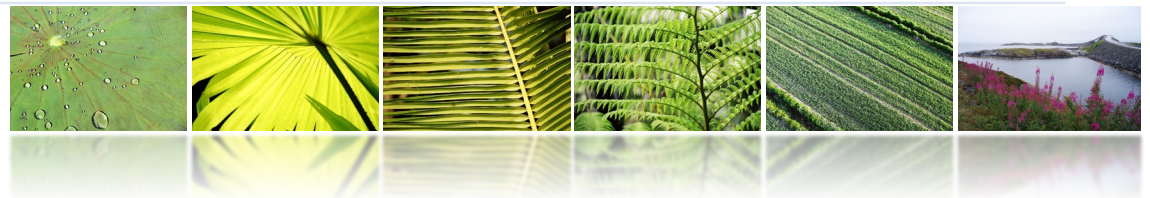




United Nations  
Statistics Division

# Primary oil and oil products



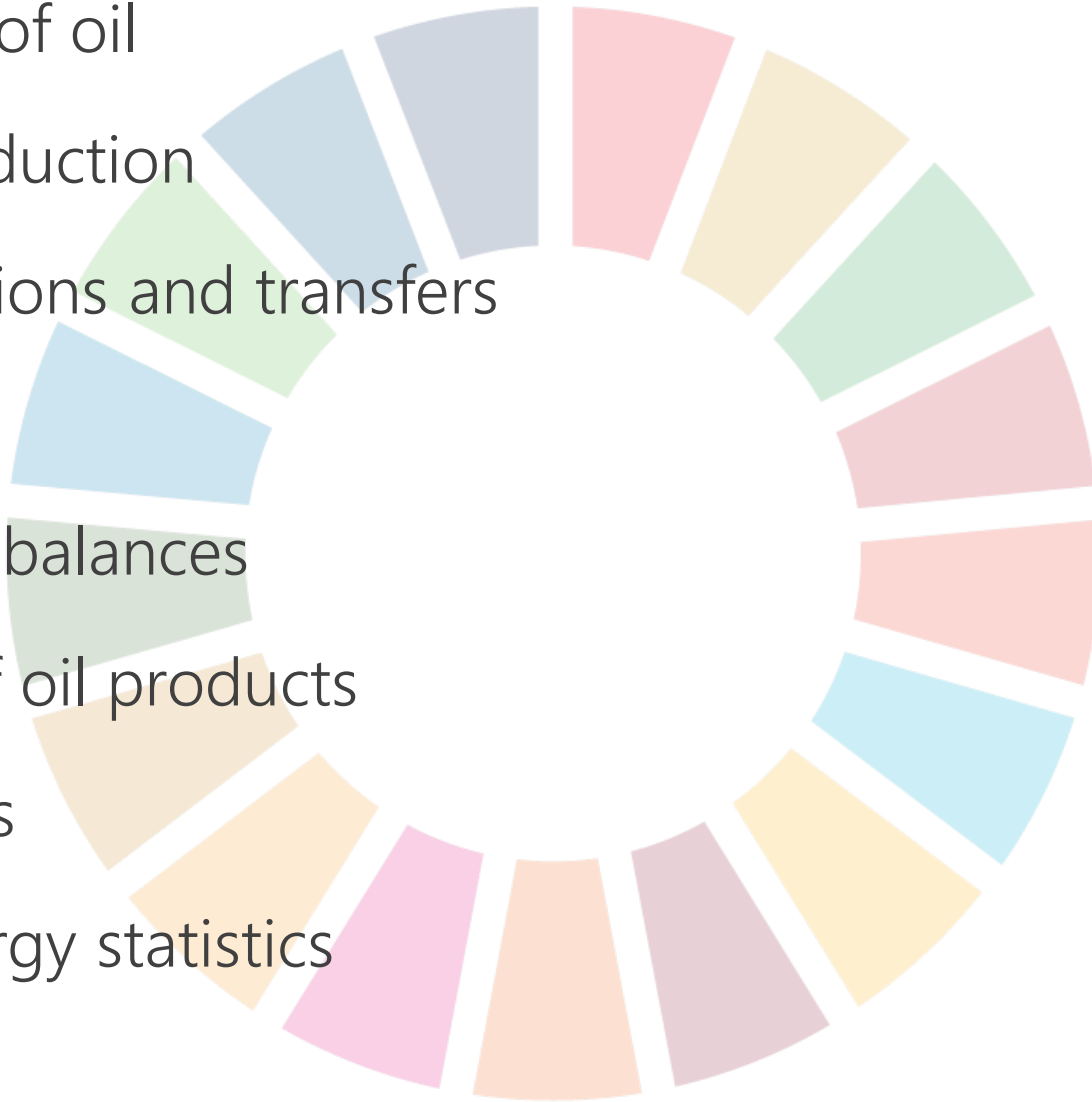
Leonardo Souza  
Chief, Energy Statistics Section

Workshop on Energy Statistics for Western African Countries  
15-19 October 2019, Dakar, Senegal

# Content

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- Importance of oil
- Primary Production
- Transformations and transfers
- Other flows
- Commodity balances
- Definition of oil products
- Data sources
- Units in energy statistics

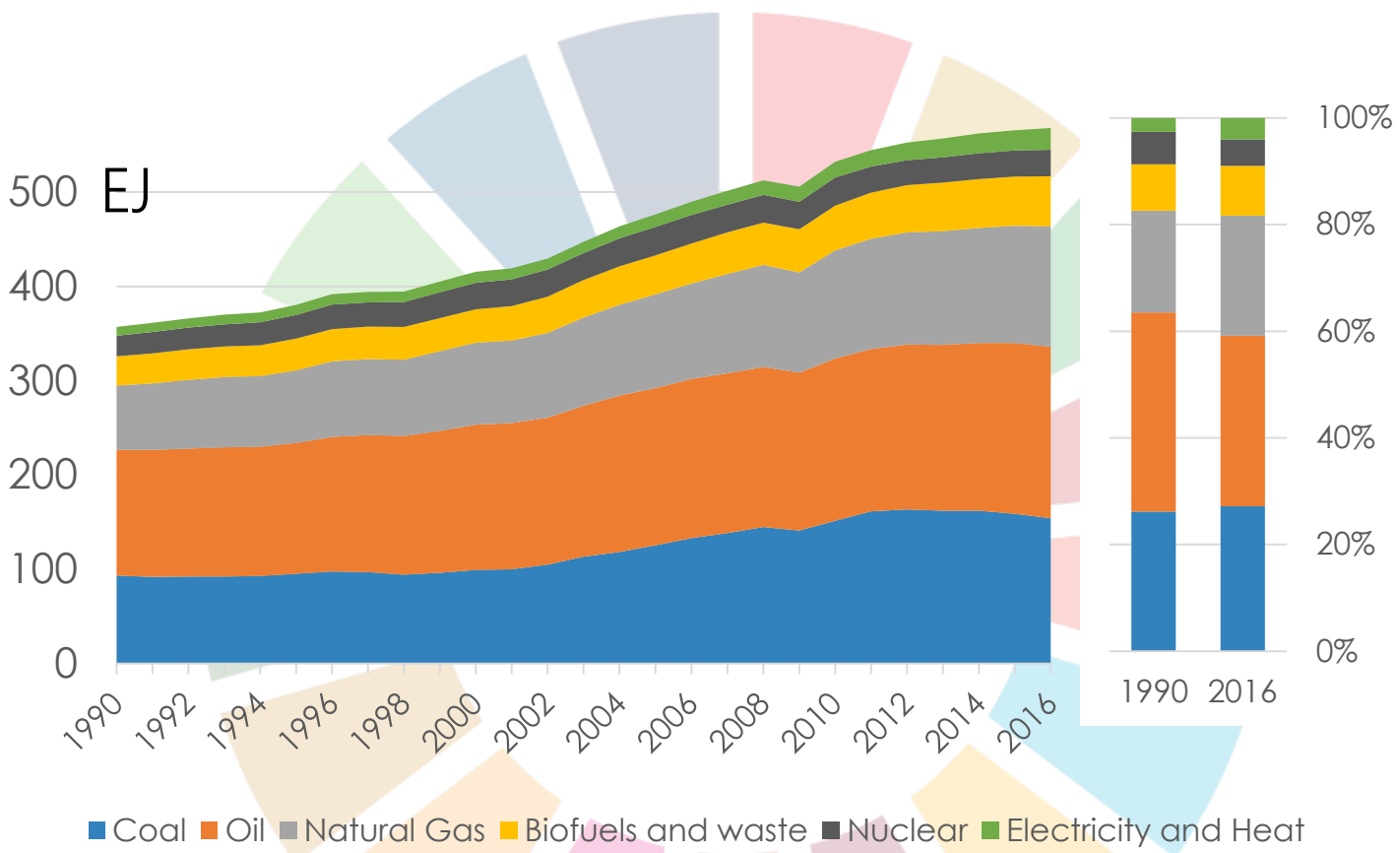




# Importance of oil

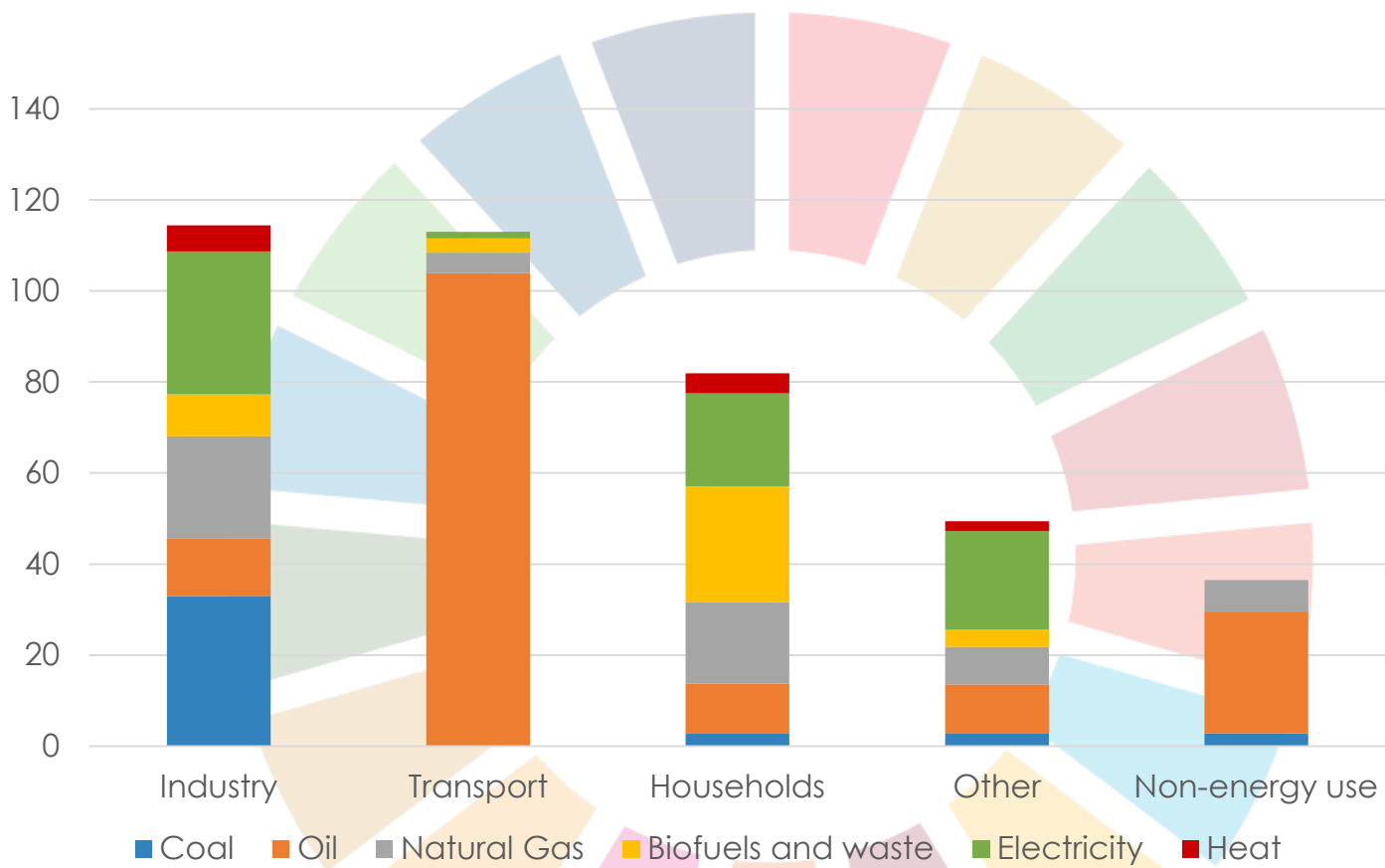
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# World Total Energy Supply, 1990-2016



