Energy Markets & Economics

Lecture 1: Introduction to the economics of power markets

Institute of Economic Studies
Charles University, Prague
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Energy Markets & Economics: Course Objective and Schedule

Course objective

Gain a good understanding of the power sector, with a focus on theoretical concepts and the practical application of economic concepts to power markets.

Source schedule:

In total there are eight lectures (no seminars).

- Wednesday 5 June, 2024: (2 sessions in total): one morning sessions (11:00 - 12:30), one afternoon session (14:00 - 15:30)
- Thursday 6 June, 2024: (3 sessions in total): two morning sessions (9-10:30 a 11:00 - 12:30), one afternoon session (14:00 - 15:30)
- Friday 7 June, 2024: (3 sessions in total): two morning sessions (9-10:30 a 11:00 - 12:30), one afternoon session (14:00 - 15:30)

**Please note that the form of lecture delivery could be changed depending on the epidemiological situation*

Energy Markets & Economics: Lecture Overview

- **Lecture 1** (Wednesday): Introduction to the economics of the power sector (supply and demand for power, structure of the industry - generation, transmission and distribution, retail supply);
- **Lecture 2** (Wednesday): Possible models for organising the power sector, technical characteristics that affect that choice and sector liberalisation;
- **Lecture 3** (Thursday): Need for regulation and current approaches to regulation and related concepts (cost plus or rate of return, price cap vs revenue cap, RIIO, concept of RAB, etc.);
- **Lecture 4** (Thursday): Wholesale trade, including energy only markets and capacity markets, and competition issues;
- **Lecture 5** (Thursday): Investment decision making in generation and transmission;
- **Lecture 6** (Friday): CO_2 emissions and decarbonisation policy instruments (energy efficiency);
- **Lecture 7** (Friday): Other decarbonisation policy instruments (EU ETS, and support for renewable energy); and
- **Lecture 8** (Friday): Retail supply, retail competition and pricing (including concepts of long run and short run marginal costs, average costs and market failures related to information).

Energy Markets & Economics: Course Requirements

Requirements

Course participation.

The final grade is based on a final written exam that will be held on Friday 21st of June (i.e., you'll have two weeks to prepare for the final exam after the lectures are finished).

Grading

You are required to get at least 51% in your final exam in order to successfully pass the course. The course is not graded (only pass / fail). If you pass the course, you'll be accredited with 3 credits towards your studies. However, when grading the exam, we will assess your overall performance and provide you with a total score achieved (anywhere between zero to 100 percent). This information will be just for you, as in the system only a pass / fail mark will be inserted.

In order to achieve at least 51% from the final exam, you'll need to have a good understanding of the 8 lectures covered in this course.

Lecture 1

The aim is to provide an **overview of the power sector and how it is organised**, as well as an understanding of basic technical and economic concepts related to electricity supply and demand.

We will cover the following topics:

1. The importance of energy to the economy and people's lives
2. Measuring electricity and related concepts
3. Demand for power
4. Electricity supply and the power sector value chain
    1. Electricity generation
        - Conventional generation sources;
        - Renewable generation sources (RES);
    2. Electricity networks (transmission & distribution)
    3. Retail markets

1. The importance of energy to the economy and people's lives

The importance of energy to the economy

Energy is one of the key ingredients to our lives and economic activity…

- Energy is used in industrial processes, transportation, business activities…
- Energy consumption by households broken down by end-use:
  - space heating (64.4%);
  - water heating (14.5%);
  - lighting and electrical appliances (fridges, computers, phones, TVs) (13.6%);
  - cooking (6%); space cooling (0.5%), other uses (1.1%).

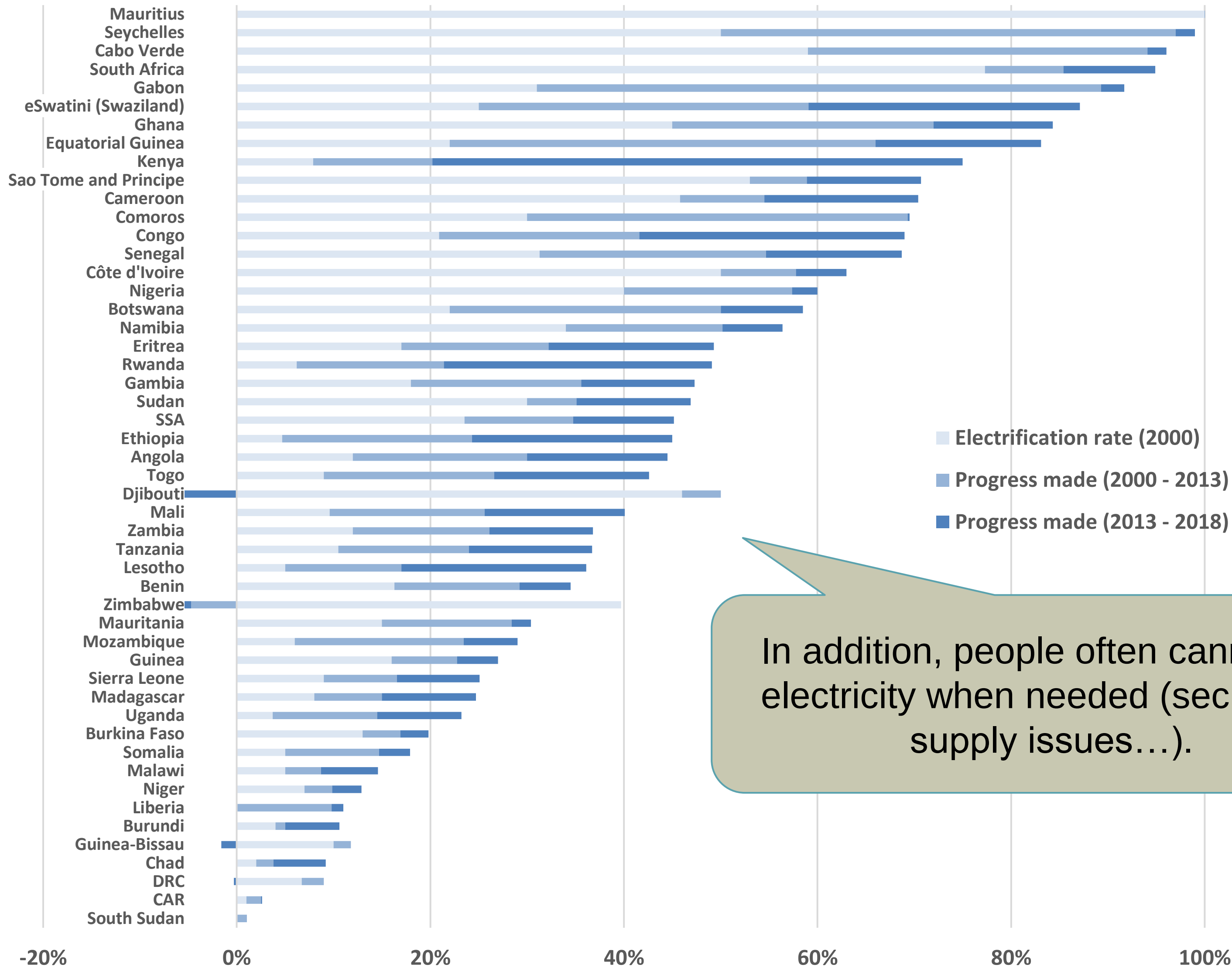
Source: Eurostat, Energy consumption in EU households, data for 2021.

Demand for a particular form of energy depends on its own price and prices of other sources...

- Some energy needs can be met by several different energy sources
- For example, homes can be heated using electricity, natural gas, oil or wood – this is because each of these energy sources can be converted to thermal energy
- Similarly, for cooking we could use electricity, propane, wood, natural gas or charcoal…. (i.e. they are substitutes for one another, at least in the longer term)

Even though other sources of energy can be used, the **focus of this course** is **electrical energy** or **electricity**

Despite electricity being vital, some countries & regions have very low electricity access rates. In Sub-Saharan Africa only 48% of the population have access …



In addition, people often cannot get electricity when needed (security of supply issues…).

Source: IEA (2018), IEA (2015), IEA (2013), IEA (2011).

2. Measuring electricity and related concepts

A brief recap from high school… Electricity is the flow of electrons, while it may not be visible, it can be turned on and off and measured…

Measuring electricity *Electricity measured at a single point in time = power*	• Electricity is measured in units of power called **Watts** (James Watt – inventor of the steam engine). A Watt is the **unit of electrical power** equal to one ampere under the pressure of one volt. • 1 kW = 1,000 Watts; • 1 MW = 1,000 kW, or 10^6 Watts; • 1 GW = 1,000 MW or 10^9 Watts. • One W, kW, MW or GW is the amount of electricity used, generated or transmitted **at a point in time**. • Power consumption of small devices is measured in Watts, of larger devices and households in kilowatts (kW), and of large factories in megawatts (MW). • Electricity **generation capacity is measured in MW or GW.**
Electricity use over time (consumption and generation) *Electricity measured over time = energy = power x time*	• Electricity use over time is measured in **Watthours** (Wh), which is a measure of energy. • A Watthour is equal to the energy of one Watt steadily supplied to, or taken from, an electric circuit for one hour. • The amount of electricity that a customer uses is typically measured in **kilowatthours** (kWh), where one kWh is one kilowatt generated or consumed for one hour. A power plant's output is typically measured in megawatthours (MWh) or gigawatthours (GWh). • For example, using a 60-Watt (0.06 kW) light bulb for five hours will require 300 Watthours (0.3 kWh) of electrical energy. • Electric utilities **measure the electricity consumption of their customers with meters** (at the point where the power line enters the customer's property).

