# *Oil:*
# *Social, environmental and economic concerns*

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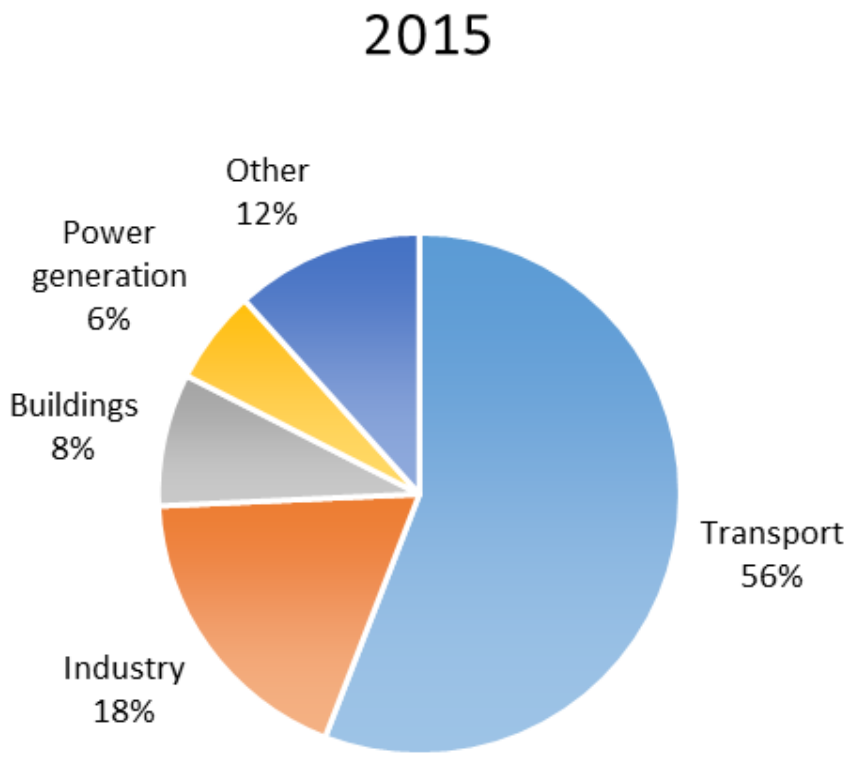
Introductory lecture – Energy commodities and technologies