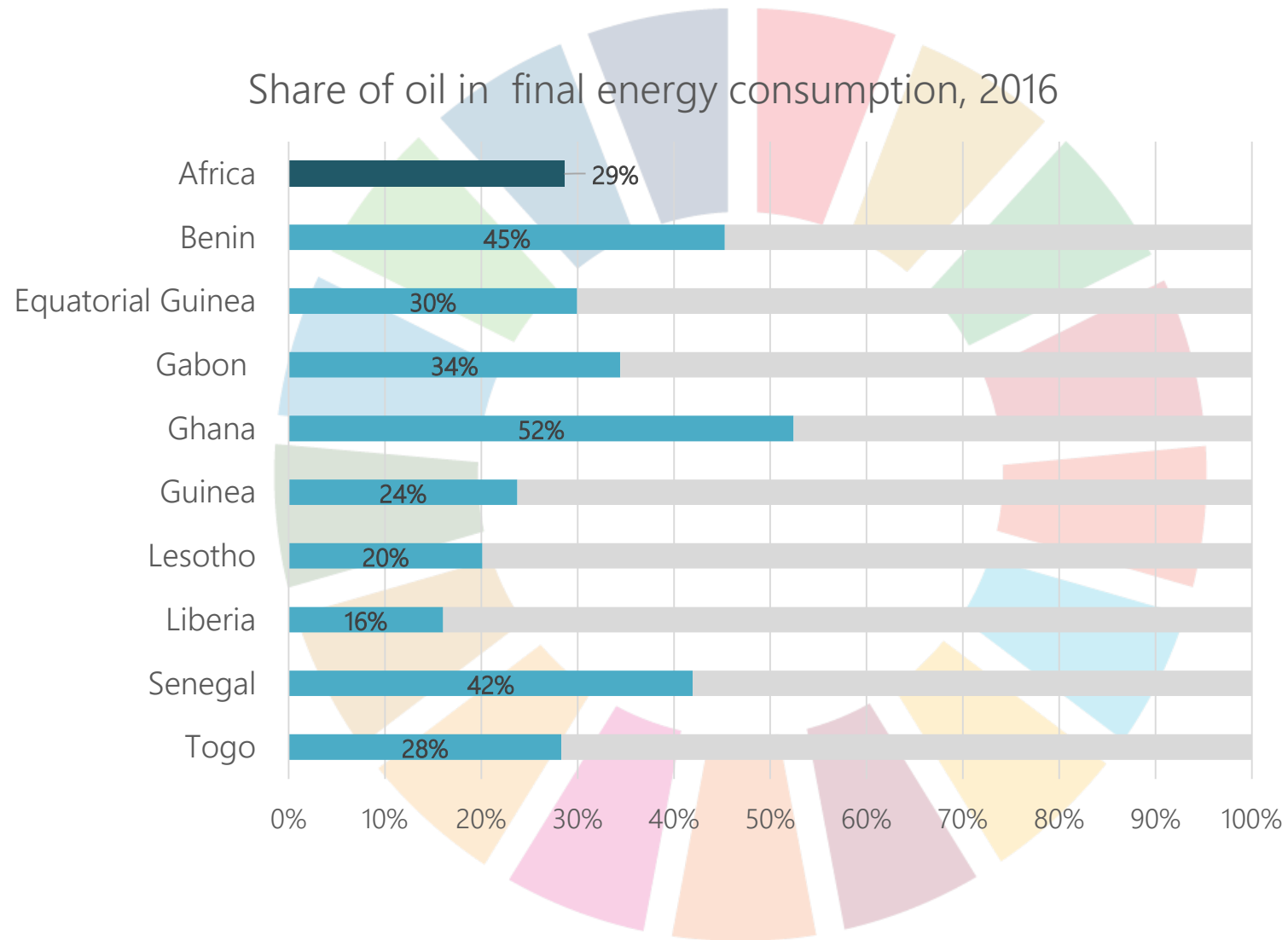
**Oil is the largest source of world's energy supply**

# World Total Final Consumption, 2016



Importance of oil for transportation

# Importance of oil for the region

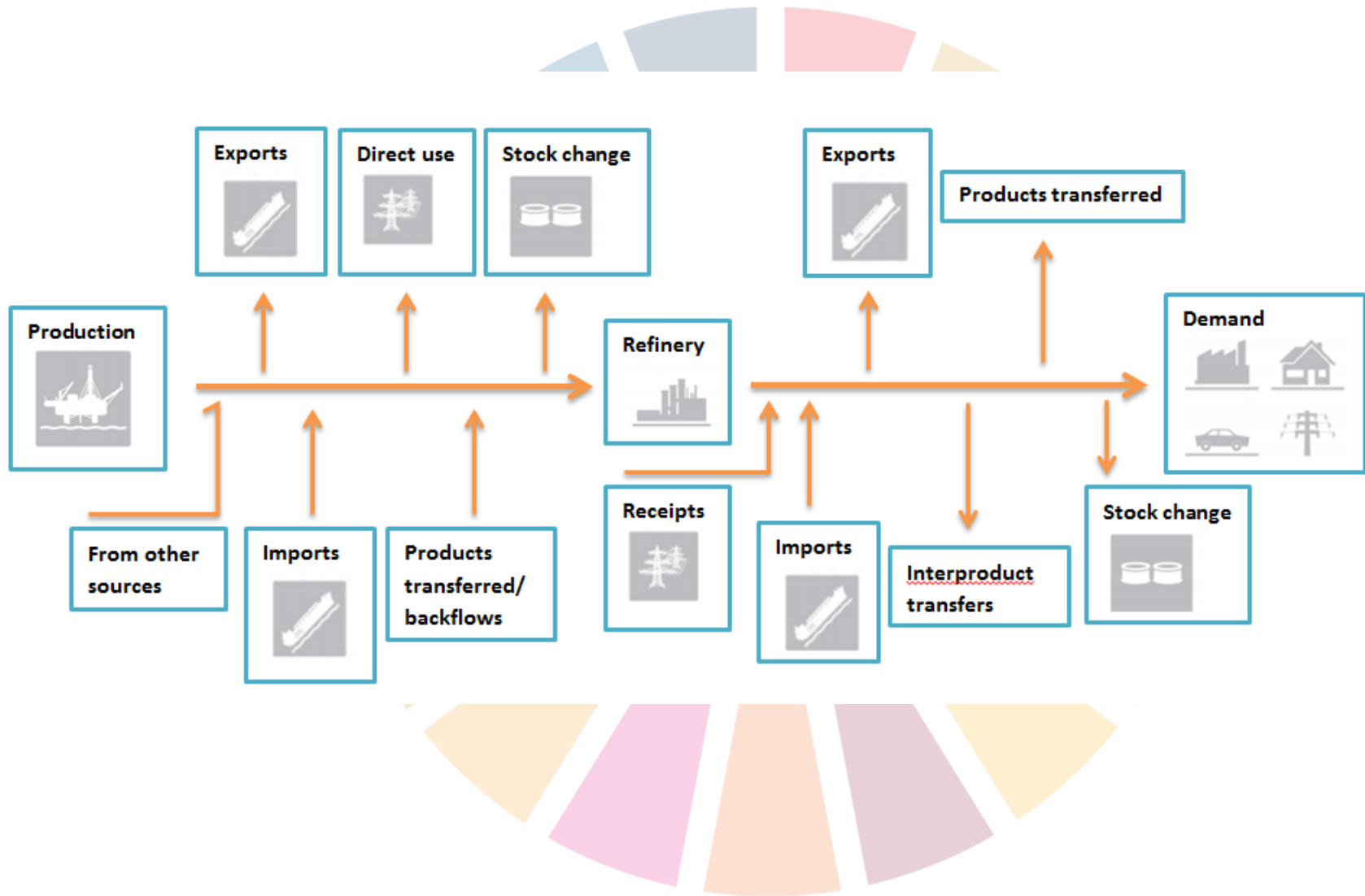




# Primary production

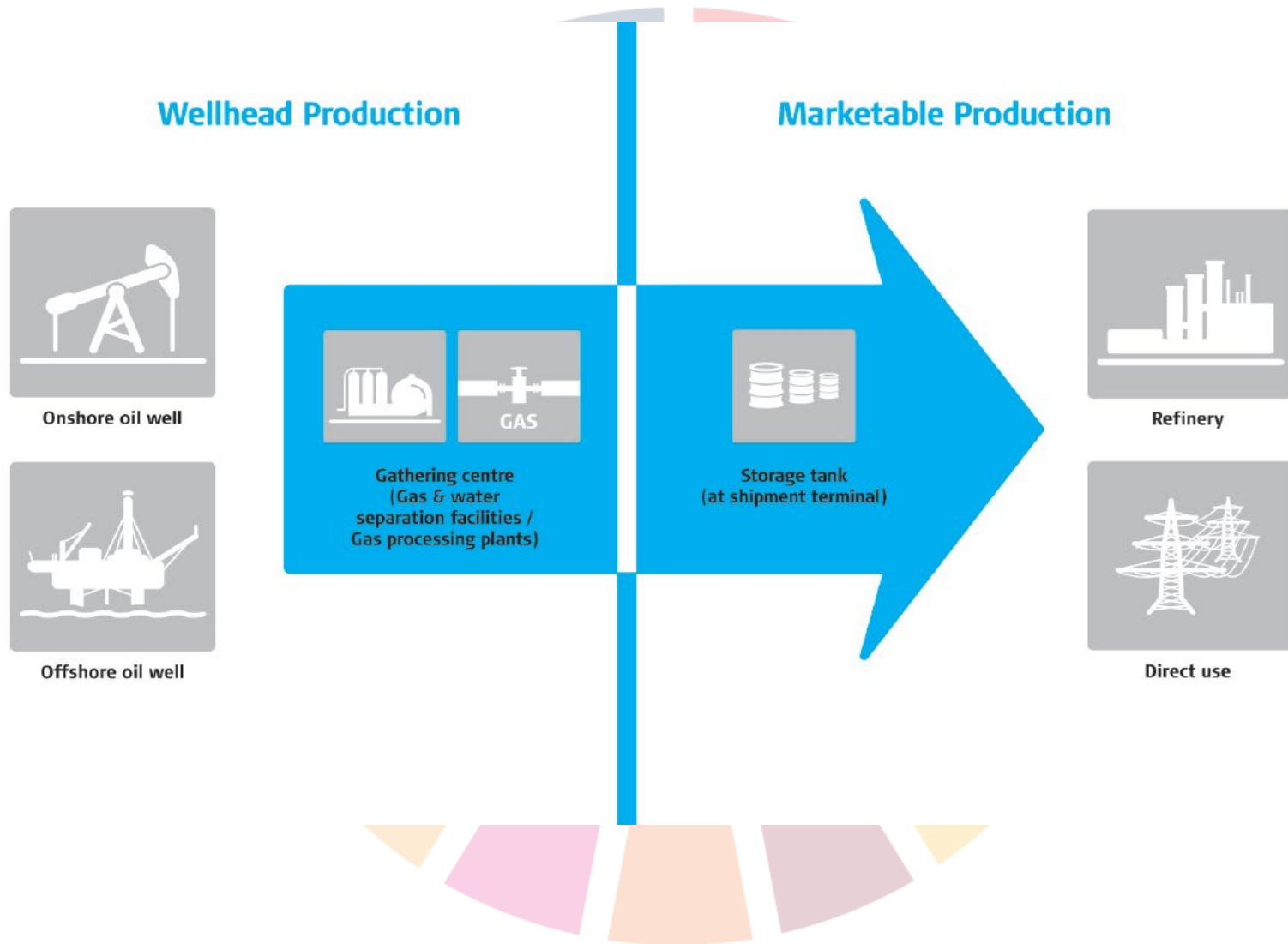
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# Oil flows in an economy





# Primary production



# Conventional crude oil

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A mineral oil of fossil origin extracted by conventional means from underground reservoirs, and comprises liquid or near-liquid hydrocarbons and associated impurities such as sulphur and metals.

