Energy transition Challenges

Operational perspective

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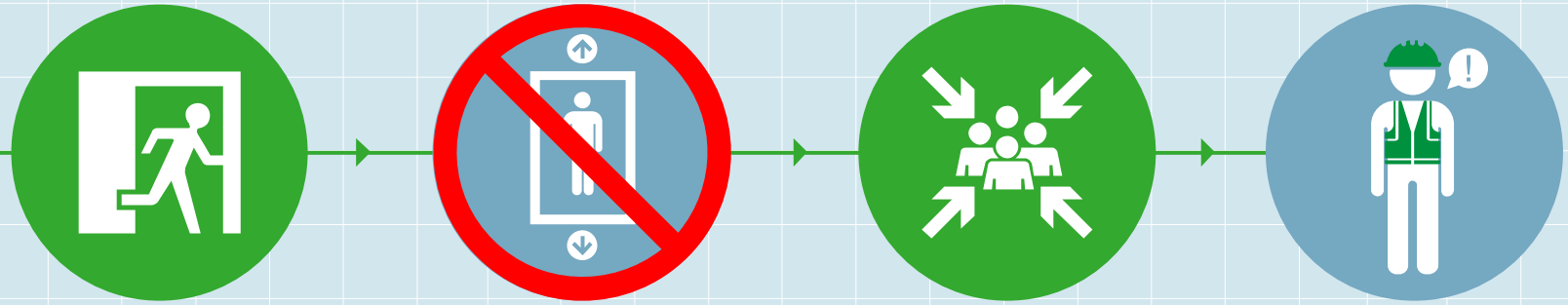
A moment for safety

Together we provide a safe working environment. We learn from mistakes and sharing ideas, concerns and asking questions are a matter of course.

We also draw attention to the following safety measures in case of evacuation of the premises



