EUROPEAN ENERGY FORUM

Online Briefing Session

Energy security: an electricity system perspective

Electricity system security: from basics to lessons learned

In cooperation with the EEF Associate Members

E.DSO SHAPING SMARTER GRIDS FOR YOUR FUTURE

entsoe Reliable Sustainable Connected

Chatham House Rule

@EEF_EnergyForum #EEF_BriefingSession

System security

Presented by ***Tahir Kapetanovic****, Chair of the System Operation Committee, ENTSO-E*
Timothée Decroix*, Chair of the Policy and Communication Group, ENTSO-E*

Emergency synchronization of Ukraine – united Europe despite war!

24.02.2022 Russian attack and war in Ukraine (on this day Ukrenergo according to plan disconnected from IPS/UPS*)

24-26.02.2022 Ukrenergo/Moldelectrica winter-island test, all test cases successful (also after 24.02.2022!);

26.02.2022 Ukrainian Ministry of energy decides not to re-connect to IPS/UPS*

27 (28) .02.2022 Ukrenergo (Moldelectrica) Request for emergency synchronization

01.03.2022 ENTSO-E Task Force established … 11.03.2022 ENTSO-E decision „GO“!

16.03.2022 afternoon: synchronization, in parallel operation ever since!

** Integrated Power System / Unified Power System Russlands*

Synchronous areas and system security

50 Hertz – the heartbeat of interconnected Europe

Transmission System Operators (TSOs) ensure system balance at all times, keeping frequency (close to) 50 Hertz

Frequency corresponds to the rotation speed of synchronous generators connected to the grid

When imbalances occur (and this is often) load/frequency control by TSOs prevents system collapse

