




Oil: Social, environmental and economic concerns

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Introductory lecture – Energy commodities and technologies

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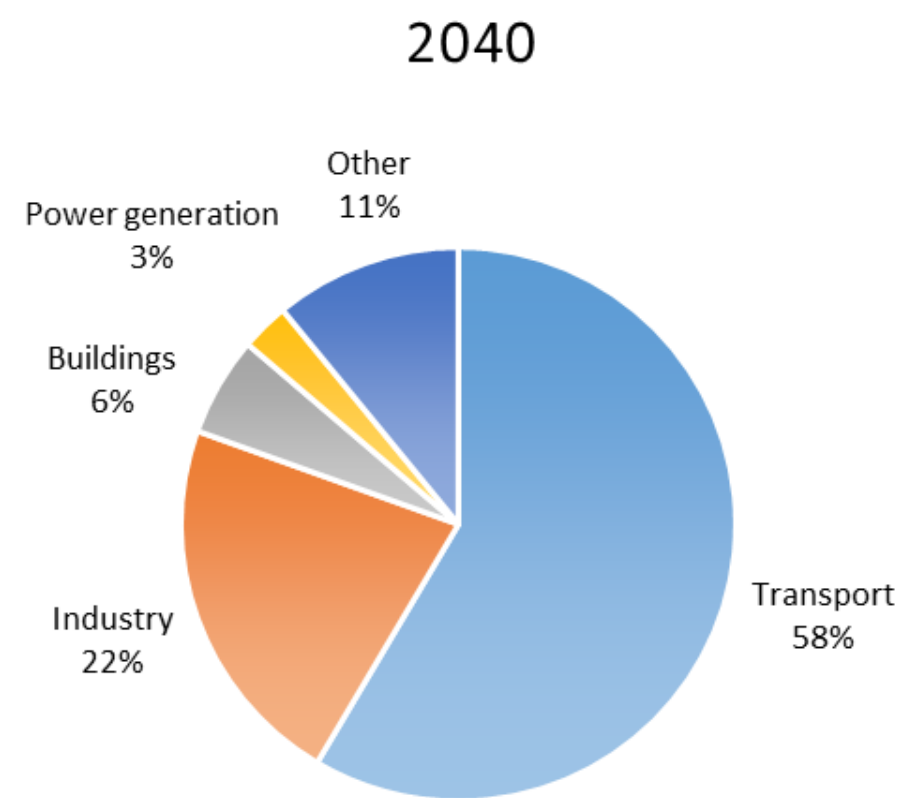
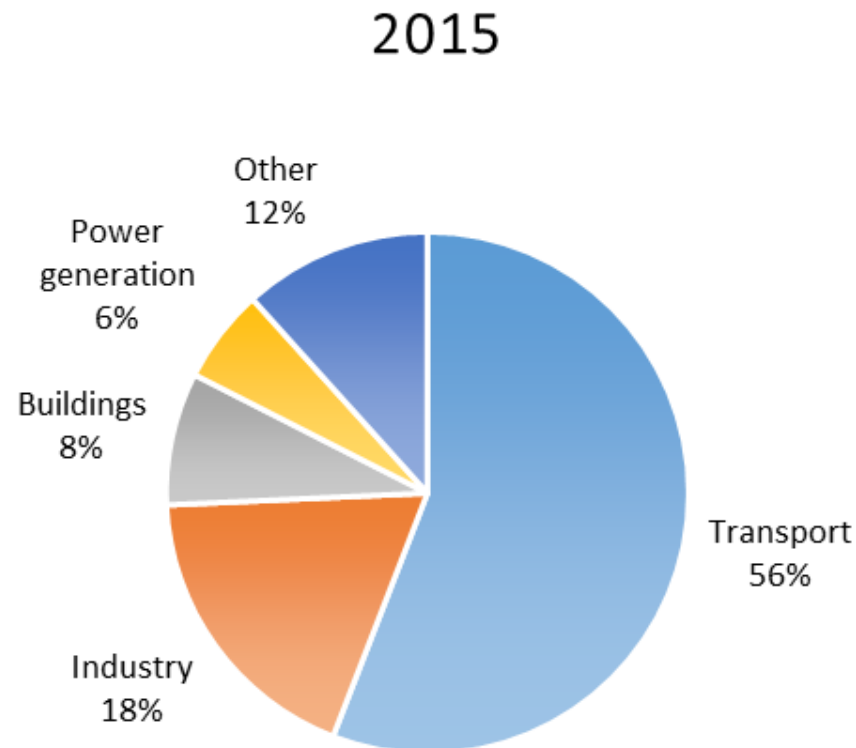
Commodity: global trends