Follow the escape route as indicated

Use the stairs instead of the lift

Go to the assembly point

Follow the instructions of the in-company emergency responder

Contents

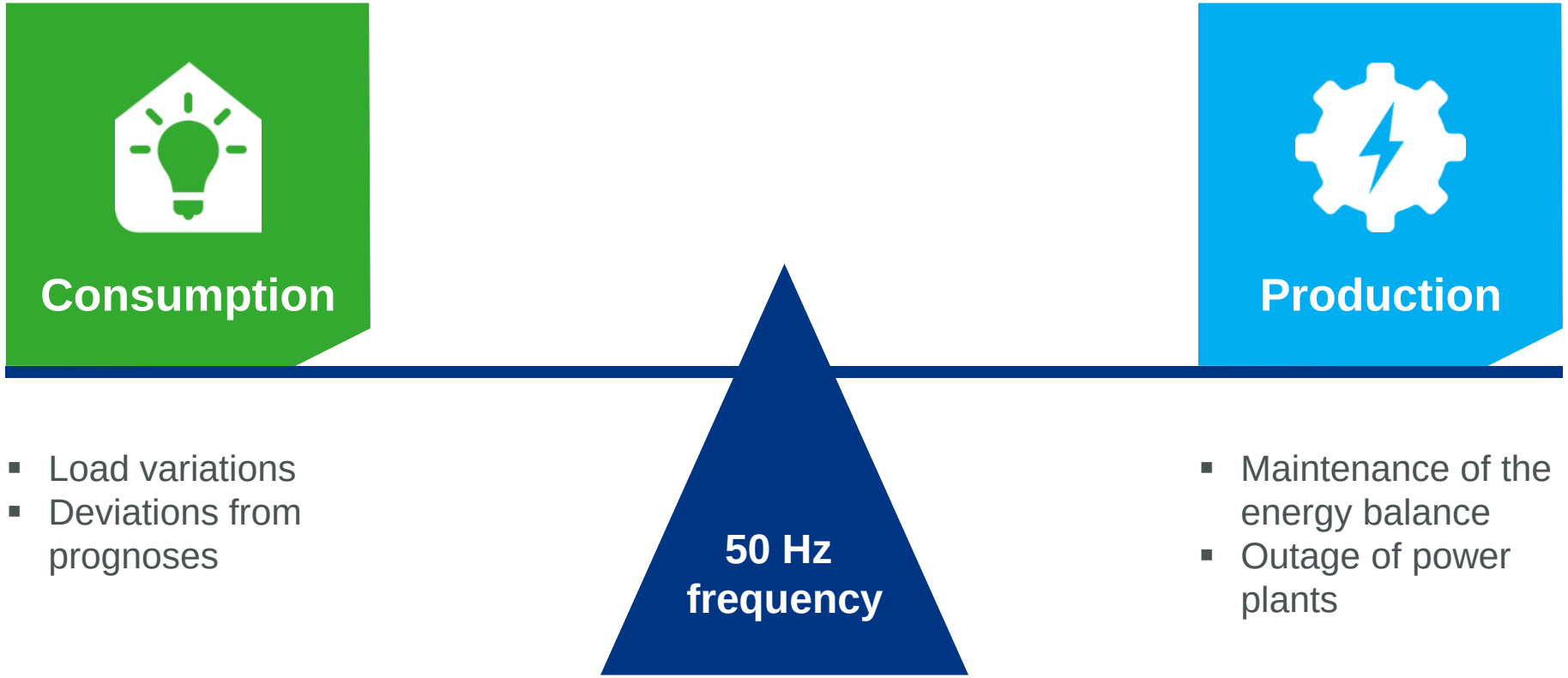
99.99999% grid availability

What is it about?

Environmental drivers CO2 emissions Climate change	Development of European Internal Energy Market	Rapid increase shares of renewable in the electricity sector
Energy Transition Electrification Sustainability	Integration: sectors markets	Flexibility Controllability Observability
Regulation Harmonisation Affordability	Cooperation Coordination Interoperability	Regulation Harmonization

Maintaining the balance

Maintenance of the energy balance: the amount of electricity produced must always exactly match the amount of electricity consumed.



- Load variations
- Deviations from prognoses

- Maintenance of the energy balance
- Outage of power plants

The European Extra High Voltage grid

A grid operator's tasks
Main tasks

Transmission services
Ensure a robust and efficient high-voltage grid

Market facilitation
Facilitate an efficient and stable electricity market

System services
Maintain the balance of electricity, 24/7

Zooming into Operational Challenges

Challenges

- Transition to RES
- Decrease of Conventional Power Plants
- Integration of Power Electronics
- Realization new transmission capacity
- Market Design
- Regional and vertical Coordination

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Consequences

Weather dependent energy system	Inertia Stability
On- & off-shore AC-DC hybrid system	Security of supply Congestions
Resilience Risk preparedness	Data exchange Cyber security

Increasing shares of RES

Impact on System Operation

- Especially based on Wind and Solar Energy
- Increased volatility of renewables in the generation mix
- Increased operational uncertainty and risks
- Requires accurate forecast algorithms
- Often has priority and its curtailment is one of the last remedial actions
- Significant share embedded in the distribution network
- Long distance power transmission
- Security of supply under pressure: More volatile and increased power flows
- Volatile Markets and tending to become short-term oriented
- RES not always providing ancillary services, but required in EU NetCode Requirements for Generation (RfG)