# *Commodity: global trends*

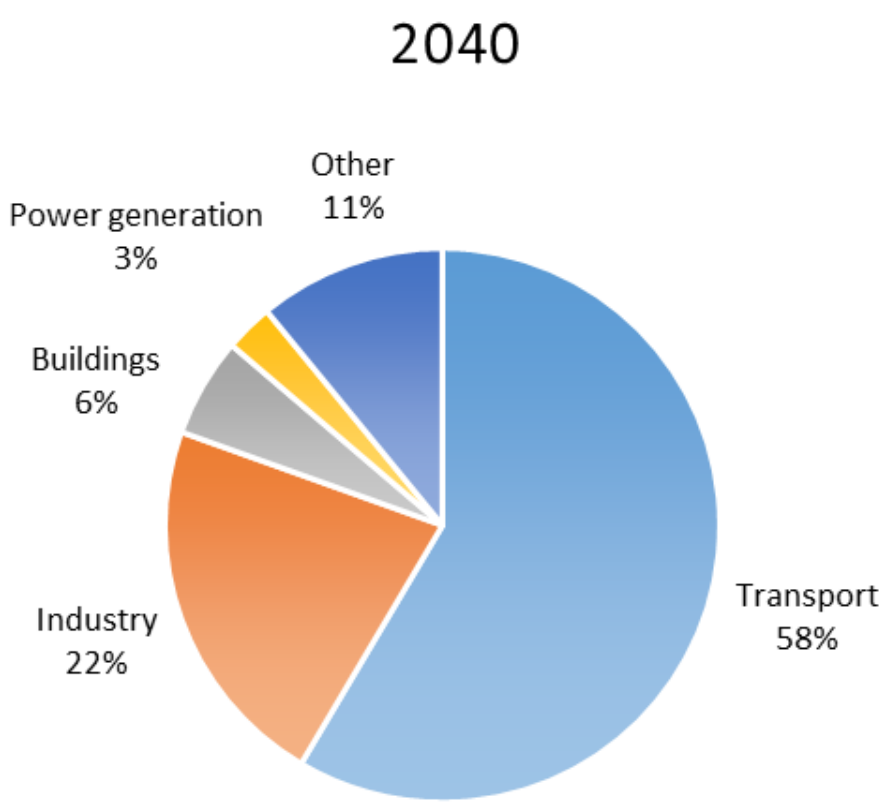
- Demand
- Supply
- Resources

# Demand

Total: 92.5 mb/d



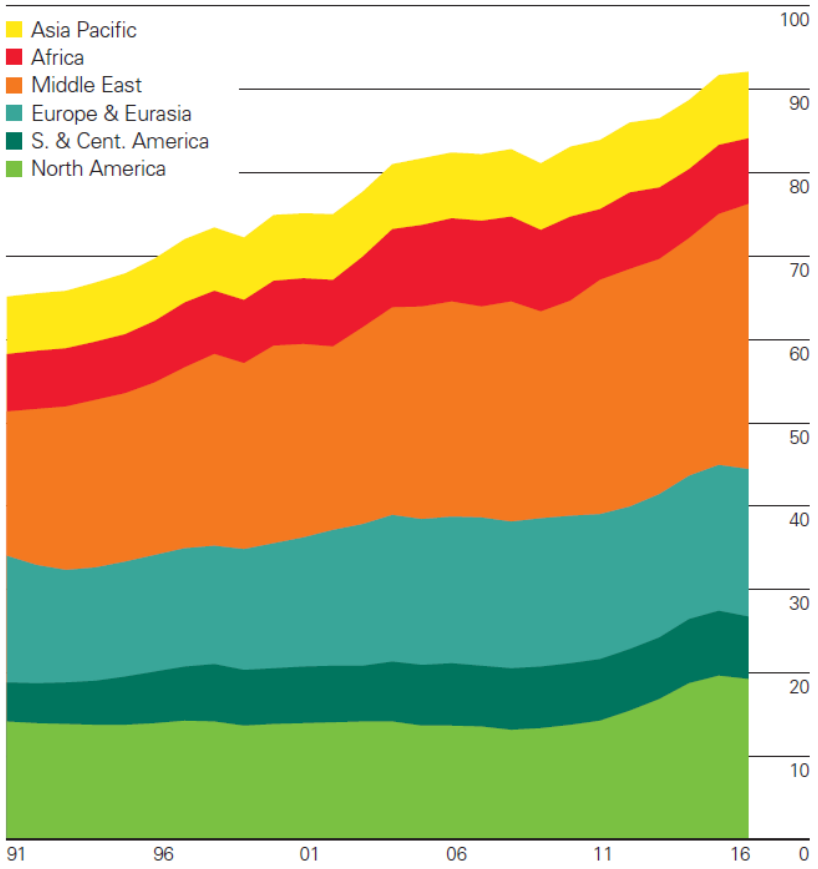

Total: 103.5 mb/d



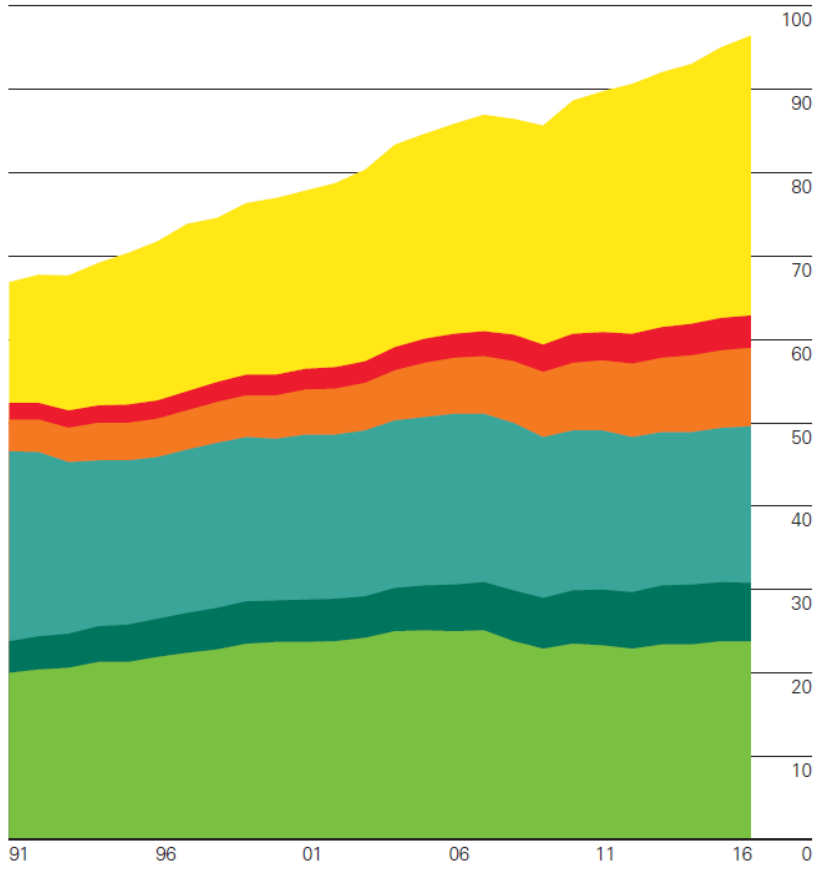

*Source: IEA World Energy Outlook 2016.*

# Supply

Oil production (mb/d)




Oil consumption (mb/d)




*Source: BP Statistical review of World Energy 2017.*

# Resources

## Conventional resources:

- Crude oil
- NGLs (Natural Gas Liquids): including heavier molecules than Methane, like Ethane, Propane, Butanes, Pentanes…

## Unconventional resources:

- EHOB (Extra-Heavy Oil and Bitumen): aka oil sands. Highly dense and viscous crude oil trapped in unconsolidated sandstone. Main deposits: Alberta (Canada) and Orinoco (Venezuela).
- Kerogen oil: aka oil shale. Produced from fine-grained sedimentary rock containing kerogen (solid mixture of organic compounds). Main producer in 2009: Estonia.