Electricity generation capacity (MW), electricity generation (MWh) and capacity factor (%).

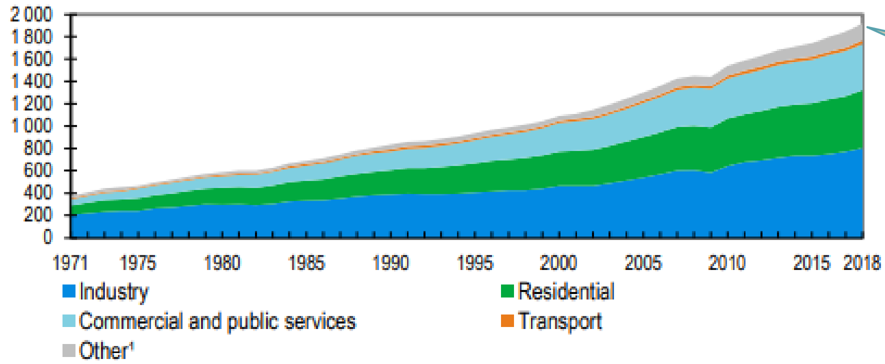
Electricity generation capacity	• The **maximum electric or power output** an electricity generator (or generation unit in a power station) can produce under specific conditions. □ Nameplate generator capacity: maximum output a generator can produce without exceeding design limits (determined by the generator's manufacturer). □ Available generator capacity: power able to be generated, which varies due to breakdowns and maintenance outages, air temperature (for gas turbines), plant aging etc. • Helps to understand how big an electricity load a generator can supply, normally measured in MW.
Electricity generation	• The **amount of electricity that is produced** by a generator **over a specific period of time.** • E.g. a generator with 1 MW capacity that operates consistently at that capacity for one hour will produce 1 megawatthour (1 MWh) of electricity. • Many generators **do not operate at their full capacity all the time**. A generator's output may vary according to conditions at the power plant, fuel costs, and/or as instructed by the electric power grid operator in order to match generation output with load or to manage electricity flows on the grid. • **Net generation** = the amount of gross generation minus the electricity used to operate the power plant (for powering water pumps, coal conveyor belts, lighting etc.).
Capacity factor	• Is a measure **of average output of an electricity generator during a specific period of time**. • Capacity factor = electricity output (kWh) / maximum possible output (kWh) during that time period, expressed as a percentage. • E.g. a generator with 1 MW capacity that produces an electrical output of 4,160 MWh over a period of one year --> capacity factor is 47.5% = (4,160 MWh / (1MW * 8760h)).

3. Electricity demand

Demand for electricity …

Electricity is used for a variety of purposes

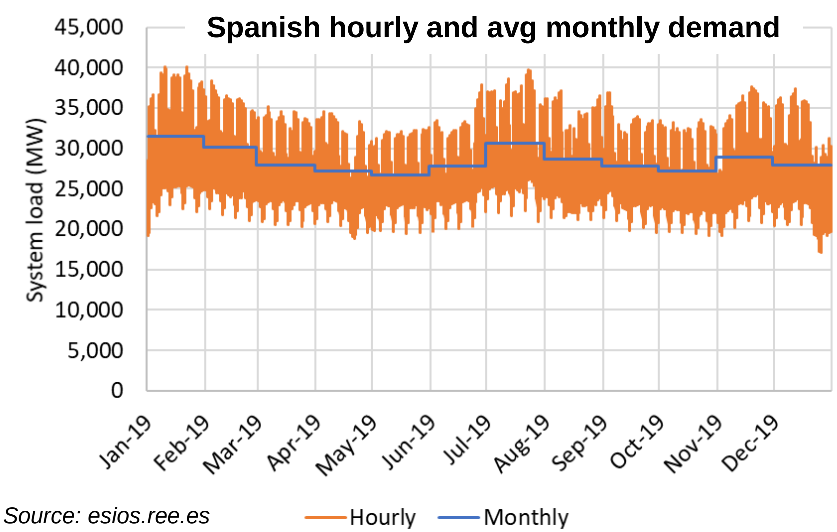
Total global final elec. consumption (Mtoe)



1,950 Mtoe ≈ 22,800 TWh
(1Mtoe is about 11630 GWh)

Source: International Energy Agency (IEA), World Energy Outlook, Key World Energy Statistics 2020, p. 41
Mtoe = million tonnes of oil equivalent, which is just a different unit for energy.

Demand varies over time



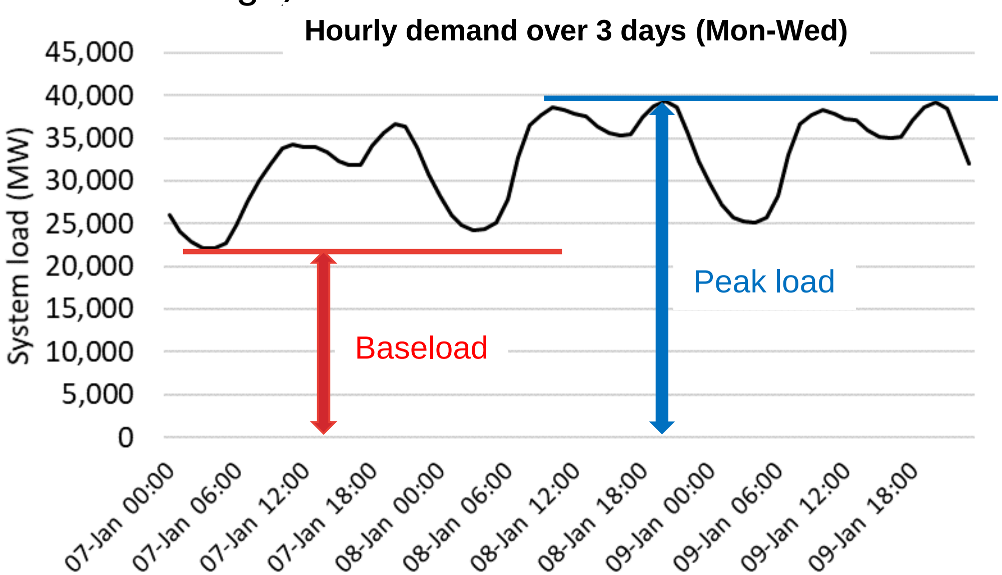
Source: esios.ree.es

- Demand varies over time and is not perfectly predictable.
  - With significant variation from year to year, month to month, day to day and hour to hour.
  - People use more electricity in the morning and in the evening (peak times). They use less when they're at school or work and on the weekends (shoulder and off-peak times), air conditioners run much more in summer times, heaters run more in winter, etc.

Demand for power and its characteristics…

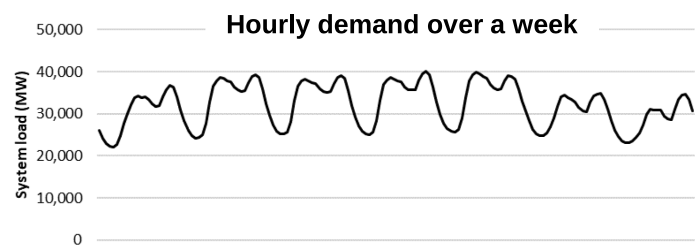
Electricity demand

- Characterised as baseload and peak.
  - **Baseload demand**: present throughout the day (minimum amount of electricity needed at any point) or week or year, depending on the time period looked at.
  - **Peak demand**: describes periods with the highest electricity use (usually mornings and evenings).



