

Oil

The IEA oil data system

IEA Data Training Workshop in South Africa
Pretoria, 11-13 October 2010

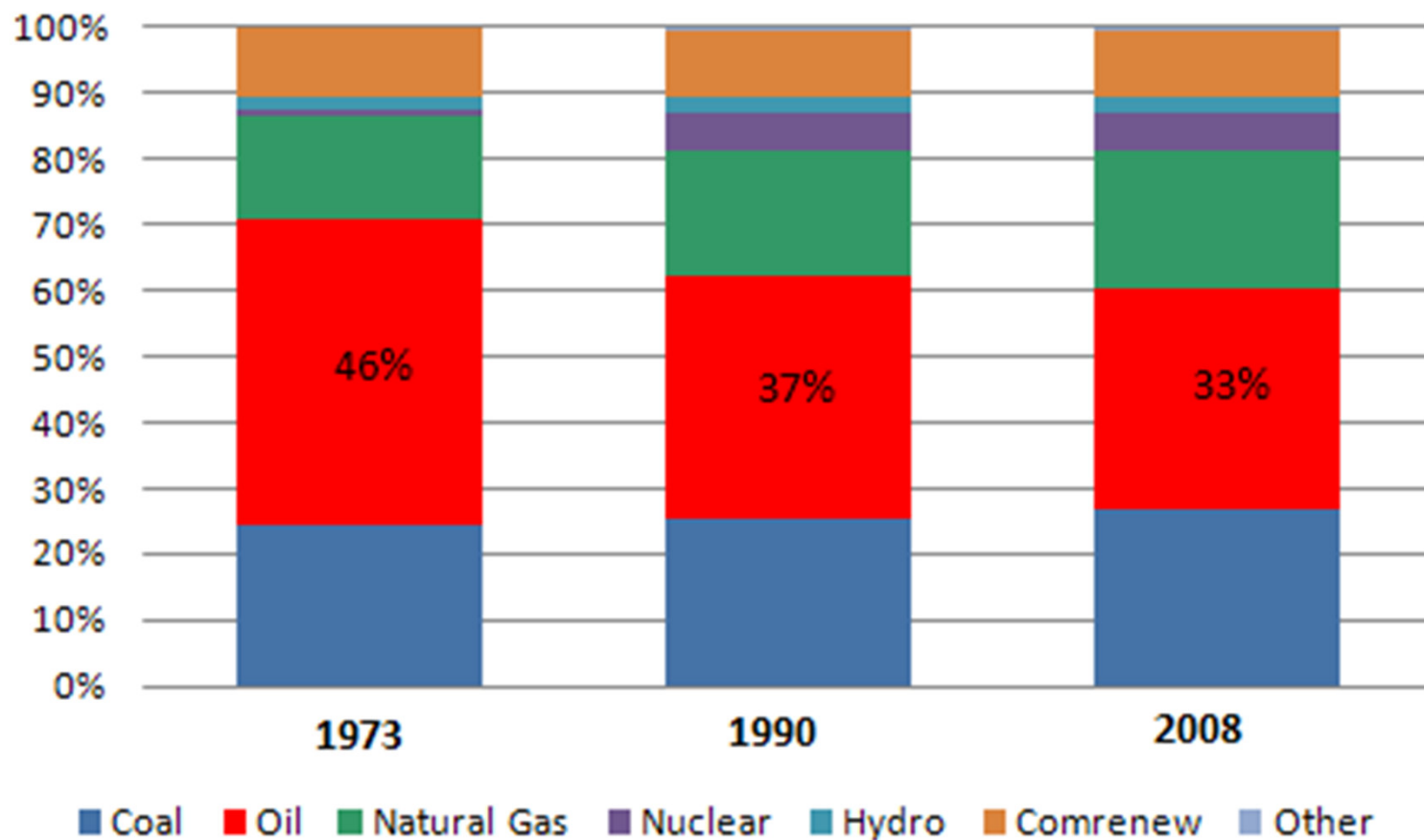
Roberta Quadrelli
Head, non-OECD Statistics



International
Energy Agency

- **Overview: The Importance of Oil**
- **Oil data collection and IEA Annual Oil Questionnaire**

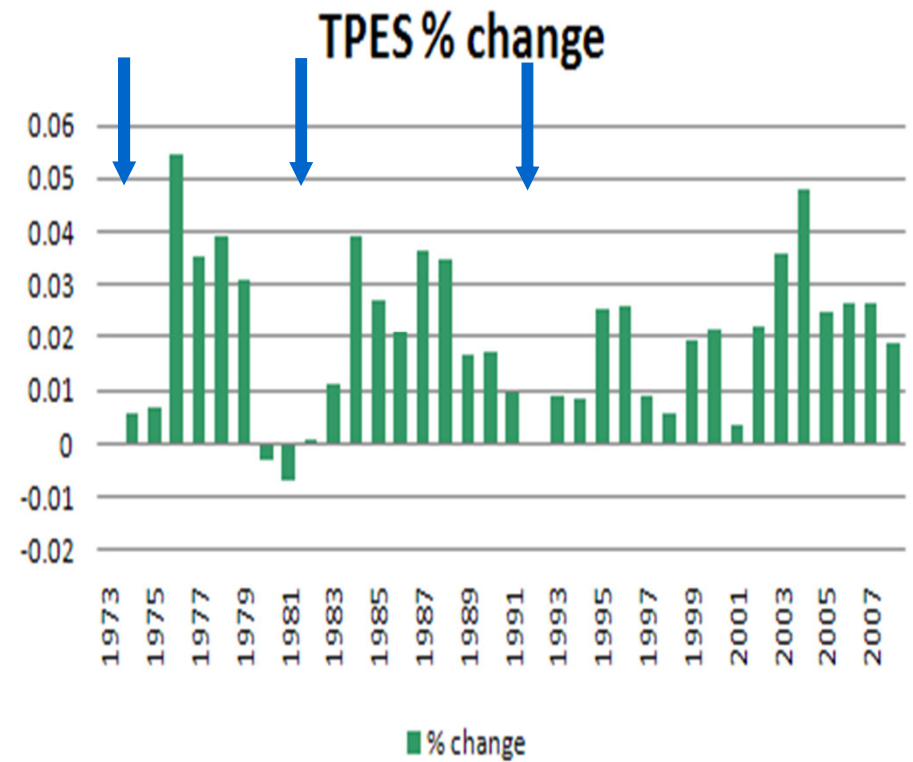
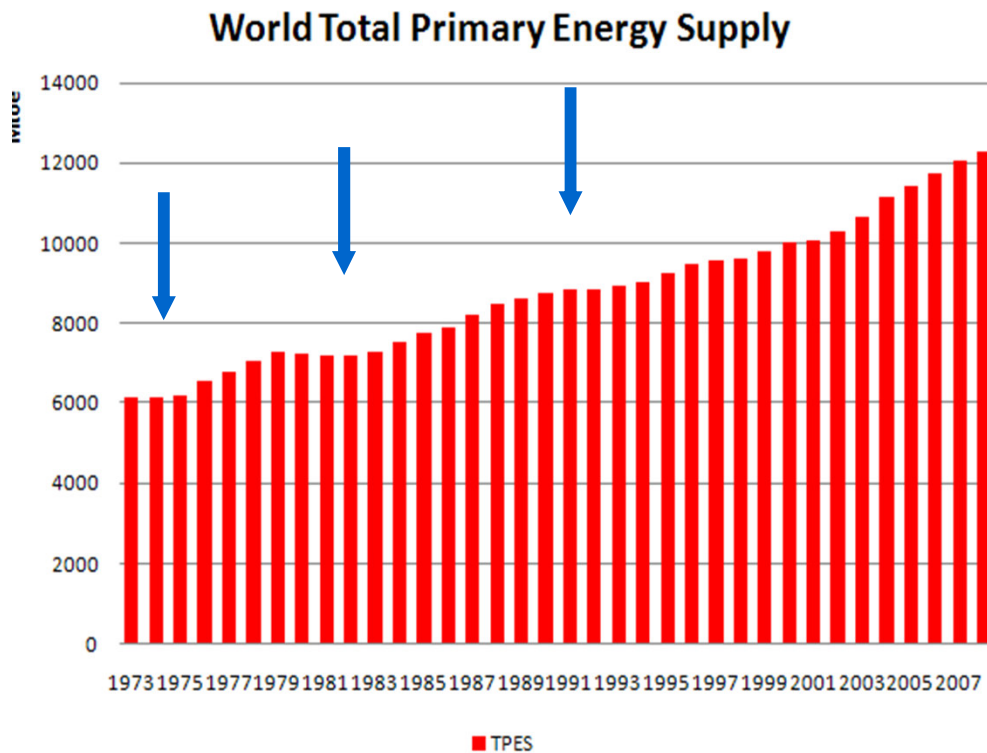
World - Total primary energy supply