- Tight oil: light crude oil contained in petroleum-bearing formations of low permeability. Produced by hydraulic fracturing of the rocks (similar process as for shale gas). Main reserves: Russia, US, China, Argentina, Libya, Venezuela. Currently developed in US and Canada.

# Resources

Oil resources (billion barrels)

| | Conventional | | Unconventional | | | Total | |
|---|---|---|---|---|---|---|---|
| | Crude oil | NGLs | EHOB | Kerogen oil | Tight oil | Resources | Proven reserves |
| **OECD** | **319** | **144** | **808** | **1 016** | **135** | **2 422** | **254** |
| Americas | 250 | 101 | 805 | 1 000 | 104 | 2 260 | 237 |
| Europe | 59 | 25 | 3 | 4 | 16 | 107 | 13 |
| Asia Oceania | 10 | 18 | - | 12 | 16 | 56 | 4 |
| **Non-OECD** | **1 882** | **404** | **1 068** | **57** | **285** | **3 697** | **1 448** |
| E. Europe/Eurasia | 260 | 65 | 552 | 20 | 88 | 984 | 142 |
| Asia | 125 | 50 | 3 | 4 | 56 | 239 | 46 |
| Middle East | 940 | 153 | 14 | 30 | 29 | 1 166 | 803 |
| Africa | 316 | 87 | 2 | - | 54 | 459 | 130 |
| Latin America | 242 | 50 | 497 | 3 | 57 | 849 | 326 |
| **World** | **2 201** | **548** | **1 876** | **1 073** | **420** | **6 118** | **1 703** |