Decommissioning of Conventional PP

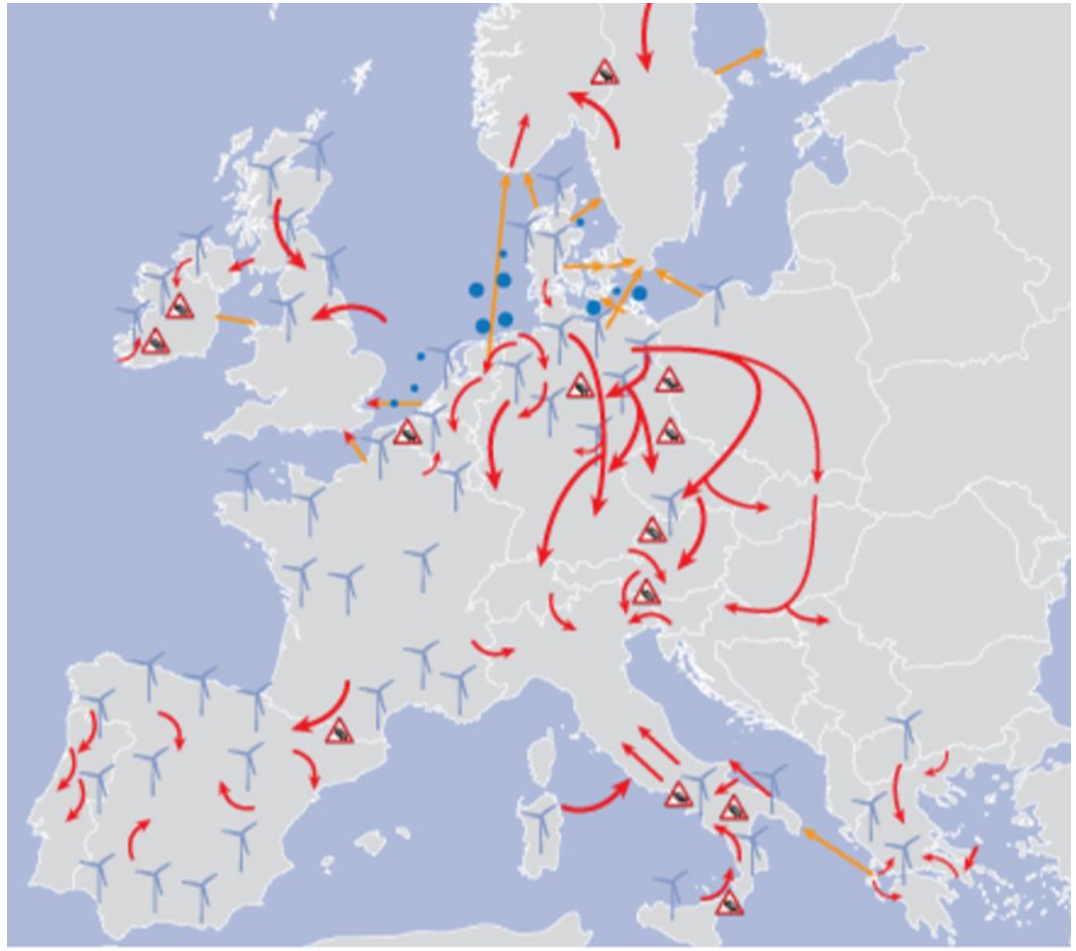
Impact on System Operation

Synchronous machines have been providing all flexibility needed to operate the power system … And now?

- **Decrease of system inertia**
  - More frequent, faster and less damped dynamic phenomena are expected (e.g. larger fluctuations in frequency)
- **Reduction of short circuit power level:**
  - Impact on fault current support
  - Larger voltage dips and larger propagation of low voltages during disturbances
  - Impacts the operation of protection relays
- **Impacts the active and reactive power reserves availability**
  Decrease of redispatch possibilities, endangering network security
  Will conventional power plants keep on delivering system supporting services?
- **Prices expected to become more volatile: rise at times without wind or sun**

The grid is not a copper plate

- Increased **uncertainty due to RES** volatility and **more dynamic markets**
- **Decommissioning of conventional power plants**
- **Limitations to build new infrastructure** to increase transmission capacity
- **Volatile and increased power flows** and **long-distance** power transmission
- **Operational complexity**, which requires more **integration and coordination**