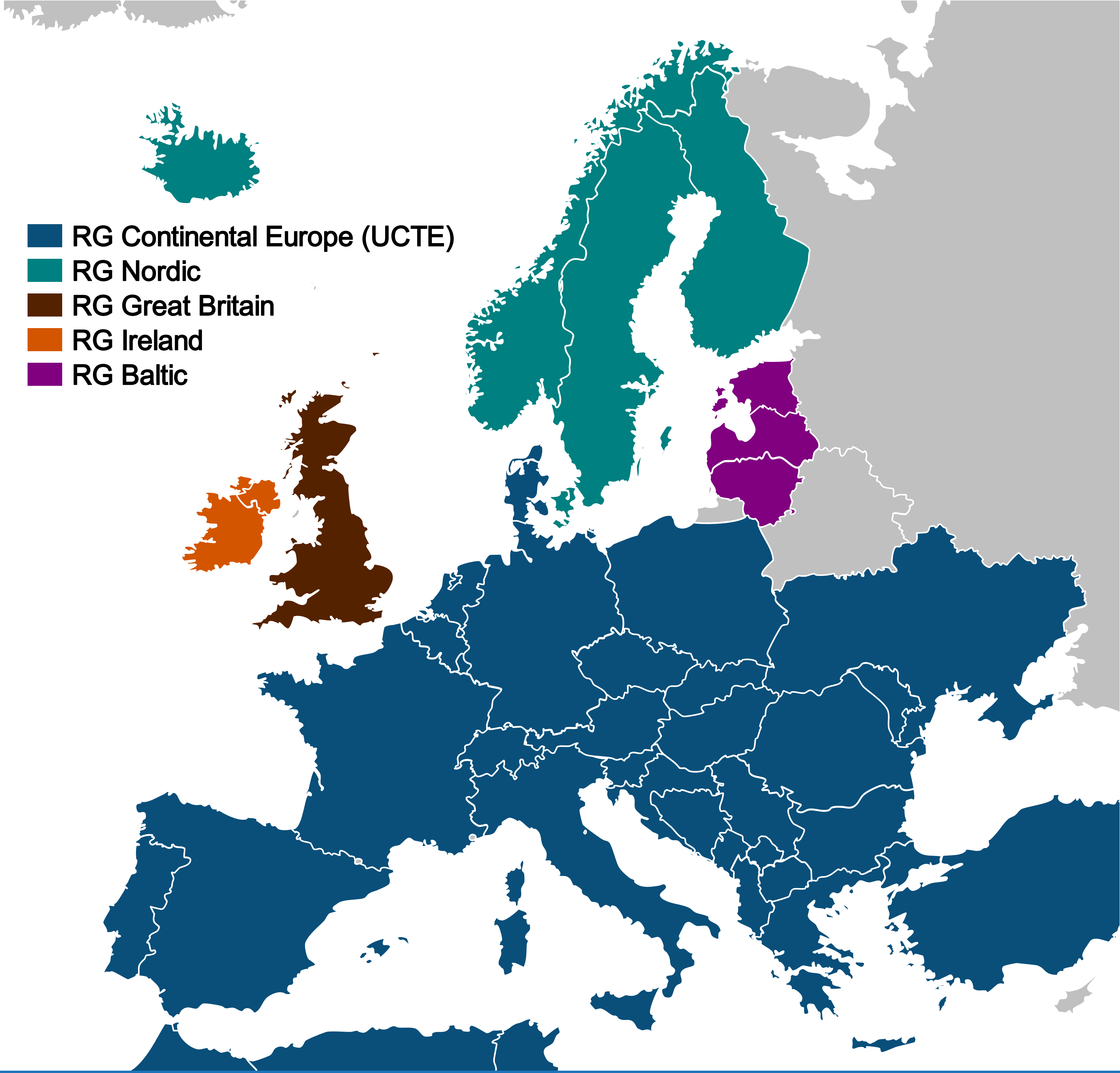
1 **Production**

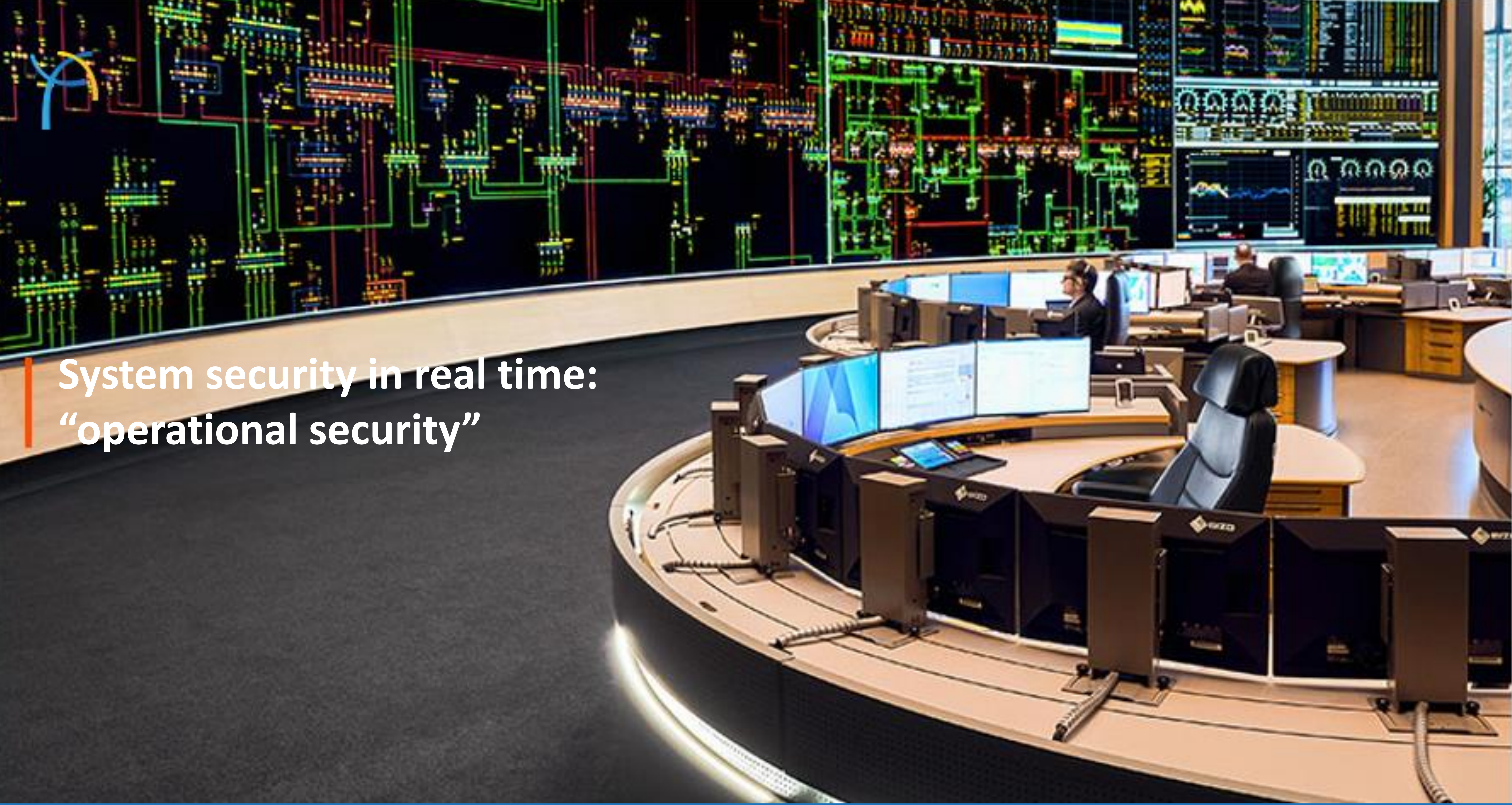
2 **Consumption**

Synchronous areas

- **Synchronous areas = where frequency is the same**

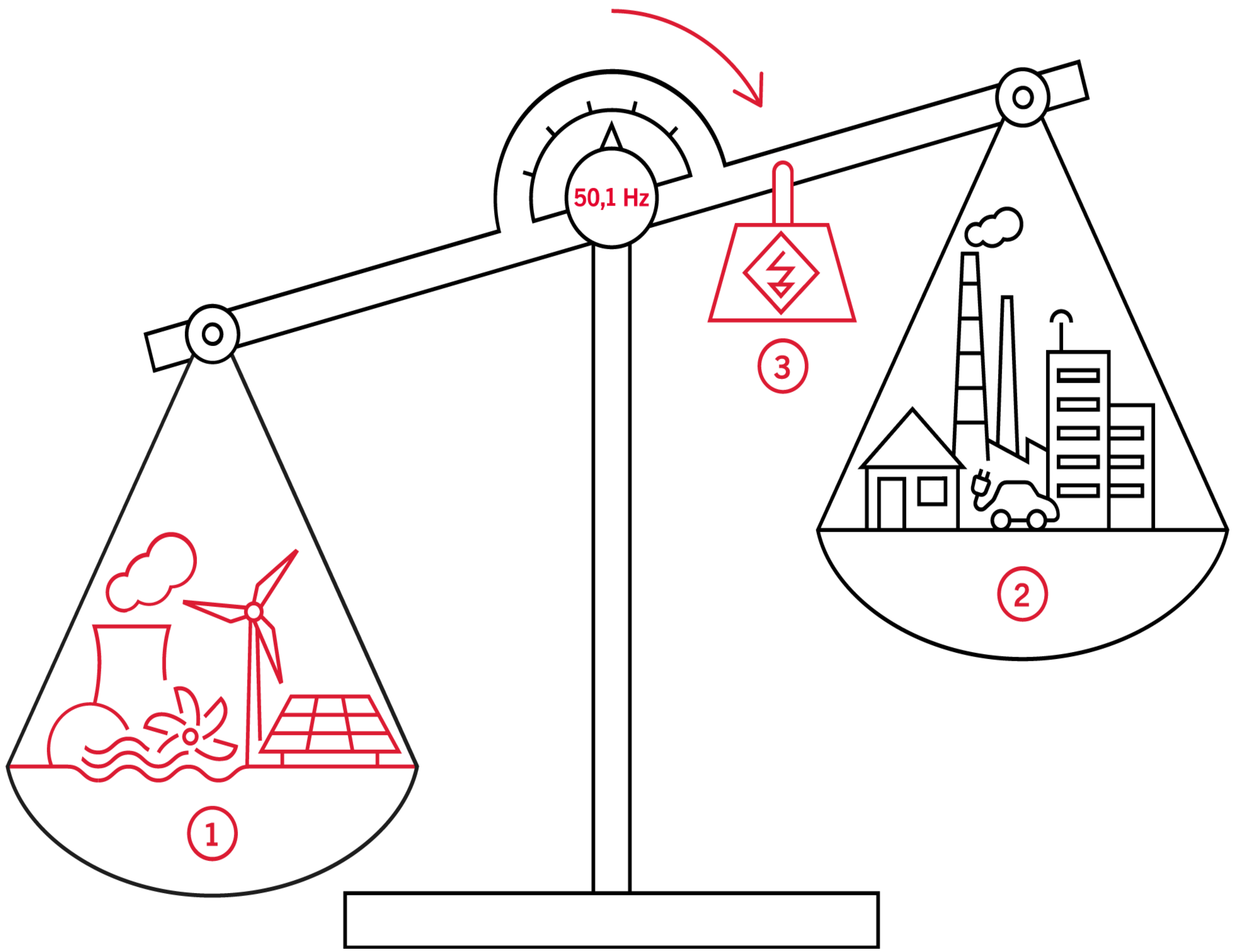
- **The Continental Europe Synchronous Area** (CESA) is the largest synchronous system in the world: >400 mio. people in 24 countries





System security in real time: “operational security”

System security in real time: how to ensure the system is balanced ?



- **Operational security** means that no single incident (e.g. line tripping) propagates further and leads to a blackout ➔ (N-1) criterion
- **Market** mechanisms for demand/generation balance
- **Imbalances** in real time after market is closed **are managed by TSOs activating reserve**
- When deviations are very large, **automatic protection schemes** prevent blackout by disconnecting excessive load

1 Production
2 Consumption
3 Balancing

Balancing the system is just one but not only system security measure

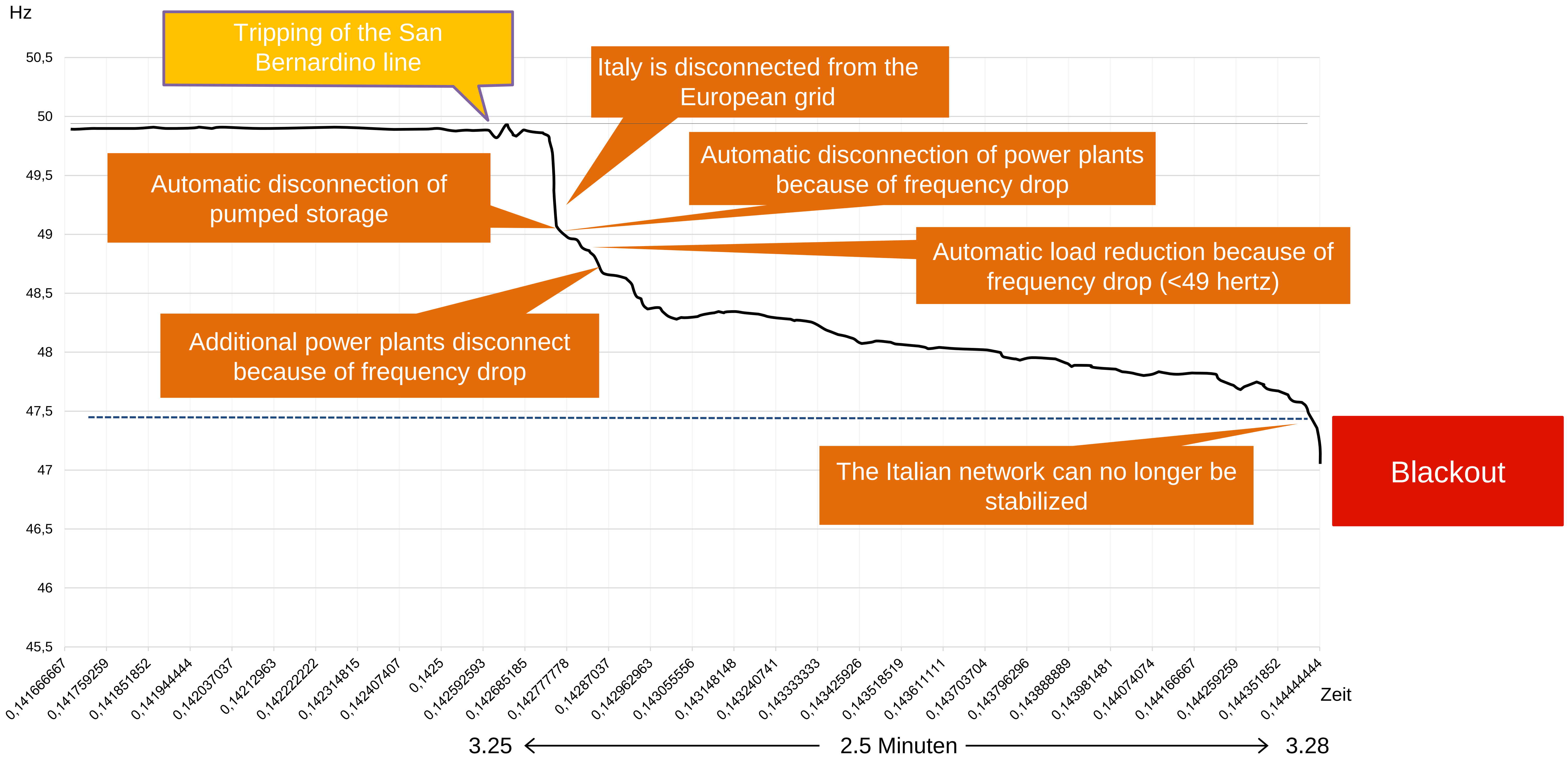
- **System security relies further on:**

- **Security standards** for those connected to the grid (network codes)
- **Ancillary services,** provided to the TSOs to ensure system parameters are good (frequency, voltage, etc.)
- **Consideration of physical grid limitation**
  - **'(N-1) criterion'** must always be respected
    - *"the rule according to which the elements remaining in operation within a TSO's control area after occurrence of a contingency are capable of accommodating the new operational situation without violating operational security limits" (Guideline on electricity transmission system operation, Regulation (EU) 2017/1485)*
  - **Market design must consider the grid constraints** … the capacity that can be allocated to the market.
  - **Redispatching** and countertrading are tools for TSOs to manage the congestions by lowering the power feed-in on one side of the congested area and increasing it on the other side.

Case study #1: Blackout in Italy on 28. September 2003

- Lasted more than 12 hours
- Impacted 56 mio. people

Case study #1: a path to a blackout



System security in real time: “operational security”

Ensuring security of supply requires also an adequate system

- **System Adequacy has two components**

- **Generation adequacy**, i.e. ensuring that enough generation capacity is available to cover the demand (+ losses)

- **Infrastructure adequacy**, i.e. ensuring that the grid is can accommodate the power flows at all times

  – **Main challenge = (much too) long licensing proceedings for all electricity infrastructure, especially lines**

ENTSO-E Ten Year Network Development Plan – infrastructure needs

Main findings of the TYNDP 2022 System needs study[1]

In 2030

- 64 GW of capacity increases after 2025 on over 50 borders
- 17 TWh of curtailed energy saved each year
- Dependence on gas for power generation decreases by 9 TWh/year
- 14 Mton of CO_2 emissions avoided each year
- Generation costs decrease by 5 billion euro per year
- Existing transmission projects do not cover all system needs, a 15 GW investment gap remains

In 2040

- 88 GW of capacity increases after 2025 on over 65 borders, 41 GW of storage in 19 countries and 3 GW of CO_2-free peaking units in 4 countries
- 42 TWh of curtailed energy saved each year
- Dependence on gas for power generation decreases by 75 TWh/year. That's equivalent to 14 % of the EU gas-based electricity generation in 2021.
- 31 Mton of CO_2 emissions avoided each year
- Generation costs decrease by 9 billion euro per year
- Increased security of electricity supply, with 1,6 TWh of avoided energy-not-served
- There are opportunities for new solutions to address the needs throughout Europe

ENTSO-E winter 2022/2023 adequacy outlook (www.entsoe.eu)

1

Tight periods foreseen with best available projections (reference case)

- Situation this winter is critical but manageable with operational measures.
- Hydrological situation to be closely monitored.
- Nuclear availability is low and adds stress to the system.
- Electricity supply depends strongly on gas in all winter scenarios.
- Simultaneous scarcity situations in various countries need close attention.

- ➢ System stress in Irish system, France, Southern Norway, Malta and Cyprus when counting on efficient use of market resources only.
- ➢ Loss of Load Expectation raises to higher levels than last winters.
- ➢ Minimum gas needs for electricity adequacy equals about one third of total European usable gas storage.

2

Additional risks can materialise (sensitivities)

- Additional stress elements can materialise and become problematic, especially if they coincide.
- Nuclear unavailability higher than foreseen will have local but strong impact.
- Further constraints in fuel supply increase adequacy risks.
- Switch from gas to direct electric heating can stress the electricity system and indirectly create extra demand of gas for power supply.

- ➢ Additional nuclear unavailability in Nordic system has notable impact
- ➢ French nuclear unavailability has high local impact.
- ➢ Further fuel constraints in Germany and Poland would have a local impact on adequacy.
- ➢ Fuel switch of residential users would mean higher adequacy risk.