*Source: IEA World Energy Outlook 2016.*

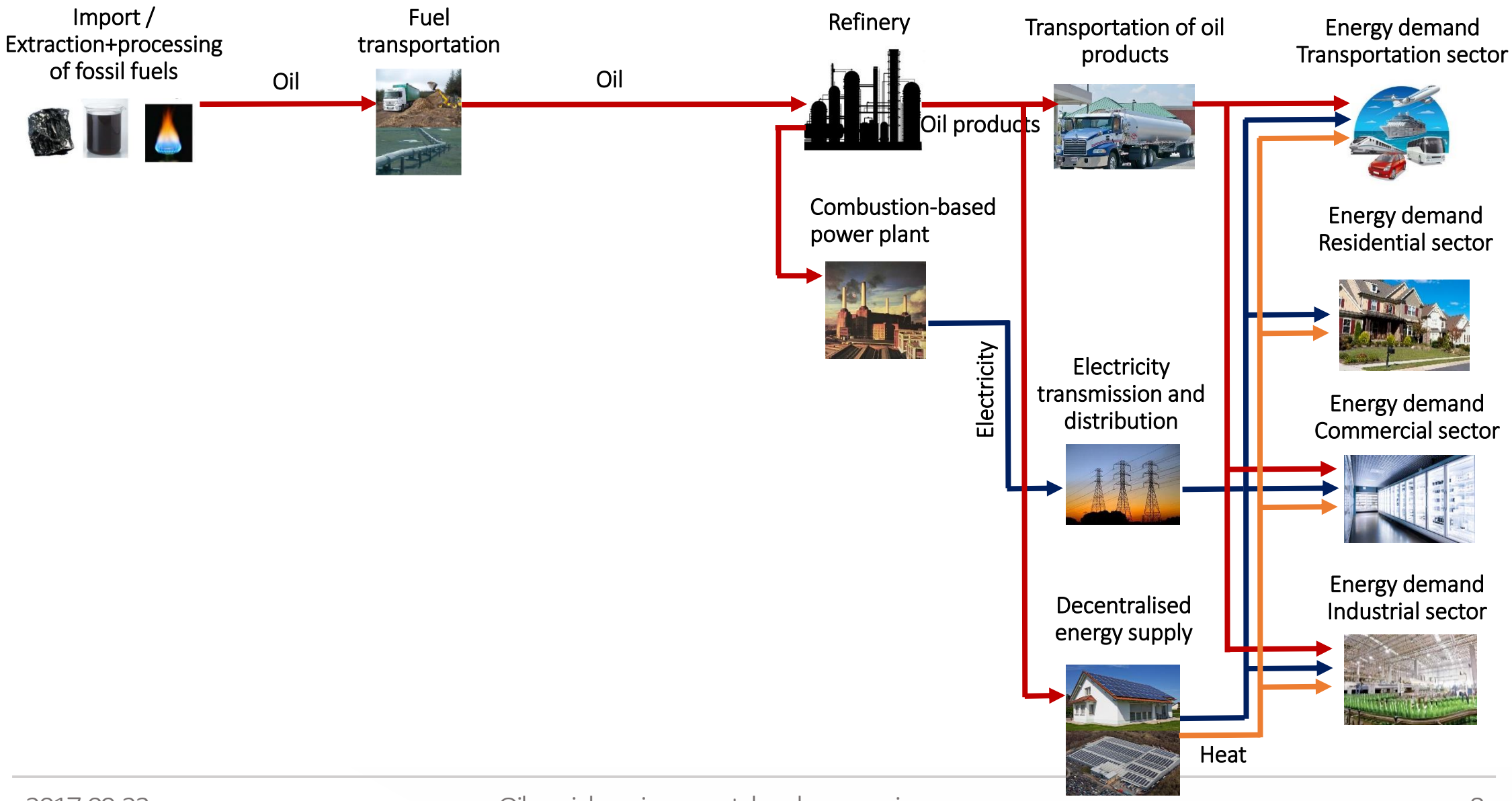
*Proven reserves = 90% probability to be extracted profitably*