Source: esios.ree.es

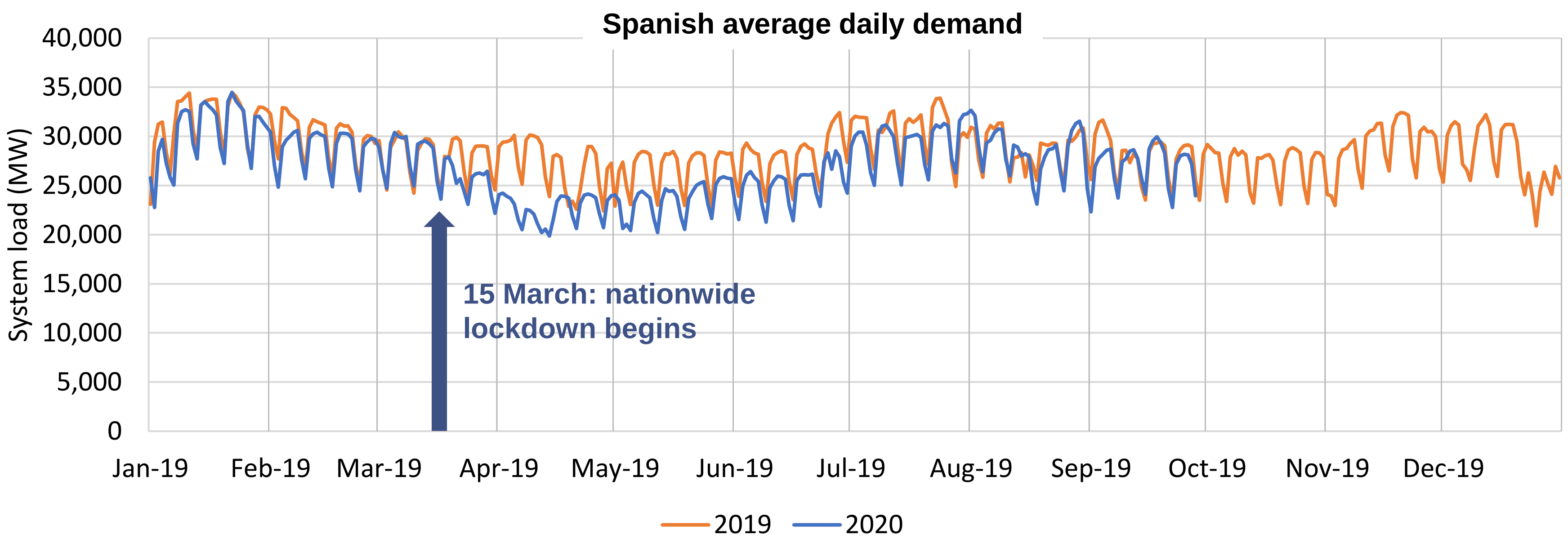
- Electricity generation injected into the grid must vary to meet consumption taken off the grid in real time, i.e. second by second, minute by minute. Storage is now used to help this balance but storage is still expensive.
- Recently, some demand side management has been used to smooth the peaks and reduce overall system costs (reduce the need to build more power stations and T&D lines).



Demand is correlated to economic activity …

Electricity demand

- Comparing demand (more correctly, system load = consumption + network losses) in one year to the another shows the effects of economic activity, timing of holidays, weather ...
  - Covid-19 had a significant effect on Spanish demand in late March and April 2020, with the effect reducing slowly over time until it largely disappeared by late July.



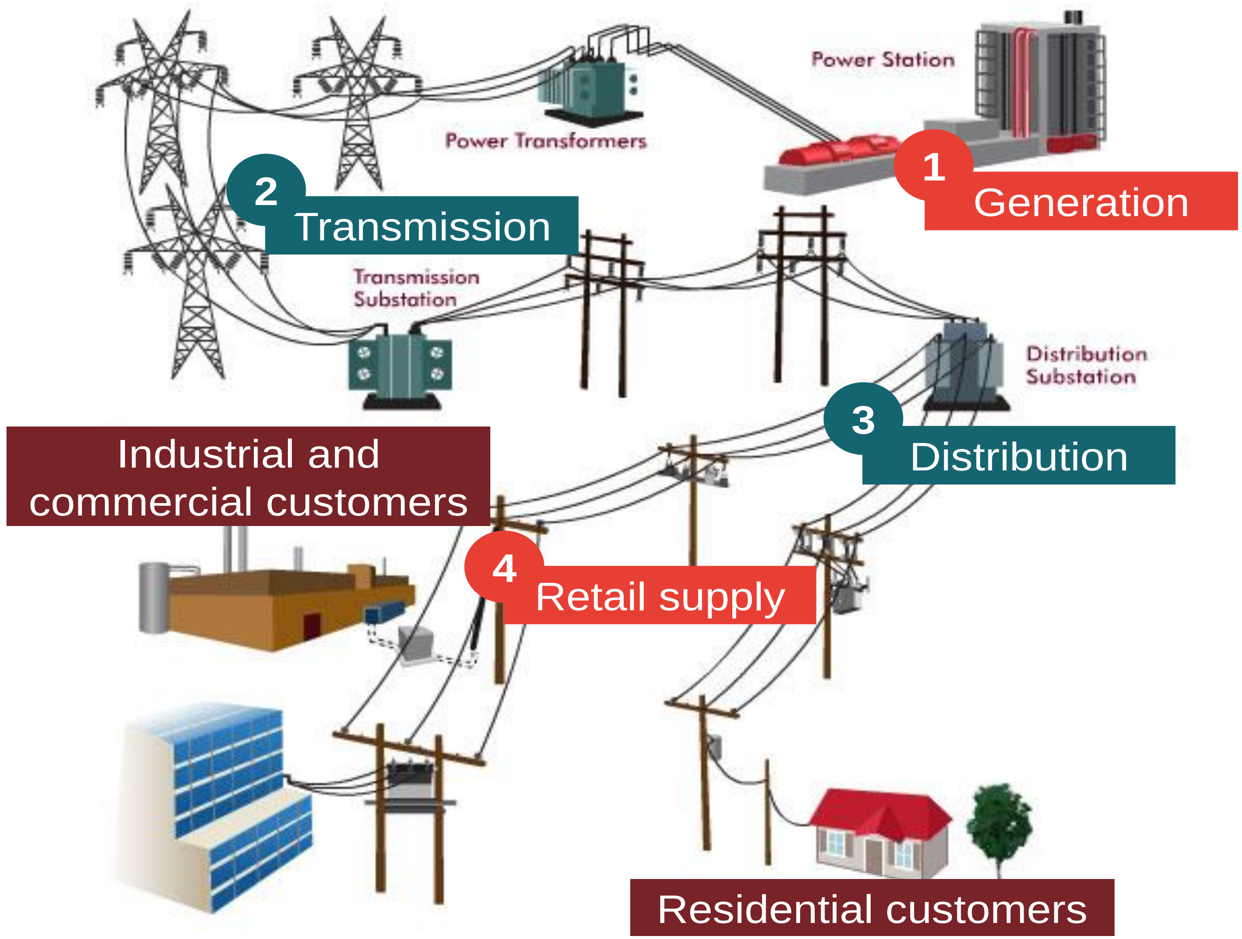
Note: the graph for 2020 starts on Tuesday 31 Dec 2019 to align weekends for 2020 with 2019

Source: esios.ree.es

4. Electricity supply and the power sector value chain

Power sector value chain (supply of electricity)

Several steps involved



4.1 Electricity generation

Electricity is not freely available so it must be produced.

Electricity is generated using different energy sources …

- From fossil fuels (oil, natural gas, coal, lignite) (together conventional generation sources), or from nuclear energy (uranium), or from renewable energy sources (RES).
- First step is to obtain primary energy sources (coal, natural gas, petroleum, uranium, sunshine, wind or the flow of water) = energy acquisition.
- These are then converted to electricity (a secondary source of energy).

Conventional generation sources

- Coal power plants;
- Natural gas power plants;
- Power plants burning oil;

Sometimes referred to as 'dispatchable generation sources' as their output can be adjusted relatively easily to balance the system.

Nuclear power generation

Renewable generation sources (RES)

- Hydropower;
- Wind (onshore and offshore wind);
- Solar (solar PV, CSP);
- Marine;
- Bioenergy;
- Geothermal.

Some RES generation is also dispatchable, e.g. hydro (particularly storage hydro and pumped storage), biomass and biogas.

Current power generation mix …

Generation by fuel

Electricity generation by primary energy source (2021 data)	Electricity generated (TWh)	Share in generation
Coal (fossil fuel)	10,036	35.3%
Oil (fossil fuel)	735	2.6%
Natural gas (fossil fuel)	6,440	22.7%
Nuclear (uranium)	2,703	9.5%
Hydroelectricity	4,200	14.8%
Wind electricity	1,592	5.6%
Solar electricity	849	3.0%
Other RES (geothermal, biofuels, waste, heat, wave, etc.)	1,292	4.6%
Other sources	570	2.1%
World total	**28,177**	**100%**

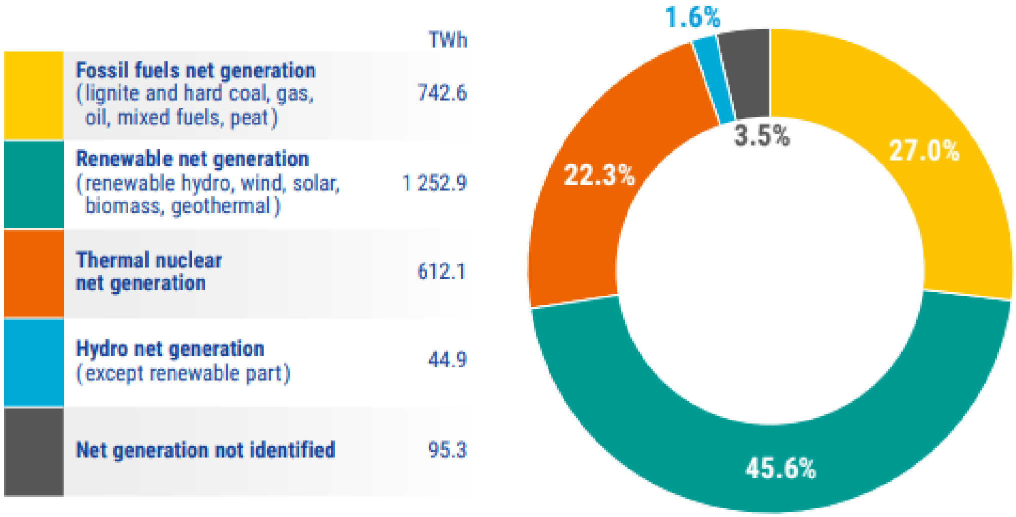
Source: International Energy Agency (IEA)

