

Course: Global Energy Transitions and Climate Policy

lecture 1. Global Energy Resources and Markets

Dr. Behnam Zakeri

Energy, Climate, and Environment Program

International Institute for Applied Systems Analysis, IIASA, Austria

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What To Expect?

At the end of this course, you will:

- understand the key parameters governing global energy transitions
- learn the role of environmental technologies in mitigation of climate change
- develop knowledge on different perspectives in international energy and climate policy debate
- gain an overview on the role of planning and scenario analysis tools in policy making
- discuss possible solutions for achieving an energy or climate policy target
- discuss and present the interest if a stakeholder group in policy debate

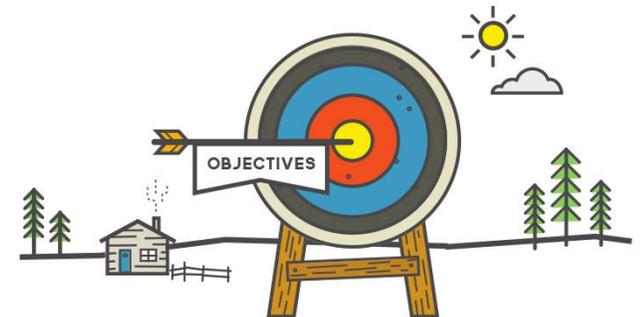


Image: <https://community.articulate.com>

Requirements

What you need to follow the topics in this course:

- Motivation, curiosity, and time
- Energy (?)
- **Group work spirit**
- Active participation

→ The course is multi-disciplinary, no need for in-depth knowledge on energy or mathematics



Image: <https://www.pinterest.co.uk/eglapadula>

The Agenda Today

- Energy and development
- World energy mix
- Energy resources
- Global fossil energy markets
- Geopolitics of energy markets

Energy

- Meeting our daily needs (electricity, heating, cooling, cooking, etc.)
- Driver of industrialization
- Mobilization and transportation
- Improving well being and comfort
- Modernization of society
- Digitalization and the need for Electricity

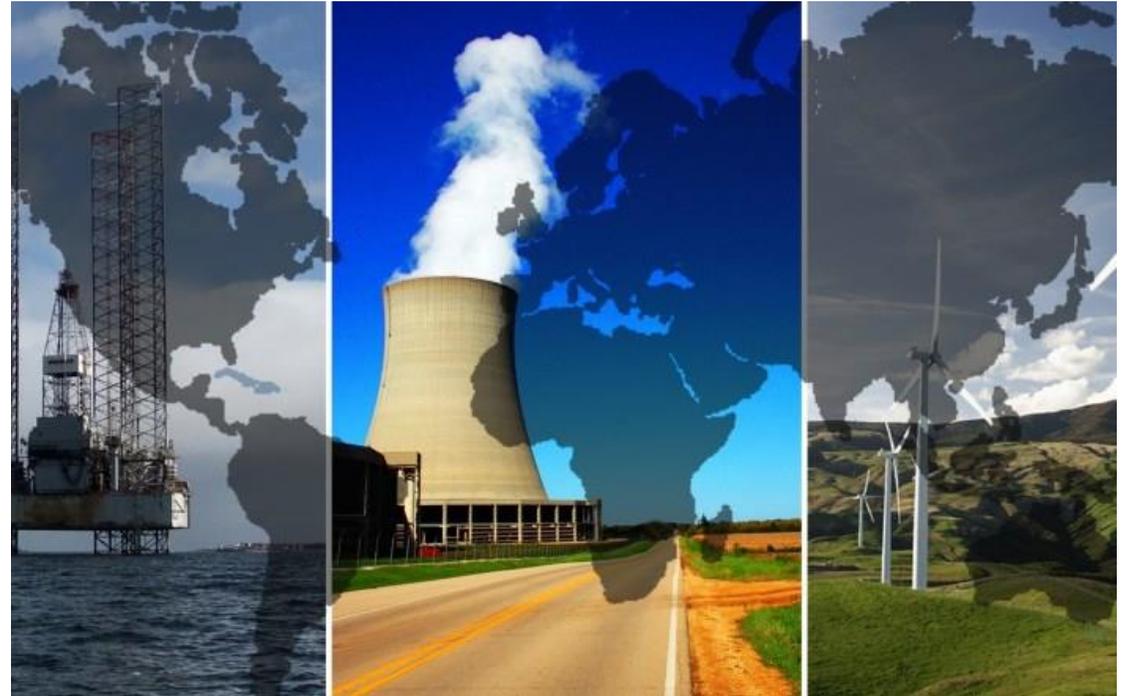


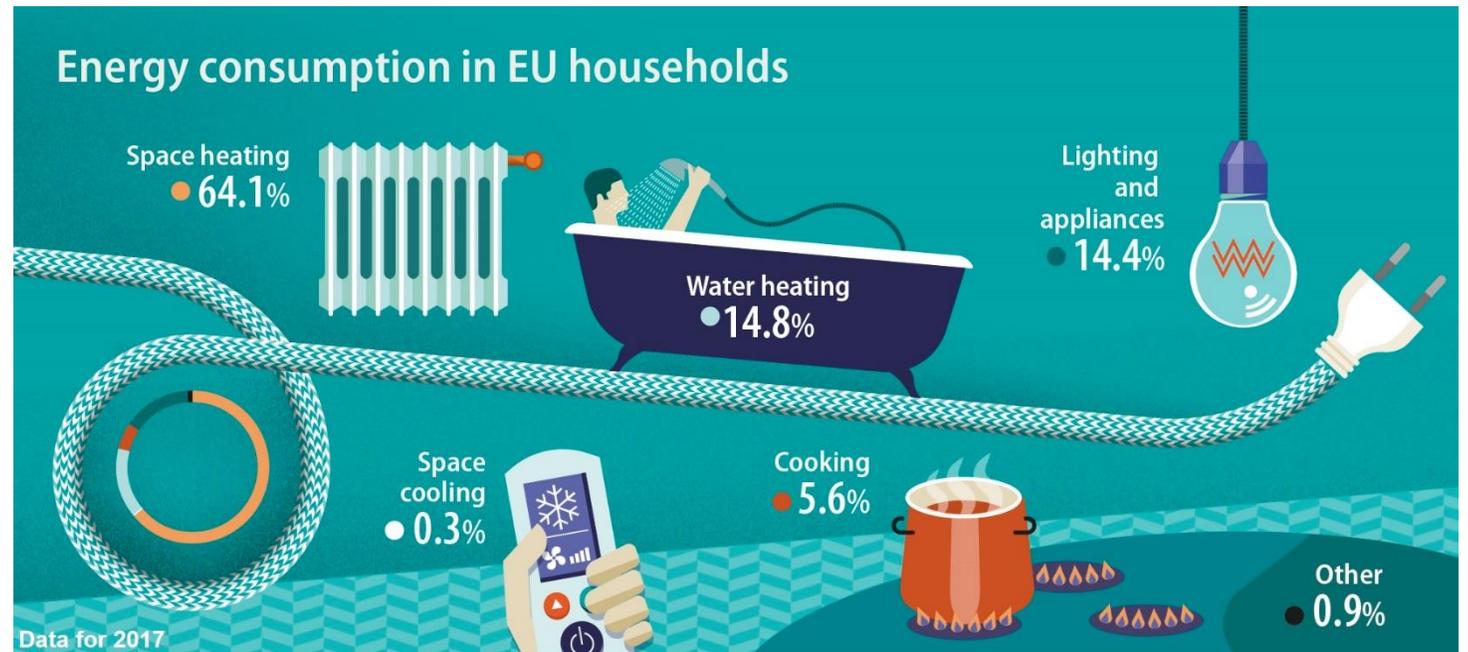
Image: <https://footprint2africa.com>

Household Energy Consumption (EU)

- Heating a major role in cold climate countries
- Cooling has a higher share in hot climate countries and global south
- Electricity use growing

With digitalization

- Energy use declining with energy efficiency and modern equipment



ec.europa.eu/eurostat

Energy and Development

- Energy use directly linked with human development index
- HDI is based on:
 - life expectancy
 - education
 - income
- UN Sustainable Development Goal No. 7

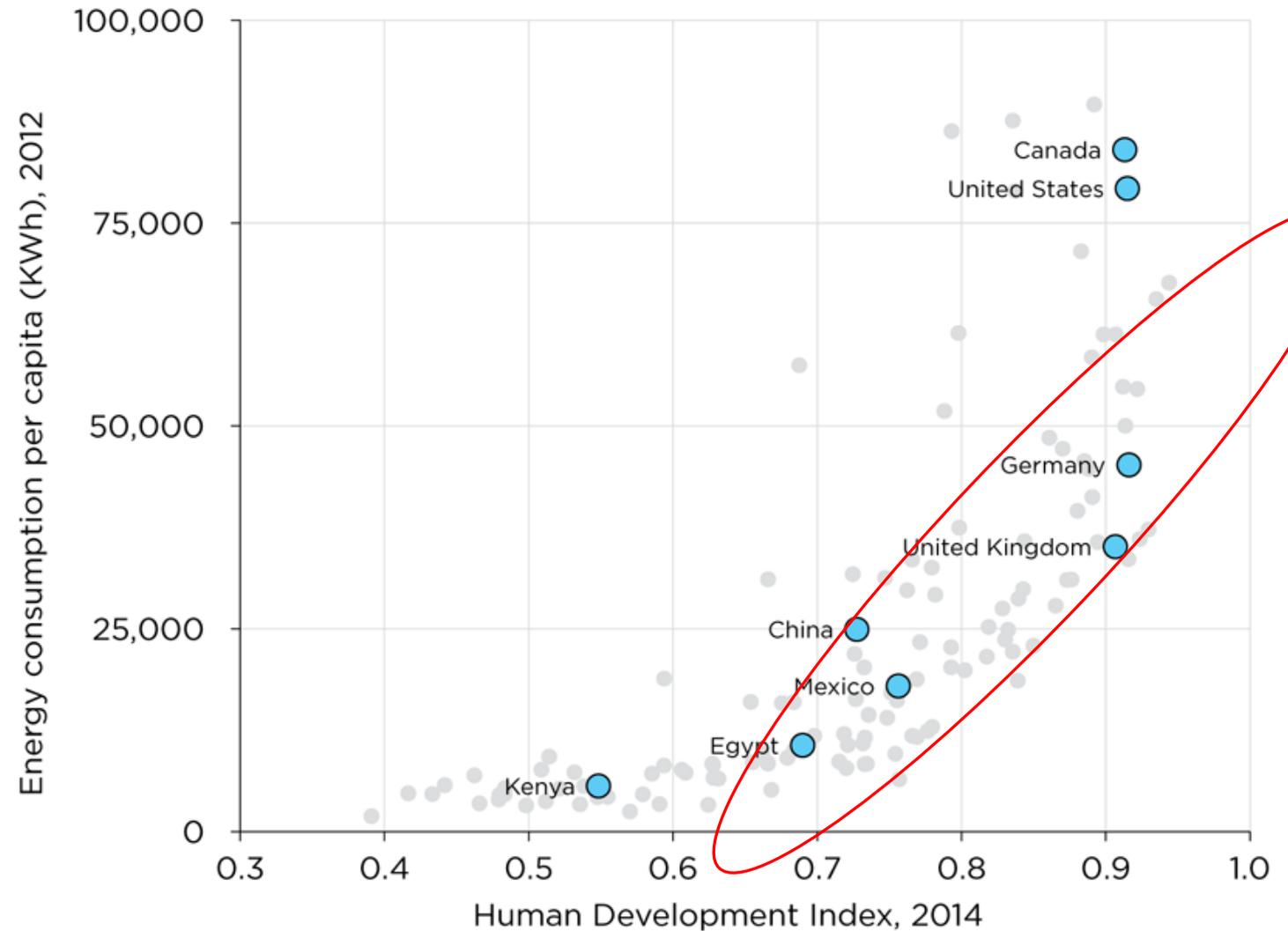


Image: <https://ourrenewablefuture.com>

Energy and Economy

- Energy use is positively correlated with GDP
(GDP: gross domestic product)
- Energy is driver of industry
 - Steel, aluminium and cement
 - Road and construction

