SAARC ENERGY CENTRE

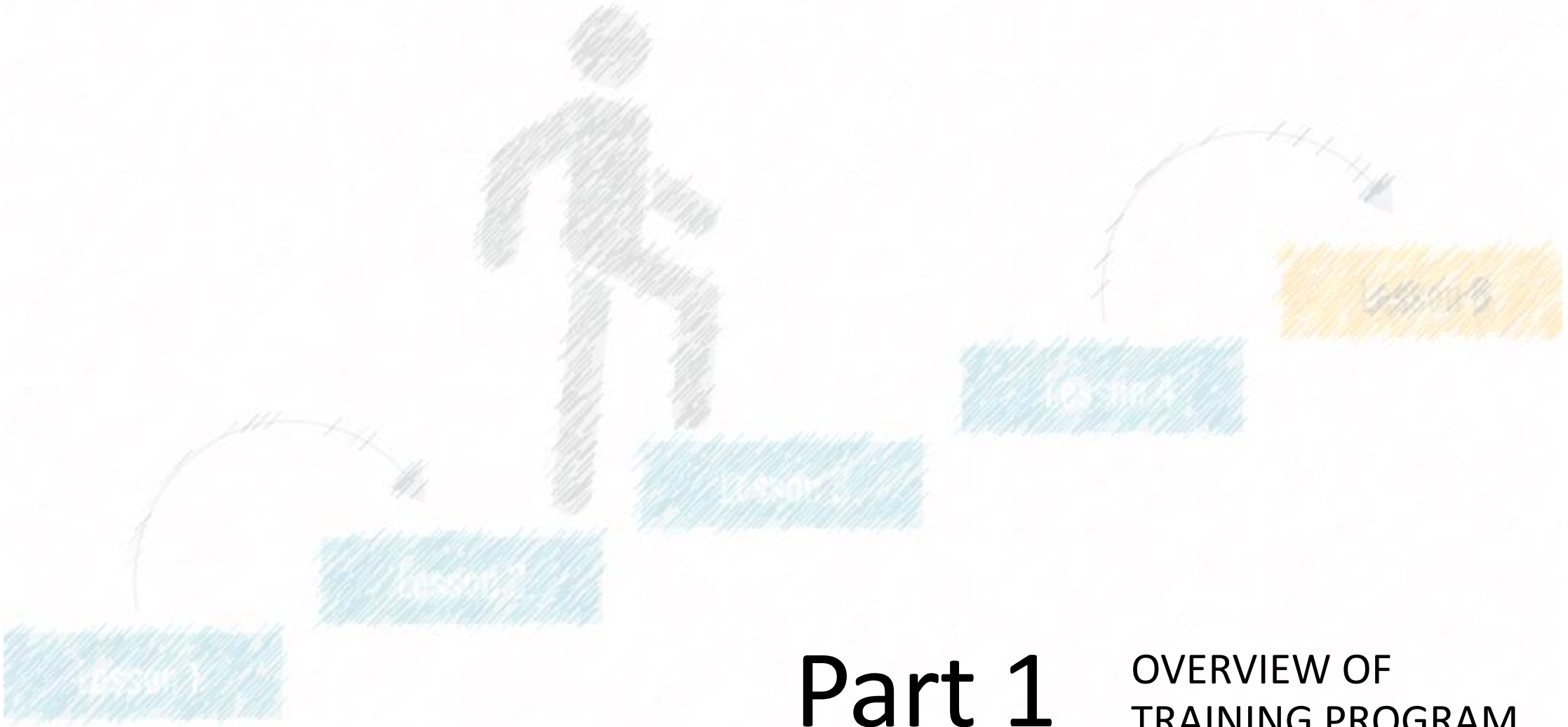
Training on Energy Statistics

DAY 1

Engr. Muhammad Faizan Khan

Consultant

SAARC Energy Center



Part 1

OVERVIEW OF
TRAINING PROGRAM

Overview of Training Program

- Importance of Data
- Role of Energy Statistics
  - Classification of Energy
  - Energy System and Energy Supply Chain
  - Energy Accounting Framework
    - Commodity Flows
    - Energy Balance Flows

Overview of Training Program (continued)

- Data Collection Methodologies
  - Sources of Energy
  - Energy Product Categorization
  - Data Collection Systems
- Exercise
  - Data collection
- Data Presentation

Overview of Training Program (continued)

- Statistical Analysis
- Tools for Data Analysis
- Units, Conversions, and Calorific Values

Part 2

IMPORTANCE OF DATA

Introduction: Energy

- Plays a crucial role in human and economic development, and in society's well being.
- Without energy, economic activity can be seriously hampered.
- Mostly consumed by industry, services, homes, and transport.
- Currently Oil is the most traded commodity.
- Neither of the conventional sources e.g. Oil, gas, coal etc. are unlimited sources.
- Growing demand for energy coupled with depleting sources/ reserves calls for a close monitoring of energy situation in a country.

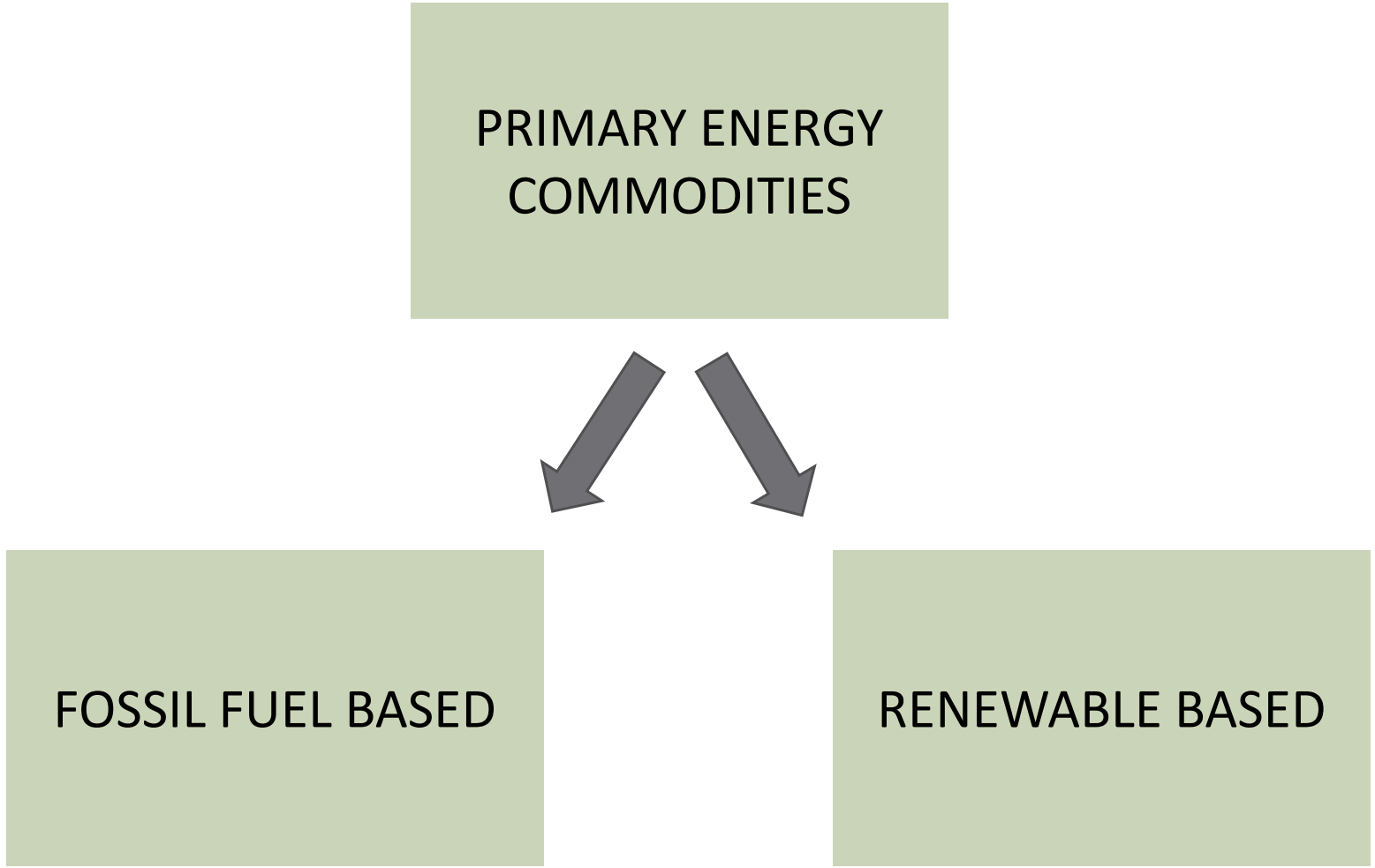
Introduction: Fuel and Energy

- Fuel is a substance that is burned as a source of heat or power.
- Heat is derived from the combustion process.
- The provision of energy as heat or power in mechanical and electrical form is the main reason behind burning fuels.

Primary and Secondary Energy Commodities

- Energy captured or extracted directly from Natural resources is termed as Primary Energy Commodity.
- Any energy Commodities that are not primary but are produced from primary commodities are called Secondary commodities.
- Secondary energy comes from **transformation** of primary or secondary energy.

Primary and Secondary Energy Commodities



Types of Energy Utilized

- Solid fossil fuels and manufactured gases
- Oil
- Natural gas
- Renewables and waste
- Electricity and heat

Introduction to Units

- PHYSICAL (OR NATURAL) UNITS
  - **Mass units**
    - Solid Fuels
    - KG, tonnes, pounds
  - **Volume units**
    - Liquids and Gases
    - Litres, cubic meters, gallons, barrels, cubic feet

Introduction to Units

- ENERGY UNITS
  - Based on calorific value or heating value of the fuel
  - Typical values
    - 26 gigajoule/tonne (GJ/t) for coal
    - 35.6 megajoule/cubic metre (MJ/m^3) for gas
  - Joules, calories, British thermal unit, thousand tons of oil equivalent, thousand tons of coal equivalent

Why Energy Statistics?

- Because they’re vital and can be used

- Few Examples
  - Households Consumption
    - Electricity, heating, fuels etc.
  - Energy Companies
    - Electricity production, fuel input, stocks, throughput etc.
  - Policy Makers
  - Energy Market Analysts
    - Gas, Electricity, oil etc.

Why Energy Statistics?

- Demand Forecasting
  - Needed for short term and long term
  - Becomes even more important when a larger share of electricity generation is from conventional hydrocarbon based/non-renewable sources.
    - Over estimation results in wastage
    - Under estimation results in peak demand periods accompanied by outages

How can Energy Data Help

- Overall Production and Consumption of Energy
- Better Policy Making
- Rationalize overall Energy Generation Mix
- Take measures in response to changing energy commodity prices
- Balance demand and supply
- Rely on Energy efficient mechanisms

How can Energy Data Help (cont'd)

- Be more receptive to climate change and its policies
- Determine appropriate share on renewables in energy mix
- Rely more on energy exports than imports
- Consider depleting sources of energy
- Identify the sectors that are energy starved
- Gauge the development of individual sectors through their energy consumption

Role of Energy Statistician

- An Energy Statistician should be aware of at least the following basic parameters
  - Conventions and definitions used for collection and presentation of energy statistics
  - Units of measurement for fuel and energy
  - Main fuel conversion processes

Quality Data is Not Available

Basic Energy information is usually not readily available because

- Market liberalization
- Additional data requests
- Budget cuts
- Diminishing expertise

Quality Data is Not Available

Possible Solutions

- Sound energy information systems
- Capacity building of professionals and statisticians

