

# Petrochemistry

## Introduction – Crude oil

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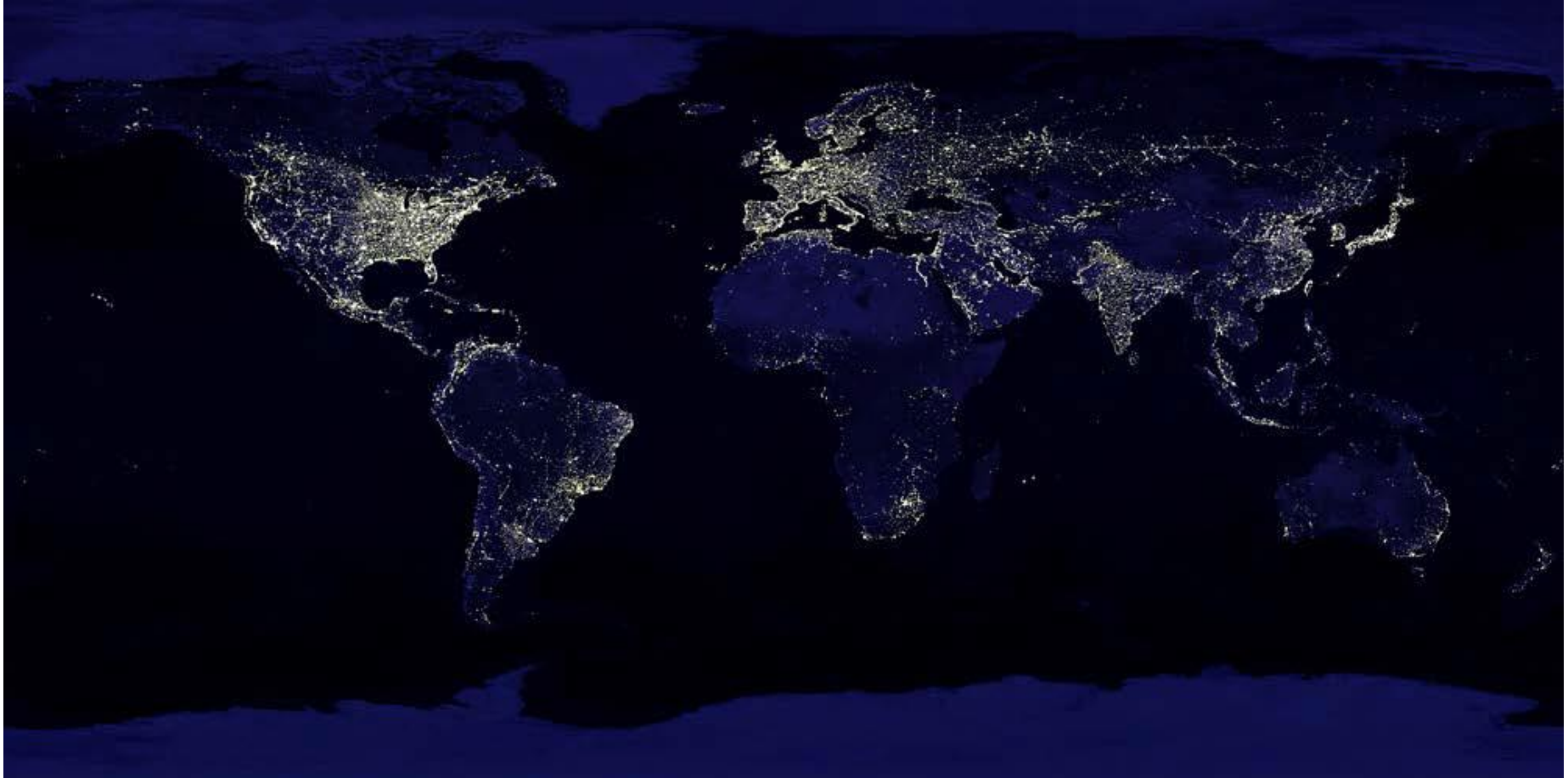
2022  
BME