The various crude oils may be classified according to their sulphur content (sweet or sour) and API gravity (heavy or light).



# Natural gas liquids (NGL)

---

- Natural gas liquids are a mixture of ethane, propane, butane (normal and iso), (iso) pentane and a few higher alkanes collectively referred to as pentanes plus.
- NGL are produced in association with oil or natural gas. They are removed in field facilities or gas separation plants before sale of the gas. All of the components of NGL except ethane are either liquid at the surface or are liquefied for disposal.

# Other hydrocarbons

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- Includes non-conventional oils and hydrogen. Non-conventional oils refer to oils obtained by non-conventional production techniques, that is, oils extracted from reservoirs containing extra heavy oils or oil sands which need heating or treatment (e.g., emulsification) in situ before they can be brought to the surface for refining/processing.
- They also include oils extracted from oil sands, extra heavy oils, coal and oil shale which are at, or can be brought to, the surface without treatment and require processing after mining (ex situ processing). Non-conventional oils may also be produced from natural gas.

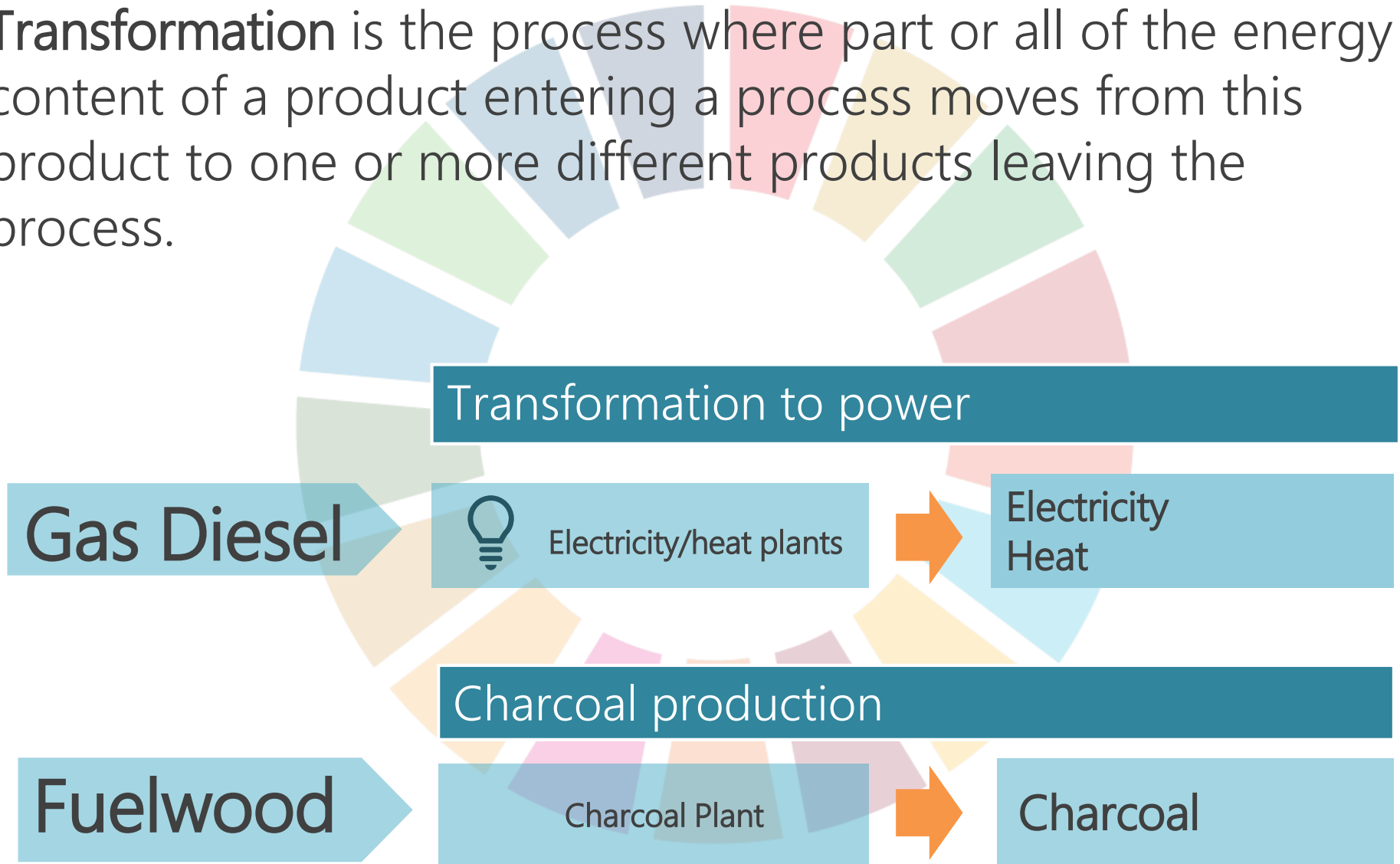


# Transformations and transfers

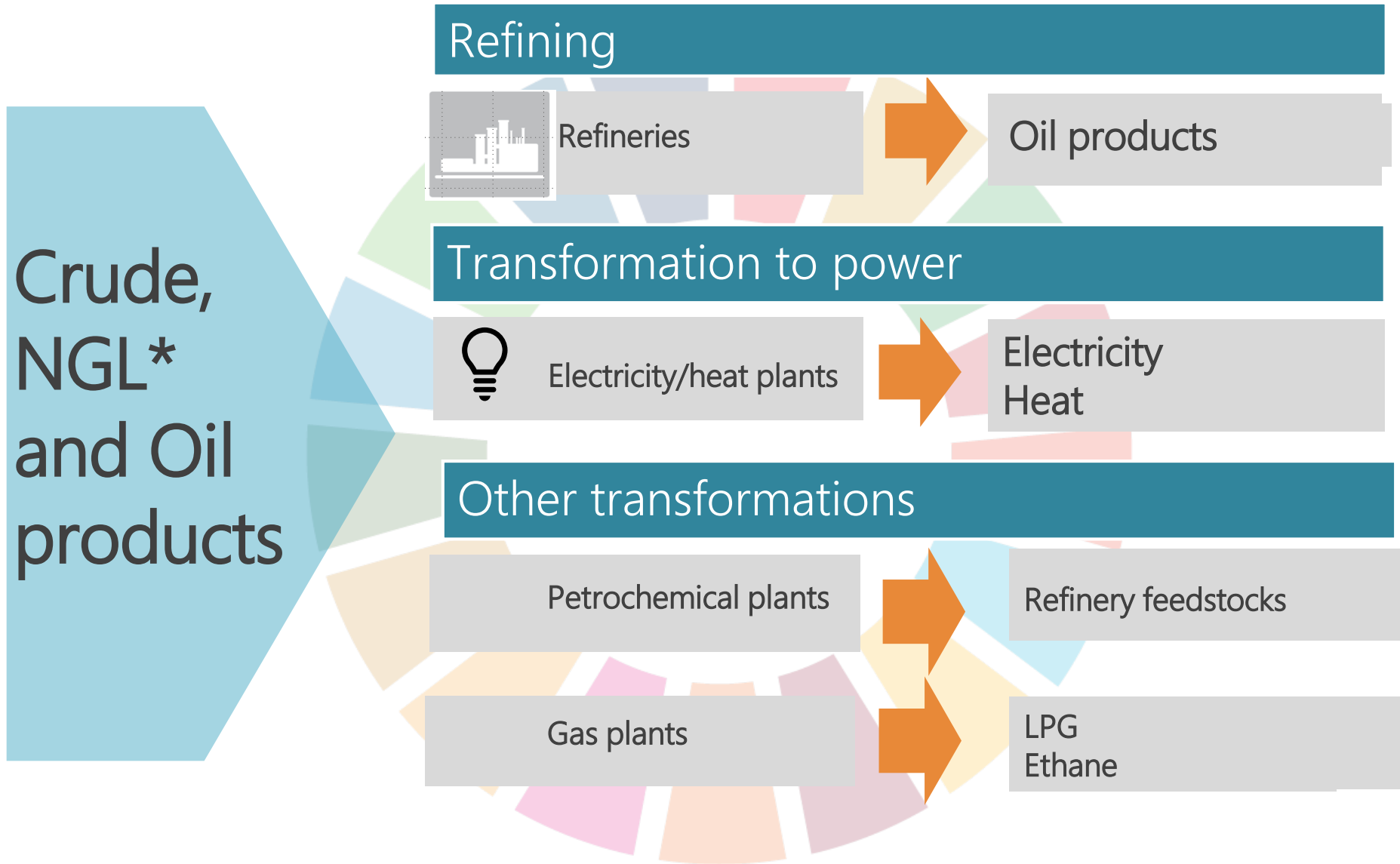
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# Transformations

**Transformation** is the process where part or all of the energy content of a product entering a process moves from this product to one or more different products leaving the process.