- Demand
- Supply
- Resources

Demand

Total: 92.5 mb/d

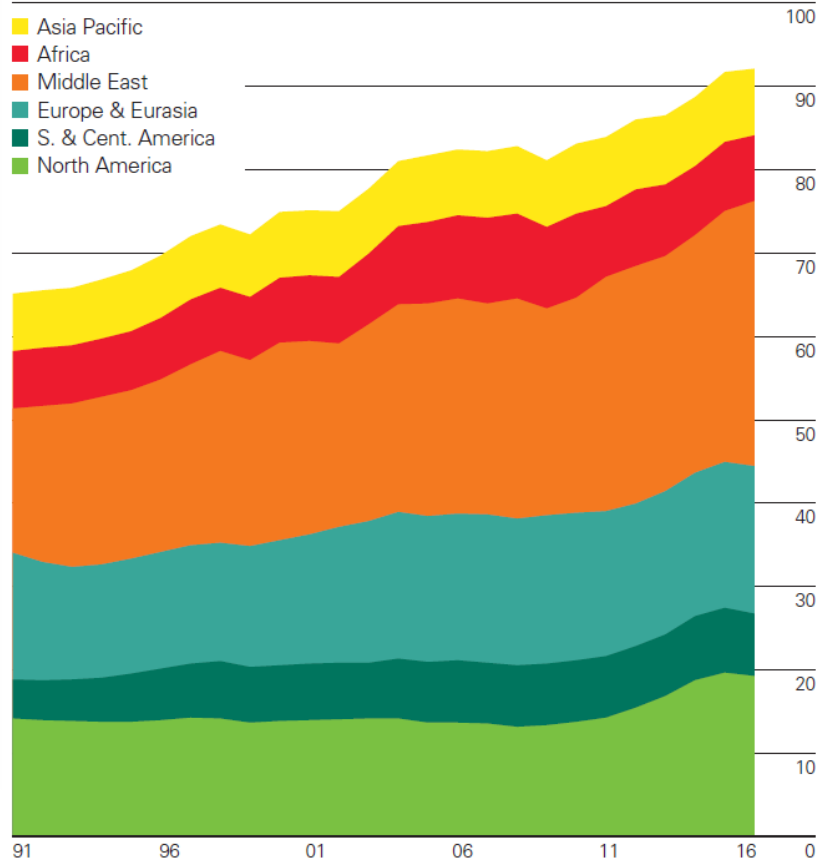
Total: 103.5 mb/d



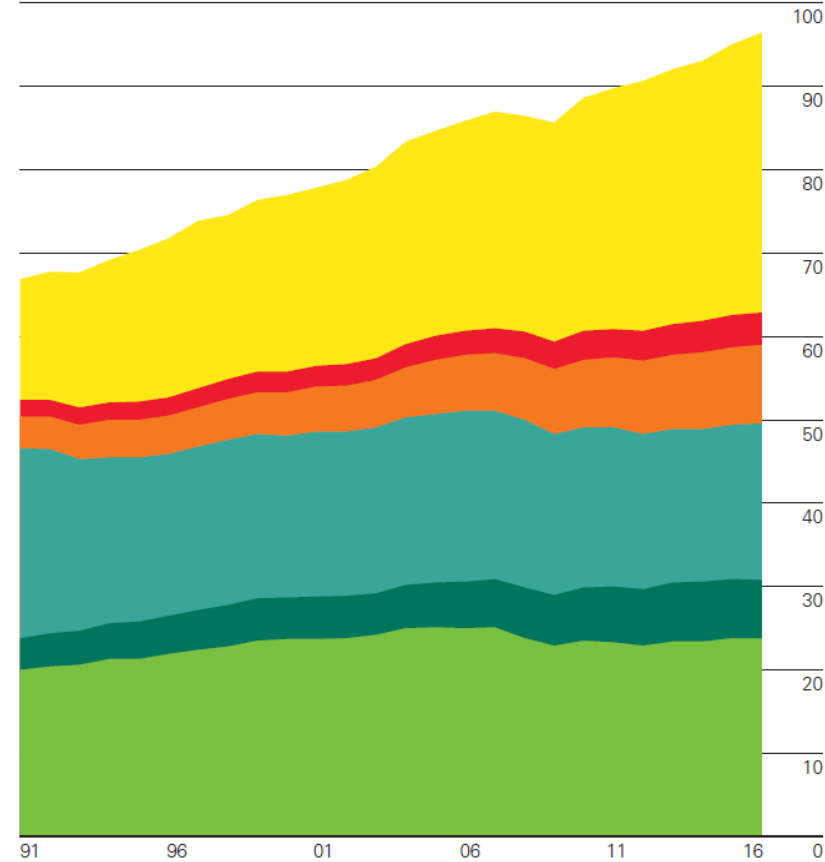
Source: IEA World Energy Outlook 2016.