*Reserves to Production ratio (R/P) of around* ***40 years***

# *Technologies in the oil chain*

- Extraction
- Transportation and storage
- Refinery
- Combustion-based power plants
- Economic, Environmental and Social concerns

# Sample Reference Energy System



# Extraction

## Processes - conventional oil:

- Conventional wells: lately case drilling is used
- Deepwater production: made possible by floating platforms. 3000 m reached in 2005.
- Enhanced Oil Recovery (EOR): CO2, N2 or CH4 injected to displace and replace oil.

## Processes - unconventional oil:

- Cycle Steam Simulator (CSS): steam injected in the well to allow oil to flow. Used with Extra Heavy Oil.
- Steam Assisted Gravity Drainage (SAGD): similar to CSS, but oil is allow to drop onto a lower horizontal collector by gravity.
- Retorting: heating in the absence of Oxygen.

| Key characteristics | |
|---|---|
| *Conventional oil* | |
| Capital cost | 5.3-63.7 $/boe |
| VOM cost | 3.2-8.3 $/boe |
| Recovery factor | 30-50% |
| Energy use | 0.8-2.3 GJ/toe |
| CO2 Em. factor | 64.9-273.6 ton/ktoe |
| *Unconventional oil* | |
| Capital cost | - |
| VOM cost | 6.6-19.7 $/GJ |
| Recovery factor | 10-70% |
| Energy use | 20-30% of produced |
| CO2 Em. factor | 9.3-15 gCO2/MJ |

# Transportation and storage

## Oil tankers

Usually for international transportation of crude oil.

## Pipelines

Usually for domestic transportation to refinery sites. Equipped with pumping stations.

## Trucks and railway

For short-distance transportation of limited quantities from small wells to refineries.

## Storage

In shallow or underground tanks, or oil tankers. For market (prices) or security reasons.

| Key characteristics | |
|---|---|
| *Oil tankers* | |
| Capital cost | 48-151 M$ |
| Fuel consumption | 2.2-3.8 g diesel/ton-km |
| Lifetime | 29 years |
| CO2 Em. factor | 3.8-6.6 gCO2/ton-km |
| *Pipelines* | |
| Capital cost | 2.3 M$ / km |
| Energy use | 0.5% of transported |
| Lifetime | 25-40 years |
| CO2 Em. factor | - |

# Refinery

Basic process consists in atmospheric + vacuum distillation. Refineries can be categorised based on complexity:

**Topping:** basic processes.

**Hydro-skimming:** in addition to basic processes, they include hydrotreating and reforming units for light compounds.

**Conversion:** compared to hydro-skimming they also include catalytic cracking and hydrocracking for heavier oils.

**Deep-conversion:** like conversion refineries, with addition of coking units for the heaviest oil fractions.

| Key characteristics | |
|---|---|
| Capital cost | 31 k$ / barrel – day |
| O&M cost | 3-4 $ / barrel |
| Efficiency | 90% |
| Energy use | Increasing 61 MJ/m3 crude oil feedstock per additional 1 kg/m3 sulphur |
| CO2 Em. factor | 47.4 kg CO2/barrel Can increase 40% with low quality crude |
| Capacity factor | 83-93% |