Power generation mix

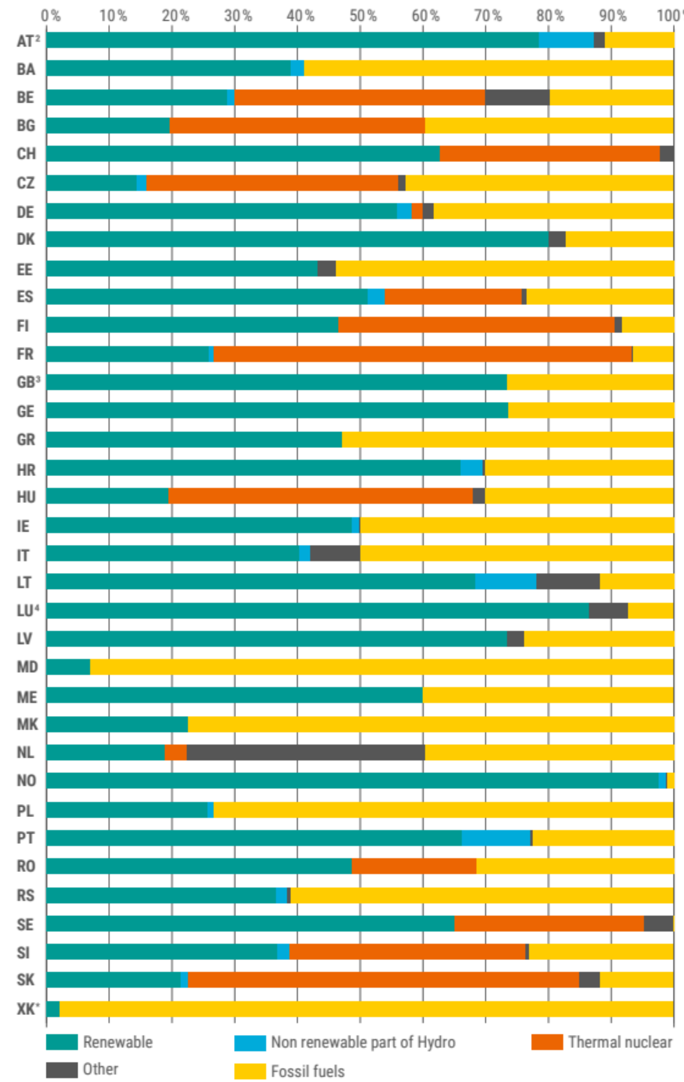
- Refers to **the percentage of electricity generation from each primary energy source** over some period of time (normally one year);
- Different generation mix and technologies are more / less suited to different countries:
  - The availability of primary resources on its territory or the possibility of importing them;
  - Demand pattern;
  - Cost of the generation technology and of the primary energy source to fuel it; and
  - Policy choices determined by many factors such as economic, historical, social, demographic, environmental and geopolitical.

There are substantial differences in generation mix among regions and substantial differences among countries …

Generation mix in ENTSO-E member TSOs in 2023[1]



Share of energy produced of each member TSOs 2023 in %[1]



Source: Statistical Factsheet 2023, ENTSO-E, [link]

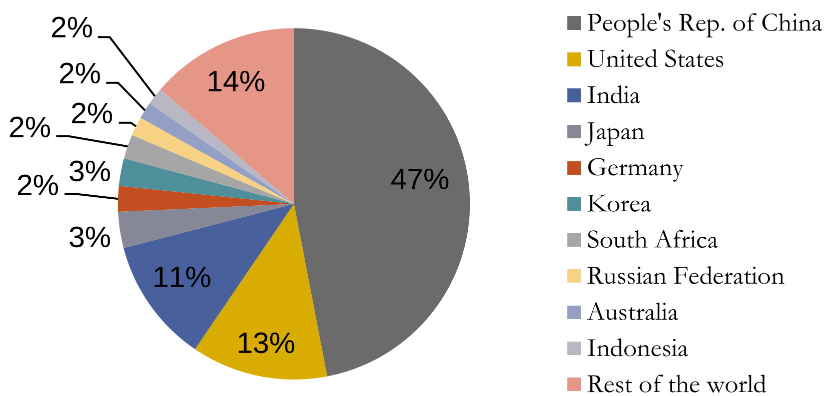
Conventional generation: Coal fired power plants

Coal currently plays a key role in electricity generation

- Coal plays a vital role in electricity generation worldwide. Coal-fired power plants currently produce roughly 35% of generated power worldwide (10,036 TWh in 2021).
- Coal plants tend to be large units that run continuously over time (i.e. **baseload generation units**) – they have **high capital costs but low marginal costs**.
- Coal is a low cost fuel but produces the **highest amount of air pollutants and CO_2 emissions**.
- In the 1970s and 1980s coal power plants were the default choice. Now the world is becoming more conscious about the environment and climate change. For example, the UK set a target in 2015 to phase out coal generation by 2025 (in 2012, coal represented 40% of UK electricity).

Which countries use coal fired generation

Coal power generation by country



Total of 10,160 TWh of electricity produced (38%).

Source: International Energy Agency (IEA), World Energy Outlook, Key World Energy Statistics

Coal is abundant with proven reserves at the end of 2015 of 892,000 million tonnes or 114 years production at the current rate. The reserves are distributed around the world, with 27.5% in North America, 34.8% in Europe and Eurasia, and 32.3% in Asia-Pacific.

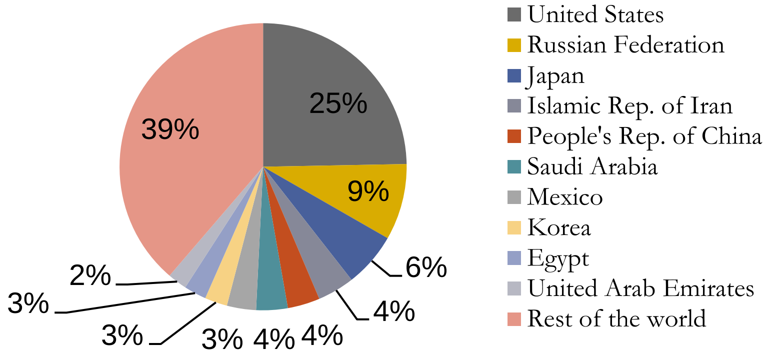
Conventional generation: Natural gas power plants

NG is becoming more and more important in power gen.

- Approx. 23% of global electricity generated comes from burning natural gas.
- Currently gas fired generation is very popular (due to environmental and technological improvements over time, its relative abundance, **lower capital cost** and high efficiency). Many countries have switched from coal and nuclear generation technologies to gas power generation technologies. NG is the **cleanest of the fossil fuels**.
- NG can be either transported through pipelines or in the form of LNG (makes gas tradable over long distances and in places that pipelines can't reach).
- Typically gas is more expensive than coal but gas power stations have a **higher efficiency** and are quicker and cheaper to build.
- NG power plant technologies: **open cycle gas turbines** (OCGTs) and **combined cycle gas turbines** (CCGTs). Efficiency of between 35% to 42% for OCGT and between 52-60% for CCGT.

Which countries use NG generation

Electricity production from NG by country



Source: International Energy Agency (IEA), World Energy Outlook, Key World Energy Statistics

Total of 6,150 TWh of electricity produced (23%).

At the end of 2015 there was 6600 trillion cubic feet of proven gas reserves, or 53 years production at the current rate. Of this 43% was in the Middle East and 30% in Europe and Eurasia.

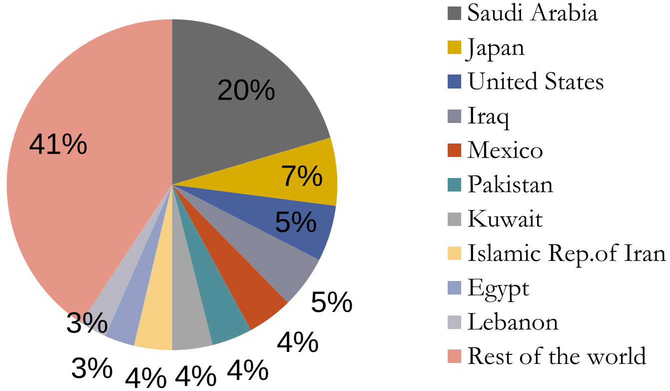
Conventional generation: Oil fired power plants

Importance of oil and diesel in power gen wen t down

- Broadly two types of **fuel oil** are used in power generation:
  - **Heavy fuel oil** (HFO) which is dirty, thick and cheaper (what's left over in the refinery after producing petrol, etc). This can be burned by steam turbines and reciprocating engines.
  - **Diesel** (or distillate, gasoil), like the diesel used in cars. It is cleaner, very liquid and more expensive. It can be burned in OCGTs and CCGTs, i.e. the more efficient and lower capex plants.
- The importance of oil and diesel in power generation has declined – from 24.8% in 1973 to 4.3% in 2014 and 2.6% in 2021. The reduction is largely due to its high price relative to coal and gas. Restrictions on emissions, particularly sulphur emissions, has also reduced the use of fuel oil.