Part 3

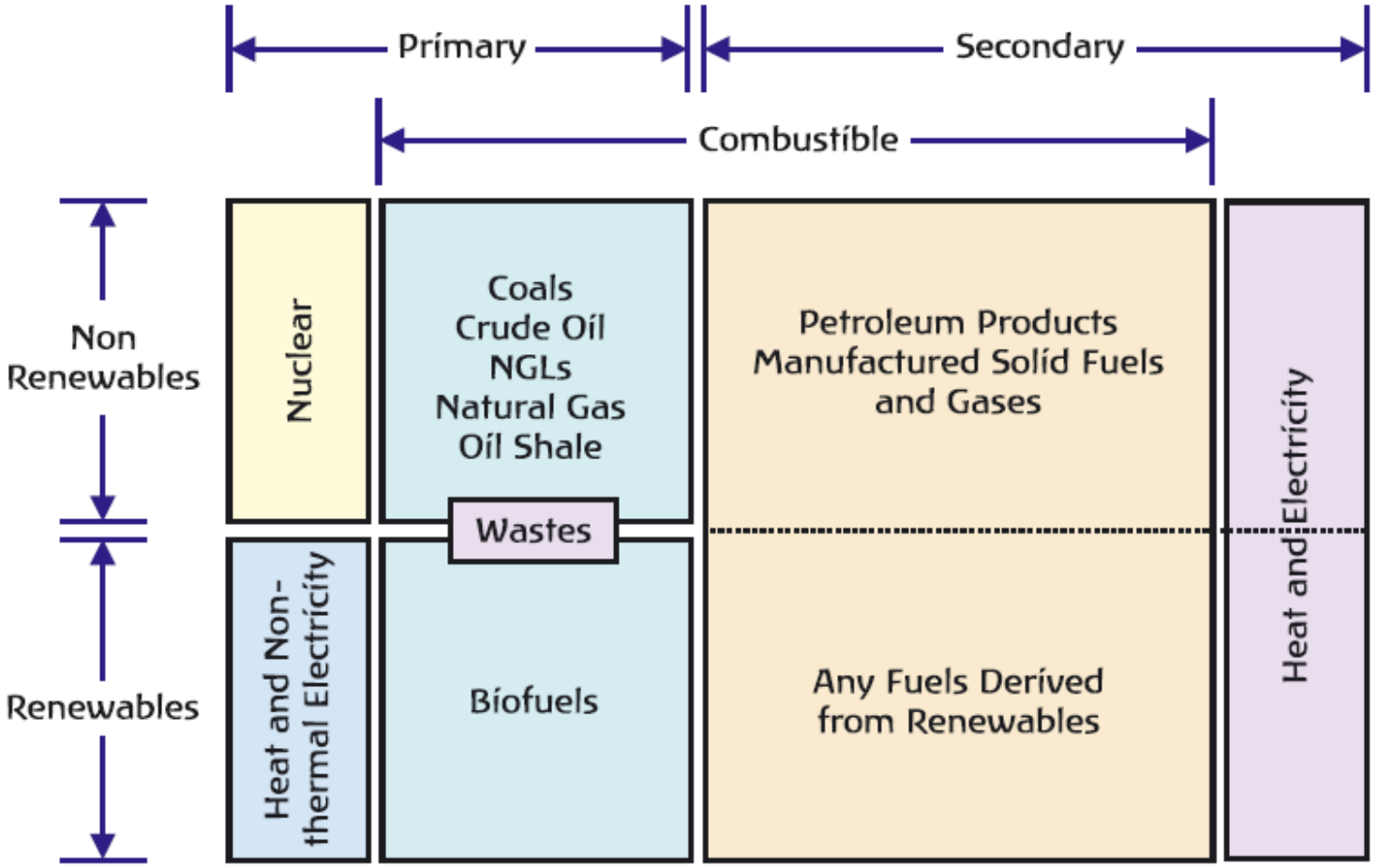
ROLE OF ENERGY STATISTICS

Role of Energy Statistics

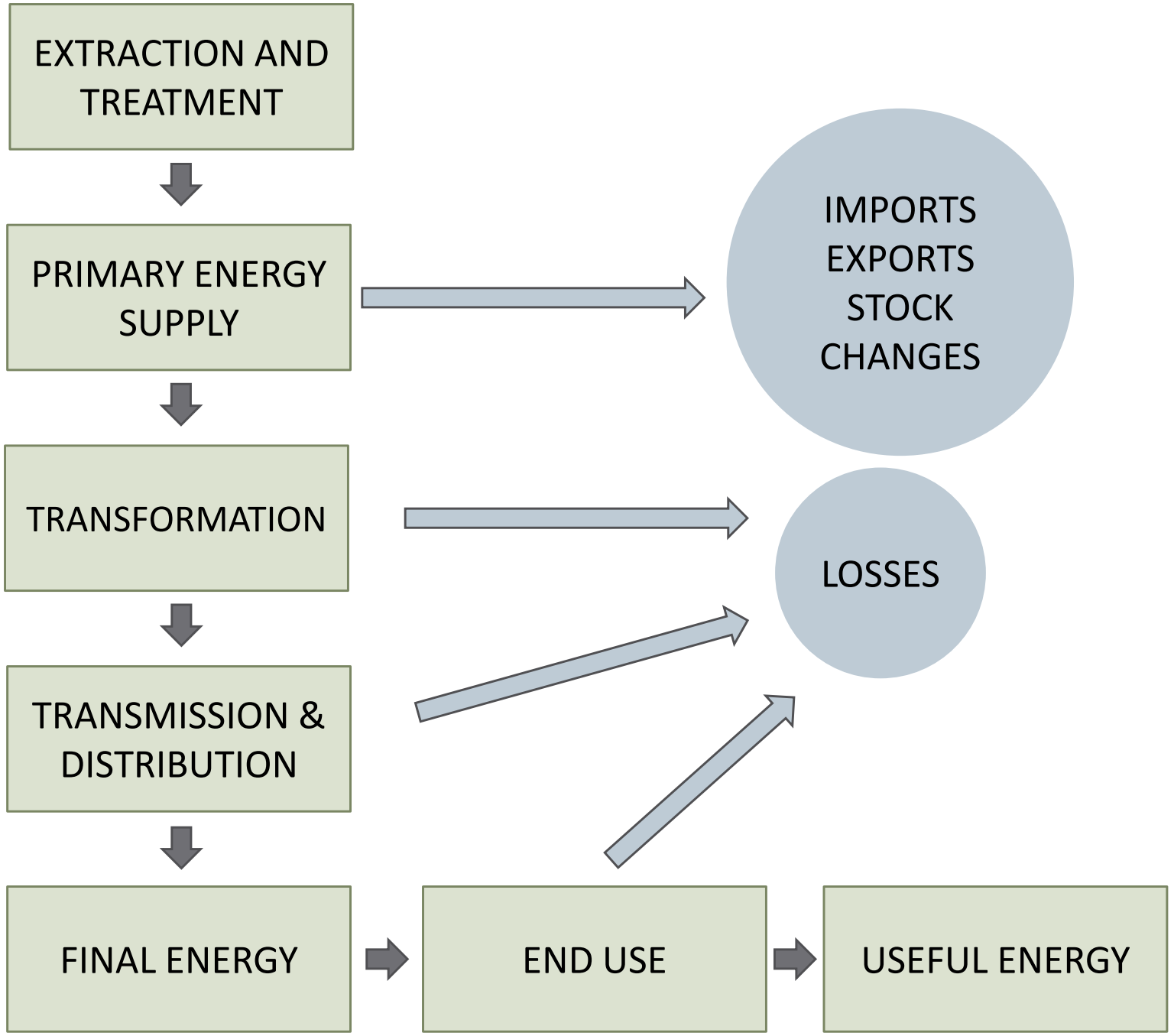
- Classification of Energy
- Energy System and Energy Supply Chain
- Energy Accounting Framework
  - Commodity Flows
  - Energy Balance Flows

Classification of Energy

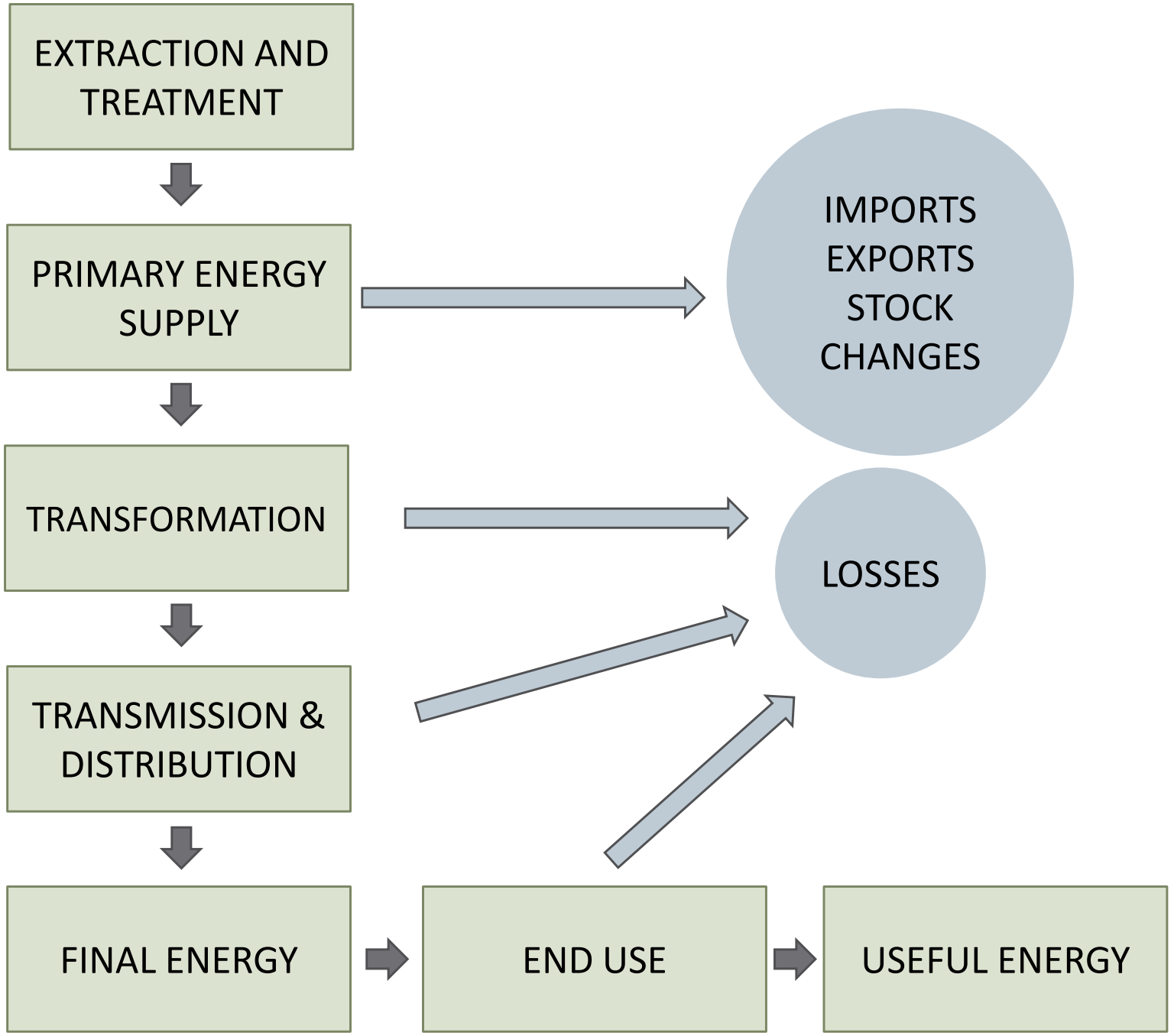
Conventionality	Renewability	
	Renewable	Non-Renewable
Commercial	Large Scale Hydro Geothermal Nuclear	Fossil Fuels Other Nuclear
Traditional/ Non-Traditional	Animal Residues Crop Residues Windmills and watermills Fuelwood (Sustainable)	Unsustainable Fuelwood
New and Novel	Solar Mini and Micro hydro Tidal and wave	Oil from Oil Sands Oil from coal and gas