# Combustion-based power plants

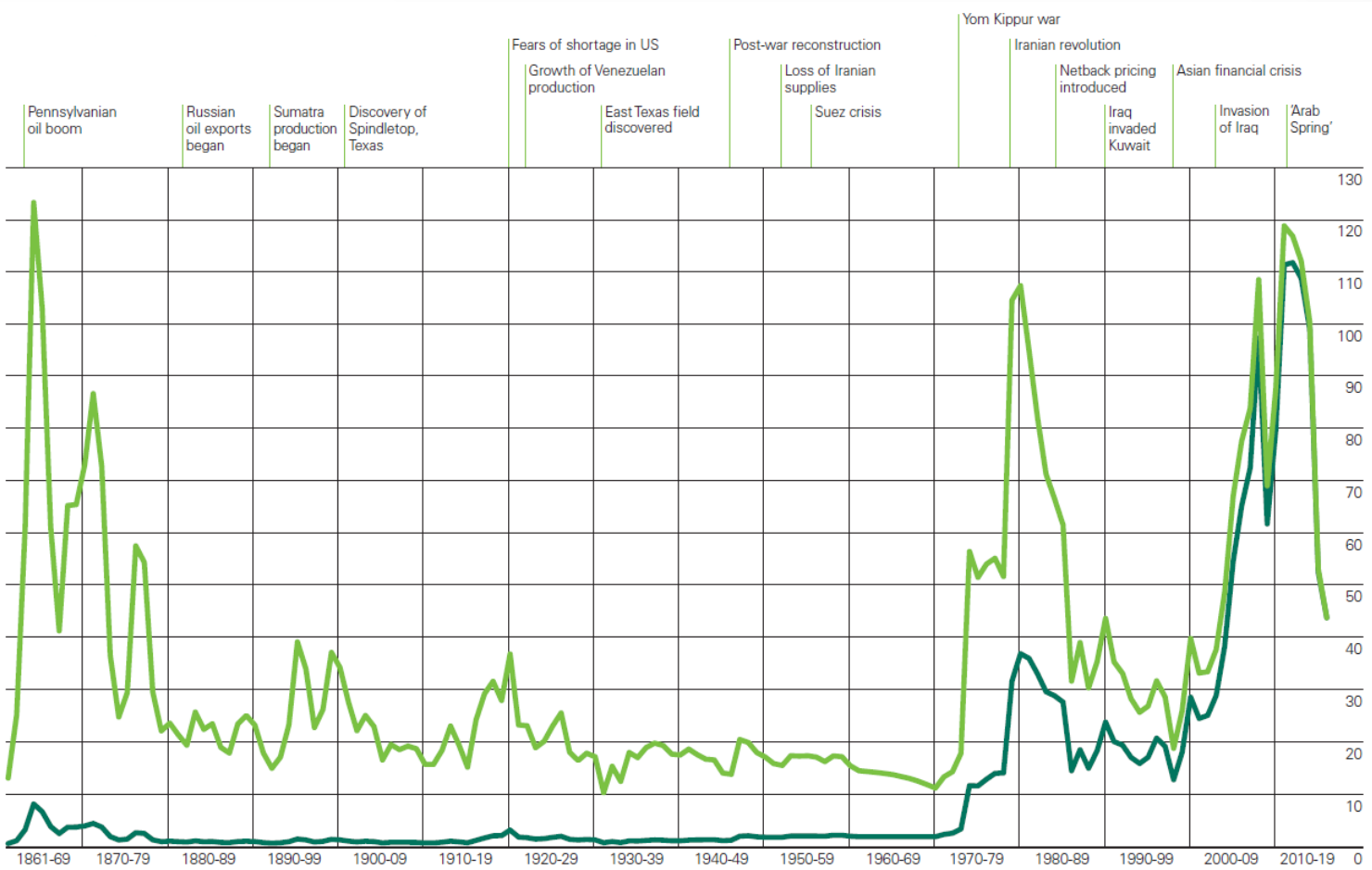
Utility scale power generation from oil products like heavy fuel oil or diesel has been phasing out and has now a minor share. Small diesel generators are still used as backup (e.g. in hospitals, factories or households), especially in developing countries.