Oil: largest source of energy
Significant reduction of oil share in time



World – Effect of oil crises on the energy market



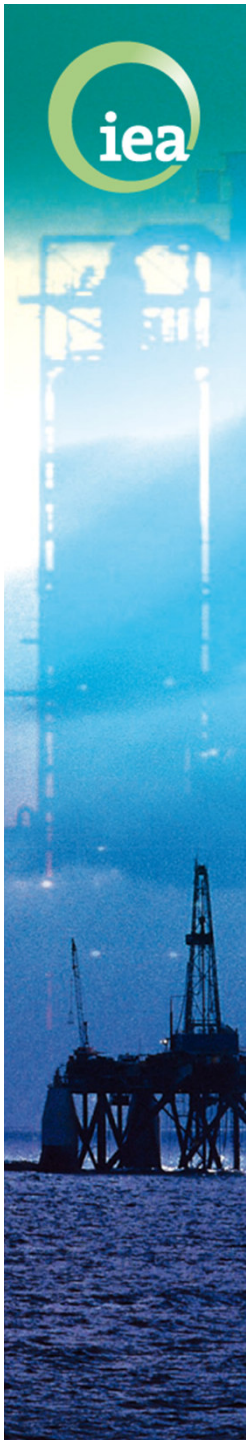
1973 oil embargo

1980 Iran/Iraq war

1990 Gulf crisis

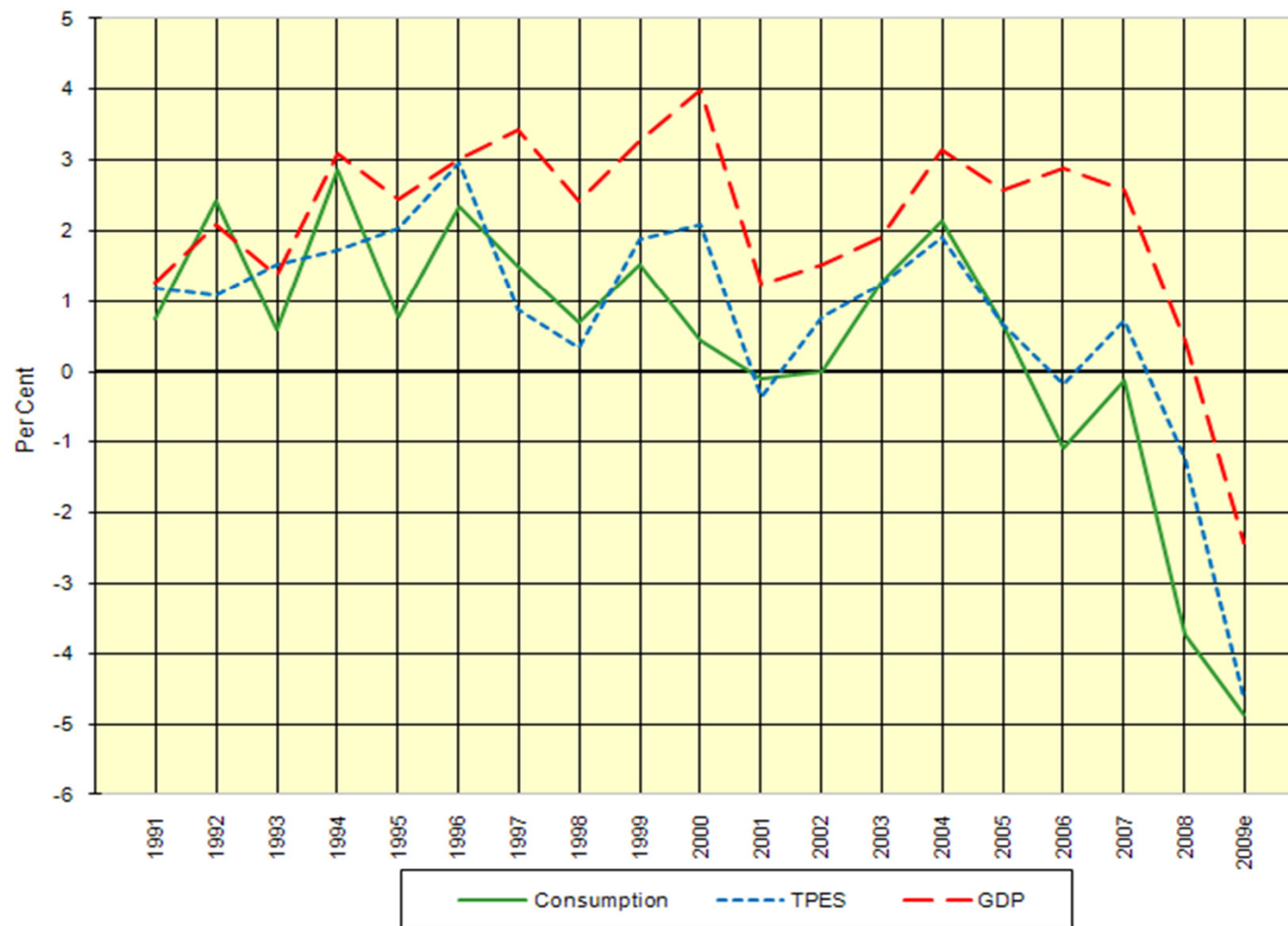
Crude oil spot prices

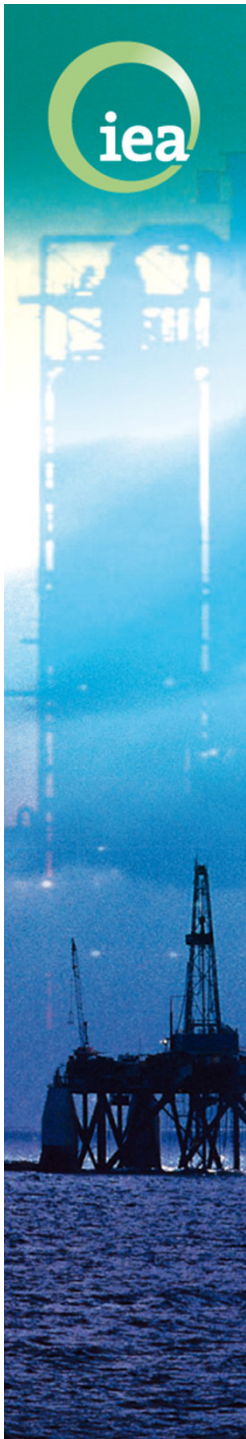




Relationship between oil consumption, TPES and GDP

OECD

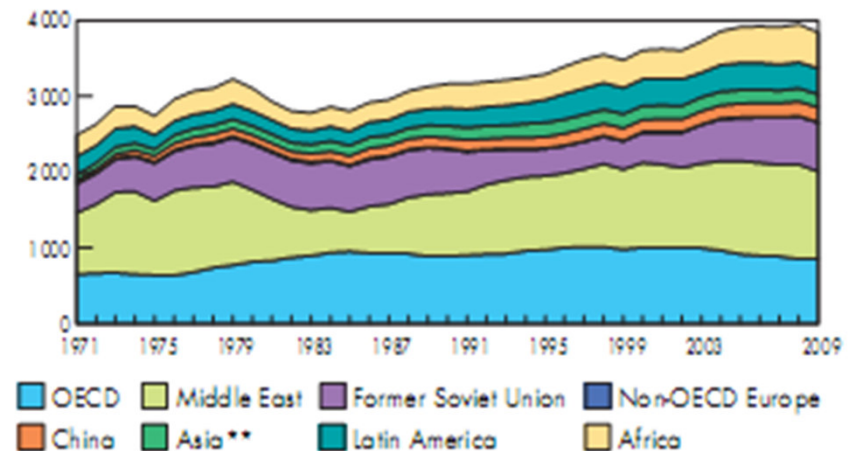




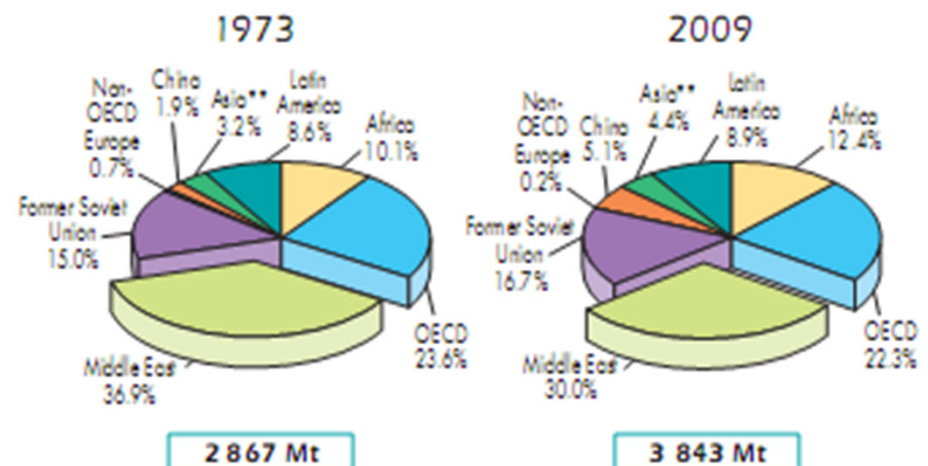
Oil production: global trends

Crude Oil Production

Evolution from 1971 to 2009 of crude oil* production by region (Mt)



1973 and 2009 regional shares of crude oil* production



*Includes crude oil, NGL, feedstocks, additives and other hydrocarbons.

**Asia excludes China.

Crude oil: global trade

Producers, net exporters and net importers of crude oil*



Producers	Mt	% of world total
Russian Federation	494	12.9
Saudi Arabia	452	11.8
United States	320	8.3
Islamic Rep. of Iran	206	5.4
People's Rep. of China	194	5.0
Canada	152	4.0
Mexico	146	3.8
Venezuela	126	3.3
Kuwait	124	3.2
United Arab Emirates	120	3.1
Rest of the world	1 509	39.2
World	3 843	100.0

2009 data

Net exporters	Mt
Saudi Arabia	355
Russian Federation	241
Islamic Rep. of Iran	120
United Arab Emirates	108
Nigeria	102
Angola	92
Norway	90
Kuwait	89
Iraq	88
Venezuela	74
Others	593
Total	1 952

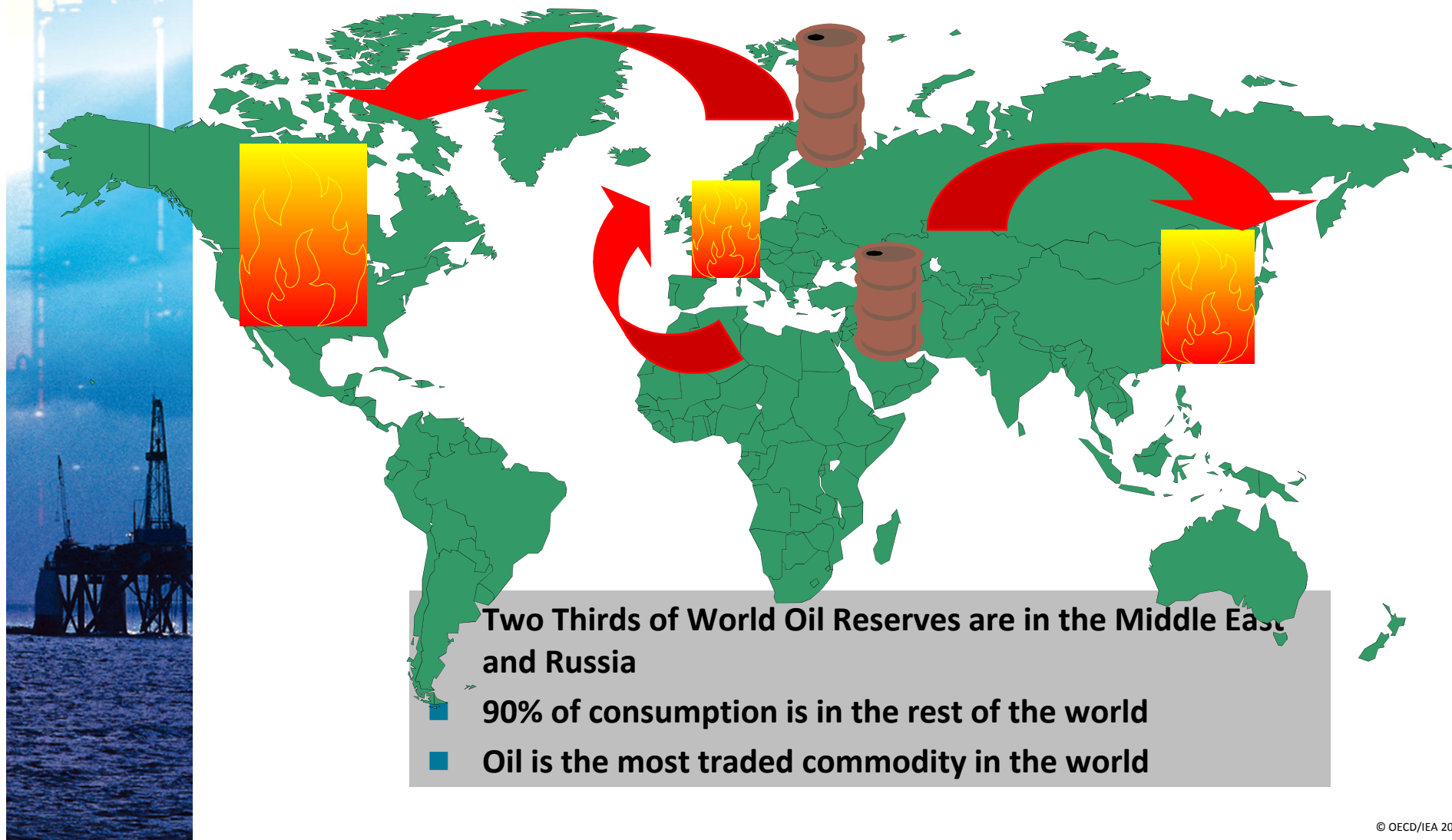
2008 data

Net importers	Mt
United States	564
Japan	199
People's Rep. of China	175
India	128
Korea	116
Germany	105
Italy	88
France	83
Spain	61
Netherlands	57
Others	514
Total	2 090

2008 data

*Includes crude oil, NGL, feedstocks, additives and other hydrocarbons.