# Introduction: Energy

Demand – usage

The **energy consumption** is  
unbalanced on the world

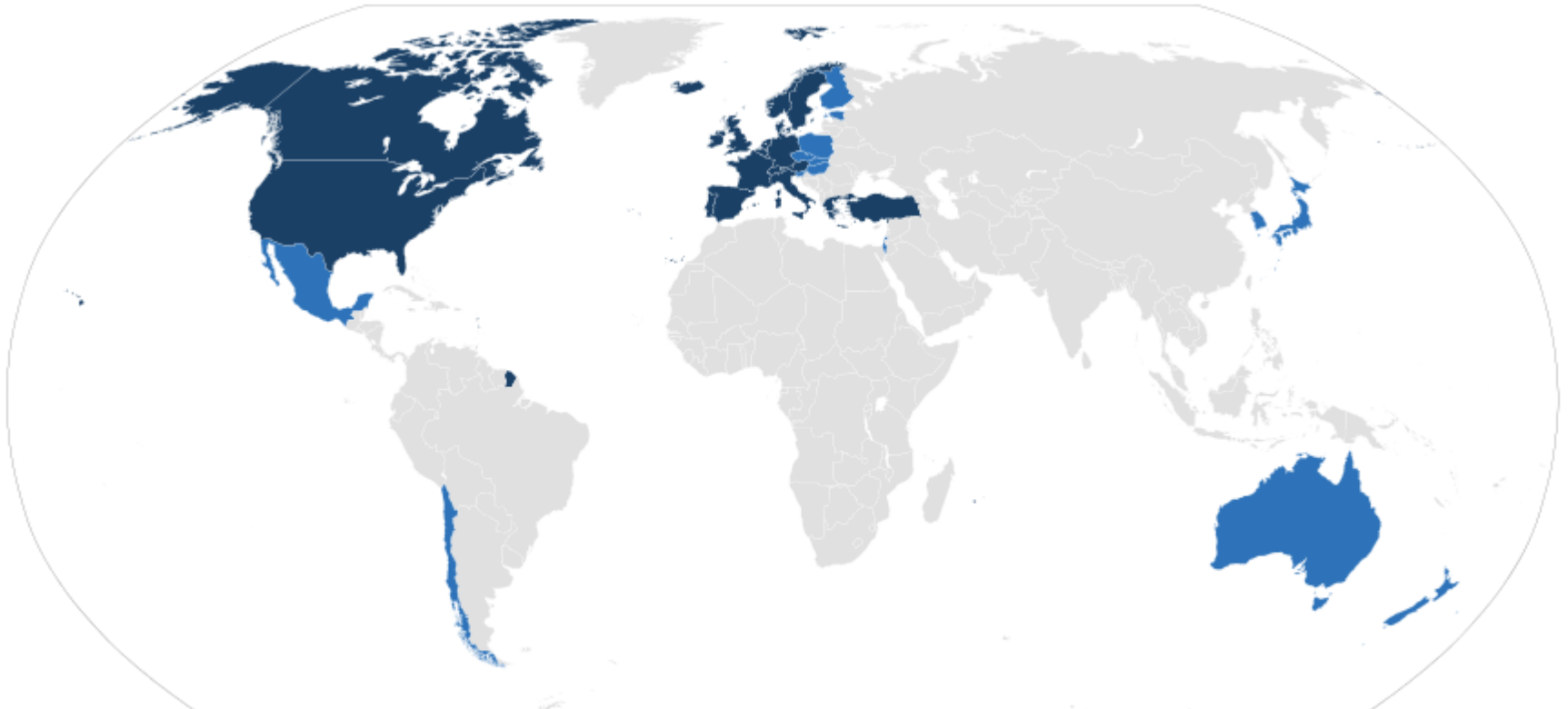




# OECD member countries

## Significant outsiders:

African, South-American and Arab countries, China, India, Russia



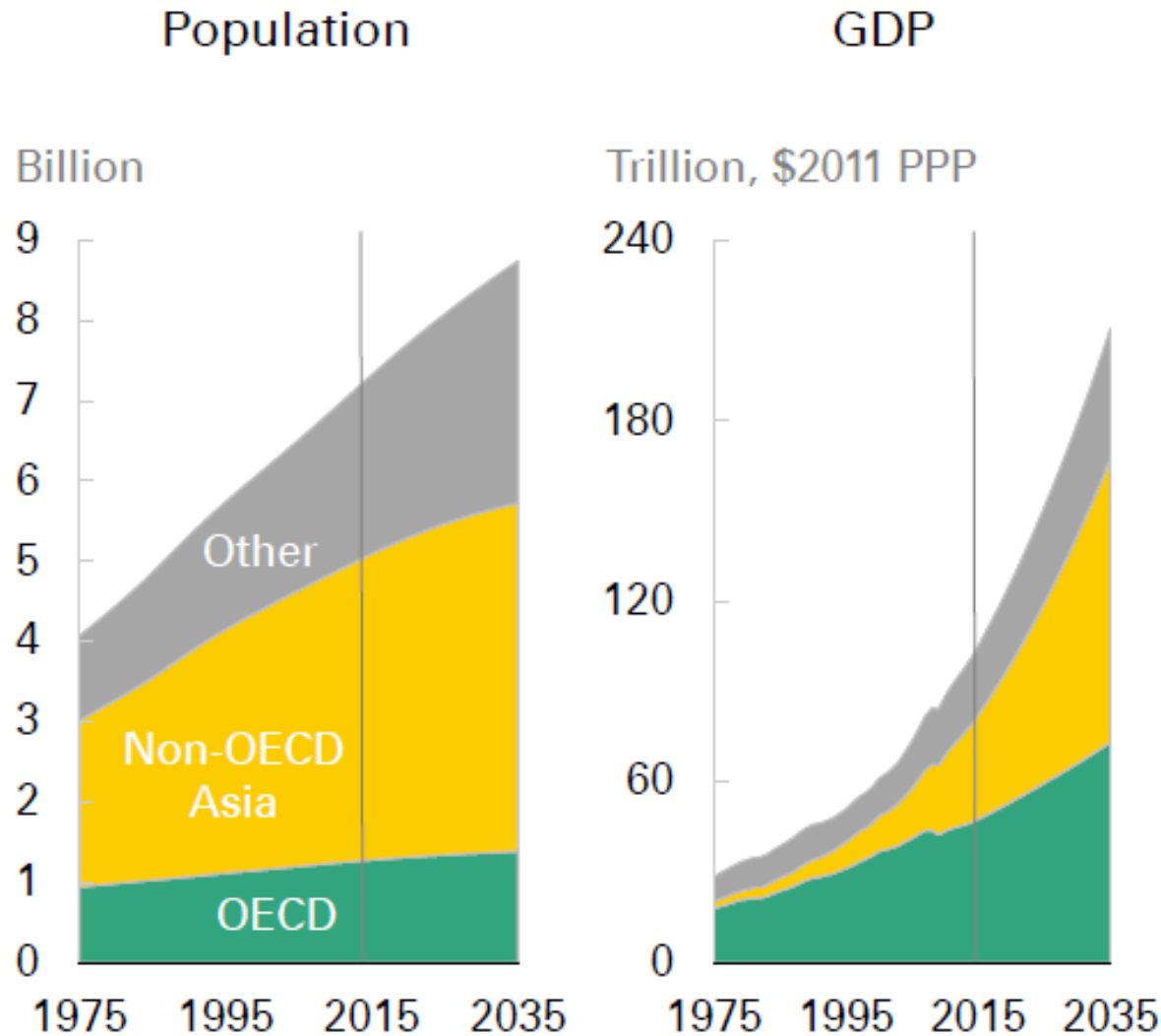
Organisation for Economic Co-operation and Development<sup>8</sup>

# The **energy industry** changes continuously



- The used **energy types** are changing (Norway 2025)
- The **balance of demand** is changing
- **New sources** do appear on the scene, e.g.
  - shale gas
  - tight oil, shale oil
  - ultra-deepwater oil
  - new forms of renewable energy (solar energy – Chile)
- **Countries** do expand and contract (India vs. Venezuela)
- Energy production and consumption are affected by **disruptions**, like outrageous events (Niger delta riot, ISIS) or extreme weather (forest fire: Canada, Alberta 2016/05, 1,1mbpd)
- **New policies** are created to address climate change or bolster energy security