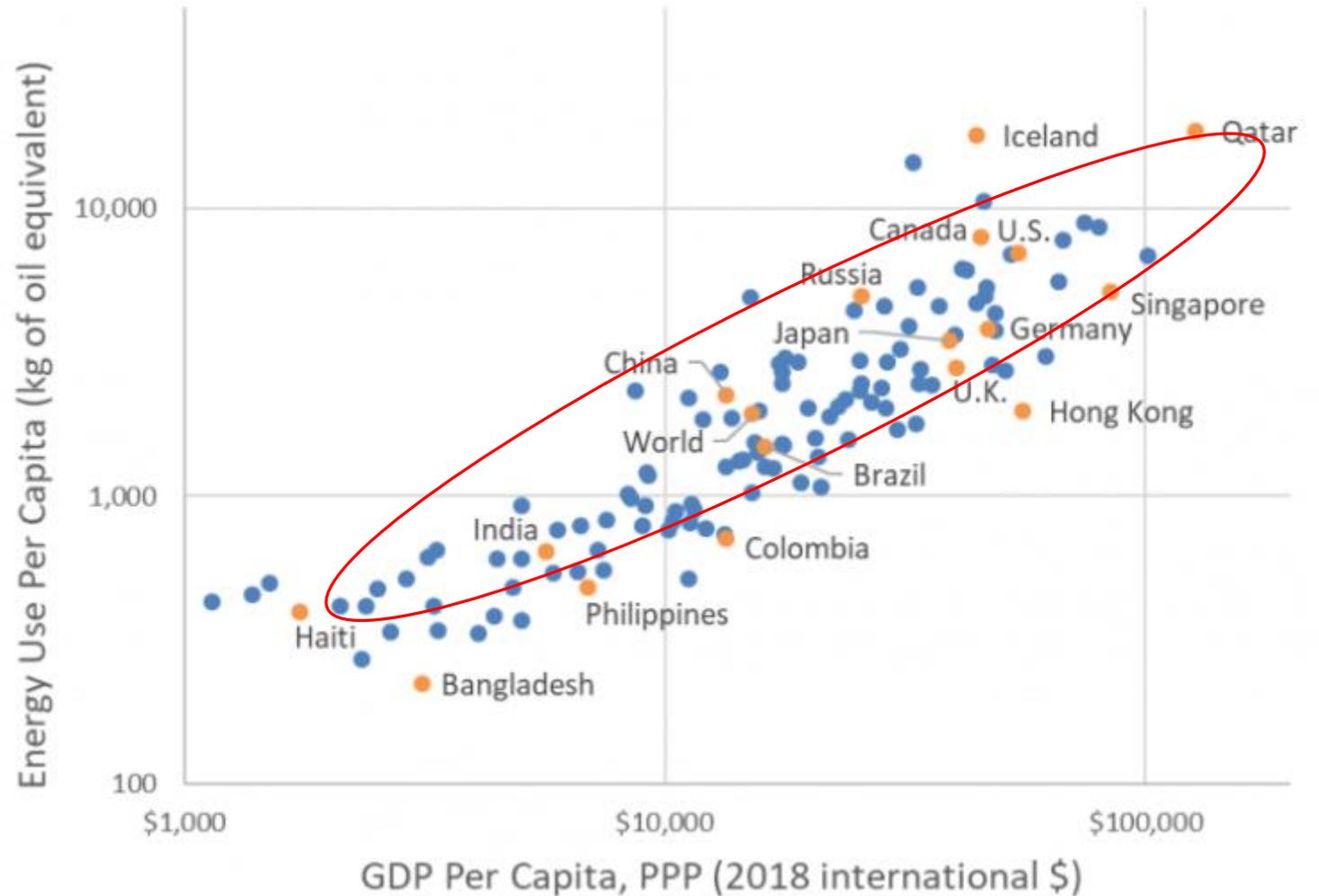


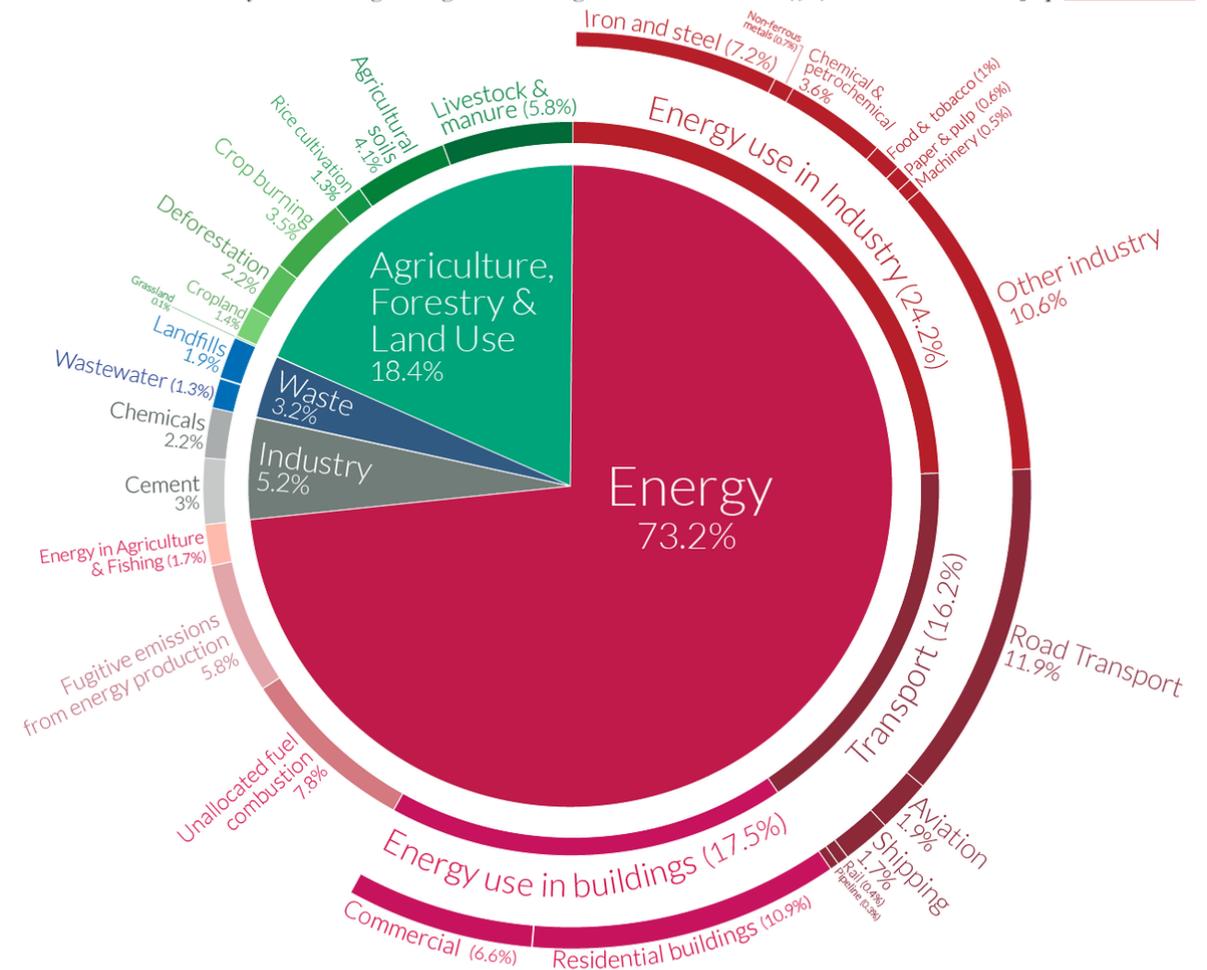
Image: <https://lifepowered.org/>

Energy and Climate Change

Energy is responsible for 73% of GHGs
(GHG: greenhouse gases)

- Energy use in industry 24%
- Energy for transportation 16%
- Energy use in buildings 17.5%

Global greenhouse gas emissions by sector
This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO₂eq.



OurWorldinData.org – Research and data to make progress against the world's largest problems.
Source: Climate Watch, the World Resources Institute (2020). Licensed under CC-BY by the author Hannah Ritchie (2020).

Energy Consumption History

- World primary energy use
- Today 6 times higher than 1950
- Transitions between fuels
- Huge dependence on fossil fuels

(cf. Austria's primary energy use 1.4 EJ)

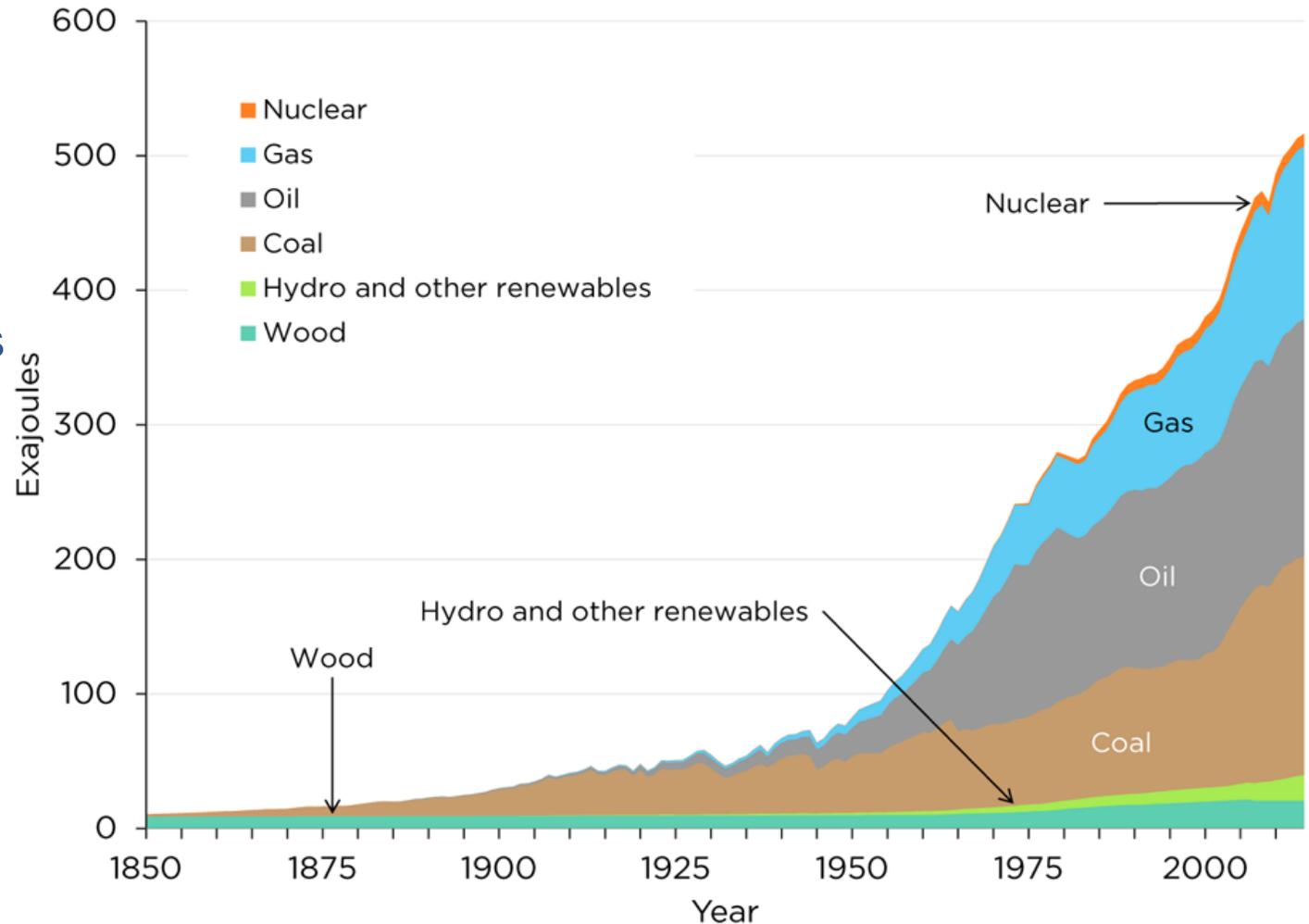


Image: <http://ourrenewablefuture.org/>

World Energy Mix

- World primary energy mix in 2015:

82% fossil

13% renewables of which,

Less than 1% solar and wind

Oil remains the backbone of energy mix, mainly for transportation

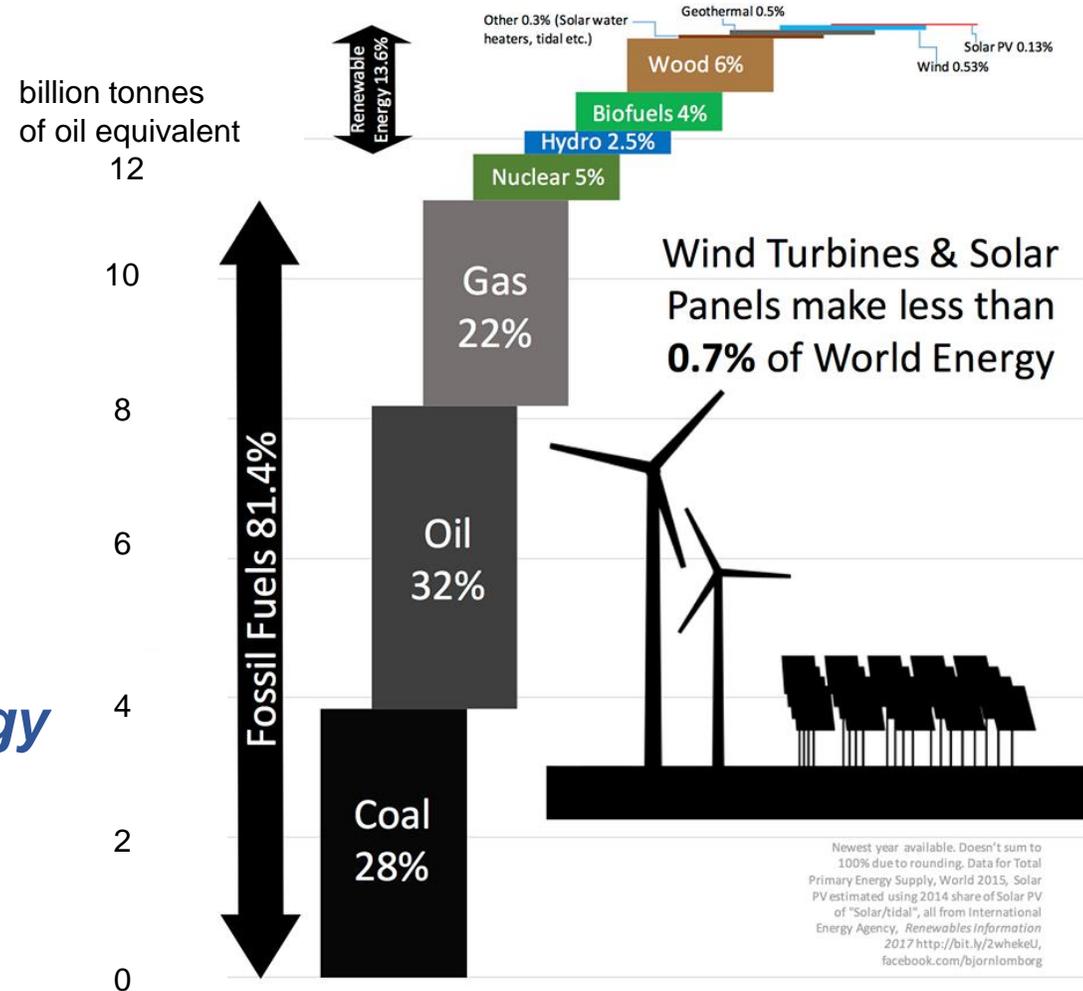


Image: <http://electricityasia.wordpress.com/>

How much resources are left?

Resources:

3000 years coal

233 years gas

178 years oil

Reserves:

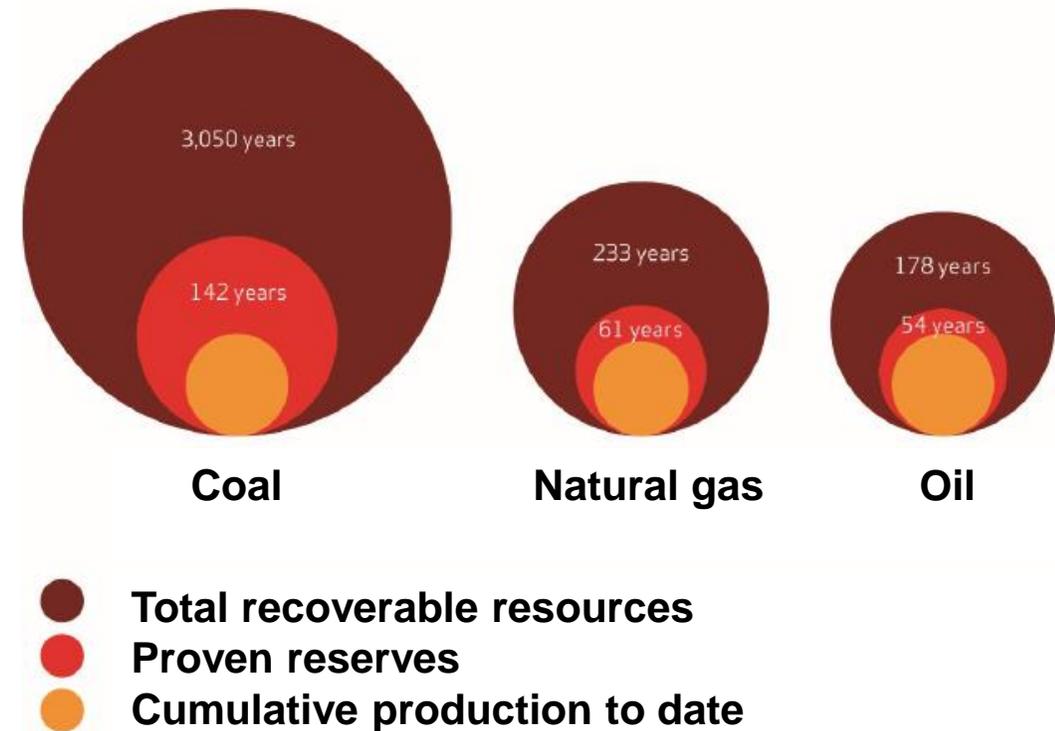
142 years coal

61 years gas

54 years oil

(when is “peak oil”?)

Fossil fuel resources by type



Source: IEA World Energy Outlook 2013

Question?

- Form groups of 3-4 students
- ***Discuss in your group:***
 - What are main energy resources in your country?
 - Is your country a net energy importing or energy exporting country?
 - What are the main energy resources for heating and cooking at your home?

Energy Markets

- **Energy market:** “An actual or nominal place where buyers and sellers interact to trade energy commodities.”
- Energy markets, such as oil, gas, and coal markets –
Buyers (they demand that commodity)
Suppliers (they supply that resource)
- **Market price (such as oil price):**
is defined by the market equilibrium

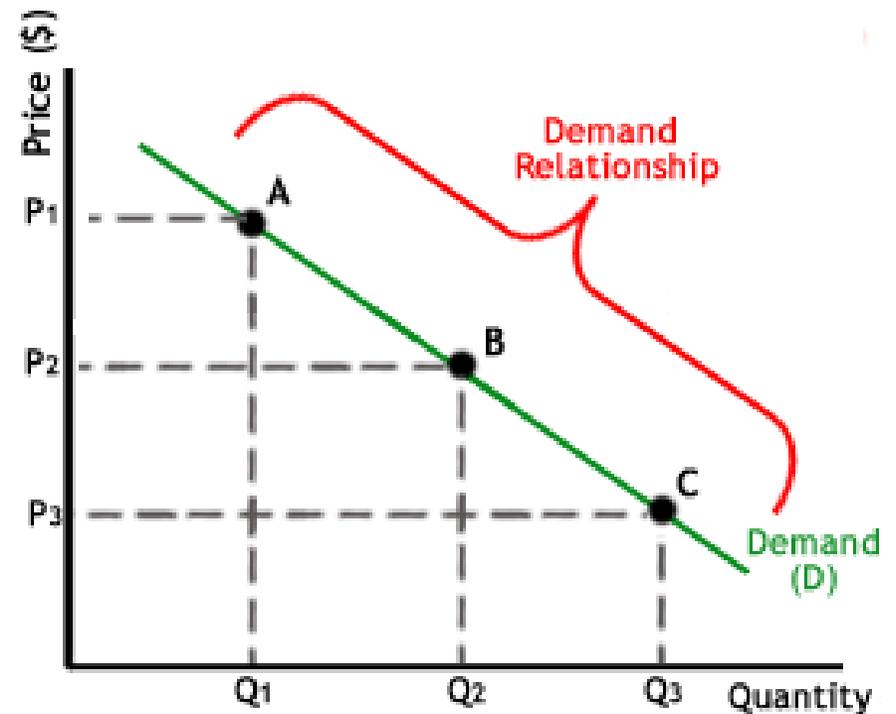


Image: <https://politico.com>

Supply and Demand

- **Demand curve:**
relationship between demanded commodity and price
- The higher the price,
the less willingness to buy

How much are you willing to pay for a bottle of water?



Supply and Demand (2)

- **Supply curve:**
relationship between supplied commodity and price
- The higher the price,
the more supply of the commodity