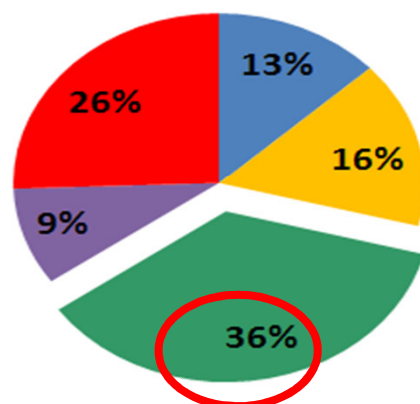
Oil Trade



World uses of oil

1973 and 2008

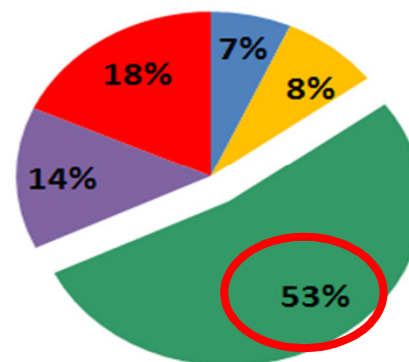
1973



■ Transformation ■ Industry ■ Transport ■ Non-energy use ■ Other

TPES = 6115 Mtoe

2008

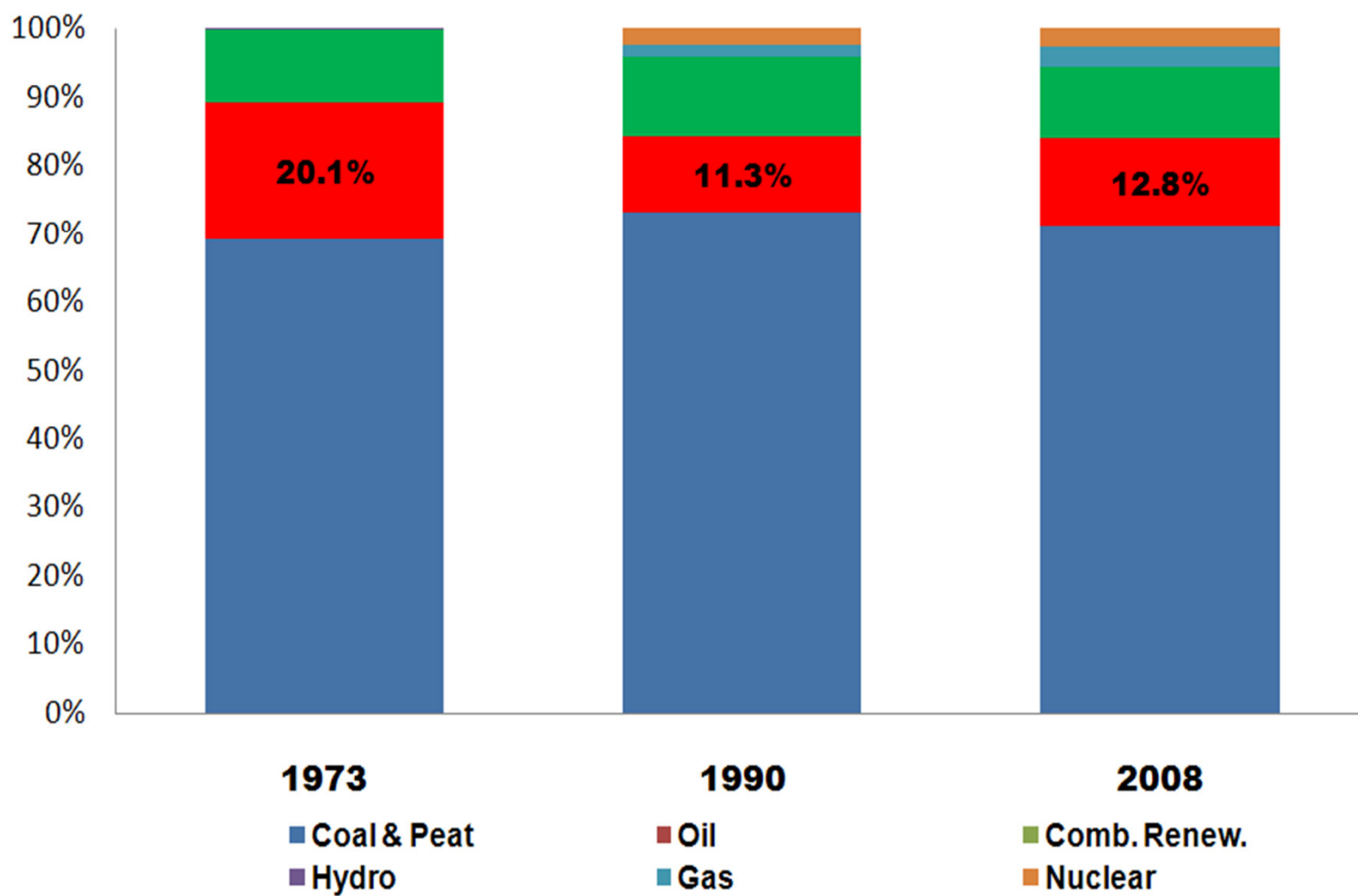


■ Transformation ■ Industry ■ Transport ■ Non-energy use ■ Other

TPES=12 267 Mtoe

Natural Gas
16.2%

South Africa - Total primary energy supply



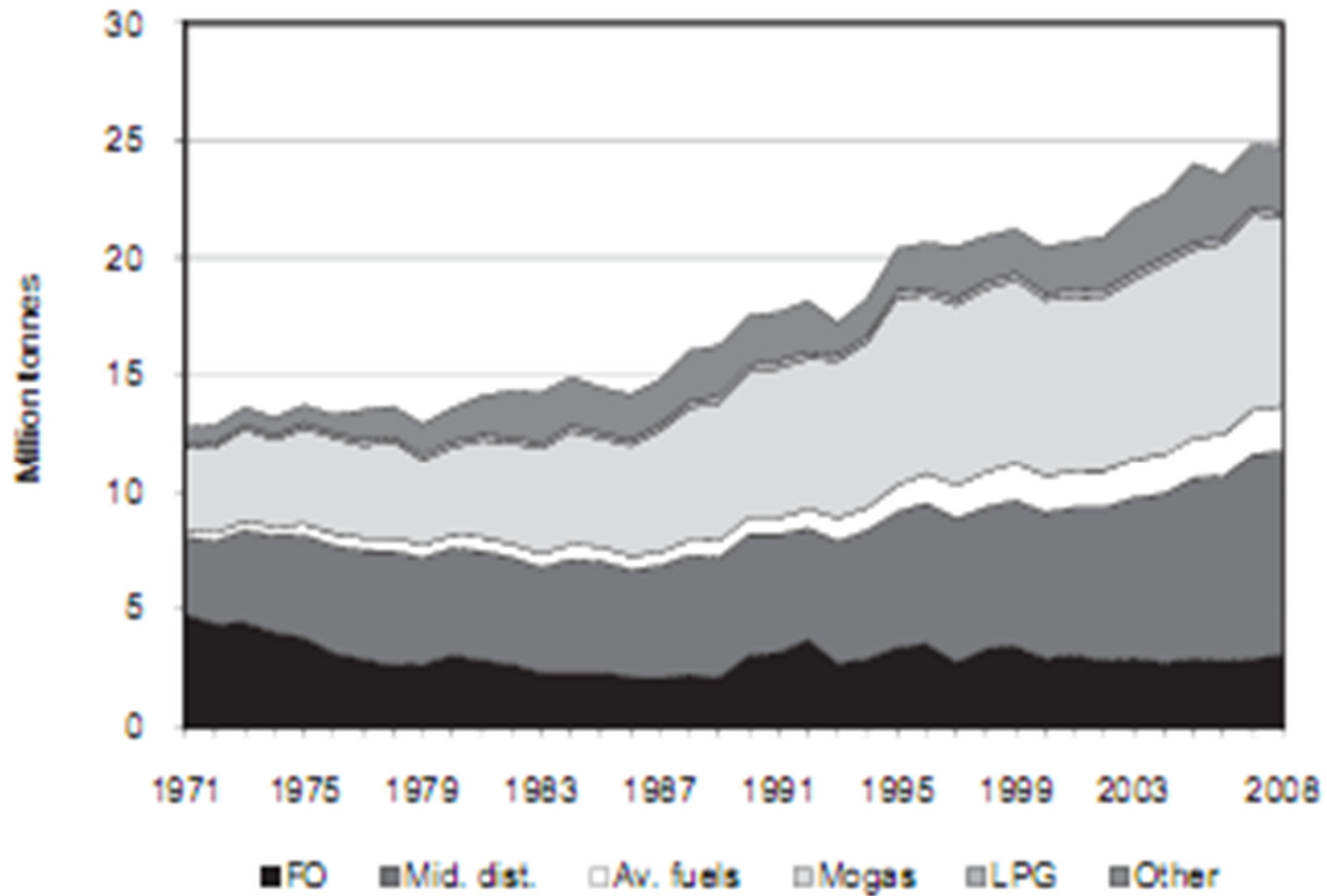
World Oil share in TPES

46%

37%

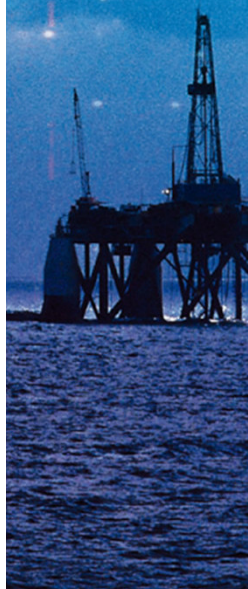
33%

South Africa: oil demand by product





Oil data collection and IEA Annual Oil Questionnaire





Some “oil” principles....