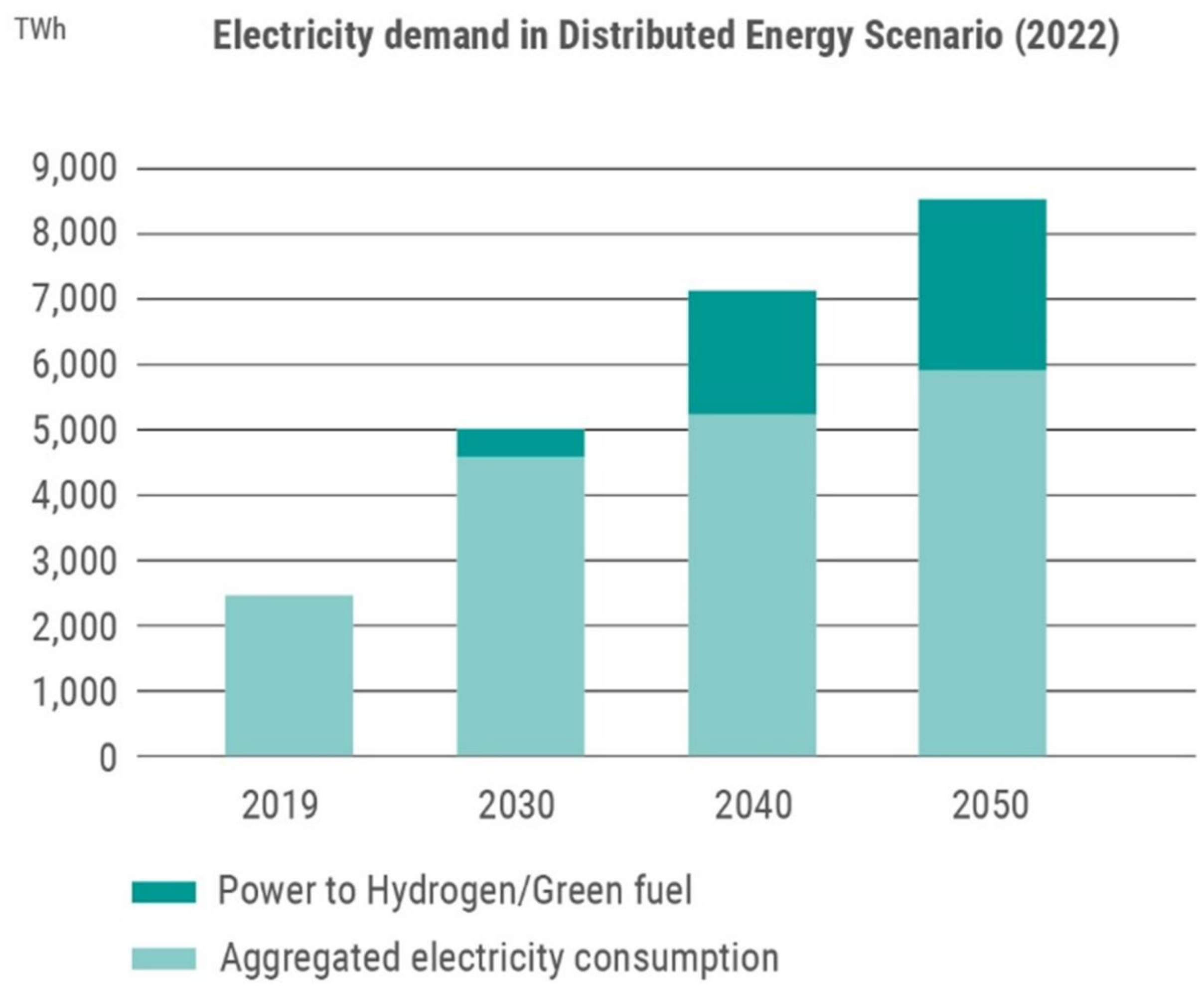
3

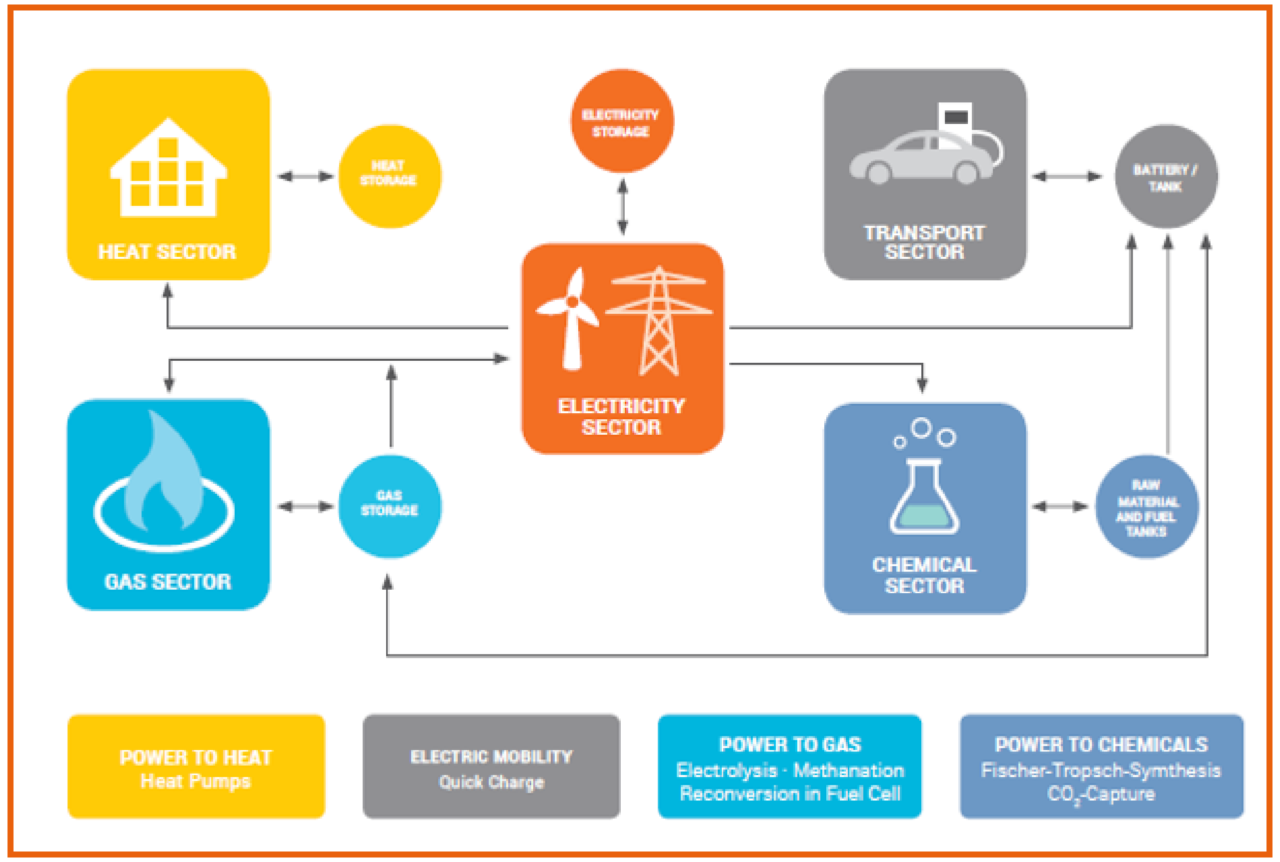
Need for early coordinated measures (preparedness)

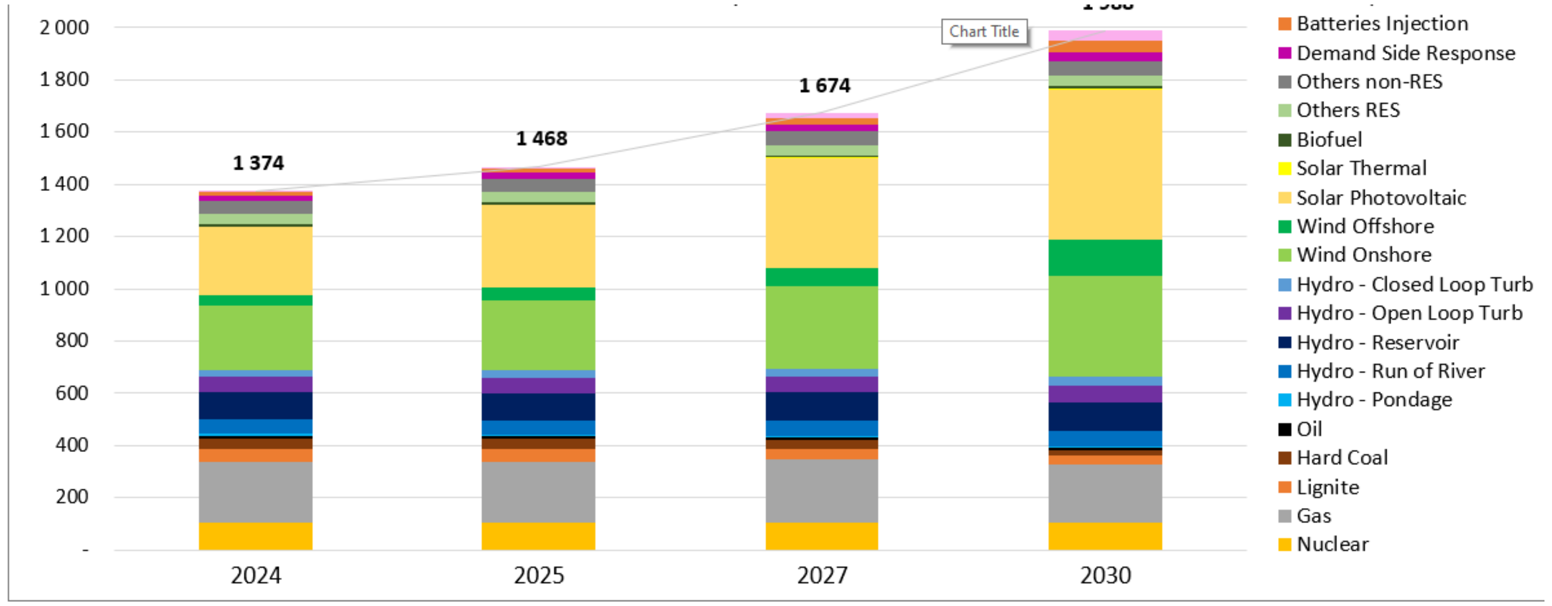
- TSOs are pro-actively taking measures at national level and closely coordinating at regional and pan-European levels.
- Coordination and cooperation among the European States and National Risk Preparedness Plans are key for this winter.
- Demand reduction reduces significantly the risk for the system.
- System adequacy relies on all market participants.