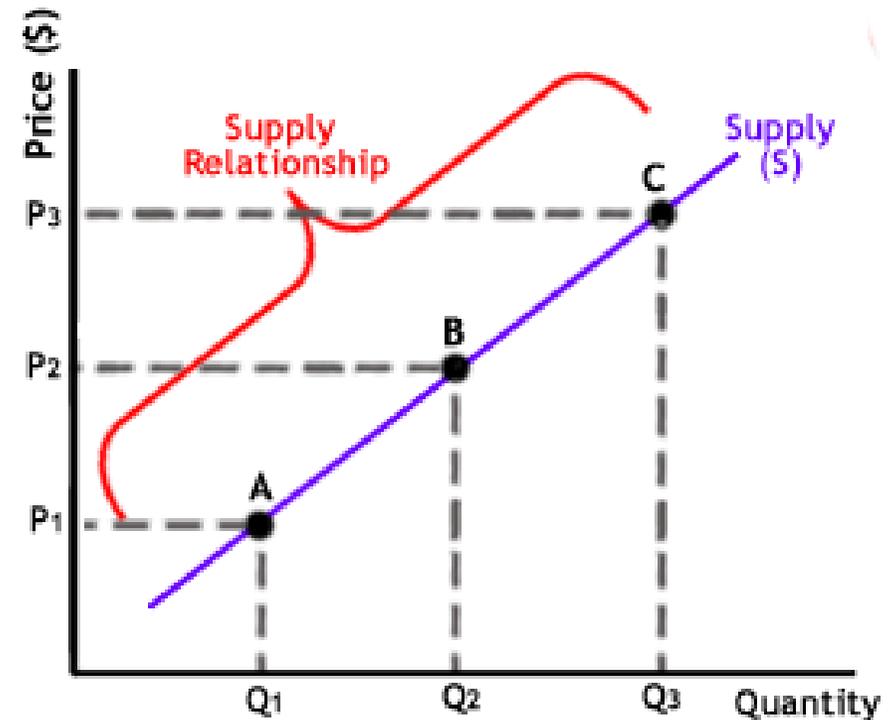
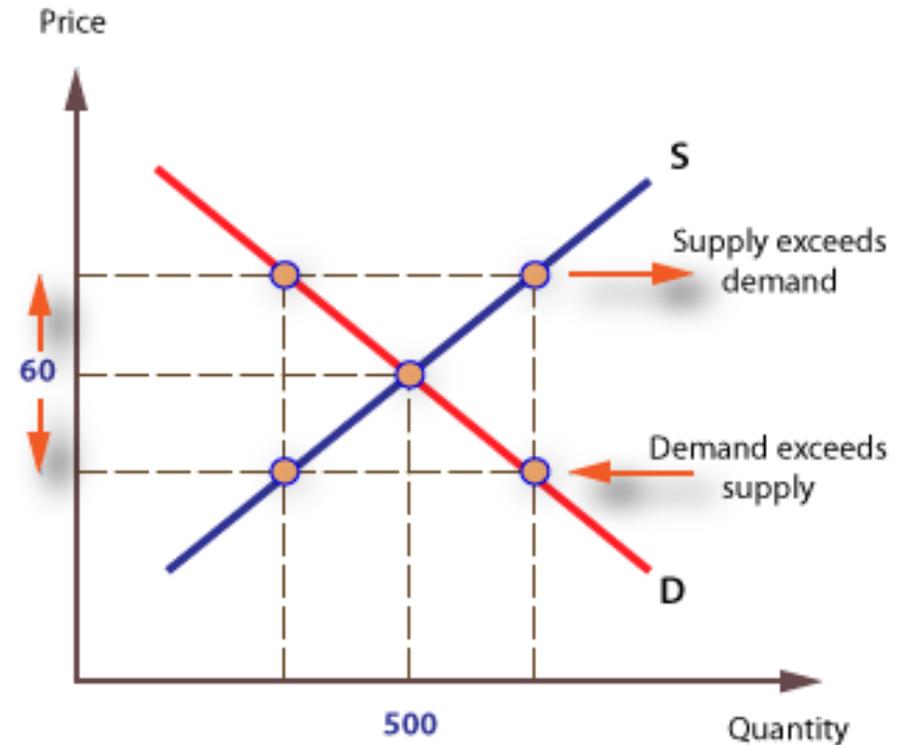
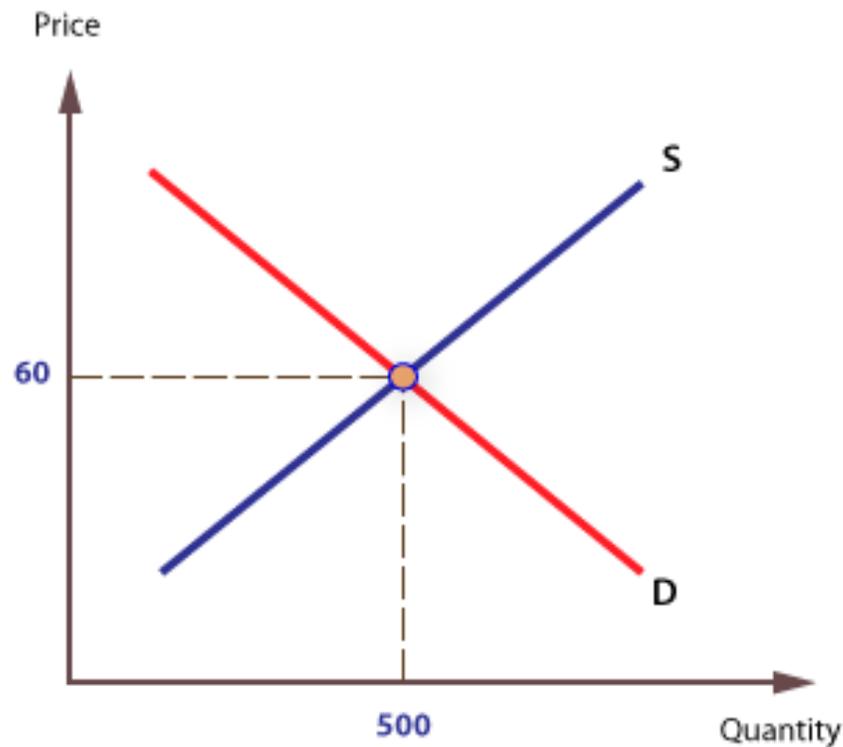


Image: <https://investopedia.com>

Market Equilibrium

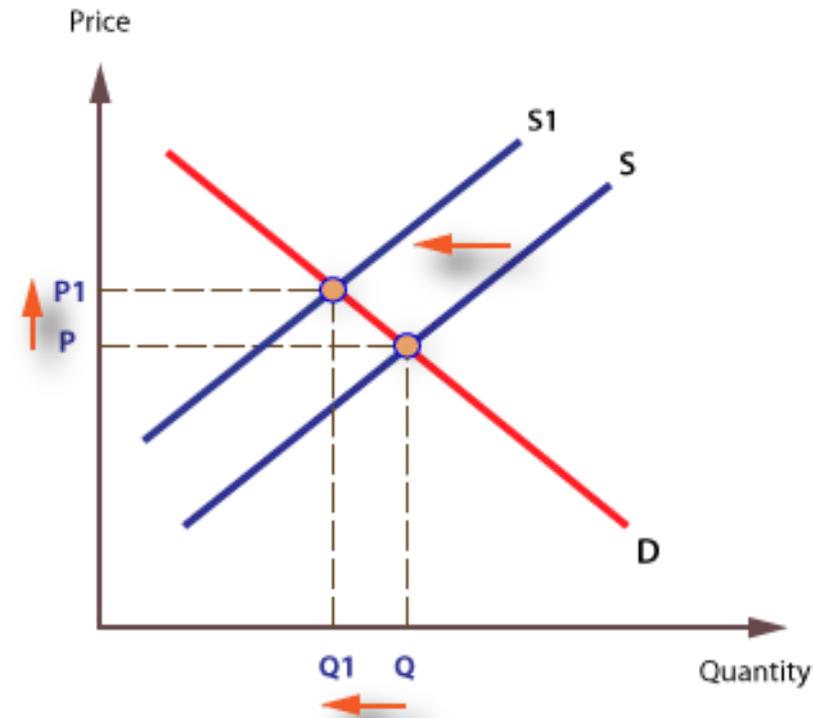
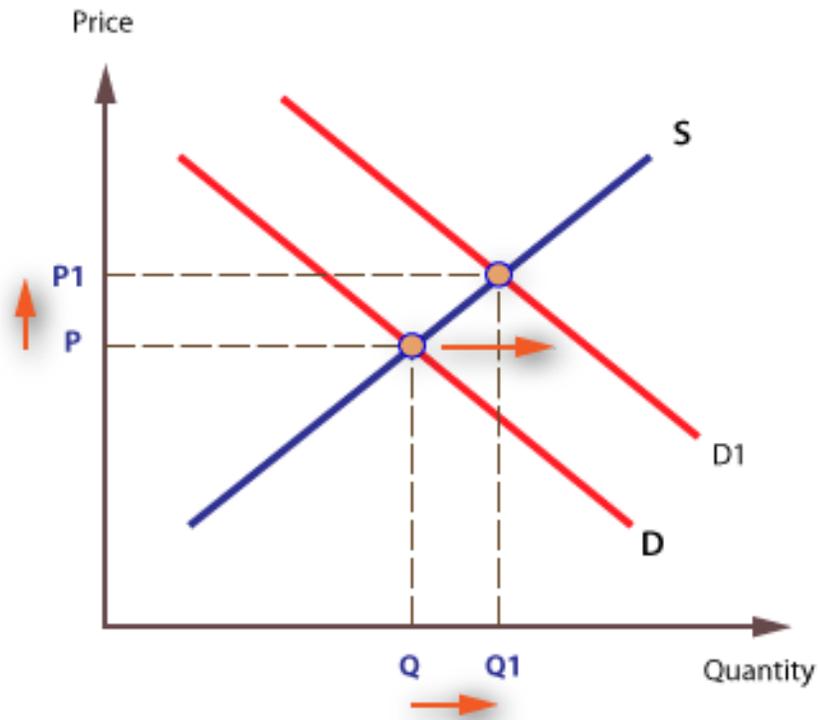
- When supply and demand cross each other = balance
- Price becomes stable (market price)



Images: <https://www.economicsonline.co.uk>

Causes of Price Change

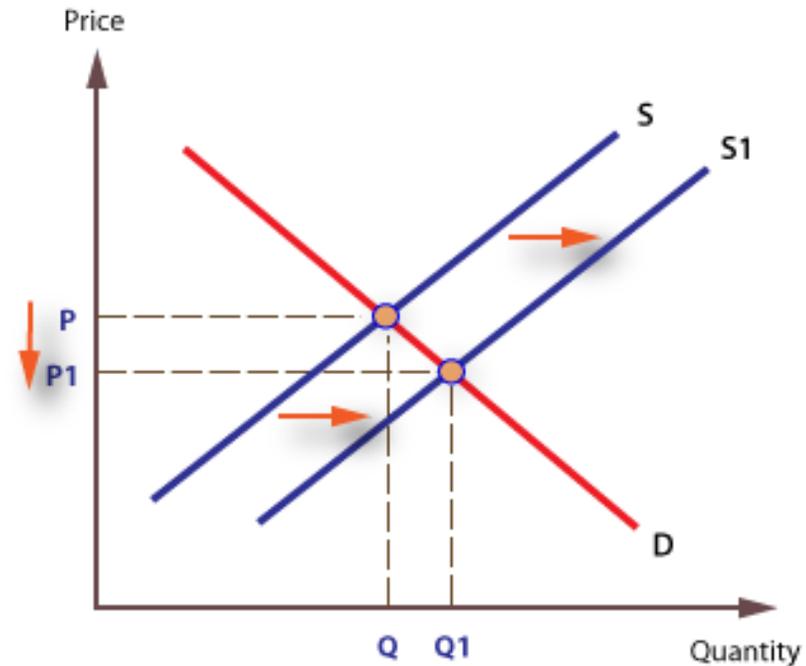
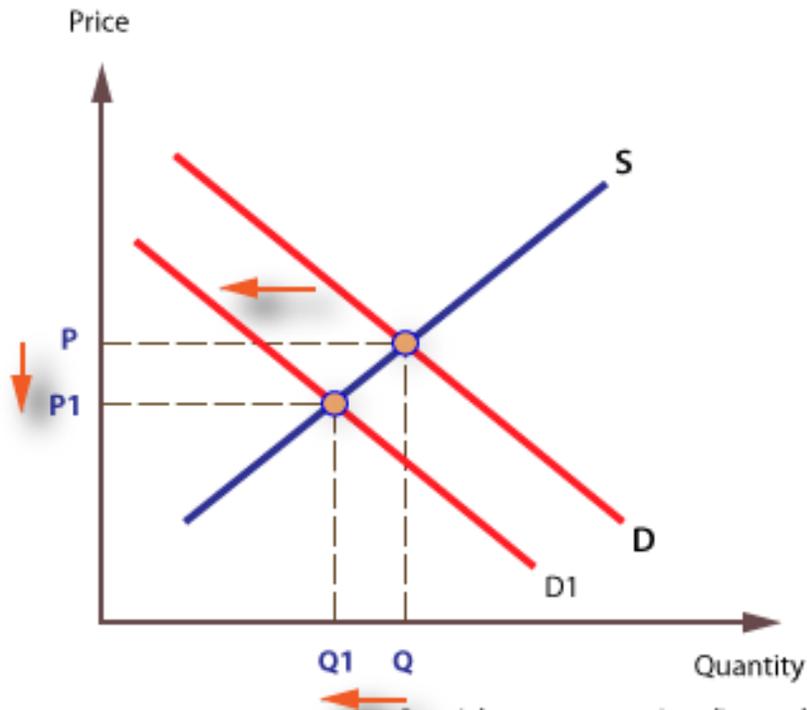
- An increase demand → **Price increase**
- A decrease in supply → **Price increase**



Images: <https://www.economicsonline.co.uk>

Causes of Price Change (2)

- A decrease in demand → Price decreases
- Increase in supply → Price decreases



Images: <https://www.economicsonline.co.uk>

Question?