- Oil can be expressed in various units – how to convert ?
- Crude oil needs refining, as it has limited use in its raw state.
- Crude oil and petroleum products can be easily stored, and fulfill a security function.

Units of reporting - Density

- Oil is usually measured in mass or volume.
Units of mass: metric ton
Units of volume: litres, barrels or cubic metres.
- Conversion from mass to volume (and reverse) is essential.
- To convert, we need to know the density:
- **Density = mass per unit volume**
- Density for oil is often shown as specific gravity (relative mass per volume compared to water).
- Density differs for various crude oils and products

Examples of Specific gravity:

Brent: 0.83,

Mexican Maya: 0.9,

Motor gasoline: 0.7 - 0.79

Bitumen: 1 - 1.1

Examples of Conversions Volume to Mass

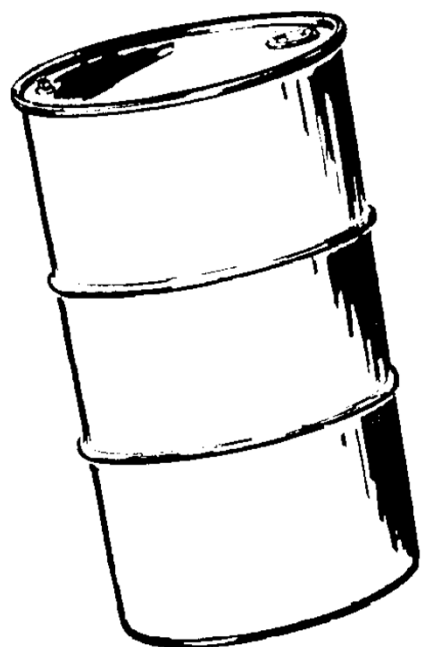
Imports	Reported data in barrels per day (volume)	Number of days/month	Density mass/volume (average)	Volume/mass tonne/barrel conversion factor	Converted data in metric tons (mass)
Crude oil	1020	31	0.13569	$1/0.13569=7.37$	$(1020 \times 31)/7.37=4290$
Motor gasoline	546	28	0.11806	$1/0.11806=8.47$	$(546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

Note: Density varies with quality

A few words on Oil Refining

■ What is produced?

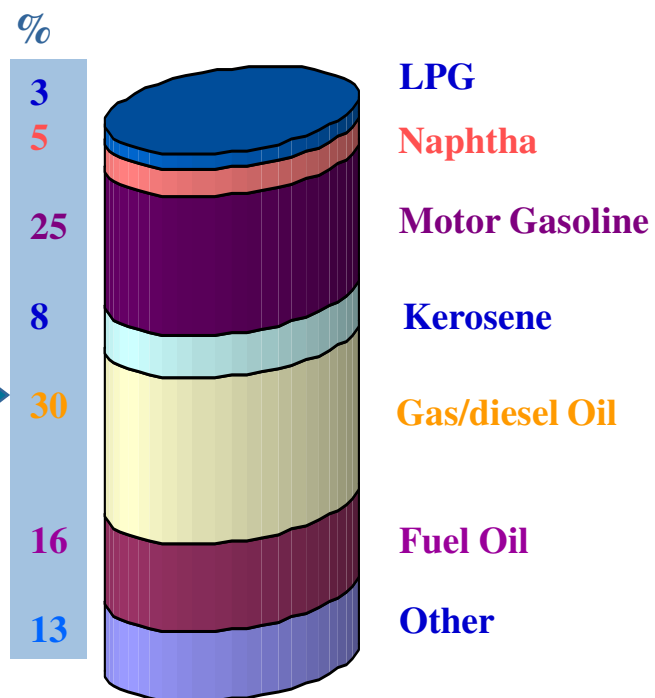
Crude Oil



refining

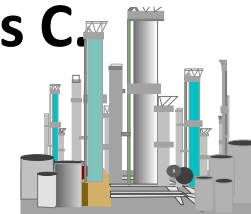
■ What is consumed?

World - Oil product consumption



Refining

- **First Process: simple distillation which separates the various hydrocarbons included in the crude oil into fractions. (Atmospheric Distillation)**
- **Crude oil is put into a distillation column and heated until the various fractions boil off. The different fractions have a different boiling point and are recovered at their specific distillation temperature.**
- **Lighter fractions distill at lower temperatures than heavier. E.g. LPG is recovered at less than 30 degrees C, while gasoil distills between 180 and 380 degrees C.**

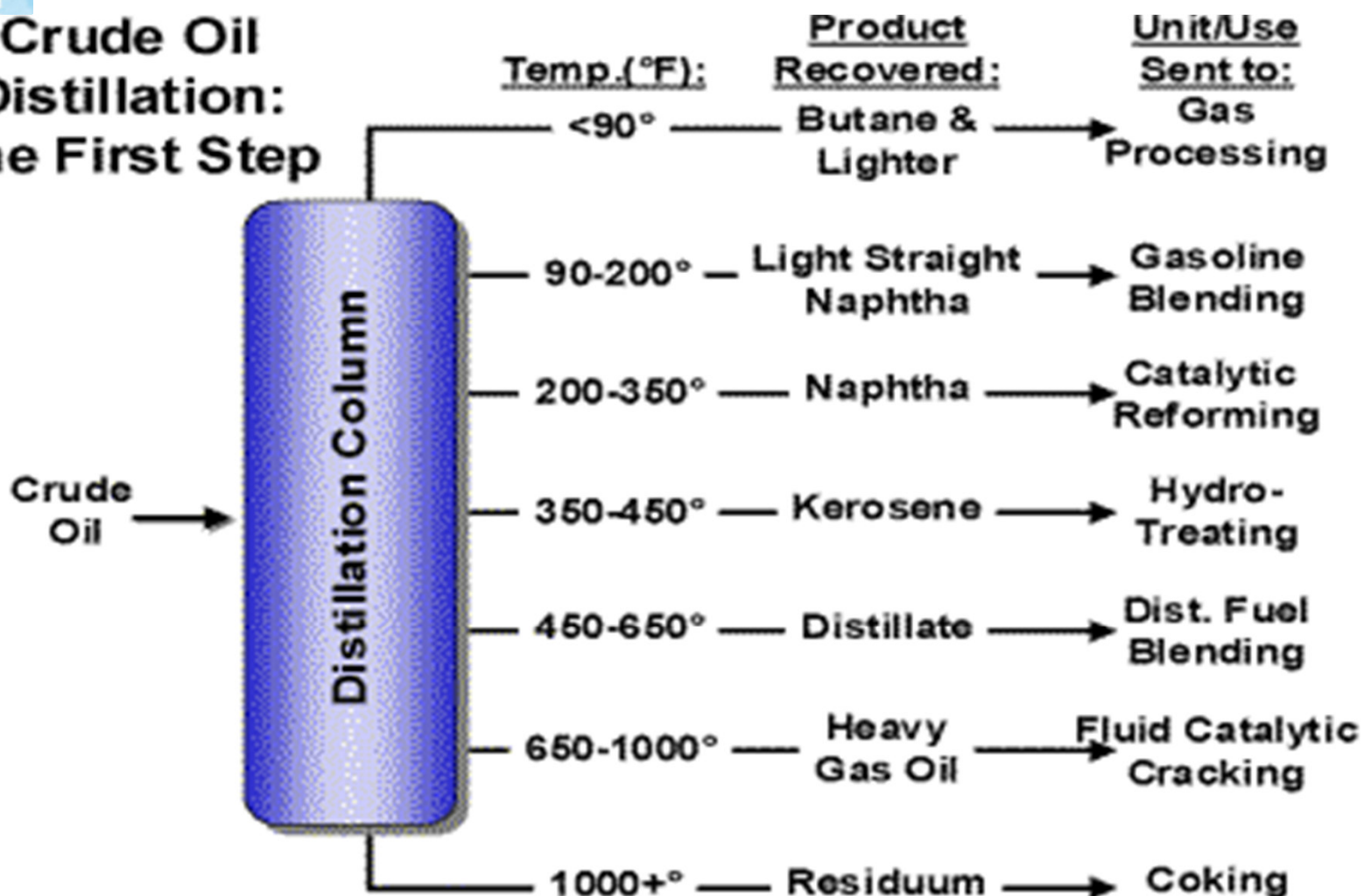


Further Refining

- To optimise (upgrade) output, further processing is needed, either by increasing heat, changing pressure, by adding catalysts, by removing sulfur or by breaking down the molecular structure.
- Variety of processes, many of them highly complex.
- Examples:
 - Vacuum distillation further distills the residuum where atmospheric pressure is reduced
 - Hydrotreater removes sulfur, using catalysts
 - Catalytic cracker uses distillate to produce finished heating oil and diesel by using a catalyst
 - Coker: a thermal process producing lighter products and petroleum coke from residuum