Which countries use oil and diesel fired generation

Electricity production from burning oil by country



Source: International Energy Agency (IEA), World Energy Outlook, Key World Energy Statistics

At the end of 2015, oil had 1700 thousand million barrels of proven reserves or 51 years production. Of this, 47% was in the Middle East, 19% in Central and South America and 14% in North America.

Considerable variation – e.g. Hawaii – 70% of total electricity generated; US as a whole – 1% of electricity generated.

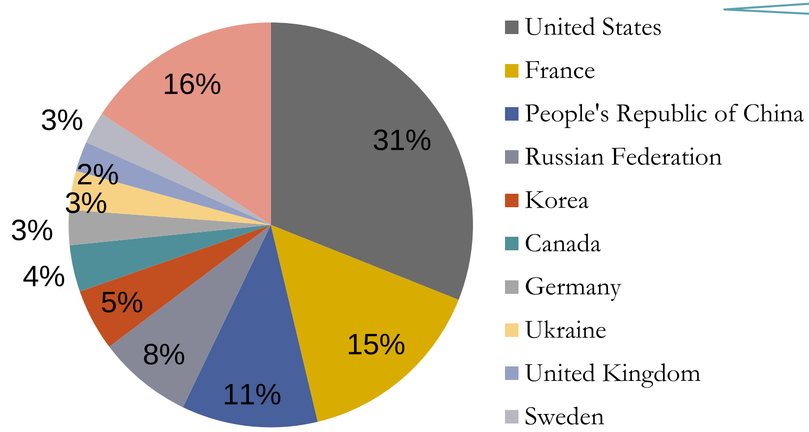
Non-conventional generation: Nuclear

A controversial technology

- Nuclear power plants are used as baseload units (they have **high initial capital cost but very low variable costs of production**).
- **Use uranium** to generate power. The uranium atom is split into two and as this happens energy is released in the form of radiation and heat. This nuclear reaction is called the fission process.
- Nuclear power is a controversial method of producing electricity (radiation). Unanswered questions about very long term storage of radioactive waste.
- Some serious accidents of nuclear power generation (Chernobyl, Ukraine in 1986; Fukushima, Japan in 2011).

Which countries use nuclear powered generation

Electricity production from nuclear



Source: International Energy Agency (IEA), World Energy Outlook, Key World Energy Statistic.

Total of 2,703 TWh of electricity produced (around 9.5% of world-wide generation).

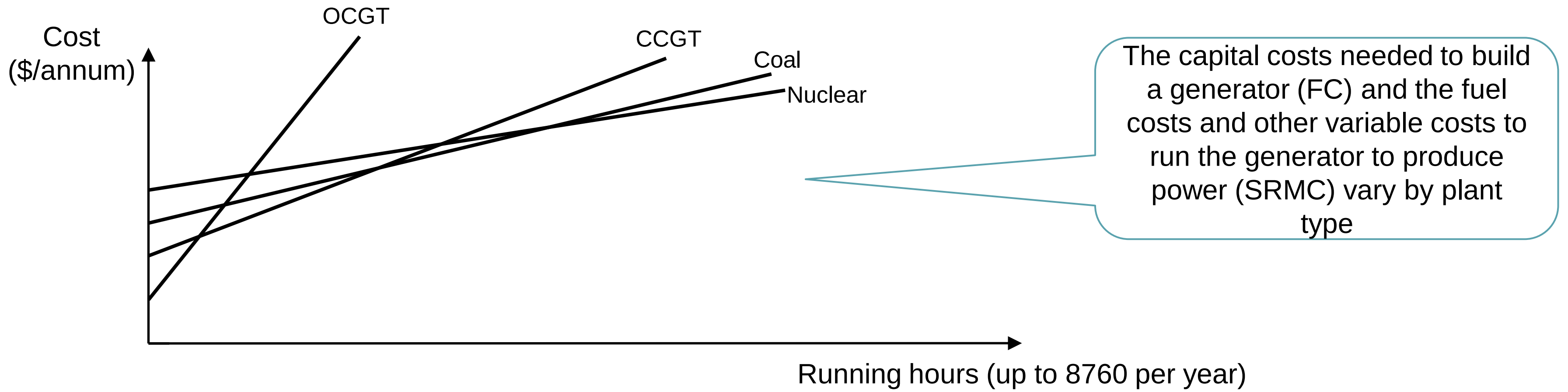
Accidents occur with a low frequency. However, the enormous effect of an accident means that Governments ultimately bare the responsibility for the accident. Neither generation companies nor insurance companies have sufficiently large balance sheets to cover the risk of a major accident.

Why do we need a mix of generation technologies?

There are several reasons for using different technologies…

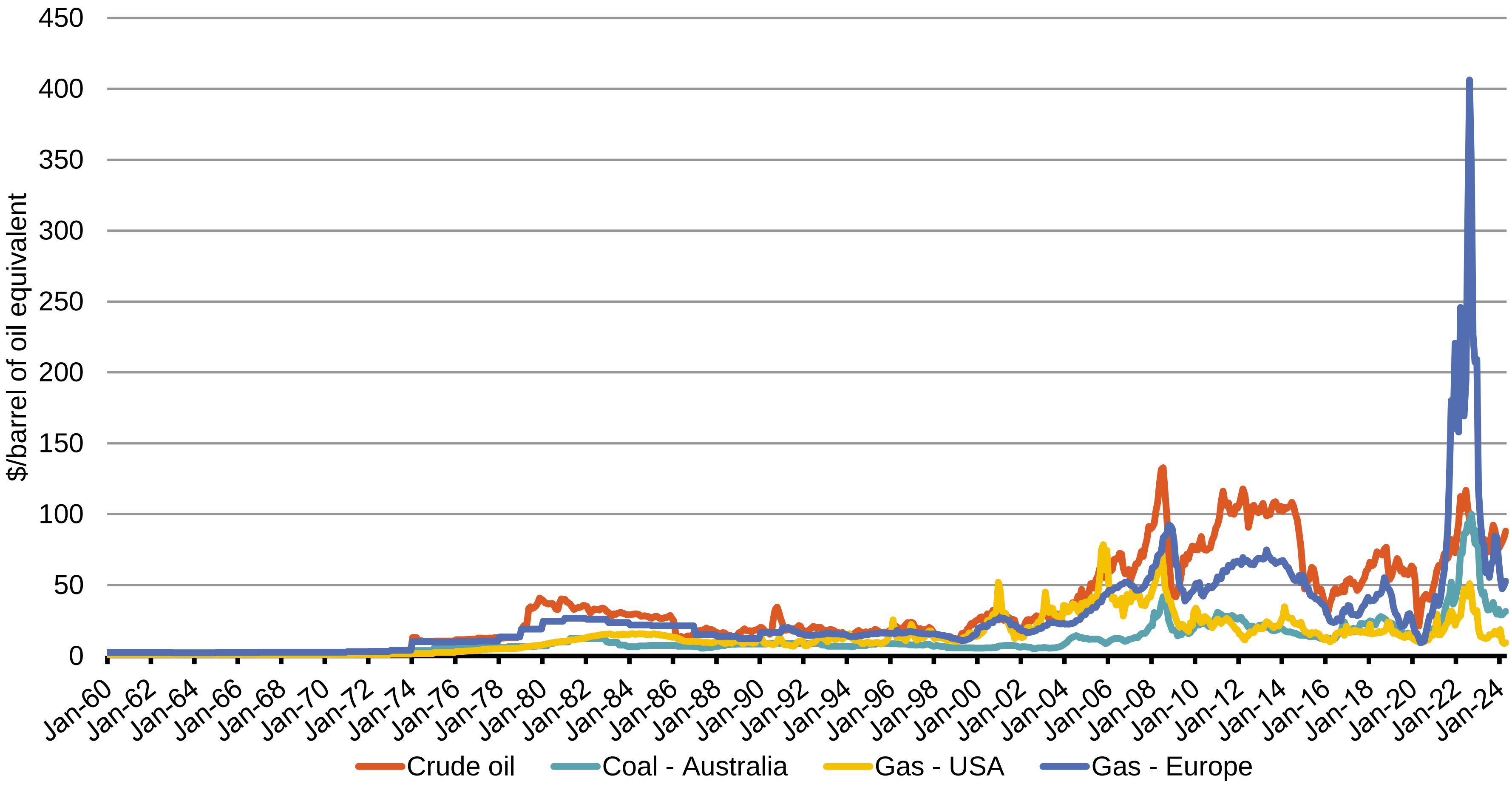
- Economic reasons: Due to an uneven demand profile within a year, there are opportunities for investments in different technologies since they offer different combinations of fixed & variable costs.
- Strategic / political reasons: fuel diversification is a reasonable strategy, balancing the objectives of supply independence and affordable electricity prices.
- Environmental reasons: different generation technologies have different environmental impacts (emissions, noise, visual and landscape).