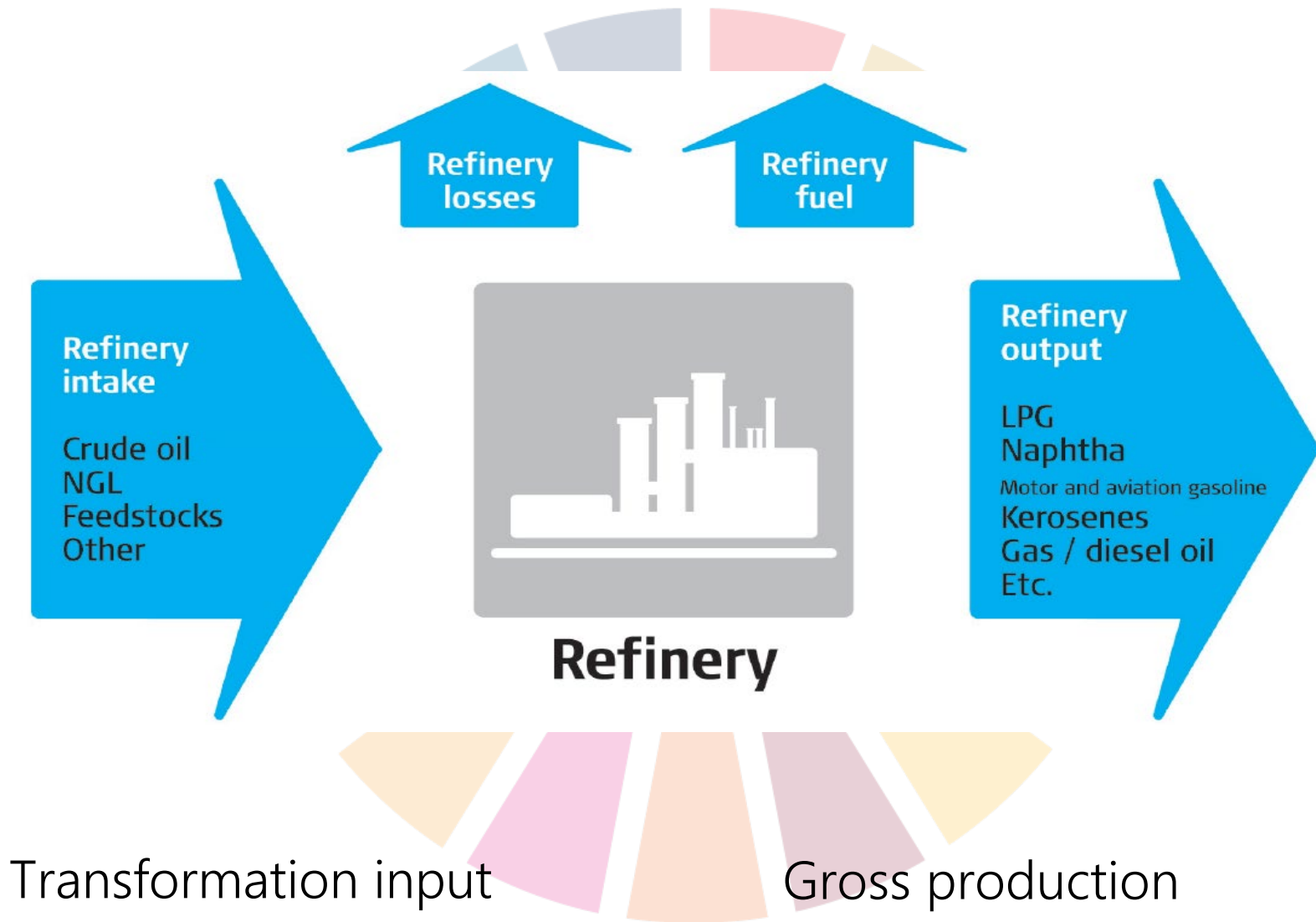


# Oil flows – transformations



\*includes additives and oxygenates and other hydrocarbons

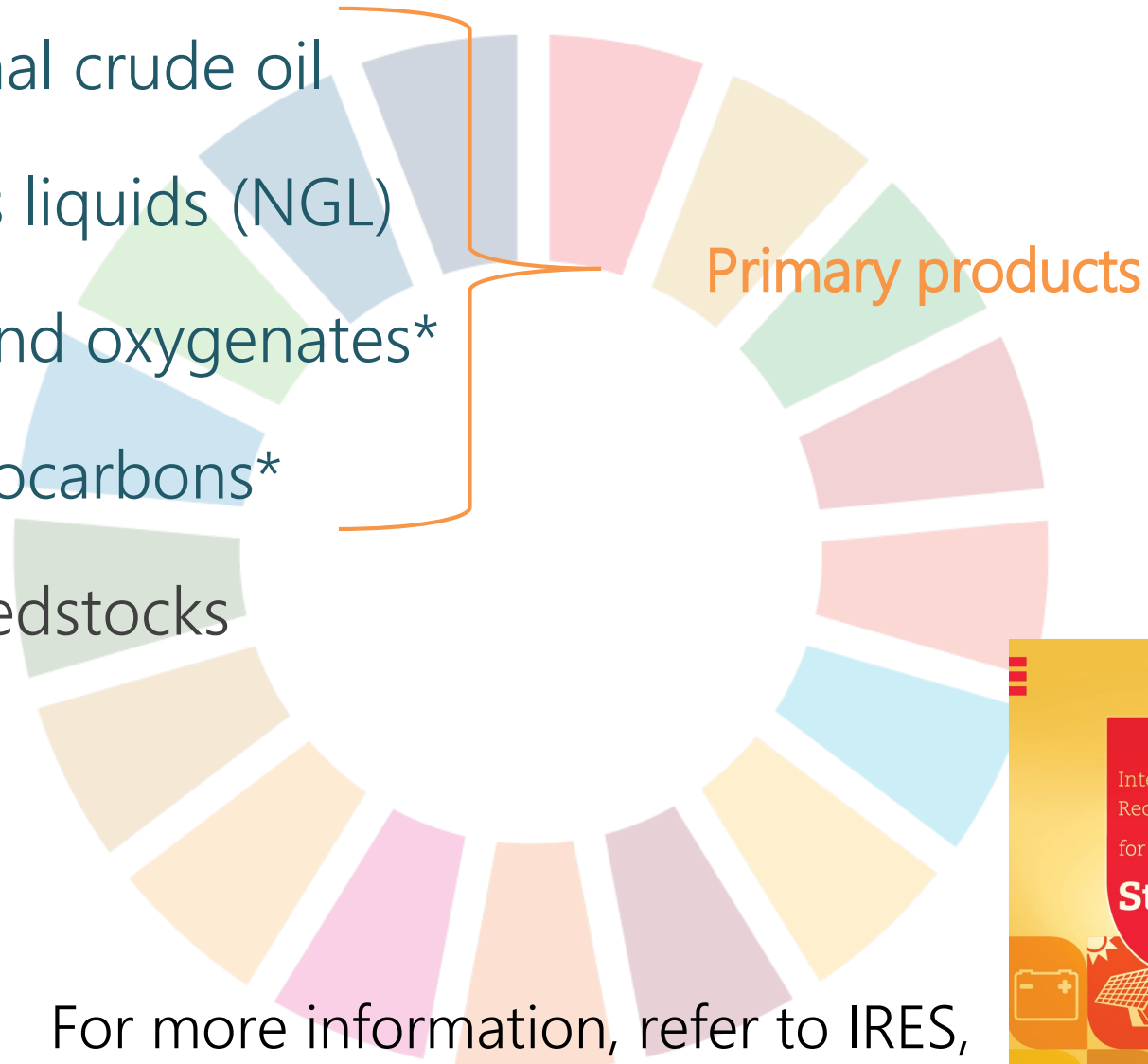
# Refining



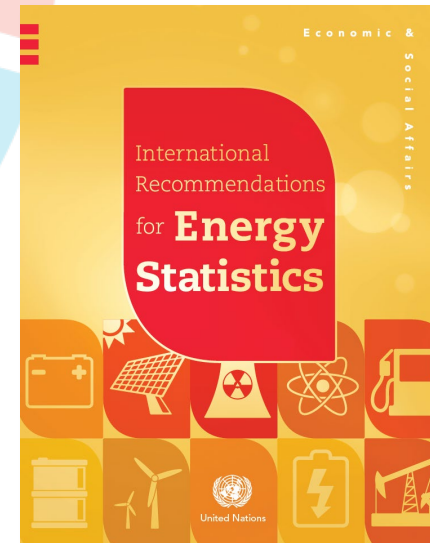


# Refinery intake

- Conventional crude oil
- Natural gas liquids (NGL)
- Additives and oxygenates\*
- Other hydrocarbons\*
- Refinery feedstocks



For more information, refer to IRES,  
<https://unstats.un.org/unsd/energystats/methodology/ires/>



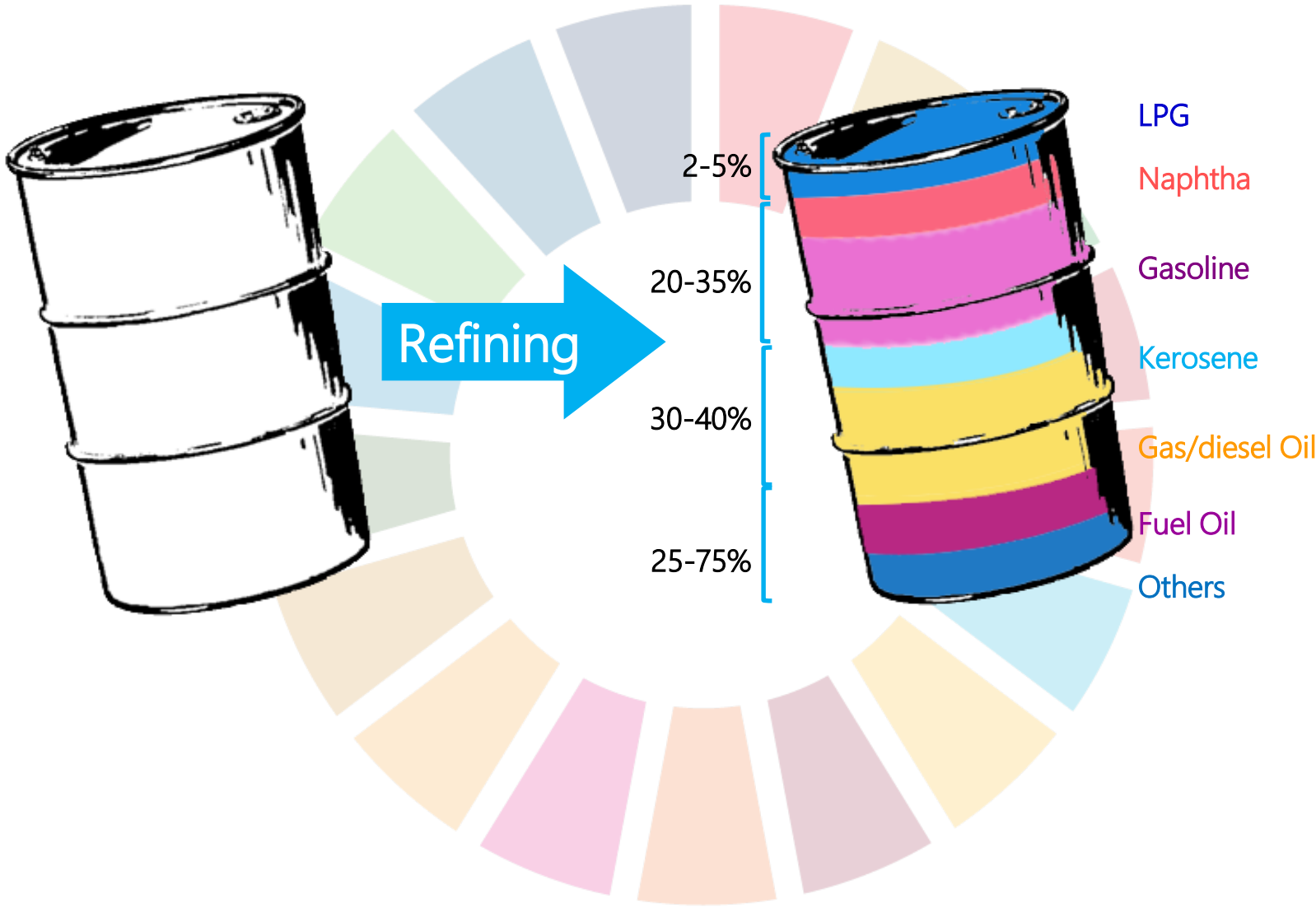
\* can also be secondary products

# Refinery intake

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- Additives and oxygenates
  - Compounds added to or blended with oil products to modify their properties (octane, cetane, cold properties, etc.).
  - Examples are: (a) oxygenates such as alcohols (b) esters and (c) chemical compounds
- Refinery feedstocks
  - oils or gases from crude oil refining or the processing of hydrocarbons in the petrochemical industry that are destined for further processing in the refinery excluding blending.
  - Examples are: naphthas, middle distillates, pyrolysis gasoline and heavy oils from vacuum distillation and petrochemical plants.

