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STRIDE Smart grid workshop

Lecture 2

Smart grid motivation

Project co-funded by the Europen Union (ERDF, IPA).

Contents

- The traditional electricity grid
  - Challenges
- Smart grid solutions and motivations
  - Overview of smart grid benefits
  - Smart grid barriers
- Processes, people and policies for developing Smart grids
  - Smart grid in short

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The traditional power grid

- Four development phases of Power system
- Old fashioned
- Created with different energy needs in mind
- Changes in recent years – electricity market, renewable energy sources, electric vehicles, etc.
- Main purpose - sufficient supply of reliable, high quality electricity to its consumers
- Centralised control system
- Large and dislocated power plants

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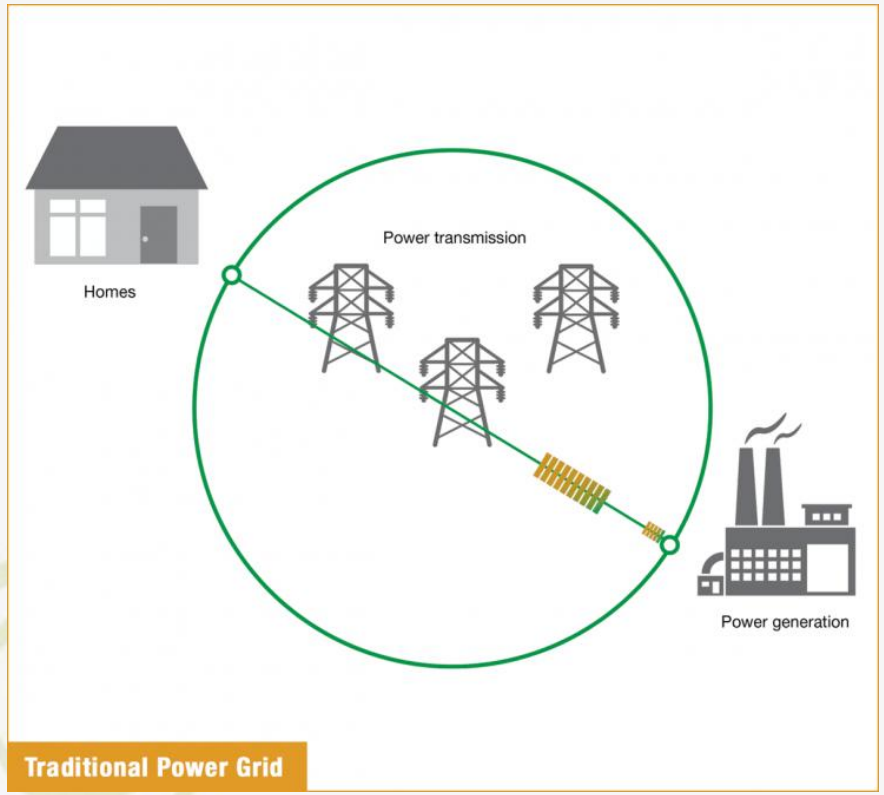
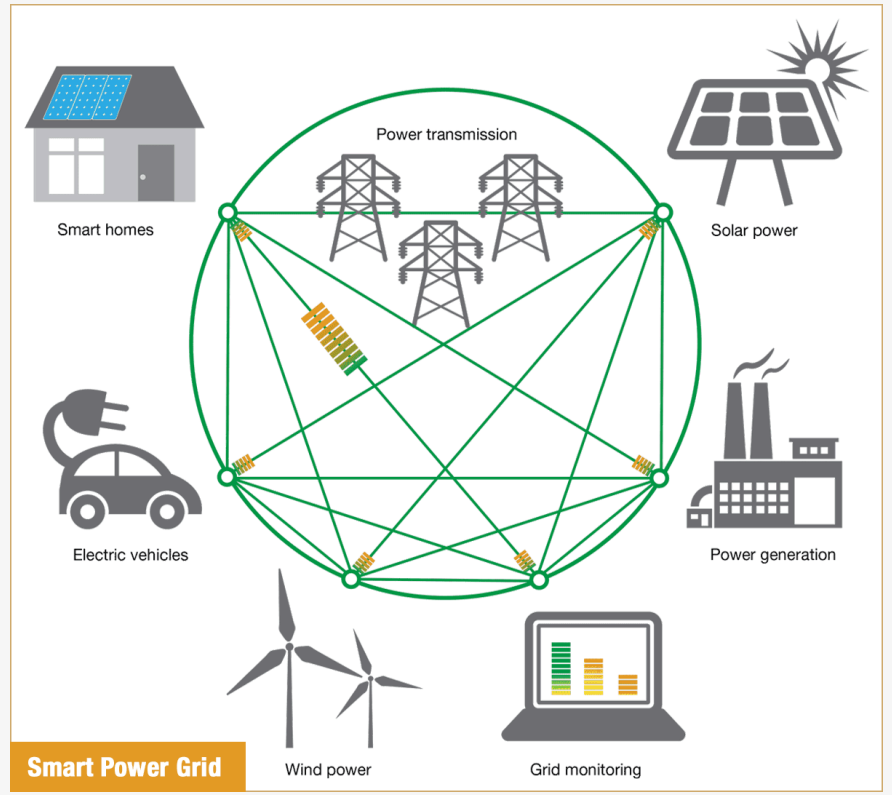
The history of changes in the Power systems





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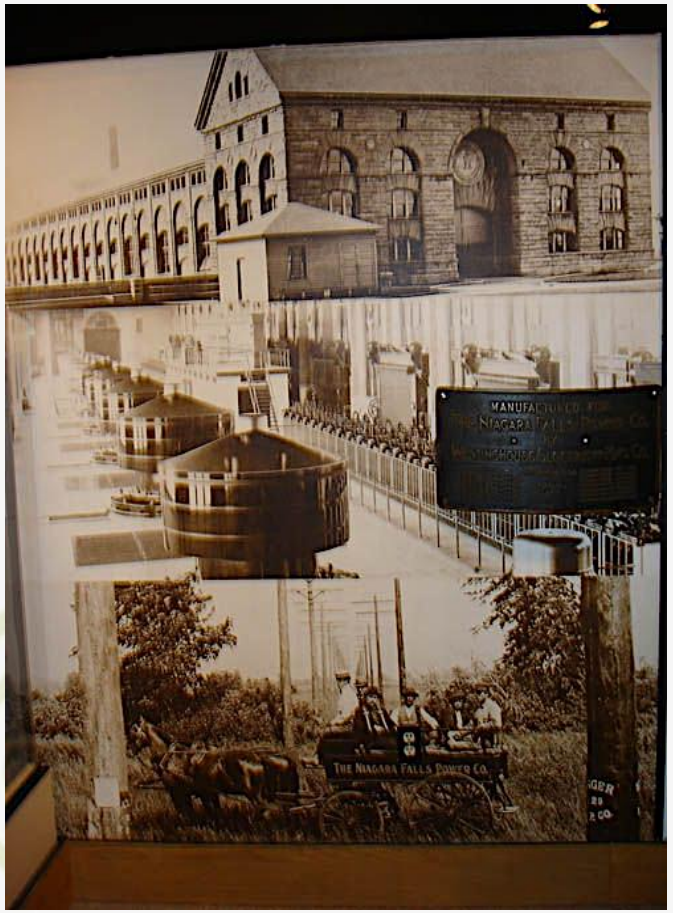
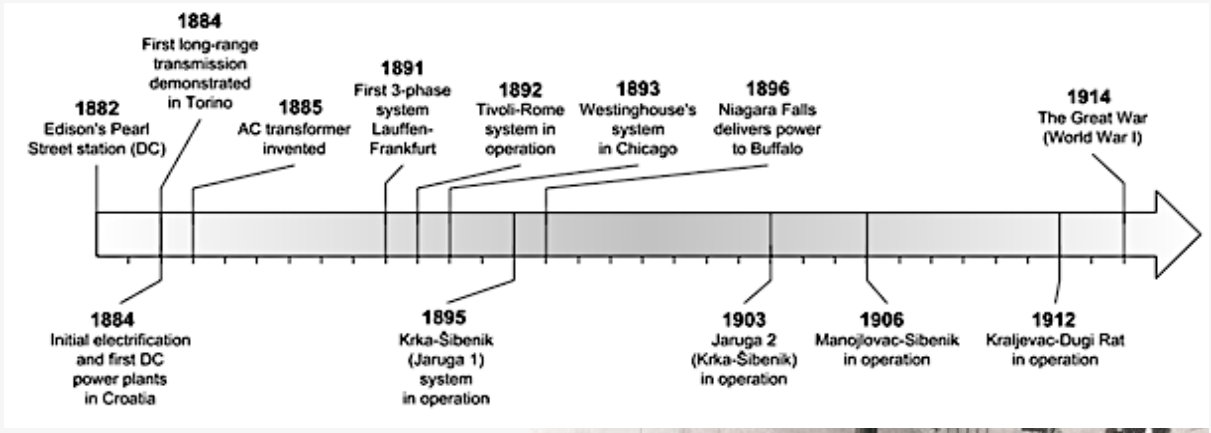
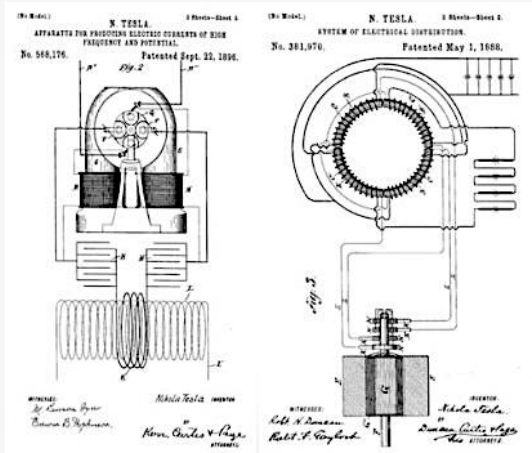
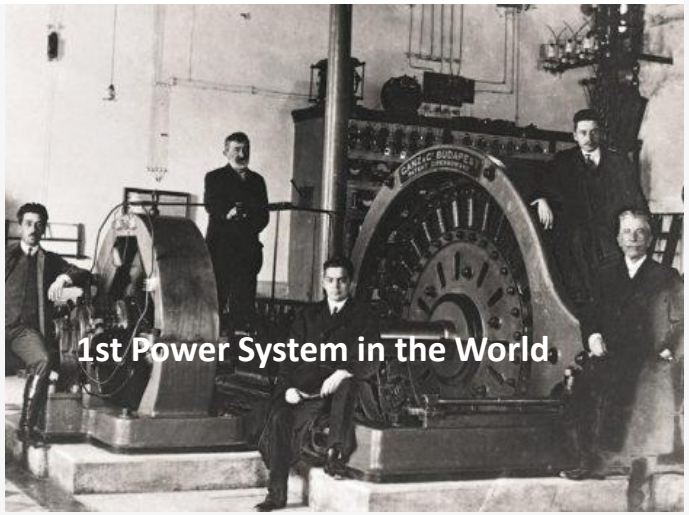
Energy 1.0: To make it work (1890 - 1920)









Šibenik

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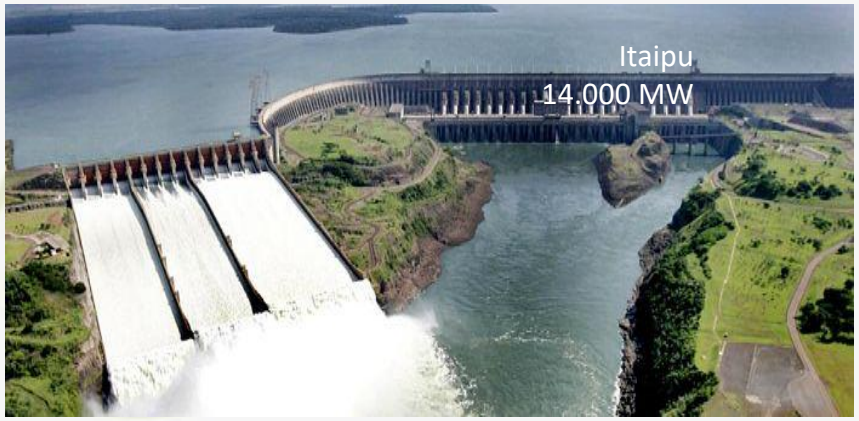
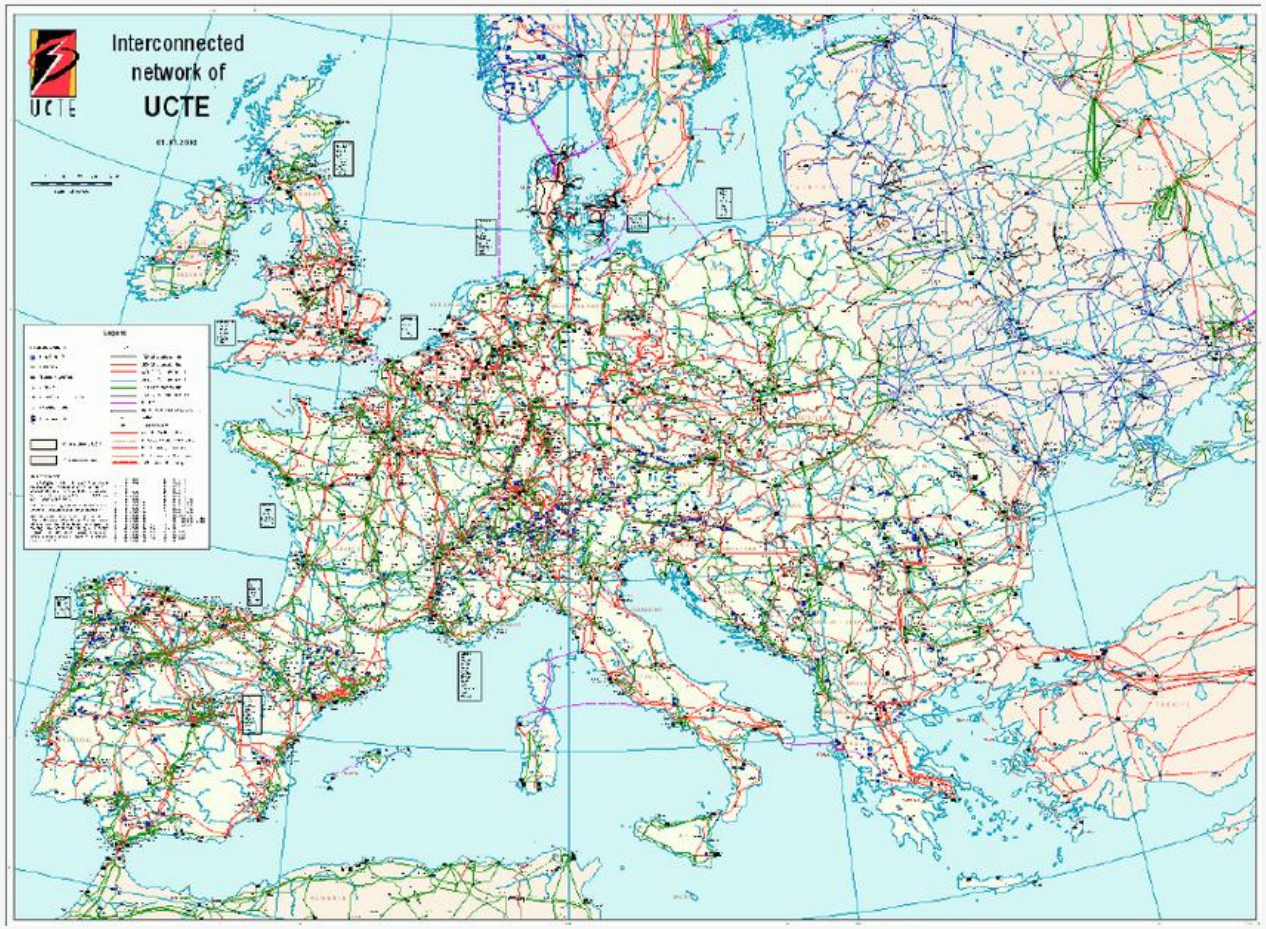
Energy 2.0: To make it big and affordable (1920-1990)





Over of 1 TW

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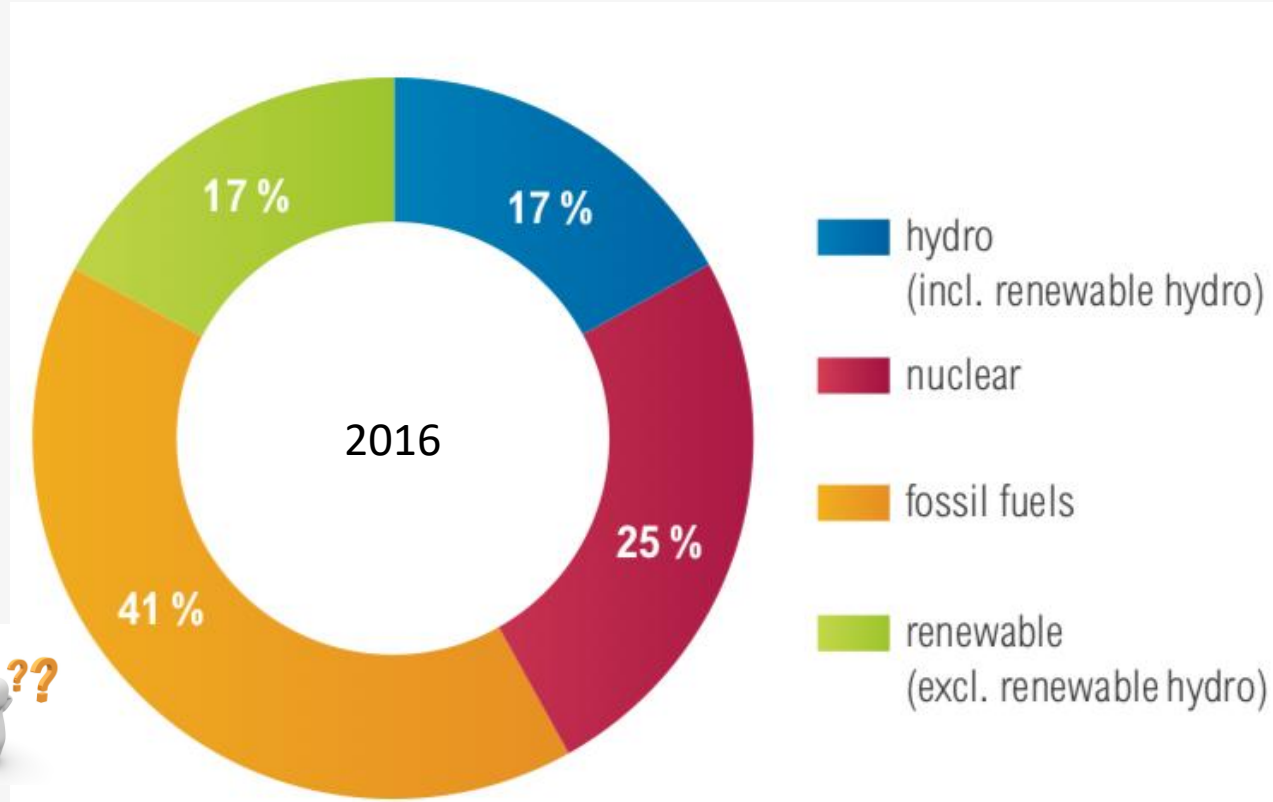
Energy 3.0: To make it sustainable, market based and still affordable (from 1990)



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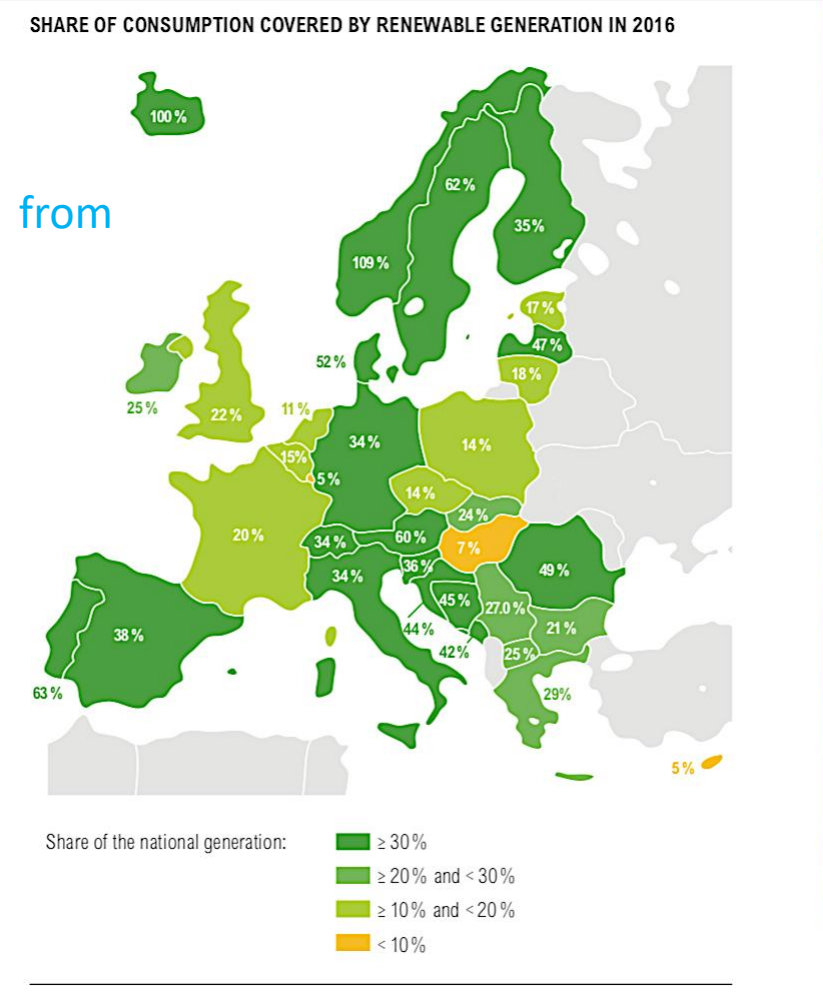
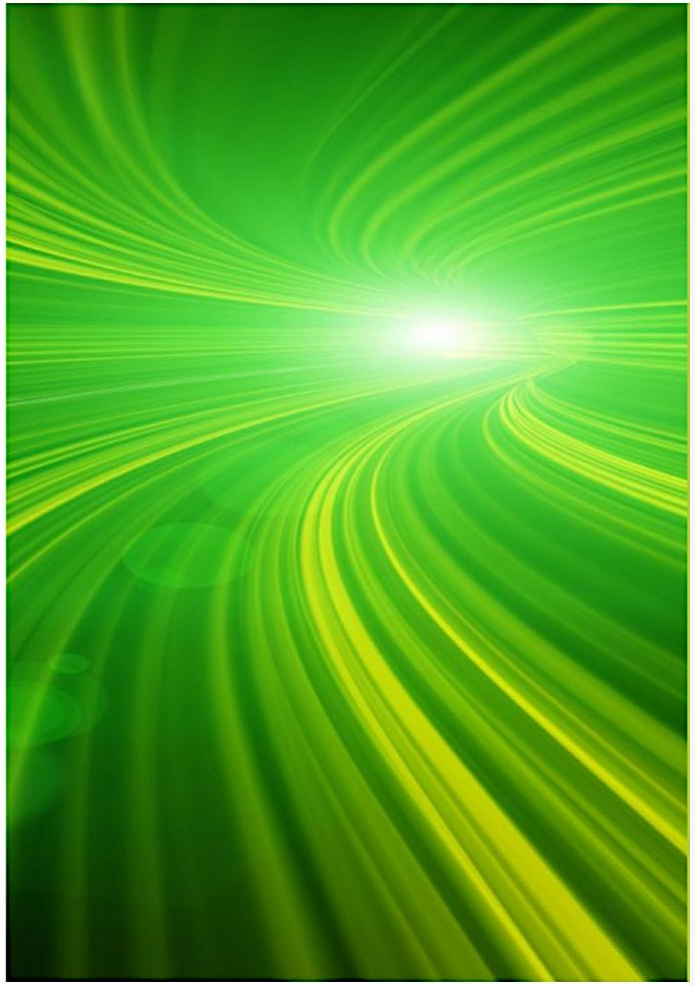
Energy 4.0: To make it SMART, environmentally friendly, sustainable, market based, and still affordable …

od …

from





Till ???

https://docstore.entsoe.eu/Documents/Publications/Statistics/electricity_in_europe/entsoe_electricity_in_europe_2016_web.pdf

