KTH ROYAL INSTITUTE OF TECHNOLOGY

Metrology for future sustainable energy networks

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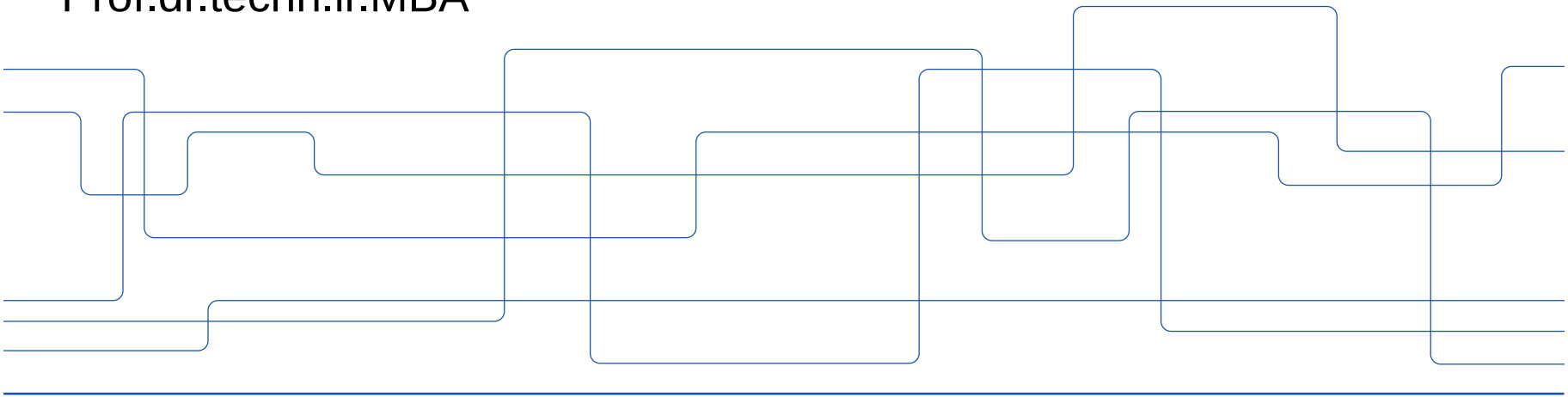