# Refinery output



# Refinery efficiency

Refinery gross output

Refinery intake

Refinery gross output

Refinery intake

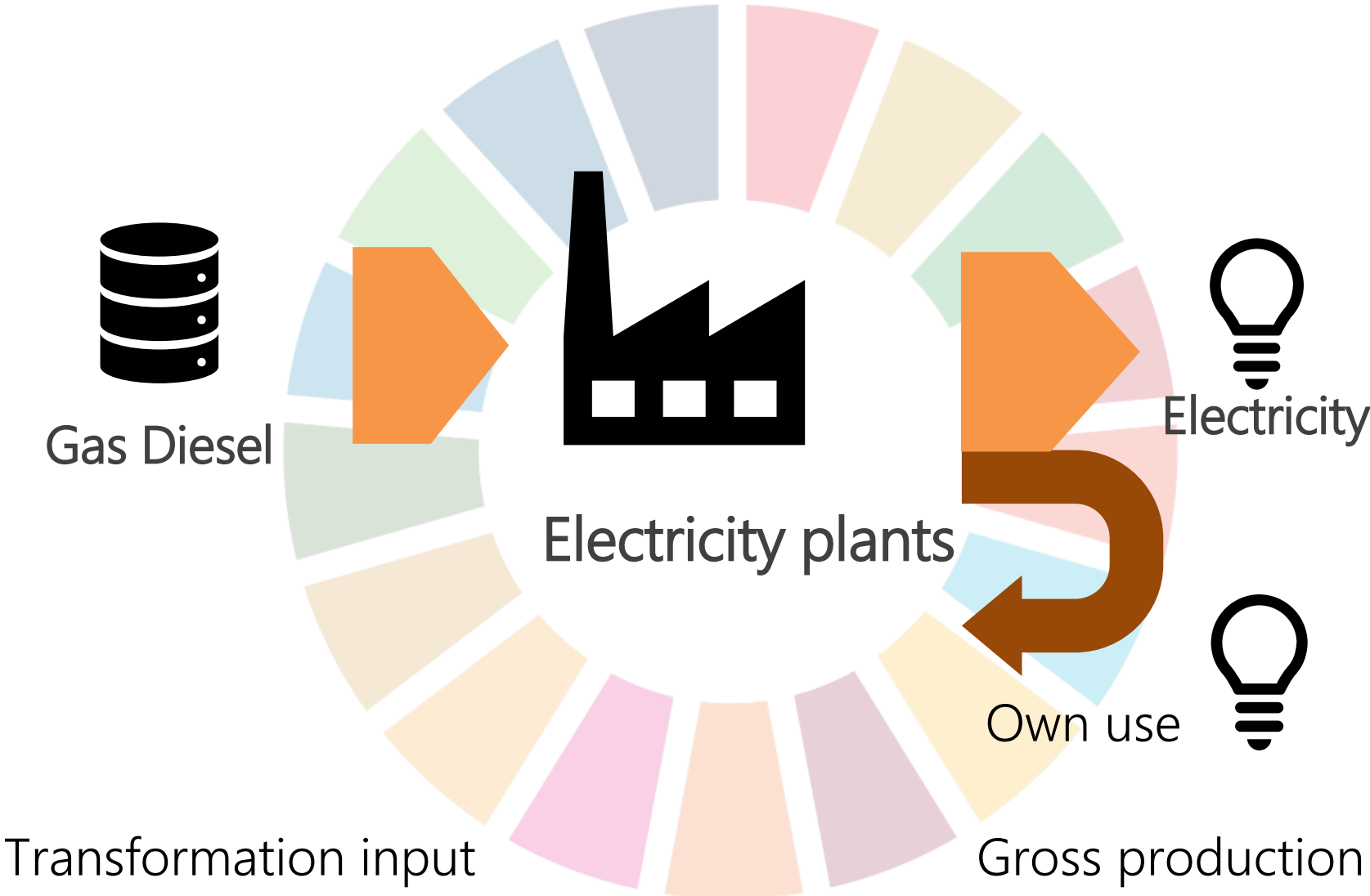
$>1 \rightarrow$  Refinery gains

$<1 \rightarrow$  Refinery losses

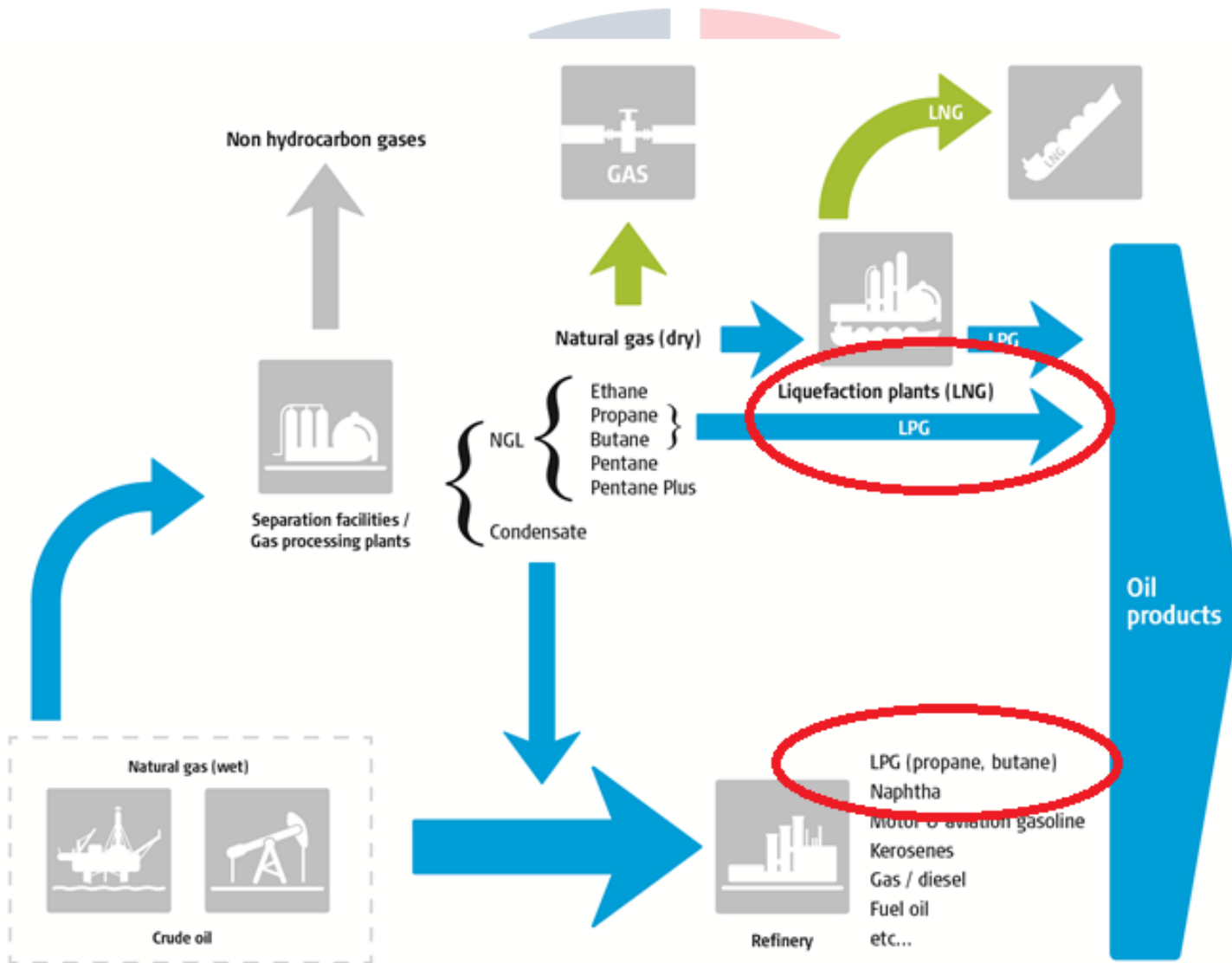
- ✓ Mass units (e.g. tonnes) – small losses and no gains.
- ✓ Volume units (e.g. barrels) – gains are possible and likely because lighter products are produced.
- ✓ Energy units (e.g. TJ, toe) – small losses with no gains.



# Transformation to power



# Gas plants



# Transfers

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- Transfers are essentially statistical devices to overcome practical classification and presentation issues resulting from changes in use or identity of a product.
- Transfers comprise products transferred and interproduct transfers.
  - **Products transferred** refers to the reclassification (renaming) of products, which, for example, is necessary when finished oil products are used as feedstock in refineries.
  - **Interproduct transfers** refer to the movements of fuels between product categories because of reclassification of a product that no longer meets its original specification. For example, aviation turbine fuel that has deteriorated or has been spoiled may be reclassified as heating kerosene.



# Final consumption

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# Final consumption

## Final consumption

### Final energy consumption

#### Manufacturing, construction and non-fuel mining industry

- Iron and steel
- Chemical and petrochemical
- Other manufacturing
- Construction
- Non-fuel mineral industry



#### Transport

- Road
- Rail
- Domestic navigation
- Pipeline transport
- Others



#### Other

- Households
- Agriculture, forestry, fishing
- Commerce and public services
- Not elsewhere specified (other)



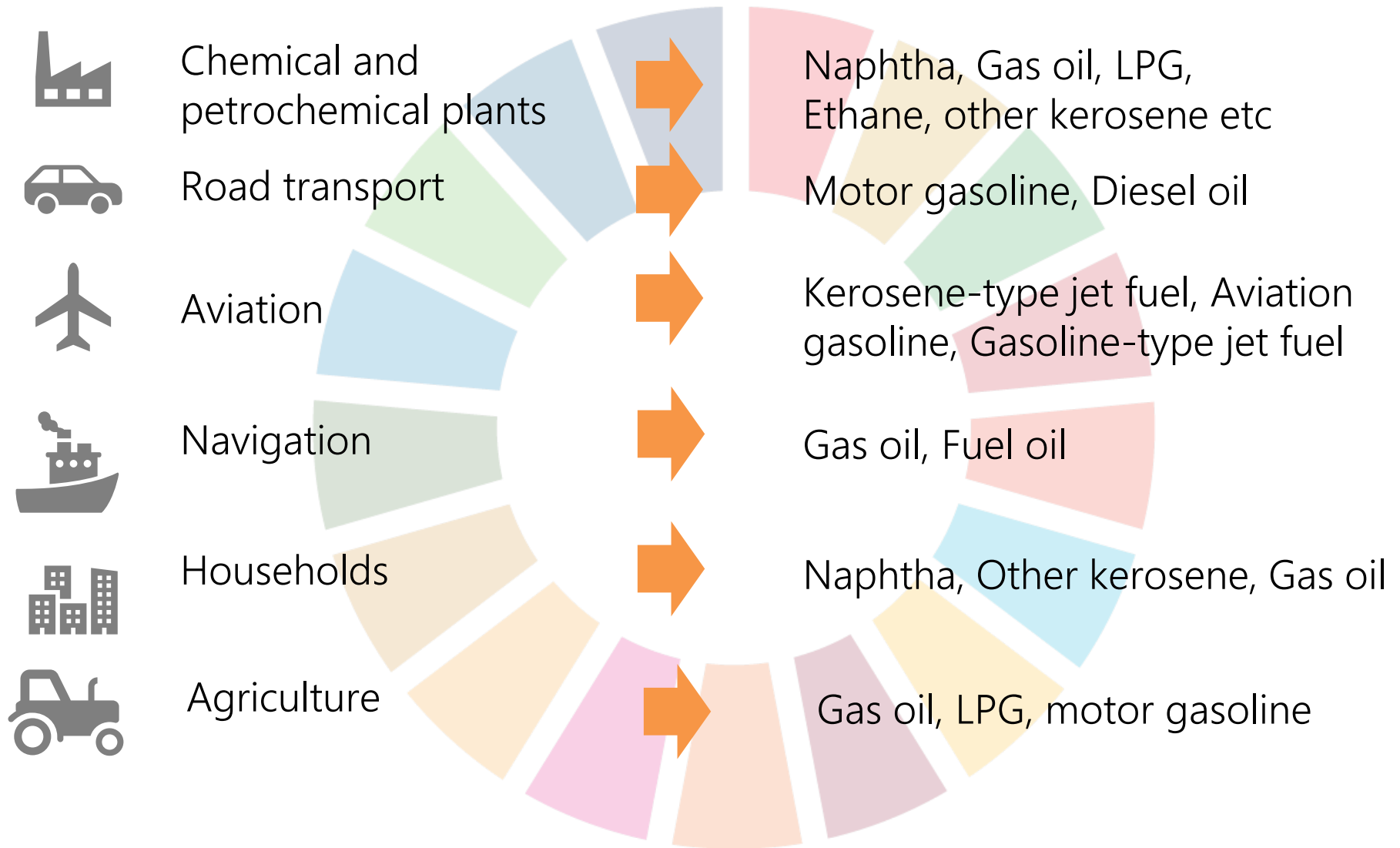
#### Non-energy consumption

# International Bunkers and Transport

- **International bunkers** are quantities of fuels delivered to merchant ships (including passenger ships) and civil aircraft of any nationality for consumption during **international voyages/flight** transporting goods or passengers.
- International voyages/flights take place when the ports of departure and arrival are in different national territories. Fuels delivered for consumption by ships during domestic transportation, fishing or military uses are not included here, but are considered part of **final consumption of energy**.



# Final consumption



# Non-energy use

---

- Lubricants and grease for their slippery properties
- Bitumen (asphalt) for its waterproofing properties
- Naphtha, gas oil, LPG, ethane - feedstocks to petrochemical plants (fertilizers, plastics, synthetic rubber, pesticides)
- Petroleum coke - the manufacture of soda ash, silicon carbide and carbon anodes.



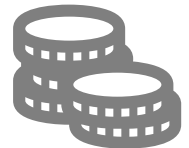


## Other flows

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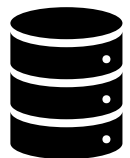
# Trade

- **Imports** of energy products comprise all fuel and other energy products entering the national territory.
  - goods simply being transported through a country (goods in transit) and goods temporarily admitted are excluded,
  - re-imports (i.e. domestic goods exported but subsequently readmitted) are included.
  - The bunkering of fuel outside the reference territory by national merchant ships and civil aircraft engaged in international travel is also excluded from imports.
- **Exports** of energy products comprise all fuel and other energy products leaving the national territory.
  - Goods simply being transported through a country (goods in transit) and goods temporarily withdrawn are excluded, while
  - re-exports (i.e. foreign goods exported in the same state as previously imported) are included.
  - Also excluded are quantities of fuels delivered for use by merchant ships (including passenger ships) and civil aircraft of all nationalities during international transport of goods and passengers



# Stock changes

- Stock changes.
  - For the purposes of energy statistics, stocks are quantities of energy products that are held on the **national territory** and can be used to:
    - (a) maintain service under conditions where supply and demand are variable in their timing or amount due to normal market fluctuations, or
    - (b) supplement supply in the case of a supply disruption.
  - Stocks used to manage a supply disruption may be called “strategic” or “emergency” stocks and are often held separately from stocks designed to meet normal market fluctuations, but both are considered here.
  - **Stock changes** are defined as the increase (stock build) or decrease (stock draw) in the quantity of stocks over the reporting period and thus are calculated as a **difference between the closing and opening stocks**.