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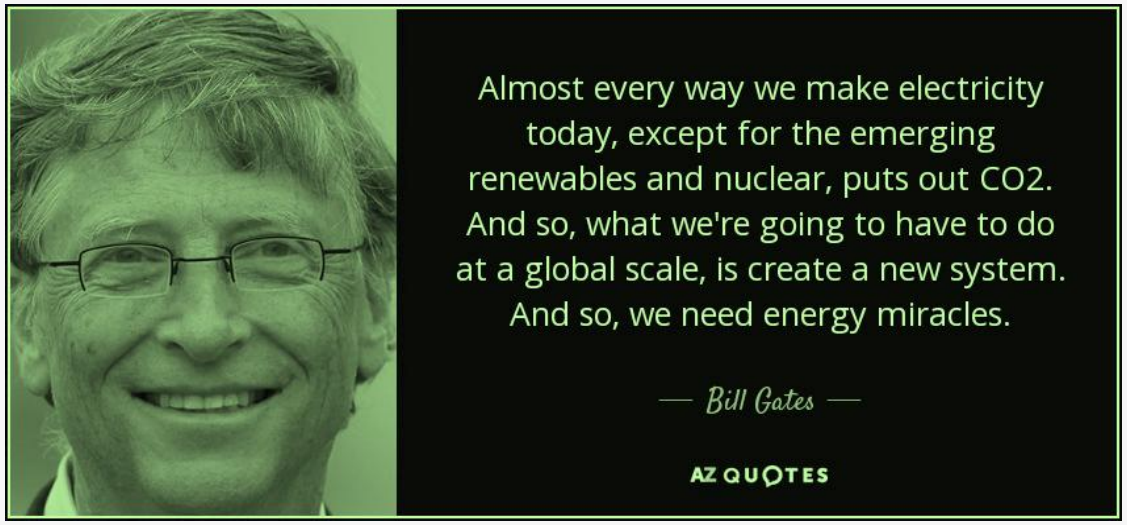
The new energy system Energy 4.0 … is “simply” smart and green



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If the answer is yes, the question is HOW

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The Power system

General

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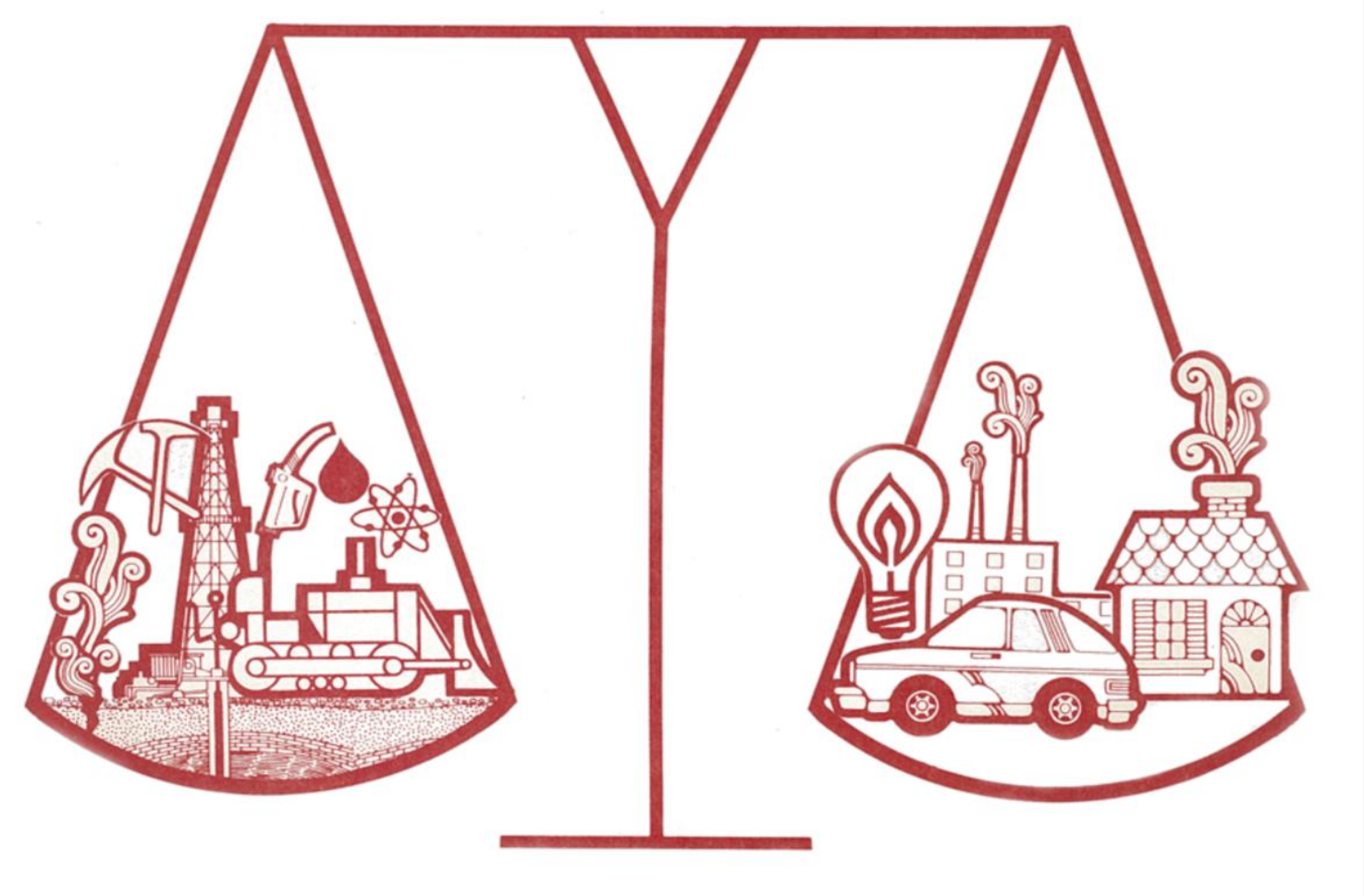
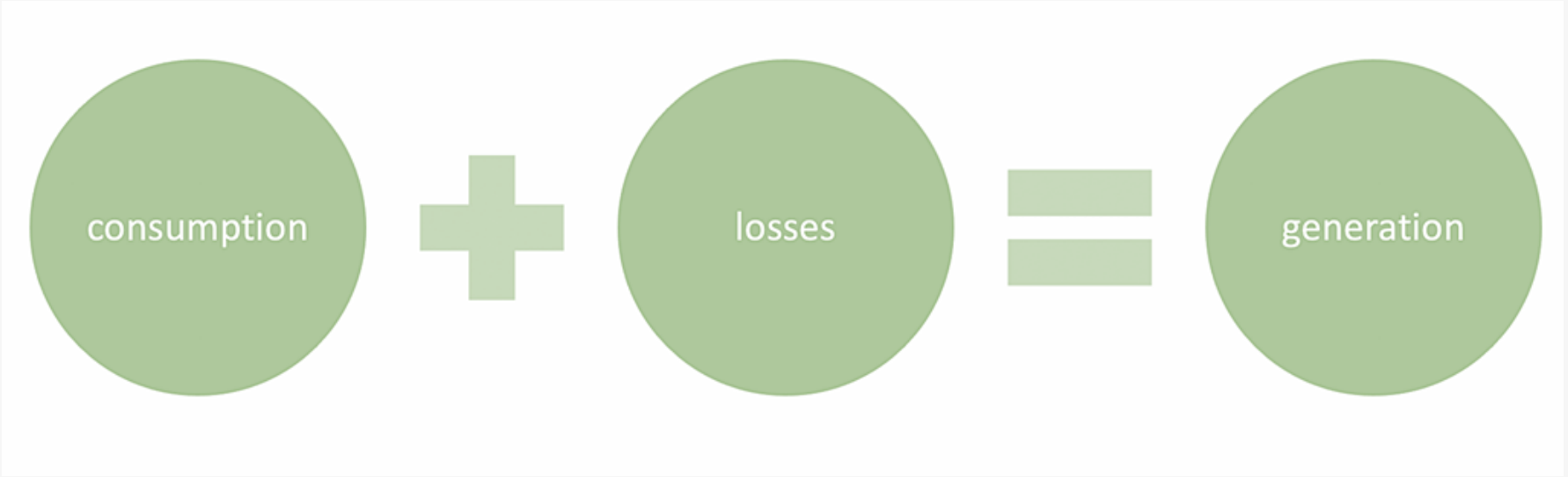
Production and consumption balance (1)



Source: https://coloradogeologicalsurvey.org/publications/energy-balance-colorado-1981/

Project co-funded by the Europen Union (ERDF, IPA).

Production and consumption balance (2)



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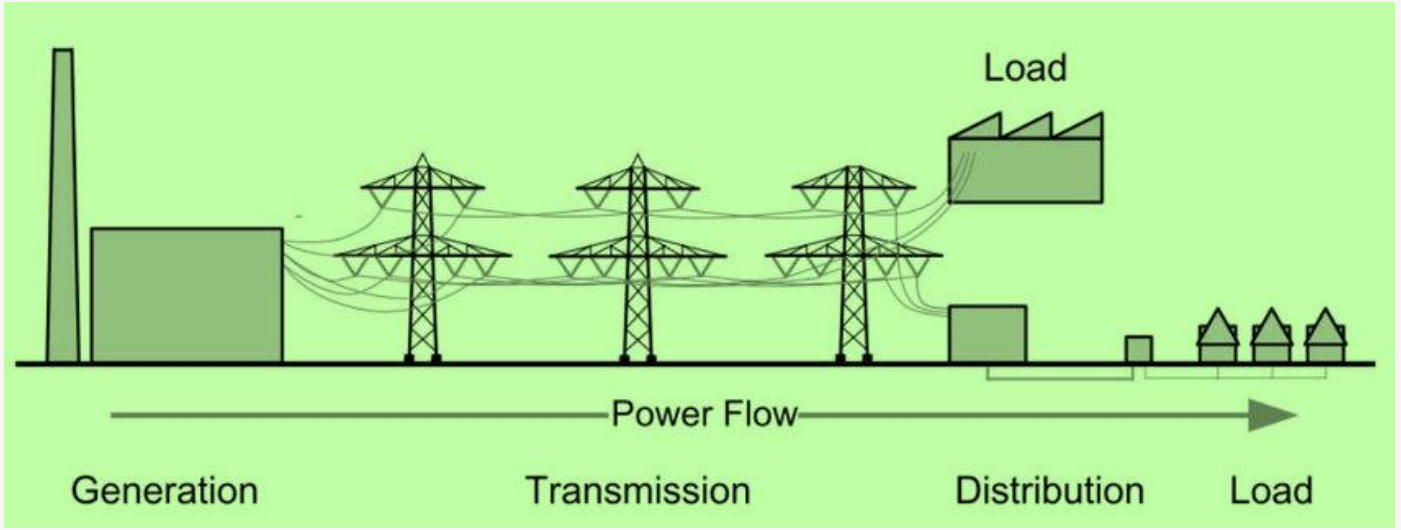
Traditional power system division

- Generation
- Transmission
- Distribution
- Consumption

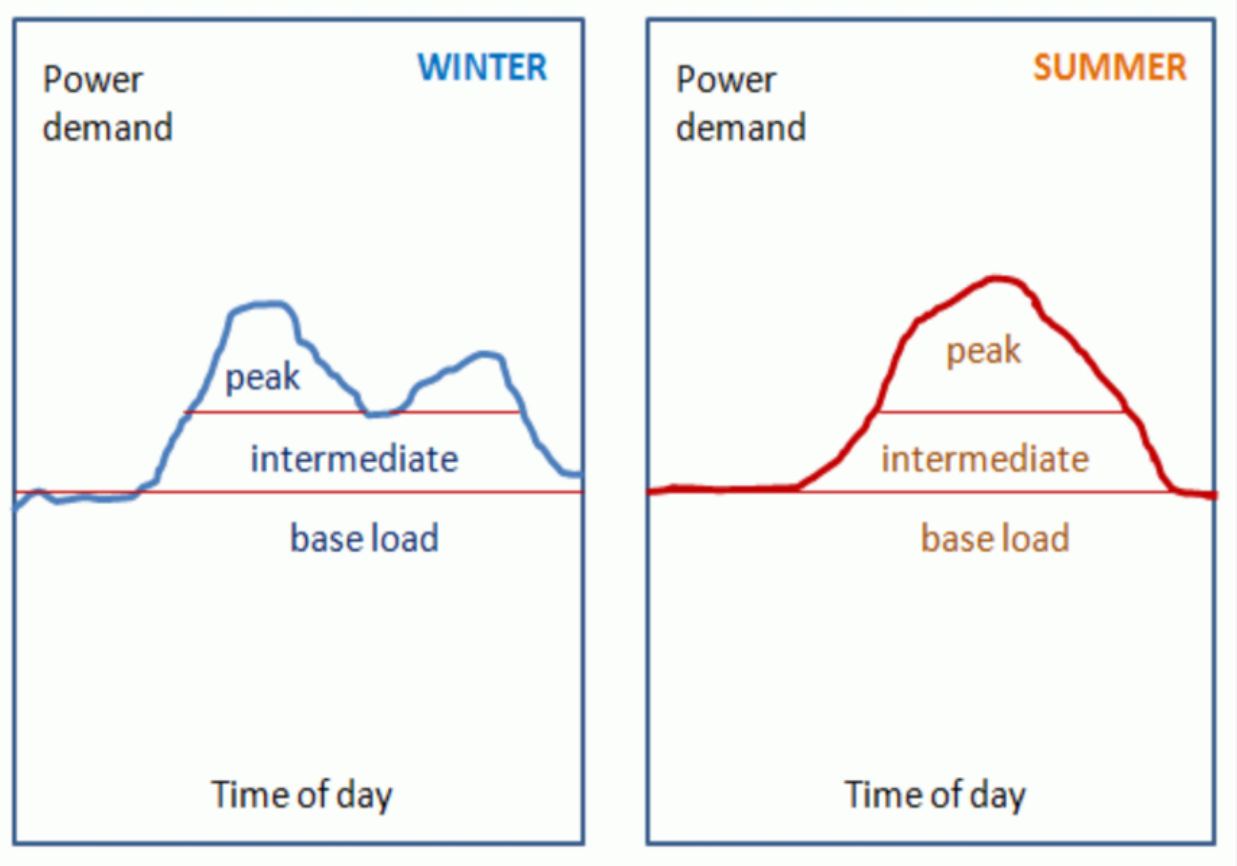


Source: https://www.researchgate.net/figure/Traditional-power-system-structure-1_fig22_320626855

Project co-funded by the Europen Union (ERDF, IPA).

Typical daily power demand curves

- Daily load curve predictions
- Base, intermediate and peak load

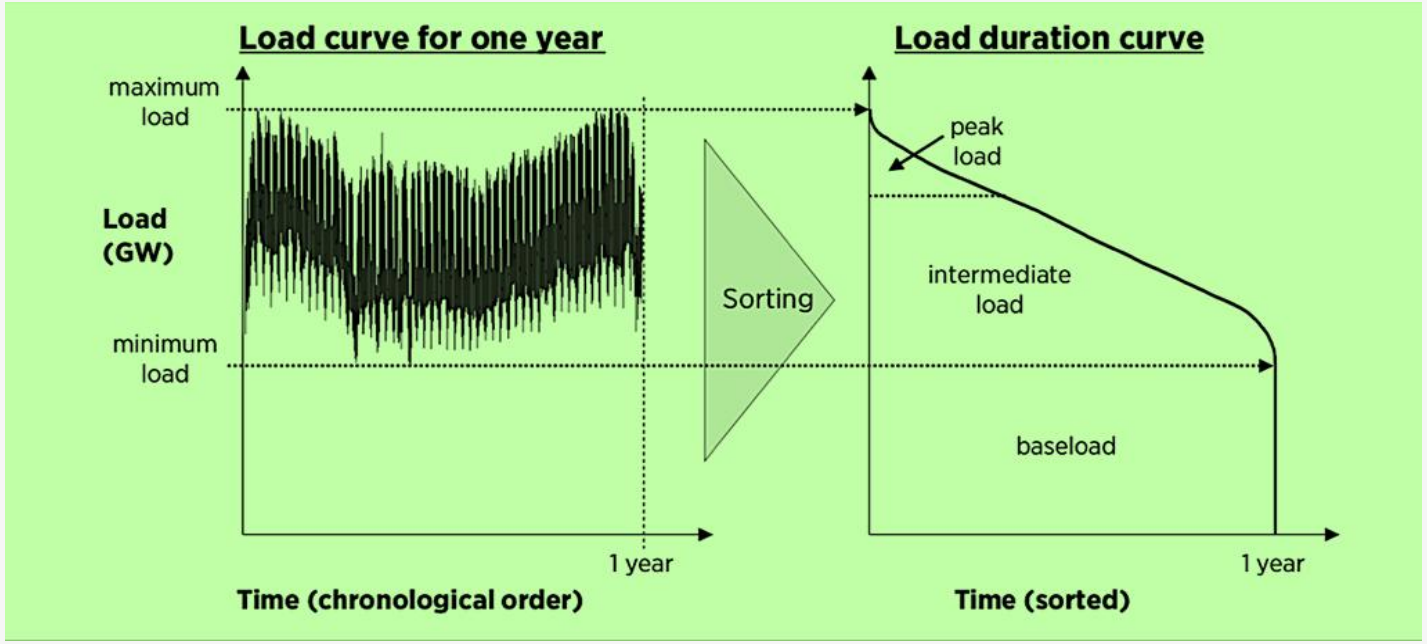


Source: https://www.e-education.psu.edu/eme807/node/667

Project co-funded by the Europen Union (ERDF, IPA).

Example of a yearly load curve

- The yearly load curve of Electrical Power System
- Shows the time during which base, intermediate and peak load occur

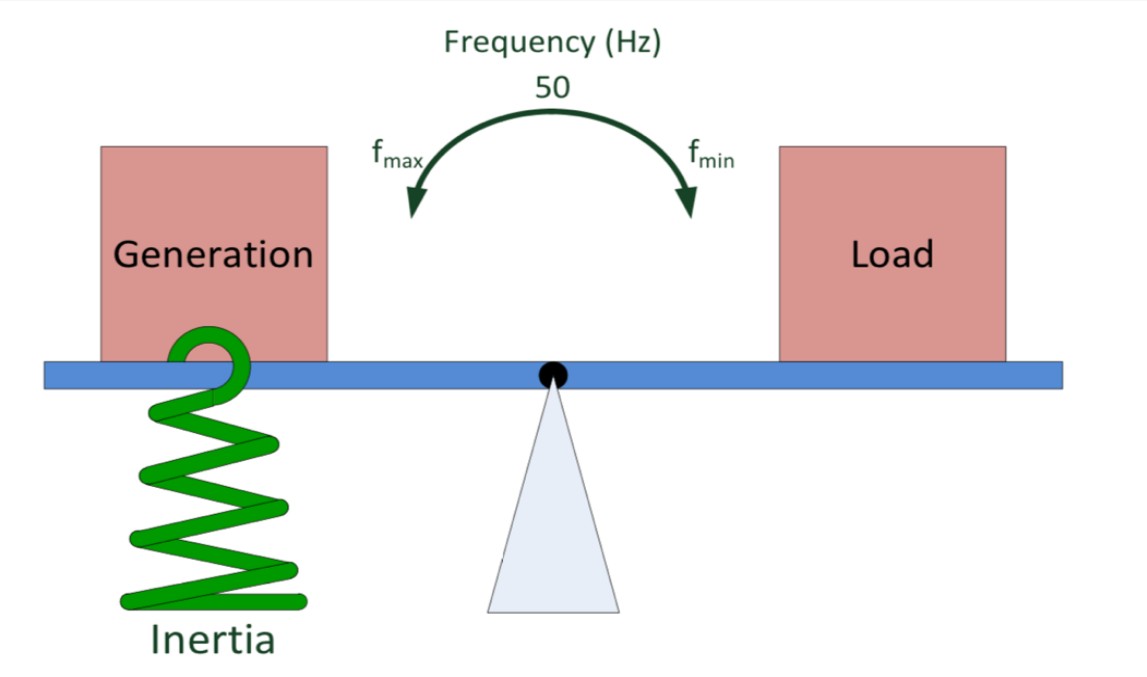


Source: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_Baseload_to_Peak_2015.pdf

Project co-funded by the Europen Union (ERDF, IPA).

Power system inertia (1)

- Interconnected grids
- Same frequency and phase
- High physical inertia - helps with balancing

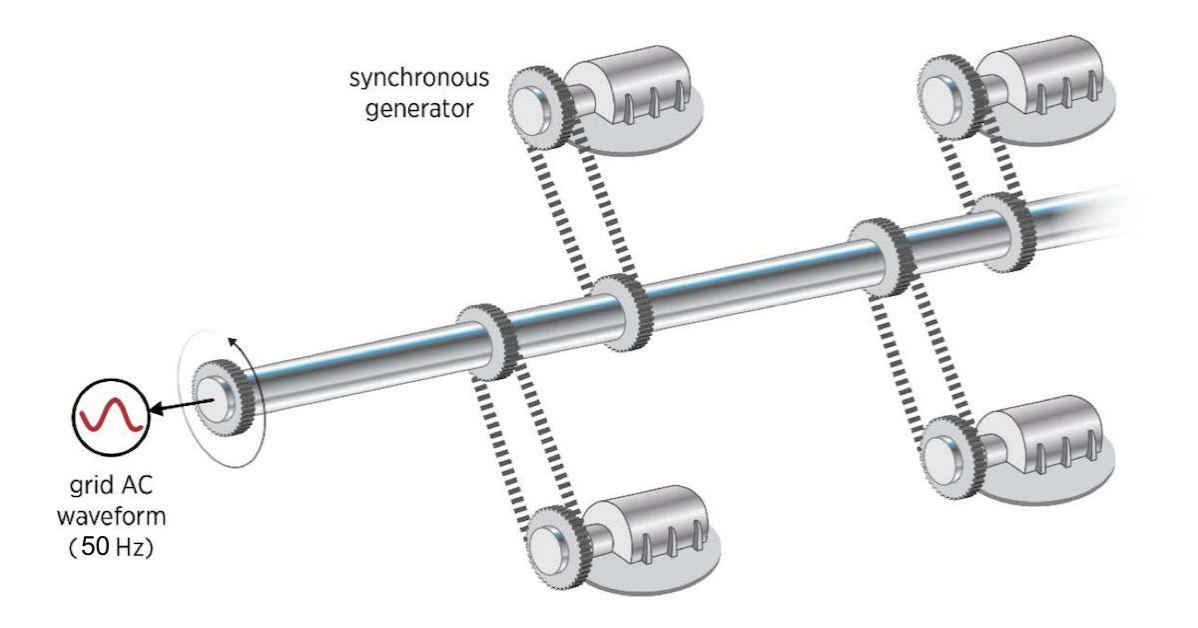


Source: https://www.diva-portal.org/smash/get/diva2:1369967/FULLTEXT01.pdf

Project co-funded by the Europen Union (ERDF, IPA).

Power system inertia (2)

- Synchronous generators - provide inertia via their rotating masses
- Helps maintain the frequency and ensures grid security
- Necessary in case of sudden disturbances

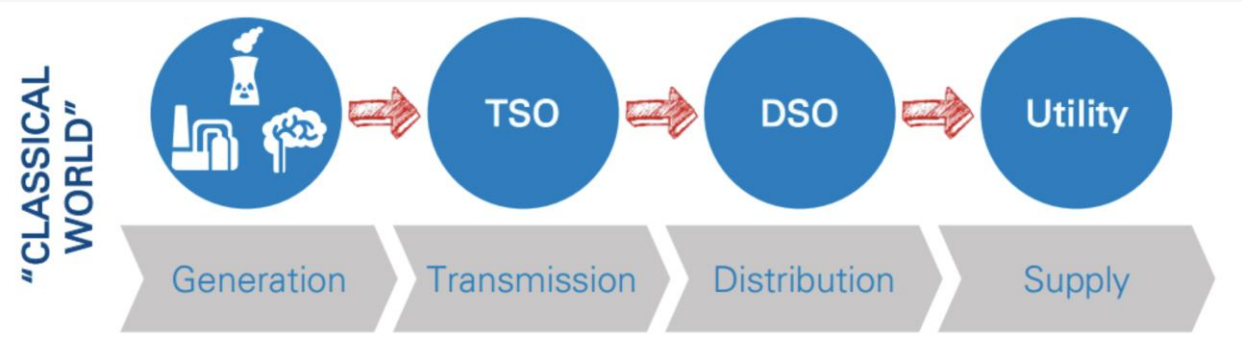


Source: https://www.nrel.gov/docs/fy20osti/73856.pdf

Project co-funded by the Europen Union (ERDF, IPA).