- ➢ If 10% demand reduction objective is met, adequacy risks become negligible and critical gas dependency reduces by 30%.
- ➢ Even a 5% peak shaving can mitigate most risks in continental Europe, with a remaining risk in France.

What changes





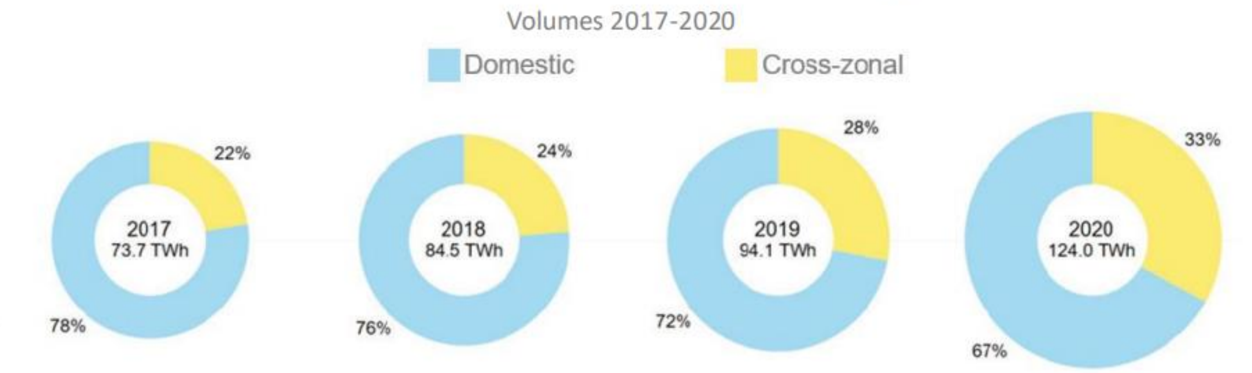


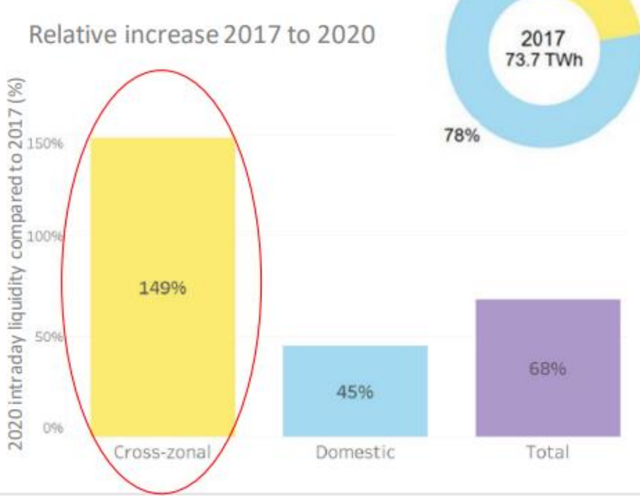
- Steady increase of generation capacity over the horizon
- Renewables increase their share in the total mix up to more than 55% in 2030
- Consistent growth of flexibility (Electrolysers, Batteries and DSR)

ACER
European Union Agency for the Cooperation of Energy Regulators

In 2020, despite the pandemic, market integration progressed

EVOLUTION OF INTRADAY TRADE IN EUROPE (% AND TWH)

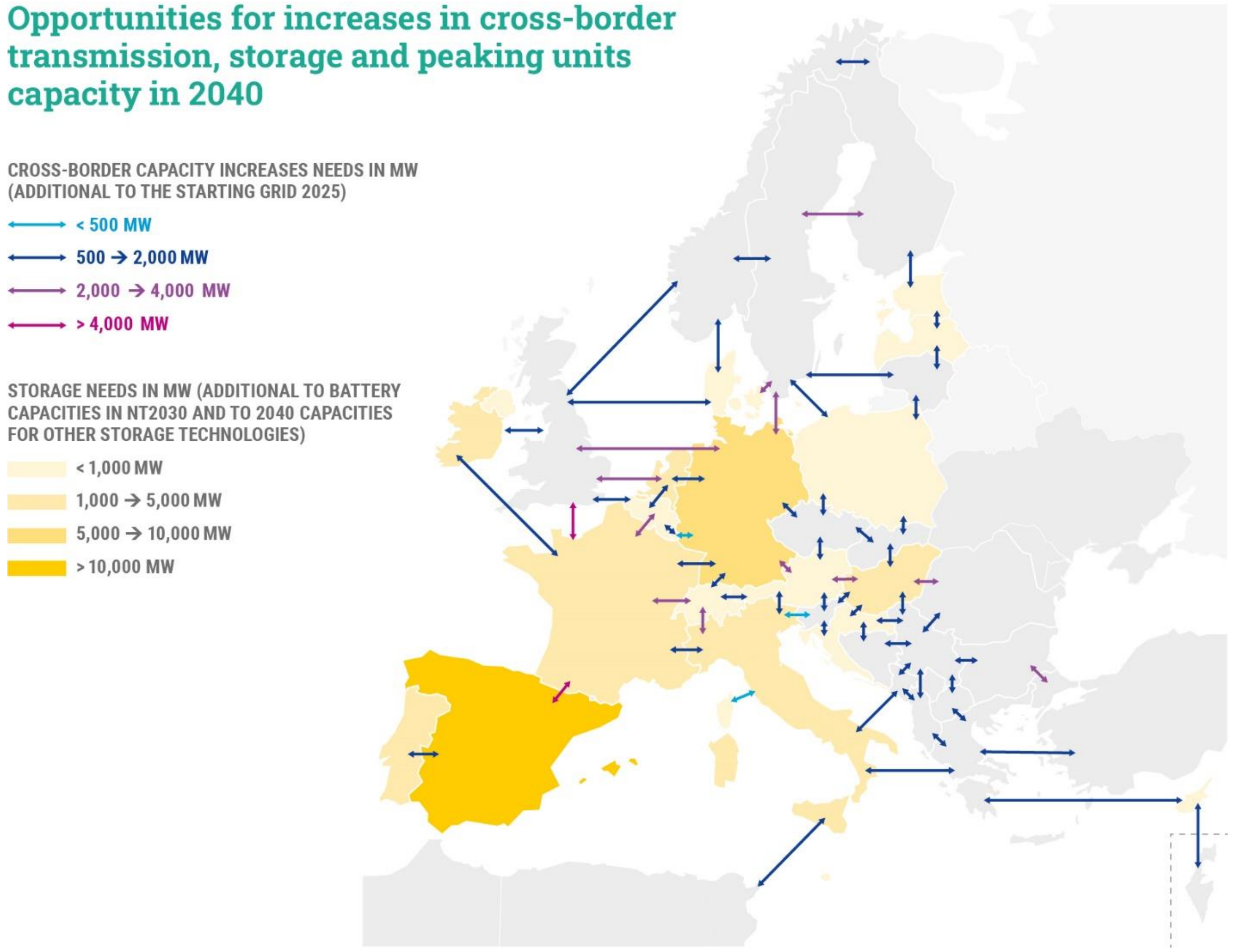




Similarly, 2020 saw further progress in the integration of EU intraday markets; an important achievement to facilitate large-scale integration of renewable resources, not least to manage their intermittency and variability.

Outstandingly, cross-zonal intraday trades increased by around 150% following the go-live of single intraday market coupling in 2017.

Infrastructure – Connecting the means and the needs



- ***Short term:*** *huge* ***investments*** *in* ***interconnectors****, generation from renewable sources (i.e.* ***offshore****) to reach the 2030 climate objective & EU targets*

- ***Medium-long term:*** *in the 2030-2040 timeframe, a* **6 billion euros/year investments** *(in cross-border capacity, storage and peaking units)* ***produces a 9 billion/year increase in socio-economic welfare (TYNDP 2022)***

Achieving EU targets:

1. Public-private-partnerships *for direct electrification and the decarbonization of the other sectors*
2. **Streamlining permitting** processes for both **grid infrastructure** and **RES projects** (in particular offshore)
3. Good **market design** and **regulatory framework**
4. Strengthening **links** with **EU neighbourhood countries** to ensure **security of supply** and allow further **flexibility** in the system

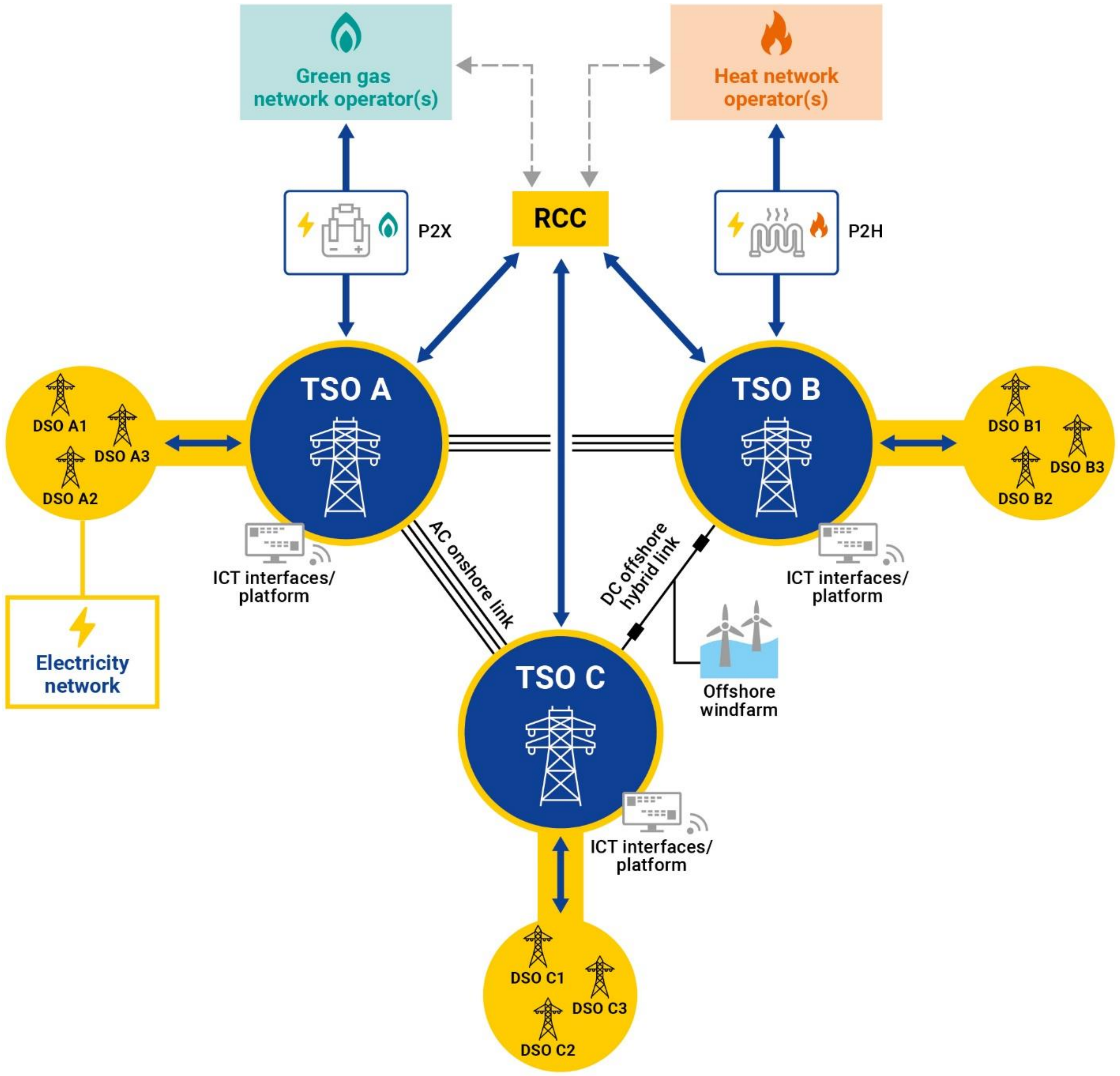
ENTSO-E Vision: operating a system of systems in 2050

The future power system will be much more **complex** than today, with growing weather dependency, sector integration and large-scale flexibilities.