# Key drivers behind growing demand for energy



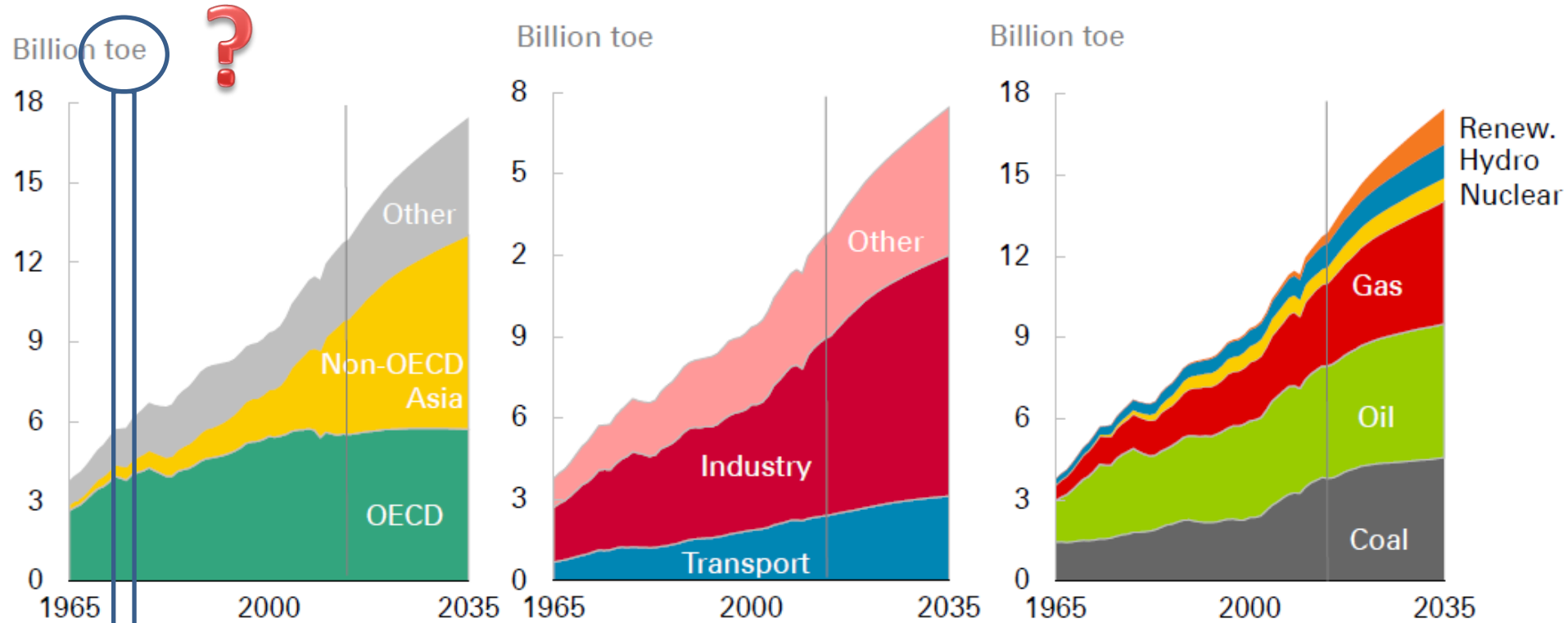
# Energy consumption – by



## Regions

## Final sector

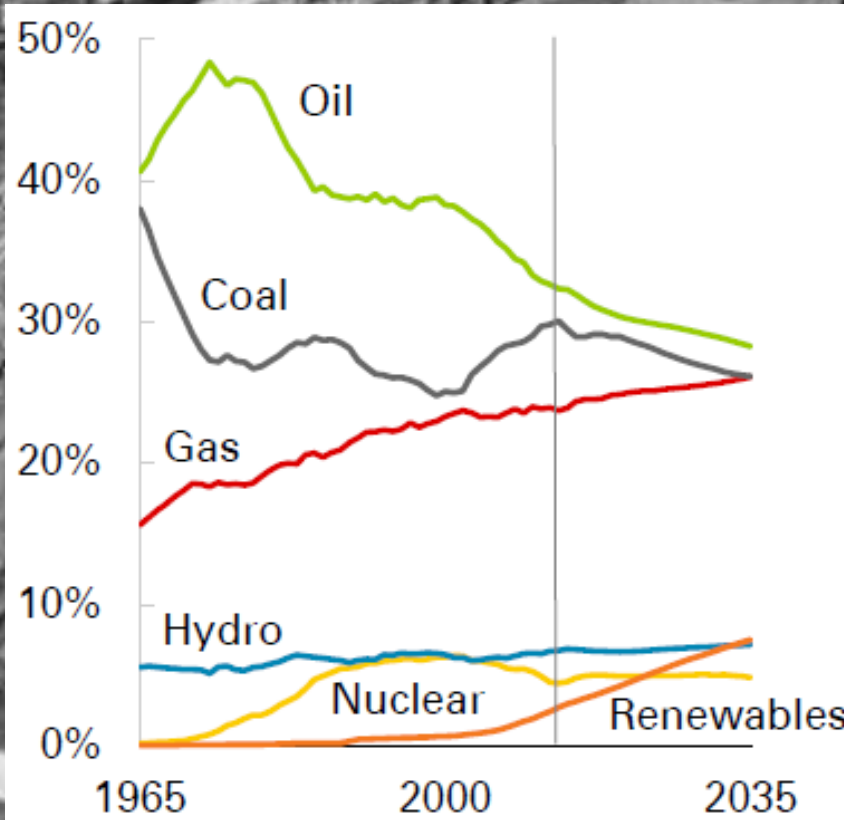
## Source



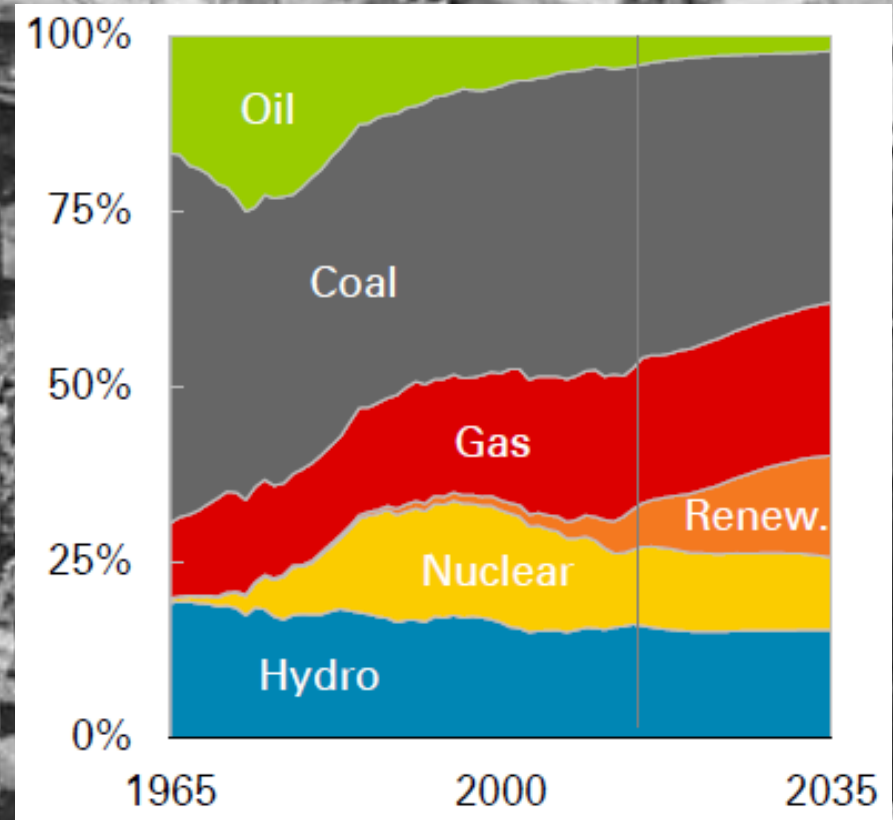
toe = Tonne of Oil Equivalent



# Primary energy consumption



Shares of primary energy

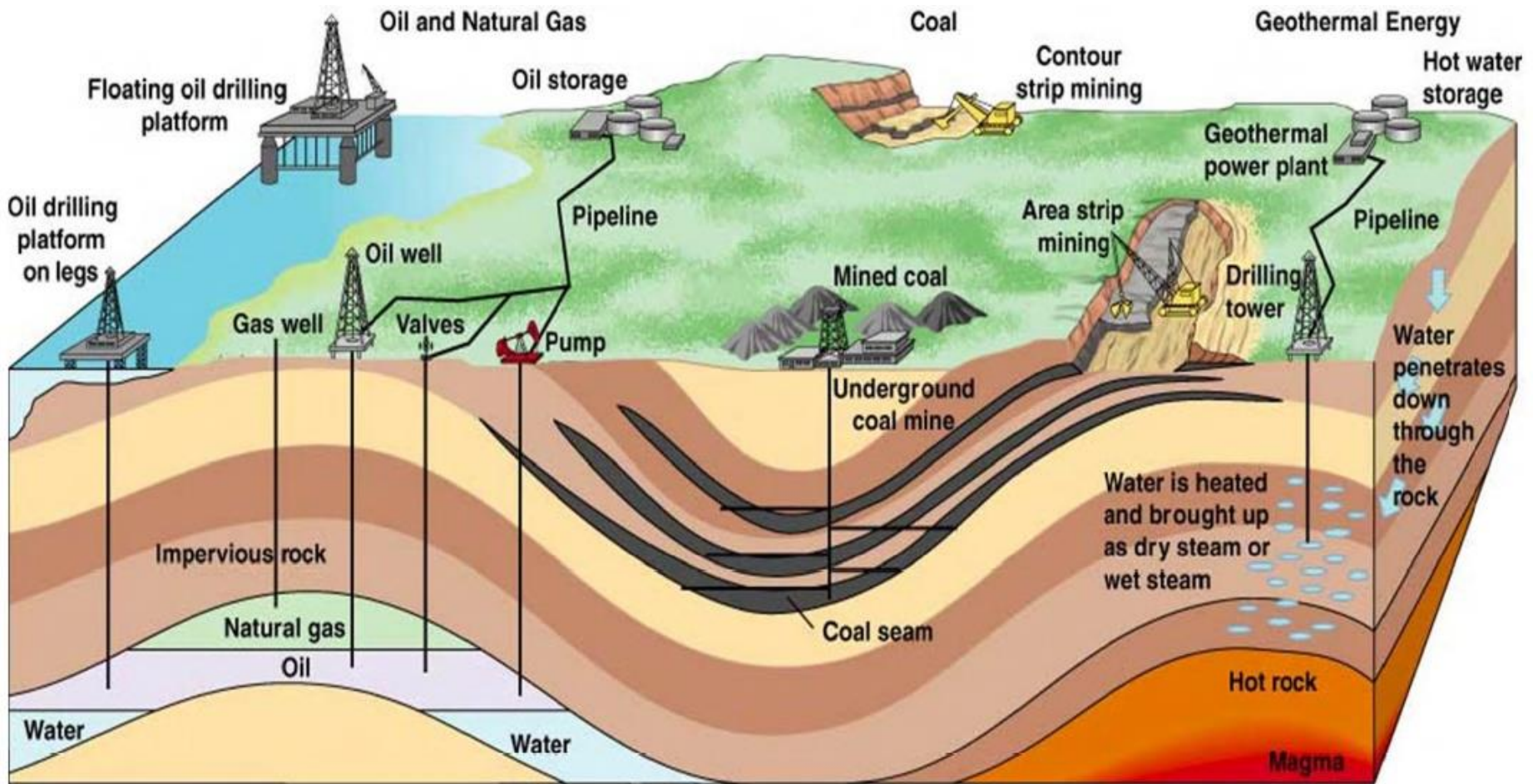


Primary energy to power



# Introduction: Sources of energy

# Possible energy sources **underground**



# Other energy sources

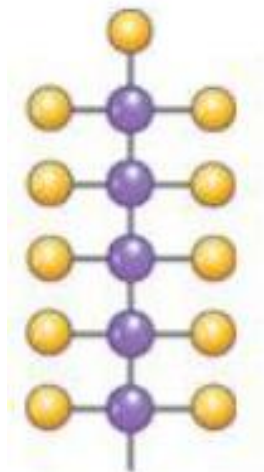


**Crude oil**

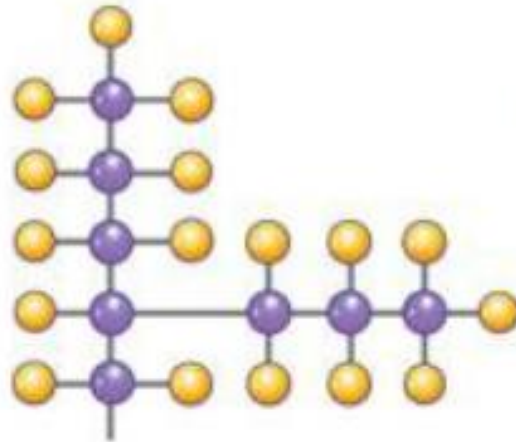
# Definition

- „Crude oil” or petroleum, is a **mineral of organic origin**: anaerob decomposition (without oxygen) material derived from prehistoric algae and zooplankton remains
- Its main components are the **liquid phase hydrocarbons**, but it may contain dissolved gases and/or solid hydrocarbon as well
- The crude oil is a complex hydrocarbon mixture but also consists **sulphur, nitrogen** or oxygen containing compounds. There are **metallic components** (Ni, V, ...) in complex form and some **dissolved water** present too.

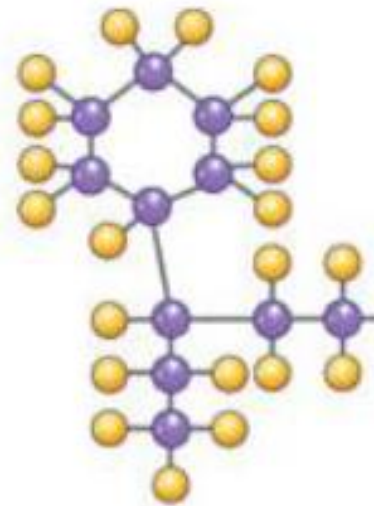
# Composition: types of **hydrocarbons**