# Commodity balances

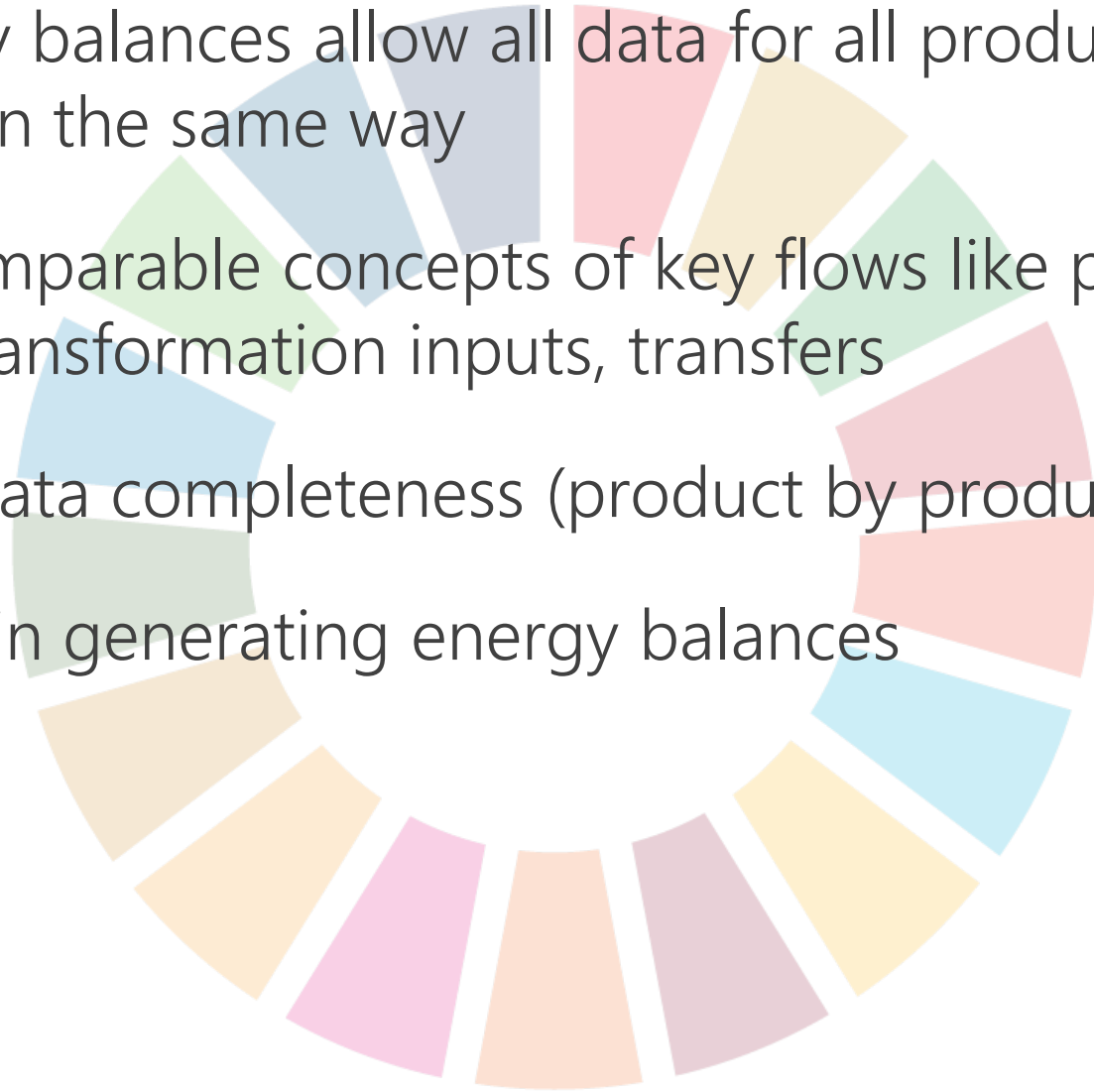
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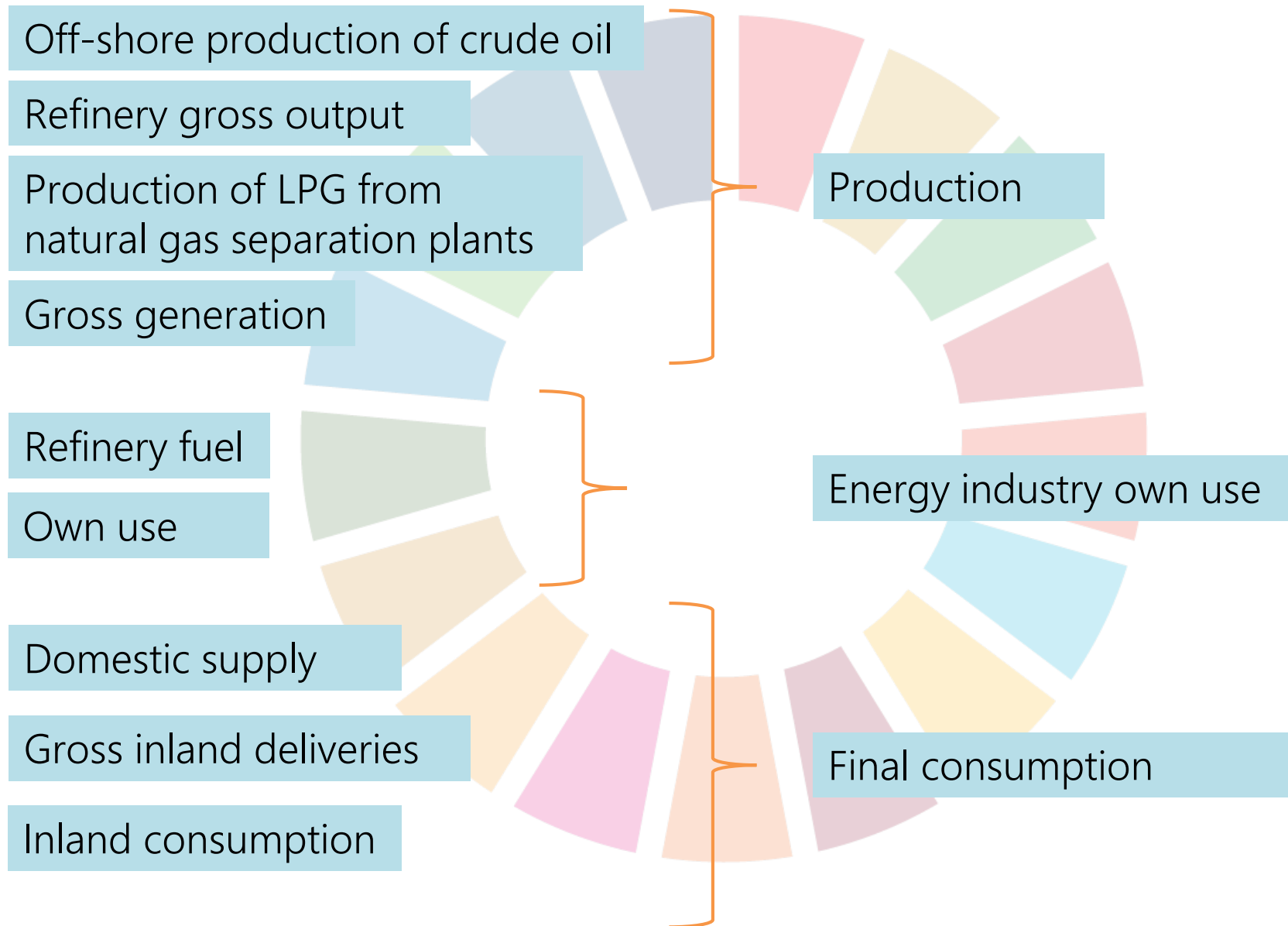
# Why to create commodity balances

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- Commodity balances allow all data for all products to be presented in the same way
- Directly comparable concepts of key flows like production, own use, transformation inputs, transfers
- Check on data completeness (product by product)
- A key step in generating energy balances



# Energy data – commodity balances



# What flows are collected annually?

Production

- from plants/from refinery
- electricity and heat by source and type of plants

Receipt from other sources

Import and Export

Marine Bunkers

Stock Changes

---

**= Total Energy Supply**

Transfers and recycled products

Statistical Differences

Transformation Sector (21 sub-sectors)

Energy industries own use (17 sub-sectors)