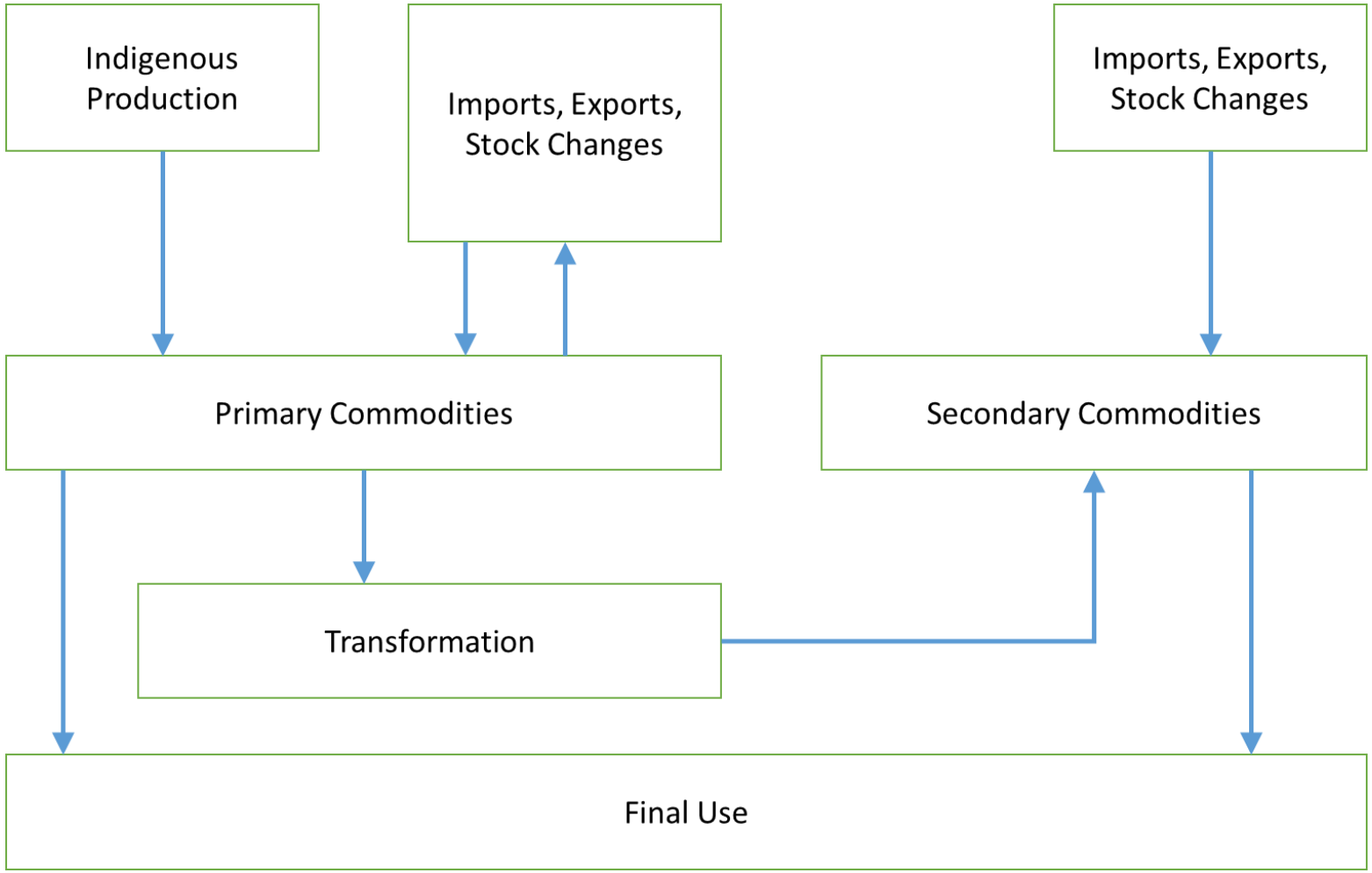
Terminology for Energy Commodities



Energy Supply System

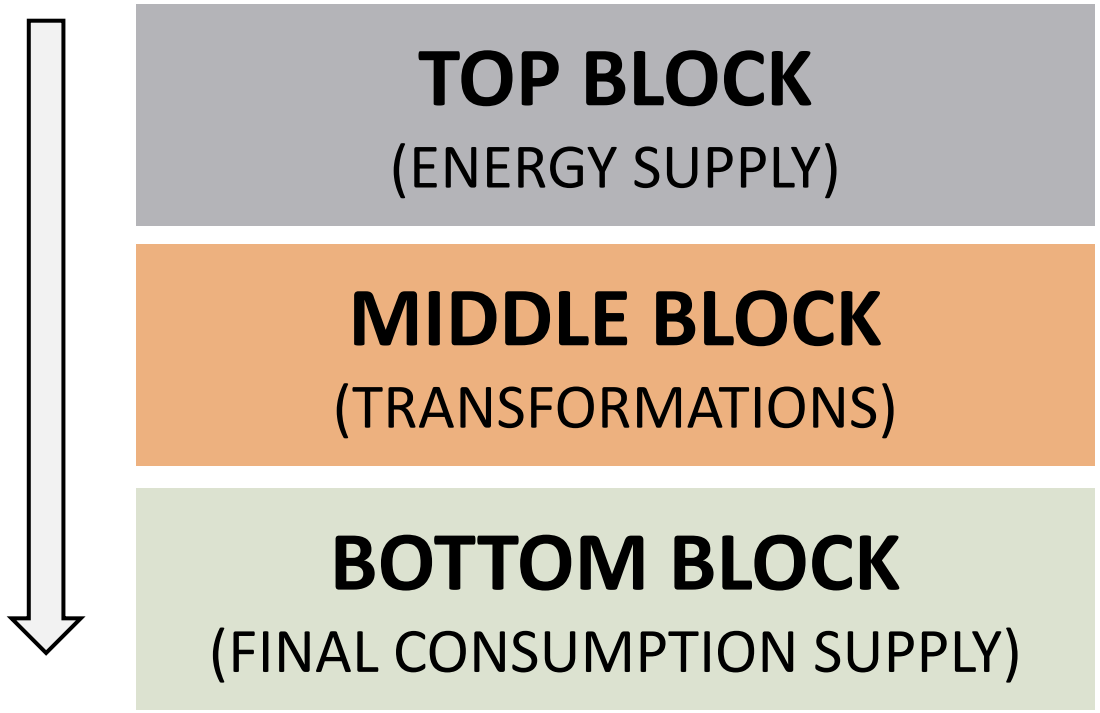


Energy Supply System



Energy Commodity Flow

The Concept of Blocks



ENERGY SUPPLY = TRANSFORMATIONS + CONSUMPTION

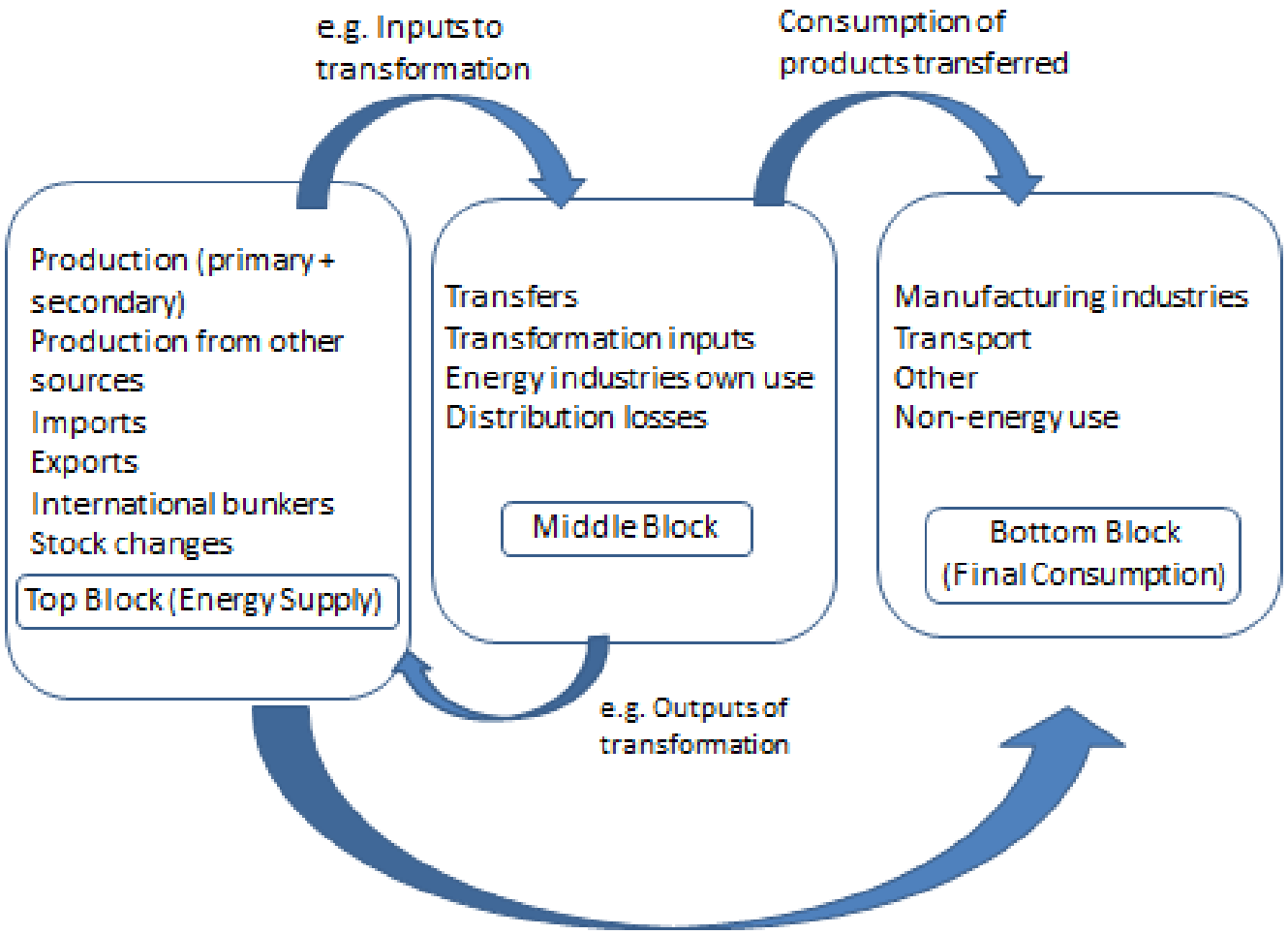
TOP BLOCK = MIDDLE BLOCK + BOTTOM BLOCK

Commodity Balances

- Energy statistics expressed in natural units can be presented in the form of ***commodity balances***

- They show the supply and use of the **energy products.**

- A commodity balance provides a check on the completeness of the data and a simple means of assembling the main statistics of each energy product.



Flows in Commodity Balance

2015 | Indicators | Balances | Coal | Electricity and Heat | Natural Gas | Oil | Renewables and Waste

Unit - 1000 tonnes	Crude oil	Natural gas liquids	Refinery feedstocks	Naphtha	Liquified petroleum gases	Motor gasoline	Aviation gasoline	Jet kerosene	Other kerosene	Gas/diesel	Fuel oil
Production	0	0	0	0	0	0	0	0	0	0	0
From other sources	0	0	0	0	0	0	0	0	0	0	0
Imports	0	0	0	0	222	169	0	93	13	619	0
Exports	0	0	0	0	0	0	0	0	0	0	0
International marine bunkers	0	0	0	0	0	0	0	0	0	0	0
International aviation bunkers	0	0	0	0	0	0	0	0	0	0	0
Stock changes	0	0	0	0	0	0	0	0	0	0	0
Domestic supply	0	0	0	0	222	169	0	0	13	619	0
Transfers	0	0	0	0	0	0	0	0	0	0	0
Statistical differences	0	0	0	0	0	0	0	0	0	0	0
Transformation	0	0	0	0	0	0	0	0	0	0	0
Electricity plants	0	0	0	0	0	0	0	0	0	0	0
CHP plants	0	0	0	0	0	0	0	0	0	0	0
Heat plants	0	0	0	0	0	0	0	0	0	0	0
Oil refineries	0	0	0	0	0	0	0	0	0	0	0
Other transformation	0	0	0	0	0	0	0	0	0	0	0
Energy industry own use	0	0	0	0	0	0	0	0	0	0	0
Losses	0	0	0	0	0	0	0	0	0	0	0
Final consumption	0	0	0	0	222	169	0	0	13	619	0
Industry	0	0	0	0	0	0	0	0	1	9	0
Transport	0	0	0	0	9	169	0	0	0	496	0
Residential	0	0	0	0	119	0	0	0	10	0	0
Commercial and public services	0	0	0	0	0	0	0	0	2	0	0
Agriculture / forestry	0	0	0	0	0	0	0	0	0	114	0
Fishing	0	0	0	0	0	0	0	0	0	0	0
Other non-specified	0	0	0	0	0	0	0	0	0	0	0
Non-energy use	0	0	0	0	0	0	0	0	0	0	0
- of which chemical/petrochemical	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

TOP BLOCK
(ENERGY SUPPLY / PRODUCTION)

MIDDLE BLOCK
(TRANSFERS / TRANSFORMATIONS)

BOTTOM BLOCK
(FINAL CONSUMPTION)

Commodity Balance Example

Importance of Sign Conventions

TOTAL ENERGY SUPPLY

+ Production (primary and secondary products)
+ Production from other sources
+ Imports of Energy
- Exports of Energy
- International (aviation and marine) bunkers
± Stock Changes

STOCK CHANGES

Initial Stock (Start of Year) – Final Stock (End of Year)

CASE 1: STOCK INCREASE (Initial = 50, Final = 100)

Stock Change = 50 – 100 = **- 50**

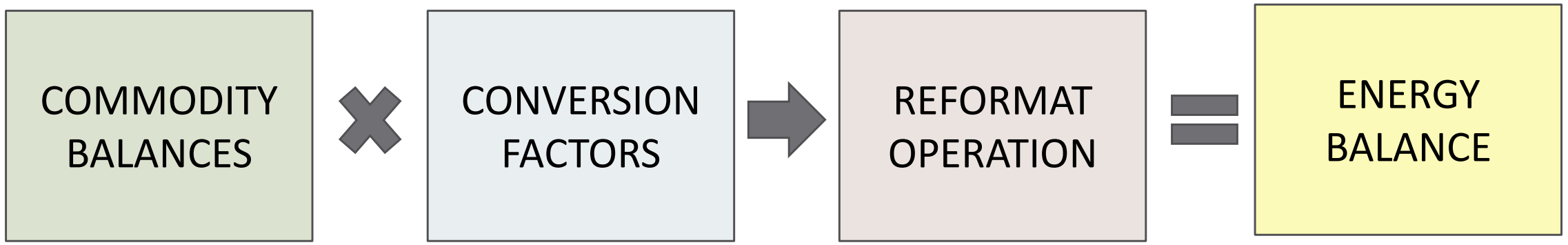
CASE 2: STOCK DECREASE (Initial = 100, Final = 50)

Stock Change = 100 – 50 = **+ 50**

Energy Balance Basics

- Requires a a **common unit** to sum together the contribution of different energy.
- Uses Energy Units
- It allows users
  - To see transformation efficiencies of fuels
  - Relative importance of the different fuel supplies in their contribution to the overall energy supply mix.