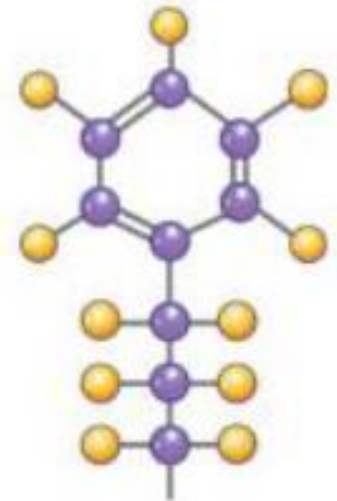
Paraffin



Branched  
Paraffin



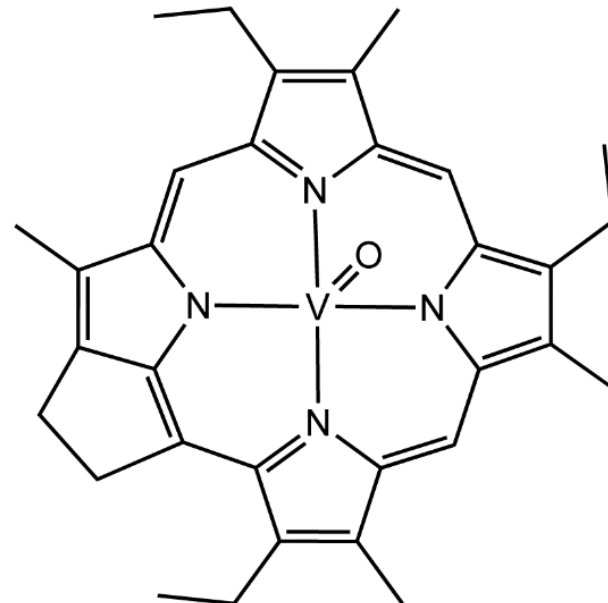
Naphthene



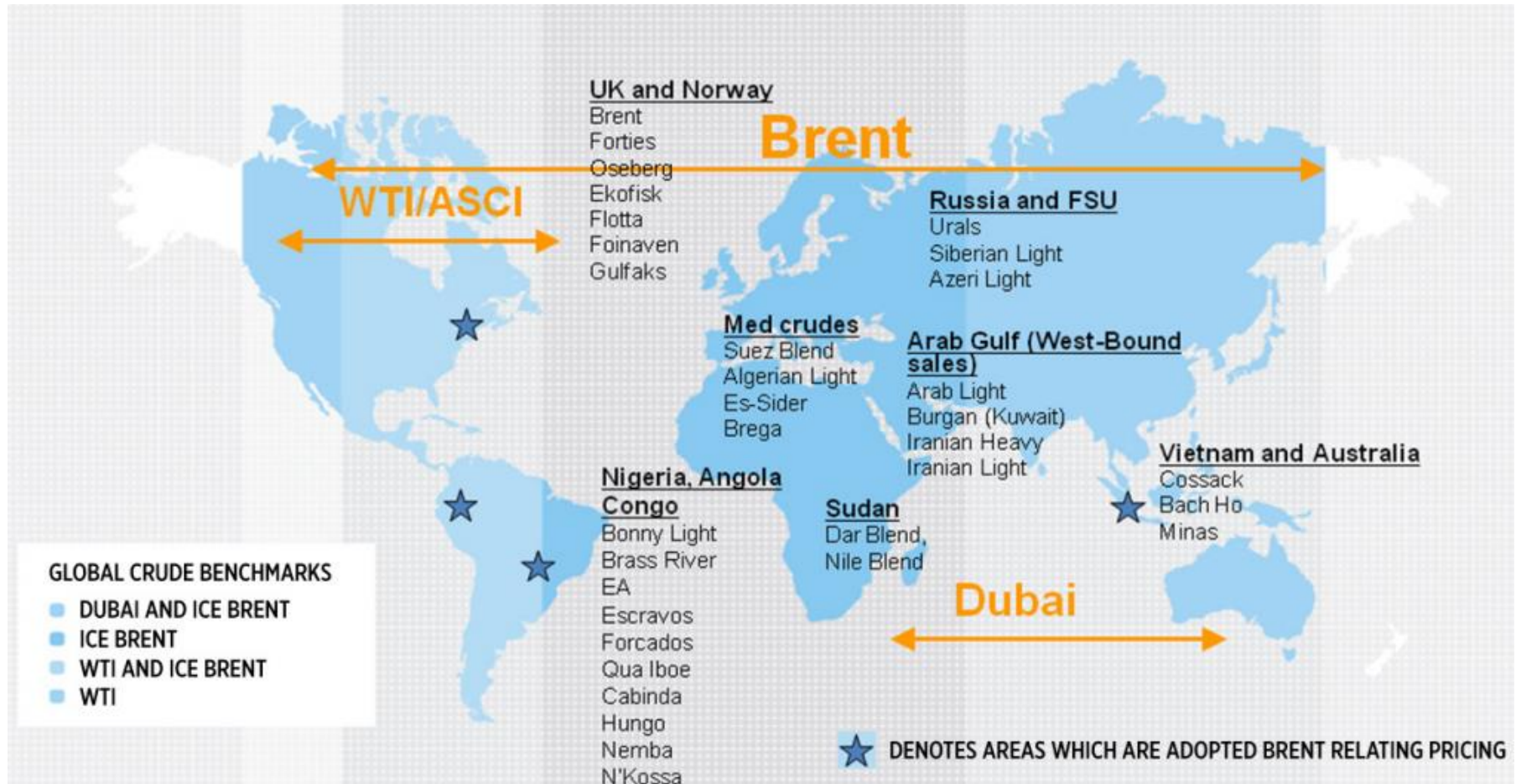
Aromatic

# Composition: types of **impurities**

- Sulphur containing compounds
  - Elemental sulphur
  - Hydrogen sulphide
  - Mercapthanes
  - Sulphides-disulphides
  - Thiophenes and derivatives
- Nitrogen containing compounds
  - Amines
  - Nitriles
  - Pyrroles
- Oxygen containing compounds
  - Organic acids
  - Phenols
- Organic metal complexes
  - Mainly Ni, V



# Benchmark crude oils worldwide



Benchmark crude oil is crude oil that serves as a **pricing reference**, making it easier for sellers and buyers to determine the prices of multitudes of crude oil varieties and blends.



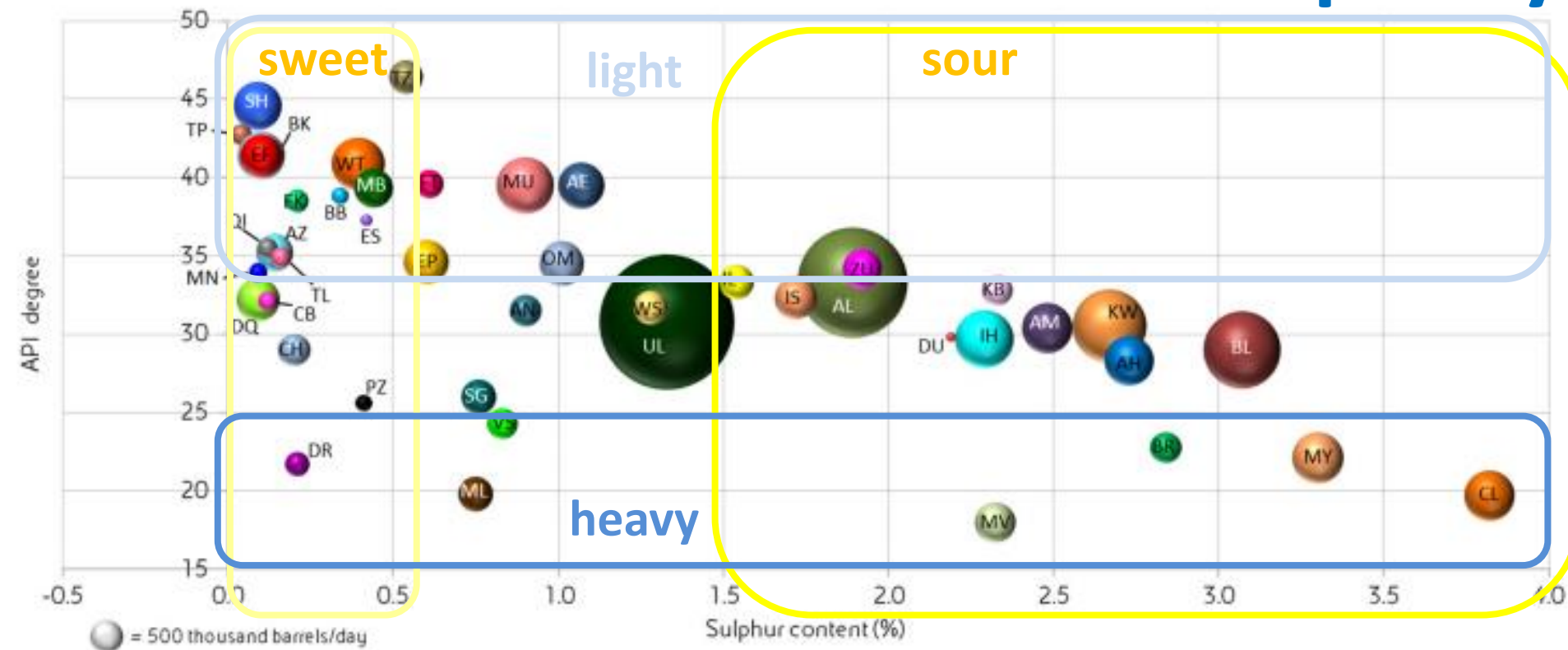
# General classification of crude oil



Crude are generally classified according to:

Location of origin	e.g. Brent
Density	Light, Intermediate, Heavy
Sulphur content	Sweet vs. Sour