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.

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

Proven reserves = 90% probability to be extracted profitably

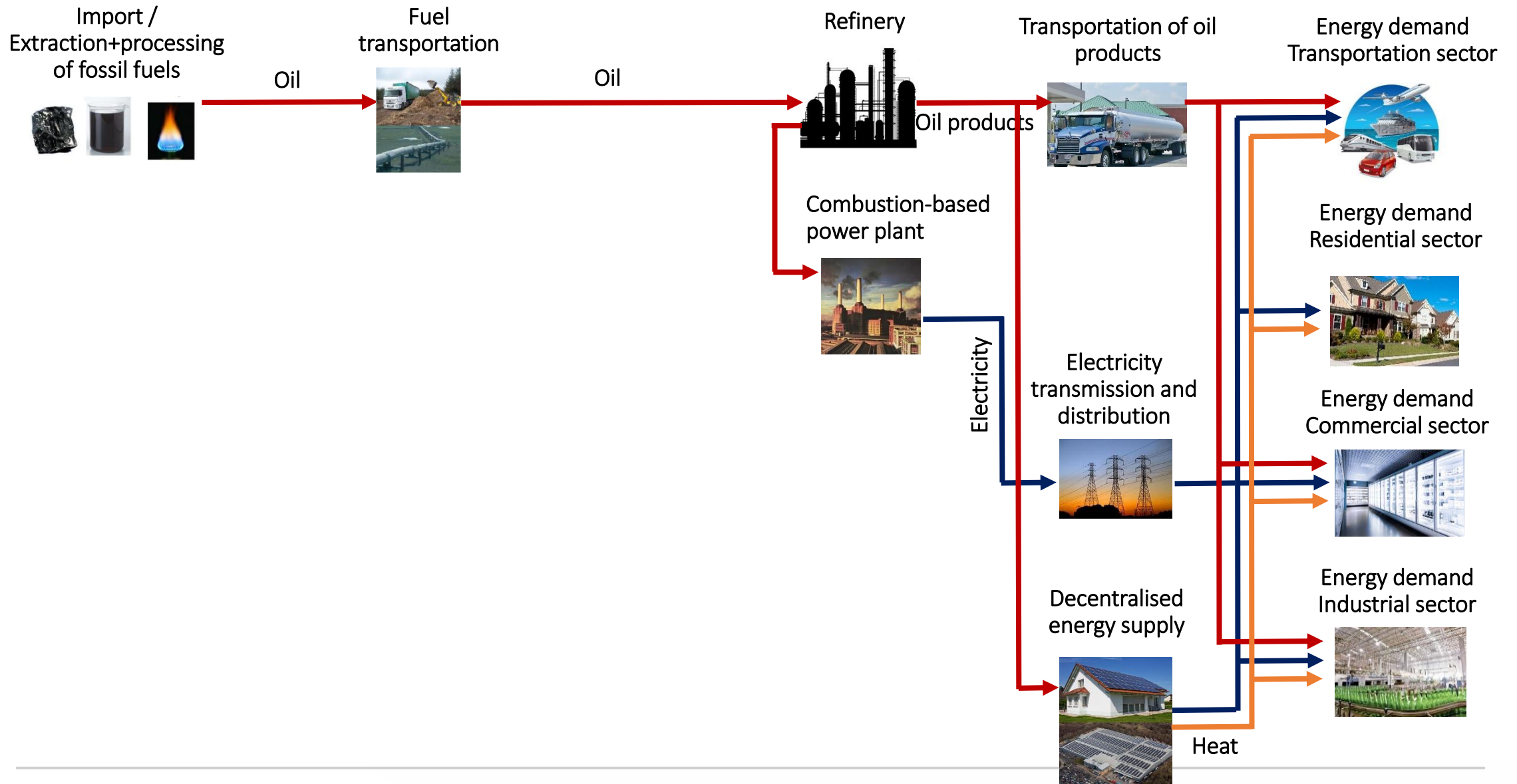
Reserves to Production ratio (R/P) of around 40 years

Source: IEA World Energy Outlook 2016.