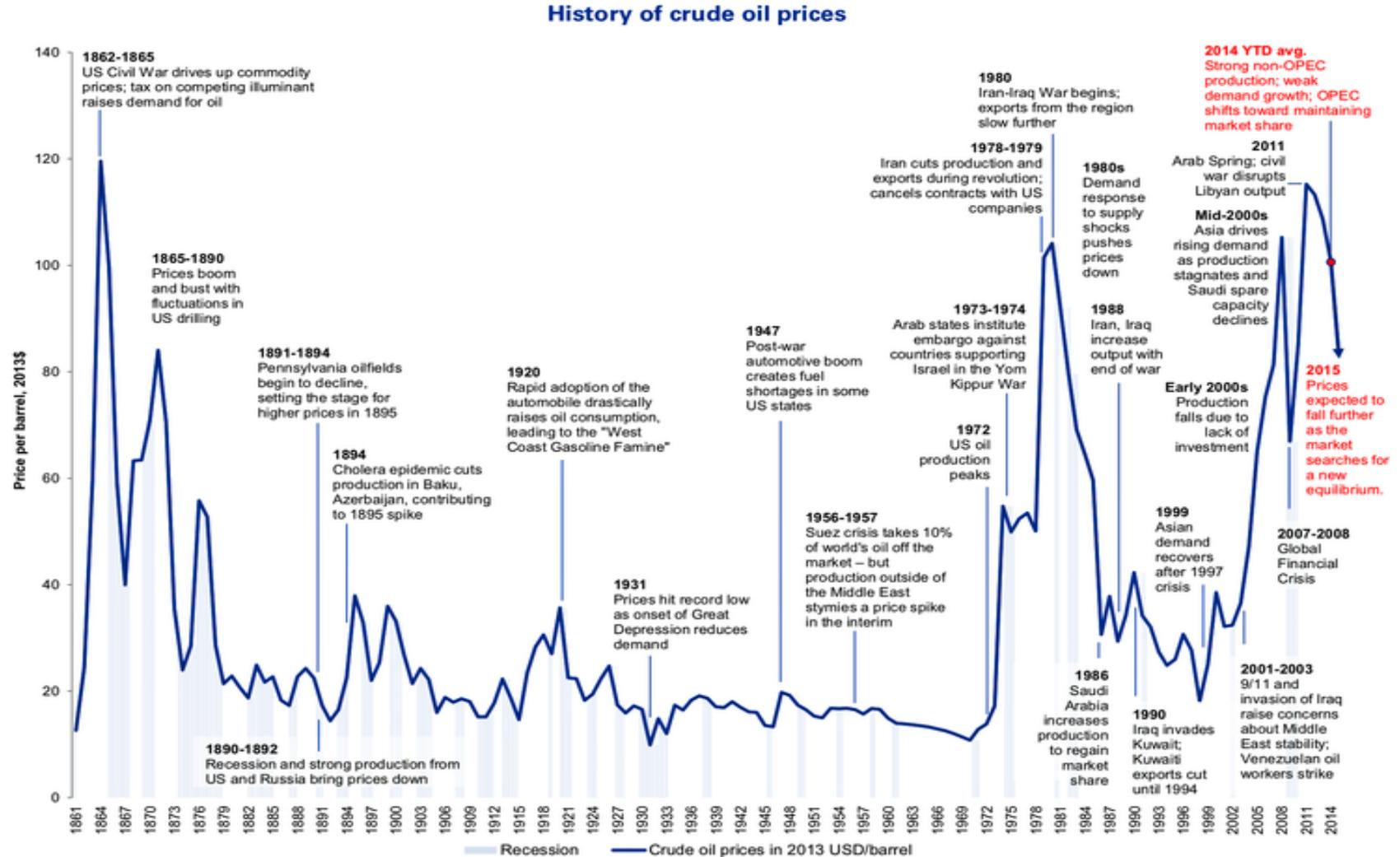
- What are the causes for the change in oil prices?

Oil Prices

- Influence of big suppliers, e.g., OPEC (40% of oil reserves)
- Oil trade is based on “future contracts” → Risk of future events
- Demand for oil and oil products (mainly driven by industry and transport)
- Risks related to geopolitical conflicts (wars, sanctions, bans)
- Accidents, natural disasters and disruptions in oil supply (e.g., BP Deepwater Horizon spill in Gulf of Mexico, Suez Canal blockage)
- Production cost and technology improvements

History of Oil Prices

- Conflicts in the Middle East
- Economic Recession



Note: 2014 YTD average price is as of December 8, 2014.

Source for data: BP, NBER/Federal Reserve Bank of St. Louis.

Source for annotations: Hamilton, James, "Historical Oil Shocks," University of California, San Diego; various news sources; Goldman Sachs Global Investment Research.

Image: <https://businessinsider.com>

Fossil Fuel Reserves vs. Resources

- Reserves:**

”we can use them,
they are there,
they are economically proven”

- Resources:**

”we know they are there, or
They probably are there, or
They maybe are there”

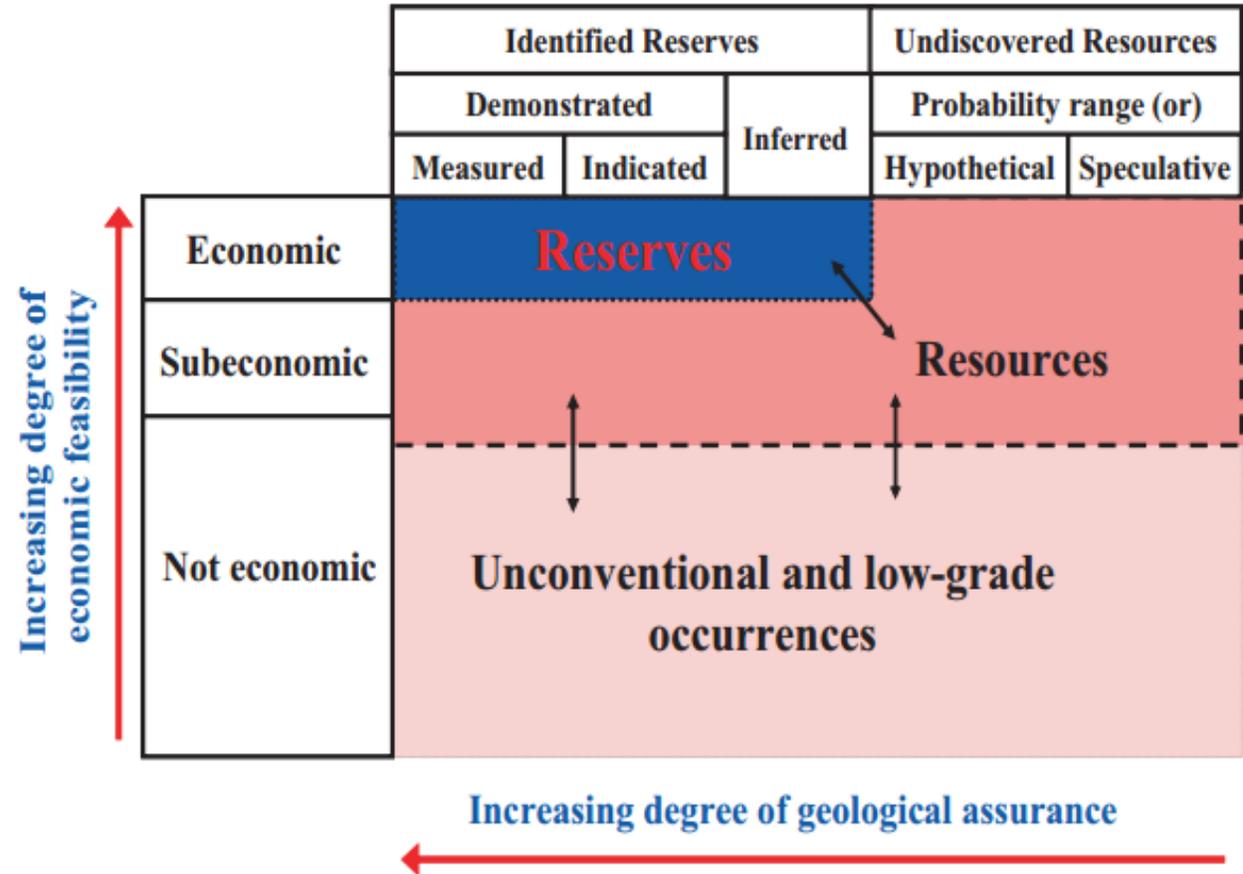


Figure 7.1 | Principles of resource classification. Source: McKelvey, 1967.

Conventional vs. Unconventional Energy Resources

- Economic feasibility of extraction
- Shale oil and shale gas boom, especially in US
- Until 10 years ago, gas estimated to remain only for 40 years, but now?

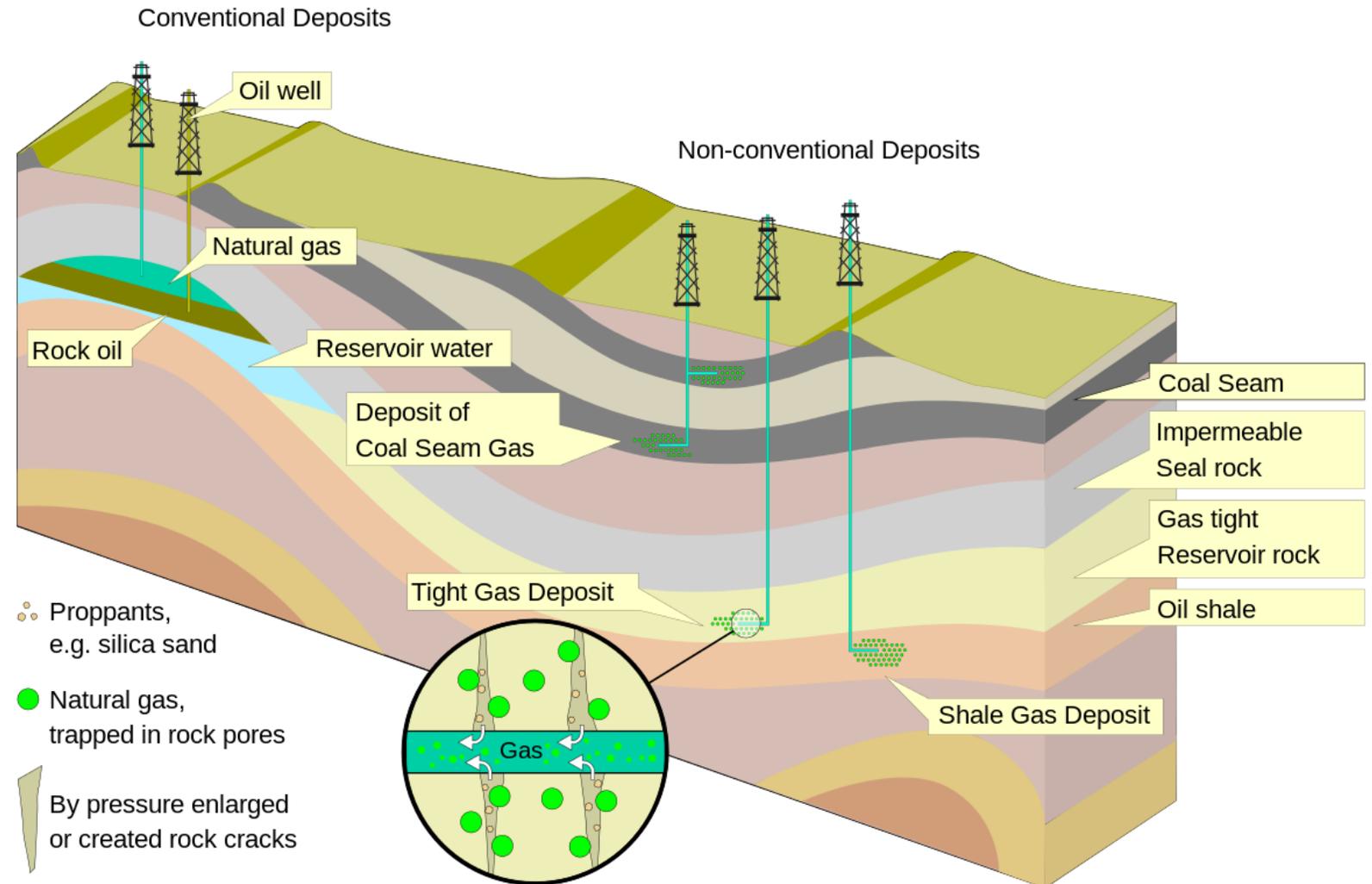


Image: <https://sv.Wikipedia.org>

Oil Supply Cost Curve

- From cheapest ones in the Middle East to the most expensive ones (tight oil and oil sands) in North America