Energy Balance Construction

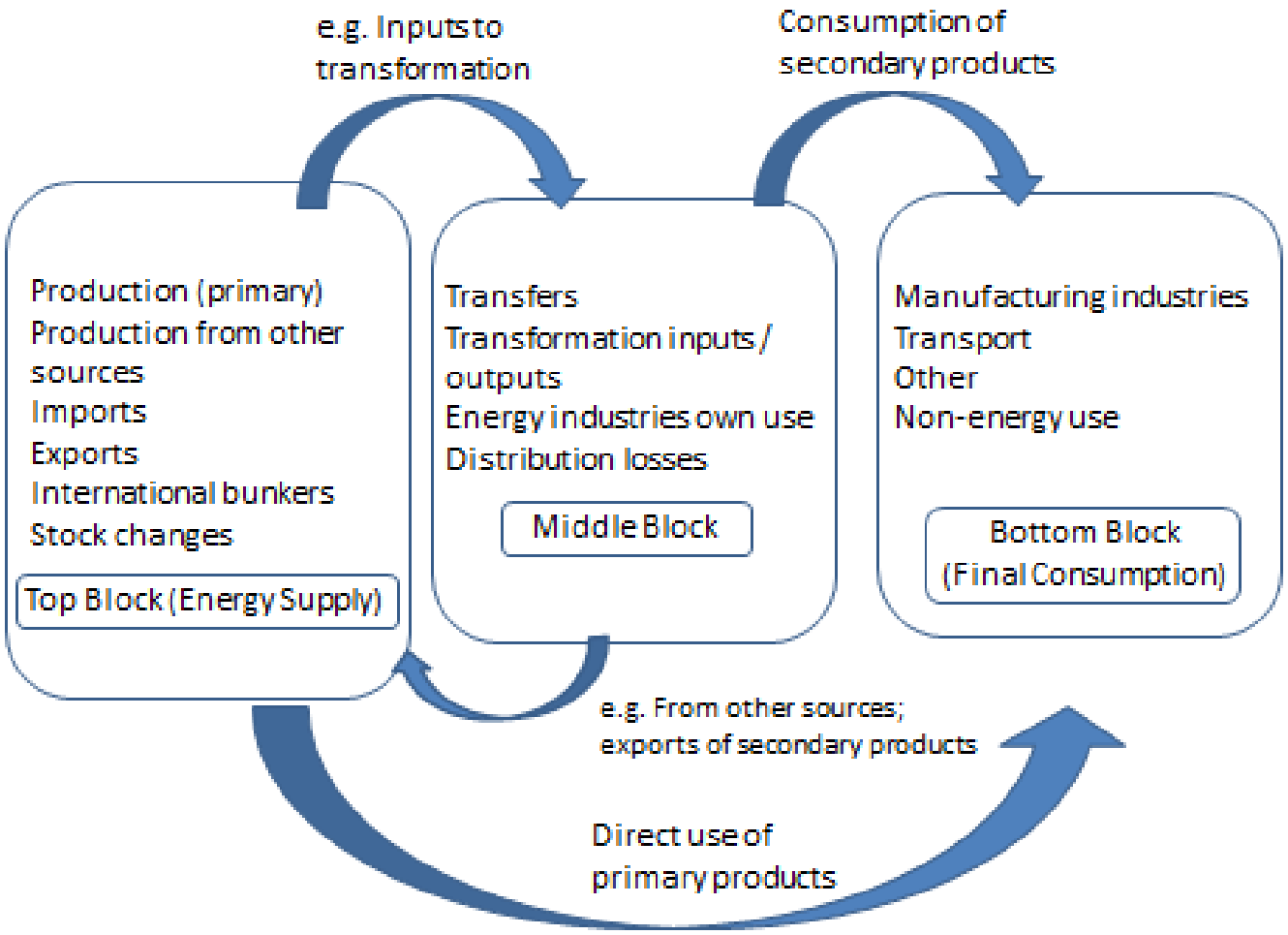


BLOCKS IN ENERGY BALANCE

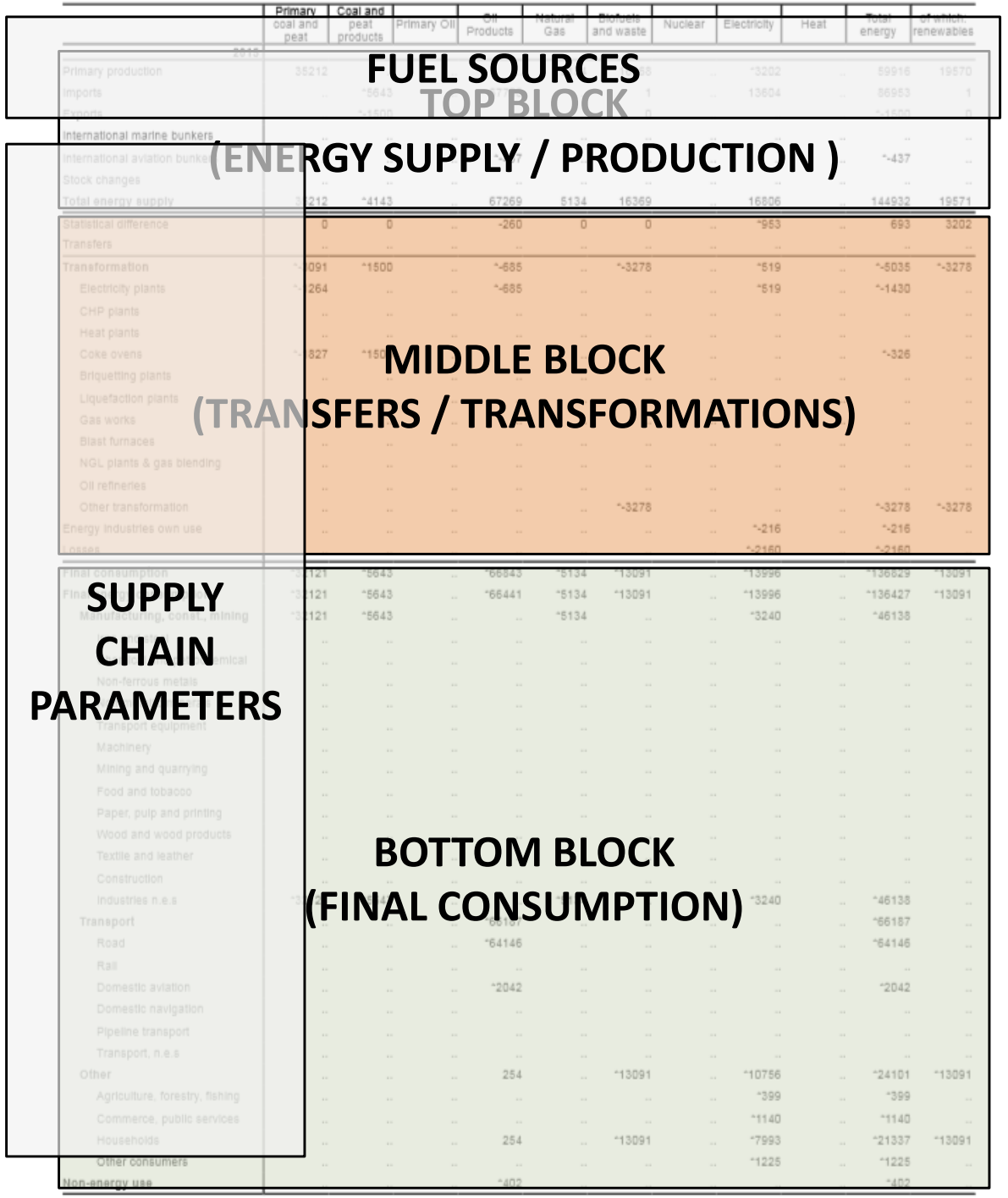
TOP BLOCK
(ENERGY SUPPLY)

MIDDLE BLOCK
(TRANSFORMATIONS)

BOTTOM BLOCK
(FINAL CONSUMPTION SUPPLY)



Flows in Energy Balance



Energy Balance Example

(Energy Balance Sheet)

Purpose of Energy Balances

The energy balance is a multi-purpose tool to

- Enhance the relevance of energy.
- Provide comprehensive information on the energy supply and demand in the national territory.
- Serve as a quality tool for energy statistics.
- Ensure comparability between different reference periods and between different countries;

Flow Definitions

Scope of Commodity and Energy Balances:

A commodity balance and an energy balance follow the territory principle i.e. the flow of energy within the country.

Any Commodity or Energy Balance Framework consists of three building blocks.

1. Top Block: Supply
2. Middle Block: Transformation Process
3. Bottom Block: Final Consumption

Each block has its own associated flows, the definitions of which are important to know in order to create an energy balance sheet.

Top Block: Supply

- Production:

In the balances, production refers to the quantities of fuels extracted or produced, calculated after any operation for removal of inert matter or impurities (e.g. sulphur from natural gas).

- From Other Sources:

All inputs of origin other than primary energy sources explicitly recognized in the tables are listed under inputs from other sources.

Top Block: Supply

- Imports and Exports

Comprise amounts having crossed the national territorial boundaries of the country whether or not customs clearance has taken place.

Top Block: Supply

- International marine bunkers:

Covers those quantities 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.

- International aviation bunkers:

Includes deliveries of aviation fuels to aircraft for international aviation. Fuels used by airlines for their road vehicles are excluded.

Top Block: Supply

- Stock changes:

Reflects the difference between opening stock levels on the first day of the year and closing levels on the last day of the year of stocks on national territory held by producers, importers, energy transformation industries and large consumers.

- Total Primary Energy Supply (TPES) (Also Total Energy Supply (TES))

Total primary energy supply (TPES) is made up of production + imports - exports - international marine bunkers - international aviation bunkers ± stock changes.

Top Block: Supply

- Transfers:

Transfers comprise inter-product transfers, products transferred and recycled products.

- Statistical Difference:

In the energy balance, the statistical difference is the numerical difference between the total supply of an energy product and the total use of it.

Statistical differences arise because the data for the individual components of supply are often derived from different data sources by the national administration.

Middle Block: Transformation

- Transformation processes:

Transformation processes comprises the conversion of primary forms of energy to secondary and further transformation

- Main Activity Electrical Plants:

Refers to plants which are designed to produce electricity only. If one or more units of the plant is a CHP unit (and the inputs and outputs can not be distinguished on a unit basis) then the whole plant is designated as a CHP plant.

Middle Block: Transformation

- Main Activity CHP (Combined Heat & Power) Plants:

Refers to plants which are designed to produce both heat and electricity (sometimes referred to as co-generation power stations).

- Main Activity Heat Plants:

Refers to plants (including heat pumps and electric boilers) designed to produce heat only and who sell heat to a third party (e.g. residential, commercial or industrial consumers) under the provisions of a contract.

Middle Block: Transformation

- Sub-Categories of Heat Producing Entities:
  - Heat Pumps
  - Electric Boilers
  - Chemical Heat for Electricity Production
  - Patent Fuel Plants
  - Coke Ovens
  - Gas Works
  - Blast Furnaces

Middle Block: Transformation

- Oil Refineries:

Includes the manufacture of finished oil products.

- Non-Specified Transformation:

Includes any other non-specified transformation

Middle Block: Transformation

- Energy Industries Own Use:

Energy industry own use covers the amount of fuels used by the energy producing industries (e.g. for heating, lighting and operation of all equipment used in the extraction process, for traction and for distribution).

- Energy Industry Categories:
  - Coal Mines
  - Oil and Gas Extraction
  - Patent Fuel Plants
  - Coke Ovens
  - Gas Works
  - Gasification Plants for Bio Gases
  - Blast Furnaces
  - Oil Refineries

Bottom Block: Final Consumption

- Final consumption

  Equal to the sum of the consumption in the end-use sectors.

- Energy used for transformation processes and for own use of the energy producing industries is excluded.
- Final consumption reflects for the most part deliveries to consumers.

Bottom Block: Final Consumption

- Industry Consumption:

Industry consumption is by the following categories of Industries:

- Iron and Steel
- Chemical and Petrochemical
- Non-Ferrous Metals
- Non-Metallic Minerals
- Transport Equipment
- Machinery
- Mining and Quarrying
- Food and Tobacco
- Paper, pulp and print
- Wood and Wood Products
- Construction
- Textiles and Leather
- Non-specified Industry

Bottom Block: Final Consumption

- Transport Sector Consumption

It covers the consumption in all the transportation sector including:

  - Domestic Aviation
  - Road
  - Rail
  - Pipeline Transport
  - Domestic Navigation
  - Non-Specified Transport

- Other Energy Consuming Sectors:
  - Residential
  - Commercial and Public Services
  - Agricultural/ Forestry
  - Fishing
  - Non-Specified (Other)

Bottom Block: Final Consumption

- Non Energy Use:

Non-energy use covers those fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel.

Net Calorific Value and Unit Conversions

- An energy balance requires the use of a **common unit** to sum together the contributions of the various different products, collected in **different physical units**. The common unit needs to be an energy unit, such as Joule, tonne of oil equivalent (toe), GWh, etc.
- Calorific values represent the amount of **energy per unit of mass** or **volume** of a given product.
- The commodity balance can then be converted to an energy balance automatically by **multiplying** the figures in the commodity balance with the calorific values for each energy product and at the same time make the necessary adjustments in layout.

Example to Calculate Average Calorific Value

	Production (1000 metric tons)	Calorific value (TJ/1000 metric tons)	Average calorific value (TJ/1000 metric tons)	Production (TJ)
Mine A	1.5	10.28		15.42
Mine B	2.5	12.1		30.25
Total	4		$= \frac{1.5 \times 10.28 + 2.5 \times 12.10}{1.5 + 2.5} = 11.42$	$= 11.42 \times 4 = 45.67$

Conversion from **Commodity Balance** to **Energy Balance**

COMMODITY BALANCE

	Crude Oil (kt)	Motor Gasoline (kt)
Production	100	30
Import		
Export	-10	-24
Supply	90	6
Oil Refineries	88	
Final Consumption	2	6

ENERGY BALANCE

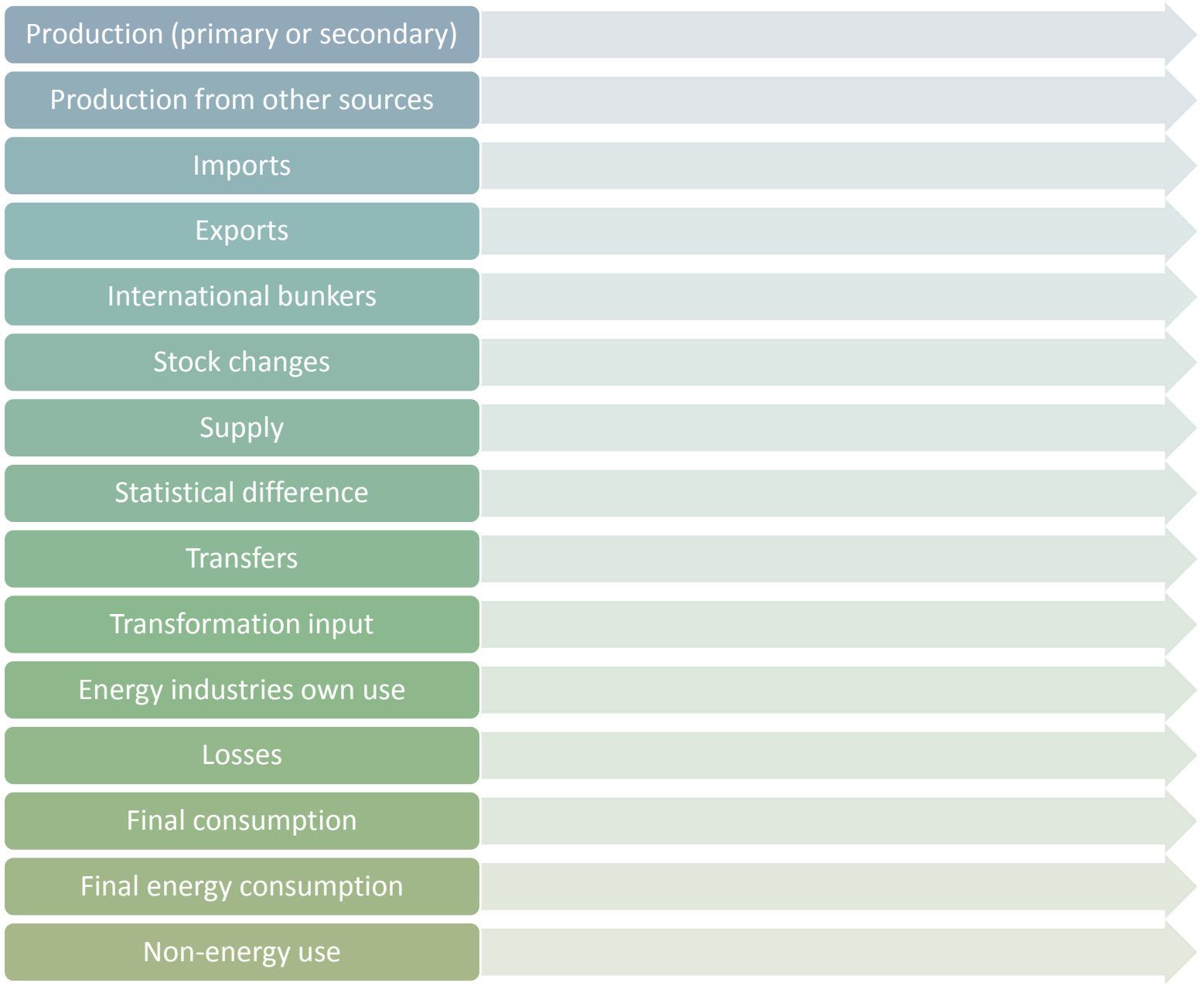
	Crude Oil (TJ)	Motor Gasoline (TJ)
Production	4230	
Import		
Export	-423	-1063
Supply	3807	-1063
Oil Refineries	-3722	1329
Final Consumption	85	266