Fixed and variable costs over time…



The optimal investment choice and optimal plant dispatch will vary over time, as the SRMC of generators change over time and also as capital costs change

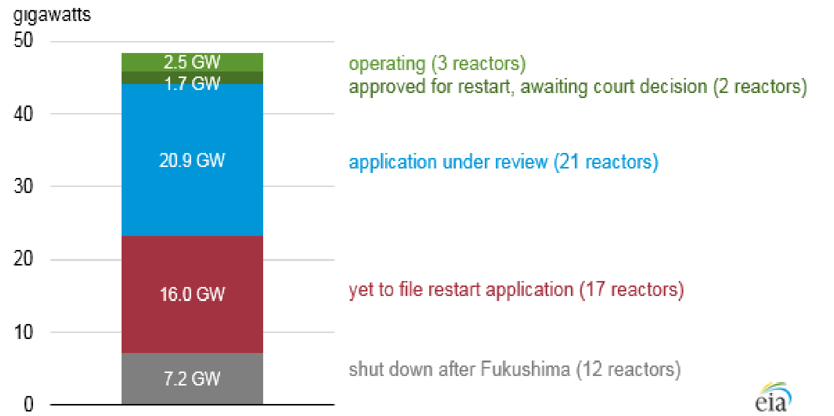
High fluctuation of fuel prices over time (the main driver of SRMC for fossil fired generation)



Source: World Bank Commodity Price Data (The Pink Sheet), showing monthly prices in nominal US dollars, 1960 to present as updated on September 2, 2020

Optimal generation mix… Other factors to consider…

Fukushima accident



Source: U.S. Energy Information Administration, based on Institute of Energy Economics, Japan, and IAEA Power Reactor Information System

Fukushima led many countries to revisit their nuclear generation policies. For example, Germany announced plans to close almost immediately 8 nuclear reactors and to close the other 9 by 2022. Nonetheless, some countries are still planning a major nuclear expansion – e.g. UK and South Africa (plans to add 9.6 GW of nuclear power – although facing some legal challenges)

Advantages of nuclear power

- Advantages of using nuclear power. Nuclear power stations do not burn fossil fuels to produce electricity and consequently they do not produce damaging, polluting gases or CO_2.
- However, when thinking about CO_2 emissions, one should consider the life cycle emissions, including the emissions resulting from the concrete and steel used in the construction of a nuclear power plant and other types of power plants.
- Some countries heavily rely on nuclear power generation.

Country (top 10 producers)	Share of nuclear in total domestic electricity generation
France	71.0%
Ukraine	52.8%
Sweden	42.0%
Korea	22.6%
United Kingdom	19.5%
United States	18.9%
Russian Federation	18.4%
Canada	15.4%
Germany	11.8%
People's Republic of China	4.1%
Rest of the world	7.6%
World	**10.10%**

Source: International Energy Agency (IEA), World Energy Outlook, Key World Energy Statistics 2020, p.19

Key disadvantage of thermal generation: environmental impact…

Fossil fuelled generation produces pollutants…

- The combustion of fossil fuels leads to the production of carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NOx), sulphur oxides (SOx), unburned hydrocarbons (HC), and solid particles.

Environmental impact of different technologies

Efficiency (primary energy use) and environmental impact	OCGT	CCGT	Coal
Efficiency	35-42%	52-60%	46%
CO2 and other GHG emissions, kg/MWh	527.50	370.00	1002
Nox, g/MWh	50.00	30.00	180-800

IAE, Energy Technology Network, ETSAP – Technology Brief E02 – April 2010 – www.etsap.org; Centre for Climate and Energy Solutions, Leveraging natural gas to reduce greenhouse gas emissions, June 2013; U.S. Energy Information Administration (https://www.eia.gov/tools/faqs/faq.php?id=74&t=11).

Burning NG produces less CO_2 than burning coal …

Coal versus gas fired generation: amount of CO_2 emissions

	Gas OCGT	Gas CCGT	Coal	Emission factor (coal vs. OCGT)	Emission factor (coal vs. CCGT)
GWh produced annually	6,150	6,150	6,150	n/a	n/a
CO_2 and other GHG emissions, kg/MWh	528	370	1,002	2	3
Million tonnes of CO_2 produced annually	3.2	2.3	6.2	2	3
Million tonnes of CO_2 over 20 years	65	46	123	2	3

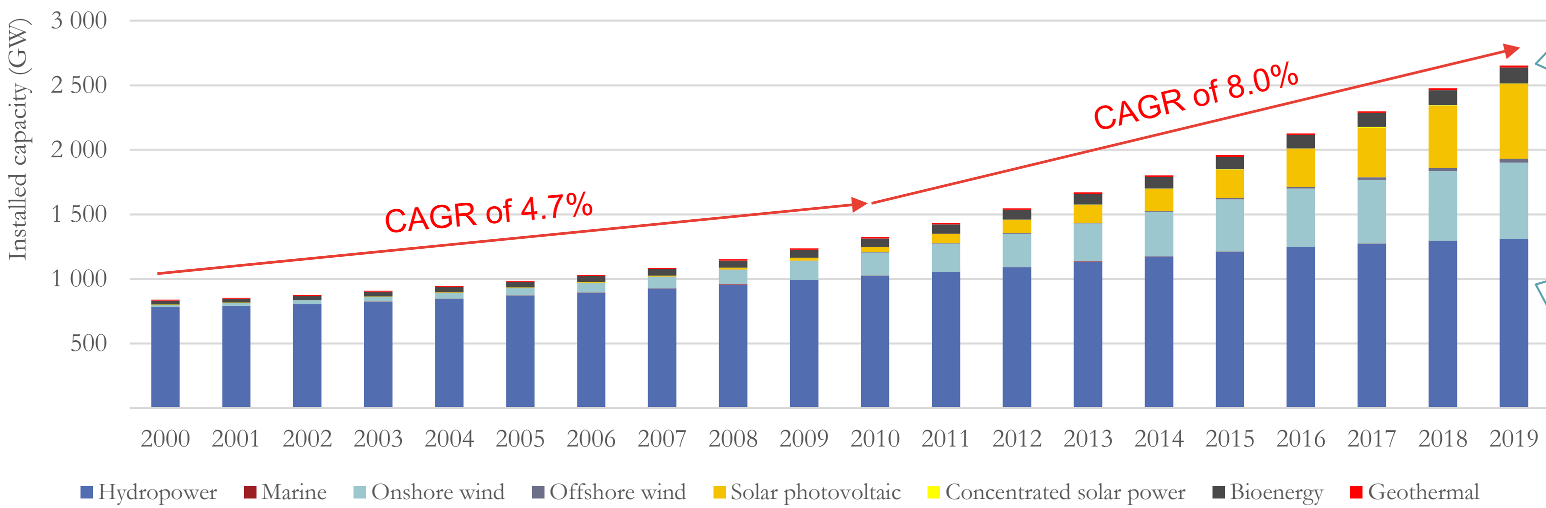
Source: Ibid.

Renewable generation capacity has been increasing …

Overview of RES…

- Renewable technologies **do not require any fossil fuel to operate**. They rely on natural resources (sunshine, wind, rain, geothermal heat).
- Hydropower, wind energy (onshore, offshore), solar (PV, CSP), bioenergy (biomass).
- Relatively expensive to build (though substantial technology learning curves) and have relatively low operating costs. Often supported through subsidies.
- Currently ~ 30 percent of electricity is generated from renewable energy.