TSO's and DSO's

- Ensuring security of supply and quality of service
- Consumption prediction
- Market clearing
- Redispatch



Source: http://www.adlittle.cn/en/insights/viewpoints/what's-next-tsos

Project co-funded by the Europen Union (ERDF, IPA).

Classical power system's challenges (1)

- Growing energy demand
- High greenhouse gas emissions
- High dependence on imported raw materials for energy production
- Increase in peak electricity demand
- Growing number of decentralised renewables in the energy mix - stability issues

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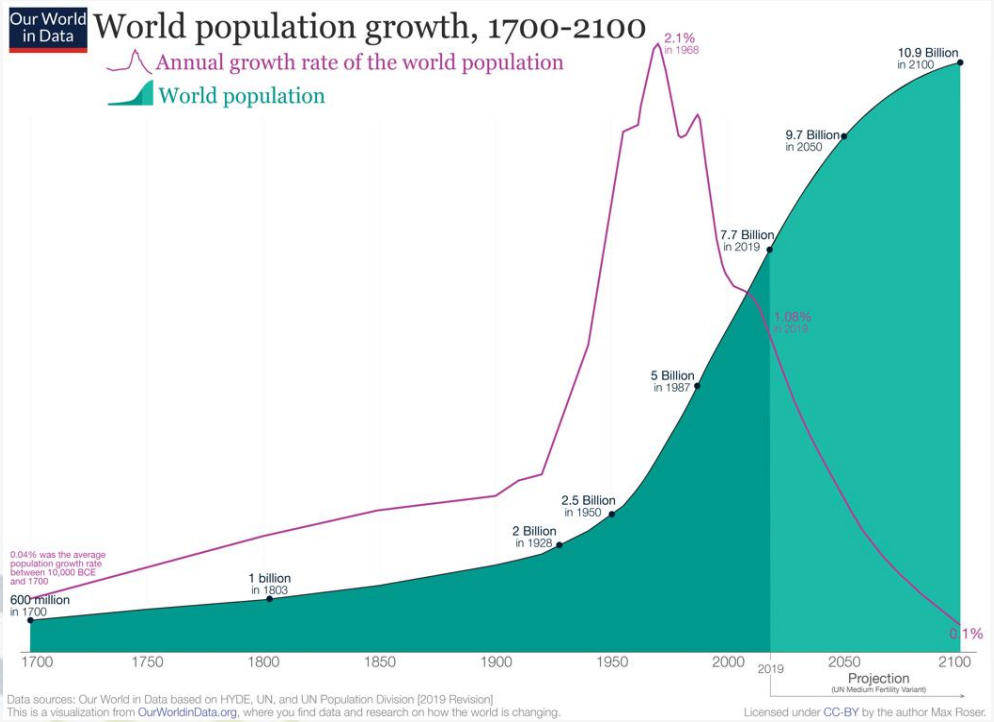
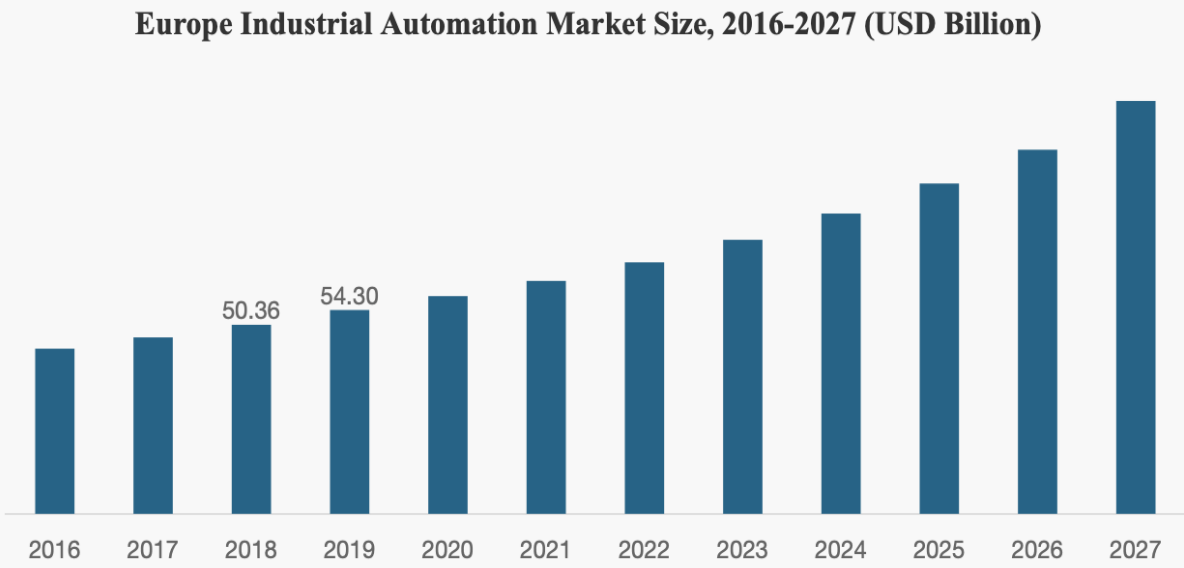
Classical power system's challenges (2)

- Reliability challenges
  - Supply interruptions
  - VoLL (Value of Lost Load)
- Growing number of EV's
- No consumer participation - passive consumption
- Manual monitoring and restoration

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 1: Growing energy demand



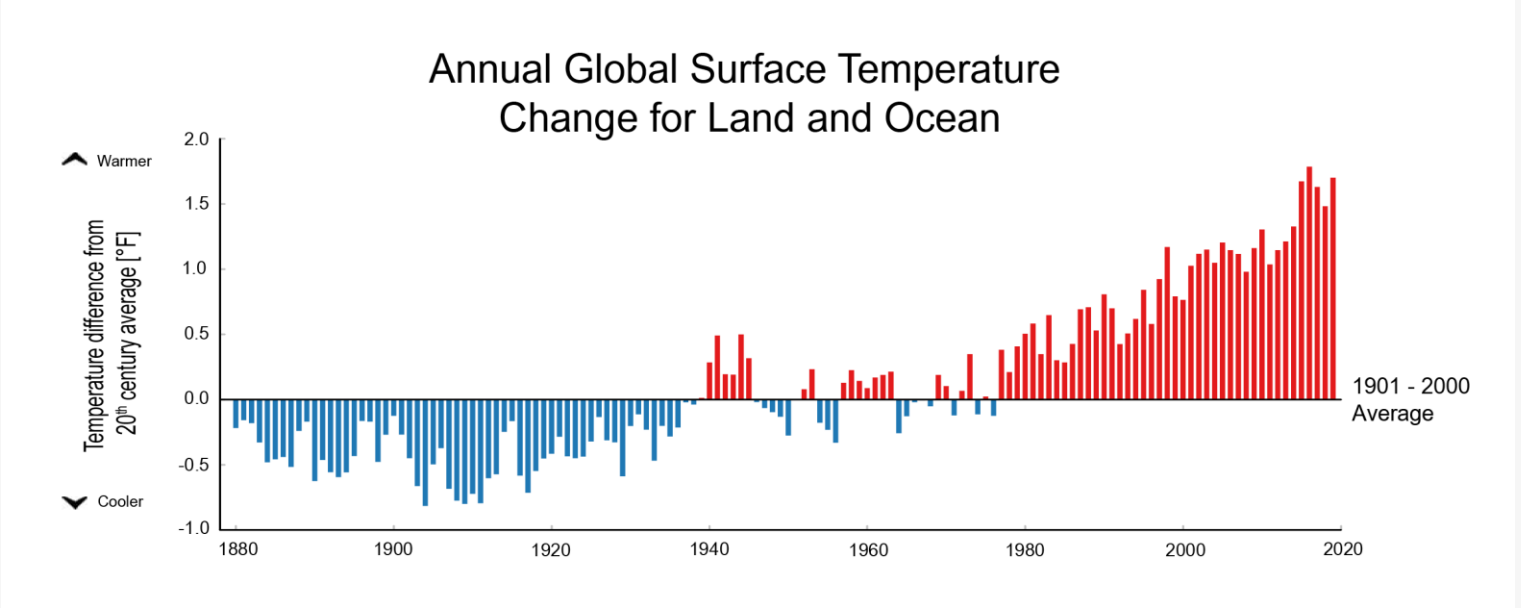


Project co-funded by the Europen Union (ERDF, IPA).

Sources: https://ourworldindata.org/future-population-growth : https://www.fortunebusinessinsights.com/industry-reports/industrial-automation-market-101589

Challenge 2: High greenhouse gas emissions (1)

- Climate change - the defining issue of our time
- Large scale global impacts
- Average global temperature rise of 1.5℃ above pre-industrial levels ????



Source: https://www.globalchange.gov/browse/indicators/global-surface-temperatures

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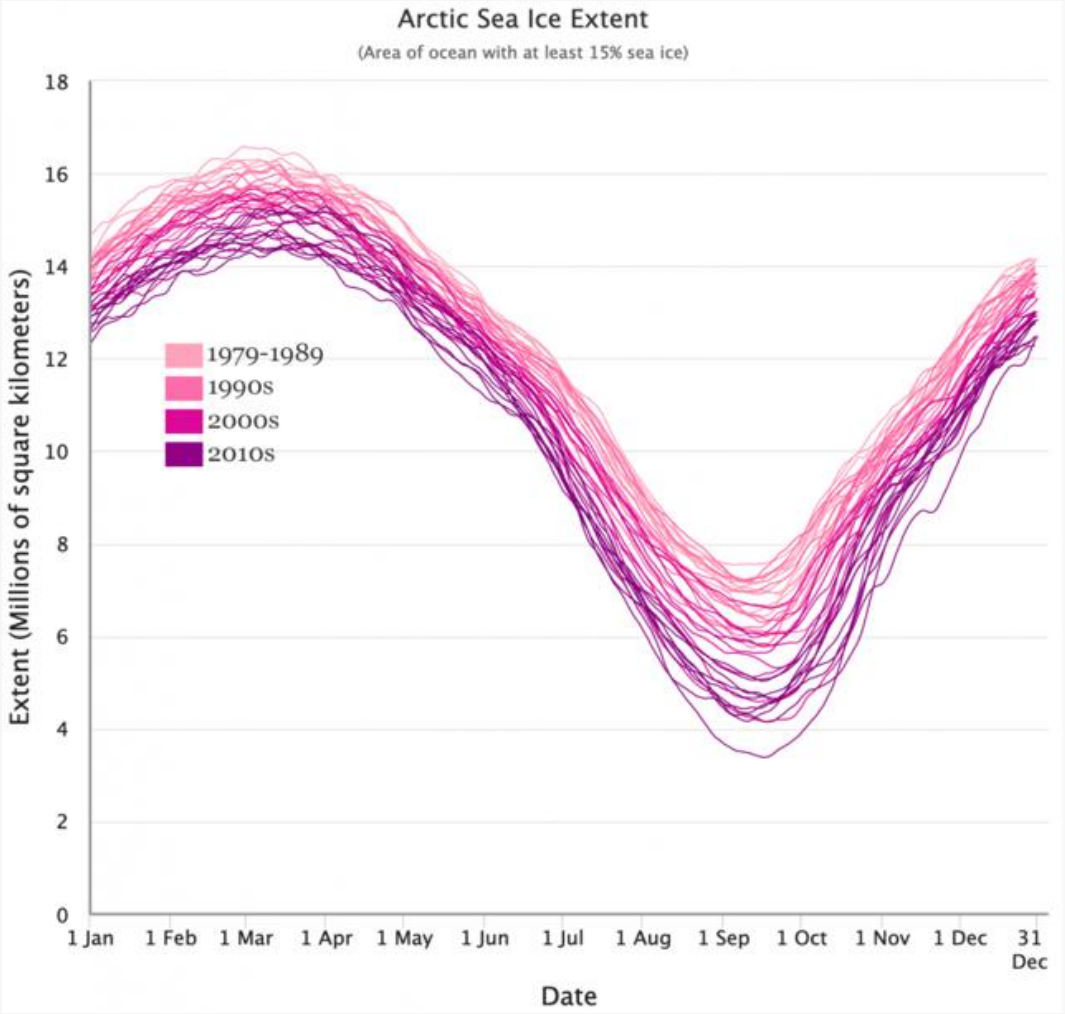
Challenge 2: High greenhouse gas emissions (2)

- Polar regions - more drastic temperature change
- Arctic amplification – Arctic warmed at twice the speed
- Nearly 4°C from 1960
- Ice and snow cover decrease



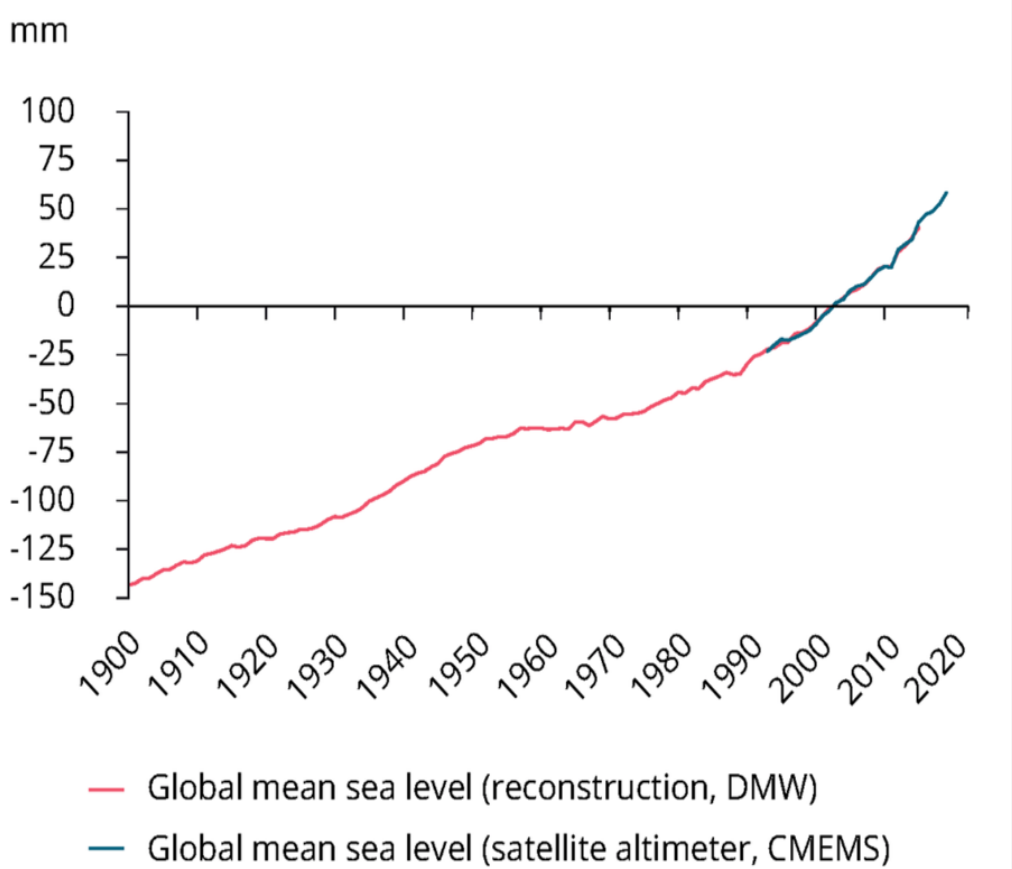
Source: https://nsidc.org/cryosphere/arctic-meteorology/climate_change.html

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 2: High greenhouse gas emissions (3)

- Oceans warming
- 19cm sea level rise from 1901 to 2010
- Predicted 40cm - 63cm rise by 2100

Observed change in global mean sea level



Source: https://www.eea.europa.eu/data-and-maps/indicators/sea-level-rise-7/assessment

Project co-funded by the Europen Union (ERDF, IPA).

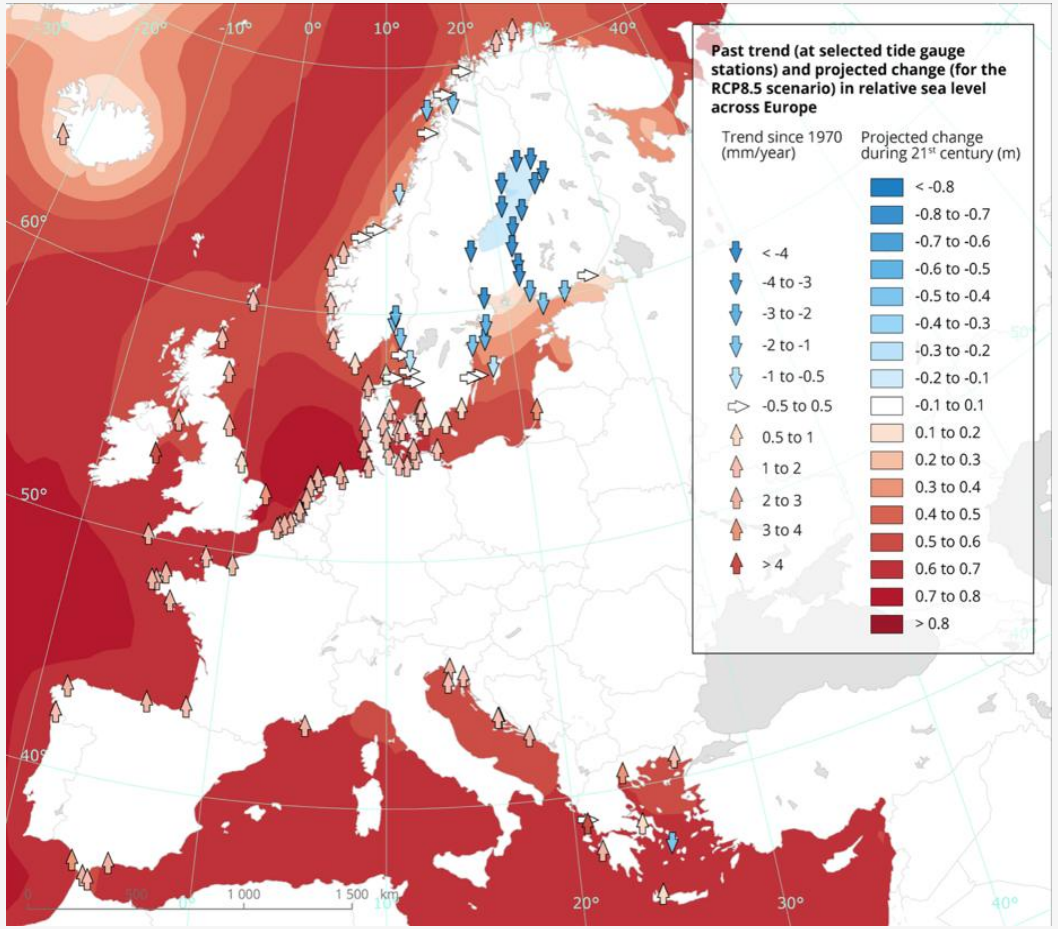
National Geographic
Prediction in February 2014: increase 4°C

4° Turn Down the Heat
Why a 4°C Warmer World Must be Avoided

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 2: High greenhouse gas emissions (4)

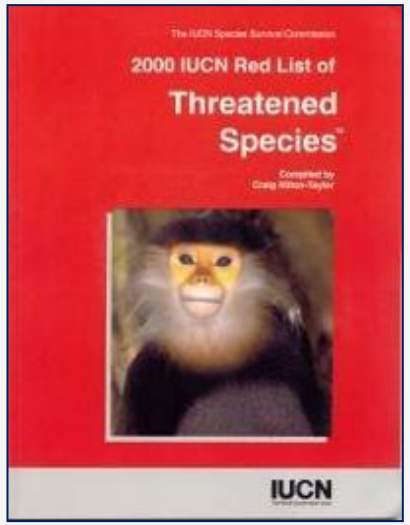
- Rising temperatures affect animal species
- Increased risk of floods, droughts, wildfires, drinking water shortage, hurricanes and typhoons

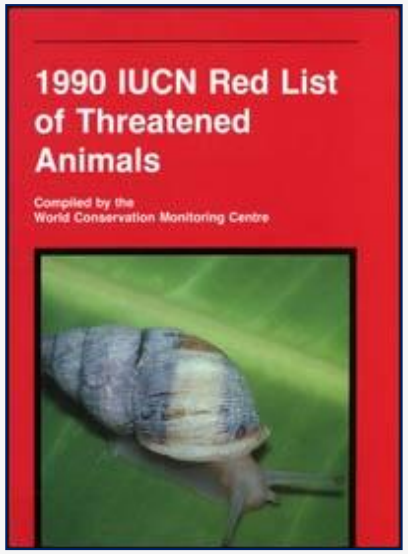


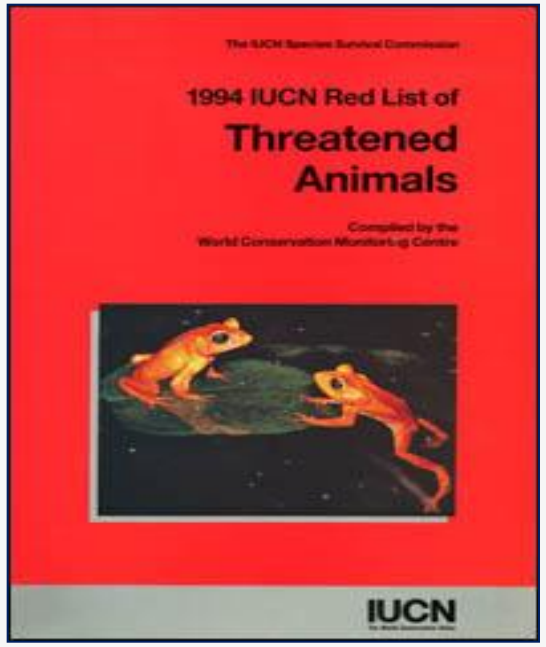
Source: https://www.eea.europa.eu/data-and-maps/indicators/sea-level-rise-7/assessment

Project co-funded by the Europen Union (ERDF, IPA).