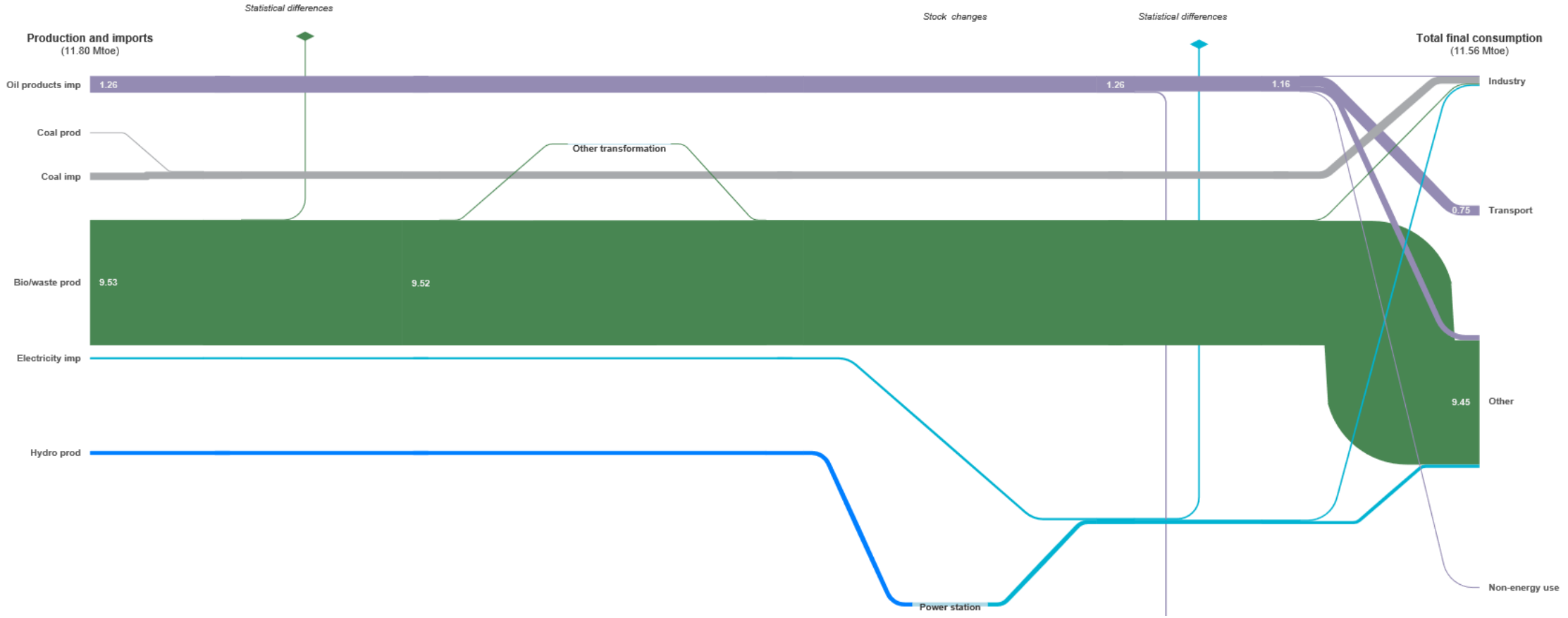
Motor Gasoline in kt x **44.3 TJ/kt** = Motor Gasoline in TJ
Crude Oil in kt x **42.3 TJ/kt** = Crude Oil in TJ

Layout changes: From Commodity to Energy Balance Format

- The layout adjustments imply changes in the transformation category.
- In particular, secondary energy production is represented as **positive numbers** in the transformation and not any longer in the top row of the balance to avoid double counting, as the corresponding primary energy is already included under production.
- The **energy input** remains in the transformation category, but as **negative** figures. The advantage of such representation is that the sum of the input and output will represent the losses of the transformation process.

Template of a General Statistical Balance





Energy Balance Example

(Sankey Diagram)

Part 4

DATA COLLECTION METHODOLOGIES

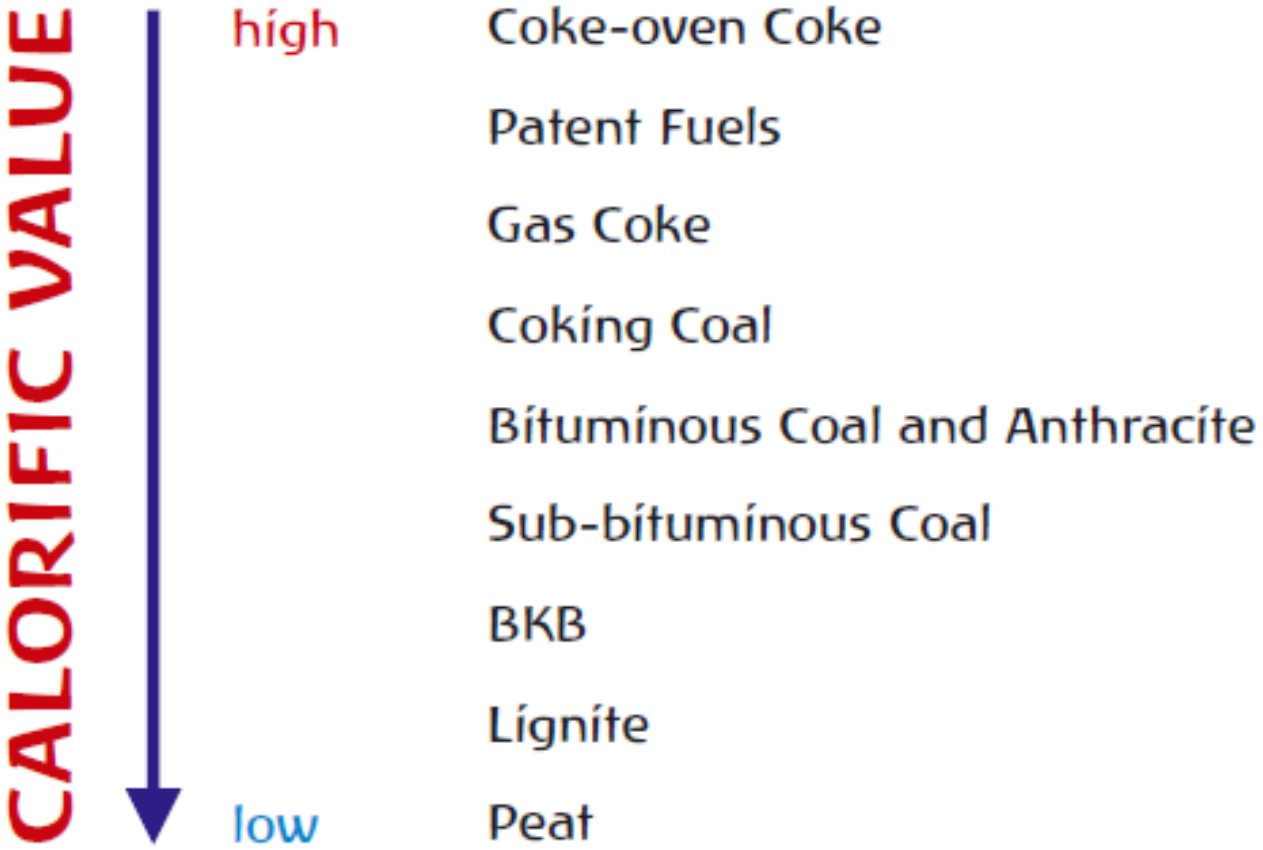
Sources of Energy/ Energy Products

- Coal, Peat, Oil Shale and Oil Sand
- Crude, NGL, Refinery Feedstocks
- Oil Products
- Natural Gas
- Biofuels and Waste
- Electricity and Heat

SOLID FUELS

Primary and Derived Coal Products

PRIMARY COAL PRODUCTS	Coking coal	SOLID FOSSIL FUELS
	Other bituminous coal and anthracite	
	Sub-bituminous coal	
	Lignite/brown coal	
	Peat	
DERIVED FUELS	Patent fuels	
	Coke-oven coke	
	Gas coke	
	Briquettes	
	Gas-works gas	MANUFACTURED GASES
	Coke-oven gas	
	Blast-furnace gas	
	Oxygen steel-furnace gas	



Heat Content of Coal

Units for Solid Fuels and Manufactured Gases

- Units for Solid Fuels
  - Solid fuels are usually measured by mass.
  - Coal data can also be found in terms of tonnes of coal equivalent (tce).

- Units for Manufactured Gases
  - Manufactured gases can either be measured according to energy content or volume

Generally

Solid fuels are reported in **thousand metric tons (kT)**

Gaseous fuels are expressed in terms of their gross energy (heat) content and reported in **terajoules (TJ)**.

Coal, Peat, Oil Shale and Oil Sands

- **Anthracite**

  Anthracite is a high rank coal used for industrial and residential applications.

  Highest carbon content (about 90% fixed content)

  Highest energy density

Coal, Peat, Oil Shale and Oil Sands

- **Coking Coal**

  Coking coal refers to bituminous coal with a quality that allows the production of a coke suitable to support a blast furnace charge.

  Also known as **Metallurgic coal**.

  Coking coal is an essential ingredient in steel production and is different than thermal coal which is used to generate power.

Coal, Peat, Oil Shale and Oil Sands

- **Other Bituminous Coal**

  Includes all bituminous coal that is not included under coking coal nor anthracite.

  Lower carbon content (less than 90% fixed carbon).

If bituminous coal is used in coke ovens it should be reported as coking coal.

Coal, Peat, Oil Shale and Oil Sands

- **Sub-Bituminous Coal**

  Properties range from those of lignite to those of bituminous coal

  Non-agglomerating coal with a gross calorific value between

  20 000 kJ/kg and 24 000 kJ/kg

Coal, Peat, Oil Shale and Oil Sands

- **Lignite**

  Generally referred to as Brown coal.

  Lignite is also a non-agglomerating coal

  Carbon content 60-70%

  Gross calorific value of less than 20 000 kJ/kg

Coal, Peat, Oil Shale and Oil Sands

- **Patent Fuel**

  Patent fuel is a composition fuel manufactured from hard coal fines with the addition of a binding agent.

  Consumption of patent fuels during the patent fuel manufacturing process is included under energy industry own use.

Coal, Peat, Oil Shale and Oil Sands

- **Coke Oven**

  The Coke Oven is a 3x3x3 structure made by placing Coke Oven Bricks in 3x3x3 cube.

- Built similar to the Blast Furnace.

- Used to produce Coal Coke and Creosote Oil.

Coal, Peat, Oil Shale and Oil Sands

- **Coke Oven Coke**

  Coke oven coke is the solid product obtained from the carbonization of coal, principally coking coal, at high temperature.

  Low in moisture content and volatile matter.

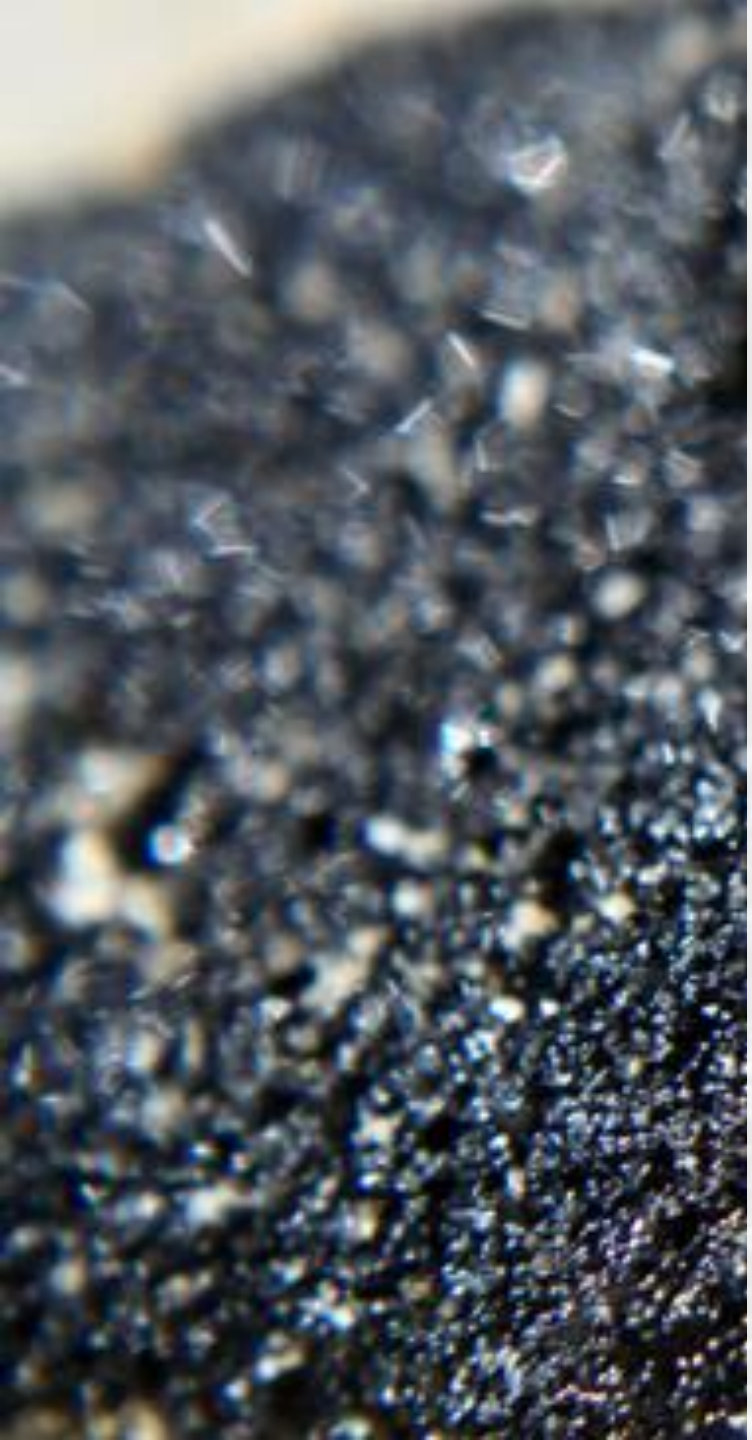
  Also included are
  - Semi-coke
  - Lignite coke
  - Coke breeze
  - Foundry coke

Coal, Peat, Oil Shale and Oil Sands

- **Gas Coke**

  Gas coke is a by-product of hard coal used for the production of town gas in gas works.

  Energy industry own use includes the consumption of gas coke at gas works.



Coal, Peat, Oil Shale and Oil Sands

- **Coal Tar**

  Coal tar is a result of the destructive distillation of bituminous coal or of the low-temperature carbonization of brown coal.

  Coal tar from bituminous coal is the liquid by-product of the distillation of coal to make coke in the coke oven process.

  Coal tar can be further distilled into different organic products (e.g. benzene, toluene, naphthalene), which normally would be reported as a feedstock to the petrochemical industry.

Coal, Peat, Oil Shale and Oil Sands

- **BKB (Brown Coal Briquettes)**

  Brown coal briquettes are composition fuels manufactured from lignite, produced by briquetting under high pressure with or without the addition of a binding agent.

Coal, Peat, Oil Shale and Oil Sands

- **Gas Works Gas**

  Gas works gas covers all types of gas produced in public utility or private plants, whose main purpose is the manufacture, transport and distribution of gas.

Coal, Peat, Oil Shale and Oil Sands

- **Coke Oven Gas**

  Coke oven gas is obtained as a by-product of the manufacture of coke oven coke for the production of iron and steel.