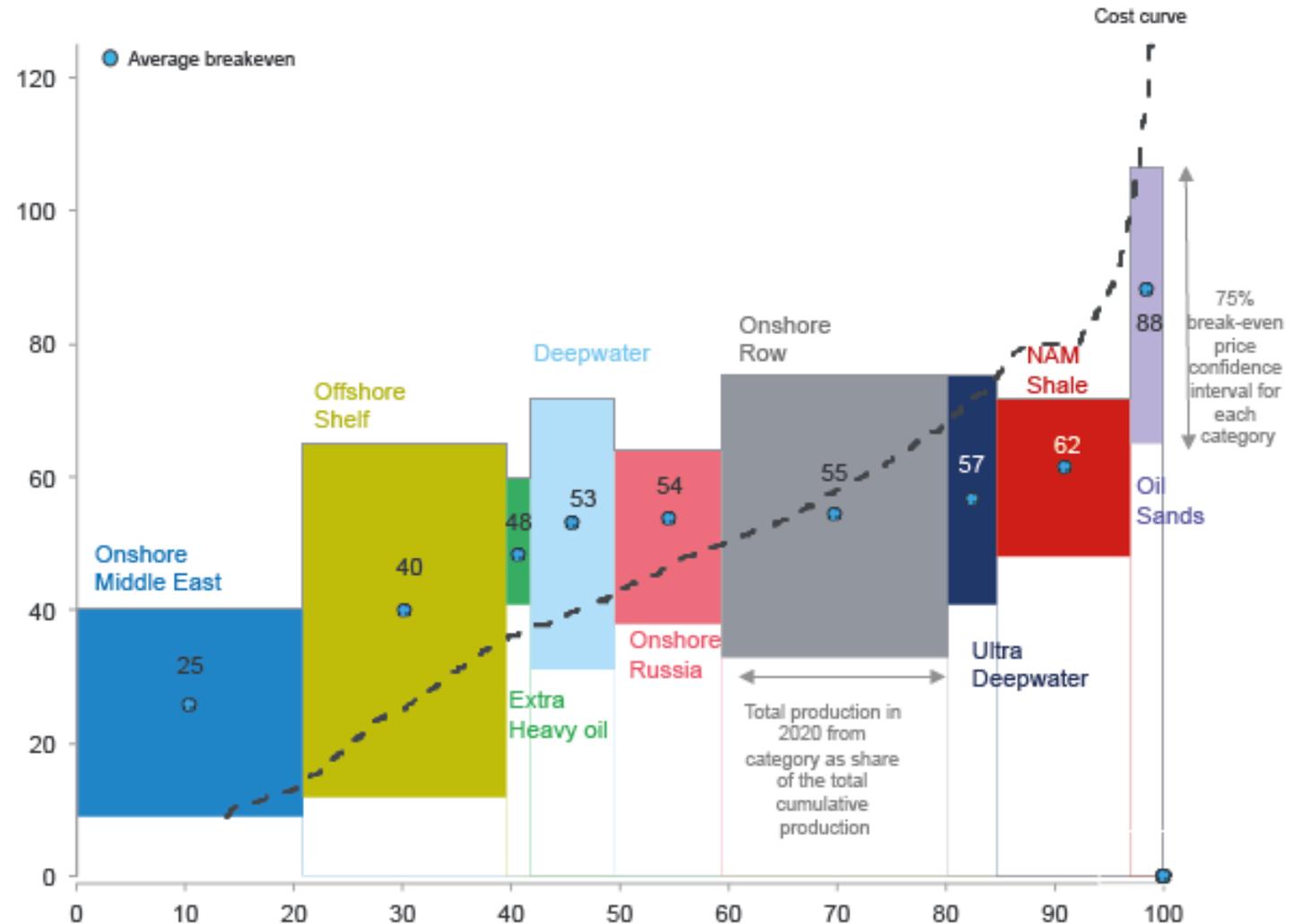
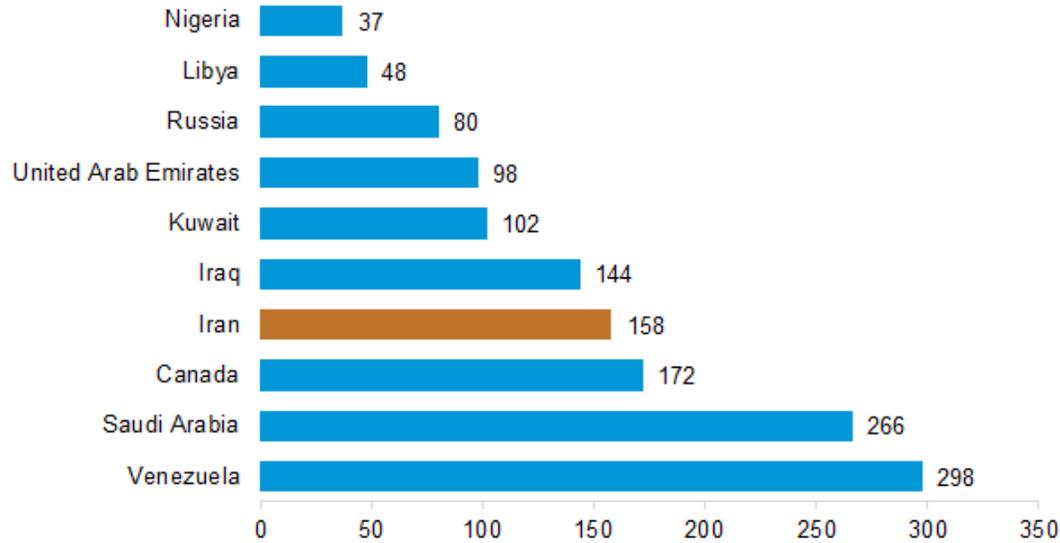


Image: <https://ourrenewableenergy.com>

Proved Oil Reserves Worldwide

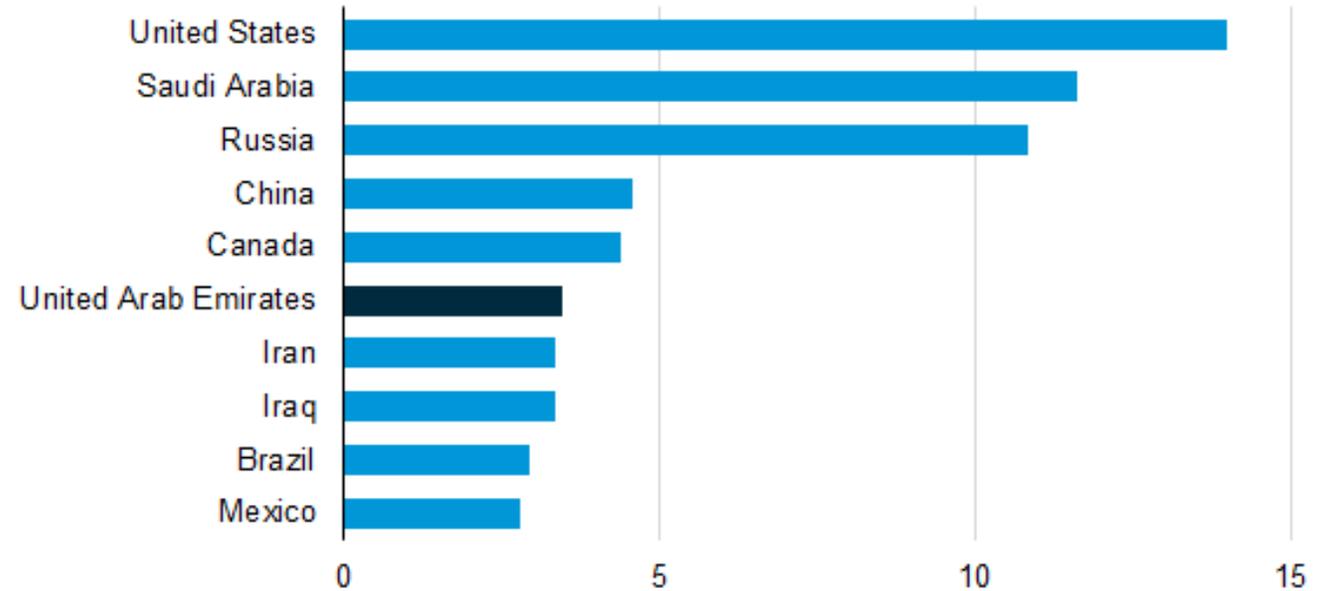
Largest proved reserve holders of crude oil

billion barrels



Top 10 global oil producers (2014)

million barrels per day



Source: *Oil & Gas Journal*, January 2015.



Energy Density and Transportation

• Oil: Energy dense per mass and volume → Transport by ship and train

Coal: ship and train

Natural gas: low energy density per volume → Needs to be pipelined or pressurized (LNG)