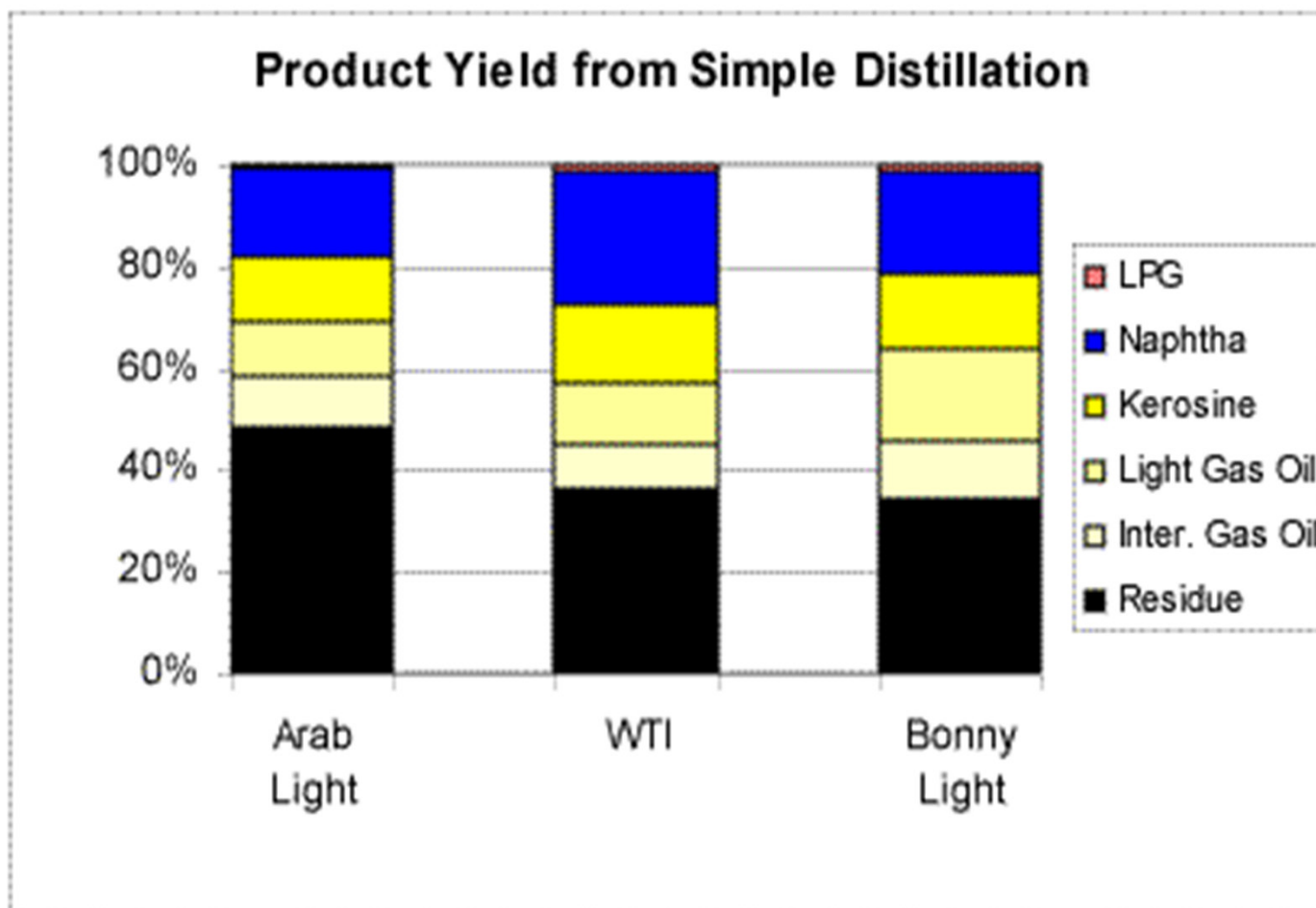
How are oil products derived?

Crude Oil Distillation: The First Step



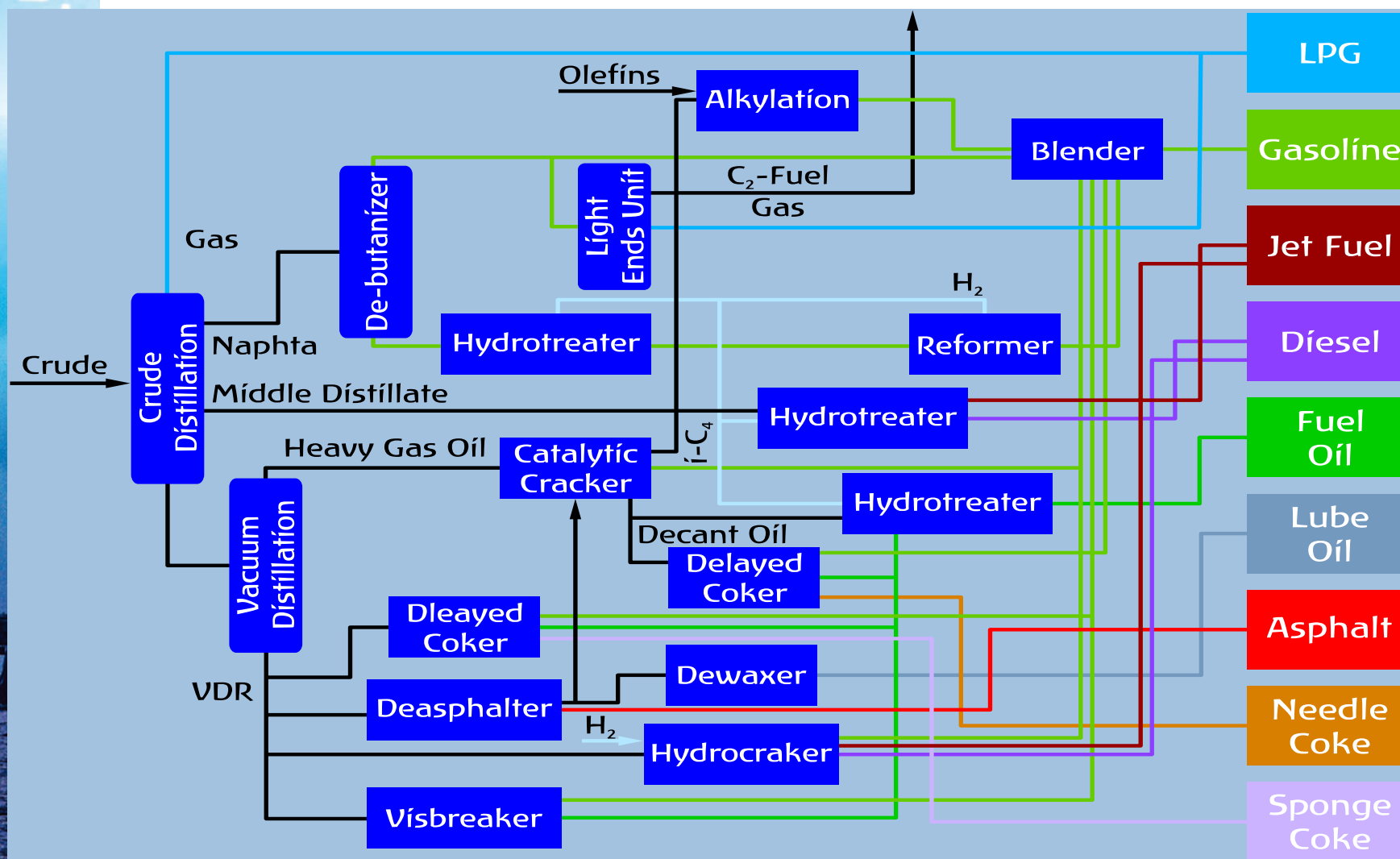
Source: EIA

Refining yields



Source: Energy Intelligence Group, *Int'l Crude Oil Market Handbook*

Oil Refining



Oil Refining: It is complicated !

Crude

Crude
Distillation

Gas

N

M

VD

Only need to report
selected flows

LPG

Gasoline

Jet Fuel

Diesel

Fuel
Oil

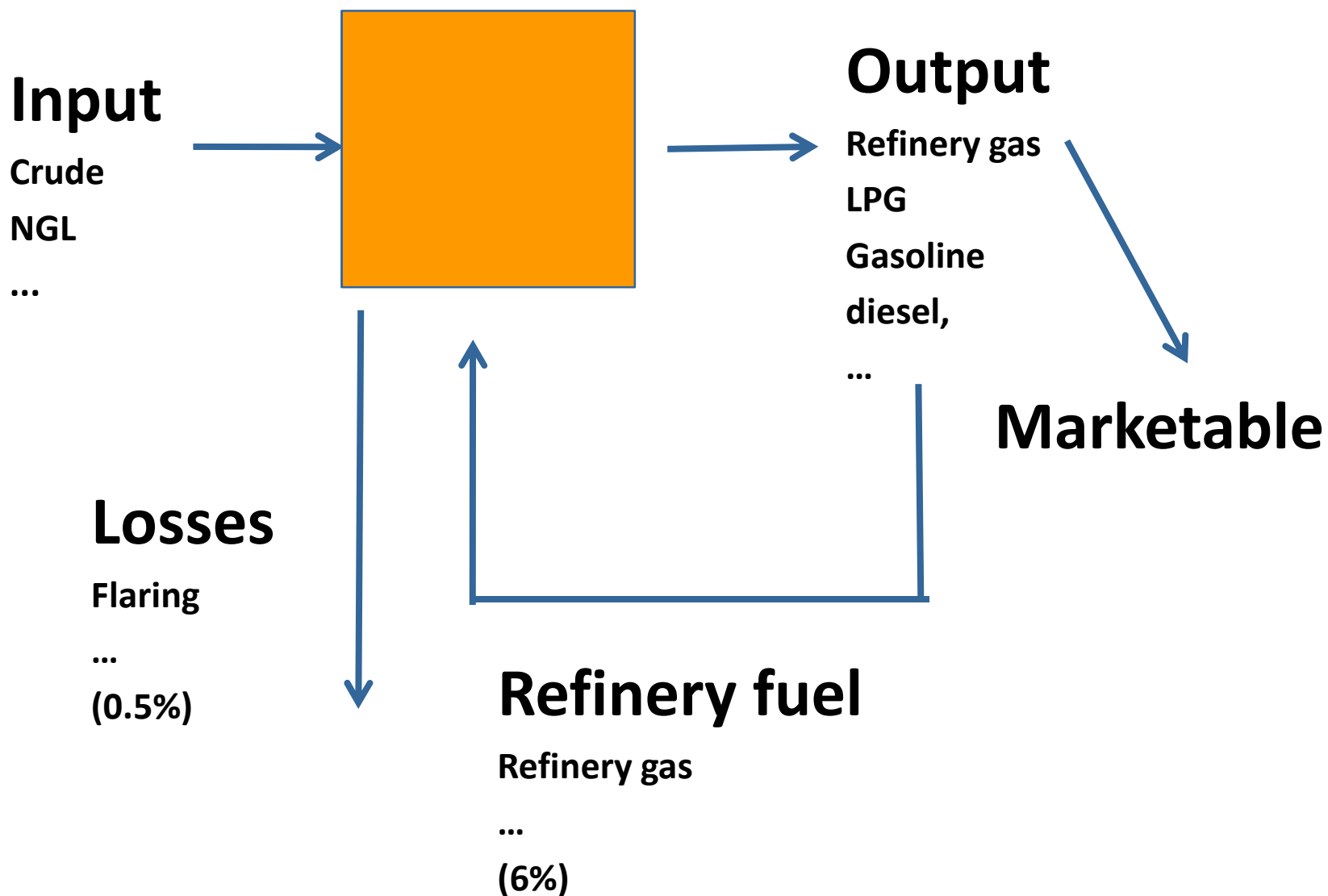
Lube
Oil

Asphalt

Needle
Coke

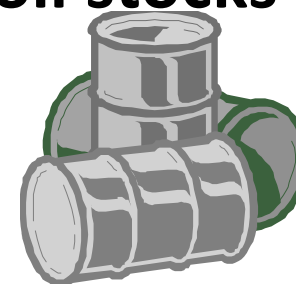
Sponge
Coke

Simplified refinery balance



Oil Stocks

- **Essential** to sustain the global oil supply system
- Balance supply and demand:
 - build (supply larger than demand)
 - drawn (demand larger than supply)
- Leading indicator of prices
- Fulfill a strategic need e.g. government stocks
- Product stocks as important as crude oil stocks



Types of Stocks

■ Primary

held by companies supplying the markets: producers, refiners and importers, in refinery tanks, bulk terminals, pipeline tankage, barges, coastal tankers, tankers in port (if they are to be discharged) and in inland ship bunkers.