Red lists







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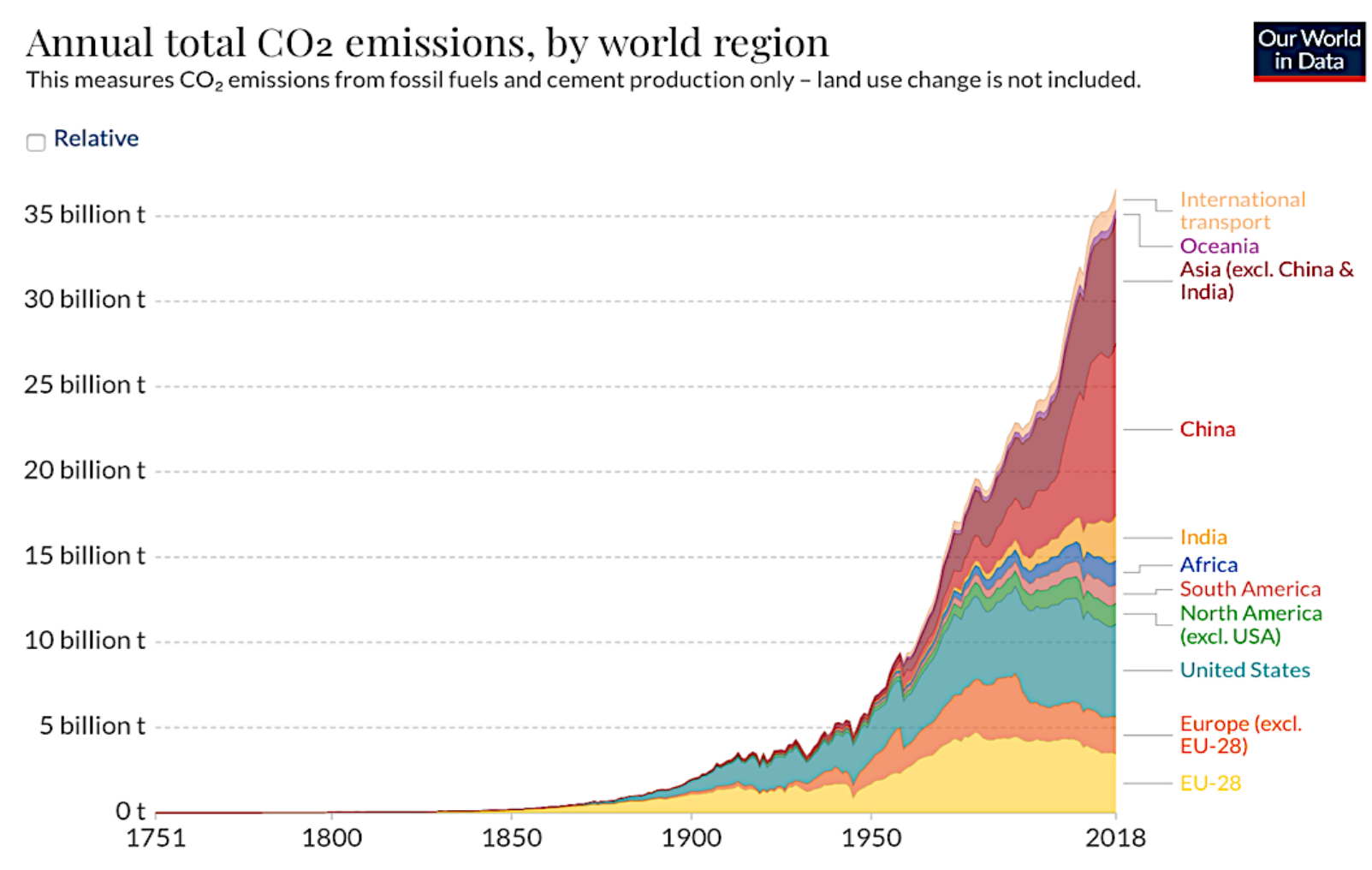
Challenge 2: High greenhouse gas emissions (5)

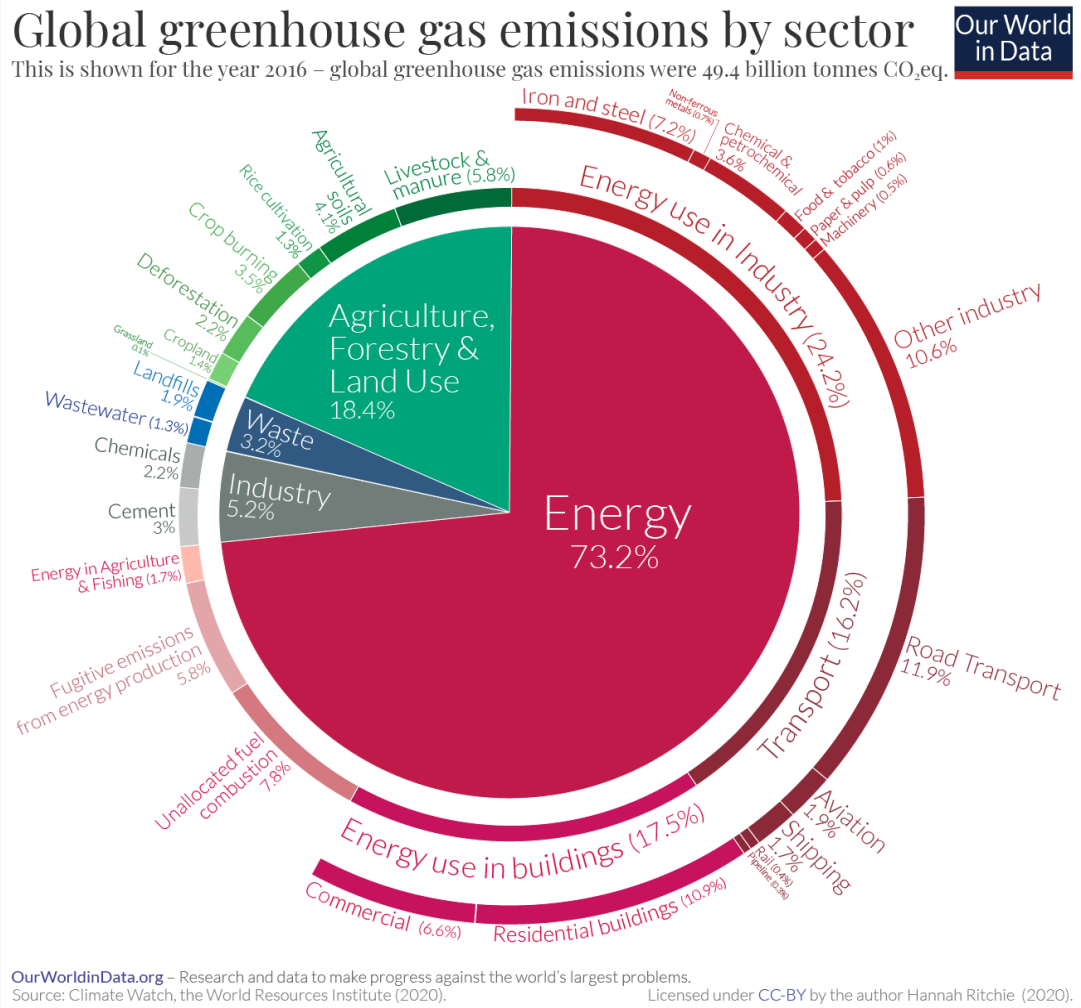


Source: https://ourworldindata.org/grapher/annual-co-emissions-by-region?time=earliest..latest

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 2: High greenhouse gas emissions (6)

- Energy sector - most emission contribution
- 73.2% of emissions
- Coal fired electricity - 30% of global CO2 emissions in 2019
- 2/3 of the increase in global emissions in 2018 from the power sector



Source: https://ourworldindata.org/ghg-emissions-by-sector

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 2: High greenhouse gas emissions (7)

- Negative
  - additional generation od over 100 TWh in 2018 - 2/3 of GHG emissions increase due to additional generation from fossil-fuel power plants
  - China, India and the USA - 85% of net increase in emissions from fossil-fuel electricity generation
- Positive
  - Germany, Japan, Mexico, France and the UK - lowered emissions due to high RES integration
  - combined savings from renewables in Europe and China - 2/3 of global avoided emissions

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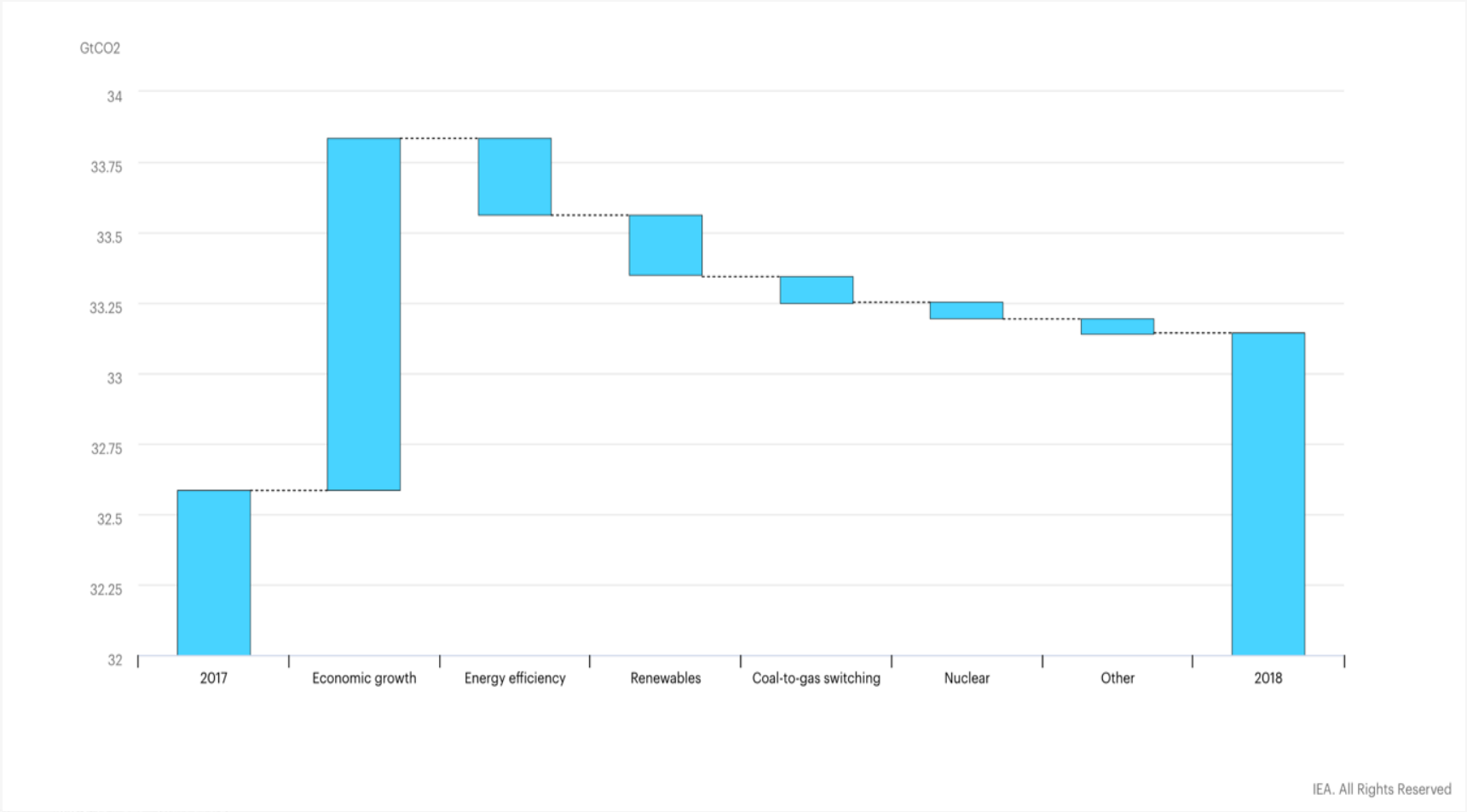
Challenge 2: High greenhouse gas emissions (8)

Change in global energy-related CO2 emissions and avoided emissions, 2017 – 2018



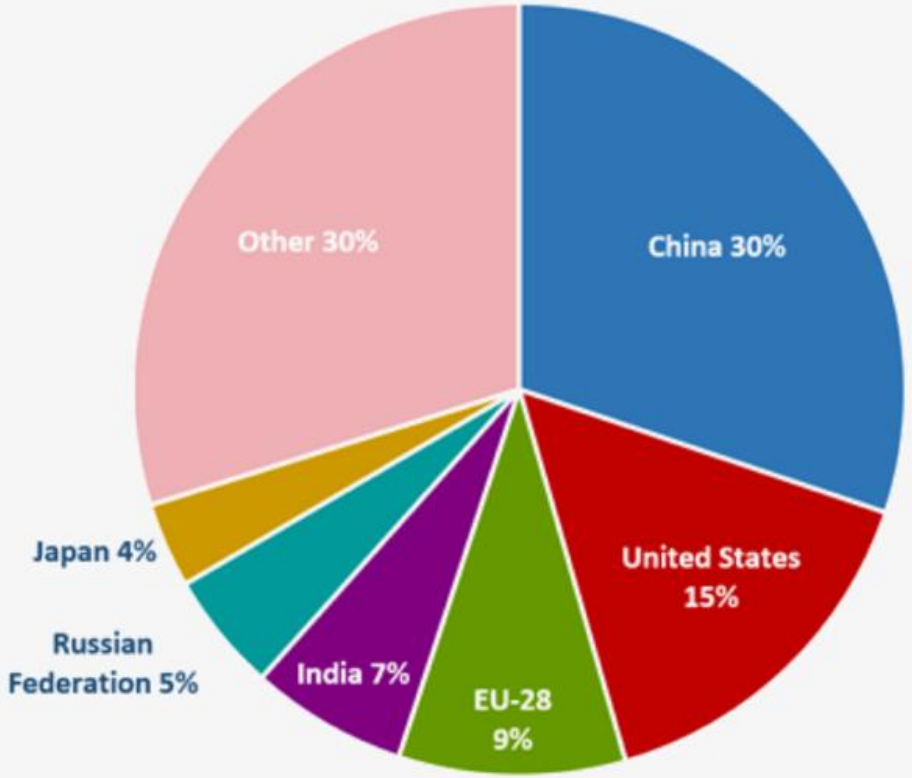
Source: https://www.iea.org/data-and-statistics/charts/change-in-global-energy-related-co2-emissions-and-avoided-emissions-2017-2018

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 2: High greenhouse gas emissions (9)

- EU – limiting global warming to 1.5°C
- EU – 6.66% of global population – 9% of GHG emissions in 2014

Global CO_2 emissions by country or region, 2014



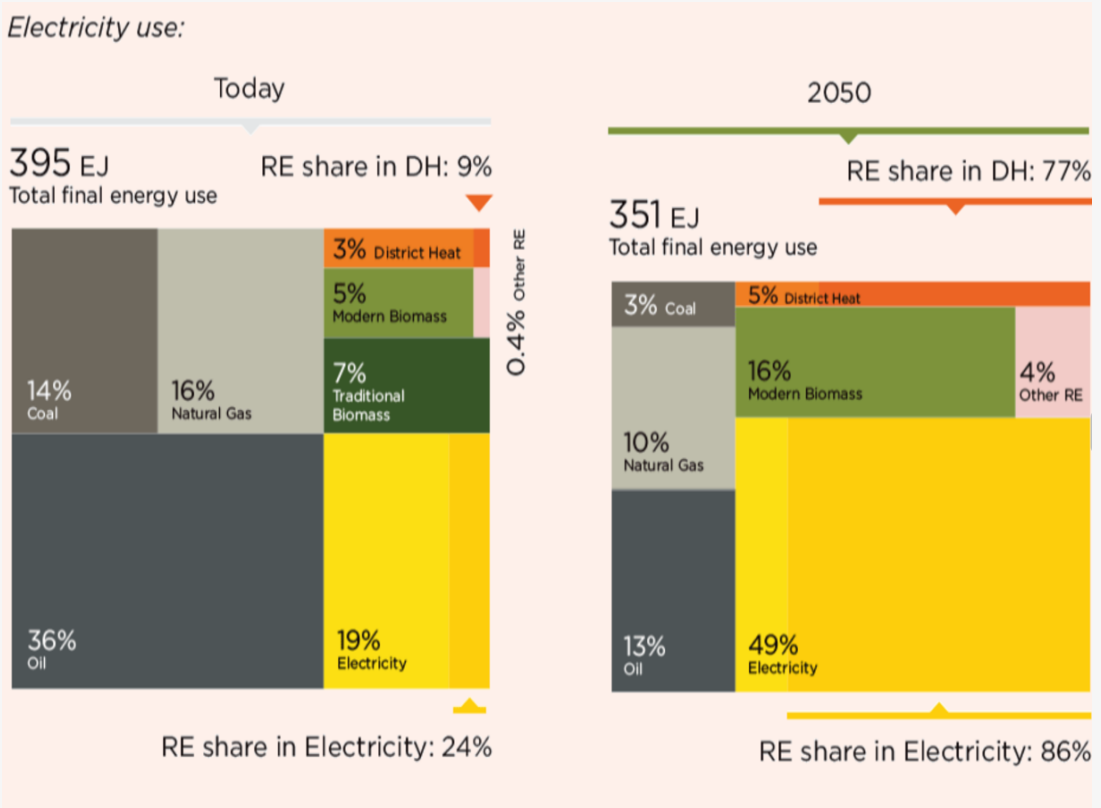
Source: https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 2: High greenhouse gas emissions (10)

- Electrification of transportation, building and industrial sectors
  - Great GHG emission reductions
  - 90% of necessary GHG reductions by 2050 if used with RES
  - Potentially detrimental to current power grid (smart grid solutions)

Electrification projects by 2050

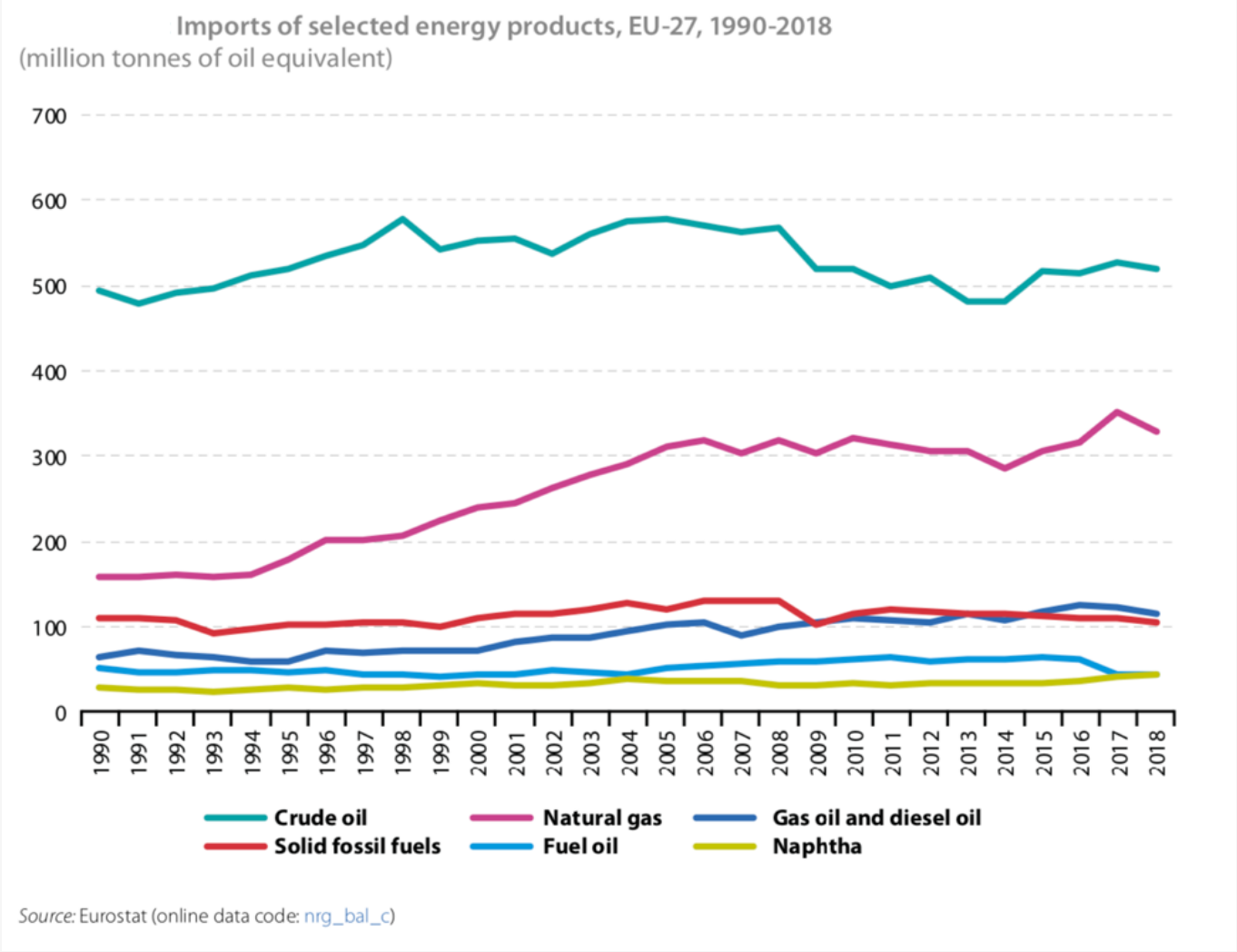


Source: https://www.irena.org/DigitalArticles/2019/Apr/How-To-Transform-Energy-System-And-Reduce-Carbon-Emissions

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 3: High dependence on imported raw materials for energy production (1)

- None of the EU member states have a positive energy balance
- 2018 - EU imported 58% of energy from abroad

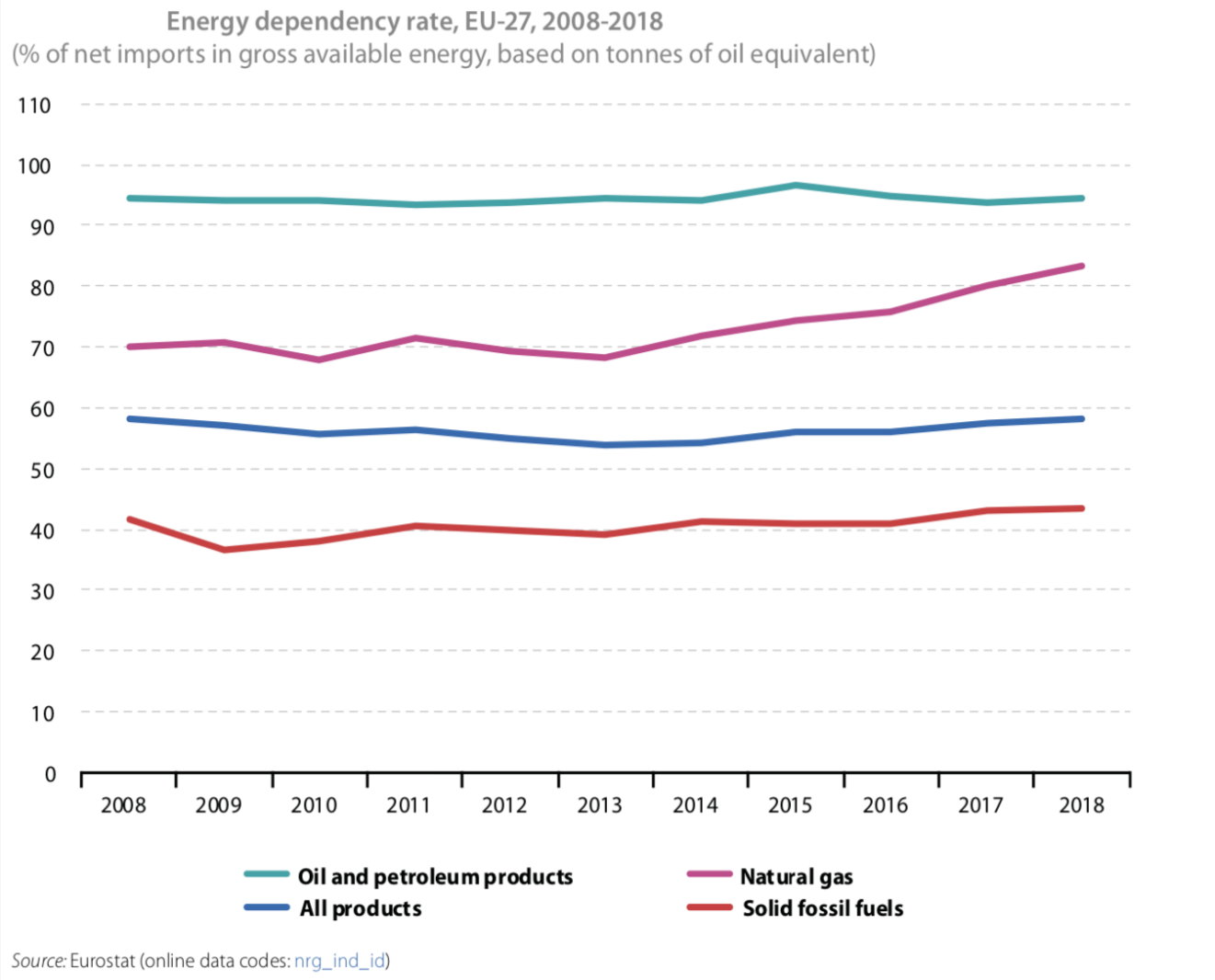


Source:https://ec.europa.eu/eurostat/documents/3217494/11478276/KS-DK-20-001-EN-N.pdf/06ddaf8d-1745-76b5-838e-013524781340?t=1605526083000

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 3: High dependence on imported raw materials for energy production (2)

- 2018 dependency on:
  - Oil and petroleum products - 94,6%
  - Natural gas - 83,2%
- Transport sector:
  - Biggest driver - 2/3 of final oil demand
  - Biggest GHG emitter in the EU



Source:https://ec.europa.eu/eurostat/documents/3217494/11478276/KS-DK-20-001-EN-N.pdf/06ddaf8d-1745-76b5-838e-013524781340?t=1605526083000

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 3: High dependence on imported raw materials for energy production (3)

- 2009 natural gas import crisis - example that highlights dangers of energy dependency
- Energy dependency - big challenge to energy security
- Strategies to lower dependency:
  - Reducing usage of fossil fuels
  - Increasing available on sight production - mainly renewables
  - Electrification of the transport sector
  - Implementation of smart grids

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Challenge 4: Increase in peak electricity demand (1)

- By the end of the century:
  - Cooling electricity consumption rise - 156% ↑
  - Net electricity consumption rise - 17%
  - Rising peak demand
- Problems with higher peak demand:
  - Added stress on the system
  - Higher reserve margins needed to avoid outages
  - More difficult system management