Renewable technologies and their share in capacity installed worldwide…



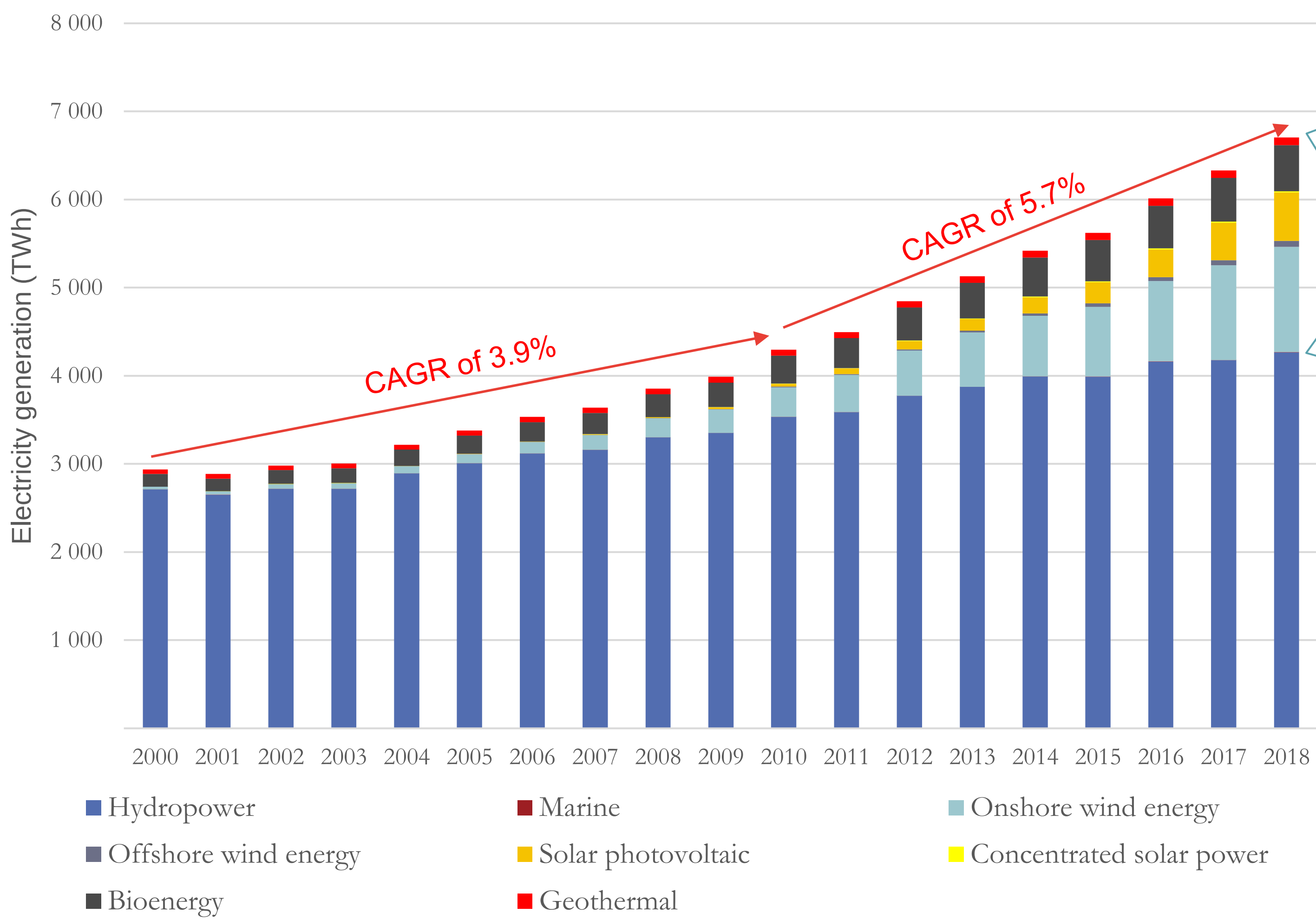
Source: IRENA, Renewable Capacity Statistics 2019

A total of 2,533 GW of installed RES capacity worldwide.

Hydro share down from 88% in 2005 to 49% in 2018. Solar PV and onshore wind both 22% capacity share.

Renewable generation…

Renewable technologies and their share in power generation worldwide…

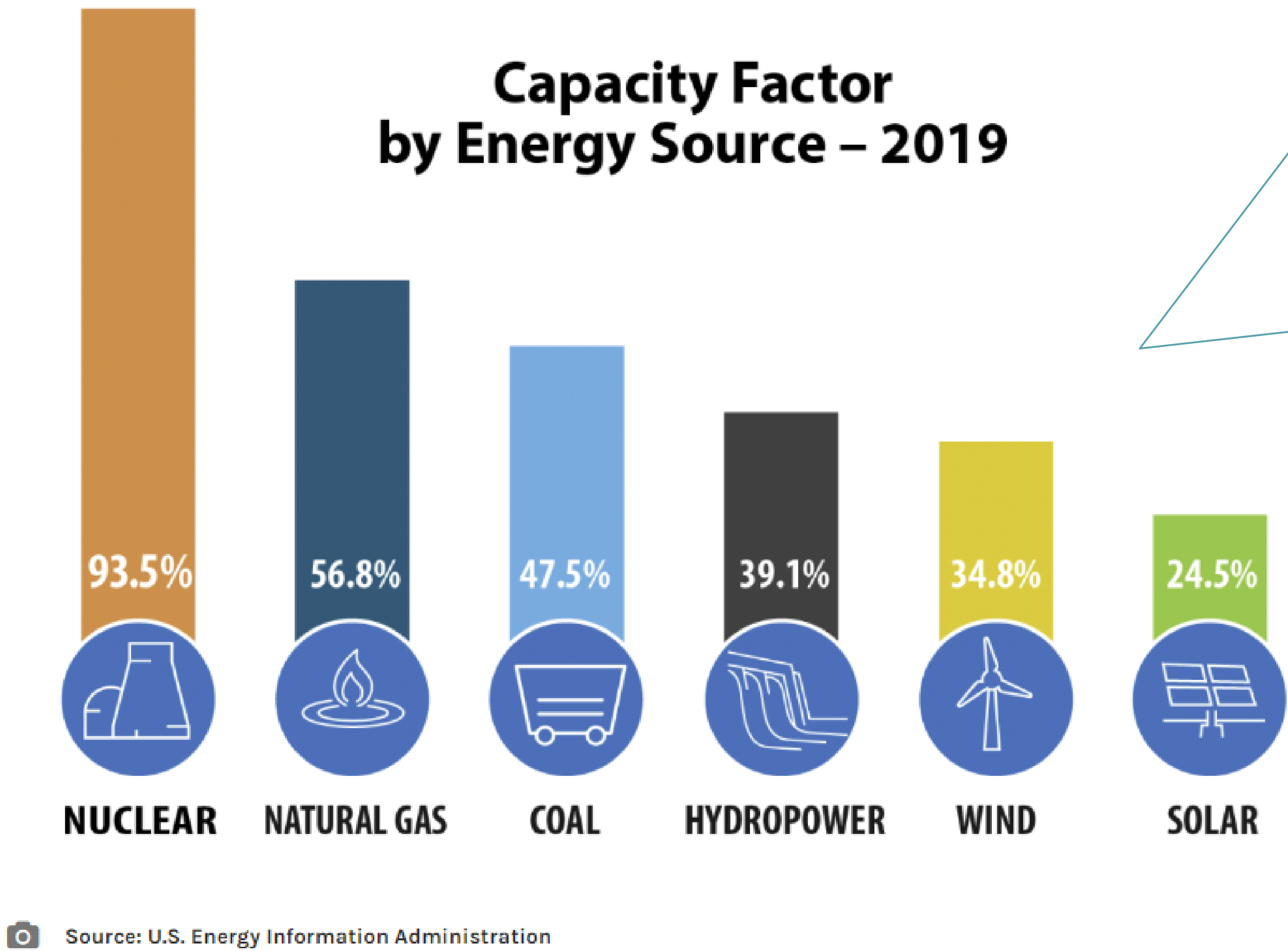


Approx. 6,700 TWh (25%) of el. generated from RES worldwide.

Hydro share down from 89% in 2005 to 64% in 2018. Onshore wind 18%, solar PV and bioenergy both 8% gen. share.

Source: IRENA, Renewable Capacity Statistics 2019

Typical capacity factors…

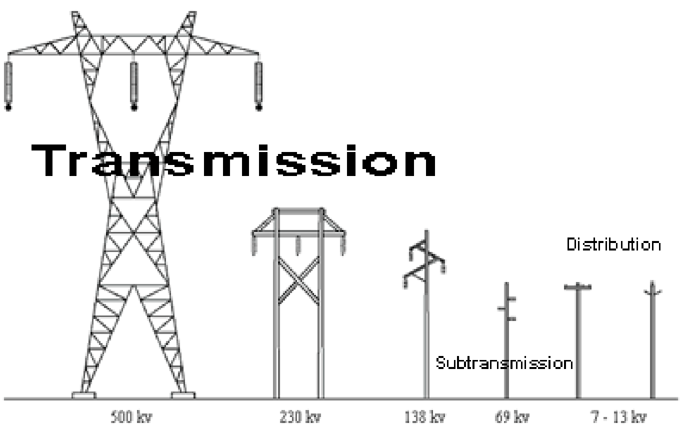


Capacity factor of each power plant is determined by a number of factors (conditions at the power plant, age, scheduled and unscheduled outages, fuel costs, availability of the primary energy source, and/or as instructed by the electric power grid operator).

4.2 Electricity transmission and distribution (T&D)

Transmission and distribution networks

The capacity to send power along transmission or distribution lines relates to voltage level, length of the lines, ambient temperature, etc.



Transmission grid

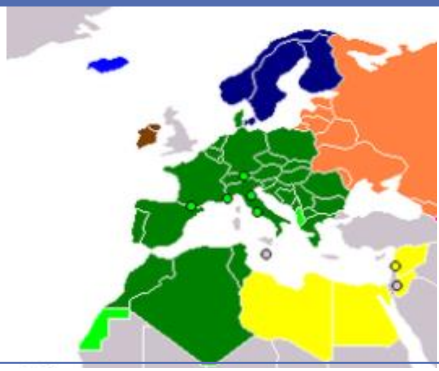
- A network of high voltage lines strung on pylons and underground cables (underground cables are expensive!).
- Takes electricity from power plants and delivers it across the country to large consumers and distribution grids.
- High voltages reduce the energy lost in the network (network losses) for a given amount of power delivered. The GB transmission grid is 400kV, 275 kV and 132kV.
- Transformers at the power station increase voltage to deliver to the transmission network, transformers then reduce voltage to deliver electricity to distribution networks.

Distribution grid

- Is a network of lines strung on poles and underground cables.
- Takes electricity from the transmission network and delivers it across a region or city to industrial, commercial and household end consumers. Small power stations, including a lot of RES, are usually connected to the D network.
- Is a low voltage network. Typical voltages are 230V (400V 3-phase), 11kV, 33kV, 66kV and 132kV.