# Crude oil quality



- UL - Urals (Russia)
- WT - West Texas Int. (U.S.A.)
- AL - Arab Light (Saudi Arabia)
- MB - Mixed Blend S. (Canada)
- AZ - Azeri Light (Azerbaijan)
- BB - Brent Blend (U.K.)
- KW - Kuwait (Kuwait)
- AM - Arab Medium (Saudi Arabia)
- BL - Basrah Light (Iraq)
- AH - Arab Heavy (Saudi Arabia)
- BR - Bow River (Canada)
- DQ - Daqing (China)
- CB - Cabinda (Angola)
- CH - Changqing (China)
- CL - Cold Lake (Canada)
- DR - Duri (Indonesia)
- EK - Ekofisk (U.K., Norway)
- EP - Espo (Russia)
- ES - Es Sider (Libya)
- FT - Forties (U.K.)
- IH - Iran Heavy (Iran)
- DU - Dubai (U.A.E.)
- IL - Iran Light (Iran)
- IS - Isthmus (Mexico)
- KB - Kirkuk Blend (Iraq)
- ML - Marlim (Brazil)
- MU - Murban (U.A.E.)
- AE - Arab Extra L. (Saudi Arabia)
- MV - Merey (Venezuela)
- MY - Maya (Mexico)
- OM - Oman (Oman)
- AN - Alaskan Nth. Sl. (U.S.A.)
- PZ - Pazflor (Angola)
- QI - Qua Iboe (Nigeria)
- MN - Minas (Indonesia)
- SG - Shengli (China)
- SH - Saharan B. (Algeria)
- TL - Troll (Norway)
- TP - Tapis (Malaysia)
- TZ - Tengiz (Kazakhstan)
- VS - Vasconia (Colombia)
- WS - West Texas Sour (U.S.A.)
- ZU - Upper Zakum (U.A.E.)
- BK - Bakken Blend (U.S.A.)
- EF - Eagle Ford (U.S.A.)

Source: ENI World Oil and Gas Review 2015



# API gravity

- The American Petroleum Institute gravity, or API gravity, is a measure of how heavy or light a petroleum liquid is compared to water. If its API gravity is greater than 10, it is lighter and floats on water; if less than 10, it is heavier and sinks.
- $\text{API gravity} = 141.5/\text{SG} - 131.5$       where  $\text{SG} = \rho_{\text{oil}}/\rho_{\text{water}}$
- Crude oil is classified as light, medium or heavy, according to its measured API gravity:
  - Light crude oil is defined as having an API gravity higher than 31.1 °API
  - Medium oil is defined as having an API gravity between 22.3 °API and 31.1 °API
  - Heavy oil is defined as having an API gravity below 22.3 °API.

# Classification of crude oil: UOP K



- The characterization factor was introduced by UOP. Is based on the observation that the specific gravity of the hydrocarbons are related to their H/C ratios and their boiling points are linked to the number of carbon atoms in their molecules.
- $K_{UOP} = (1.8T)^{1/3} / SG$ 
  - where  $SG = \rho_{oil} / \rho_{water}$ ,  $T = (T_{20} + T_{50} + T_{80}) / 3$  from the TBP distillation
  - TBP:
    - Specifications for ASTM D2892 Packed Columns (True Boiling Point)  
Distillation Column Efficiency: 15 Theoretical Plates  
Vacuum Range: 100 to 2 mmHg  
Packing Types: Propak, Helipak, Structured Packing
- $K_{UOP} / K_W$ :
  - n-paraffins > i-paraffins > olefins > naphthens > aromatic hydrocarbons
  - Average  $K_W$  of crude oils: 10-13

# Crude oil assay



## Alaskan North Slope - Summary Crude Oil Assay Report

Source of Sample		Light Hydrocarbon Analysis			Assay Summary / TBP Data		
Reference:	MM15ANS2	H2S*	ppm wt	-	Gravity (°API)	32,0	
Name:	Alaskan North Slope	Methane	%wt	0,00	Sulphur (%wt)	0,962	
Origin:	United States of America	Ethane	%wt	0,01	Yield on Crude	%wt	%vol
Sample Date:	2015.07.27	Propane	%wt	0,18	Gas to C4	2,45	3,65
Comments:		Isobutane	%wt	0,45	Light Distillate to 149°C	17,80	21,05
		n-Butane	%wt	1,80	Kerosene 149 - 232°C	13,20	14,20
		Isopentane	%wt	0,99	Gas Oil 232 - 369°C	23,35	23,05
		n-Pentane	%wt	1,42	Vacuum Gas Oil 369°C - 550°C	25,15	23,10
		Cyclopentane	%wt	0,17	Residue above 550°C	18,05	14,95
		C6 paraffins	%wt	2,11			
		C6 naphthenes	%wt	1,37			
	Benzene	%wt	0,34	Volume expansion:	0,3 per cent vol		
		*Dissolved in liquid			on crude distributed across whole distillation		

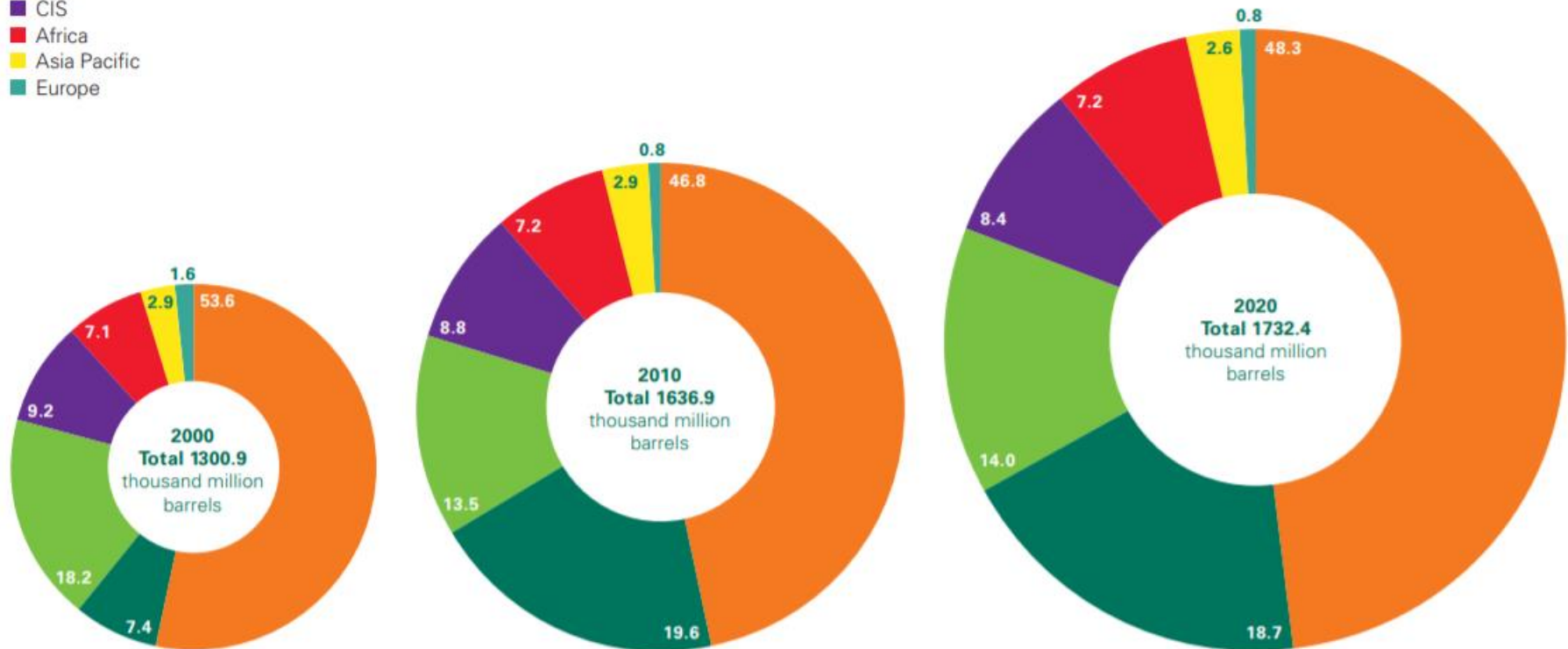
Cut Data	Crude	Distillates									Residues			
		Light Naphtha	Heavy Naphtha		Kero	Light Gas Oil	Heavy Gas Oil	Light Vacuum Gas Oil	Heavy Vacuum Gas Oil	AtRes	VacRes			
Start (°C API)	IBP	C5	95	149	175	232	342	369	509	550	369	509	550	585
End (°C API)	FBP	95	149	175	232	342	369	509	550	585	FBP	FBP	FBP	FBP
Yield on crude (% wt)	100	7,95	9,85	4,05	9,10	19,00	4,35	20,35	4,80	3,60	43,20	22,85	18,05	14,45