Difficulty building new transmission capacity

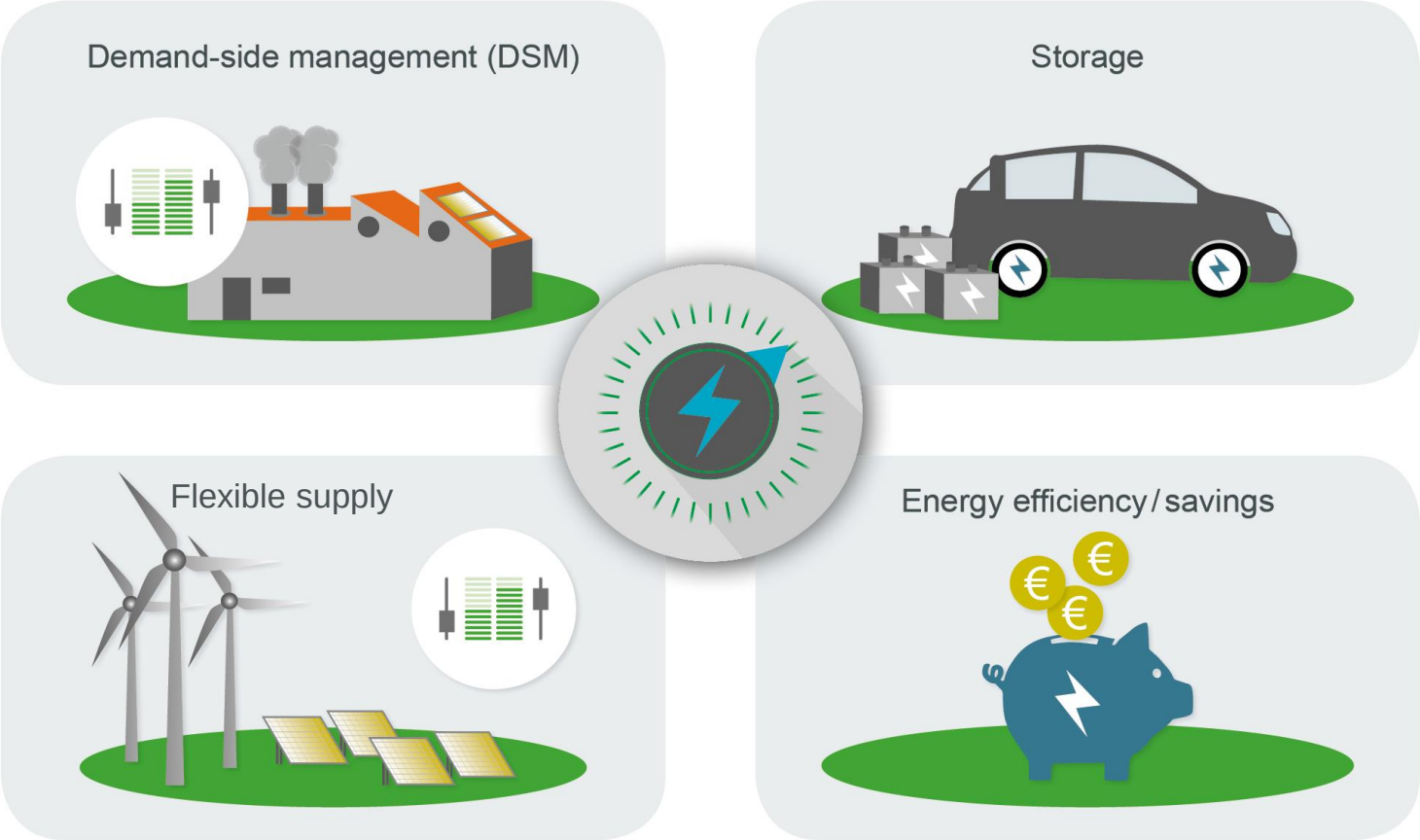
- There is a need for increasing transmission capacity
  - Long realization process (licensing and building) increases the likelihood of operating the system with congestion management schemes and closer to the security limits

- An efficient use of the existing infrastructure
  - **Location and Diversity**
  - **Solutions for power flow control technology**
  - **Market based ancillary services**
  - **Investment and design choices directly influence how the system is operated**

What do we require?

Flexibility in the right Location

Optimal dispatch of flexibility resources is needed to guarantee security of supply and affordability. Expected increase in the number of players, data exchanges.