FUTURE

SUSTAINABLE

ENERGY

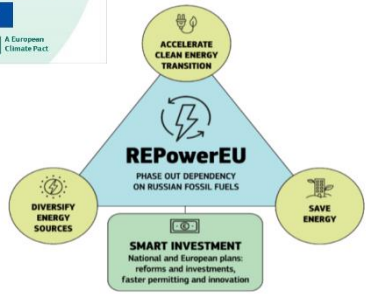
Net Zero Emissions by 2050

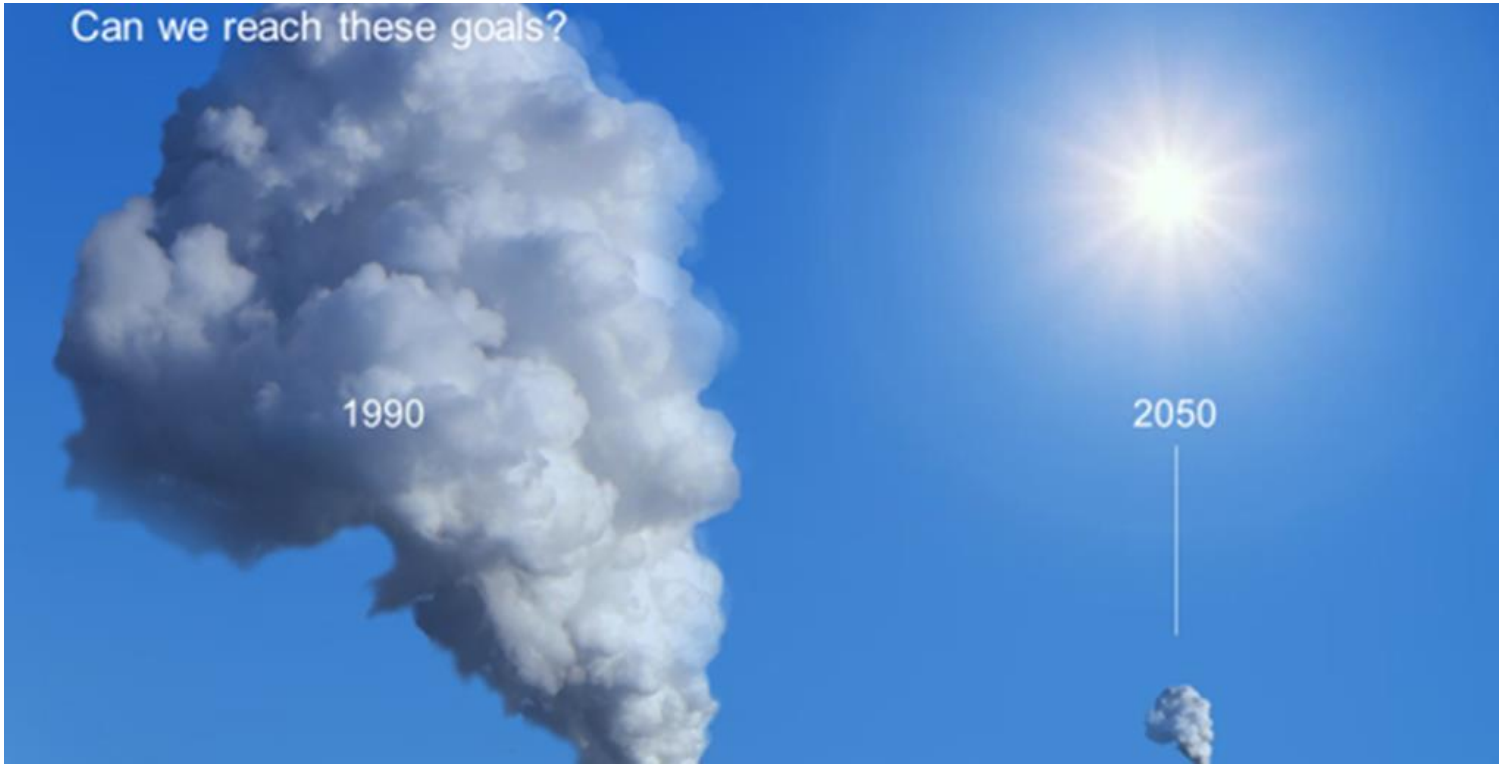
Emissions have to come down and many are committed to reach this target

European Green Deal: **The first climate-neutral continent by 2050** through boosting the economy, improving people's health and quality of life, caring for nature and leaving no one behind

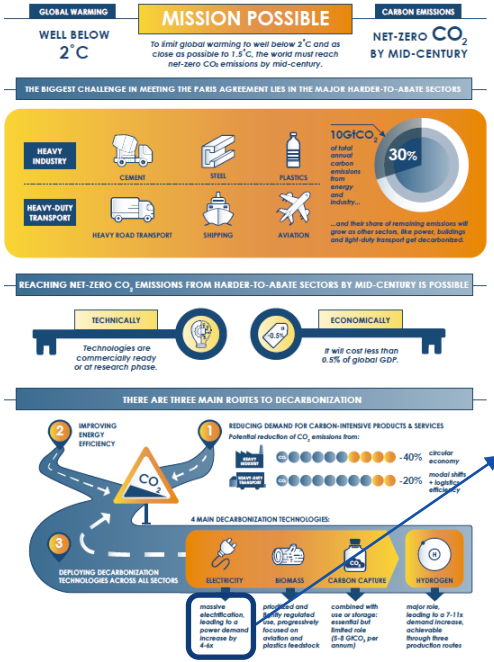
REPowerEU is about rapidly **reducing our dependence on Russian fossil fuels** by fast forwarding the clean transition and joining forces to achieve a more **resilient energy system** and a true Energy Union.

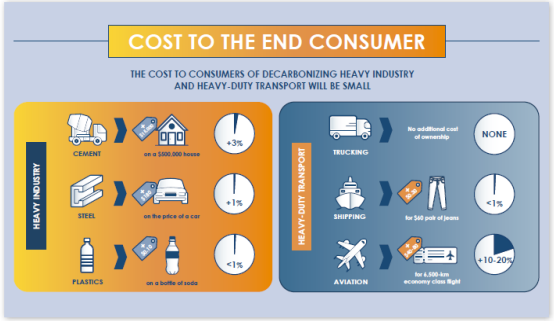
- USA's Inflation Reduction Act with a 369 billion USD investment in Energy Security and Climate Change
- Japans Green Transformation
- Korea's, China's and India's ambitious clean energy targets