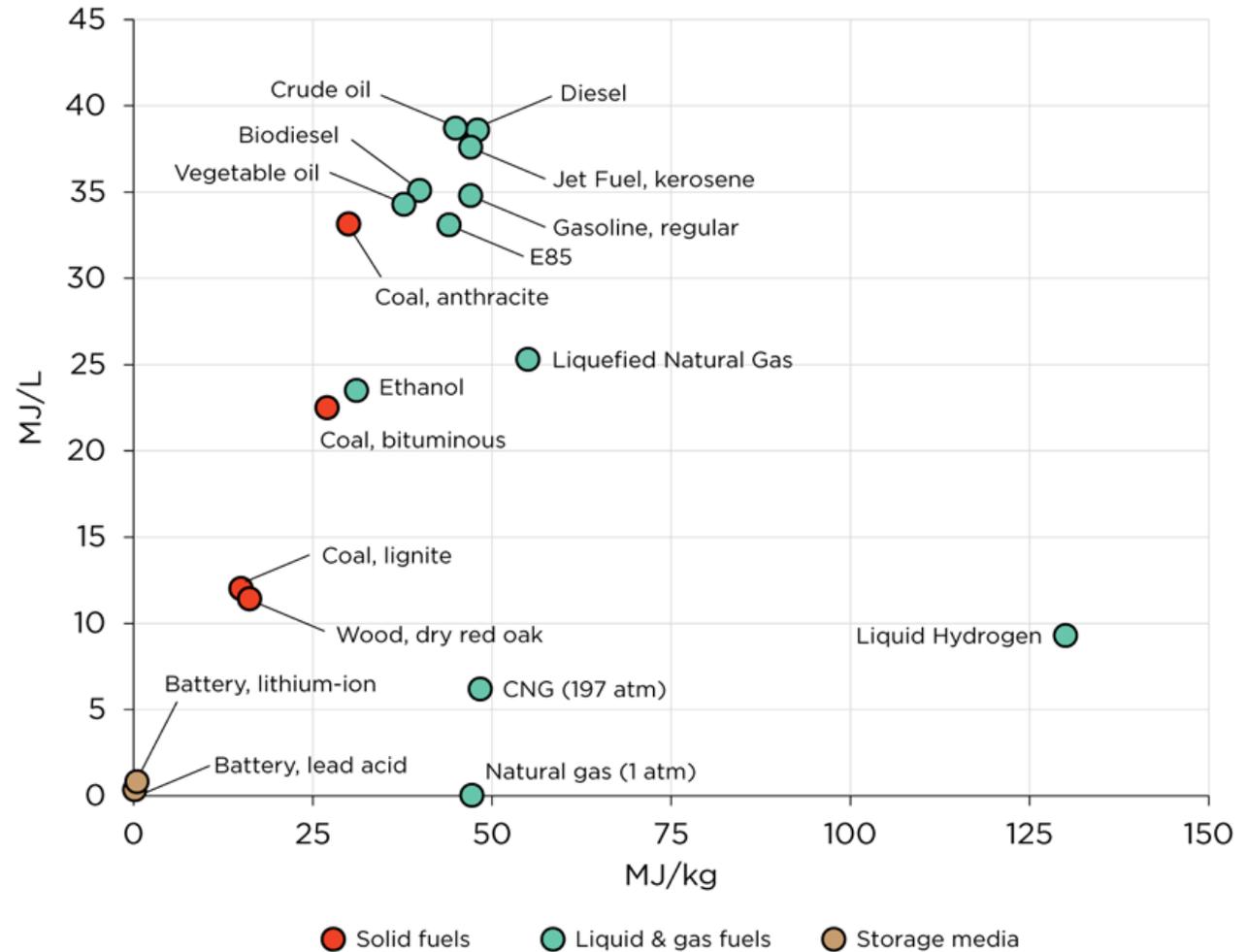


Image: <https://ourrenewablfuture.com>

Coal Reserves Worldwide

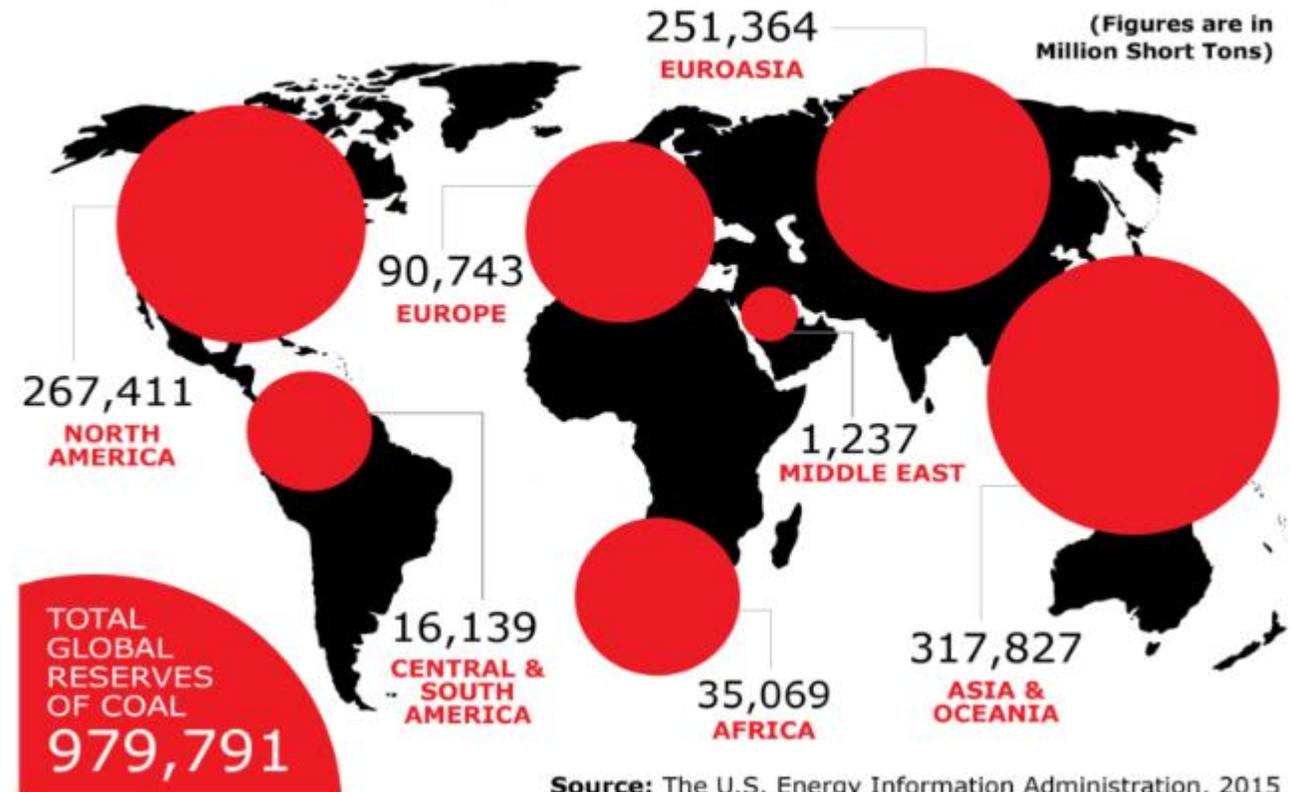
- Coal reserves are abundant
- Distributed around the world
- The cheapest fossil fuel
- Rather stable prices
- The most polluting and CO2 emitting fuel

WORLD COAL RESERVES BY REGION

Coal reserves are available in almost every country. The biggest reserves are in the Asia & Oceania region.



(Figures are in Million Short Tons)



Source: The U.S. Energy Information Administration, 2015

Coal Production

- Coal responsible for 40% of electricity worldwide
- China the biggest producer and consumer of coal

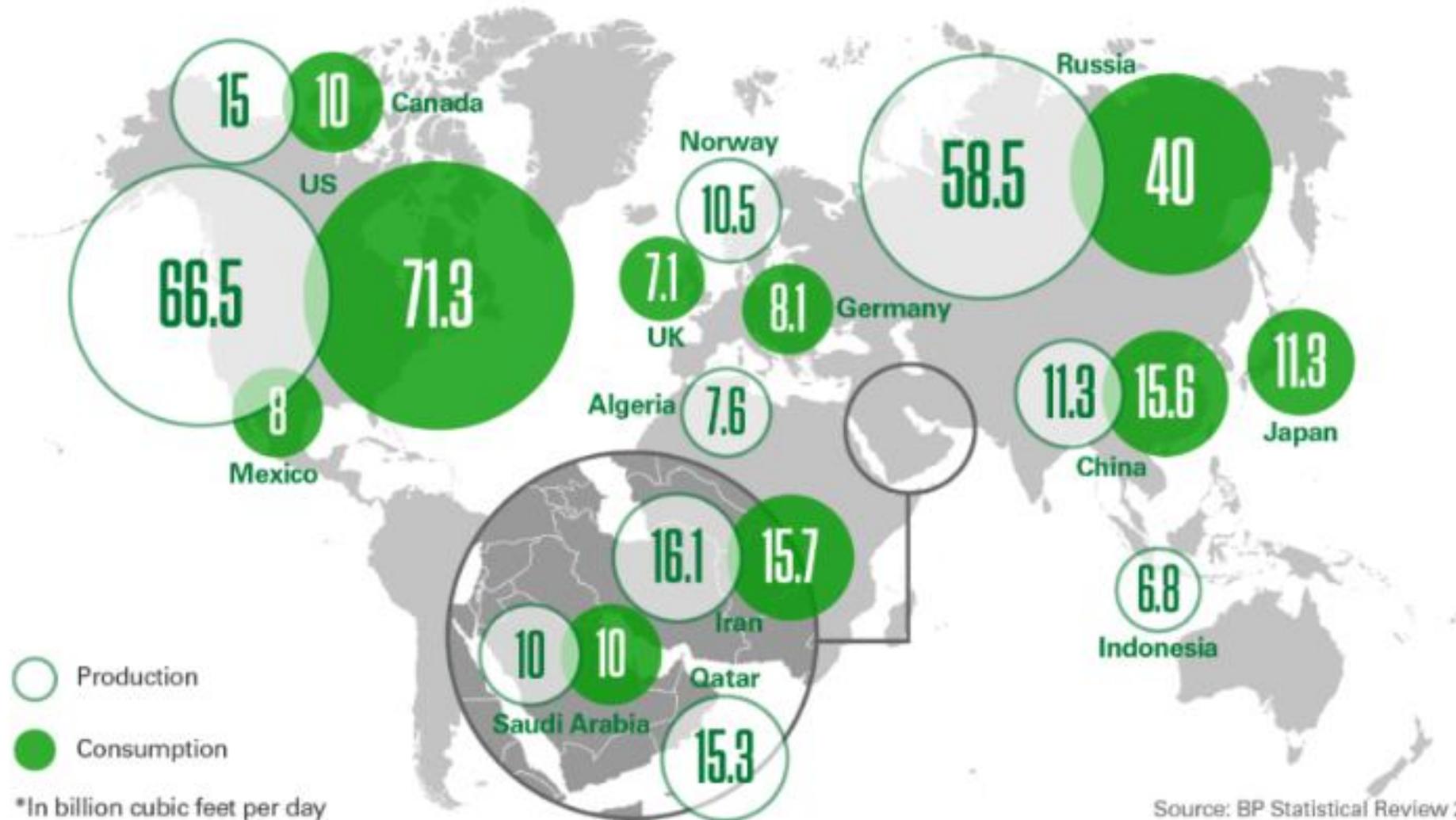
TOP COAL PRODUCING COUNTRIES

Coal is the world's largest source of electricity, accounting for around 40% of global electricity production. And China firmly holds the first place among coal producing countries.