Technologies in the oil chain

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

Sample Reference Energy System



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	
<i>Conventional oil</i>	
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
CO ₂ Em. factor	64.9-273.6 ton/ktoe
<i>Unconventional oil</i>	
Capital cost	-
VOM cost	6.6-19.7 \$/GJ
Recovery factor	10-70%
Energy use	20-30% of produced
CO ₂ Em. factor	9.3-15 gCO ₂ /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/m ³ crude oil feedstock per additional 1 kg/m ³ sulphur
CO ₂ Em. factor	47.4 kg CO ₂ /barrel Can increase 40% with low quality crude
Capacity factor	83-93%



Combustion-based power plants



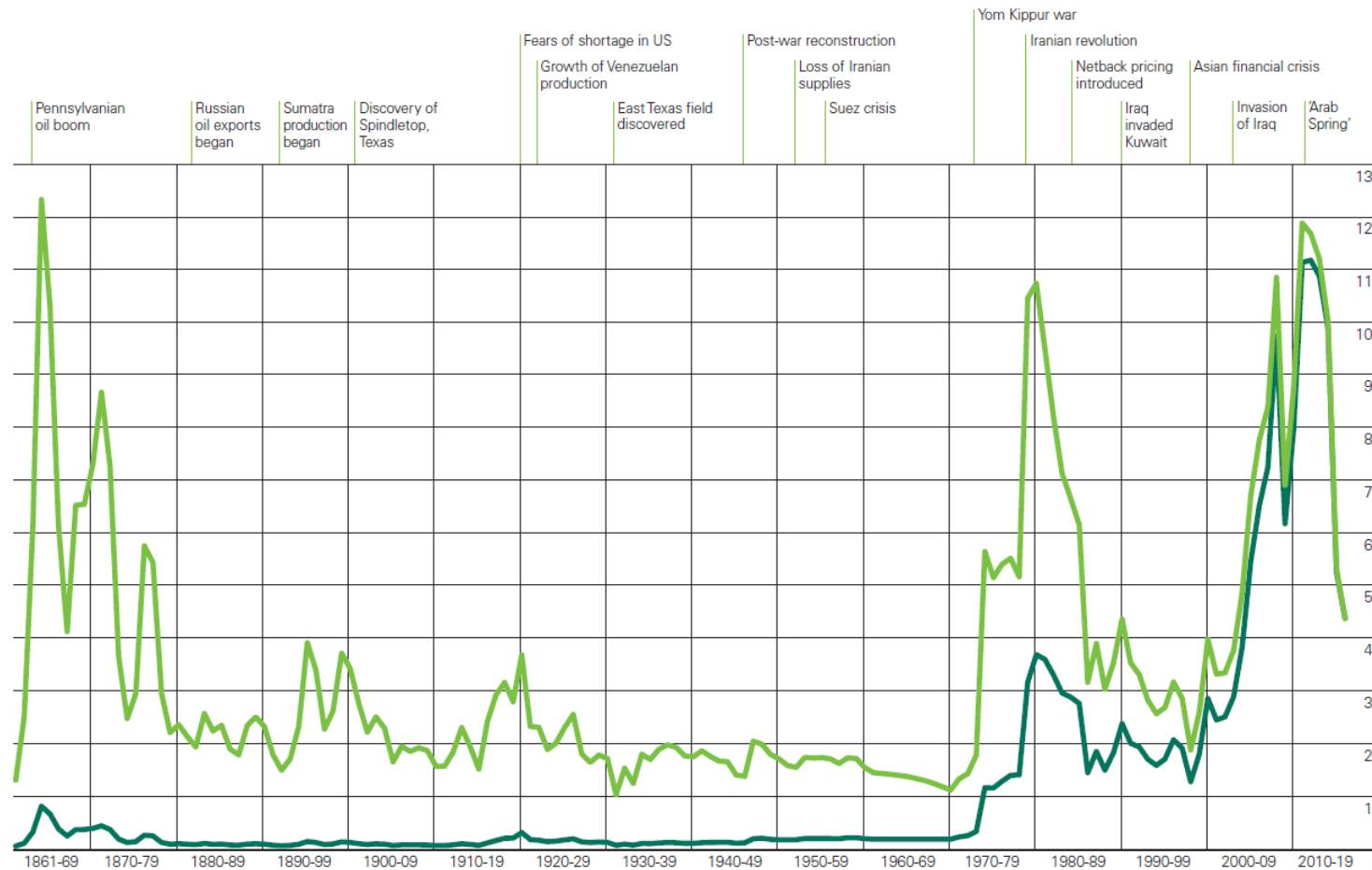
Utility scale power generation from oil products like heavy fuel oil or diesel has been phasing out and has now a minor share. Small diesel generators are still used as backup (e.g. in hospitals, factories or households), especially in developing countries.