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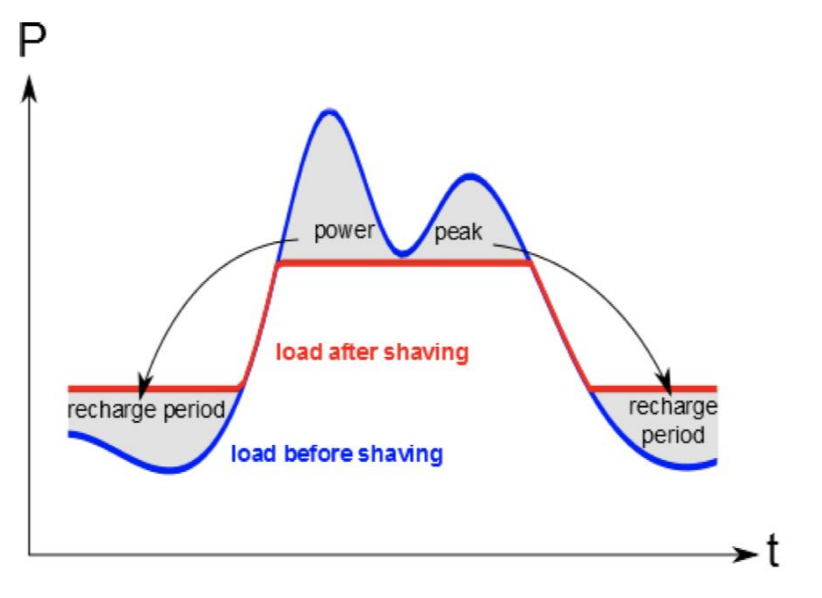
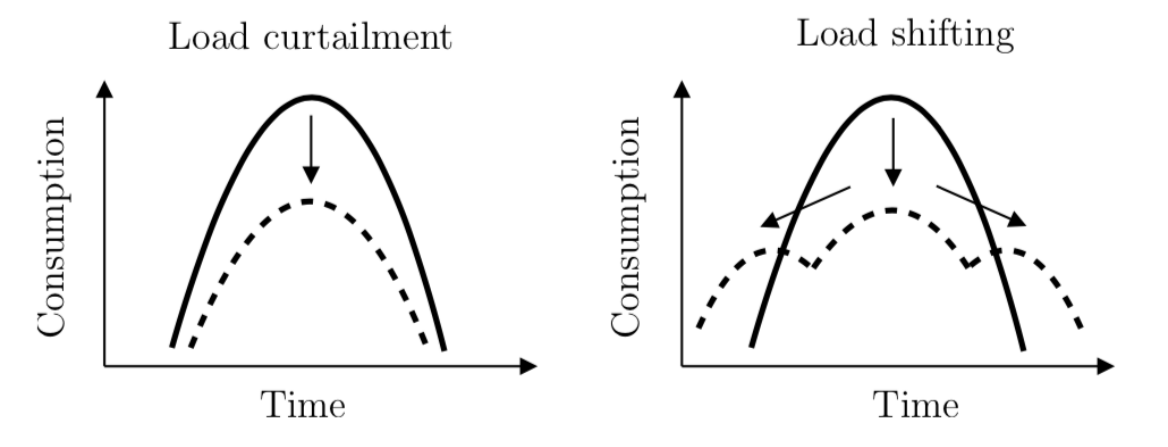
Challenge 4: Increase in peak electricity demand (2)

Peak shaving using energy storage systems



Peak shaving and shifting using demand side management



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Sources: https://www.sandia.gov/ess-ssl/EESAT/2013_papers/Peak_Shaving_Control_Method_for_Energy_Storage.pdf , https://www.researchgate.net/publication/337023176_Leveraging_Consumers%27_Flexibility_for_the_Provision_of_Ancillary_Services

Challenge 5: Growing number of decentralised renewables in the mix (1)

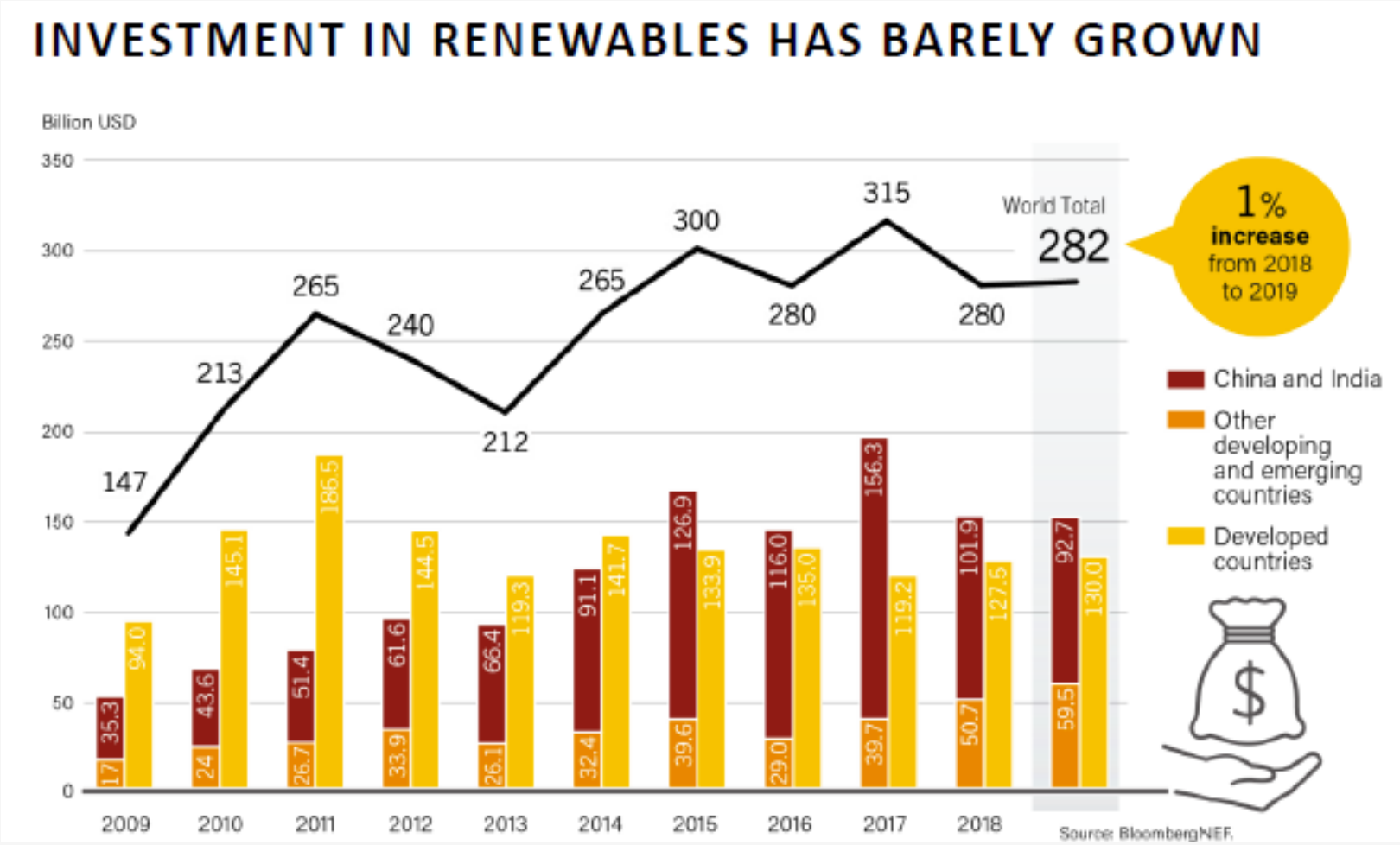
- More renewables
  - Necessary to meet policy targets
  - Enable higher energy independence
  - Lower GHG emissions
  - Lower energy market prices
- EU renewable sources - growing since 2005
- 2018 and 2019 - renewables
  - 1/5 of final energy for heating and cooling
  - 1/3 of all consumed electricity
  - 1/12 of final energy consumption in transportation

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix

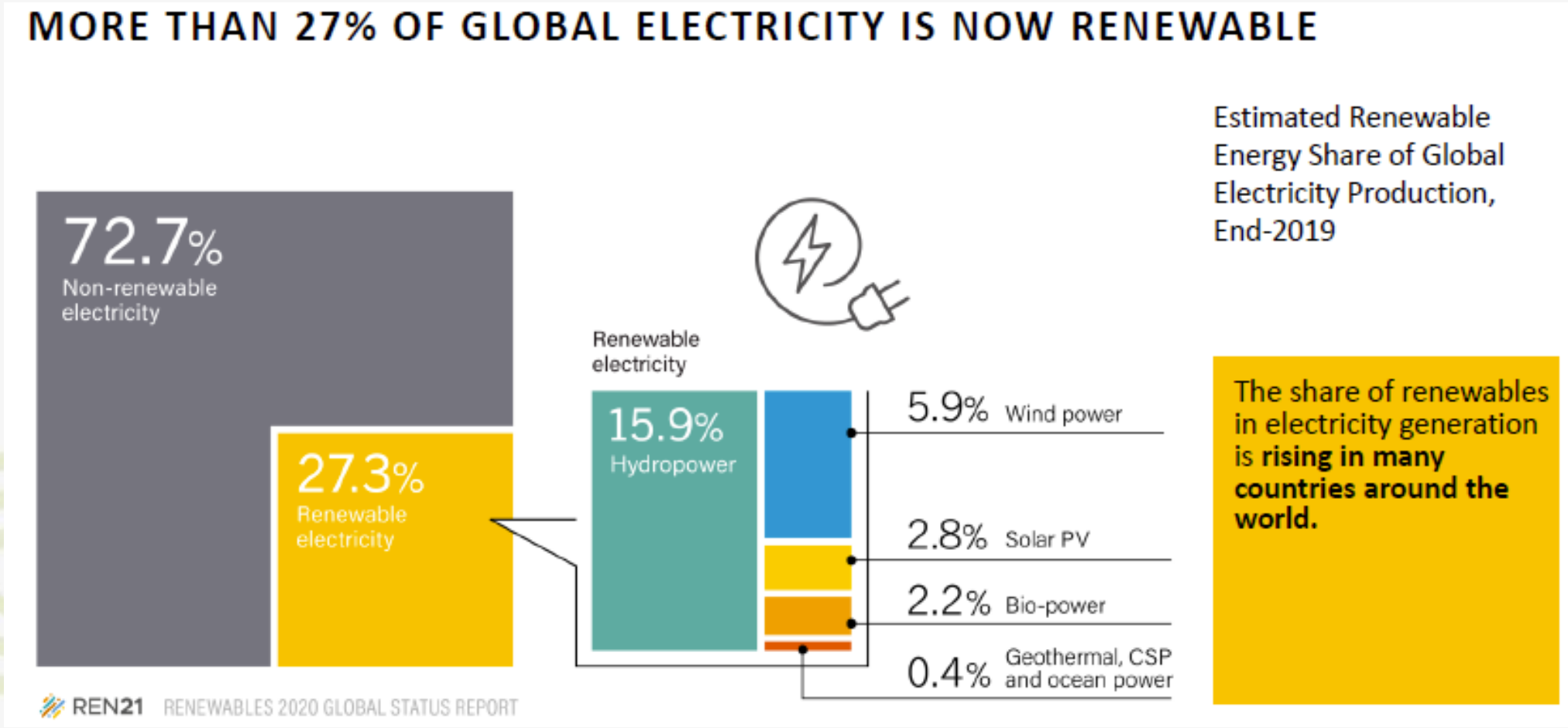
Global investment in renewables

- Emerging and rising economies have outpaced developed countries in investing in renewable energy capacity for the fifth year in a row, reaching $ 152 billion.



Project co-funded by the Europen Union (ERDF, IPA).

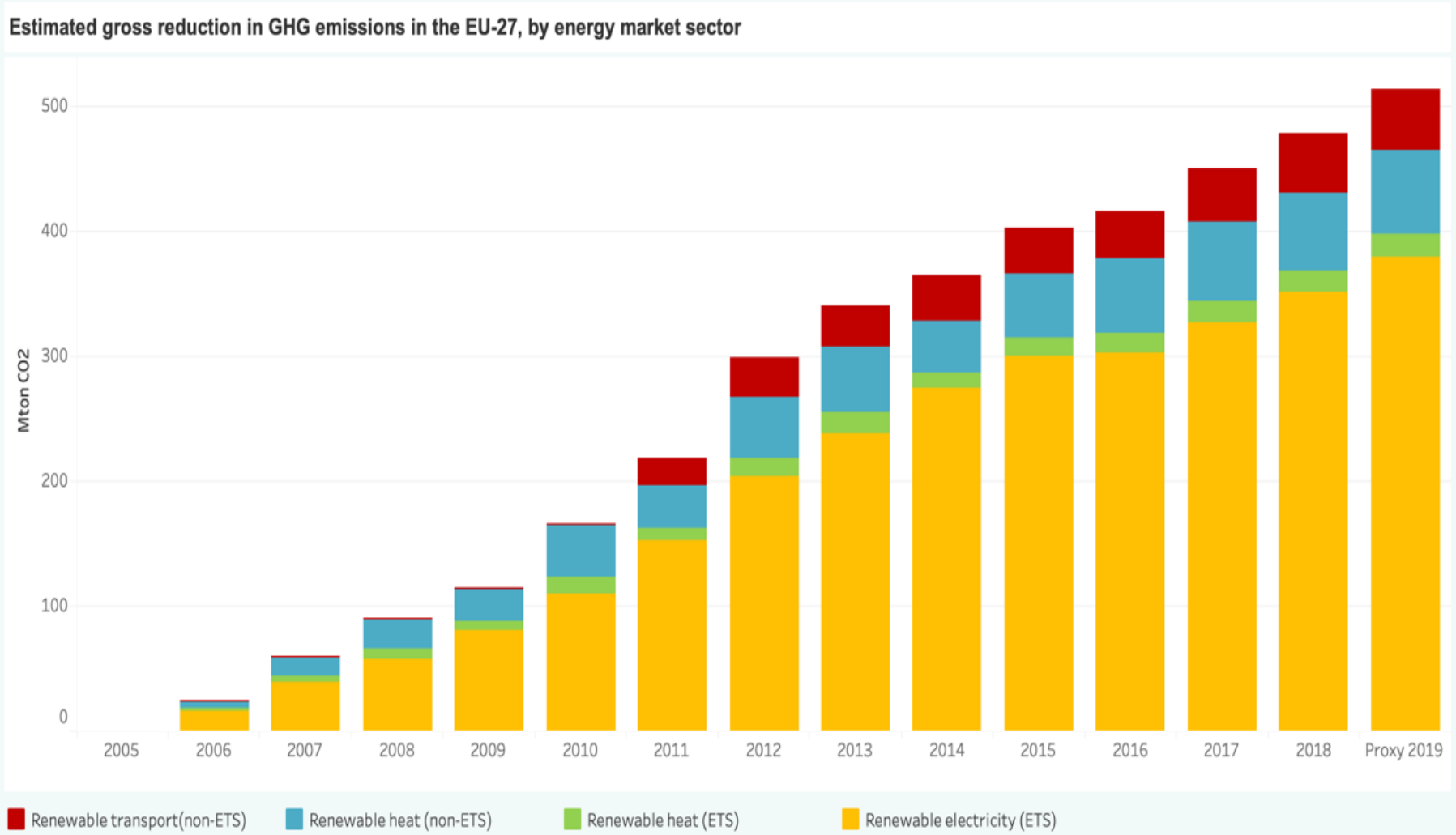
Share of renewable sources in electricity production 2019



Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix (2)

EU

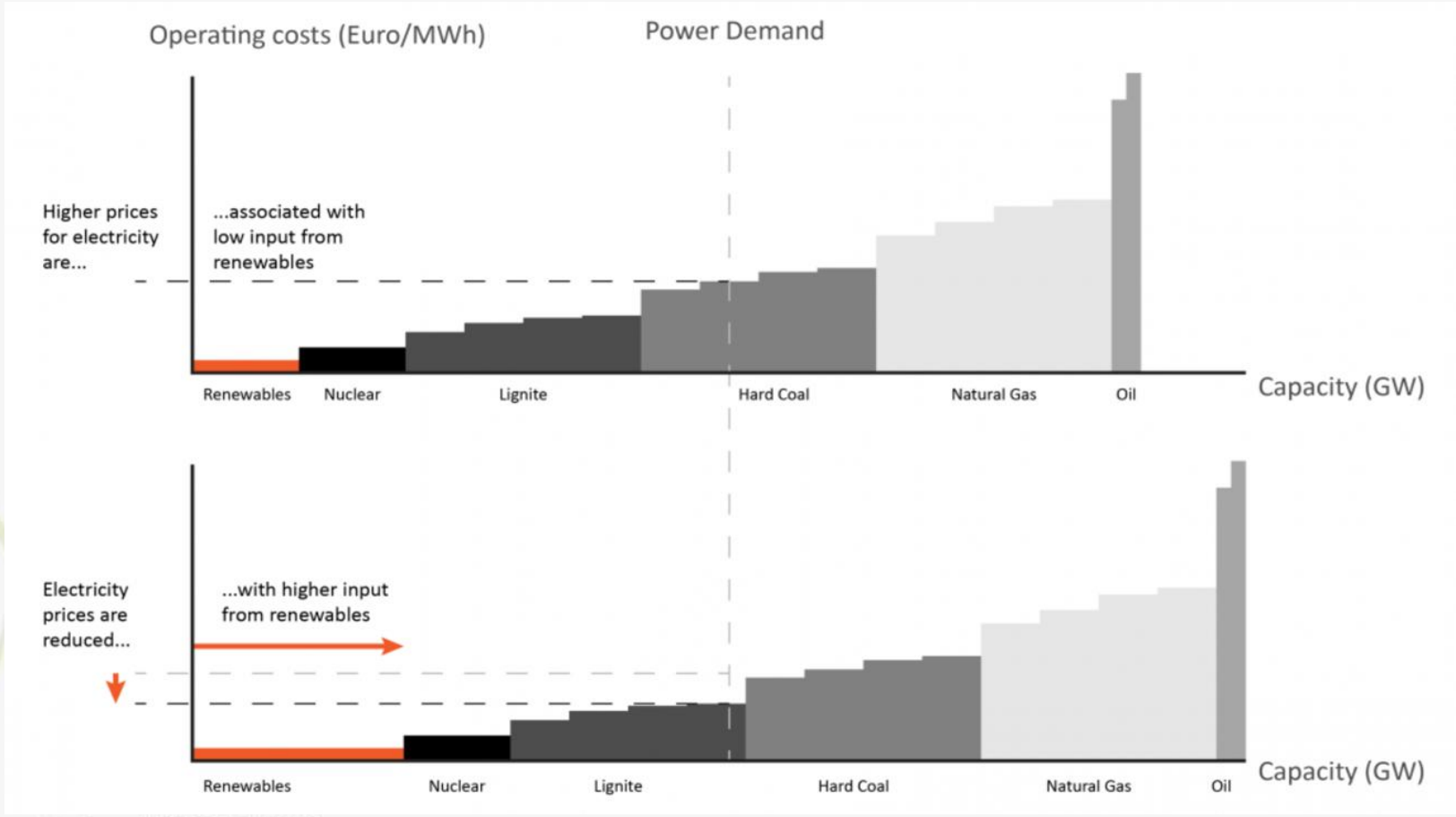


Source: https://www.eea.europa.eu/themes/energy/renewable-energy/renewable-energy-in-europe-2020

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix (3)

- Renewables - lower market price of electricity (*Merit order*)

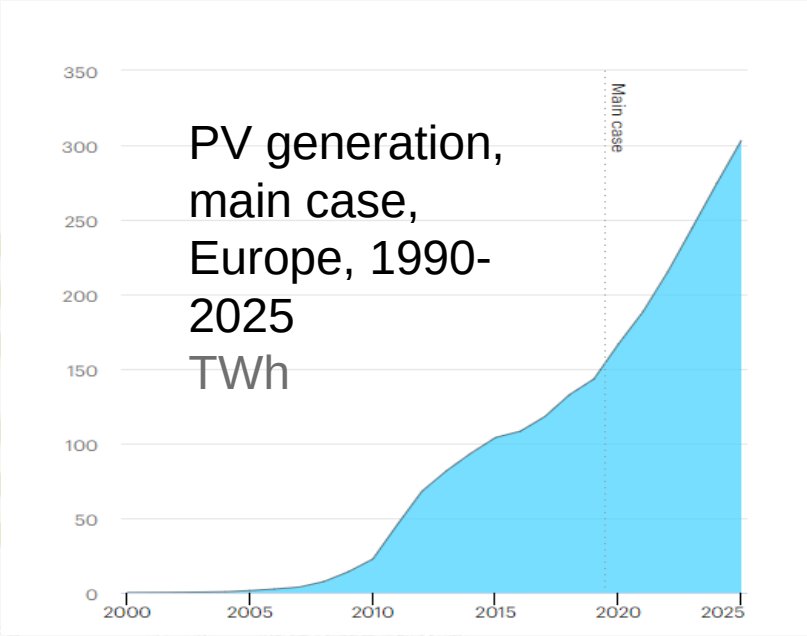


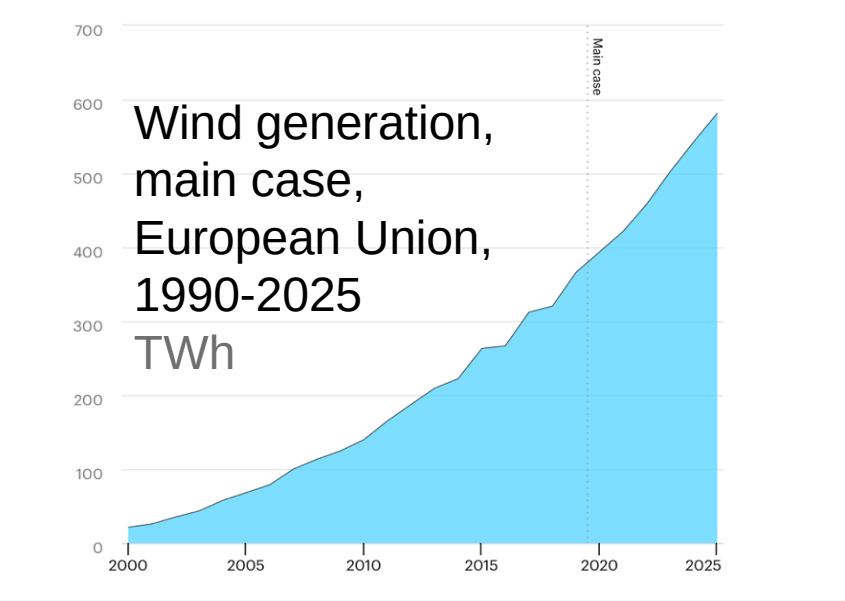
Source: https://www.cleanenergywire.org/factsheets/setting-power-price-merit-order-effect

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix (4)

- Lowering prices of solar and wind generation
- IEA - solar PV leading electricity source worldwide by 2040
- Policy support enables lowered financing and installation costs
- Projected solar and wind generation growth





Sources: https://www.iea.org/articles/renewables-2020-data-explorer?mode=market&region=Europe&product=PV , https://www.iea.org/articles/renewables-2020-data-explorer?mode=market&region=European+Union&product=Wind

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix (5)

- Despite Covid-19 electricity demand drop - supply from renewables rising
- Problem - issues with grid flexibility
- Among renewables
  - Pumped storage hydropower most convenient for grid functioning
  - Provides inertia
  - Less dependent on weather
  - Provide seasonal storage

Project co-funded by the Europen Union (ERDF, IPA).