Distribution Losses

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**Final Consumption =**

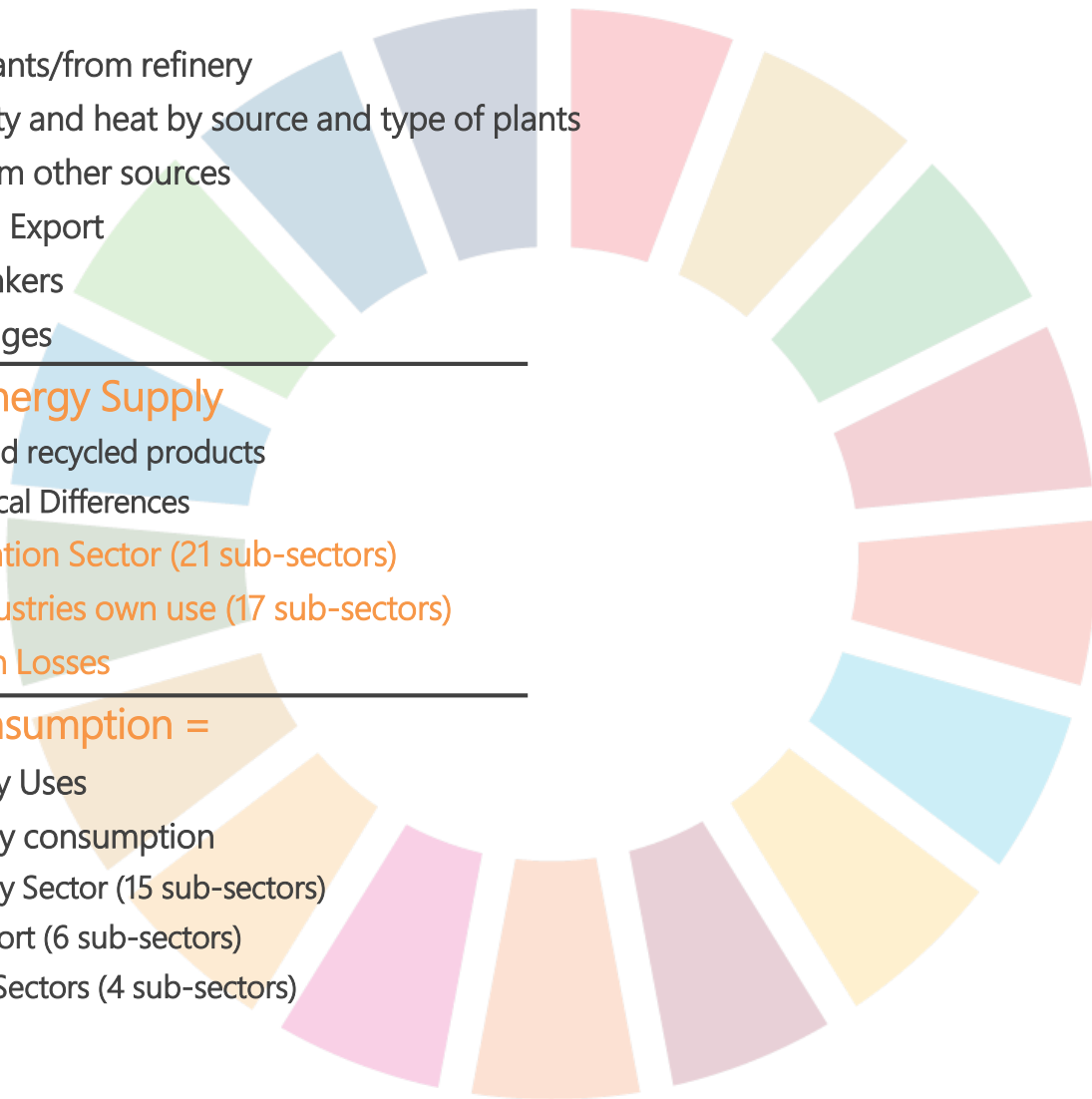
Non Energy Uses

Final energy consumption

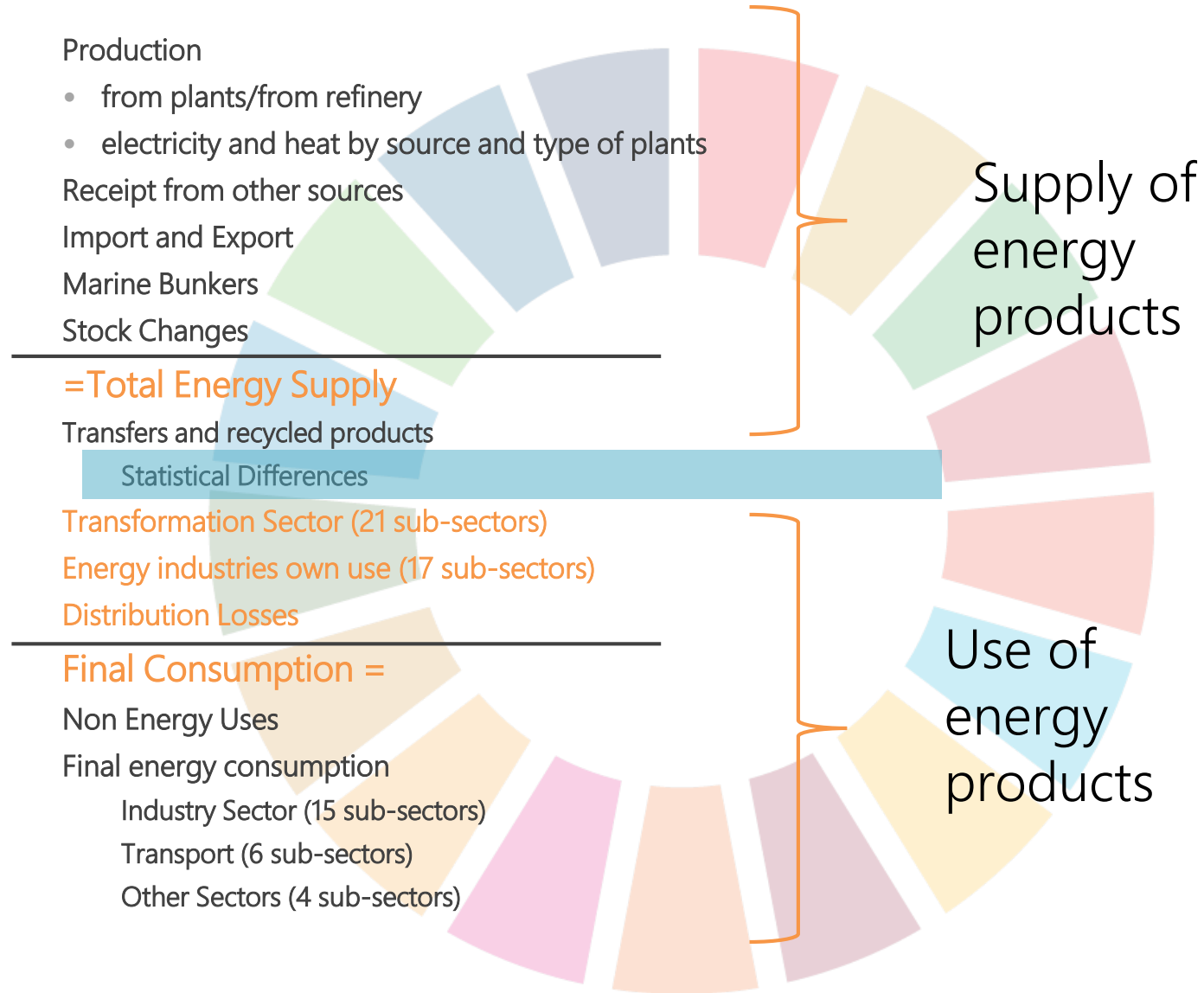
Industry Sector (15 sub-sectors)

Transport (6 sub-sectors)

Other Sectors (4 sub-sectors)



# Supply and use of energy products



# Transformation and own use

## Gas Oil/ Diesel Oil (DL); Metric tons, thousand (WSR)

DL08	Transformation
DL088	Transformation in electricity, CHP and heat plants
DL08811	Electricity plants - Main activity producers
DL08812	Electricity plants - Autoproducers
DL081	Coke ovens
DL082	Gas works
DL083	Briquetting plants
DL085PP	Petrochemical plants
DL087	Natural gas blending plants
DL089	Other transformation

Gas Diesel transformed into other form of energy (e.g. electricity)

## DL09 Energy industries own use

DL0911	Coal mines
DL0912	Oil and gas extraction
DL0921	Coke ovens
DL0922	Gas works
DL0924	Blast furnaces
DL0925	Oil refineries
DL0927	Electricity, CHP and heat plants
DL0928	Other energy industry own use

Gas Diesel used to keep running the industry, e.g. some engines in the electricity plant.

## Total Electricity (EL); Kilowatt-hours, million (HWU)

EL015C	From combustible fuels – Main activity
EL015CE	From combustible fuels – Main activity – Electricity plants
EL0927	Own use by electricity, CHP and heat plants

Electricity from gas diesel used within the electricity plant!

# Main activity producers & autoproducers

## Gas Oil/ Diesel Oil (DL); Metric tons, thousand (WSR)

DL088	Transformation in electricity, CHP and heat plants
DL08811	Electricity plants - Main activity producers
DL08812	Electricity plants - Autoproducers
DL08821	CHP plants - Main activity producers
DL08822	CHP plants - Autoproducers
DL08831	Heat plants - Main activity producers
DL08832	Heat plants - Autoproducers

## Main activity producers

- Privately or publicly owned companies
- Produce electricity or heat as their principal activity
- Formerly known as public utilities
- In practice, plants called: power plant, CHP plant, heat plant

## Autoproducers

- Privately or publicly owned companies
- Produce electricity and/or heat wholly or partially for their own use as support to their primary activity
- E.g.: Waste recycling facilities, paper mill, etc

# Electricity, CHP and Heat plants

## Gas Oil/ Diesel Oil (DL); Metric tons, thousand (WSR)

DL088	Transformation in electricity, CHP and heat plants
DL08811	Electricity plants - Main activity producers
DL08812	Electricity plants - Autoproducers
DL08821	CHP plants - Main activity producers
DL08822	CHP plants - Autoproducers
DL08831	Heat plants - Main activity producers
DL08832	Heat plants - Autoproducers

Electricity plant

CHP plant

Heat plant

- Plants producing only electricity
- The electricity may be obtained directly from natural sources (e.g. hydro) or from the heat obtained from the combustion of fuels or nuclear reactions.

- Plants producing both heat and electricity from at least one generating unit in the plant.
- Sometimes called: "co-generation" plants

- Plants designed to produce heat only for deliveries to third parties.
- Including heat pumps and electric boilers.
- Deliveries of fuels for heat generated by an autoproducer for its own purposes are classified as final consumption.



# Definition of oil products

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# Definitions of oil products

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- Refinery gas
  - Includes a mixture of non-condensable gases, mainly consisting of hydrogen, methane, ethane and olefins obtained during distillation of crude oil or treatment of oil products (e.g., cracking) in refineries or from nearby petrochemical plants.
- Ethane
  - A naturally gaseous straight-chain hydrocarbon ( $C_2H_6$ ).
- Liquefied petroleum gases (LPG)
  - LPG refers to liquefied propane ( $C_3H_8$ ) and butane ( $C_4H_{10}$ ) or mixtures of both. Commercial grades are usually mixtures of the gases with small amounts of propylene, butylene, isobutene and isobutylene stored under pressure in containers.
- Naphtha
  - Light or medium oils distilling between  $30^{\circ}C$  and  $210^{\circ}C$  that do not meet the specification for motor gasoline.

# Definitions of gasolines

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- Gasolines
  - Complex mixtures of volatile hydrocarbons distilling between approximately 25°C and 220°C and consisting of compounds in the C<sub>4</sub> to C<sub>12</sub> range
- Aviation gasoline
  - Gasoline prepared especially for aviation piston engines with additives that assure performance under flight conditions. Aviation gasolines are predominantly alkylates (obtained by combining C<sub>4</sub> and C<sub>5</sub> isoparaffins with C<sub>3</sub>, C<sub>4</sub> and C<sub>5</sub> olefins) with the possible addition of more aromatic components including toluene. The distillation range is 25°C to 170°C.
- Motor gasoline
  - A mixture of some aromatics (e.g., benzene and toluene) and aliphatic hydrocarbons in the C<sub>5</sub> to C<sub>12</sub> range. The distillation range is 25°C to 220°C.
- Gasoline-type jet fuel
  - Light hydrocarbons for use in aviation turbine power units, distilling between 100°C and 250°C. They are obtained by blending kerosene and gasoline or naphtha in such a way that the aromatic content does not exceed 25 per cent in volume, and the vapour pressure is between 13.7 kPa and 20.6 kPa.

# Definitions of kerosenes

---

- Kerosenes
  - Mixtures of hydrocarbons in the range  $C_9$  to  $C_{16}$  and distilling over the temperature interval  $145^{\circ}\text{C}$  to  $300^{\circ}\text{C}$ , but not usually above  $250^{\circ}\text{C}$  and with a flash point above  $38^{\circ}\text{C}$ .
- Kerosene-type jet fuel
  - A blend of kerosenes suited to flight conditions with particular specifications, such as freezing point.
- Other kerosene
  - Kerosene that is used for heating, cooking, lighting, solvents and internal combustion engines.

# Definitions of gas oil

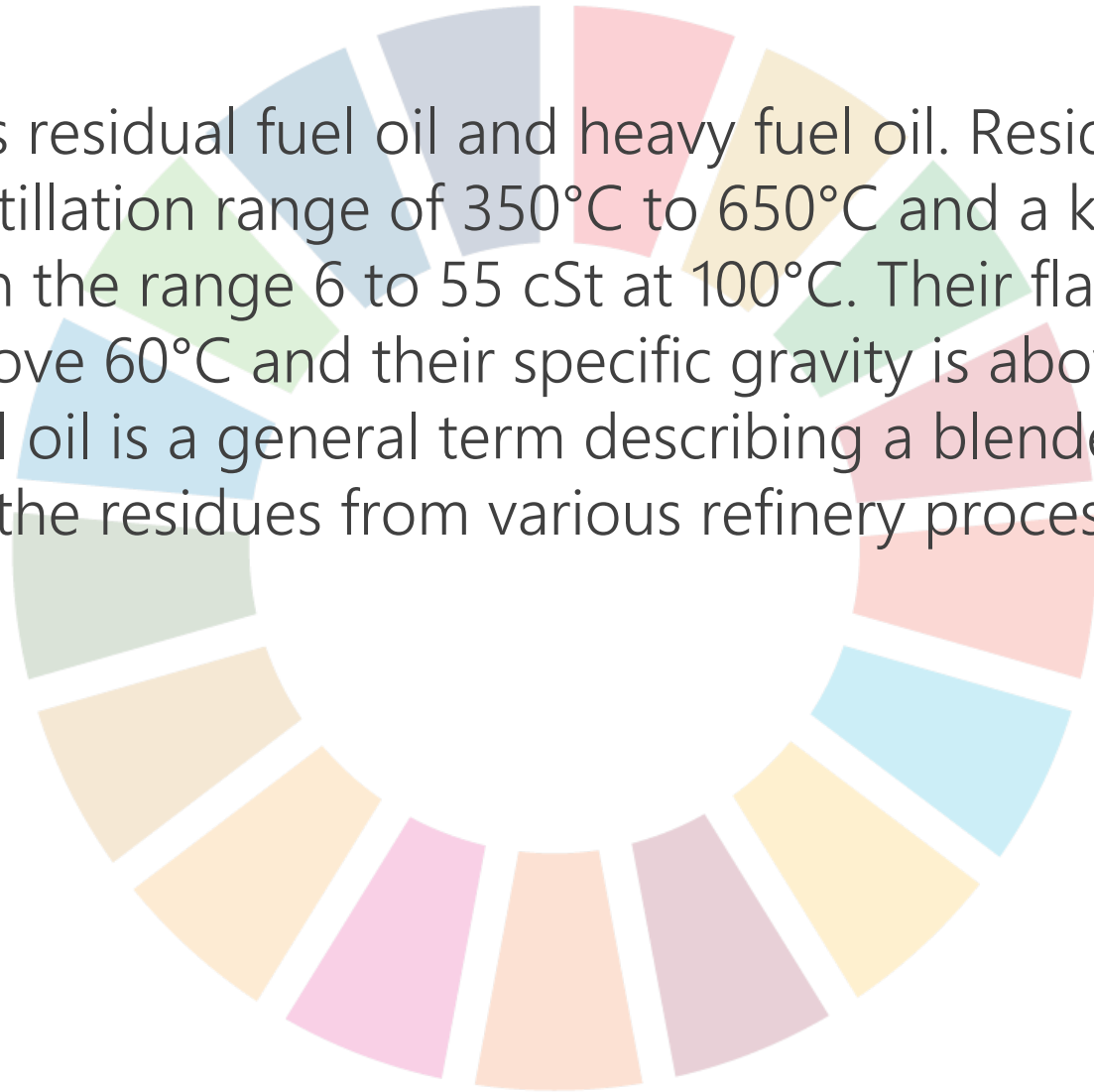
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- Gas oil/diesel oil and heavy gas oil:
  - This group includes gas oils and heavy gas oils
- Gas oil/diesel oil
  - Gas oils are middle distillates, predominantly of carbon number range  $C_{11}$  to  $C_{25}$  and with a distillation range of  $160^{\circ}\text{C}$  to  $420^{\circ}\text{C}$ .
- Heavy gas oil
  - A mixture of predominantly gas oil and fuel oil that distills in the range of approximately  $380^{\circ}\text{C}$  to  $540^{\circ}\text{C}$ .

