdom (UK) is no longer part of the European Union (EU) and has entered into a transition period until 31 December 2020. In this publication with data up to 2019, the UK is still included in the EU28 aggregate. However, it is excluded from the EU27_2020 aggregate.
United States	USA	Includes the 50 states and the District of Columbia but generally excludes all territories, and all trade between the U.S. and its territories. Oil statistics include Guam, Puerto Rico[10] and the United States Virgin Islands; trade statistics for coal include international trade to and from Puerto Rico and the United States Virgin Islands. Starting with 2017 data, inputs to and outputs from electricity and heat generation include Puerto Rico.

[10] Inputs to and outputs from electricity and heat generation up to 2016, and natural gas data for the entire time series for Puerto Rico are included under Other non-OECD Americas.

Memo: European Union - 27	EU27_2020	Refers to the EU28 aggregate with the exclusion of the United Kingdom. Namely includes Austria; Belgium; Bulgaria; Croatia; Cyprus[11]; the Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; the Netherlands; Poland; Portugal; Romania; the Slovak Republic; Slovenia; Spain and Sweden. Please note that in the interest of having comparable data, all these countries are included since 1990 despite different entry dates into the European Union.

Abbreviations

Btu: British thermal unit

CCUS: Carbon capture, utilisation and storage

GWh: gigawatt hour

kcal: kilocalorie

kg: kilogramme

kJ: kilojoule

Mt: million tonnes

m3: cubic metre

PJ: petajoule

t: metric ton

TWh: terawatt hour

TJ: terajoule

toe: tonne of oil equivalent

GCV: gross calorific value

GHGs: Greenhouse gases

HHV: higher heating value = GCV

LHV: lower heating value = NCV

NCV: net calorific value

CHP: combined heat and power

PPP: purchasing power parity

TES: total energy supply

IEA: International Energy Agency

OECD: Organisation for Economic Co-operation and Development

SDG: Sustainable Development Goals

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