Coal, Peat, Oil Shale and Oil Sands

- **Blast Furnace Gas**

  Blast furnace gas is produced during the combustion of coke in blast furnaces in the iron and steel industry.

  It is recovered and used as a fuel, partly within the plant and partly in other steel industry processes or in power stations equipped to burn it.

Coal, Peat, Oil Shale and Oil Sands

- **Other Recovered Gases**

  By-product of the production of steel in an oxygen furnace, recovered on leaving the furnace.

  The gases are also known as converter gas or LD gas.

  The quantity of recuperated fuel should be reported on a gross calorific value basis.

Coal, Peat, Oil Shale and Oil Sands

- **Electricity/Heat Output from non-specified manufactured Gases**

  This item is only used if the detailed breakdown is not available.

- It includes coke oven gas, blast furnace gas and other recovered gases.

- Gas works gas is not included here.

Coal, Peat, Oil Shale and Oil Sands

- **Peat**

  Peat is a combustible soft, porous or compressed, fossil sedimentary deposit of plant origin.

  High water content (up to 90% in the raw state).

  Peat used for nonenergy purposes is not included here. Milled peat is included here.

- **Peat Products**

  Products such as peat briquettes derived directly or indirectly from sod peat and milled peat.

Coal, Peat, Oil Shale and Oil Sands

- **Oil Shale and Oil Sands**

  Oil shale and oil sands are sedimentary rock which contains organic matter in the form of kerogen.

  Oil shale may be burned directly or processed by heating to extract shale oil.

LIQUID FUELS

(PETROLEUM PRODUCTS)

PRIMARY OIL PRODUCTS	Crude oil	
	Natural gas liquids	
	Other hydrocarbons	
SECONDARY PRODUCTS	Additives/blending components	
INPUTS TO REFINERY	Refinery feedstocks	
SECONDARY OIL PRODUCTS	Refinery gas	Transport diesel
	Ethane	Heating and other gasoil
	Liquefied petroleum gases	Res. fuel: low-sulphur content
	Naphtha	Res. fuel: high-sulphur content
	Aviation gasoline	White spirit + SBP
	Gasoline type jet fuel	Lubricants
	Unleaded gasoline	Bitumen
	Leaded gasoline	Paraffin waxes
	Kerosene type jet fuel	Petroleum coke
	Other kerosene	Other products

Primary and Secondary Oil Products

Units for Oil

- Liquid fuels can be measured by their mass or volume. Within each of these measurements, several units are used in the oil industry:
  - The most widely used unit of mass (weight) to measure oil is the **metric ton (or tonne).**
  - The original unit for most liquid and gaseous fuels is volume. Liquids can be measured by the **litre**, the **barrel**, or the **cubic metre**.

Conversion from Volume to Mass

Imports	Reported data in barrels per day (volume)	Number of days/month	Density mass/volume (average)	Volume/mass tonne/barrel conversion factor	Converted data in metric tons (mass)
Crude oil	1020	31	0.13569	1/0.13569=7.37	(1020x31)/7.37=4290
Motor gasoline	546	28	0.11806	1/0.11806=8.47	(546x28)/8.47=1805

Crude, NGL, refinery feedstocks

- **Crude Oil**

  Crude oil is a mineral oil of natural origin.

  Exists in liquid phase under normal surface temperatures and pressure.

  It includes field or lease condensates (separator liquids) which are recovered from associated and non-associated gas.

Crude, NGL, refinery feedstocks

- **Natural Gas Liquids (NGL)**

  NGL are the liquid or liquefied hydrocarbons recovered from natural gas in separation facilities or gas processing plants.

Crude, NGL, refinery feedstocks

- **Refinery Feedstocks**

  A refinery feedstock is a processed oil destined for further processing (e.g. straight run fuel oil or vacuum gas oil) other than blending in the refining industry.

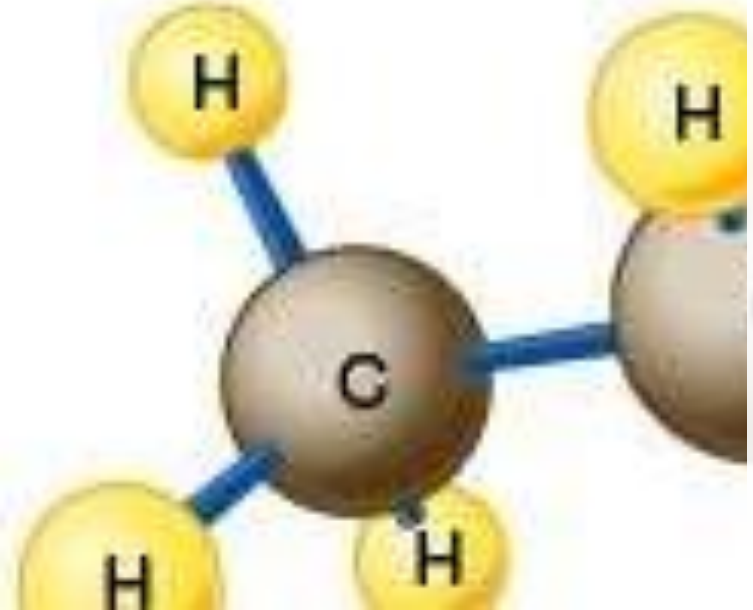
Crude, NGL, refinery feedstocks

- **Additives/ Blending Components**

  Additives are non-hydrocarbon chemical compounds added to or blended with a product to modify its properties.

  Alcohols and ethers (MTBE, methyl tertiary butyl ether) and chemical alloys such as tetraethyl lead are included here.

  The biofuel fractions of bio gasoline, biodiesel and ethanol are included under liquid biofuels.



Crude, NGL, refinery feedstocks

- **Other Hydrocarbons**

  This category includes synthetic crude oil from tar sands, shale oil, etc., liquids from coal liquefaction, output of liquids from natural gas conversion into gasoline, hydrogen and emulsified oils (e.g., Orimulsion).

Oil Products

- **Refinery Gas**

  Refinery gas includes a mixture of non-condensed gases obtained during distillation of crude oil or treatment of oil products (e.g. cracking) in refineries.

  It also includes gases which are returned from the petrochemical industry.

  Refinery gas production refers to gross production.

Oil Products

- **Ethane**

  Ethane is a naturally gaseous straight-chain hydrocarbon (C_2H_6) which is extracted from natural gas and refinery gas streams.

Oil Products

- **Liquefied Petroleum Gases (LPG)**

  Liquefied petroleum gases are light paraffinic hydrocarbons derived from
  - refinery processes
  - crude oil stabilization plants
  - natural gas processing plants.

  LPG are normally liquefied under pressure for transportation and storage.

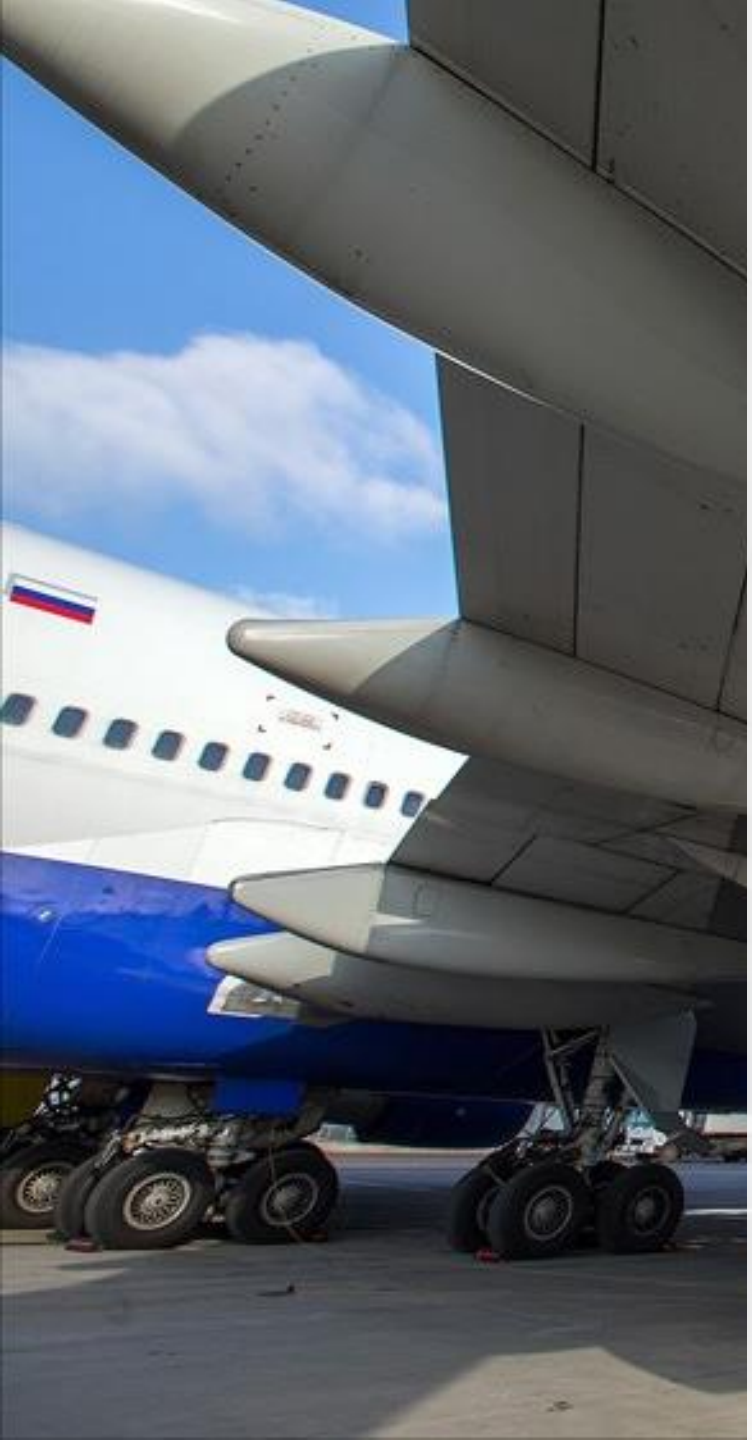
Oil Products

- **Motor Gasoline excluding Biofuels**

  Motor gasoline is light hydrocarbon oil for use in internal combustion engines such as motor vehicles, excluding aircraft.

  Motor gasoline may include additives, oxygenates and octane enhancers, including lead compounds such as TEL (tetraethyl lead) and TML (tetramethyl lead).

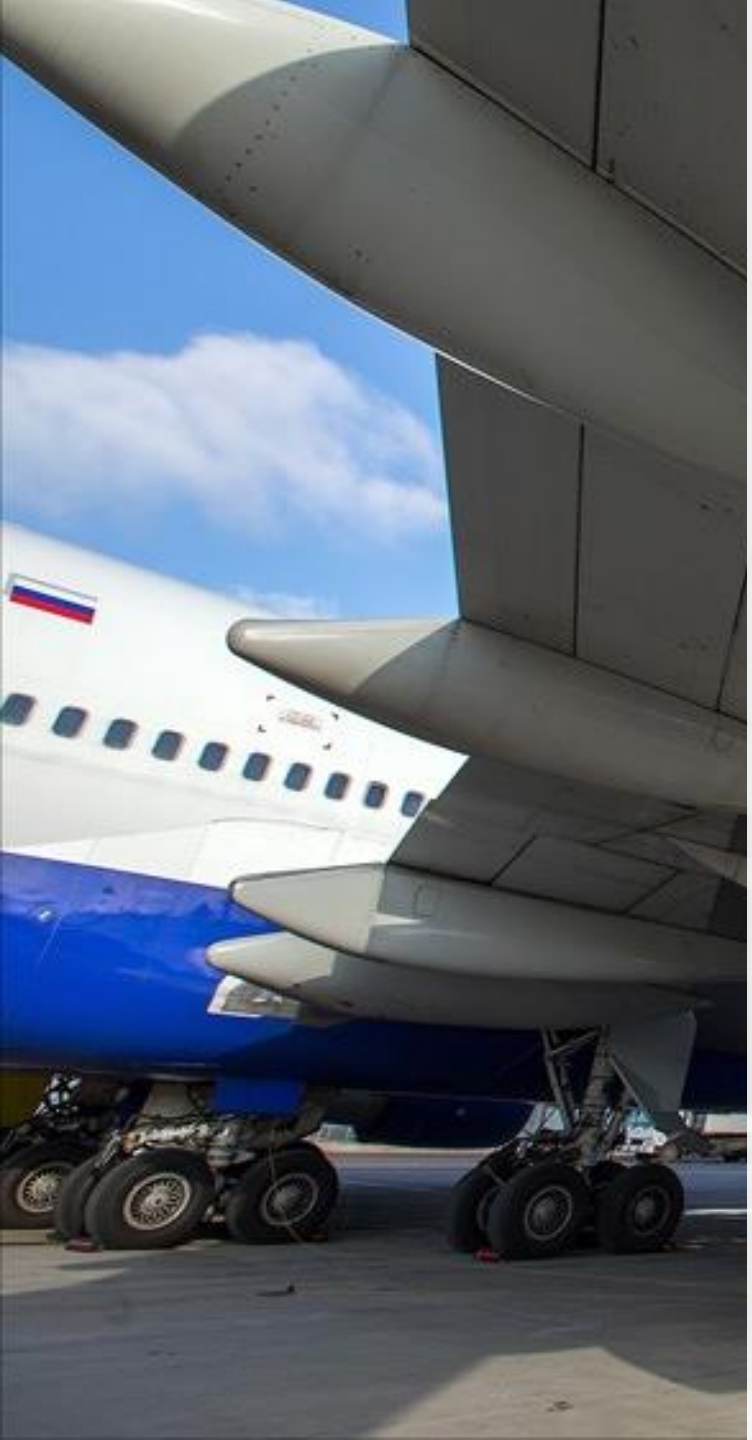
  Motor gasoline excluding biofuels does not include the liquid biofuels or ethanol blended with gasoline.