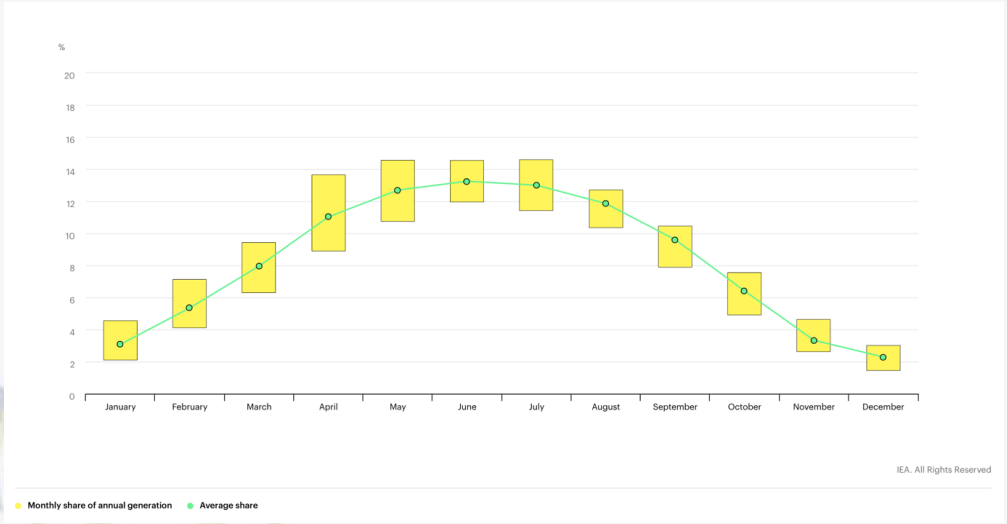
Challenge 5: Growing number of decentralised renewables in the mix (6)

- Wind and solar PV:
  - Completely dependant on weather
  - Big production variability
  - Helpful - they are complementary
    - Solar PV - highest generation during summer months
    - Wind - highest generation during colder months
    - Despite this - solar PV and wind introduce additional variability into the system

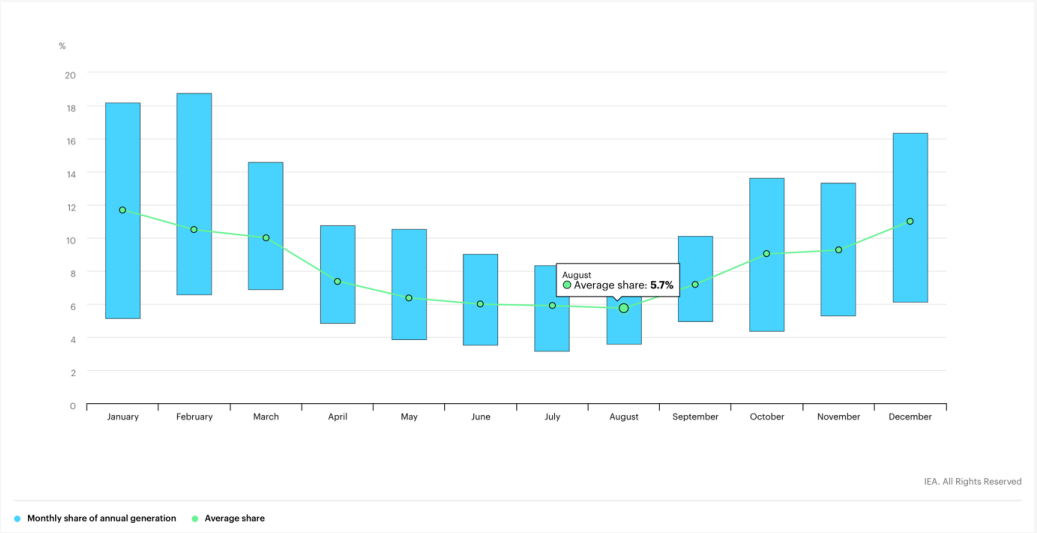
Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix (7)

Monthly generation of solar PV in Germany



Monthly generation of offshore wind in Germany

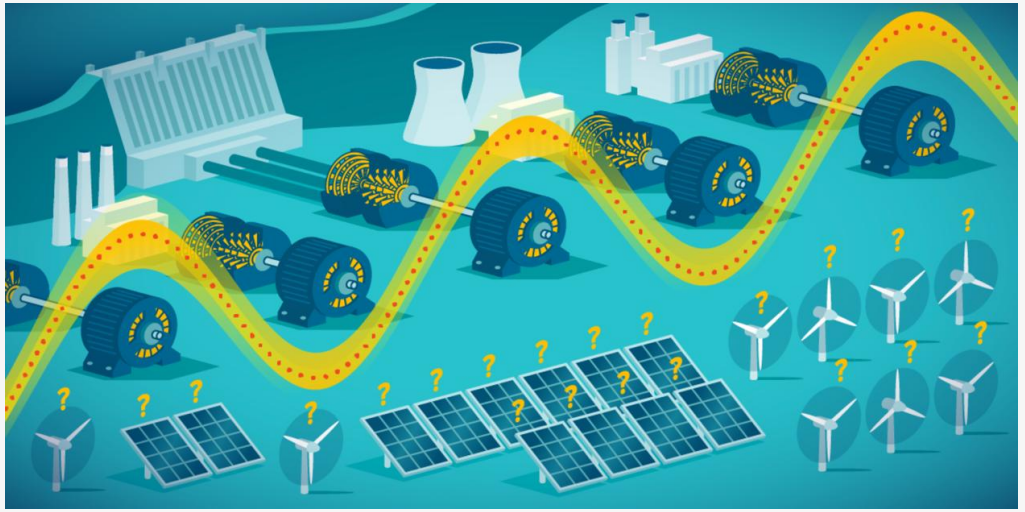


Project co-funded by the Europen Union (ERDF, IPA).

Sources: https://www.iea.org/data-and-statistics/charts/monthly-generation-of-solar-pv-in-germany , https://www.iea.org/data-and-statistics/charts/monthly-generation-of-offshore-wind-in-germany

Challenge 5: Growing number of decentralised renewables in the mix (8)

- Renewable solar PV and wind
  - Negatively impact grid inertia
  - Unpredictable, intermittent, volatile and uncontrollable
  - systems with no inertial response
- ENTSO-E - reports increased frequency fluctuations in the Nordic grid

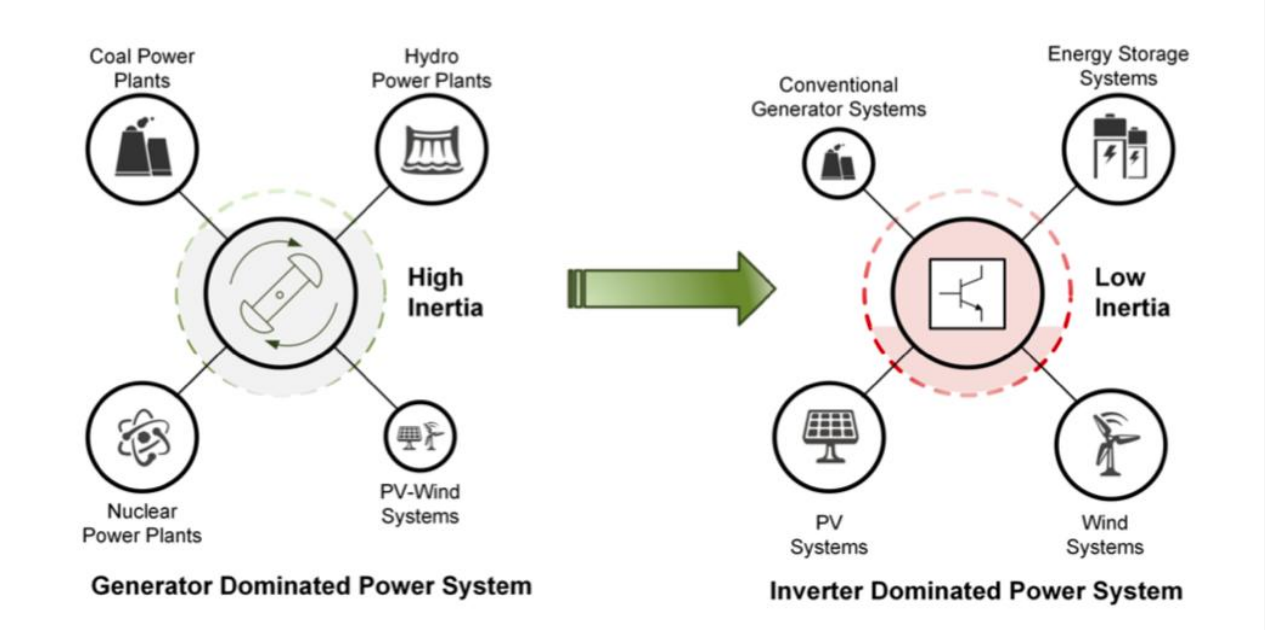


Source: https://eprijournal.com/inertia-is-a-growing-challenge-for-the-grid-but-there-are-solutions/

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix (9)

- Power grid - transition from generator to inverter dominated system
- Solution to lack of inertia - adding virtual inertia and smart grid measures

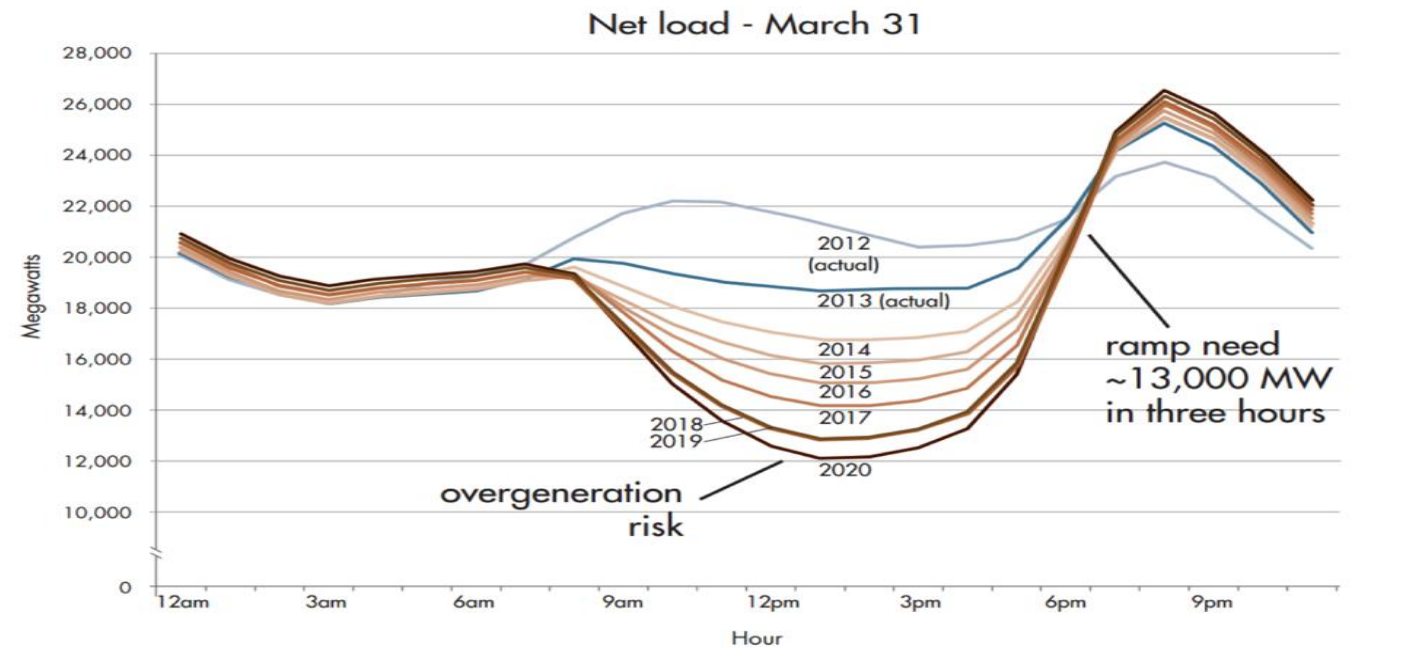


Source: https://www.researchgate.net/publication/317937853_Virtual_Inertia_Current_Trends_and_Future_Directions

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix (10)

- Second issue - solar PV "*Duck curve*"

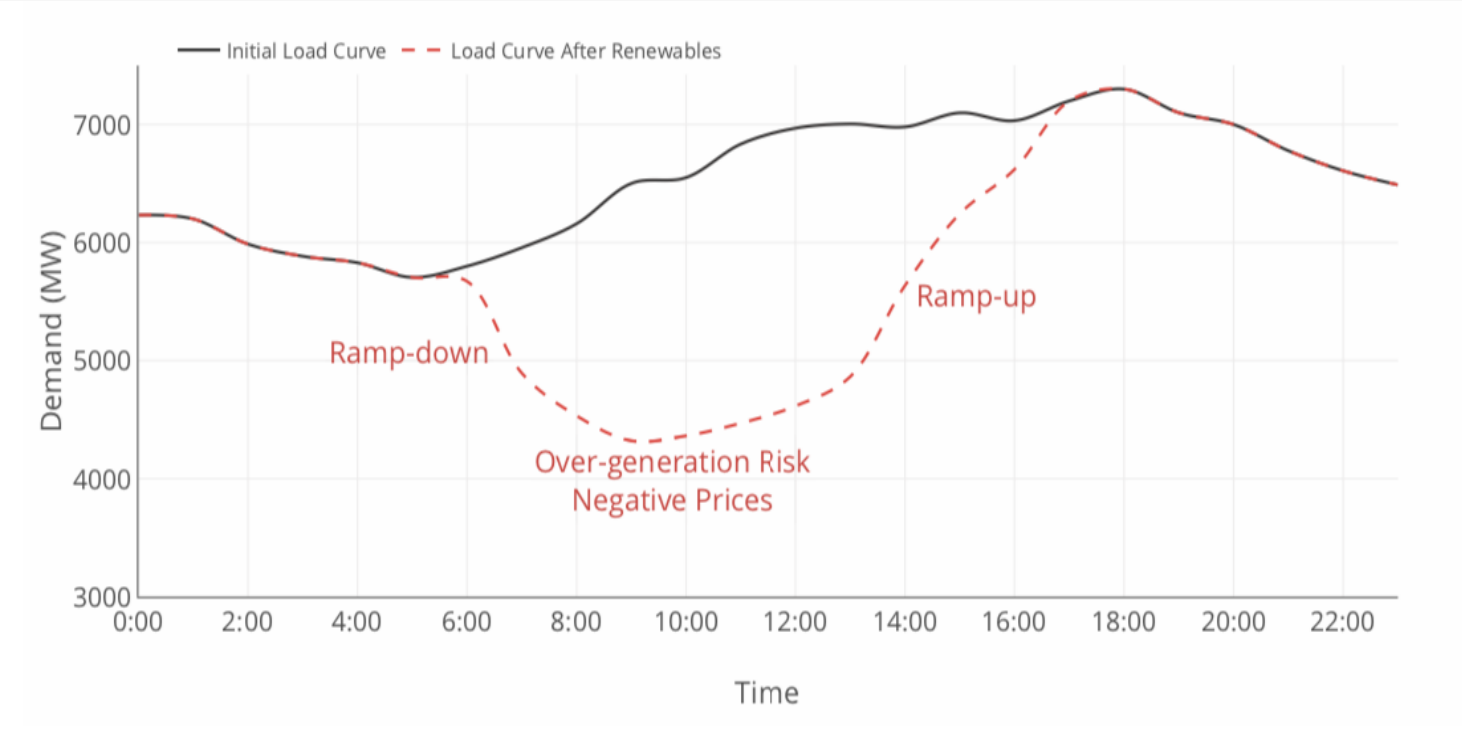


Project co-funded by the Europen Union (ERDF, IPA).

Source: https://www.nrel.gov/docs/fy16osti/65023.pdf

Challenge 5: Growing number of decentralised renewables in the mix (11)

- Difference between a typical load curve and a “Duck curve”
- Might lead to needing more power reserves or generation facilities

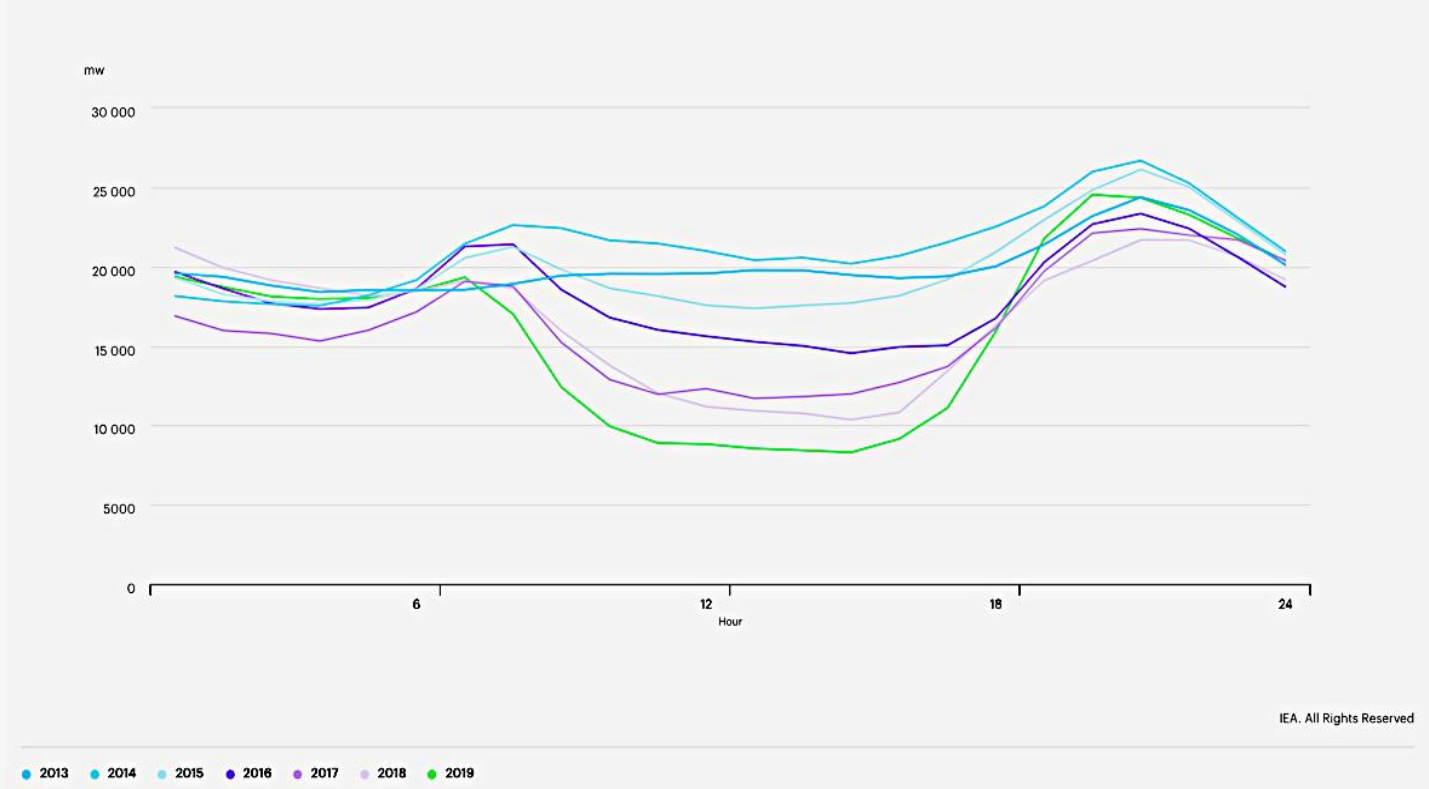


Source: https://ieeexplore.ieee.org/abstract/document/8952394

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix (12)

- Californian system - forced to curtail some energy from renewables due to large evening ramp up

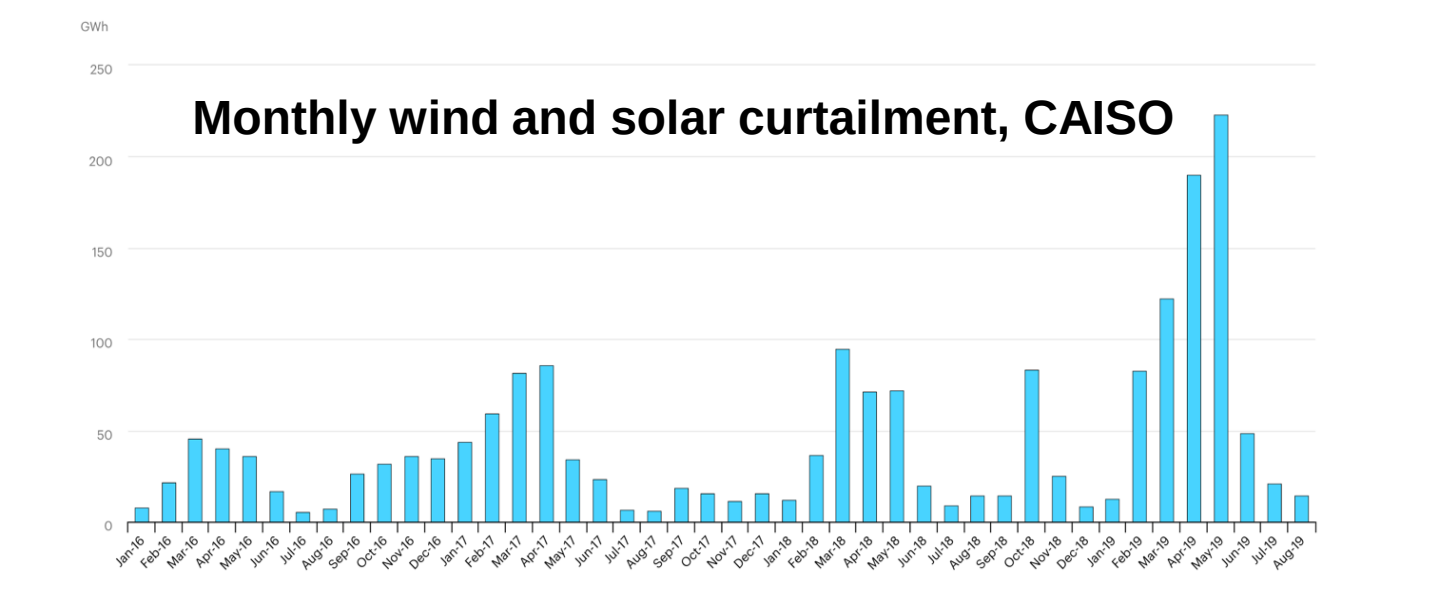


Source: https://www.iea.org/data-and-statistics/charts/the-california-duck-curve

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix (13)

- Curtailment trending upward
- Canada - ¼ of renewable energy curtailed in Ontario
- China - wind curtailment in 2018 around 7%

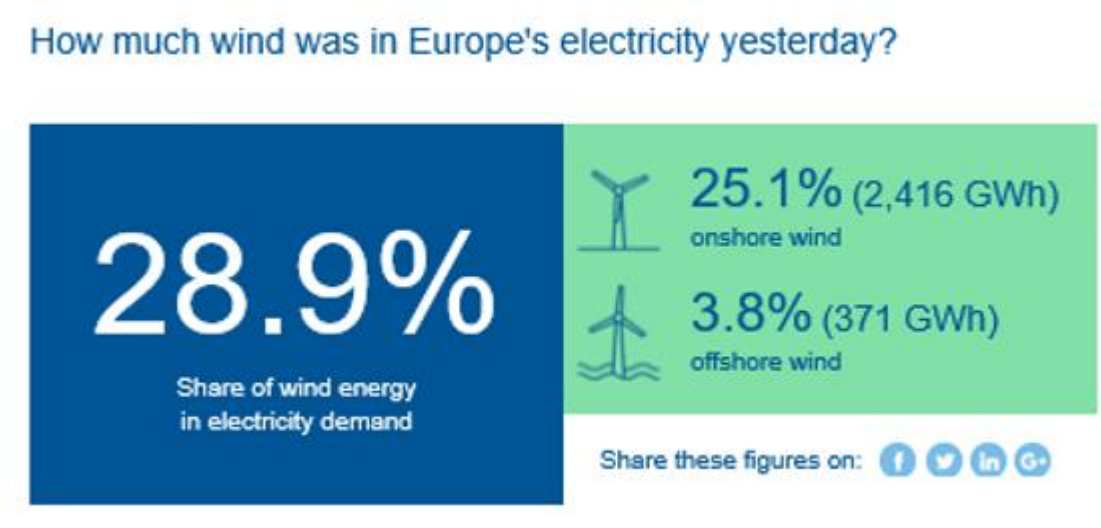


Source: https://www.iea.org/data-and-statistics/charts/monthly-wind-and-solar-curtailment-caiso

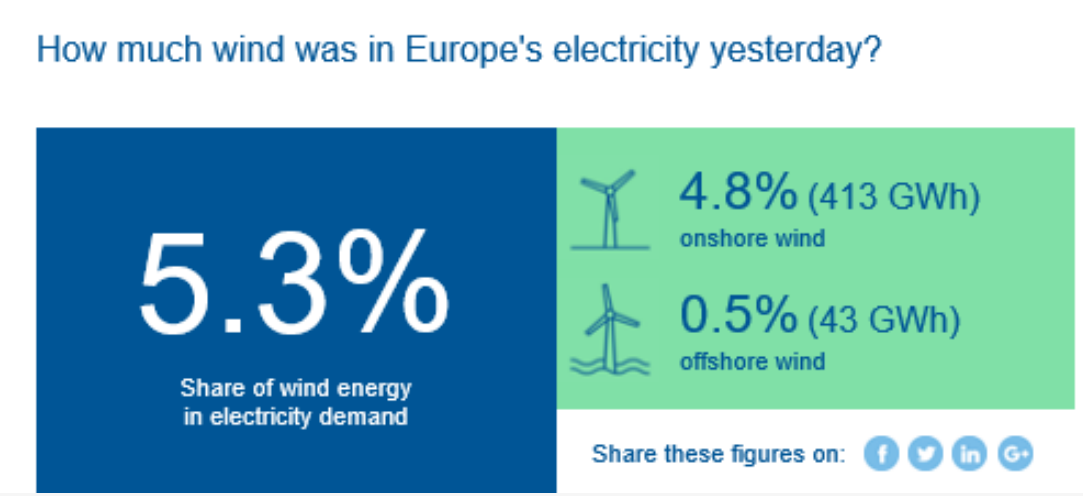
Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix (14)

- **11 March 2021**



- **19. April 2021.**



Project co-funded by the Europen Union (ERDF, IPA).