Observability And Controllability

Access to “lots” of DATA
Data exchange Platforms

Accurate data FORECAST to reduce the operational uncertainty

EMERGING TOOLS
Big Data Analytics for AWARENESS and DECISION SUPPORT
(e.g. SE, DSA, WAMS)

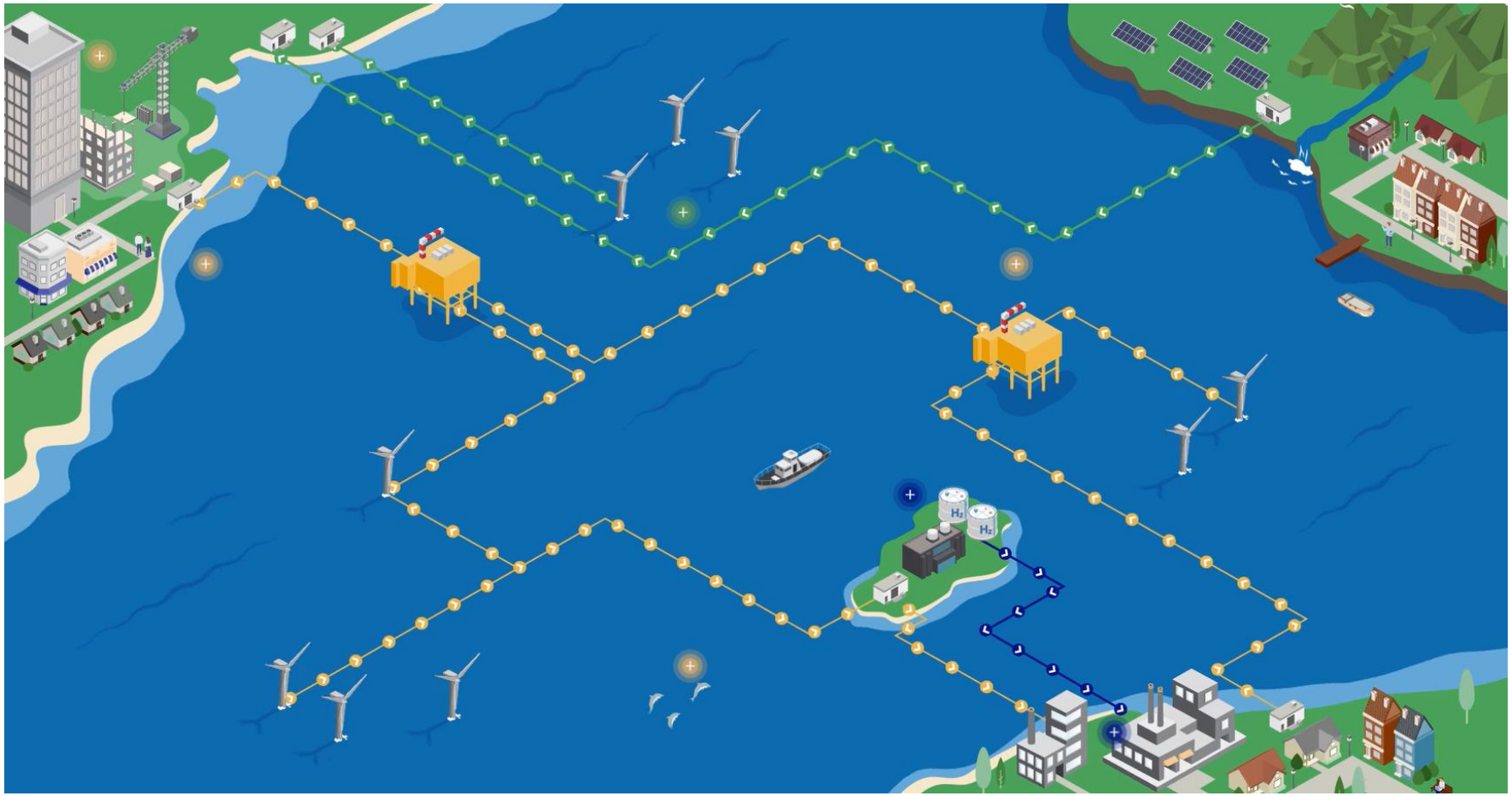
New Generation of SCADA EMS systems

Automatic Power Flow Control, System Integrity Protection Schemes (SIPS) and Wide Area Control Schemes (WACS) using fast available flexibility to keep system Stability with help of Phasor Measurement Units (PMUs)