# Definitions of fuel oil

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- Fuel oil
  - Comprises residual fuel oil and heavy fuel oil. Residual fuel oils have a distillation range of 350°C to 650°C and a kinematic viscosity in the range 6 to 55 cSt at 100°C. Their flash point is always above 60°C and their specific gravity is above 0.95. Heavy fuel oil is a general term describing a blended product based on the residues from various refinery processes.



# Definitions of other oil products

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- White spirit and special boiling point industrial spirits
  - White spirit and special boiling point (SBP) industrial spirits are refined distillate intermediates with a distillation in the naphtha/kerosene range. They are mainly used for non-fuel purposes and sub-divided as: (a) white spirit—an industrial spirit with a flash point above 30°C and a distillation range of 135°C to 200°C; and (b) industrial spirit (SBP)—light oils distilling between 30°C and 200°C.
- Lubricants
  - Oils, produced from crude oil, for which the principal use is to reduce friction between sliding surfaces and during metal cutting operations.
- Paraffin waxes
  - Residues extracted when dewaxing lubricant oils. The waxes have a crystalline structure that varies in fineness according to the grade, and are colourless, odourless and translucent, with a melting point above 45°C.

# Definitions of other oil products

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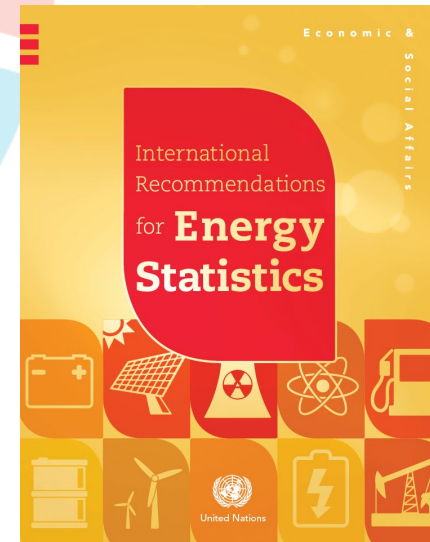
- Petroleum coke

- Petroleum coke is a black solid obtained mainly by cracking and carbonizing heavy hydrocarbon oils, tars and pitches. It consists mainly of carbon (90 to 95 per cent) and has a low ash content.
- The two most important categories are green coke and calcined coke.
  - **Green coke** (raw coke) is the primary solid carbonization product from high boiling hydrocarbon fractions obtained at temperatures below 630°C. It contains 4–15 per cent by weight of matter that can be released as volatiles during subsequent heat treatment at temperatures up to approximately 1330°C.
  - **Calcined coke** is a petroleum coke or coal-derived pitch coke obtained by heat treatment of green coke to about 1330°C. It will normally have a hydrogen content of less than 0.1 per cent by weight.

# Definitions of other oil products

- Bitumen
  - A solid, semi-solid or viscous hydrocarbon with a colloidal structure, being brown to black in color.
- Other oil products n.e.c.
  - Products (including partly refined products) from the refining of crude oil and feedstocks that are not specified above.

For more information, refer to IRES,  
<https://unstats.un.org/unsd/energystats/methodology/ires/>







# Data sources

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# Data sources

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**Refineries** – a very reliable source of information

- Often only a few in a country, so easy to census
- They hold very detailed information to monitor their activity

**Oil product distributors**

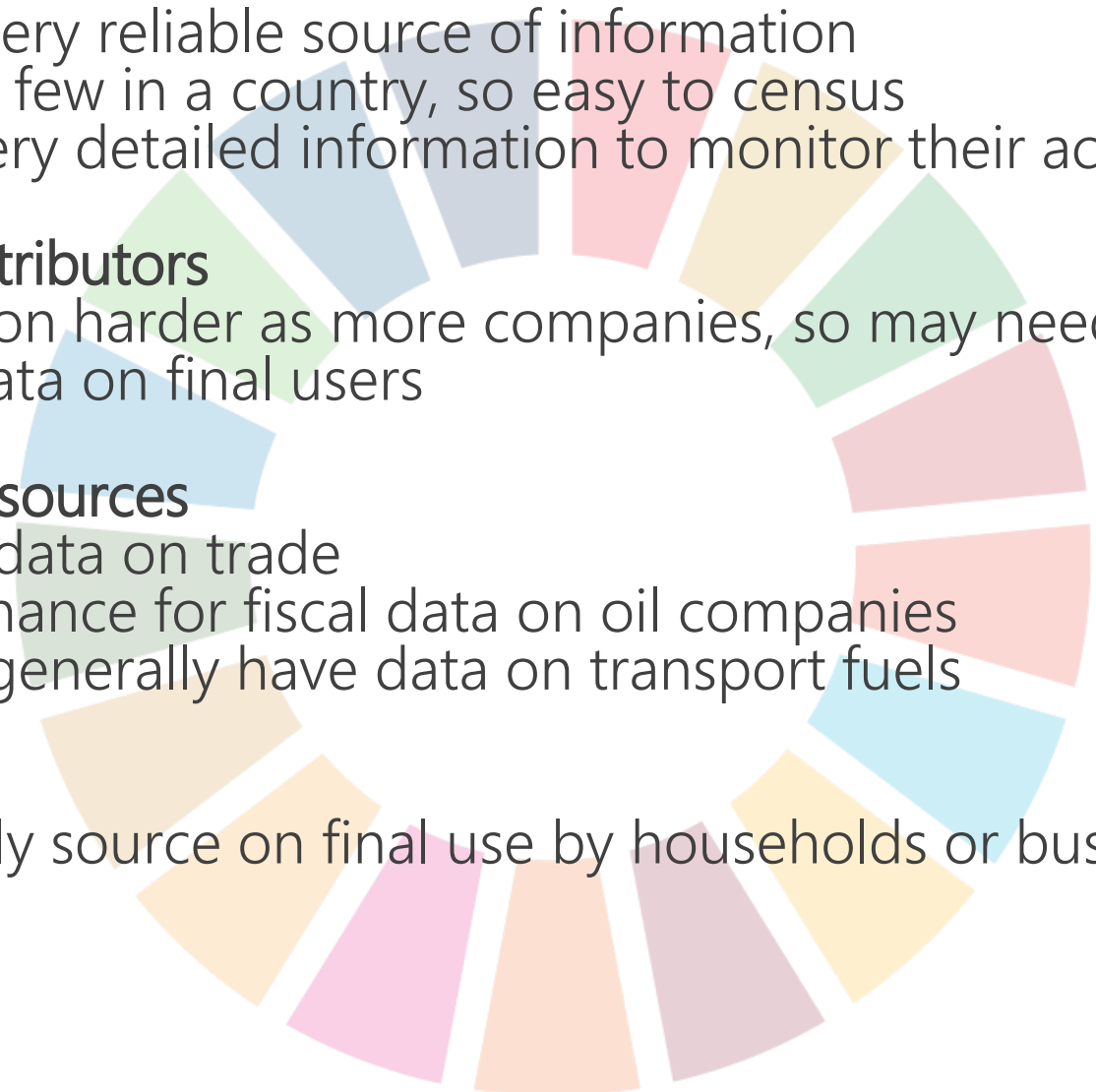
- data collection harder as more companies, so may need sample.
- Not many data on final users

**Administrative sources**

- Customs for data on trade
- Ministry of finance for fiscal data on oil companies
- Tax services generally have data on transport fuels

**Surveys**

- Often the only source on final use by households or business





# Units in energy statistics

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# Natural units

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Energy products are initially measured in Original or Natural units.

These units vary in different countries as a result of historical and other factors. :

- **Solid fuels** (e.g. coal) are measured in terms of their
  - **mass** (weight) ( e.g. kilograms, metric tons);
- **Liquid fuels** (e.g. oil) can be measured in terms of their
  - **volume**(e.g. barrels, litres, gallon) or
  - **mass** (metric tons);
- **Gaseous fuels** (e.g. methane) are measured in terms of their
  - **Volume** (e.g. cubic metres).

# Basic conversions

---

We can recalculate the quantities within the same unit category using constant values:

- 1 bbl  $\approx$  159 L
- 1 m<sup>3</sup> = 1000 L
- 1 ton = 1 000 kg

Prefix are used to present values in simplify format:

- Kilo (k) -  $10^3$
- Mega (M) -  $10^6$
- Giga (G) -  $10^9$
- Tera (T) -  $10^{12}$

E.g. 1 kt = 1 000 ton = 1 000 000 kg

# From volume to mass: densities

Liquid fuels can be measured by their mass or volume.

- To move from mass to volume we need to know density (or specific gravity of the liquid)
- E.g. crude oil can be light or heavy and we should use specific densities for calculation
- If the densities are not known, we can use average densities for different product categories.



# Example: from volume to mass

- Knowing that density of crude oil is 0.13569 (barrel/tonne), calculate how much weight is 1 mln barrels.

➤ 1 mln barrels = 1 000 000 barrels =

= 1 000 000 \* 0.13569 tonnes

= 135 690 tonnes

= 135.690 kilotonnes



density



# Energy units

---

**Electricity** is measured in units such as kilowatts or joules, and **heat** in calories or, in some countries, British Thermal Units (BTUs).

- Typical energy units:
  - GWh, joules, toe, tce
- We can recalculate the quantities between different energy unit using constant values
  - $1 \text{ GWh} = 3.6 \text{ TJ}$
  - $1 \text{ ktce} \approx 41.868 \text{ TJ}$
  - $1 \text{ ktce} = 0.7 \text{ ktce}$



# Examples: energy units

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Knowing that 1 GWh = 3.6 TJ and 1 ktoe = 41.868 TJ, convert 7 ktoe to GWh.

➤  $7 \text{ ktoe} = 7 * 41.868 \text{ [ktoe} * \text{TJ/ktoe]}$

$$= 293.076 \text{ [TJ]}$$

$$= 293.076 / 3.6 \text{ [TJ / (TJ / GWh)]}$$

$$= 81.41 \text{ [GWh]}$$

# Recommended units for dissemination

Energy products	Dimension	Unit
Solid fossil fuels	Mass	Thousand metric tons
Liquid fossil fuels	Mass	Thousand metric tons
(Liquid) Biofuels	Mass/Volume	Thousand Metric tons/ Thousand cubic metres
Gases	Energy	Terajoules
Wastes	Energy	Terajoules
Fuelwood	Volume/Energy	Thou. Cubic Metres/Terajoules
Charcoal	Mass	Thousand metric tons
Electricity	Energy	GWh
Heat	Energy	Terajoules
Common unit (eg balances)	Energy	Terajoules
Elec. installed capacity	Power	MW
Refinery capacity	Mass/time	Thousand metric tons/year



<http://un.org>  
<http://unstats.un.org/unsd>  
[energy\\_stat@un.org](mailto:energy_stat@un.org)