It will need new approaches to **operate it safely and efficiently**.

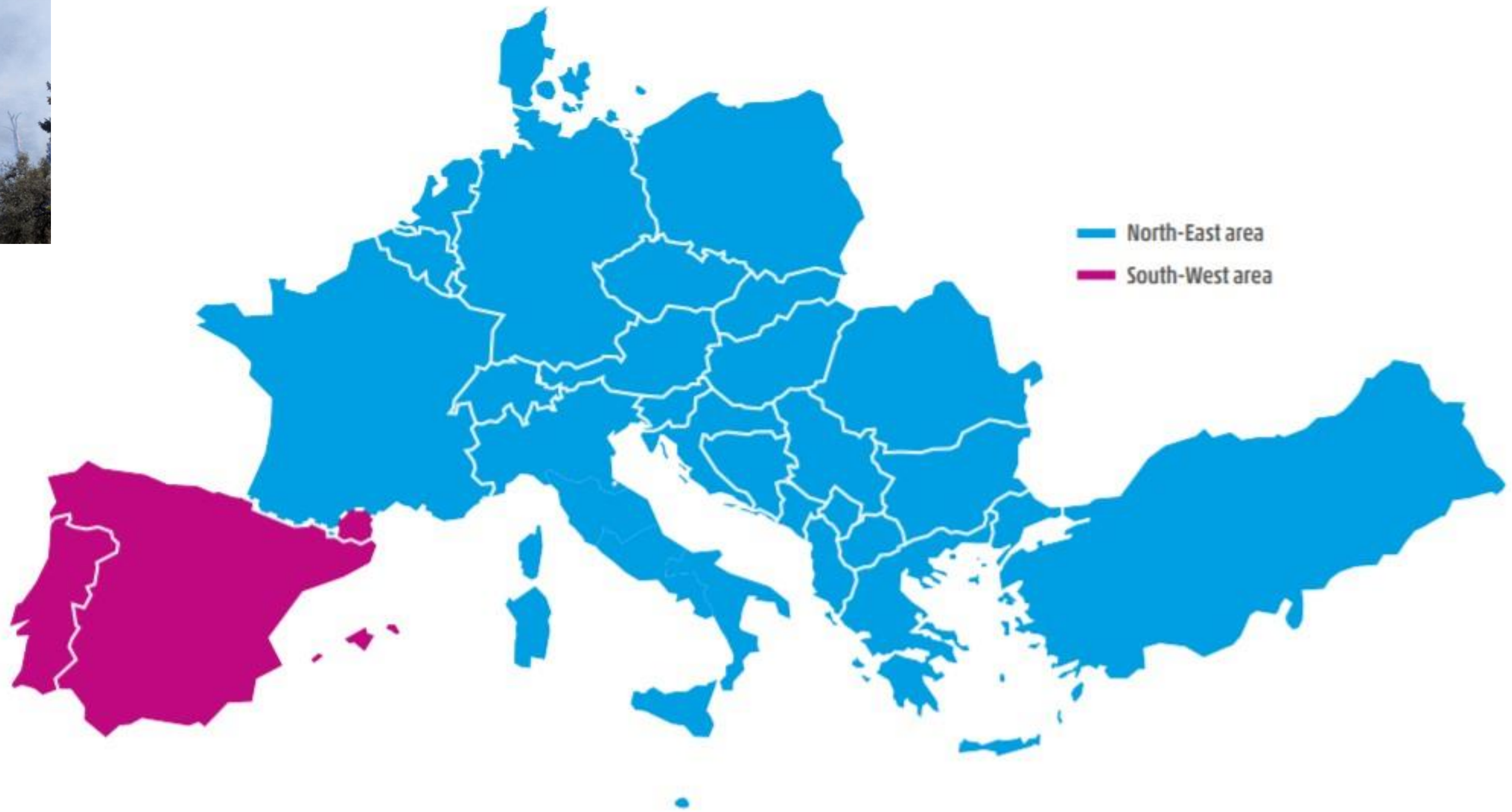
In particular, the **operation of the transmission grid** will be done in close cooperation

- amongst **TSOs** at European and Regional level, assisted by Regional Coordination Centers
- with **DSOs** inside each control zone
- with other **energy sectors** integrated with the power system



Case study #2: CESA System Separation on 24 July 2021

- In Spain and Portugal **4,872 MW of load was shed,**
  2,302 MW of pumps disconnected,
  and **3,764 MW of generators disconnected**



Case study #2: CESA System Separation on 24 July 2021

Load shedding:

- Spain, Portugal, southeast of France
- **3,561 MW** were disconnected in Spain, **680 MW** in Portugal, and **65 MW** in France, to restore the balance
- Prior to the incident, **1,995 MW** of pumped storage were connected in Spain and **422 MW** in Portugal. Due to the underfrequency condition, all of them tripped (automatic disconnection) during the frequency drop.

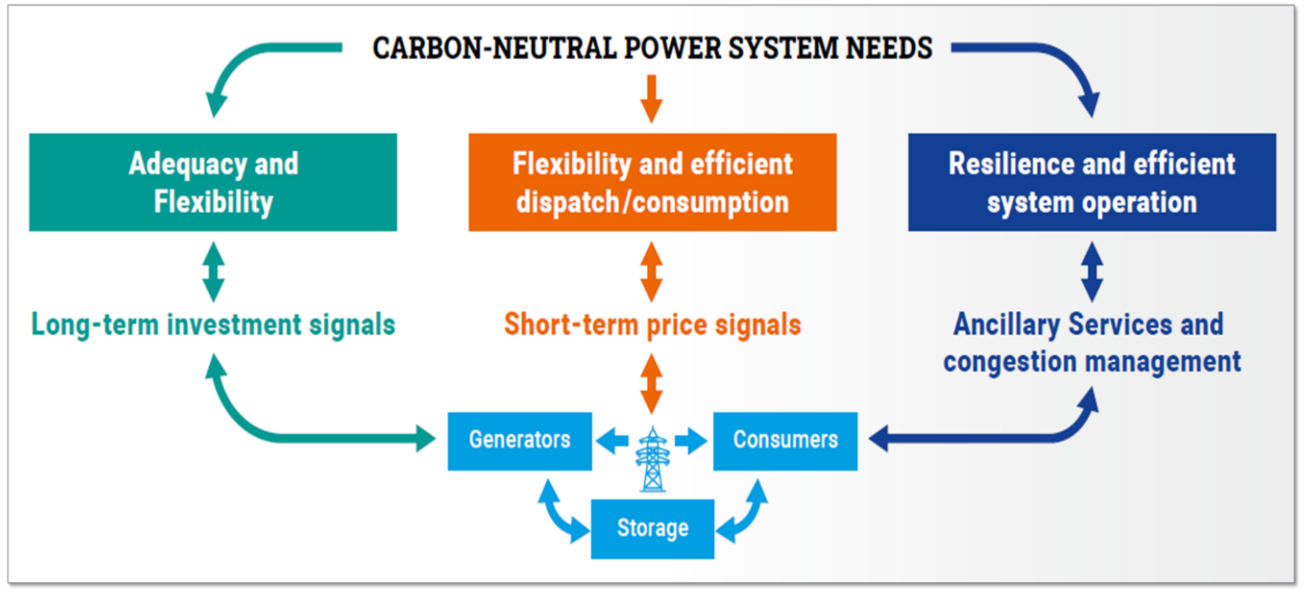
Loss of generation units

- The details of the system defence plans of Portugal and Spain have been analysed, including **the unintentional loss of generation units** and loads.
- **Most of the generation units which were disconnected** in Spain operated at the medium voltage level and were disconnected due to under- or overvoltage relays **on the DSO level**. In Portugal, most of the generator disconnections occurred due to underfrequency relays on the DSO level. As precise and reliable voltage measurements are only available at the high voltage transmission level, it is **difficult to assess the exact amount of non-conform disconnections**.
- Recommendation to **improve TSO–DSO coordination** for the definition of settings of under frequency protection settings that trip the generation connected to the distribution grids and to improve the monitoring of distributed generation.

Conclusions

ENTSO-E Vision: Key elements of a Power System for a Carbon Neutral Europe

1. The development of significant system **flexibilities**, both short and long duration, that will need to be timed with the phase-out of fossil fuel generation.
2. An **operation** of the system that will rise up to the challenge of this much more dynamic System of Systems, including the management of flexibilities, through innovation and cooperation.
3. A regulatory framework, planning and permitting procedures that will facilitate the timely deployment of the necessary **investments**, and encourage efficiency and innovation.
4. A **market design** that must evolve to allocate value where it will be most needed for the energy system, while reflecting different consumers needs and preferences.



Strengthen **investment signals** for carbon-neutral energy and flexibility sources by facilitating the introduction of well-designed two-way Contract for Differences and where necessary capacity remuneration mechanisms.

Increase accuracy of **short-term price signals** of day-ahead, intraday and balancing markets in space and time to optimise dispatch, flexibility and grid use.

Develop retail pricing solutions that facilitate **consumers engagement** and demand response while ensuring affordability and consumer protection.

TSOs, through ENTSO-E, propose this work as a basis to **start building this future together**

The role of electricity DSOs in a changing energy system

Presented by ***Santiago Gallego Amores****, Member of the Policy and Regulation Committee of E.DSO*

Index

- Who manages the electricity distribution network?
- DSOs or how to convert grid management towards a smarter system
- What are smart grids?
- Why do smarter grids matter?
- Energy security: are electricity grids resilient enough?
- DSO-TSO cooperation
- Conclusions

Who manages the electricity distribution network?