Traditionally, oil products were used for instance in:

- **Heavy Fuel Oil-fired gas turbines;**
- **Utility scale diesel generators.**

| Key characteristics | |
|---|---|
| ***HFO Gas Turbines*** | |
| Capital cost | 1490 $/kW |
| Efficiency | 35% |
| ***Diesel generators*** | |
| Capital cost | 780 $/kW |
| FOM cost | 8 $/kW/a |
| Efficiency | 35% |

# Economic concerns




*Source: BP Statistical review of World Energy 2017.*

Given the oscillation of the oil prices, it is important to have:

- Moderated ***Import dependency:*** portion of primary energy imported from other countries;
- High ***Diversity*** of the energy mix: 1) in the resources and 2) in the suppliers

# Environmental concerns

**Hydraulic fracturing (fracking).** Well-stimulation technique used for tight oil. Consists in fracturing rocks with pressurized liquid, containing water, proppants and thickening agents. Once fractures are created to extract oil or gas, the proppants hold the fractures open. Concerns regarding:

- Waste-water disposal
- Pollution of underground water
- Increased seismic activity (e.g. Canada, Montney's formation)
- No full transparency about chemicals used in the pressurized mixture

**Extraction of oil sands.** Water-consuming process. It is sometimes limited through water recycling.

**Gas flaring in production sites.** Residual natural gas extracted with oil is burnt, causing CO2 and pollutants emissions and waste of resources.

# Environmental concerns

## High number of oil spills due to accidents

BP oil rig Deepwater Horizon, US - Gulf of Mexico, 2010. Estimated 500-600 thousands tonnes oil spilled

Mingbulak oil field, Fergana Valley, Uzbekistan, 1992. Estimated 285 thousands tonnes oil spilled

| The 5 largest oil spills in history (Source: The Telegraph) | | |
|---|---|---|
| *What?* | *When and where?* | *How much? (Mgallons)* |
| Gulf war | 1991, Kuwait | 240-336 |
| Deepw. Horizon | 2010, Mex. gulf | 210 |
| Ixtoc 1 Oil Well | 1979, Mexico | 140 |
| Atlantic Empress | 1979, Trinidad | 88 |
| Fergana Valley | 1992, Uzbekistan | 88 |

# Environmental concerns

**Direct and indirect emissions of CO2 and pollutants.**

Emissions from combustion of Hydrocarbons have effects at different scales: *global, regional and local*.