Can we reach these goals?
1990
2050

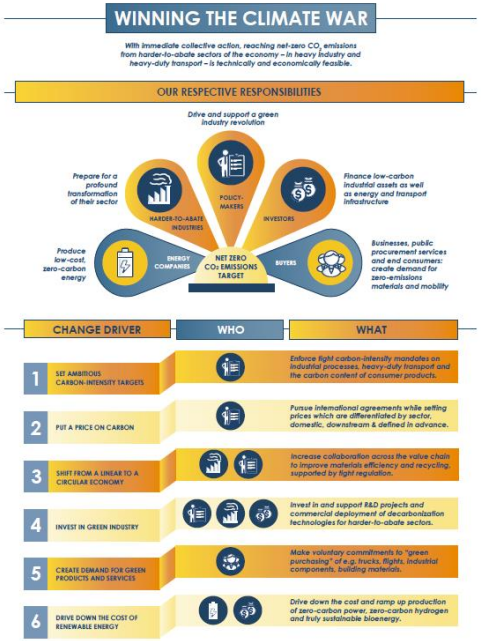
Yes we can! Technologies are ready. Will cost less than 0,5% of GDP





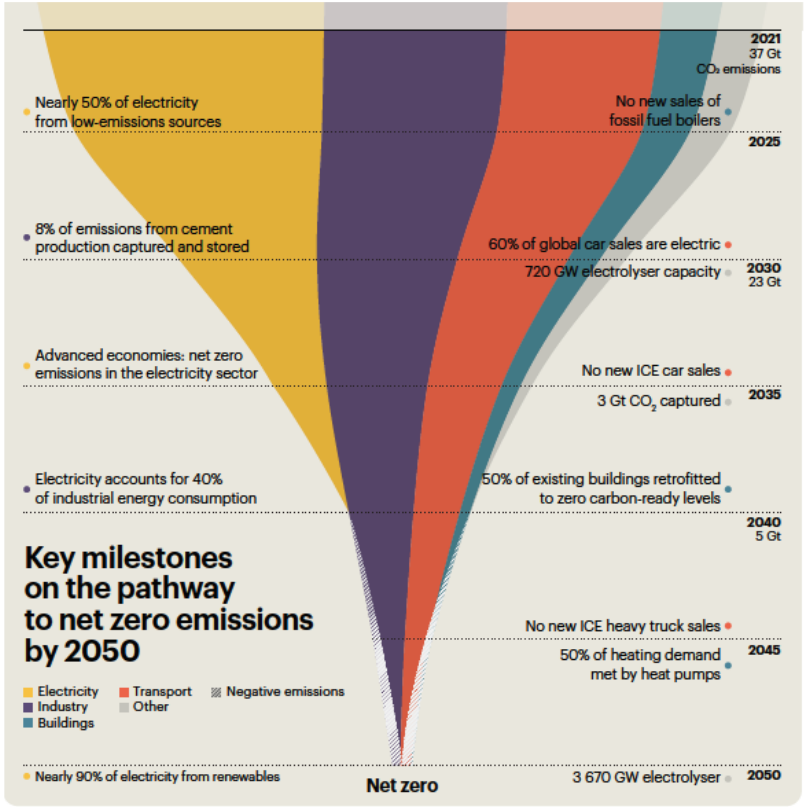
Massive electrification, leading to an electrical power demand increase in Europe by a factor 4 to 6 and internationally by a factor of 7

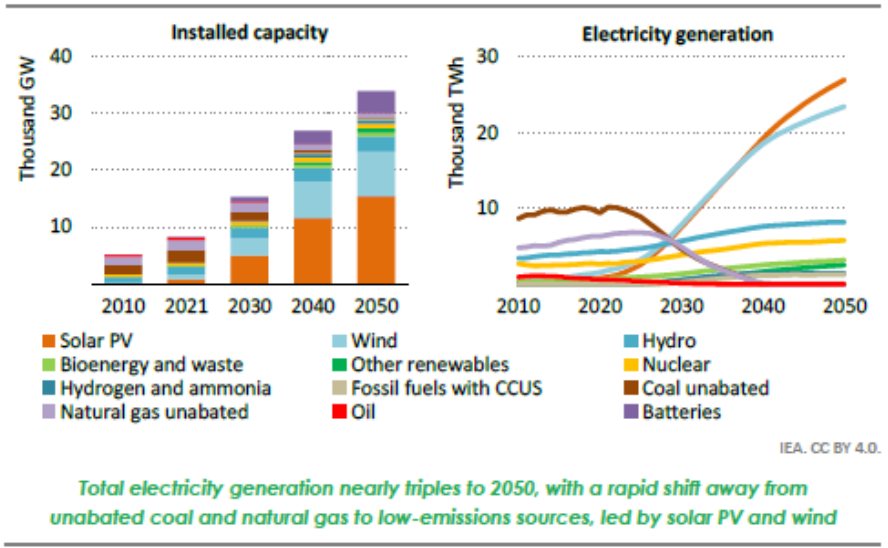
Increased demand requires increased power production and increased transmission