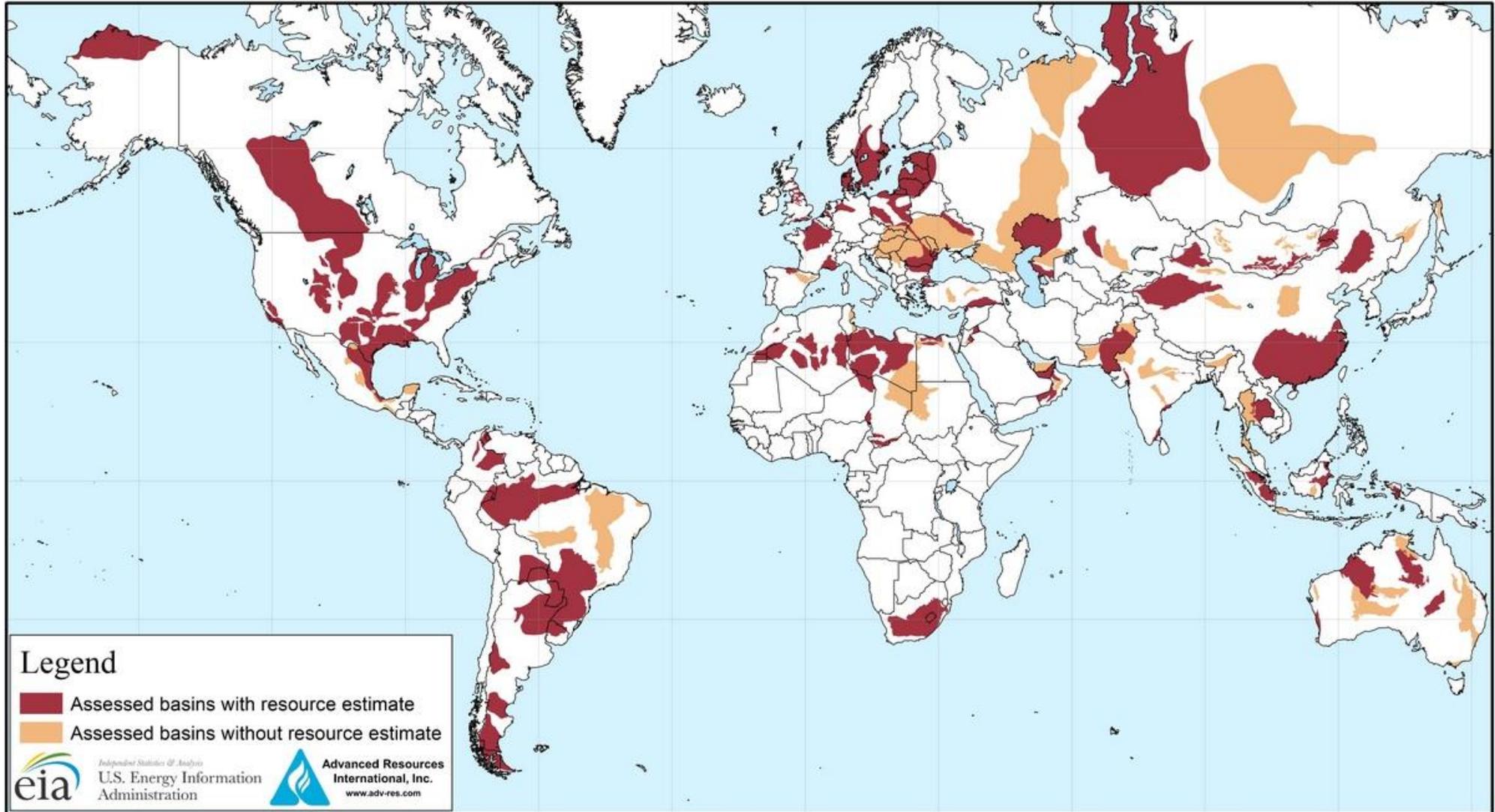
Source: World Energy Council, 2015

Gas Production and Consumption



Source: BP Statistical Review 2014

World Shale Resources

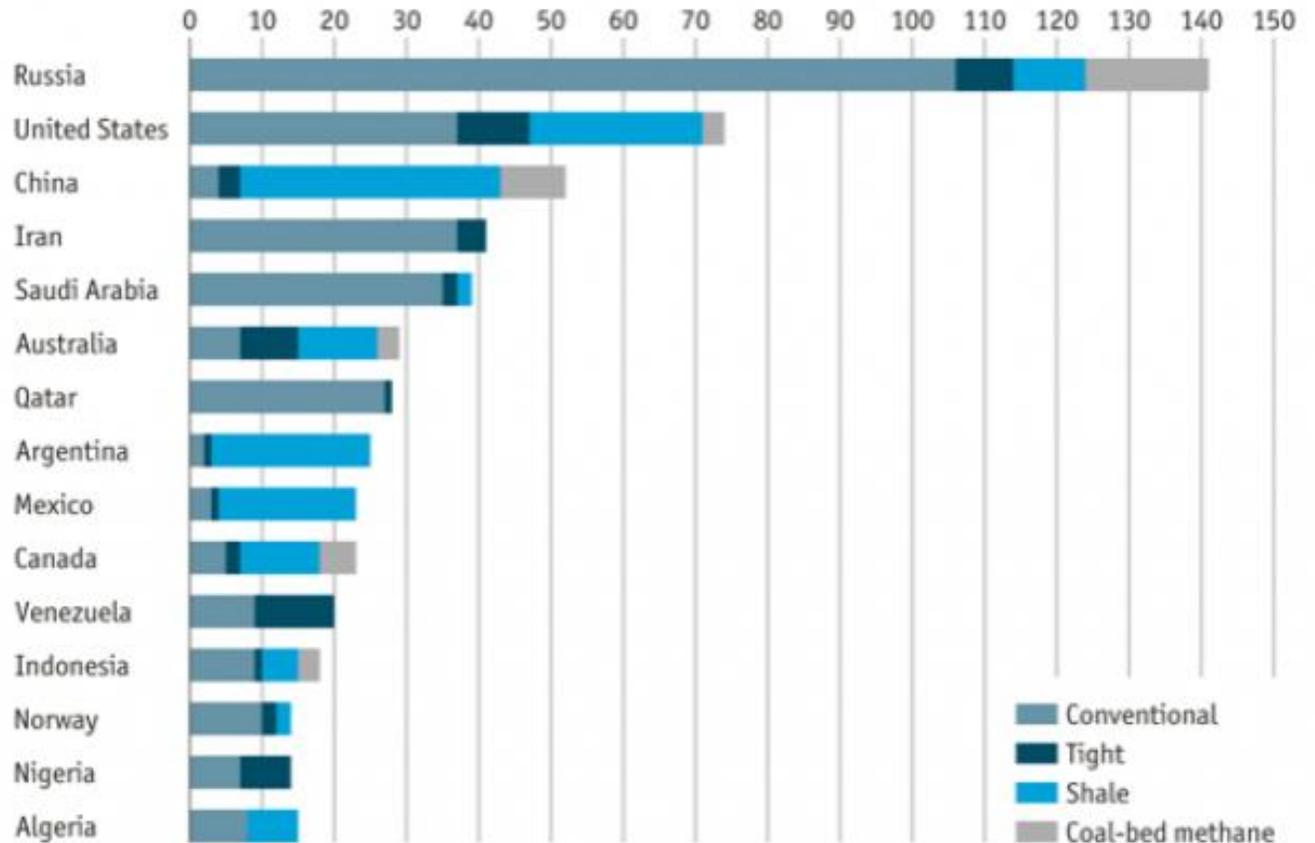


Gas Reserves Worldwide

- US shale gas boom
- Fracking technology, risk of water pollution
- Gas price in US fell down more gas production, less gas import, less coal use

Recoverable natural-gas reserves

2011, trn cubic metres

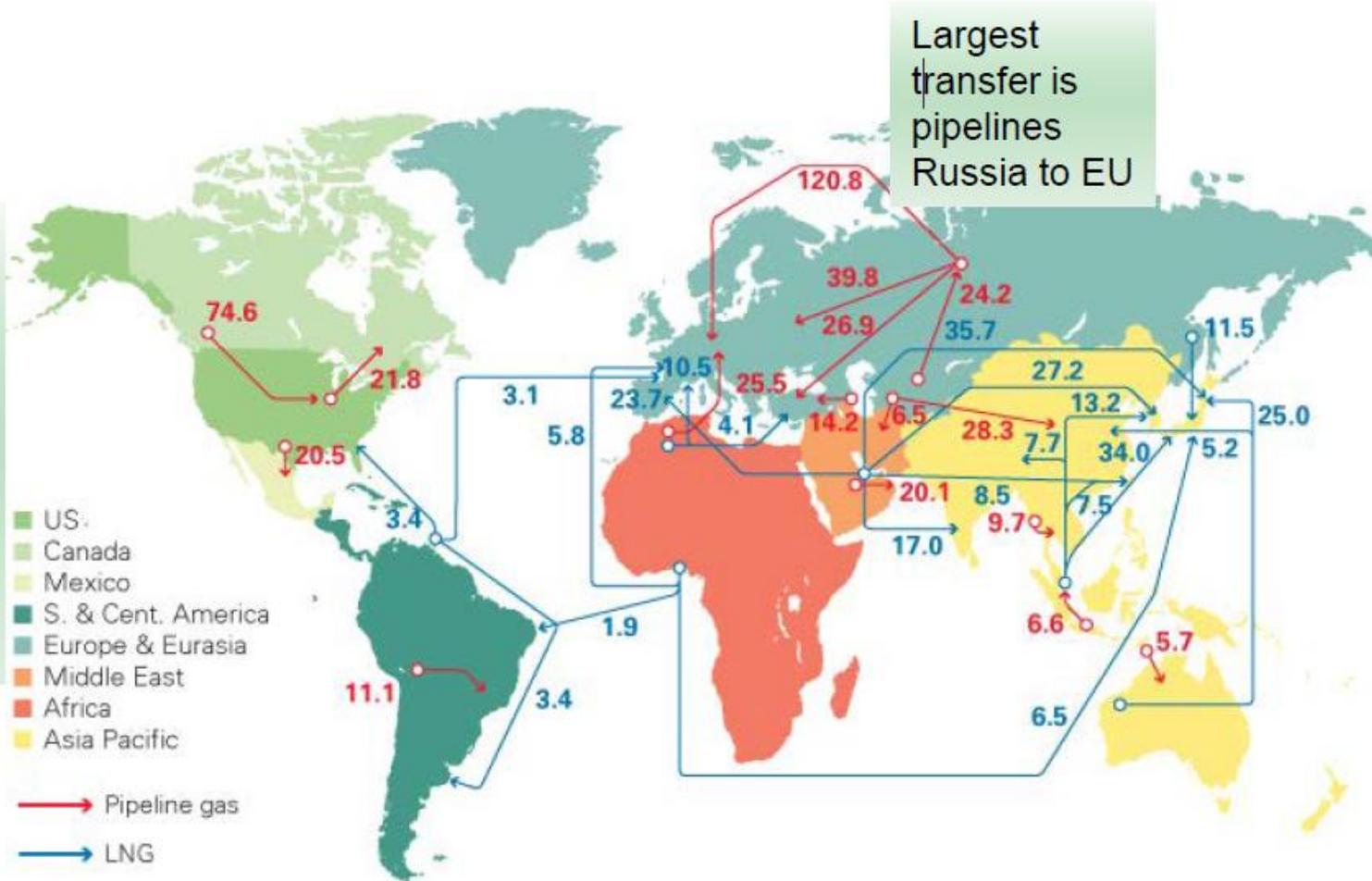


Source: IEA

Gas Transfer Worldwide

Gas trade to US has been decreasing due to shale gas boom

But Canada to US still a large transfer



Largest transfer is pipelines Russia to EU

LNG is rising, Japan has historically been largest importer; no pipelines, little domestic fuel, and now very little nuclear running post-Fukushima!

But look at China too!

Source: Includes data from Cedigaz, CISStat, FGE MENAgas service, HS Waterhorne, Wood Mackenzie, PIRA Energy Group.

Natural Gas

- Gas is mostly traded in pipelines and storage is often difficult.
- LNG transportation (by ships) is expensive but brings access to new markets.
- Gas is usually traded in regional markets and with bilateral contracts (like Europe).
- Gas price is usually indexed at least partly to other indicators, e.g. oil price.
- Markets, where LNG is a significant part of supply, are Great Britain, Spain, Portugal, East Asia, etc.
- In the EU, large consumers can mostly choose their gas provider.
- In the USA, there exists a more complex natural gas network, where gas can be traded more like electricity in Europe.

Further reading

- Global Energy Assessment

<https://iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/Home-GEA.en.html>

- Lee, Jungwoo, and Jae-Suk Yang. "Global energy transitions and political systems." *Renewable and Sustainable Energy Reviews* 115 (2019): 109370.

<https://doi.org/10.1016/j.rser.2019.109370>

- Bale, Catherine SE, Liz Varga, and Timothy J. Foxon. "Energy and complexity: New ways forward." *Applied Energy* 138 (2015): 150-159.

<https://doi.org/10.1016/j.apenergy.2014.10.057>

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- Thank you for your attention!

Dr. Behnam Zakeri

Research Scholar (Energy, Climate, and Environment Program)
International Institute for Applied Systems Analysis (IIASA)
Schlossplatz 1, A-2361 Laxenburg, Austria | www.iiasa.ac.at

Email: zakeri@iiasa.ac.at; Publications: [Google Scholar](#)

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