European transmission grid

Europe has several synchronous areas

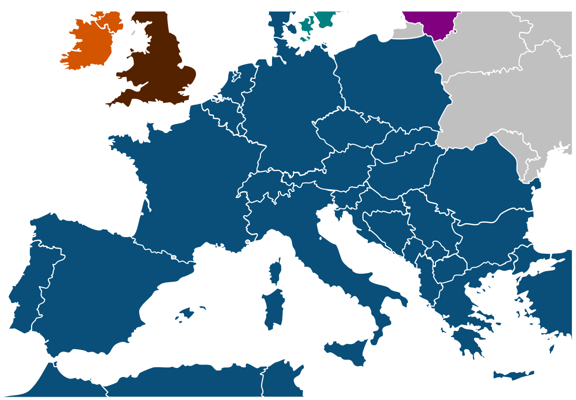


- Synchronising several countries together helps maintain a stable frequency (50Hz in EU)
- Stable frequency is important for equipment and for power stations – they turn off at low freq.

ENTSO-E

- Represents TSOs from Europe and beyond, with objectives for:
  - secure and reliable operation of the increasingly complex network;
  - facilitation of cross-border network development and the integration of renewables; and
  - enhancement of the Internal Energy Market.

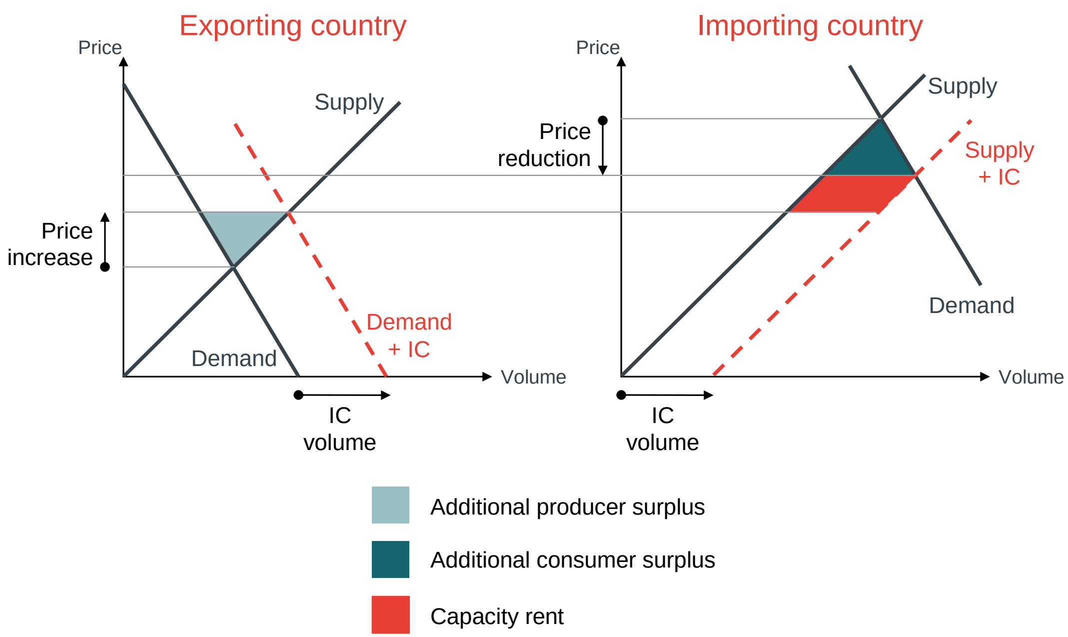
Transmission and distribution capacity



- The Continental Europe Synchronous Area is the largest synchronous electrical grid in the world, supplying over 400 million customers in 24 countries. Turkey was added recently.
  - If an event occurs anywhere in the synchronous area, generators throughout the area respond to return the frequency to 50Hz.
- The transmission system in each country is operated by a transmission system operator (TSOs). For example:
  - ČEPS (Česká energetická přenosová soustava) in the Czech Republic;
  - TransnetBW, TenneT DE, Amprion and 50Hertz in Germany;
  - National Grid, SONI in the UK; or
  - SEPS in Slovakia.

A large electricity network lowers costs and improves quality of electricity supply

Gains from trade



- Electricity interconnection adds to social welfare by allowing cheap generation to displace expensive generation, while meeting demand.
- The bigger the area of the grid, the greater the possible benefits from trade (although this comes at the incremental cost of transmission lines).

Other benefits

- Stable frequency (as we saw on the previous slide), but only if the network is synchronous.
- Broadens the market in which generators and end users (or retail suppliers) meet
  - Allows **economies of scale in generation** to be captured by allowing for **bigger generators** and **sharing reserves**.
  - Greater **diversification of consumers' electricity loads** means a **higher average load** (avg load / peak load = load factor)
  - **Greater competition** with more competing generators and end users

4.3 Retail markets

Retail markets

Retail supply is the final sale of electricity to end consumers

- Retail suppliers **buy electricity from the wholesale market and sell it to end consumers**.
  - Retail supply is largely a **risk management, customer relationship and billing activity** (and sometimes also metering).
  - This is a high volume, low margin activity.
  - Retail suppliers are typically the **main contact for small customers** with the electricity sector.
    - The retail supplier pays the network charges and passes these costs onto small end consumers along with the cost of energy.
  - In most liberalised markets, all end **consumers have the right to choose their retail supplier**
    - Since 1999 in UK
    - Required from 1st July 2007 for most European countries under the second Electricity Directive.
- **Distribution companies physically deliver power** to end consumers.
  - If a consumer switched retail supplier it would continue to receive electricity through the same wires, owned by the distribution company (distribution companies are normally different from retail supply companies).
- The **benefits of liberalised retail markets** for small consumers have been debated:
  - Retail competition puts **downward pressure on retail margins**, and **drives improvements** in customer service and product innovation (metering, green power, payment terms).
  - But, it can be **difficult to achieve strong retail competition** for small customers since many customers do not switch retail supplier – probably because consumer inaction does not lead to their electricity being shut off.

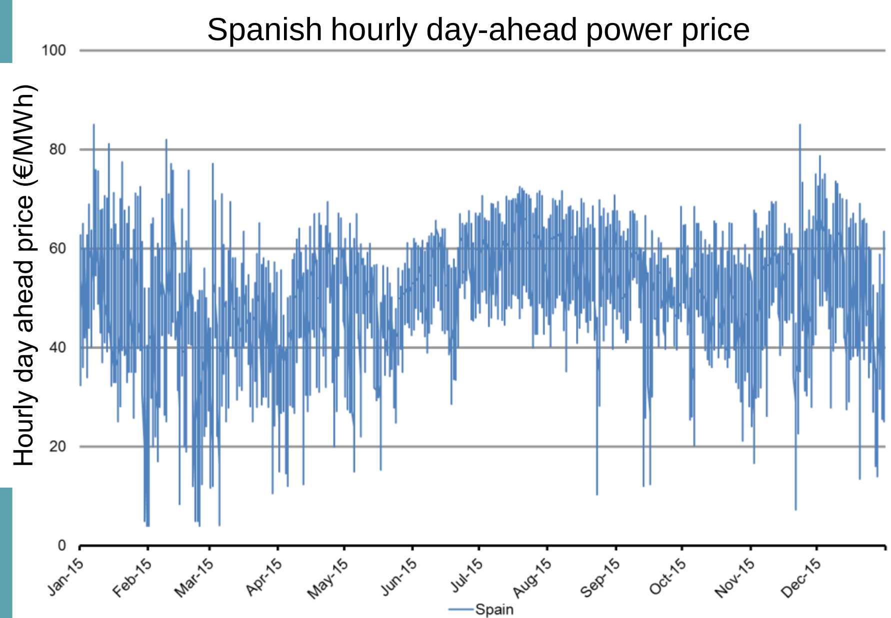
Most customers are not metered in the timescales in which the price of power varies in the wholesale market

Retail supply is risk management

Retail supply is largely a risk management activity

- Retail suppliers buy a product whose value varies minute by minute and sell it to households at prices that are set once or twice a year.
- Retail suppliers manage risk by buying electricity through a mix of forward contracts and shorter term contracts – they know that most customers will not change retail supplier but some might.

Retail markets typically rely on load profiles for smaller consumers



- The wholesale price of electricity fluctuates each hour or half hour.
- But, household interval meters measure consumption over 1-2 months.
- Infrequent measurements must be converted to hourly (or half hourly) quantities for wholesale settlement (i.e. buying of electricity by the retail supplier).
  - Retail supplier assigns a load profile to each customer with an interval meter. Profile is used to assign a quantity of consumption to each wholesale market settlement period (e.g. hour).
  - Load profile customers don't observe real time prices and have no incentive to respond to short term variations in wholesale prices.
- Many countries are installing smart meters for households to measure consumption every 30 or 60 minutes.

Recommended reading

[1] The Economics of Electricity Markets, Barryl R. Biggar, Wiley – IEEE, 1st Edition, September 2014, ISBN: 978-1118775752, 432 pages

[2] Energy Primer: A Handbook of Energy Market Basics, FERC Office of Enforcement, November 2015, Section on Electricity Demand (http://www.ferc.gov/market-oversight/guide/energy-primer.pdf)