Source: Energy Transitions Commission 2018 and IEA Energy outlook 2022

Energy Outlook 2022



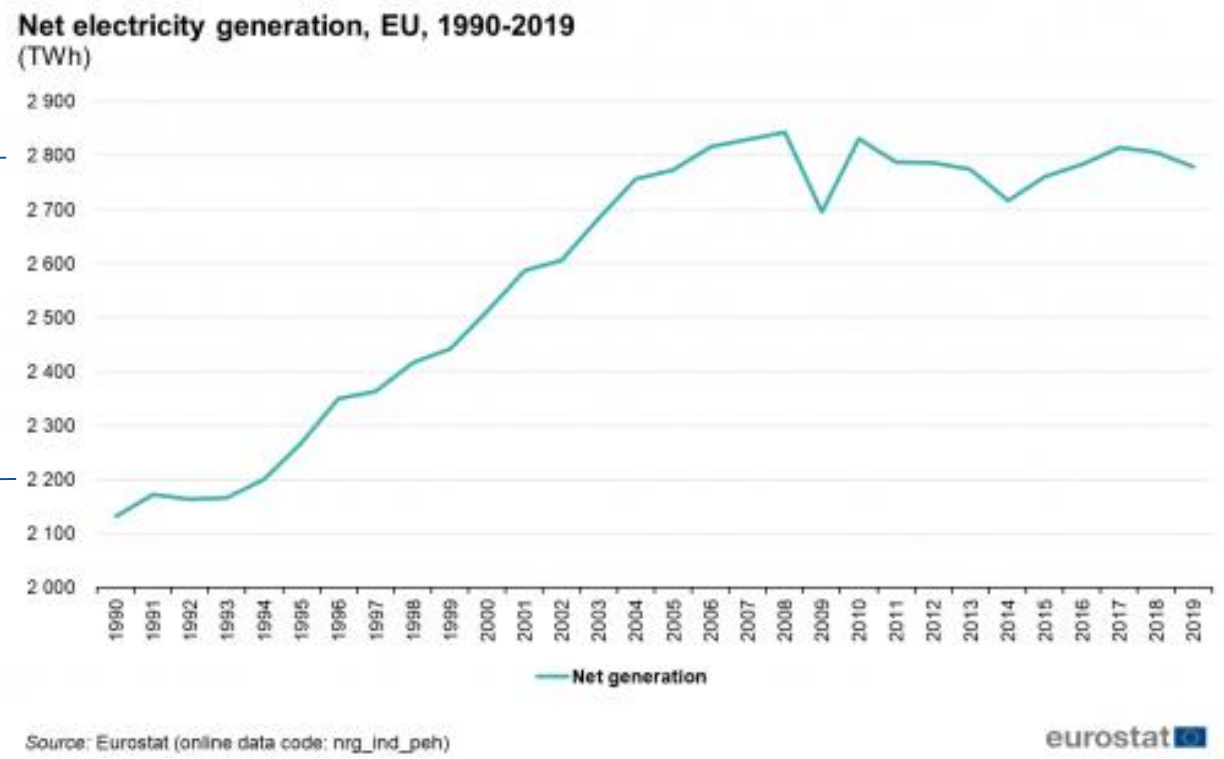


Total electricity generation nearly triples to 2050, with a rapid shift away from unabated coal and natural gas to low-emissions sources, led by solar PV and wind

Net Electricity Generation in Europe

30% increase in
20 years time

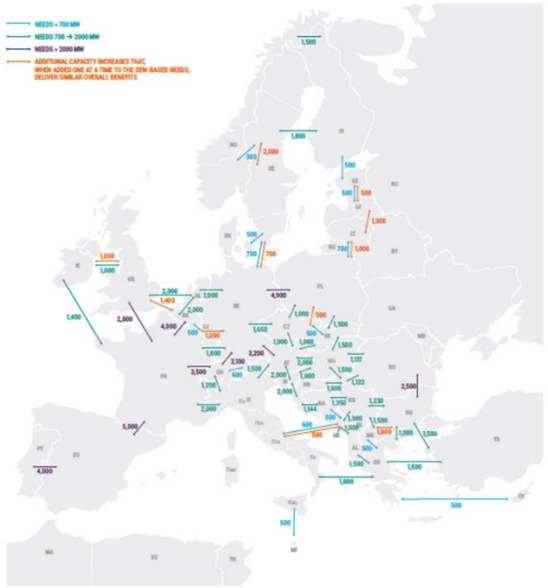
Now we need an at
least 300% increase
in 30 years time