# Proven crude oil reserves

## Distribution of proved reserves in 2000, 2010 and 2020

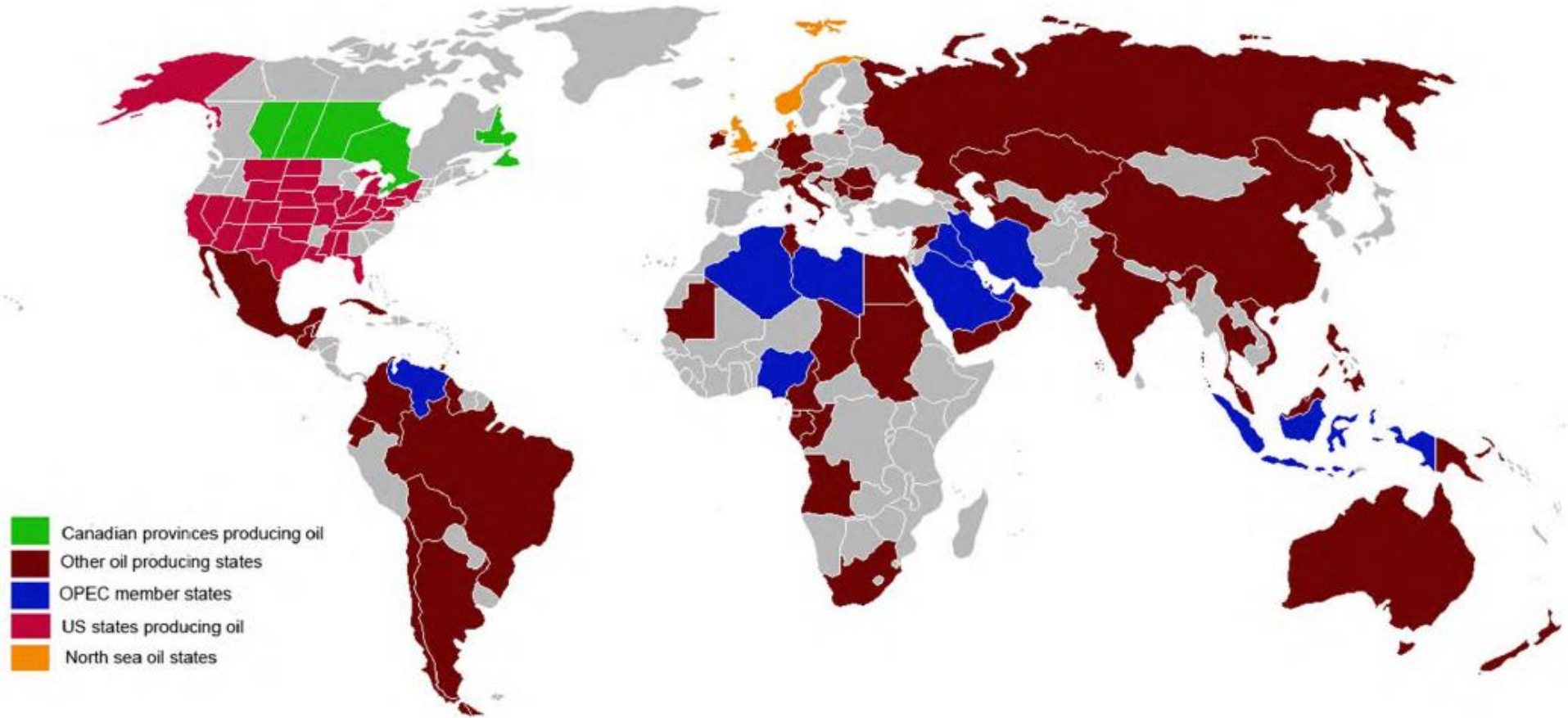
Percentage

- Middle East
- S. & Cent. America
- North America
- CIS
- Africa
- Asia Pacific
- Europe



According to estimations, proven reserves will reach its maximum around ~2040

# Oil producing countries



# Crude type: **Extra heavy**

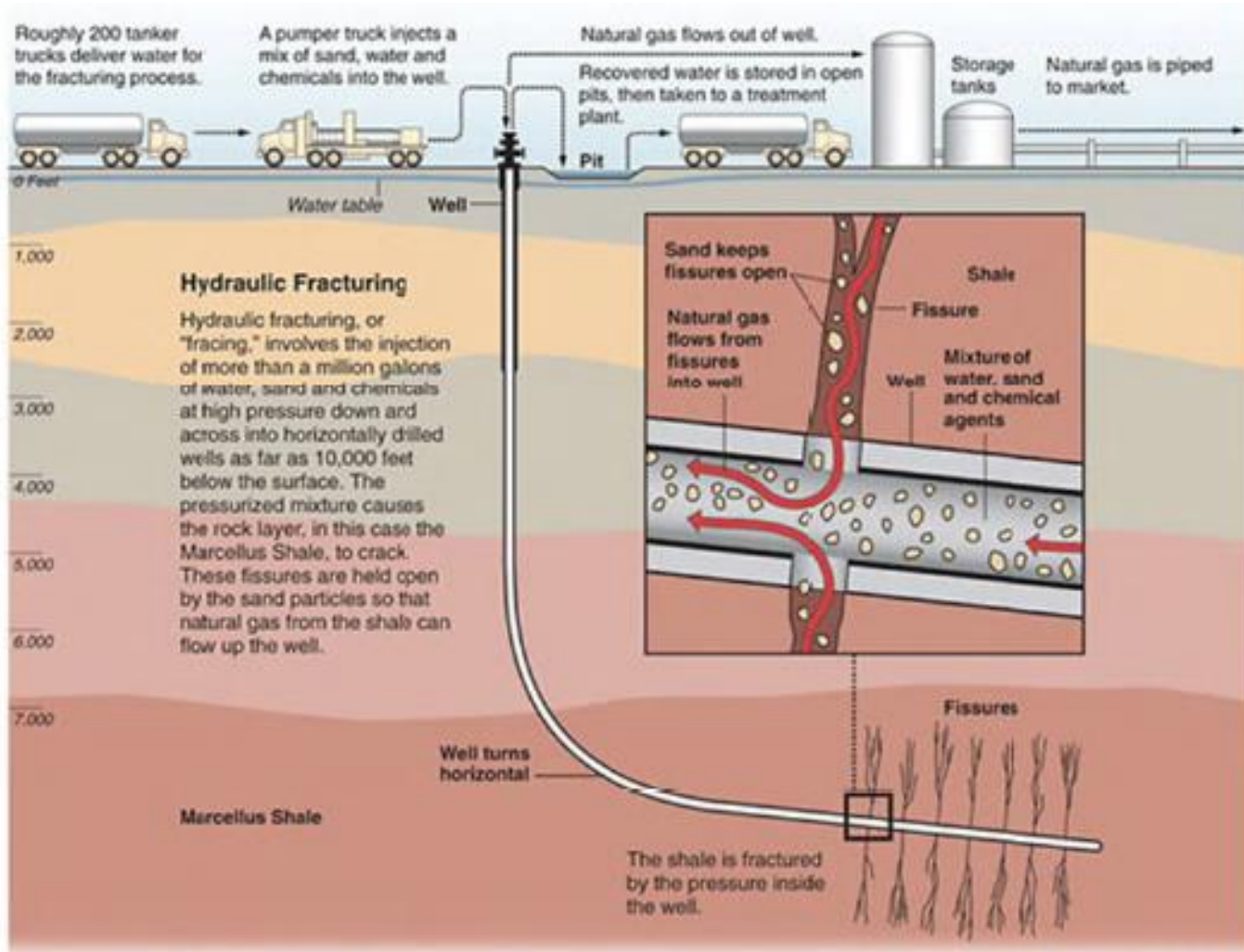
Canadian oil sands: 1.7 trillion barrels