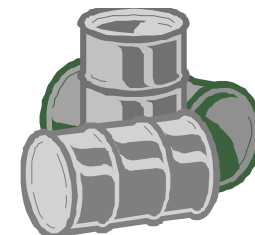
Also include stocks held for strategic purposes (governments or stockholding organisations)

■ Secondary

stocks in small bulk plants/retailers (e.g. stations)

■ Tertiary

held by end-consumers (power plants, industrial entities, households etc.)



Reporting stocks

What needs to be reported?

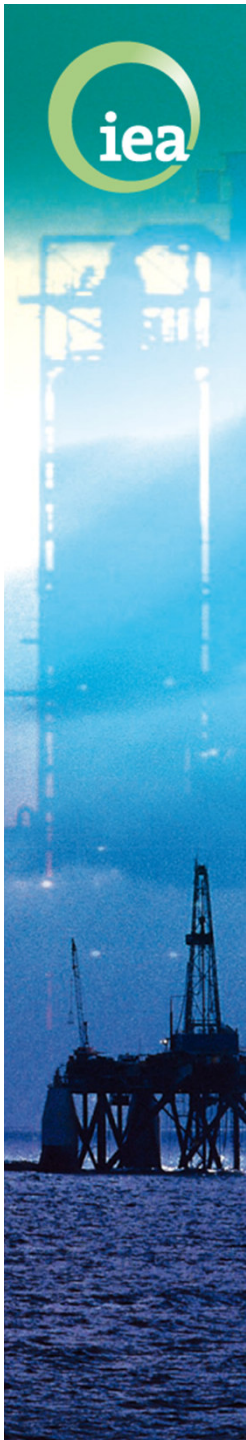
- Primary stocks

Most Important!

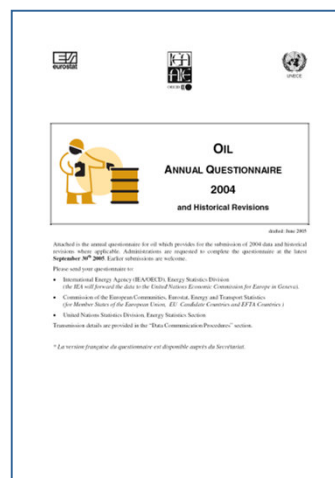
- Secondary stocks:

- Tertiary stocks:

**Difficult
to collect
data**



The IEA oil questionnaire





The IEA oil questionnaire

- **25 product categories:**
 - crude oil, NGL, refinery feedstocks, additives/oxygenates, biofuels, other hydrocarbons,
 - ethane, refinery gas, LPG, naphtha, motor gasoline, biogasoline, aviation gasoline, jet gasoline, jet kerosene, other kerosene, gas/diesel oil, biodiesel, fuel oil, white spirit, lubricants, bitumen, paraffin waxes, petroleum coke and other.
- **5 tables :**
 - ➔ Table 1: Refinery Intake
 - ➔ Table 2: Primary Supply
 - ➔ Table 3: Transformation, Energy, and Final Consumption
 - ➔ Tables 4 and 5 : Trade by origin and destination

Examples of Definitions: Crude Oil

■ 1. Crude Oil

Crude oil is a mineral oil of natural origin comprising a mixture of hydrocarbons and associated impurities, such as sulphur. It exists in the liquid phase under normal surface temperature and pressure and its physical characteristics (density, viscosity, etc.) are highly variable. This category includes field or lease condensate recovered from associated and non-associated gas where it is commingled with the commercial crude oil stream.

■ Issues and Difficulties in reporting Crude Oil

- Usually there are not too many problems in applying the definition.
- ✓ **Quality:** crude oil can be of varying quality, colour, viscosity and mineral content. The two main factors determining the quality are the **density** and the **sulfur content**.
- ✓ **Density:** Heavy crudes will yield less light products and are therefore in general of lesser quality.
- ✓ **Sulfur content:** Similarly, high sulfur crudes need desulphurization and are often less valuable. Terms used for high sulfur crudes is sour crudes, low sulphur are sweet crudes.

Examples of Definitions: Kerosene Type Jet Fuel

■ 15. Kerosene Type Jet Fuel

This is a distillate used for aviation turbine power units. It has the same distillation characteristics between 150oC and 300oC (generally not above 250oC) and flash point as kerosene. In addition, it has particular specifications (such as freezing point) which are established by the International Air Transport Association (IATA).

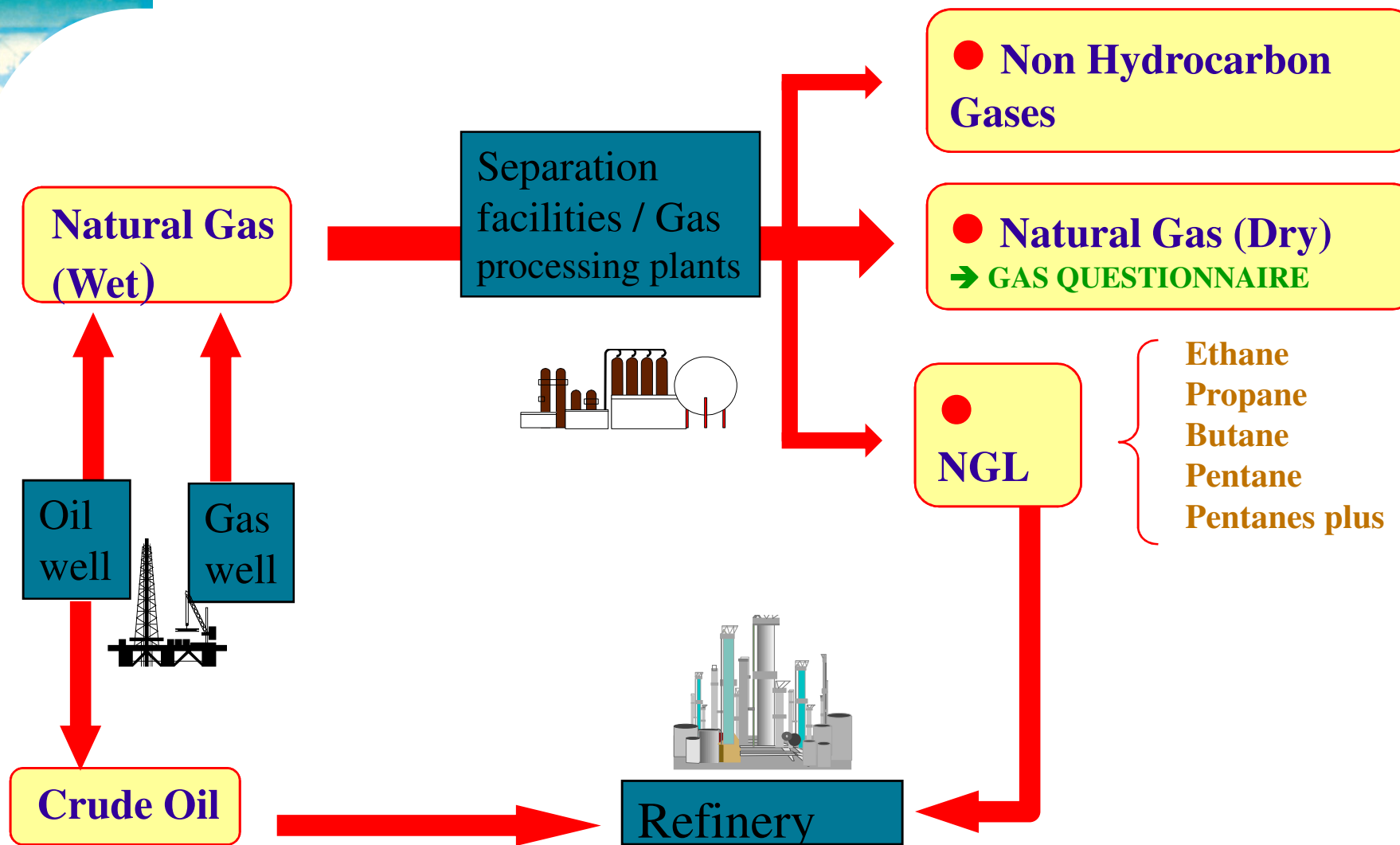
This category includes kerosene blending components.

■ Issues and Difficulties in reporting Jet Kerosene

- ✓ Use of Jet kerosene by international companies should not be shown as an export.
- ✓ Jet Kerosene is a product with very strict specifications, When it loses its properties it is often used as normal kerosene. The line inter-product transfer is used for this.