European Electricity Grid planning

2030

2040



Adresses challenges with and solutions for adding:

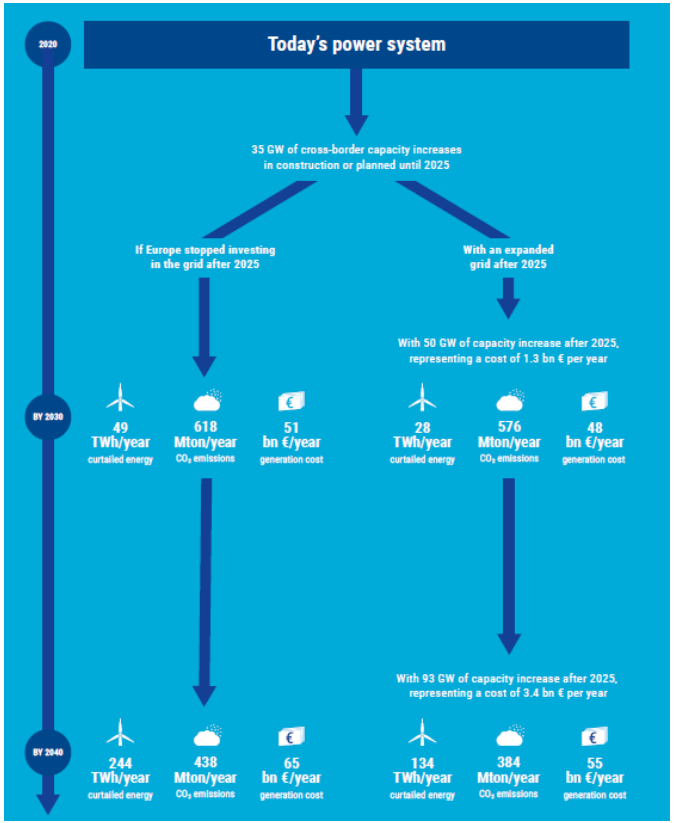
- Significant more and other type of production
- Large and/or many storage facilities
- Flexibility

It will take time to build a grid ready for a carbon free energy system, but it is a prerequisite!

Source: ENTSO-E TYNDP 2020

Green investments that create jobs

- Green Deal: 55 Mtons of CO_2 avoided and 110 TWh curtailed energy saved **each year.**
- Investing will be the key to support the economy post COVID.
  It will support European industry.
- Addressing the identified needs by 2040 would represent 45 bn€ of investments, translating directly into jobs and growth.

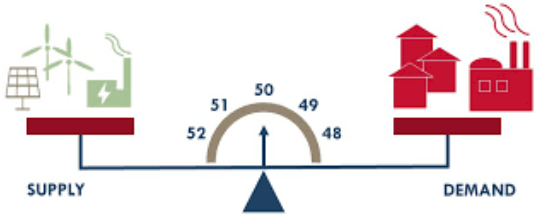


Source: ENTSO-E TYNDP 2020

So what is the problem?

- It is about keeping the lights on
  and this has become more and more difficult
- The supply and demand need to be in balance every single moment