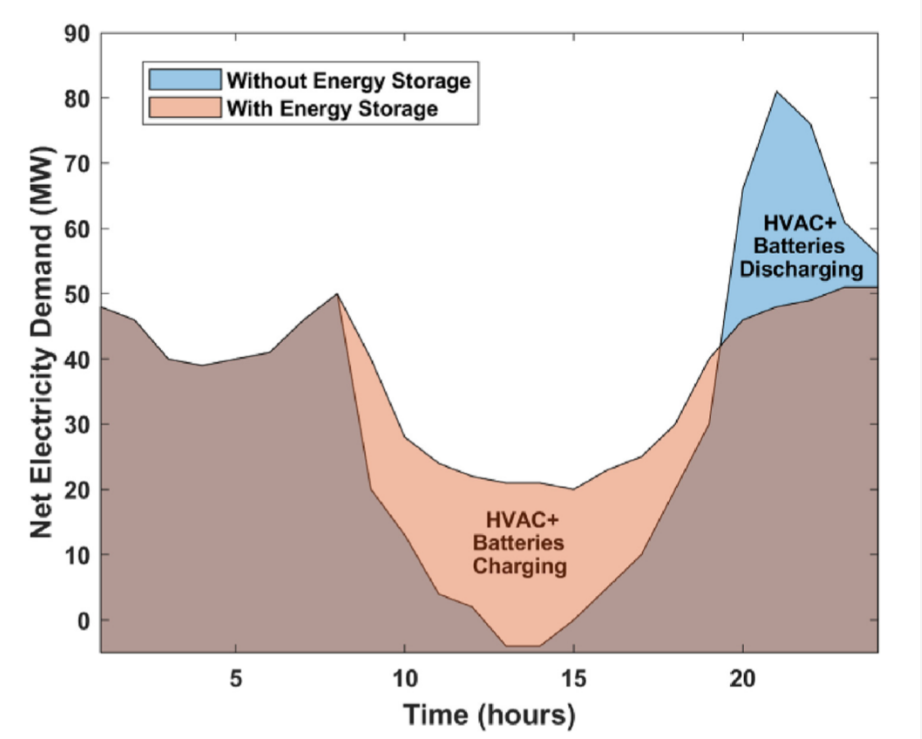
Challenge 5: Growing number of decentralised renewables in the mix (14)

- Curtailment
  - Getting rid of “free” and “green” energy
  - Longer return of investment time
  - Reduction of renewables environmental benefits
- Increase in solar PV and wind generation - brings up ancillary services costs
- Solution
  - Investments and improvements in technology
  - Adding more storage
  - Utilising demand response
  - Increasing the usage of EV’s

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 5: Growing number of decentralised renewables in the mix (15)

- IEA - “Variable energy integration and smart grid technologies can be ideally combined from a technical perspective”



Source: https://doi.org/10.1016/j.enconman.2020.113102

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 6: Reliability challenges (1)

- Supply interruptions such as blackouts and brownouts
  - Can have very negative consequences - even tragic (Venezuela, 2019)
- VoLL
  - Value of Lost Load
  - Gives a monetary value for the social and economic impact of a power outage
  - €/MWh

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 6: Reliability challenges (2)

- WTP
  - Willingness to Pay
  - Monetary amount that end users are prepared to pay to avoid an outage
  - €/h
- Annual average VoLL
  - Western Europe - 11,01 €/h
  - Southern Europe - 6,04 €/h
  - Eastern Europe - 4,03 €/h

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 7: No consumer participation (2)

- Today - passive consumers with little to no knowledge about their consumption
- Active consumer participation - important smart grid feature
- Future
  - Active consumers monitoring their consumption
  - Prosumers (producer + consumer)

Project co-funded by the Europen Union (ERDF, IPA).

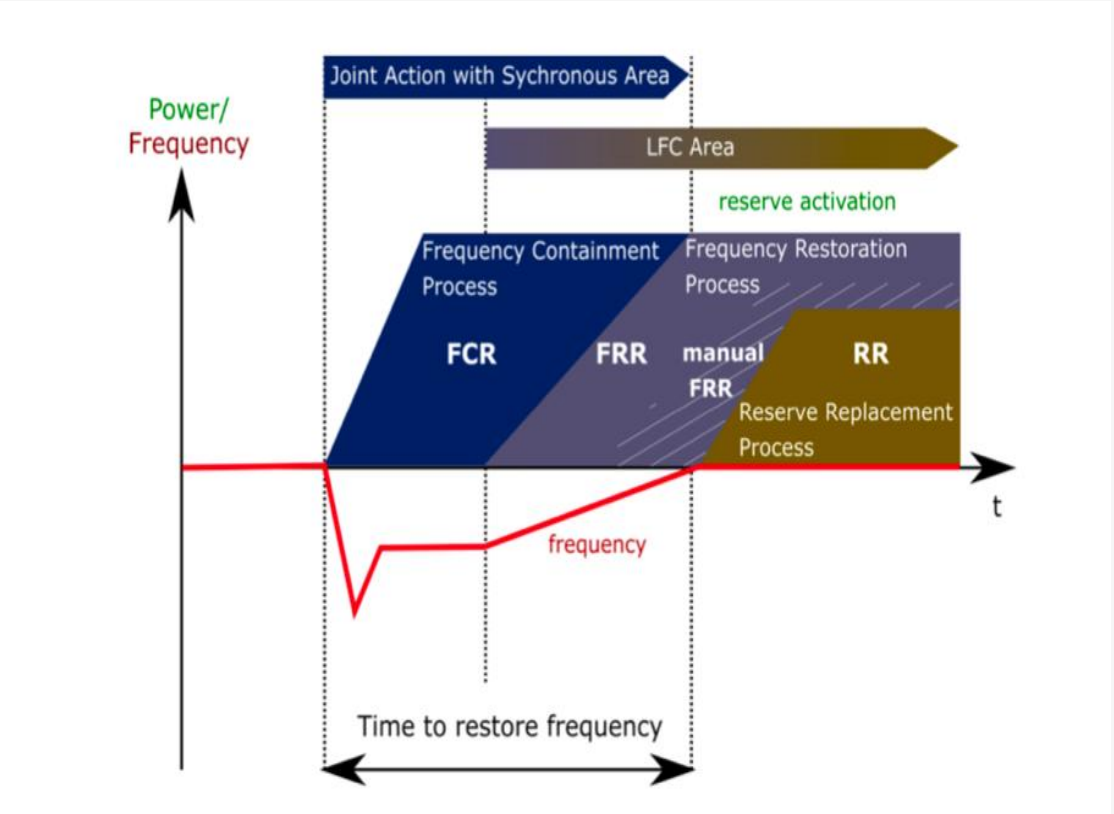
Challenge 7: No consumer participation (2)

- Active consumers
  - Financial benefits - ex. customer with a 10kW AC compressor that can operate at 50% during the most expensive 100h of the year → 500kWh net yearly reduction of consumption → 106,3€
  - Helping grid stability
  - Lowering peak demand
  - More knowledge - empowering
- Smart meters and other smart grid measures - enabling active consumer participation

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 8: Manual grid monitoring and restoration (1)

- Classical grid -
  - aFRR - automatic, within 5min
  - mFRR - manual, within 15min
  - RR - manual, within hours
- Complicated, expensive
- Smart grid solution - self-healing

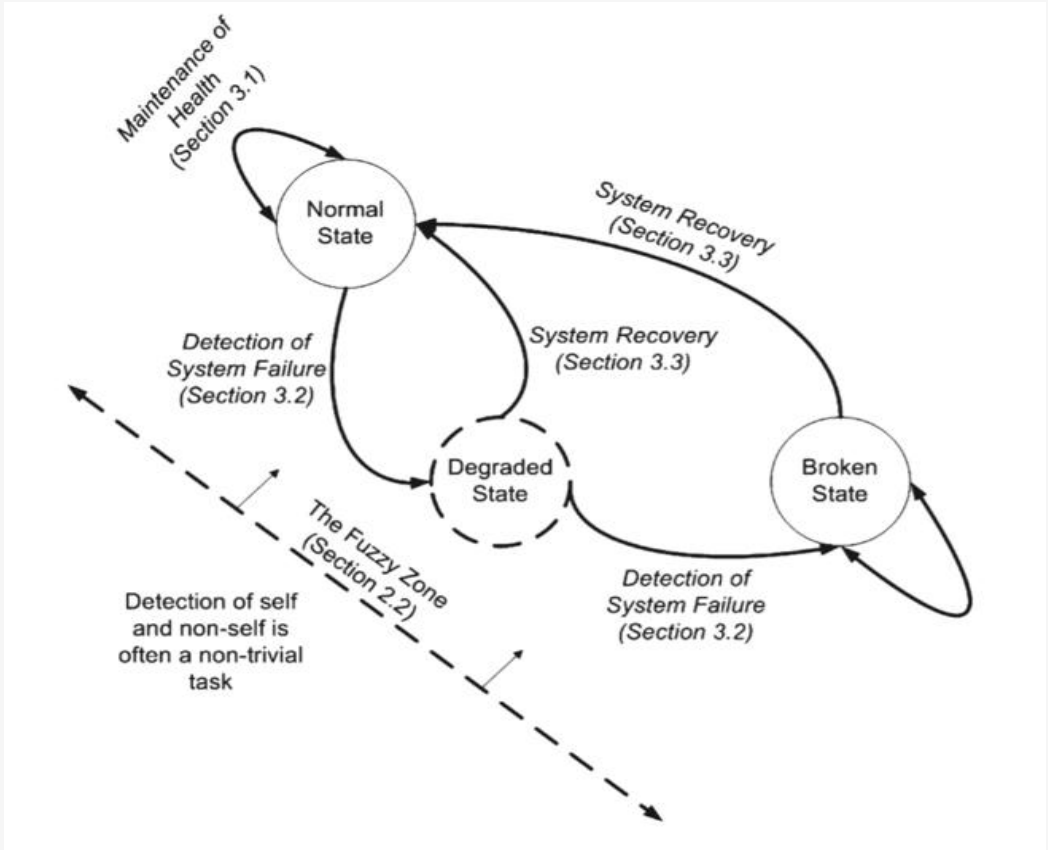


Source:https://www.researchgate.net/publication/342215929_Evaluation_of_the_Effects_of_Smart_Charging_Strategies_and_Frequency_Restoration_Reserves_Market_Participation_of_an_Electric_Vehicle

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 8: Manual grid monitoring and restoration (2)

- Self-healing
  - Protects the grid
  - Quick and accurate fault analysis
  - Distinguishes between proper and improper grid operation
  - Restores the system to a healthy state

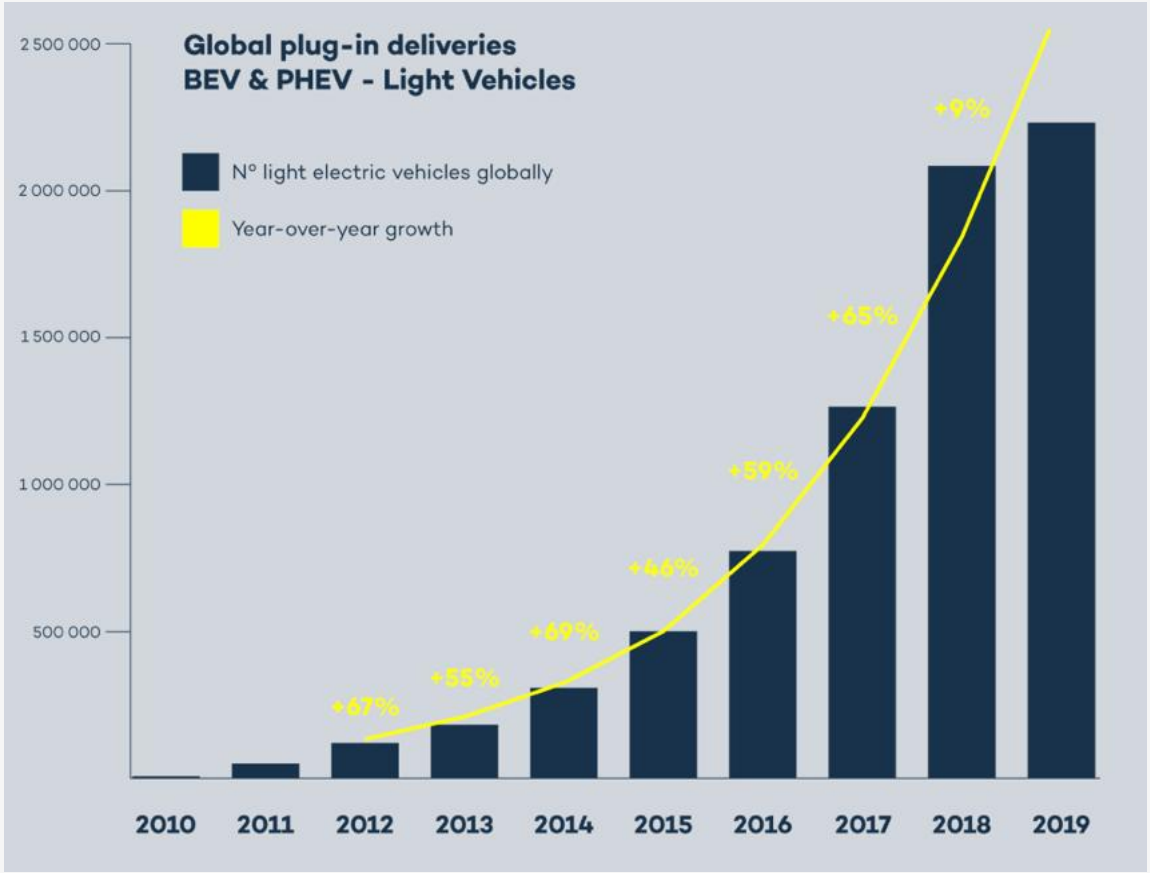


Project co-funded by the Europen Union (ERDF, IPA).

Source: https://www.researchgate.net/publication/222434671_Self-healing_systems_-_survey_and_synthesis

Challenge 9: EV growth (1)

- Electrification of the transport sector
  - Positives
    - Decarbonisation
    - Lower energy dependency
    - Offsetting renewables curtailment - by offering additional storage capacity



Source: https://www.virta.global/global-electric-vehicle-market?hsCtaTracking=7a7927c9-275d-4689-a8c5-a638a7353e86%7C5a1c2f3b-7b6b-4ec4-a3f9-63852b50a70a

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 9: EV growth (2)

- Negatives
  - Increased electricity consumption
  - Outgrowing grid capacities if not controlled
  - Uneven distribution
- Plugging in an EV - can be equal to adding 3 houses to the grid
- 2012 - 2018 - global growth rates between 46% and 69%
- 2019
  - 9% growth due to decrease in the USA and China
  - EU - 44% growth

Project co-funded by the Europen Union (ERDF, IPA).

Challenge 9: EV growth (3)

- Example of the negative consequences - Sweden
  - First half of 2019 - 253% growth in EV sales
  - The capacities of local grids are being outgrown
- Installing fast chargers at home - especially problematic
- California - using smart meters to monitor neighbourhoods in need of network upgrades

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Challenge 9: EV growth (4)

- By the 2040's - EV's adding over 30 TWh of extra battery storage capacity
- Smart charging, meters and grids - can offset the negative influences of EV's on the grid

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Some conclusions

- Population and income growth are the two biggest drivers of increasing energy demand
- In the next 20 years, we are likely to continue to see continued global integration and rapid growth in underdeveloped and middle-developed countries
- Globally, basic fundamental relations in energy remain robust - more people with higher incomes means that energy production and consumption will grow.
- Renewable energy is growing in importance (renewable energy sources are the fastest growing energy source, accounting for 40% of the increase in primary energy.
- The energy mix by 2040 is the most differential the world has ever seen.

Project co-funded by the Europen Union (ERDF, IPA).

The mobility revolution

Electric cars: lead the transition from conventional vehicles

- Autonomous vehicles: improving energy efficiency through more efficient driving
- Car shearing: can enhance the effects of new technology
- Ride pooling: reducing total miles by merging trips

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Smart grid benefits overview (1)

- Improving the grid reliability, stability, flexibility and power quality
- Improving the system resiliency
- Improving the efficiency
- Lowering GHG emissions - decarbonisation
- Electrification of additional sectors
- Lowering energy dependency
- Enabling distributed generation

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Smart grid benefits overview (2)

- Increasing consumer participation - prosumers
- Enabling predictive maintenance
- Enabling self-healing protocols
- Minimizing outage time
- Smart meters → smart devices → smart homes
- Possible economic benefits for utilities and consumers
- Job opportunities in the sector

Project co-funded by the Europen Union (ERDF, IPA).

Smart grid barriers

- High upfront investment costs
- Technical barriers
- Data privacy concerns
- Cybersecurity concerns
- Little to no policies and legislation regarding the concept of smart grids as a whole
- Low levels of public knowledge and awareness
- Lack of consumer incentives

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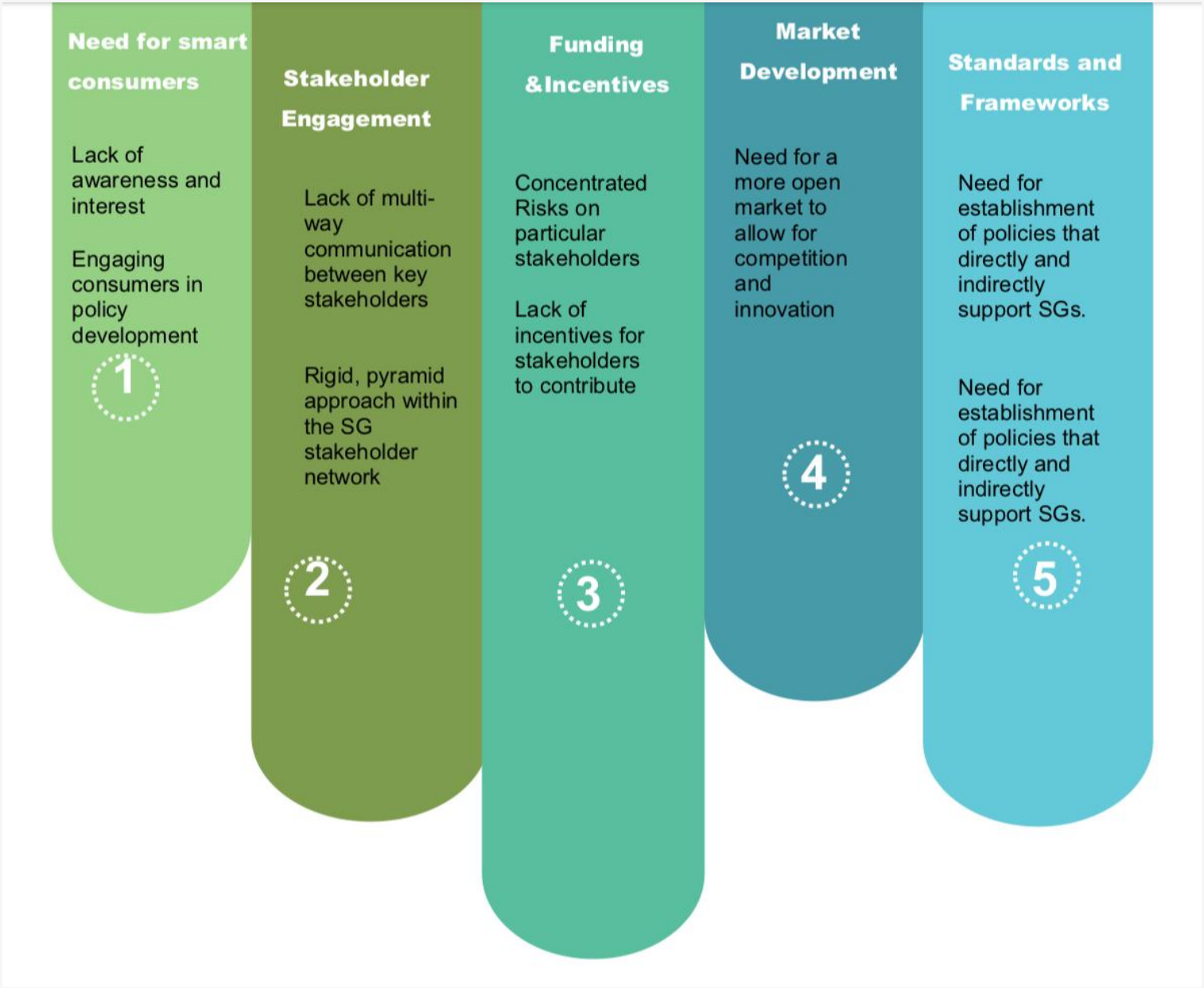
Key barriers in smart grid policy implementation



Source: https://essay.utwente.nl/77512/1/s1888250_Namratha_Nair__Nair_16-17.pdf

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Smart grid processes

- Billing
- Peak load management
  - Demand side management
  - Demand response schemes
  - Energy efficiency programmes
- Connection management
- Improved outage management
  - Customer call centres
- Tariff structure

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Smart people

- Educated labour force - capacity building
  - Utility providers
- Educated consumers and prosumers
  - Workshops, seminars and events
  - Promoting initial participation through monetary incentives
    - Smart charging,
    - Negawatt generation,
    - Demand response participation payments, etc.

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Smart policies

- Key areas impacted by necessary smart policies
  - Security
  - Tariff structure
  - Implementation timeline
  - Government incentives

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In short what the Smart grid is …

https://www.i-scoop.eu/industry-4-0/smart-grids-electrical-grid/

Project co-funded by the Europen Union (ERDF, IPA).

Power & Energy

Currently it is still very difficult for consumers to see how much electricity they are using, but smart grid devices are quickly being developed. It is hoped that by being able to monitor how much electricity they are using, consumers will use less of it, subsequently cutting energy bills and, moreover, pinpointing off-peak hours to run their energy-intensive machines.

Optimises assets and operates efficiently
A Smart Grid will be able to generate more power through the existing systems by optimising them, allowing the reduction of power-flow waste and maximising the distribution of lowest-costgeneration sources. The harmonisation of local distribution with interregional energy flows will improve thecurrent use of grid assests, reducing grid congestion and potentially outages / disruptions.

Variety of Generation Options
With CO2 emissions on the increase and primary sources of energy running out it is imperative that new sources are found and integrated into the grid system. The current electricity grid cannot facilitate energy being drawn seamlessly from a variety of energy sources via a number of distributed technologies, but this is the aim of the Smart Grid.

Accommodates all generation and storage options
All sources will be interconnected allowing consumers to access a general and renewable generated sourceof energy. Energy storage will also be available ensuring none is wasted, and that energy can be tapped at a late date should the need arise.

Energy seamlessly drawn from a variety of sources

Microgeneration
Energy obtained on a small scale can reduce demand on the grid

Smart Meters
These record usage in real-time for the purpose of billing and monitoring and can also choose periods of the day from which to draw power i.e. during off-peak to save money

Larger Network (Offices etc)
Can generate own power through solar panels, wind turbines and in turn can supply energy back to the central network grid

Isolated Microgrids
If there is a disturbance in the grid the affected microgrids can be isolated from the central grid to ensure minimal disruption to services

Power Storage
Energy that is generated during non-peak times can be stored for potential future usage, to ensure minimal wastage

Demand Response
Consumers are changing what they need from a power supplier and are moving towards flexible energy, cheaper alternatives and the option for microgeneration, all of which are not currently facilitated by the electricity grid. The development of the Smart Grid and associated "smart" technologies and devices will allow users to have a more direct control over the energy they use on a day-to-day basis.