Crude Oil and NGL



Crude, NGL and Feedstocks Balance

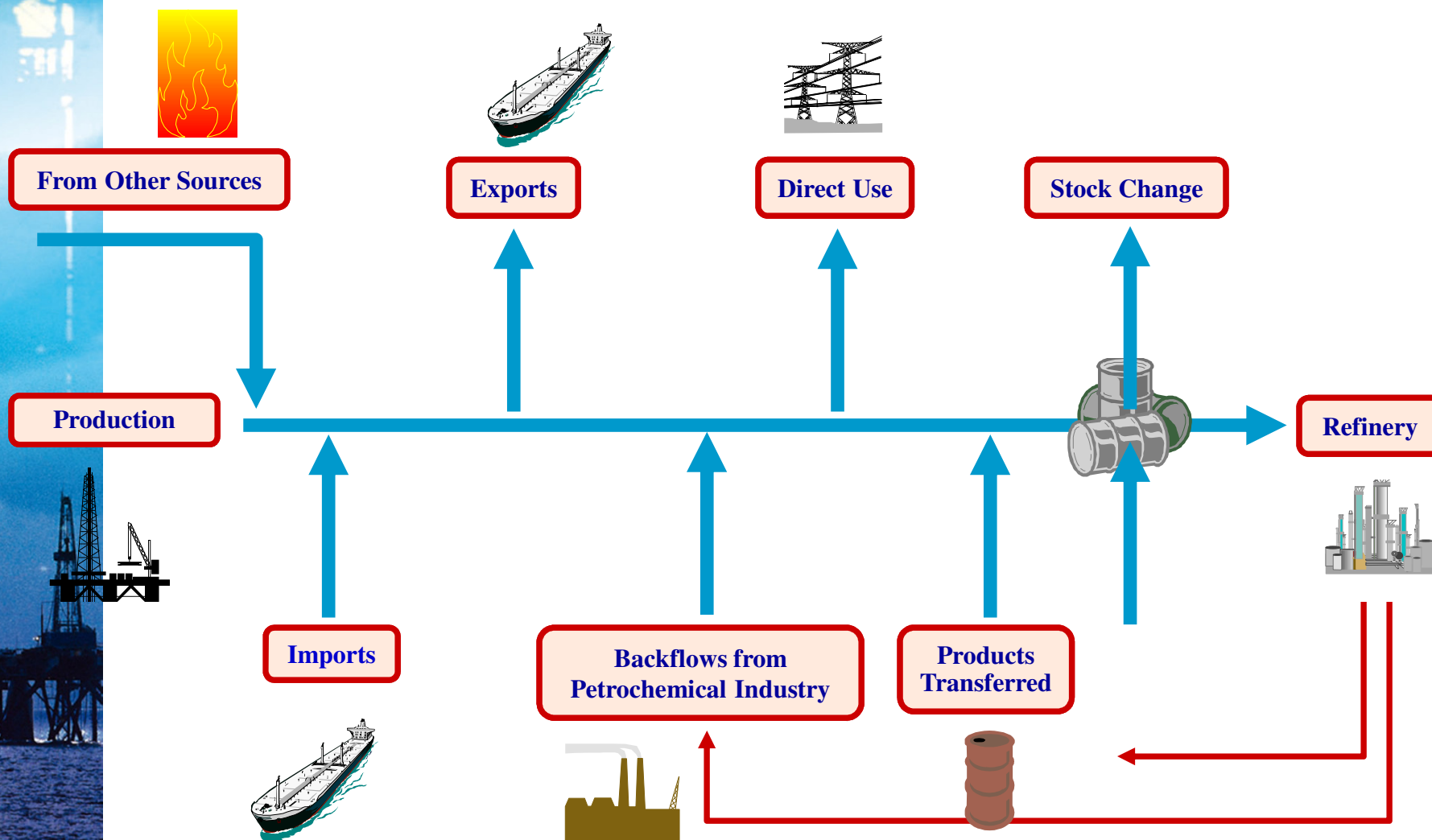


TABLE = 1

Menu

SUPPLY OF CRUDE OIL, NGL, REFINERY FEEDSTOCKS,
ADDITIVES AND OTHER HYDROCARBONS

Table 1 – Supply of primary oil

Unit: Thousand Metric Tons

		Crude Oil	Natural Gas Liquids	Refinery Feedstocks	Additives (1)/ Oxygenates	Of which Biofuels (1)	Other Hydrocarbons	TOTAL (A to F, excl. E)
		A	B	C	D	E	F	G
Indigenous Production	(+) 1							0
Other Sources	(+) 2							0
Backflows from Petrochemical Industry (2)	(+) 3							0
Products Transferred (3)	(+) 4							0
Total Imports (4)	(+) 5							0
Total Exports (5)	(-) 6							0
Direct Use (includes transfers to consumption) (6)	(-) 7							0
Stock Change (+ or -) (7)	(+) 8							0
REFINERY INTAKE (Calculated) (sum of 1 to 8)	(=) 9	0	0	0	0	0	0	0
Statistical Difference (+ or -) (9 minus 11)	(-) 10	0	0	0	0	0	0	0
REFINERY INTAKE (Observed)	(=) 11							0
MEMO ITEMS:								
Refinery Losses	12							0
STOCK LEVELS:								
Total Stocks on National Territory - Opening	13							0
- Closing	14							0
AVERAGE NET CALORIFIC VALUES:								
Unit: kJ/kg								
Indigenous Production	15							
Imports	16							
Exports	17							
Average	18							
MEMO ITEMS: From Other Sources:								
of which from Coal	19							0
of which from Natural Gas	20							0
of which from Renewables	21							0

1. Please see product definitions.
2. Total (cell G3) should correspond to Total Backflows on Table 2B (cell X5).
3. Total (cell G4) should correspond to Total Products Transferred on Table 2A (cell X9).
4. Should correspond to total imports on Table 4 (cells A101 to G101).
5. Should correspond to total exports on Table 5 (cells A94 to G94).
6. Should be carried over to Primary Product Receipts on Table 2A (row 1).
7. Opening Stock Level minus Closing Stock Level (row 13 minus row 14).

Oil Product Flow Chart

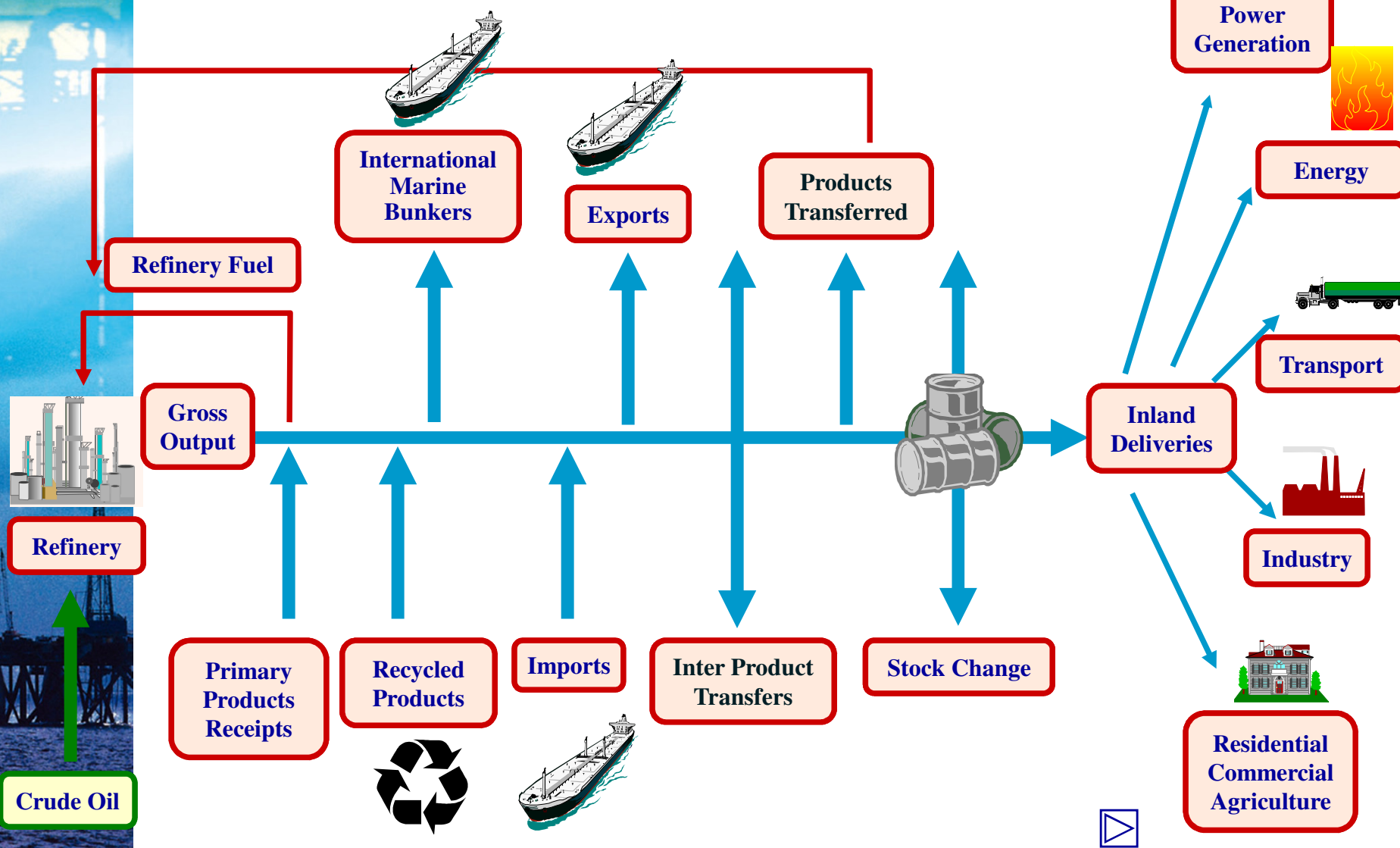


Table 2: Supply of Finished Products

TABLE = 2a

SUPPLY OF FINISHED PRODUCTS (1)

YEAR = 2009

Menu

Country

Thousand Metric Tons

		Crude Oil	Natural Gas Liquids	Refinery Gas (not liq.)	Ethane	LPG	Naphtha	Motor Gasoline	Of which Biogasoline	Aviation Gasoline	Gasoline Type Jet Fuel	Kerosene Type Jet Fuel	Other Kerosene
		A	B	C	D	E	F	G	H	I	J	K	L
Primary Product Receipts (2)	(+) 1												
Gross Refinery Output (3) (including refinery fuel)	(+) 2												
Recycled Products	(+) 3												
Refinery Fuel	(-) 4												
Total Imports (4)	(+) 5												
Total Exports (5)	(-) 6												
Intl. Marine Bunkers	(-) 7												
Interproduct Transfers (6) (+ or -)	(+) 8												
Products Transferred (7)	(-) 9												
Stock Change (+ or -) (8)	(+) 10												
GROSS INLAND DELIVERIES (Calculated)	(=) 11	0	0	0	0	0	0	0	0	0	0	0	0
Statistical Difference (9)	(-) 12			0	0	0	0	0	0	0	0	0	0
GROSS INLAND DELIVERIES (Observed)	(=) 13	0	0	0	0	0	0	0	0	0	0	0	0
STOCK LEVELS:													
Total Stocks on National Territory - Opening	14												
- Closing	15												
MEMO:													
Refinery Fuel for - Electricity Generation	16												
- CHP Production	17												
Stock Changes Public Utilities	18												
MEMO:													
Net Calorific Value of Gross Inland Deliveries (kJ/kg)	19												

1. Includes Crude Oil and indigenous NGL which does not pass through an oil refinery.

2. This mainly concerns Crude Oil (indigenous or imported) and indigenous NGL which does not pass through an oil refinery.

Total Product Receipts on Table 2A (cell X1) should be equal to Total Direct Use on Table 1 (cell G7).

3. Total Gross Refinery Output on Table 2A (cell X2) should be equal to Observed Refinery Intake on Table 1 (cell G11) minus Refinery Losses on Table 1 (cell G12).

4. Should correspond to Total Imports on Table 4.

5. Should correspond to Total Exports on Table 5.

6. Must add to zero in cell X8 on Table 2A.

7. For definition see instructions for completing Individual Tables (Table 2A). Total (cell X9) must equal Total Product Transfers on Table 1 (cell G4).

8. Opening Stock Level minus Closing Stock Level (row 14 minus row 15). Figures may have positive or negative signs.

9. Statistical Differences occur when independent figures for Gross Inland Deliveries are available and are different to those calculated. The sign of the differences can be positive or negative.

10. Report that part of refinery fuel included in the row above (4) which is used to produce electricity and/or heat.

Production

■ Indigenous Production:

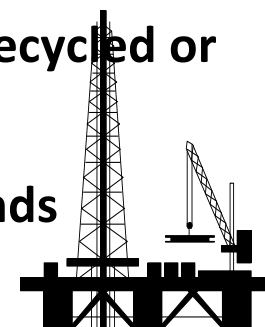
Report all production within national boundaries including off-shore production. Production should only include marketable production, excluding volumes returned to formation. Such production should include all crude oil, NGL, condensates and oil from shale and tar sands, etc. It should also include the receipts of additives/oxygenates by refineries and blending plants from outside the refinery sector.