Venezuelan heavy crudes:  
1.9 trillion barrels





# Crude type: Shale oil

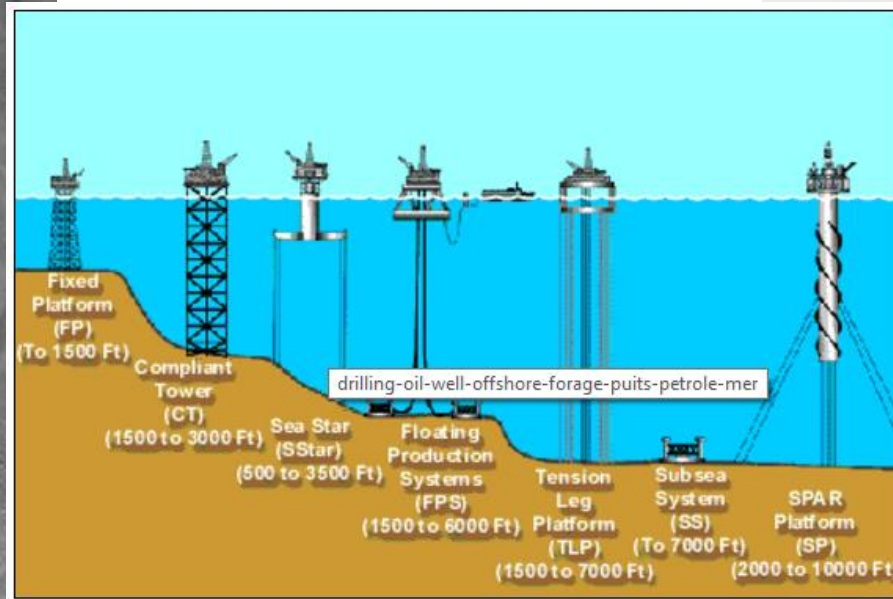


Graphic by Al Granberg

# Crude oil **supply chain**

- Research
- Well creation
- Production
  - Primary: own pressure assist to come on surface
  - Secondary: gas or water injected to assist to come on surface
- Preconditioning: water and gas separation
- Storage
- Transport

# Crude oil production



Site: ...  
22

# Crude oil preconditioning



- The oil is **collected** from the individual wells in central collecting stations
- Here **free water** is setting out and **free gases** are separated: the oil become stabilised
- The **stabilised oil** then may be transported



# Transportation of crude oil

- Via water
  - Long distance: see tankers
  - Short distance: barges
- Via land
  - Long distance: pipelines
  - Short distance: rail cars, trucks

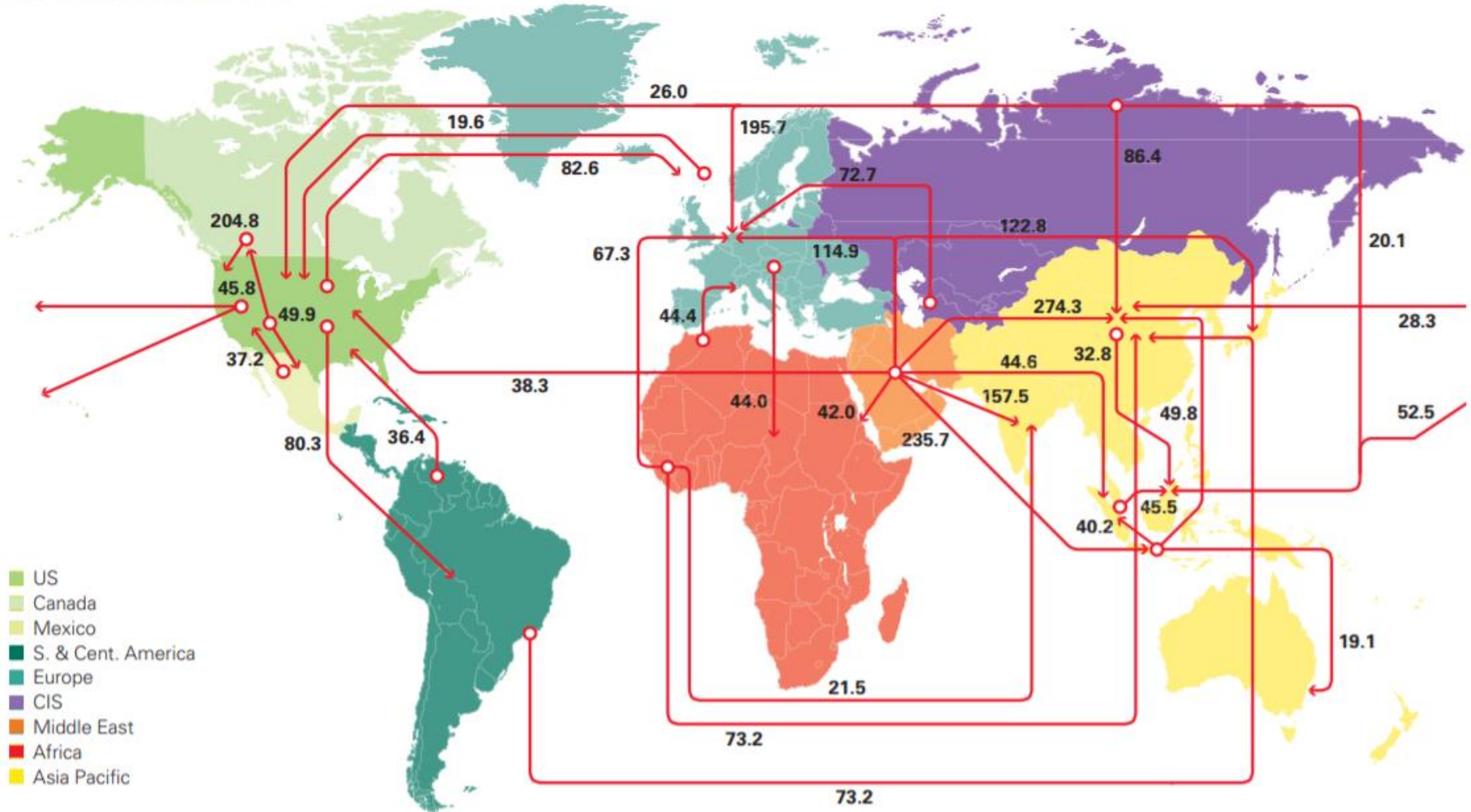




# Trade movements

## Major trade movements 2020

Trade flows worldwide (million tonnes)



# The End