Oil Products

- **Aviation Gasoline**

  Aviation gasoline is motor spirit prepared especially for aviation piston engines, with an octane number suited to the engine

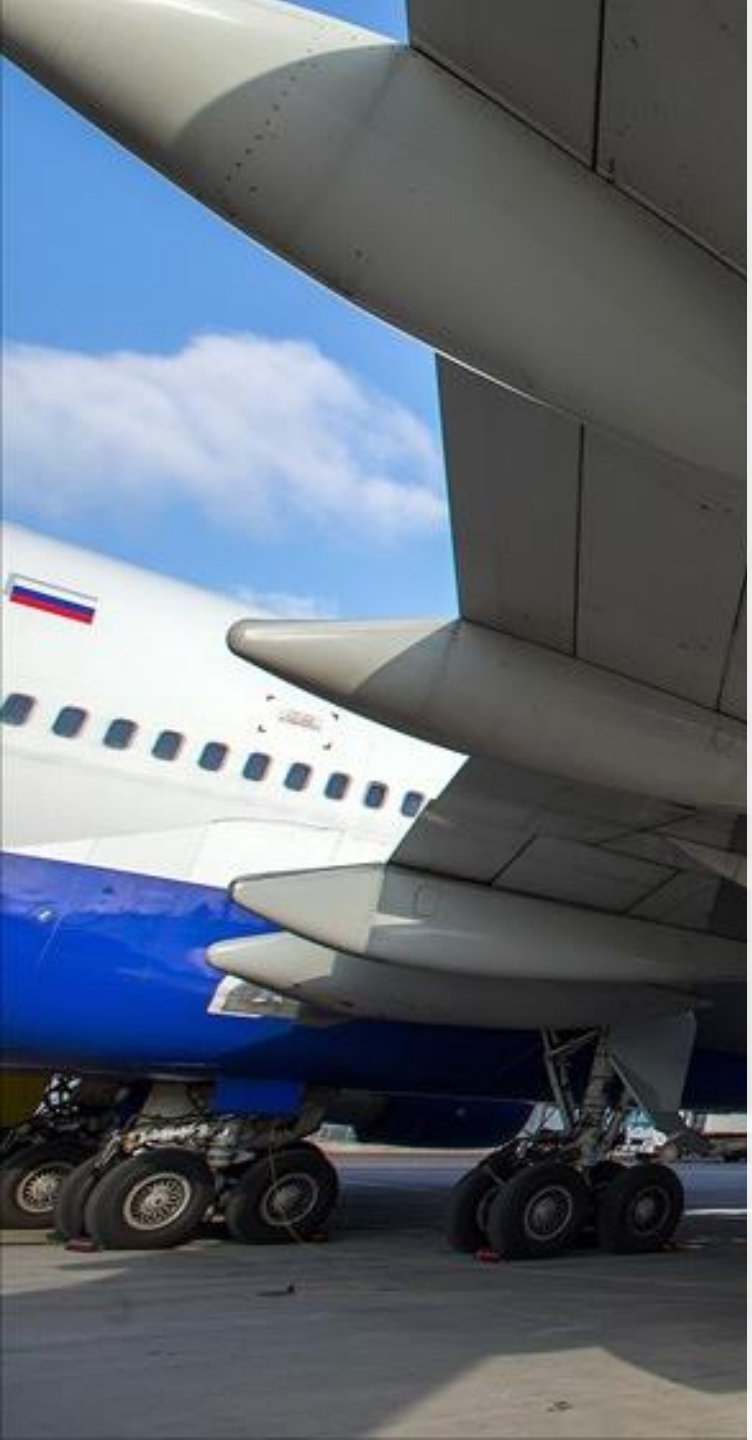


Oil Products

- **Gasoline Type Jet Fuel**

  Gasoline type jet fuel includes all light hydrocarbon oils for use in aviation turbine power units.

  This fuel is obtained by blending kerosene and gasoline or naphtha



Oil Products

- **Kerosene type jet fuel excluding biofuels**

  Kerosene type jet fuel is a medium distillate used for aviation turbine power units. It has the same distillation characteristics and flash point as kerosene.

  Includes kerosene blending components.

  Kerosene type jet fuel excluding biofuels does not include the liquid biofuels blended with jet kerosene.

Oil Products

- **Other Kerosene**

  Kerosene (other than kerosene used for aircraft transport which is included with aviation fuels) comprises refined petroleum distillate intermediate in volatility between gasoline and gas/diesel oil.

  It is a medium oil distillate between 150°C and 300°C.

Oil Products

- **Gas/Diesel Oil**

  Gas/diesel oil includes heavy gas oils.

  Distils between 180°C and 380°C

  Several grades are available depending on uses:
  - Diesel oil for diesel compression ignition
  - Light heating oil for industrial and commercial uses
  - Other gas oil including heavy gas oils which distil between 380°C and 540°C

Oil Products

- **Fuel Oil**

  Fuel oil defines oils that make up the distillation residue.

  It comprises all residual fuel oils, including those obtained by blending.

  Its kinematic viscosity is above 10 cSt at 80°C.

  The flash point is always above 50°C and the density is always higher than 0.90 kg/l.

Oil Products

- **Naphtha**

  Naphtha is a feedstock destined either for
  - The petrochemical industry
  - Gasoline production

  Naphtha comprises material that distils between 30°C and 210°C.

Oil Products

- **White Spirit and SBP**

  White spirit and Specific Boiling Point (SBP) are refined distillate intermediates with a distillation in the naphtha/kerosene range.

  White Spirit has a flash point above 30°C and a distillation range of 135°C to 200°C.

  Industrial Spirit (SBP) comprises light oils distilling between 30°C and 200°C, with a temperature difference between 5% volume and 90% volume distillation points, including losses, of not more than 60°C.

Oil Products

- **Lubricants**

  Lubricants are hydrocarbons produced from distillate or residue;

  Mainly used to reduce friction between bearing surfaces.

  This category includes all finished grades of lubricating oil, from spindle oil to cylinder oil, and those used in greases, including motor oils and all grades of lubricating oil base stocks.

Oil Products

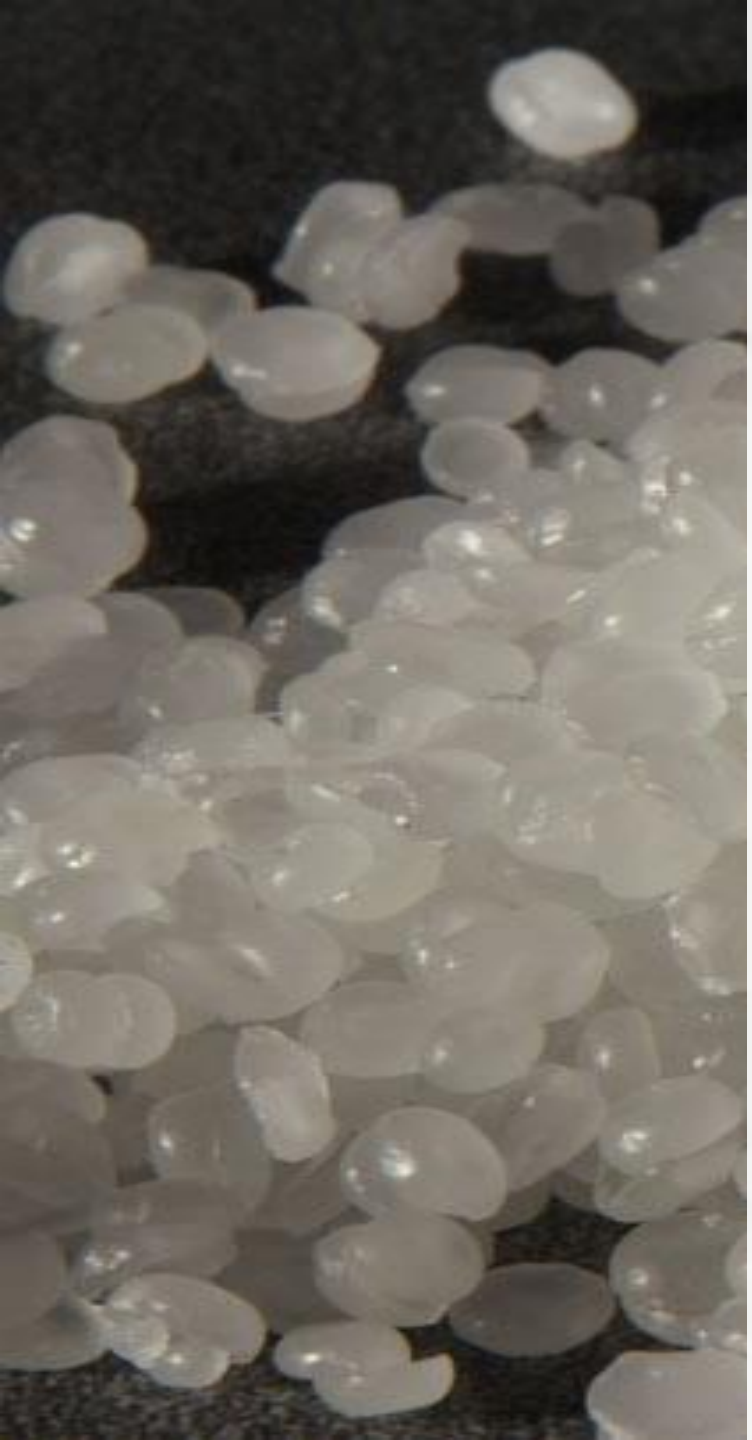
- **Bitumen**

  Bitumen is a solid, semi-solid or viscous hydrocarbon with a colloidal structure that is brown to black in color.

  It is obtained by vacuum distillation of oil residues from atmospheric distillation of crude oil.

  Primarily used for surfacing of roads and for roofing material.

  This category includes fluidized and cut back bitumen.



Oil Products

- **Paraffin Waxes**

  Paraffin waxes are saturated aliphatic hydrocarbons.

  These waxes are residues extracted when dewaxing lubricant oils, and they have a crystalline structure.

Oil Products

- **Petroleum Coke**

  Petroleum coke is defined as a black solid by-product, obtained mainly by cracking and carbonizing of petroleum derived feedstocks, vacuum bottoms, tar and pitches in processes such as delayed coking or fluid coking.

  This category also includes "catalyst coke" deposited on the catalyst during refining processes: this coke is not recoverable and is usually burned as refinery fuel.

Oil Products

- **Non-Specified Oil Products**

  Other oil products not classified above (e.g. tar, Sulphur and grease) are included here.

  This category also includes aromatics (e.g. BTX or benzene, toluene and xylene) and olefins (e.g. propylene) produced within refineries.

GASES

Natural Gas

- Natural gas comprises gases, occurring in underground deposits, whether liquefied or gaseous, consisting mainly of methane.
- It includes both "non-associated“ gas and "associated" gas, as well as methane recovered from coal mines etc.
- Production represents dry marketable production within national boundaries, including offshore production and is measured after purification and extraction of NGL and sulphur.
- It includes gas consumed by gas processing plants and gas transported by pipeline.

Natural Gas Units

- Natural gas can be measured in several units: either according to energy content (also referred to as heat) or volume.

- **Natural gas data are reported in two units:**

  - a unit of energy, the **terajoule (TJ)**, and
  - a unit of volume, **million cubic metres (Mm^3)**.

Conversion from Volume to Energy

From	Imports (Mm^3)	Calorific Value (TJ/m^3)	Imports in Terajoules (m^3 x TJ/m^3)	Calorific Value (TJ/m^3)
Netherlands	3 000	33.3	3 000 x 33.3 = 99 900	
Norway	5 000	41.0	5 000 x 41.0 = 205 000	
Total	8 000	?	99 900 + 205 000 = 304 900	304 900 / 8 000 = 38.113

BIOFUELS AND WASTES

Biofuels and Waste

- **Industrial Waste**

  Industrial waste of non-renewable origin consists of solid and liquid products (e.g. tyres) combusted directly, usually in specialized plants, to produce heat and/or power.

Biofuels and Waste

- **Municipal Waste**

  Municipal waste comprises wastes produced by households, industry, hospitals and the tertiary sector that are collected by local authorities for incineration at specific installations.

  It consists of products that are combusted directly to produce heat and/or power and

  Municipal waste is split into **renewable** and **non-renewable**.

Biofuels and Waste

- **Primary Solid Bio-Fuels**

  Primary solid biofuels is defined as any plant matter used directly as fuel or converted into other forms before combustion.

  This covers a multitude of woody materials generated by industrial process or provided directly by forestry and agriculture (firewood, wood chips, bark, sawdust, shavings, chips, sulphite lyes also known as black liquor, animal materials/wastes and other solid biofuels).

Biofuels and Waste

- **Biogases**

  Biogases are gases arising from the anaerobic fermentation of biomass and the gasification of solid biomass (including biomass in wastes).

  Biogases can also be produced from thermal processes (by gasification or pyrolysis of biomass) and are mixtures containing hydrogen and carbon monoxide along with other components.

  Biogases are used mainly as a fuel but can be used as a chemical feedstock.

Biofuels and Waste

- **Biogasoline**

  Produced from biomass such as algae

  Biogasoline includes bioethanol, biomethanol, bioETBE, bioMTBE

  Biogasoline includes the amounts that are blended into the gasoline - it does not include the total volume of gasoline into which the biogasoline is blended.

Biofuels and Waste

- **Bio Jet Kerosene**

  Liquid biofuels derived from biomass and blended with or replacing jet kerosene.

Biofuels and Waste

- **Biodiesel**

  Biodiesels includes biodiesel, biodimethylether, Fischer-Tropsch, cold pressed bio-oil and all other liquid biofuels which are added to, blended with or used straight as transport diesel or in electricity and heat generation.

  Biodiesels includes the amounts that are blended into the diesel - it does not include the total volume of diesel into which the biodiesel is blended.

Biofuels and Waste

- **Other Liquid Biofuels**

  Other liquid biofuels includes liquid biofuels, used directly as fuel, not reported in either biogasoline or biodiesels.

Biofuels and Waste

- **Charcoal**

  It covers the solid residue of the destructive distillation and pyrolysis of wood and other vegetal material.

Units for Renewables and Waste

- Because of their diverse forms, renewables and waste products have traditionally been measured in a variety of units.
  - Solid products like wood and wood waste are often measured in volume (cubic metres or cords) and mass (tonnes) units.
  - Biogases can be measured on a volume basis (cubic metres) and on an energy content basis (therms or kilowatt-hours)
  - Bioliquids in terms of volume (litres), mass (tonnes) and/or energy content (joules or megajoules).
  - Electricity-only renewable sources and technologies like hydro, solarphotovoltaic, tide, wave, ocean and wind can be measured only in terms of electricity output (usually kilo-, mega- or gigawatt-hours).

Units for Renewables and Waste

- *Values for electricity generation are reported in gigawatt-hours (GWh).*
- *Values for heat generation are reported in terajoules (TJ).*
- *Energy values for most fuels are reported in terajoules (TJ).*
- *Exceptions are charcoal and liquid biofuels that are reported in 1000 tonnes.*

ELECTRICITY AND HEAT

Electricity and Heat

- **Nuclear**

  Energy released by nuclear fission or nuclear fusion.