■ Important:

Marketable production: exclude volumes which are recycled or returned to the wells.

Onshore and off-shore production

Primary production includes oil from shale and tarsands



From other sources

■ From other sources:

Report supplies of *Additives*, *Biofuels* and *Other Hydrocarbons*, the production of which has already been covered in other fuel balances

The other sources can be:

- *From Coal*
- *From Gas*
- *From Renewable*

Trade

■ Imports and Exports:

Data should reflect amounts having crossed the national territorial boundaries, whether customs clearance has taken place or not.

■ Important

- Physical flow (not customs flows)
- Crude Oil, NGL: country of origin
- Oil products: country of last consignment
- Transit trade not included
- Include imports by large industries
e.g. Petrochemical industry



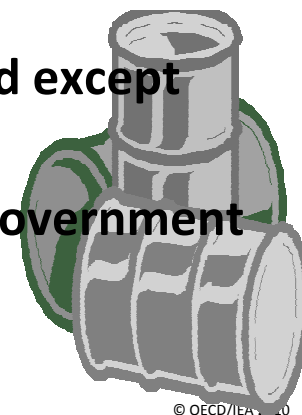
Stocks

Total stocks on national territory:

All stocks on national territory, including stocks held by governments, by major consumers or by stockholding organisations, stocks held on board incoming ocean vessels, stocks held in bonded areas and stocks held for others, whether under bilateral government agreement or not.

Important:

- **As complete as possible statement of oil stocks in your economy (emergency and security purposes).**
- **Stocks are reported on a geographical basis, i.e. report stocks on your national territory.**
- **All stocks (primary and secondary) should be included except consumer stocks (tertiary stocks)**
- **Include stocks held for strategic purposes, or under government control.**



Stock changes

■ Stock Changes:

Stock changes should reflect the difference between opening stock level and closing stock level for stocks held on national territory. A stock build is shown as a negative number, and a stock draw as a positive number.

■ Important:

$$\begin{aligned} &\text{Opening Stock level} \\ &- \text{Closing Stocks level} \\ &= \text{Stock Change} \end{aligned}$$

+

Stock reduction

-

Stock increase

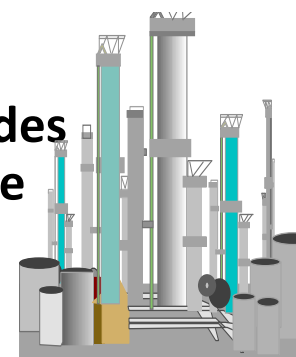
Refinery output

■ Gross Refinery Output:

Production of finished products at a refinery or blending plant. This category excludes Refinery Losses, but includes Refinery Fuel.

■ Important

- As refinery intake, this flow is information that refineries monitor very well, and the data is usually easily available.
- Note that refinery output is Gross: i.e. it includes the amount of oil used for the operation of the refinery (or refinery fuel).



Refinery fuel

■ Refinery Fuel:

All petroleum products consumed in support of the *operation* of a refinery.

This should not include products used by oil companies outside the refining process, e.g. bunkers or oil tankers. Fuels used for the production at the refineries of electricity and heat sold should also be included in this category.

■ Important

- The most frequently used refinery fuel product is refinery gas, some fuel oil and to a lesser extent gas/diesel oil are also used.
- Refineries should be able to provide this information. On average, about 6 to 7 % of the fuel intake is used as refinery fuel.

Bunkers

■ International Marine Bunkers:

Bunkers cover the quantities of fuels delivered to sea-going ships of all flags engaged in international travel. Consumption of warships should be included in Final Consumption under Other Not Elsewhere Specified. Consumption by ships engaged in fishing and in transport in inland and coastal waters is not included.

■ Important

- **These are deliveries of oils to ships for consumption during international voyages (i.e. their first port of call must be a foreign country.)**
- **The oils are used as fuel by the ship and are not part of the cargo.**

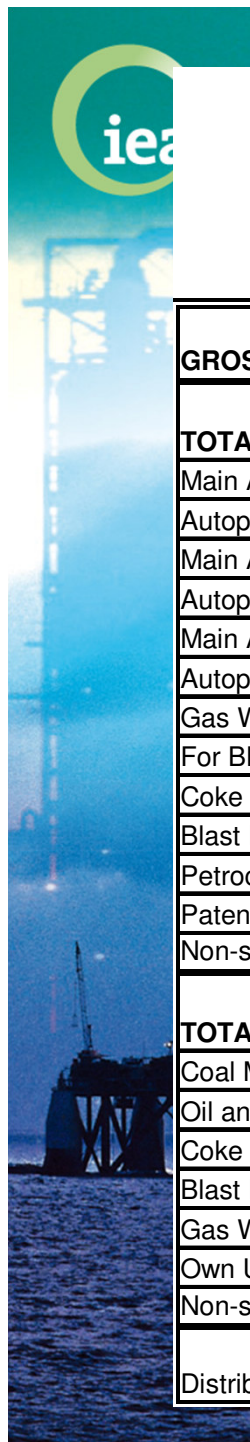


Table 3 : Gross Inland Deliveries

Gross Inland Deliveries

- **Transformation Processes**
- **Energy industry own use**
- **Losses**
- **Final Consumption**
 - Transport
 - Industry
 - Other

Memo: Non-Energy Use



		Crude Oil	Natural Gas Liquids	Refinery Gas (not liq.)	Ethane	LPG	Naphtha
		A	B	C	D	E	F
GROSS INLAND DELIVERIES (1)	1	0	0	0	0	0	0
TOTAL TRANSFORMATION SECTOR	2	0	0	0	0	0	0
Main Activity Producer Electricity Plants (2)	3						
Autoproducer Electricity Plants (3)	4						
Main Activity Producer CHP Plants (2)	5						
Autoproducer CHP Plants (3)	6						
Main Activity Producer Heat Plants (2)	7						
Autoproducer Heat Plants (3)	8						
Gas Works	9						
For Blended Natural Gas	10						
Coke Ovens	11						
Blast Furnaces	12						
Petrochemical Industry	13						
Patent Fuel Plants	14						
Non-specified (Transformation)	15						
TOTAL ENERGY SECTOR	16	0	0	0	0	0	0
Coal Mines	17						
Oil and Gas Extraction	18						
Coke Ovens	19						
Blast Furnaces	20						
Gas Works	21						
Own Use in Electricity, CHP and Heat Plants	22						
Non-specified (Energy)	23						
Distribution Losses	24						



Transformation processes

Quantities of fuel that will be transformed into another energy form

TOTAL TRANSFORMATION SECTOR
Main Activity Producer Electricity Plants (2)
Autoproducer Electricity Plants (3)
Main Activity Producer CHP Plants (2)
Autoproducer CHP Plants (3)
Main Activity Producer Heat Plants (2)
Autoproducer Heat Plants (3)
Gas Works
For Blended Natural Gas
Coke Ovens
Blast Furnaces
Petrochemical Industry
Patent Fuel Plants
Non-specified (Transformation)



Energy industry own use

Quantities of fuel that will be consumed to support the extraction or the transformation activity

TOTAL ENERGY SECTOR
Coal Mines
Oil and Gas Extraction
Coke Ovens
Blast Furnaces
Gas Works
Own Use in Electricity, CHP and Heat Plants
Non-specified (Energy)

Losses

Losses which occur outside the refinery due to transport and distribution, including pipeline.

Distribution Losses

27

This includes tanker spills e.g 1989 Exxon Valdez at the Alaska Coast, pipeline leakage, train car derailments and tanker and truck accidents.

Note: Sometimes losses are included in statistical differences

FINAL CONSUMPTION	1
TOTAL TRANSPORT SECTOR	2
International Civil Aviation	3
Domestic Air Transport	4
Road	5
Rail	6
Inland Waterways	7
Pipeline Transport	8
Not Elsewhere Specified (Transport)	9
TOTAL INDUSTRY SECTOR	10
Iron and Steel	11
Chemical (incl. Petro-Chemical)	12
Non Ferrous Metals	13
Non Metallic Mineral Products	14
Transportation Equipment	15
Machinery	16
Mining and Quarrying	17
Food, Beverages and Tobacco	18
Pulp, Paper and Printing	19
Wood and Wood Products	20
Construction	21
Textiles and Leather	22
Not Elsewhere Specified (Industry)	23
TOTAL OTHER SECTOR	24
Commerce and Public Services	25
Residential	26
Agriculture	27
Fishing	28
Not Elsewhere Specified (Others)	29
MEMO ITEM: Below categories are already included in the above sectorial breakdown.	
TOTAL NON-ENERGY USE	30
Transformation Sector	31
Energy Sector	32
Transport Sector	33
Industry Sector	34
of which: Chemical (incl. petrochem.)	35
Other Sector	36

Final Consumption

- ✓ **All energy delivered to final consumers: in Transport, Industry and Other**
- ✓ **Energy and Non-energy use**

➤ **Transport**

➤ **Industry**

➤ **Other**

➤ **Non-Energy** (separately, included above)

Transport

Oil used for transport activity, regardless of the sector

TOTAL TRANSPORT SECTOR	2
International Civil Aviation	3
Domestic Air Transport	4
Road	5
Rail	6
Inland Waterways	7
Pipeline Transport	8
Not Elsewhere Specified (Transport)	9

International / Domestic split VERY important for the **CO2** calculation

Note: Oil consumed for heating and lighting at stations and airports should be reported in the Commercial sector and **not** in Transport.



Industry

Oil used by industrial undertakings in support of their primary activities

TOTAL INDUSTRY SECTOR	10
Iron and Steel	11
Chemical (incl.Petro-Chemical)	12
Non Ferrous Metals	13
Non Metallic Mineral Products	14
Transportation Equipment	15
Machinery	16
Mining and Quarrying	17
Food, Beverages and Tobacco	18
Pulp, Paper and Printing	19
Wood and Wood Products	20
Construction	21
Textiles and Leather	22
Not Elsewhere Specified (Industry)	23

ISIC → <http://esa.un.org/unsd/cr/registry/>



Other

Oil used by the other sectors

TOTAL OTHER SECTOR	24
Commerce and Public Services	25
Residential	26
Agriculture	27
Fishing	28
Not Elsewhere Specified (Others)	29

Non – Energy Use

Energy products used as raw materials in the different sectors; i.e. not consumed as a fuel or transformed into another fuel.

MEMO ITEM: *Below categories are already included*

TOTAL NON-ENERGY USE	30
Transformation Sector	31
Energy Sector	32
Transport Sector	33
Industry Sector	34
<i>of which: Chemical (incl. petrochem.)</i>	35
Other Sector	36

South Africa: some general oil data issues

- **Data on stock changes**
- **Refinery balance**
- **Products from liquefaction (« non-crude »)**



Thank you!

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