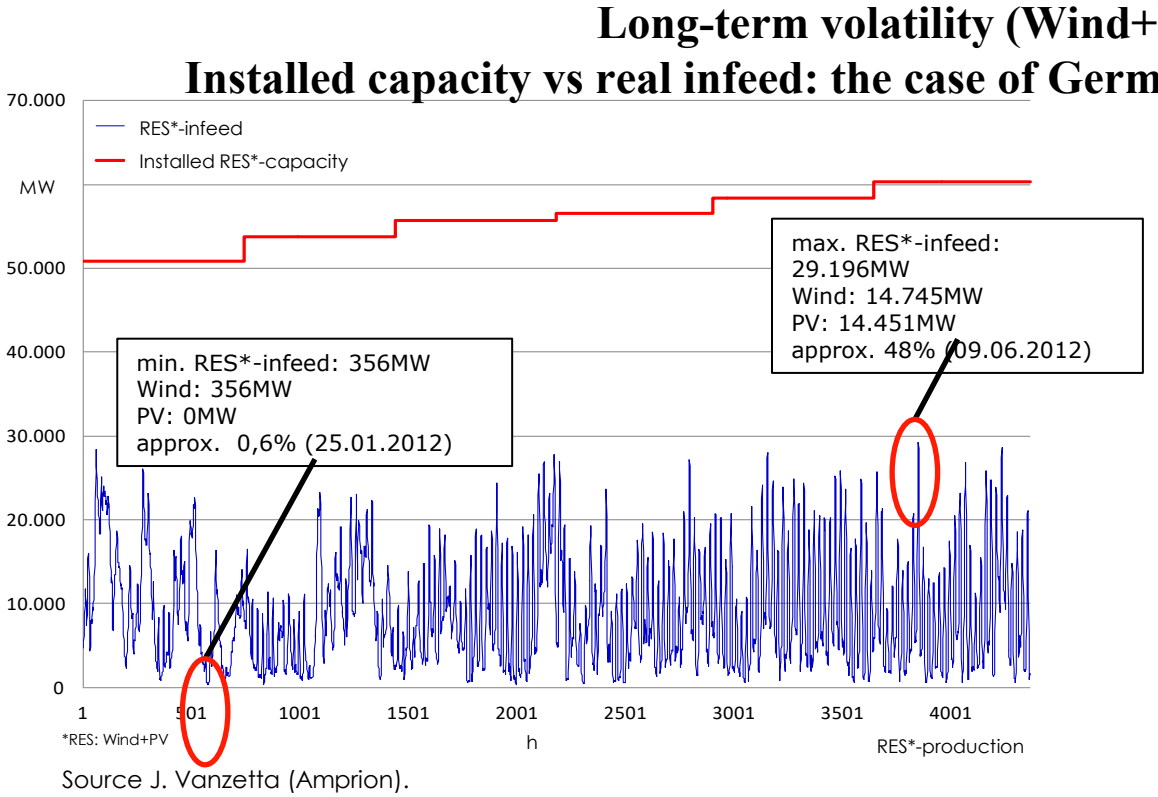
Vecteezy



- Intermittent sources
- Many things happen at the same time
- More actions needed with less time to act
- Increased complexity

Fiverr

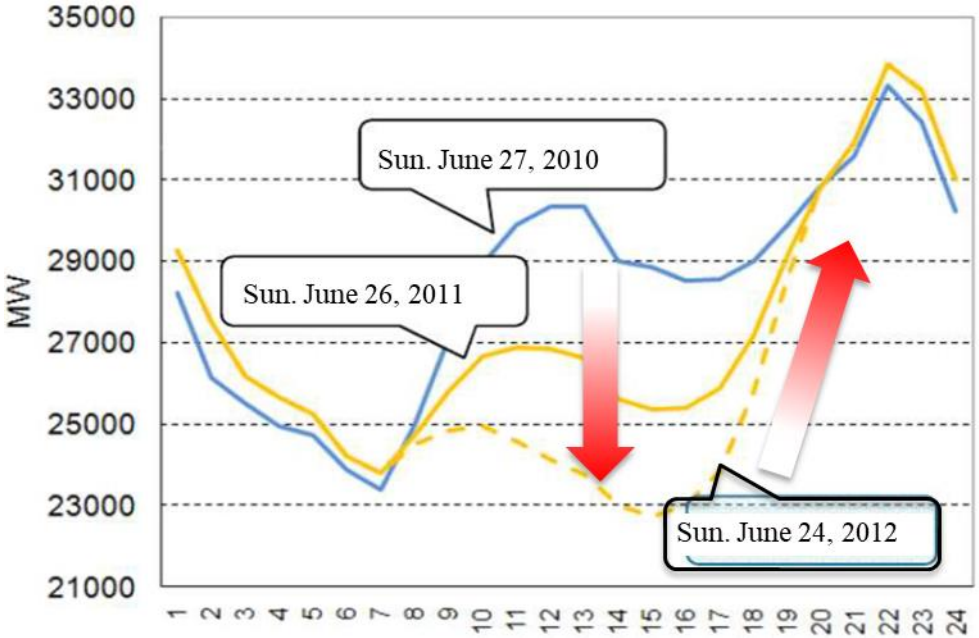
What are the challenges with Renewables?



Source J. Vanzetta (Amprion).

Challenges for the system – Daily Load Curve

- Need of faster ramping
  - Challenges control and other actors in the market
- The unchanged top load
  - Which actor is interested in generating electricity with huge capital investments for just a few hours a day?
  - Can we find enough storage to provide flexibility in the hours with unchanged top load hours?