Distribution System Operators (DSO) are the entities responsible for **distributing** and managing energy to the final consumers through the distribution grid.

Electricity distribution is a **natural monopoly** which is handled by DSOs. The EU Regulation introduced **unbundling requirements** in the third Energy Package adopted in 2009 for vertically integrated undertakings.

Who manages the electricity distribution network?

As system operators, **DSOs secure a reliable flow of electricity** through their network to their customers. They constantly **develop** and **maintain** their networks to ensure that the networks operate efficiently and with high level of system **security, reliability and efficiency** in its areas with due regards for the environment and energy efficiency.

EN — Official Journal of the European Union

DIRECTIVES

DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 5 June 2019

on common rules for the internal market for electricity and amending Directive 2012/27/EU

(recast)

(Text with EEA relevance)

CHAPTER IV

DISTRIBUTION SYSTEM OPERATION

Article 30

Designation of distribution system operators

Member States shall designate or shall require undertakings that own or are responsible for distribution systems to designate one or more distribution system operators for a period of time to be determined by the Member States, having regard to considerations of efficiency and economic balance.

Article 31

Tasks of distribution system operators

1. The distribution system operator shall be responsible for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity, for operating, maintaining and developing under economic conditions a secure, reliable and efficient electricity distribution system in its area with due regard for the environment and energy efficiency.

Who manages the electricity distribution network?

	Country	Code	Number of DSOs	Number of legally unbundled DSOs
	Austria	AT	126	11
	Belgium	BE	16	12
	Bulgaria	BG	4	4
	Croatia	HR	1	1
	Cyprus	CY	1	1
	Czech Rep.	CZ	290	3
	Denmark	DK	40	10 [4]
	Estonia	EE	34	1
	Finland	FI	77	9
	France	FR	144	6
	Germany	DE	883	80
	Greece	GR	1	1
	Hungary	HU	6	6
	Ireland	IE	1	1
	Italy	IT	128	8
	Latvia	LV	11	1
	Lithuania	LT	6	1
	Luxembourg	LU	4	1
	Malta	MT	1	0 [5]
	The Netherlands	NL	6	6
	Norway	NO	119	7
	Poland	PL	184	5
	Portugal	PT	13 [6]	1
	Romania	RO	51	8
	Slovakia	SK	3	3
	Slovenia	SI	1	1 [7]
	Spain	ES	354	5
	Sweden	SE	170	6
	Switzerland	CH	630	0
	United Kingdom	UK	14	6
	Total		3319	195

DSOs have different sizes throughout Europe in terms of network length and connected customers. Some are municipal *(e.g., in Germany)* whereas others can straddle several regions (France, Italy).

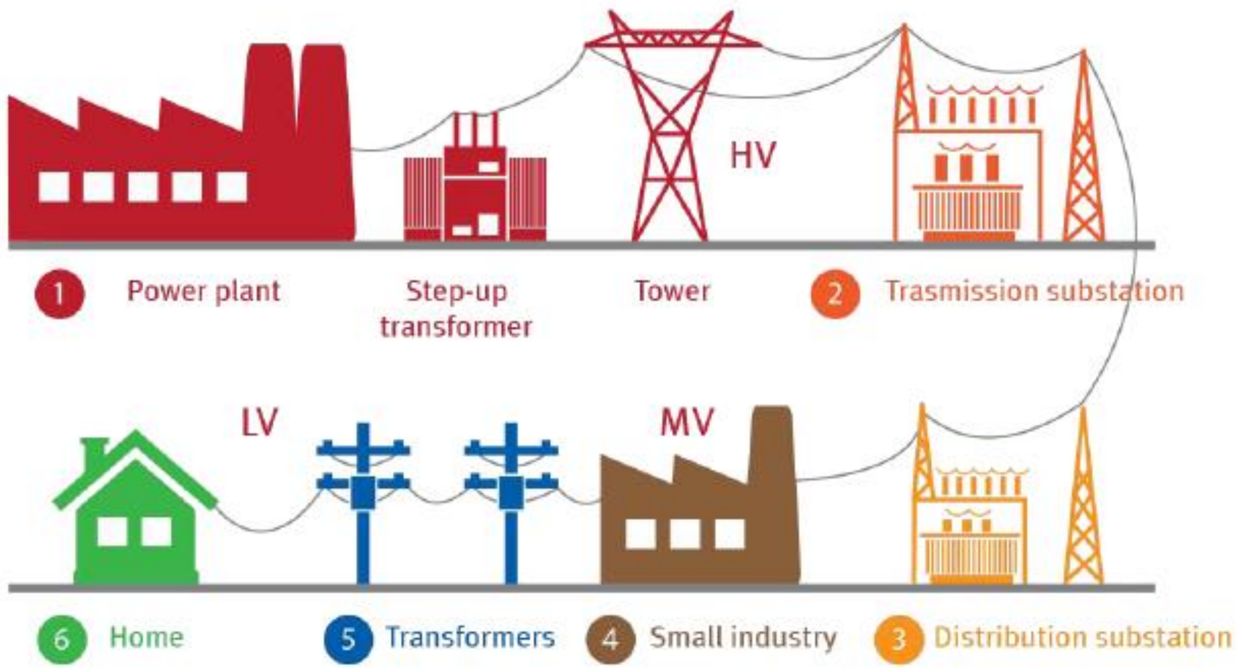
There are more than **2.400 DSOs in the EU**.

Low concentration	Medium concentration	High concentration	Very high concentration
Mainly small, local DSOs. The three largest DSOs usually deliver less than 50% of distributed power	A mix of DSOs, with the three largest accounting for more than 60% of distributed power	One dominant DSO (more than 80% of distributed power) and several local DSOs	One DSO company

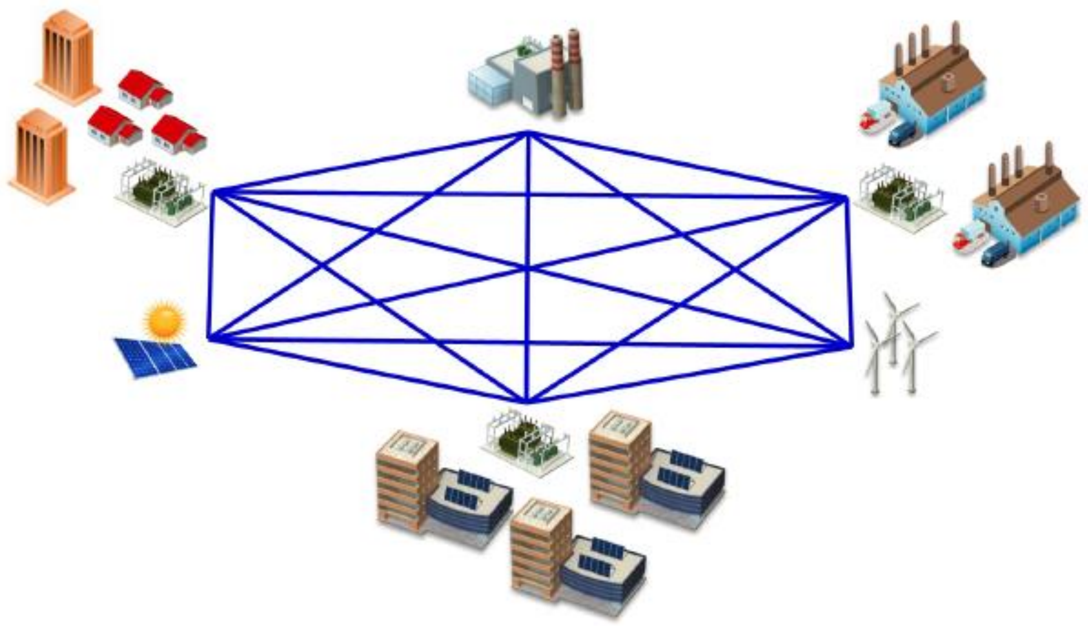
Eurelectric, 2020

DSOs or how to convert grid management towards a smarter system

People often think and talk about the power grid as if it were a linear electricity delivery system or a supply chain…

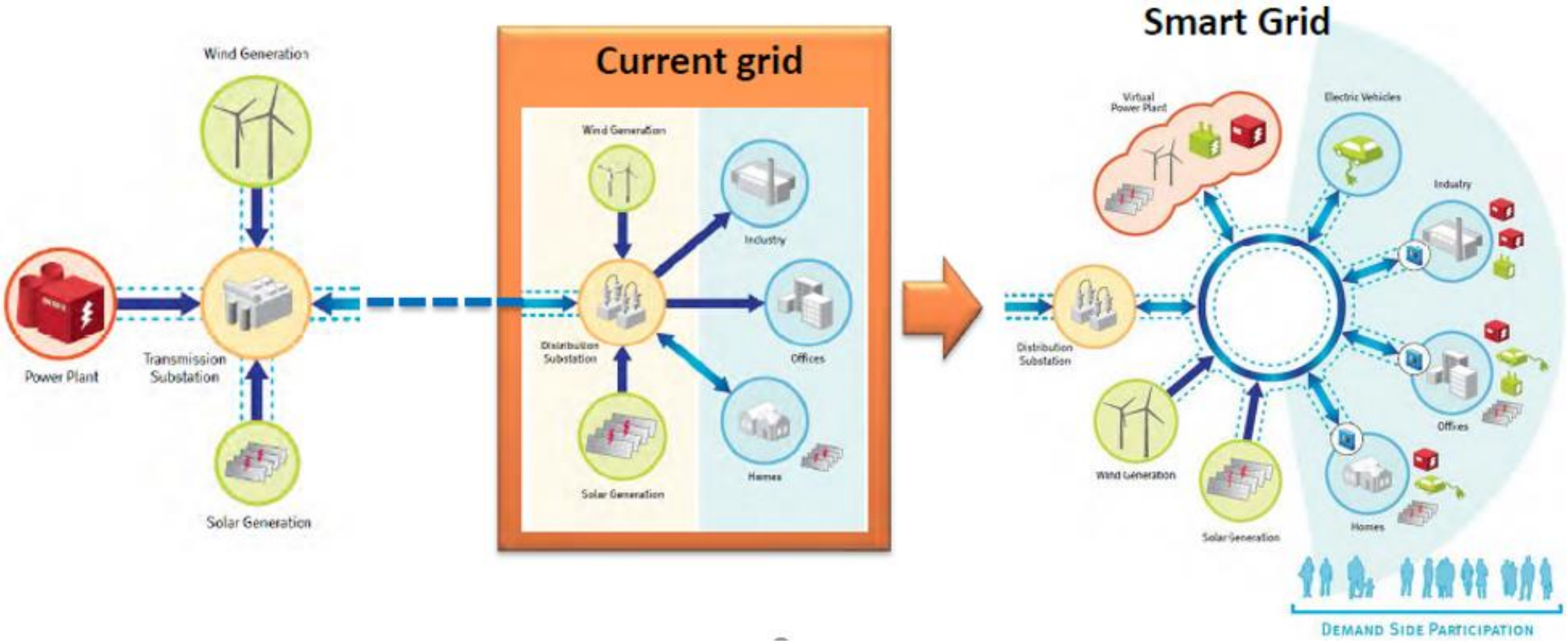


But in fact, the power grid is a network, a system of interconnected pieces that together deliver power to end consumers.