Electricity and Heat

- **Hydro**

  Hydro energy represents the potential and kinetic energy of water converted into electricity in hydroelectric plants.

Electricity and Heat

- **Geothermal**

  Geothermal energy is the energy available as heat emitted from within the earth's crust, usually in the form of hot water or steam.

Electricity and Heat

- **Solar Photovoltaic**

  Electricity from photovoltaic cells.

Electricity and Heat

- **Solar Thermal**

  Solar energy is the solar radiation exploited for hot water production and electricity generation, by:

  - flat plate collectors
  - solar thermal-electric plants

Electricity and Heat

- **Tide/Wave/ Ocean**

  Tide, wave and ocean represents the mechanical energy derived from tidal movement, wave motion or ocean current and exploited for electricity generation.

Electricity and Heat

- **Wind**

  Wind energy represents the kinetic energy of wind exploited for electricity generation in wind turbines.

Electricity and Heat

- **Heat Pumps**

  Heat pumps should include the inputs and outputs to heat pumps corresponding to the amount of heat that is sold to third parties.

Electricity and Heat

- **Electric Boilers**

  Electric boilers should include the inputs and outputs to electric boilers corresponding to the amount of heat that is sold to third parties.

Electricity and Heat

- **Heat from Chemical Sources**

  Heat from chemical sources corresponds to heat originating from processes without input energy, such as a chemical reaction.

Electricity and Heat

- **Other Sources**

  Other sources includes production not included elsewhere such as fuel cells.

Electricity and Heat

- **Electricity**

  Gross electricity production is measured at the terminals of all alternator sets in a station; it therefore includes the energy taken by station auxiliaries and losses in transformers that are considered integral parts of the station.

Electricity and Heat

- **Heat**

  Heat production includes all heat produced by main activity producer CHP and heat plants, as well as heat sold by auto producer CHP and heat plants to third parties.

  Fuels used to produce quantities of heat for sale are included in the transformation processes under the rows CHP plants and Heat plants.

Electricity and Heat

- **Heat output from non-specified combustible fuels**

  This item is only used if the detailed breakdown is not available.

Primary and Secondary Electricity

- Electricity is an energy carrier with a very wide range of applications. It is used in almost all kinds of human activity ranging from industrial production, household use, agriculture, commerce for running machines, lighting and heating.
- Electricity is produced as primary as well as secondary energy. Primary electricity is obtained from natural sources such as **hydro, wind, solar, tide and wave power**.
- Secondary electricity is produced from the **heat of nuclear fission of nuclear fuels**, from the **geothermal heat** and **solar thermal heat**, and by **burning primary combustible fuels** such as coal, natural gas, oil and renewables and wastes.
- After electricity is produced, it is distributed to final consumers through national or international **transmission and distribution grids**.

Primary and Secondary Heat

- Heat, as electricity, is an energy carrier primarily used for warming spaces and industrial processes.
- Primary heat is obtained from natural sources such as **geothermal** and **solar thermal power.**
- Secondary heat is obtained from the **nuclear fission of nuclear fuels**, and by **burning primary combustible fuels** such as coal, natural gas, oil and renewables and wastes.
- Heat can be produced and **used on site**, or **distributed** through a system of pipes to structures remote from the point of production.

Units for Electricity and Heat

- Electricity production, consumption and trade are measured and expressed in a **multiple of watt-hours**.
- Heat quantities should be expressed in energy units, usually in a **multiple of joules**, calories or British thermal units (Btu).
- Quantities of combustible fuels consumed for electricity and heat production are expressed in physical units such as metric tons, cubic metres, litres, etc., according to the type of fuel. They also should be expressed in energy units in order to calculate efficiency.

Units for Electricity and Heat

- The electricity is reported in **gigawatt-hours** (GWh).
- The heat is reported in **terajoules** (TJ).
- The electricity-generating capacity is reported in **megawatts** (MW).

Energy Product Categorization Example

- An example of energy product categorization from Eurostat can be seen in the following sheet:

Energy Product Categorization

Proposed Data Collection Systems

- Dedicated Umbrella body for Energy Statistics
  - All of the utility/ regulatory companies share their data with it
- Autonomous data collection techniques

Proposed Data Collection Systems (Cont..)

Questionnaires

- Possibly with incentives to make it more appealing for people to fill it honestly
- Better sampling techniques keeping in view the diversity in regional energy consumption.

Pros:

Details of actual energy consumption

Stocks of fuel and type of fuel used

Cons:

Greater Costs Incurred

More time consuming

Collected Data needs to be validated and verified

Energy Data Types

- Operational Data
  - Daily plant operation, refinery operating characteristics, plant outages etc. that relate to a certain energy enterprise.

- Technological Data
  - Provides detail of fuel requirements and performance of certain technical processes or energy using equipment

Energy Data Types

- Contextual Data
  - Shows general patterns of supply and consumption within many branches of economic activity and residential sector
  - Provided by energy commodity balances and price statistics

Contextual Data is usually what is focused upon by IEA, Eurostat, and UNStats

Annual Data Collection

- Based on energy type, the quantity of energy supplied and used, is reported as per the desired frequency.
- Cover all energy types, their sources, and uses (contextual data)
- Eurostat, United Nations, and IEA work closely to ensure harmony in the collected data for member countries to avoid duplication

Data Collection Questionnaires

Questionnaires are floated on monthly and annual basis by:

- International Energy Agency (IEA)
- EuroStat
- United Nations Statistics Division (UNStats)

Energy Data Collection Questionnaires by IEA

- Web Link for Questionnaires in Excel Format:
- http://www.iea.org/statistics/resources/questionnaires/annual/

- Coal Questionnaire Sample (IEA-2016):

Microsoft Excel
97-2003 Worksheet

Coal Quest. Manual.pdf

Energy Data Collection Questionnaires by Eurostat

- Web Link for Questionnaires in Excel Format:

http://ec.europa.eu/eurostat/web/energy/methodology/annual

Energy Data Collection Questionnaires by UNStats

- Web Link for Questionnaire in Excel Format

http://unstats.un.org/unsd/energy/quest.htm

Web Link for International Recommendations on Energy Statistics

http://unstats.un.org/unsd/energy/ires/default.htm

Exercise 1

- Explore the **Commodity Balance** and **Energy Balance** data for at least 3 countries from **IEA's** website. Check the data consistency using the Statistical Balance.

- Download **Commodity** and **Energy Balance** data from **UNStat's** website for any country (preferably Afghanistan) and try to verify the conversion from Commodity to Energy Balance format

- Compare the **Energy Balance formats** of IEA, UNStats, and Eurostat.

Part 5 DATA PRESENTATION

Google Developers CHARTS

RAW

The missing link between spreadsheets and vector graphics.

Data Presentation

Visual Data Presentation Tools

- In order to get better intuition and insights when dealing with energy data, there are myriad of tools that can be used to present data in various formats. Some of the commonly used tools are:

- PowerBi (https://powerbi.microsoft.com/en-us/),
- Google Charts (https://developers.google.com/chart/),
- ClicData (http://www.clicdata.com/),
- Raw (http://raw.densitydesign.org/),
- Plotly (https://plot.ly/) etc.

Data Dissemination

- Interactive web based sources:
  - Data can be illustrated in many different and convenient ways on interactive web based sources where numerous options are provided to not only apply different filters but also display energy statistics and flows through infographics, charts, and flow diagrams.
- Printed Sources
  - Various organizations that deal with energy data and statistics regularly publish reports, books, and magazines on energy statistics e.g. IEA, Eurostat, UNStats, British Petroleum etc. The most commonly published printed sources are:
    - Energy Data Books
    - Energy Balance Sheets

Part 6 STATISTICAL ANALYSIS

Basic Statistical Analysis

- Mean
- Median
- Mode
- Range
- Variance

Basic Statistical Analysis

Further Reading/ Resources:

- Probability and Statistics for Engineers and Scientists by Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, and Keying E. Ye (ISBN-13: 978-0321629111)

- Statistics Tutorial from Tutorial Point

Web Source: (http://www.tutorialspoint.com/statistics/index.htm)

- Lectures on Statistics by Khan Academy

Web Source: (https://www.khanacademy.org/math/probability)

Part 7

TOOLS FOR DATA ANALYSIS

Tools for Data Analysis

Tools for Data Analysis

- IBM SPSS

http://www.ibm.com/analytics/us/en/technology/spss/#what-is-spss

- Main Features:
  - Statistical Analysis and Reporting
  - Predictive Modelling and Data Mining
  - Decision Management and Deployment
  - Big Data Analytics

Tools for Data Analysis

- Microsoft Excel

https://products.office.com/en/excel

- Main Features:
  - What-If Analysis
  - Linear Optimization Tools
  - Data Sorting, Filtering, and Conditional Formating
  - Charts and Pivot Tables
  - Basic Statistical Analysis

Tools for Data Analysis

- MATLAB

http://www.mathworks.com/products/matlab/

- Main Features:
  - Historical and Experimental Data Analysis
  - Simulations and Physical Tests
  - Identify trends, test hypotheses, and estimate uncertainty
  - Create customized algorithms, visualizations, and models and publish customized reports

Tools for Data Analysis

- Tableau

http://www.tableau.com/products/desktop

- Main Features:
  - Data Analytics
  - Integration with multiple types of data sources
  - Big Data and Cloud Analytics
  - Data Visualization

Tools for Data Analysis

- Statistica

http://www.statsoft.com/Products/STATISTICA/Product-Index

- Main Features:
  - Big Data
  - Customer Analytics
  - Data Mining
  - Demand Forecasting
  - Process Optimization
  - Risk Management
  - Statistical Analysis

Part 7

Units, Conversion, and Calorific Value Tables

Table A3.2 ● Conversion Equivalents between Units of Volume

To: / From:	gal U.S. multiply by:	gal U.K.	bbl	ft³	l	m³
U.S. gallon (gal)	1	0.8327	0.02381	0.1337	3.785	0.0038
U.K. gallon (gal)	1.201	1	0.02859	0.1605	4.546	0.0045
Barrel (bbl)	42.0	34.97	1	5.615	159.0	0.159
Cubic foot (ft³)	7.48	6.229	0.1781	1	28.3	0.0283
Litre (l)	0.2642	0.220	0.0063	0.0353	1	0.001
Cubic metre (m³)	264.2	220.0	6.289	35.3147	1 000.0	1

Conversion Equivalents between units of Volume

Table A3.3 • Conversion Equivalents between Units of Mass

To: / From:	kg multiply by:	t	lt	st	lb
Kilogramme (kg)	1	0.001	9.84×10^{-4}	1.102×10^{-3}	2.2046
Tonne (t)	1000	1	0.984	1.1023	2204.6
Long ton (lt)	1016	1.016	1	1.120	2240.0
Short ton (st)	907.2	0.9072	0.893	1	2000.0
Pound (lb)	0.454	4.54×10^{-4}	4.46×10^{-4}	5.0×10^{-4}	1

Conversion Equivalents between Units of Mass

Table A3.4 • Conversion Equivalents between Units of Energy

To: / From:	TJ multiply by:	Gcal	Mtoe	MBtu	GWh
Terajoule (TJ)	1	238.8	2.388×10^{-5}	947.8	0.2778
Gigacalorie	4.1868×10^{-3}	1	10^{-7}	3.968	1.163×10^{-3}
Mtoe*	4.1868×10^{4}	10^{7}	1	3.968×10^{7}	11630
Million Btu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
Gigawatt-hour	3.6	860	8.6×10^{-5}	3412	1

*Million tonnes of oil equivalent.

Conversion Equivalents between Units of Energy

Table A3.5 ● Range of Calorific Values by Hard Coal Type

Hard coals	GCV (as used) MJ/kg	NCV (as used) MJ/kg	Carbon content (as used) kg/t	Moisture content (as used) %	Carbon content (dmmf)* kg/t
Anthracite	29.65 - 30.35	28.95 - 30.35	778 - 782	10 - 12	920 - 980
Coking coals	27.80 - 30.80	26.60 - 29.80	674 - 771	7 - 9	845 - 920
Other bituminous	23.85 - 26.75	22.60 - 25.50	590 - 657	13 - 18	810 - 845

Range of Calorific Values by Hard Coal Type

Table A3.6 ● Calorific Values by Coke Type

Coke type	GCV (as used) MJ/kg	NCV (as used) MJ/kg	Carbon content (as used) kg/t	Moisture content % (as used)	Carbon content kg/t (dmmf)*
Metallurgical coke	27.90	27.45	820	8 - 12	965 - 970
Gas coke	28.35	27.91	853	1 - 2	856
Low-temperature coke	26.30	25.40	710	15	900
Petroleum coke (green)	30.5 - 35.8	30.0 - 35.3	875	1 - 2	890

*dmmf: dry, mineral matter-free.

Range of Calorific Values by Coke Type

Typical Calorific Values for Coal Derived Gases

Table A3.7 ● Typical Calorific Values for Coal-derived Gases

Gas type	GCV (as used) MJ/m^3	NCV (as used) MJ/m^3	NCV (as used) MJ/kg	Carbon content (as used) kg/t
Coke-oven gas	19.01	16.90	37.54	464
Blast-furnace gas	2.89	2.89	2.24	179

Table A3.8 • *Typical Calorific Values for Selected Petroleum Products*

Product	Density kg/m^3	Litres per tonne	Gross calorific value (GJ/t)	Net calorific value (GJ/t)[1]
Ethane	366.3	2730	51.90	47.51
Propane	507.6	1970	50.32	46.33
Butane	572.7	1746	49.51	45.72
LPG[2]	522.2	1915	50.08	46.15
Naphtha	690.6	1448	47.73	45.34
Aviation gasoline	716.8	1395	47.40	45.03
Motor gasoline[3]	740.7	1350	47.10	44.75
Aviation turbine fuel	802.6	1246	46.23	43.92
Other kerosene	802.6	1246	46.23	43.92
Gas/diesel oil	843.9	1185	45.66	43.38
Fuel oil, low-sulphur	925.1	1081	44.40	42.18
Fuel oil, high-sulphur	963.4	1038	43.76	41.57

Typical Calorific Values for Selected Petroleum Products

Table A3.12 ● Gross versus Net Calorific Value of Natural Gas

1 NCV* = 0.9 GCV**

*NCV = Net Calorific Value.
**GCV = Gross Calorific Value.

Gross Vs Net Calorific Value of Natural Gas

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Thank You!