Traditionally, oil products were used for instance in:

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

Key characteristics	
<i>HFO Gas Turbines</i>	
Capital cost	1490 \$/kW
Efficiency	35%
<i>Diesel generators</i>	
Capital cost	780 \$/kW
FOM cost	8 \$/kW/a
Efficiency	35%

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.

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)

<i>What?</i>	<i>When and where?</i>	<i>How much? (Mgallons)</i>
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;

NO_x and **SO_x**: 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;

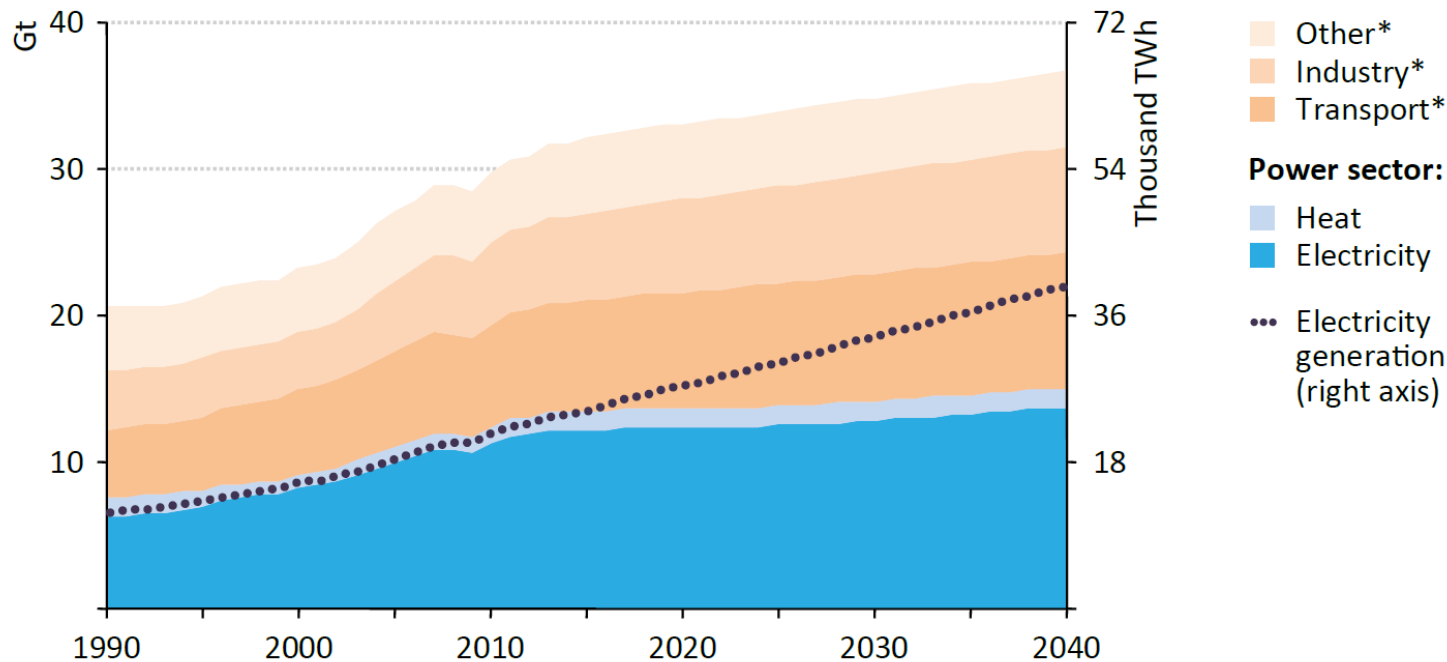
CO: effects mainly at local scale (intoxication, deathly at high concentrations).



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.



References and reading material



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Changelog and attribution



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