DSOs or how to convert grid management towards a smarter system

It is estimated that **not less than €400bn** would be needed by 2030* to modernize the EU electricity distribution grid.



(*) Connecting The Dots: Distribution Grid Investment To Power The Energy Transition, Monitor Deloitte, Eurelectric, E.DSO, 2021

What are smart grids?

EU Smart Grids Technology Platform: "electricity networks that can **intelligently integrate the actions of all users** connected to it, – generators, consumers and those that do both - in order to efficiently **deliver sustainable, economic and secure electricity supplies**".

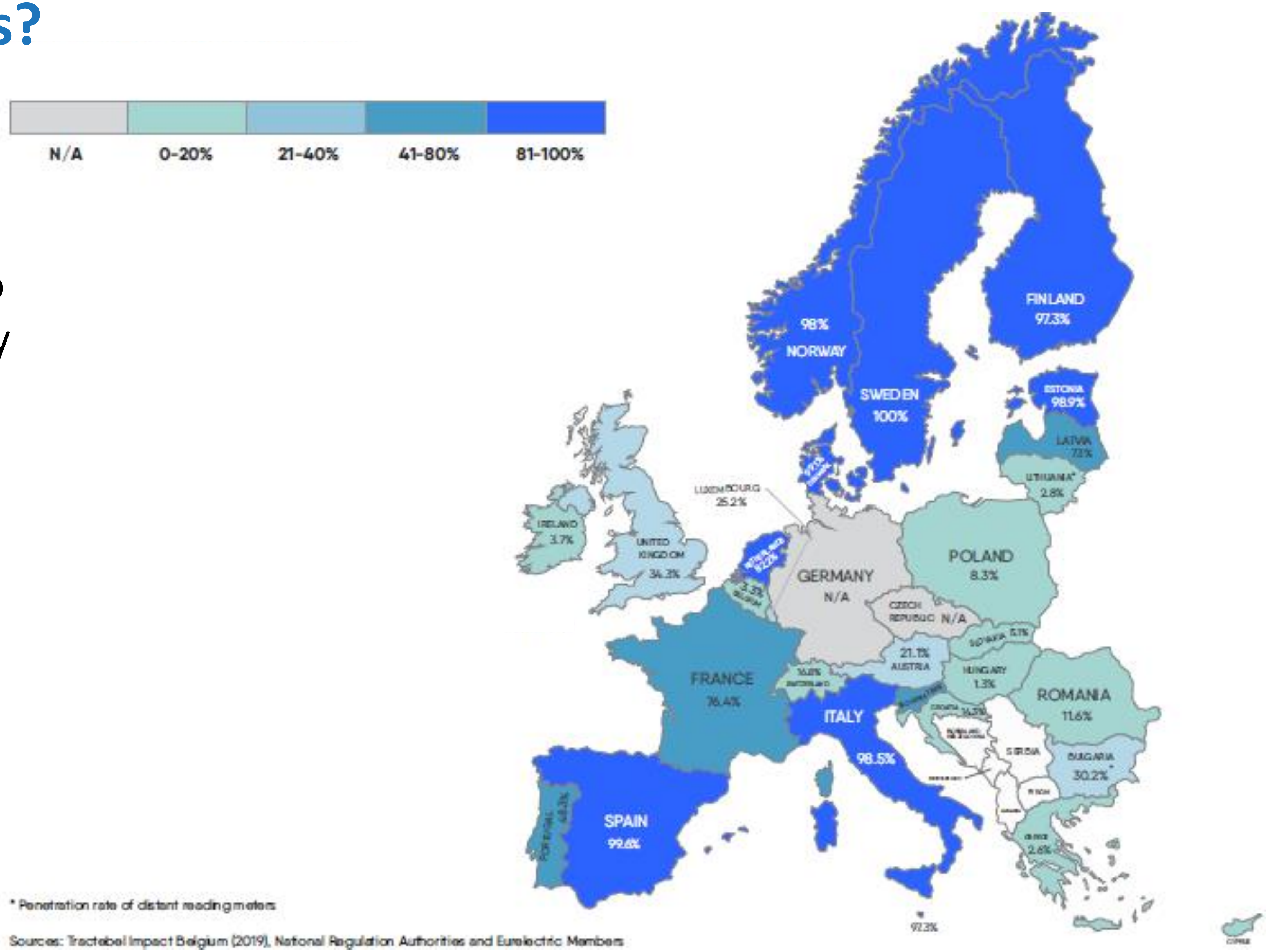
What kind of intelligence?

- New **technologies and solutions**: communications, data, control,..
- **Better use** of existing facilities and **planning**.
- **Intelligent control** and massive distributed generators and loads.
- **New services** and energy **efficiency improvements**.

What are smart grids?

Smart meters have been set to replace conventional electricity meters throughout Europe.

The European Commission encouraged the deployment of smart metering systems already in the Third Energy Package of 2009 and Clean Energy Package of 2019 updated these provisions.



* Penetration rate of distant reading meters

Sources: Tractebel Impact Belgium (2019), National Regulation Authorities and Eurelectric Members

Why do smarter grids matter?

Smart infrastructures play a crucial role in the transitioning electricity value chain:

1. Enabling dynamic tariffs for households and SMEs.

2. Digitalisation of the distribution grid and optimisation of the network operations.

3. Digitalisation of the retail market to foster innovation and new services by private actors.

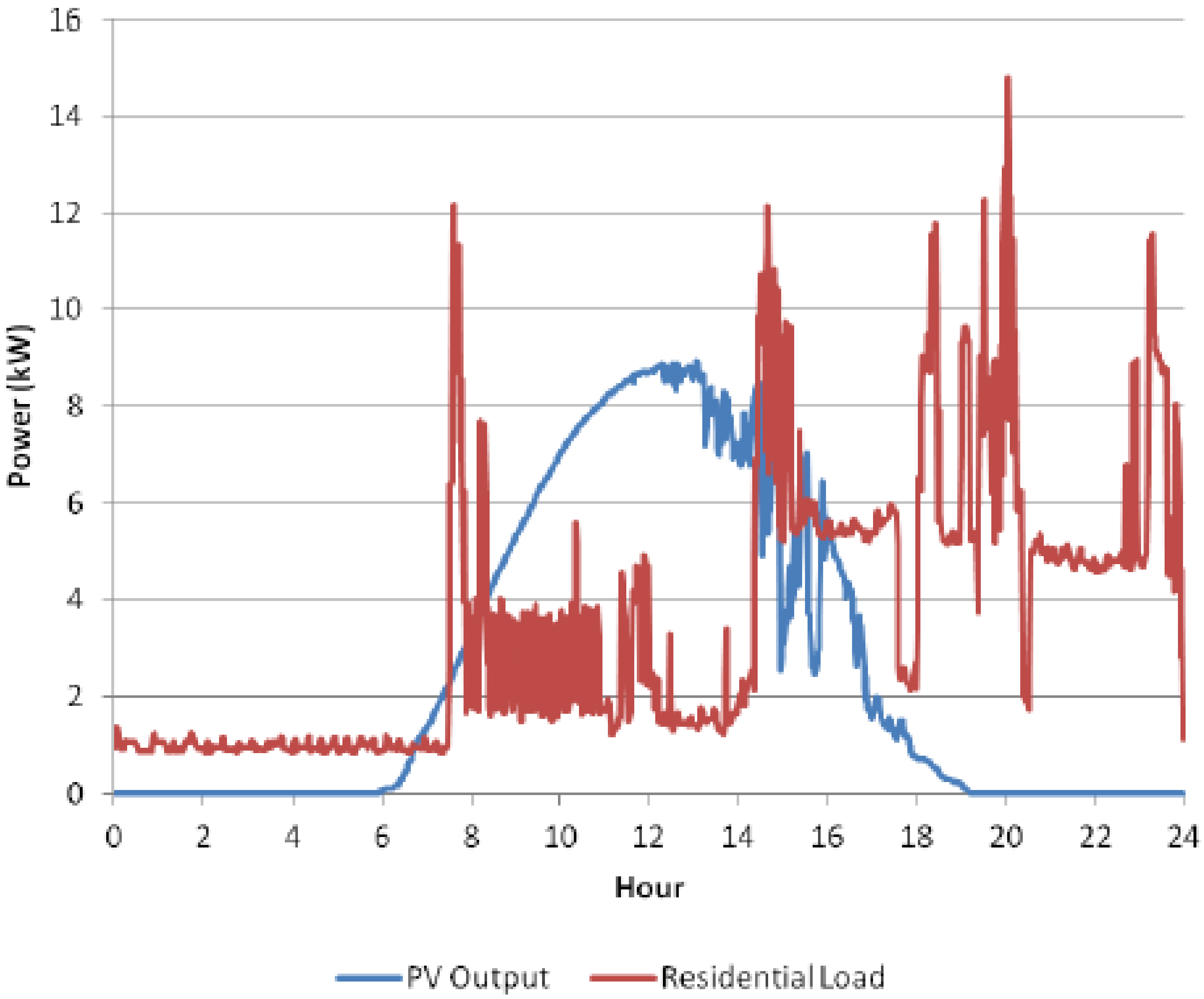
4. Integrating decentralised energy resources with flexible access.

5. Supporting actions tackling energy poverty.

6. Supporting energy efficiency.

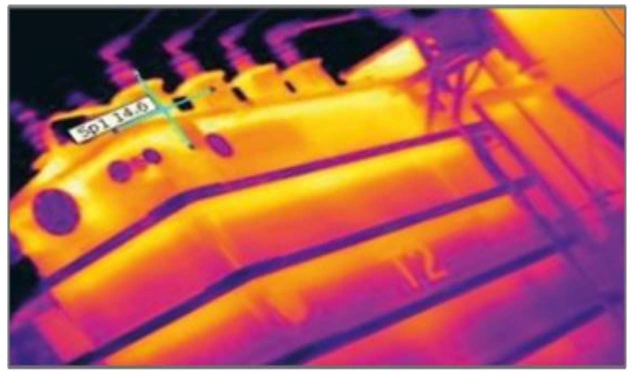
Why do smarter grids matter?