**CO2**: GHG with effect at global scale;

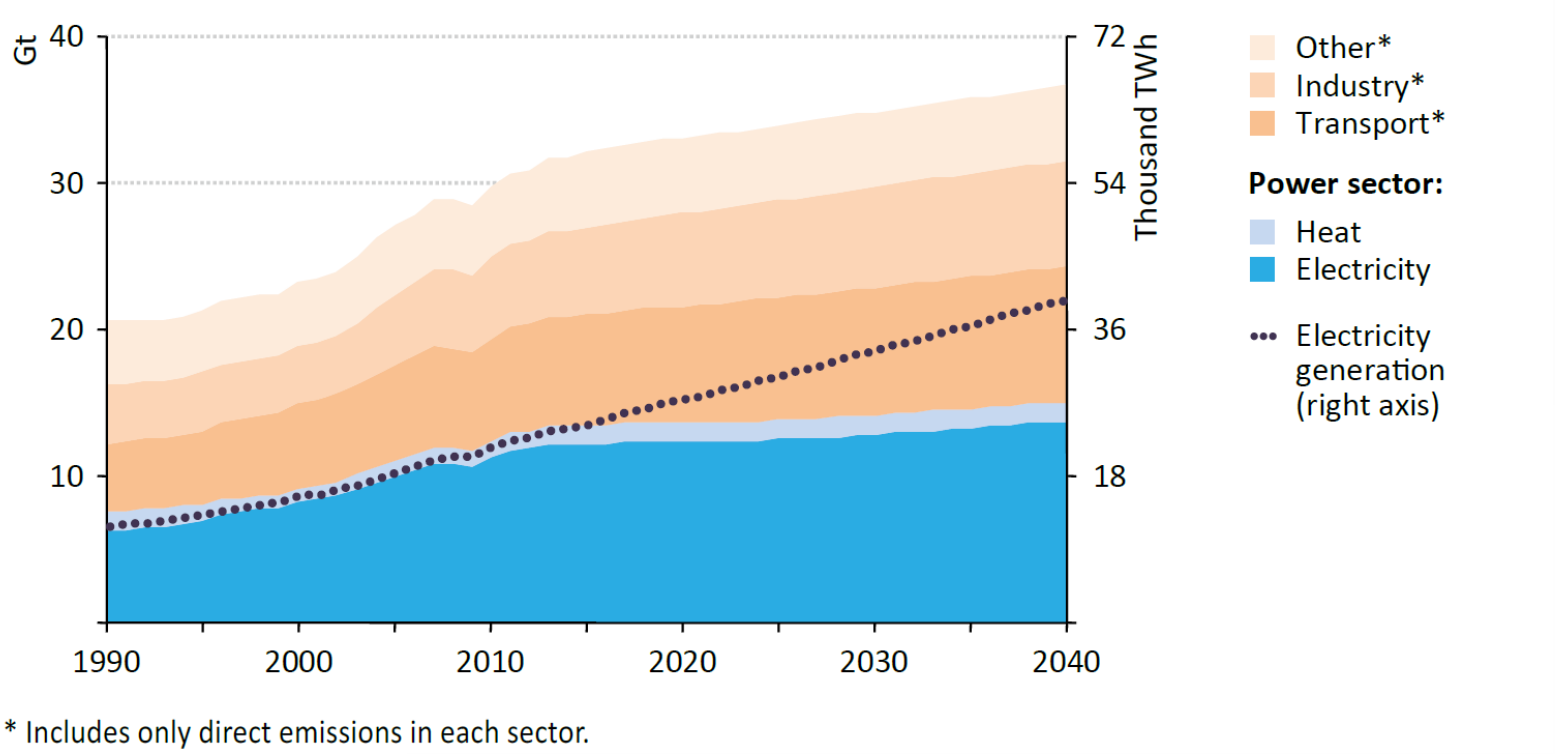
**NOx** and **SOx**: effects at regional scale (acid rains and human health impacts) and global scale (destruction of stratospheric ozone layer);

**PM (Particulate Matter)**: effects mainly at local scale;

**CO**: effects mainly at local scale (intoxication, deathly at high concentrations).

# Environmental concerns

## Direct and indirect emissions of CO2 and pollutants.




* Includes only direct emissions in each sector.

Source: IEA, World Energy Outlook 2015, New Policies Scenario.

## Global CO2 emissions by sector (direct).

Oil products-based transport sector accounts for second biggest share in global CO2 emissions.

*But we saw in the description of the oil supply chain that there are emissions along the whole chain!*

# Social concerns

- Oil often imported from politically unstable regions, where sometimes wars, civil conflicts or turmoil in act (see e.g. Nigeria, Iraq, etc.)
- Oil production activities from foreign companies do not necessarily help reduce the militarisation of some regions
- Reported cases of big displacement of population for oil extraction activities: Nigeria, Sudan, Ecuador, Colombia.
- Oil spills also harm local societies and activities: e.g. spill of Deepwater Horizon affected the fishing activities of communities along the coast.

# *Conclusions*

- There is high demand for oil in all sectors, which is not expected to decrease;
- Until it doesn't, production of conventional and unconventional oil is expected to continue, with economic, environmental and social constraints;
- The transportation sector drives large part of the demand. Electrification of this sector could contribute largely to a drop in the production.

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# Changelog and attribution

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