Case Italy - Impact on the daily load curve

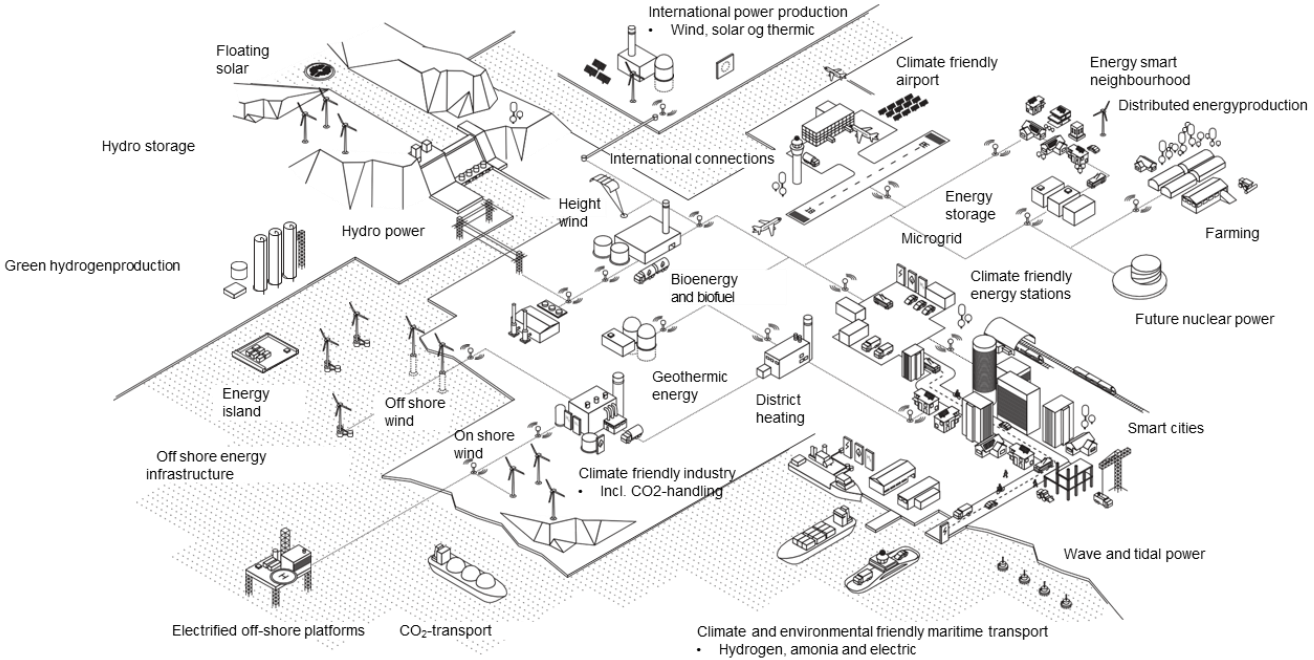
Source: Terna S.p.A.

The transition is self-reinforcing

- Strong indications (e.g. learning curves) that the energy transition will go faster than expected.
- Many different drivers for the many decisions being taken
  - Economical, Sustainable
- New challenges arrive fast
  - Margins are shrinking
  - (unwanted) events occur more frequent with less time to act (less inertia)

How are we going to solve the challenges that arrise as a consequence at a pace faster than anticipated?

Integrated energy system with Digital electricity grids as enabler



Source: Energi21

To solve the challenges faster we need:

- Both new and existing infrastructure to be fully digital
- Digital and better communication, insight, protection, control and market solutions
- More digitalization, automation, optimization, AI, IoT, Cybersecurity, open source
- **More measurements**

Better operational control

- More expected and unexpected events will occur
- With less time to act
- This will be impossible for a control based on manual processes
- We need to fully automatise protection, control and operation
- We need to automatise flexibility

Photo from Statnett

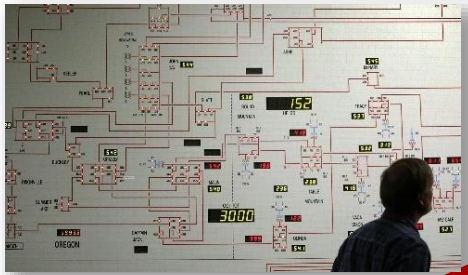
Photo from Power System Operation

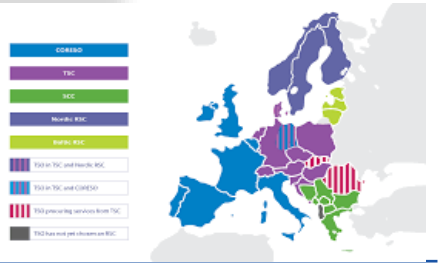
Development of the control center

Digital Transformation

- Novel use of digital technology to solve traditional problems.
- Enable new types of innovation and creativity, rather than simply enhance and support traditional methods

5-10 years!?