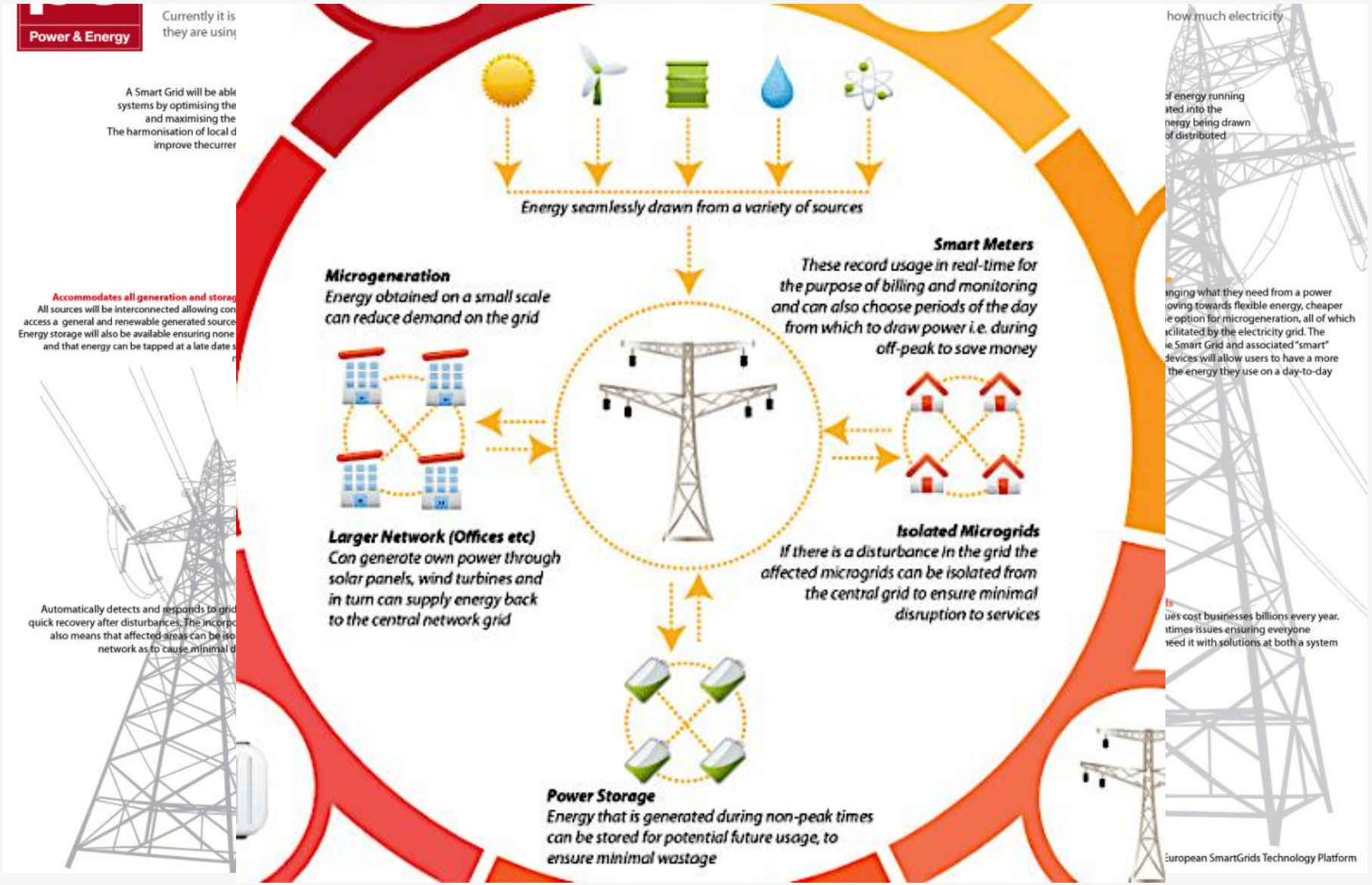
Self-healing
Automatically detects and responds to grid problems, ensuring quick recovery after disturbances. The incorporation of microgrids also means that affected areas can be isolated from the main network as to cause minimal disruption to services

Power for 21st Century Needs
Power outages and quality issues cost businesses billions every year. A Smart Grid will reduce downtimes issues ensuring everyone can obtain power when they need it with solutions at both a system and consumer level

Electricity Market
Creating an open market where alternative energy sources can be sold to customers regardless of location. Microgeneration of electricity will also be a viable source of energy and will potentially contribute a good source of income to local economies.

Sources: Office of Electricity and Energy Reliability and European SmartGrids Technology Platform

Project co-funded by the Europen Union (ERDF, IPA).



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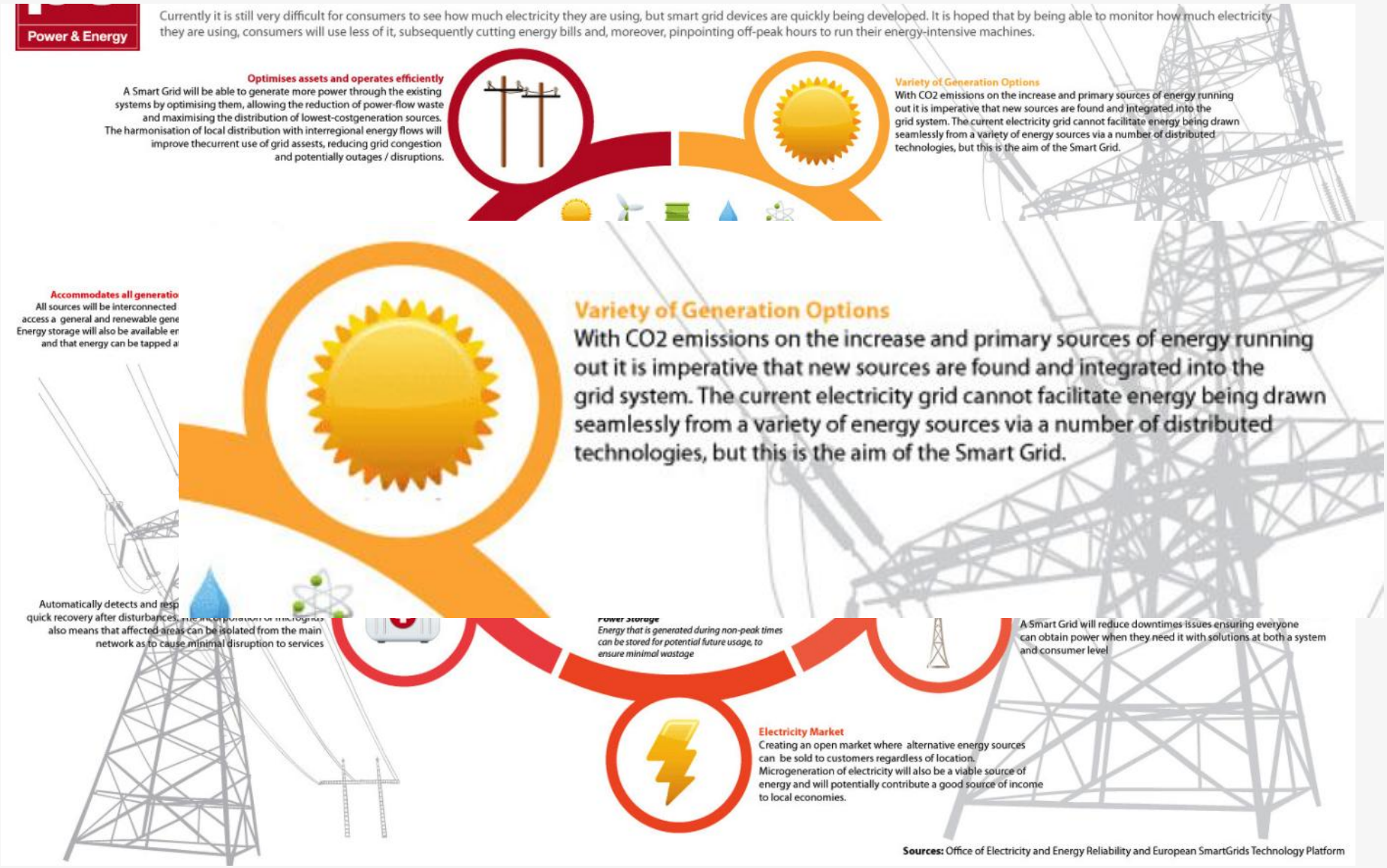
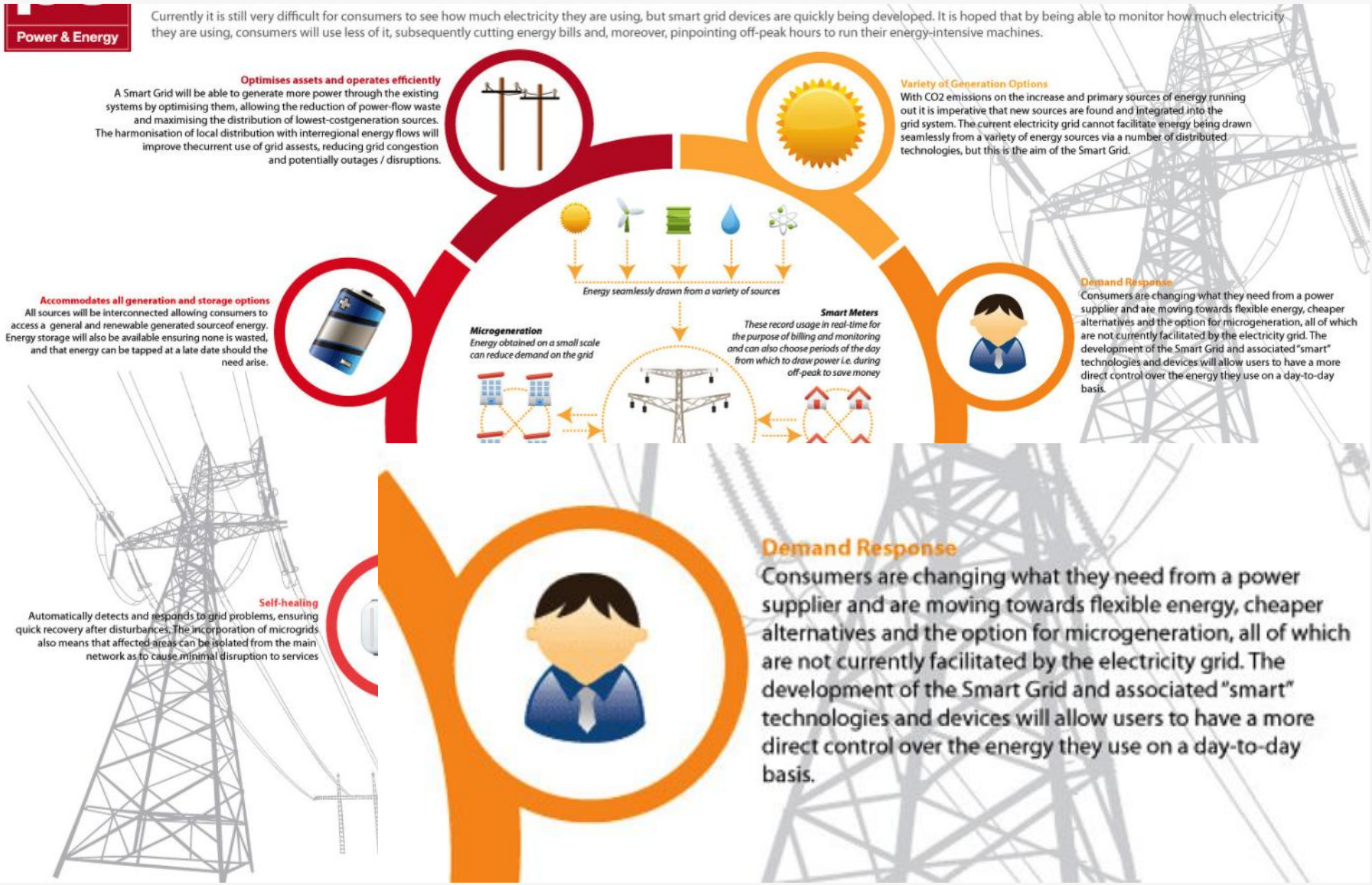
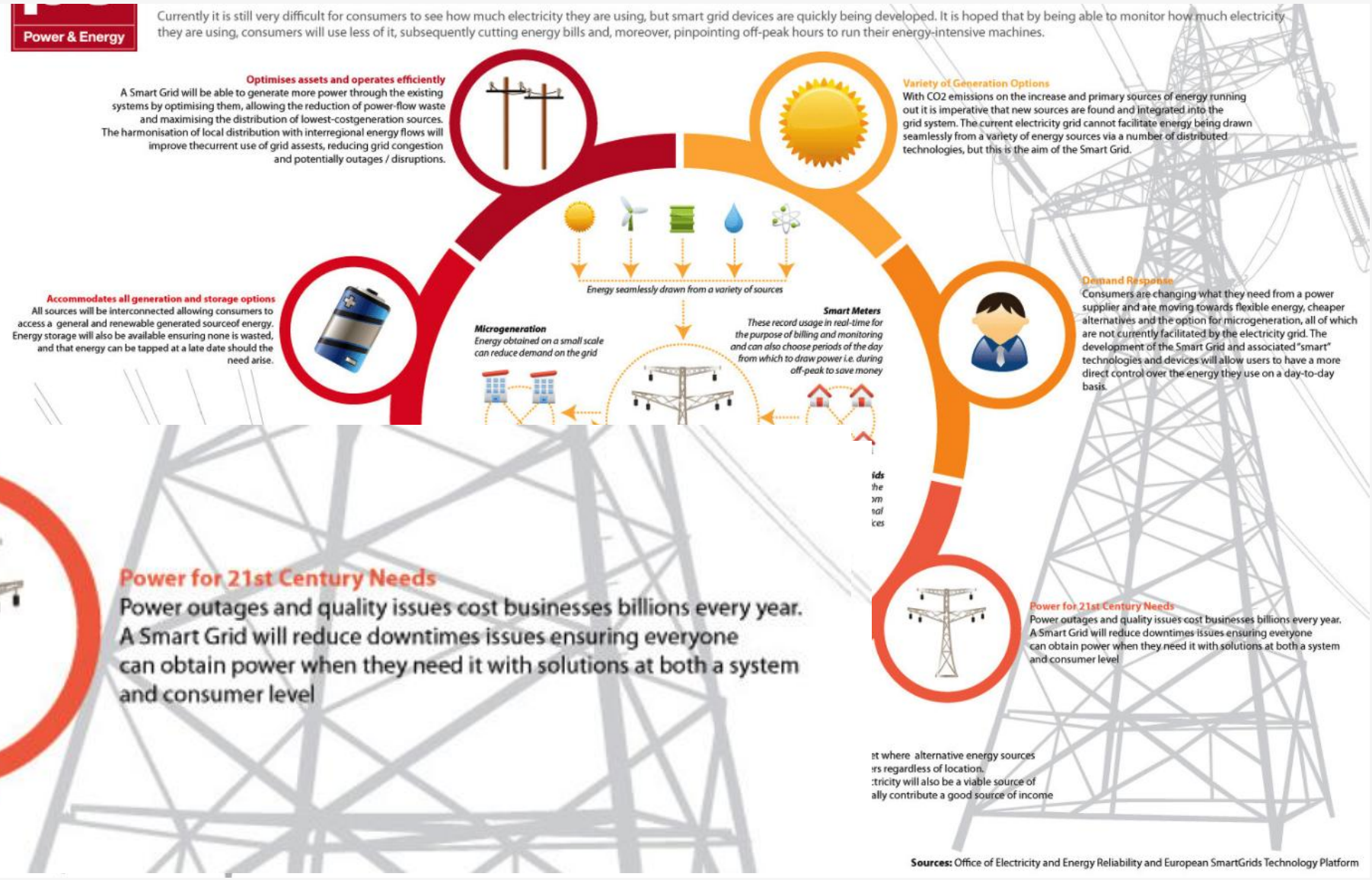


Project co-funded by the Europen Union (ERDF, IPA).



Project co-funded by the Europen Union (ERDF, IPA).



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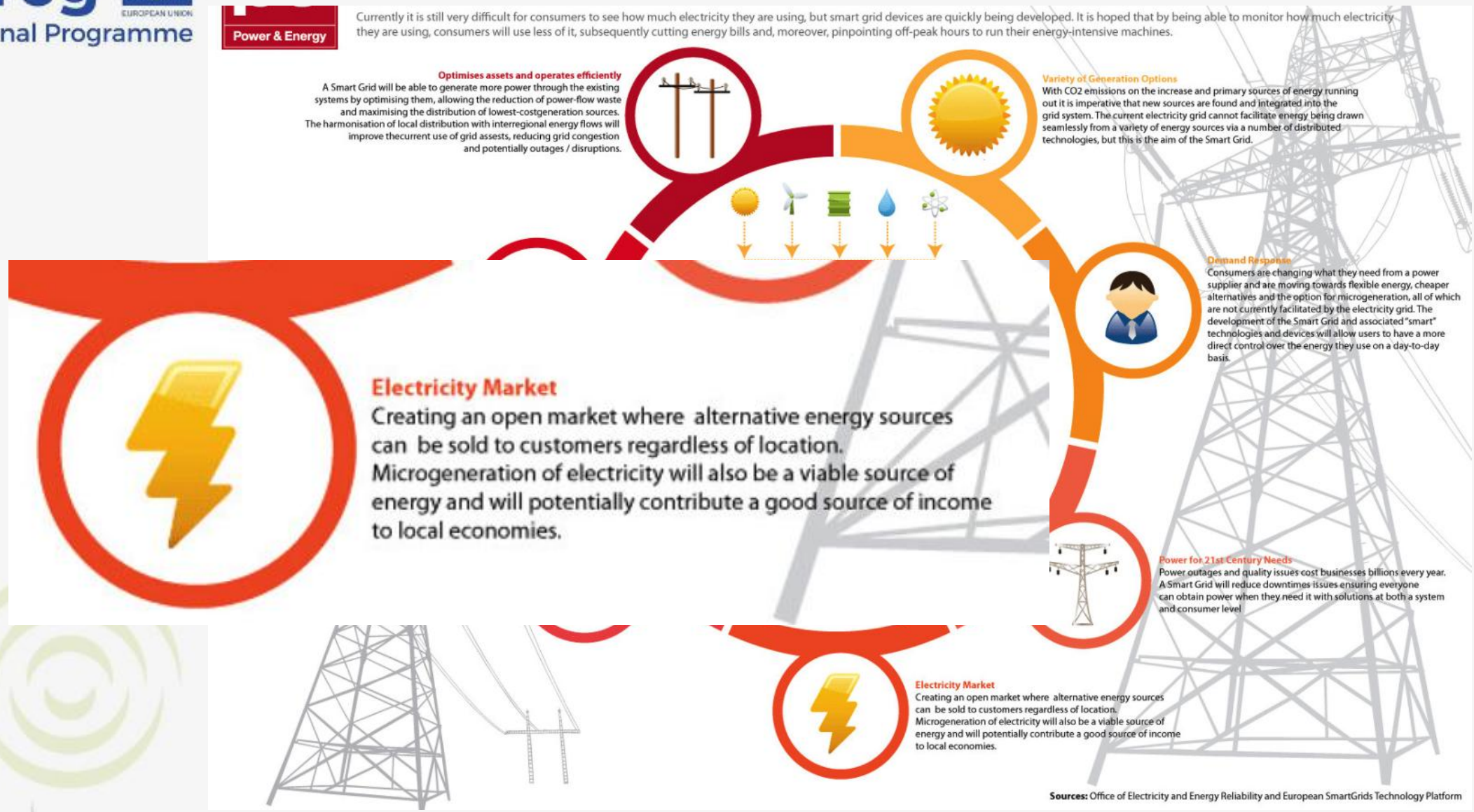

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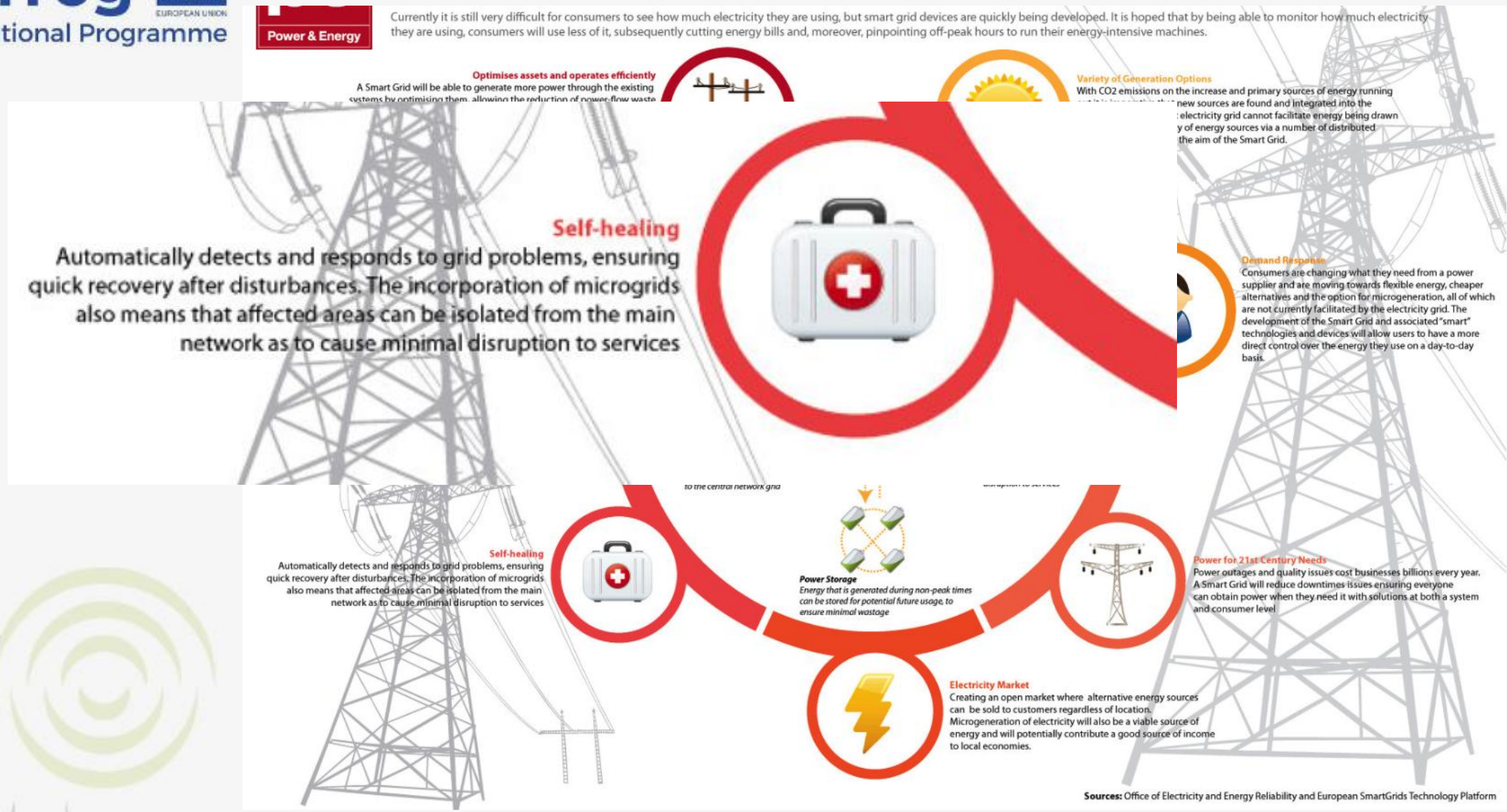

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Power & Energy

Currently it is still very difficult for consumers to see how much electricity they are using, but smart grid devices are quickly being developed. It is hoped that by being able to monitor how much electricity they are using, consumers will use less of it, subsequently cutting energy bills and, moreover, pinpointing off-peak hours to run their energy-intensive machines.

Optimises assets and operates efficiently
A Smart Grid will be able to generate more power through the existing systems by optimising them, allowing the reduction of power-flow waste and maximising the distribution of lowest-costgeneration sources. The harmonisation of local distribution with interregional energy flows will improve thecurrent use of grid assests, reducing grid congestion and potentially outages / disruptions.

Variety of Generation Options
With CO2 emissions on the increase and primary sources of energy running out it is imperative that new sources are found and integrated into the grid system. The current electricity grid cannot facilitate energy being drawn seamlessly from a variety of energy sources via a number of distributed technologies, but this is the aim of the Smart Grid.

Accommodates all generation and storage options
All sources will be interconnected allowing consumers to access a general and renewable generated sourceof energy. Energy storage will also be available ensuring none is wasted, and that energy can be tapped at a late date should the need arise.

Energy seamlessly drawn from a variety of sources

Microgeneration
Energy obtained on a small scale can reduce demand on the grid

Smart Meters
These record usage in real-time for the purpose of billing and monitoring and can also choose periods of the day from which to draw power i.e. during off-peak to save money

Demand Response
Consumers are changing what they need from a power supplier and are moving towards flexible energy, cheaper alternatives and the option for microgeneration, all of which are not currently facilitated by the electricity grid. The development of the Smart Grid and associated "smart" technologies and devices will allow users to have a more direct control over the energy they use on a day-to-day basis.

ower for 21st Century Needs
ower outages and quality issues cost businesses billions every year. Smart Grid will reduce downtimes issues ensuring everyone n obtain power when they need it with solutions at both a system nd consumer level

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y and Energy Reliability and European SmartGrids Technology Platform

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