With renewables, both load and generation are variable: the discrepancy between instantaneous demand and instantaneous supply must be reconciled. The system may be equipped with **local storage,** or some **mechanisms to export and import power** is necessary (i.e., the grid).



Why do smarter grids matter?

Smart grids can reduce losses, both technical and non-technical:



Technical losses

Fast identification of **high-losses assets.**

Imbalances

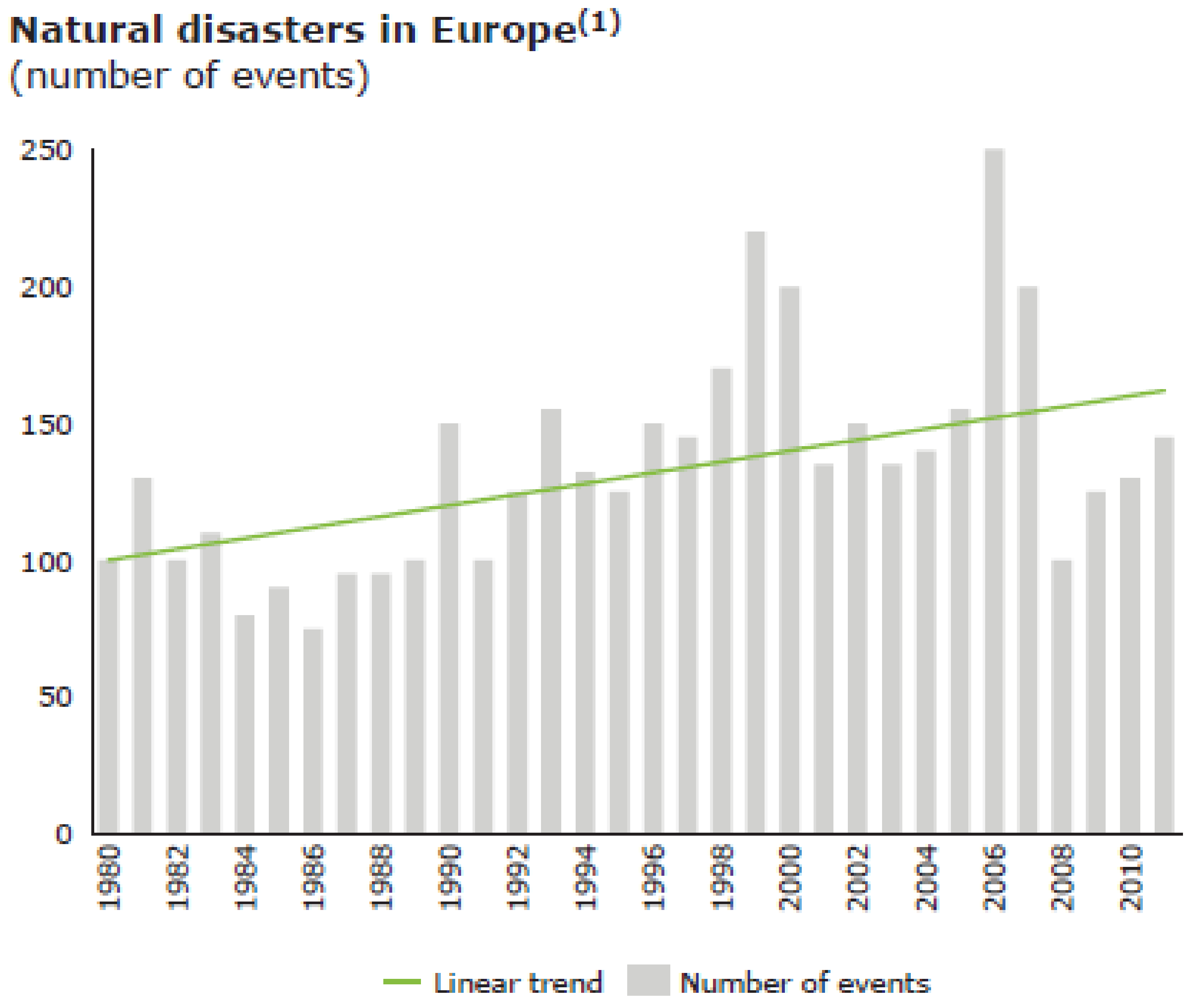
Monitoring of the Low Voltage network will identify the phase **customers are connected to.**

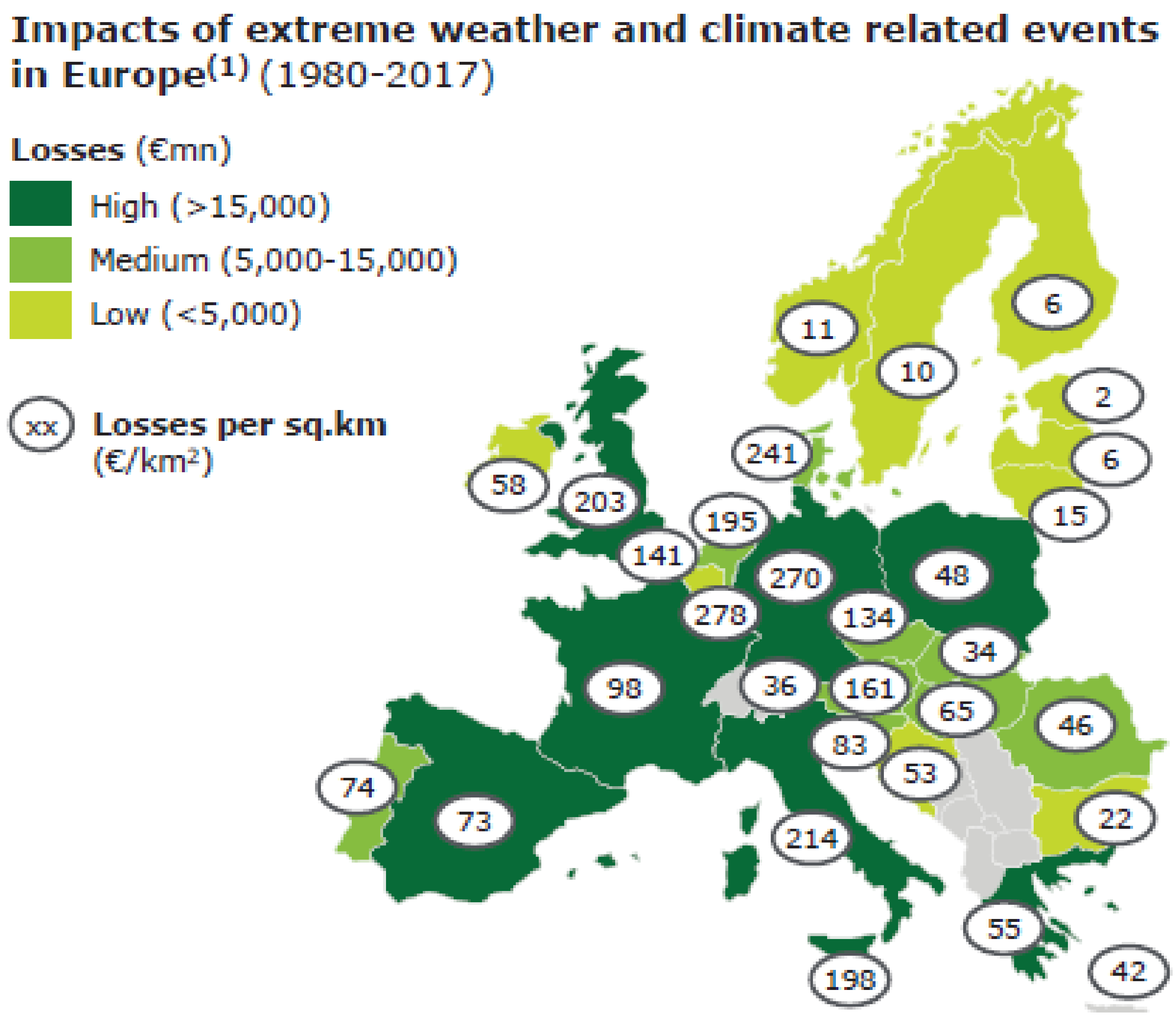
Non-technical losses.

Power balance assessments in secondary substations allows identification of illegal electricity connections.

Energy security: are electricity grids resilient enough?

Resiliency is key for climate change adaptation, but also for building stronger and safer energy infrastructures at European level.





(1) European Economic Area (EEA) member countries from 1980 to 2011.

Energy security: are electricity grids resilient enough?

Resiliency

- **Extreme weather events** are more and more frequent.
- Distribution networks must become **more resilient.**
- **Resiliency** and **reliability** are **different** concepts.

Safe and efficient operation

- Dispatch of **distributed resources** can contribute to restore supplies **faster.**
- All digital components connected to the network, behind or in front of the meter, **must be visible to the DSO** in order to:
  - ✓ Enable optimal **planning and operation** (demand forecast).
  - ✓ Ensure efficiency against **cyberattacks** (malicious remote control of demand).

Energy security: are electricity grids resilient enough?

Some examples of climate change events affecting distribution grids:

Snow-Cable icing (overhead MV line).

Heatwaves (Underground MV lines in urban areas).

Windstorm-Tree fall (overhead MV lines).

DSO-TSO cooperation: EU DSO Entity.

- **EU DSO Entity:** Regulation (EU) 2019/943 mandates DSOs and TSOs to cooperate through their recognized bodies:

2. In addition the EU DSO entity shall:

(a) cooperate with the ENTSO for Electricity on the monitoring of implementation of the network codes and guidelin adopted pursuant to this Regulation which are relevant to the operation and planning of distribution grids and tl coordinated operation of the transmission networks and distribution networks;

(b) cooperate with the ENTSO for Electricity and adopt best practices on the coordinated operation and planning transmission and distribution systems including issues such as exchange of data between operators and coordinatic of distributed energy resources;

- **E.DSO** is also cooperating with ENTSO-E in many other areas (e.g., cybersecurity knowledge, technological developments,…).

DSO-TSO cooperation: EU DSO Entity.

A **more resilient, efficient and digitalized grid** will have a positive impact on customers and society:

✓ It will contribute to **develop the role of the distribution networks** as neutral facilitators for the energy transition (i.e., renewables integration) and will facilitate **active customer participation.**

✓ It will facilitate the **electrification and decarbonization** of the economy:

Smart charging of electric vehicles.

Efficient utilization of **heat pumps.**

Management of demand **flexibility.**

✓ It will improve the **security and quality of supply**. **Cooperation with TSOs is key**.