Better control of infrastructure

- Since the margins in the power system will be challenged, we need to have accurate real time information about the status and condition of the infrastructure
- We need to know every single second of the day if there are unexpected outages to be expected and if we can utilise the infrastructure at an optimum

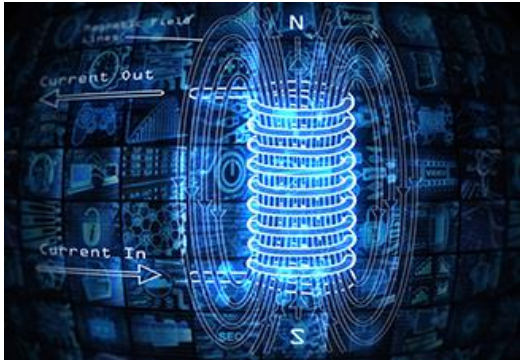


Photo from Weidmann

More AI and data transfer/interaction

- Measurement Data streams will be humongous
  - Quantity
  - Speed
- Fast and automatic decisions with better precision are needed
- Need for more AI
- Need for better data transfer, sharing and interaction

Cyber secure and digital and cyber resilient

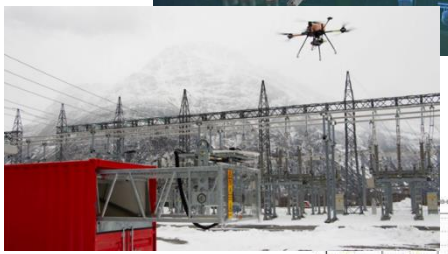
- Full digitalisation and automation increases the quality of supply
- Adds a new risk:
  - Cybersecurity risk
  - Digital resilience
- Cyber security, cyber and digital resilience are a must

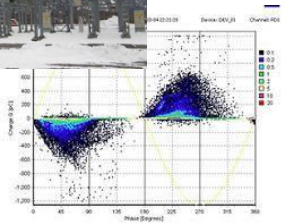
Enormous amounts of reliable and accurate measurements are needed

- No other sector has similar measurement challenges
  - Voltage, Current, Power, Losses
  - Time, Location/Position (e.g. height)
  - Temperature, Pressure
  - Vibrations, Moisture content
  - Solar radiation, ice accretion, precipitation
  - Wind velocity and speed
  - Gas detection, UV, IR
  - Magnetic field, flux, inductance, resistance, capacitance
  - etc

SI Base Units			
Base quantity		**Base unit**	
Name	**Typical symbol**	**Name**	**Symbol**
time	t	second	s
length	l, x, r, etc.	meter	m
mass	m	kilogram	kg
electric current	I, i	ampere	A
thermodynamic temperature	T	kelvin	K
amount of substance	n	mole	mol
luminous intensity	I_v	candela	cd

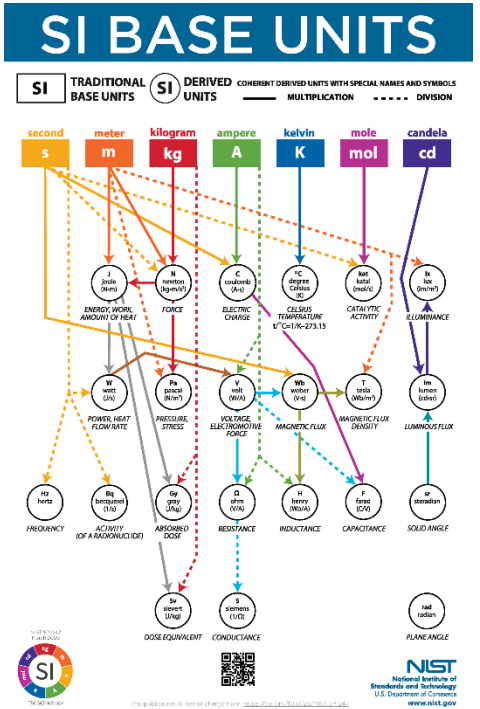
Source: NIST Special Publication 330:2019, Table 2.





Enormous amounts of reliable and accurate measurements are needed

- The challenge is to measure:
  - Small (n) and fast signals (ns) as well as the large signal (T) and slow signals (s)
  - On remote locations under extreme conditions
- Challenging to transmit fast and accurate



Laki Power

Openelectrical.org

Take ways

- Our common goal is to create a sustainable planet
- A sustainable, digital, carbon neutral energy system, with the digital electricity grid as a backbone, is one of the enablers
- It is feasible to make this transition and not too expensive
- Energy transition is self-reinforcing because of sustainable and economic drivers
- Investing in a sustainable, digital energy system will create jobs, reduce generation costs and create a sustainable economy

We need to take the right path

The path towards a digital carbon neutral energy system

Source:Tomdega - videohive.net

It is economic sustainable, it is technical feasible, it is measurable, so let’s just do it!

Questions?

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