Wide Area Monitoring System

Source: CIGRE Session 2014 C2-PS1- Q1.7

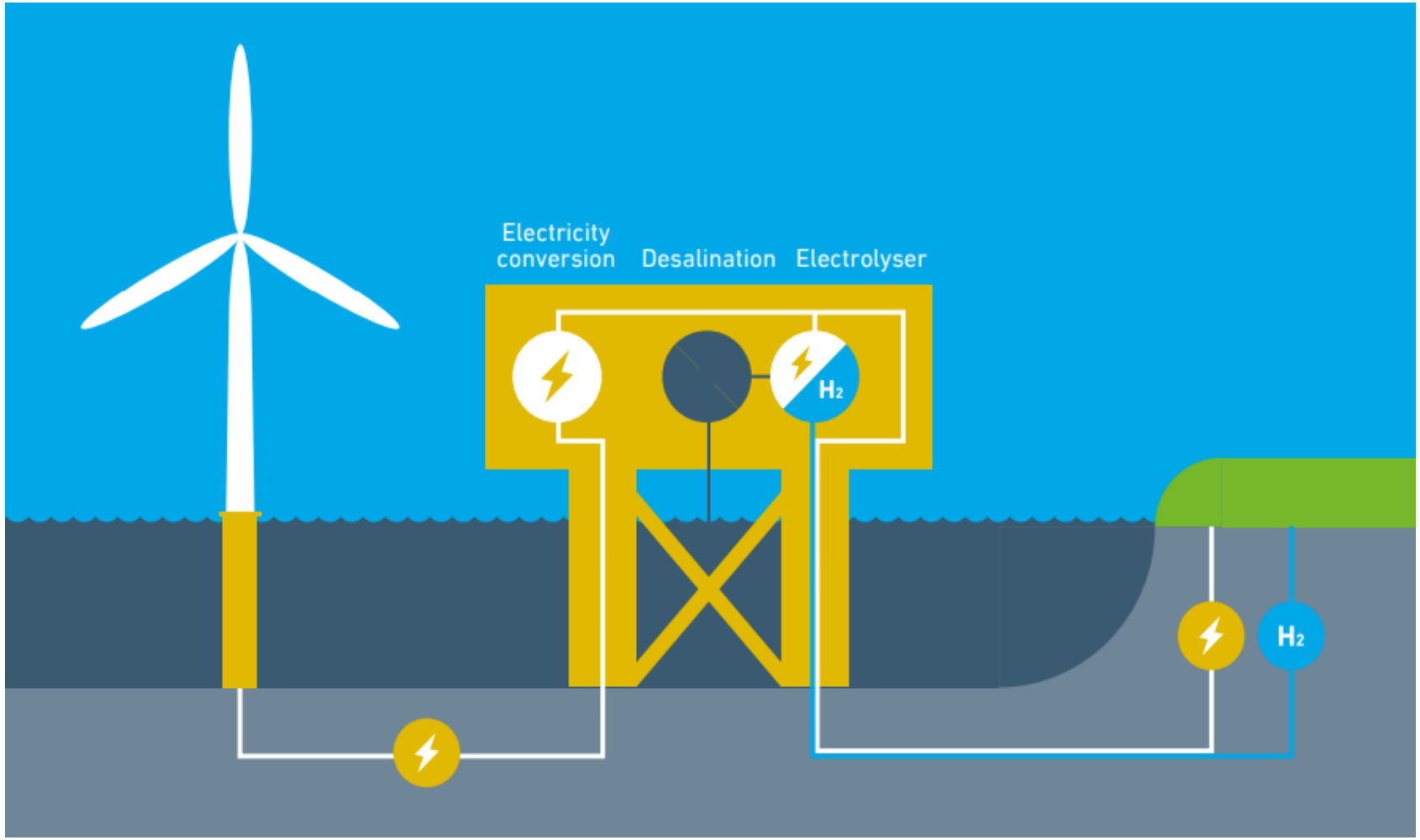
Combining wind with interconnectors



Requirements for Power Electronic Devices

- **Inertia and Fast Frequency** response
- Enhancement of **disturbance ride through capabilities for voltage and frequency contingencies**
- **Ancillary Services provision** from RES and Energy Storage System
- **Active and Reactive power control** using HVDC links or placing converters in end-to-end of corridors
- **Power Oscillation Damping**
- **System restoration support**
- **New Grid forming control concepts -** PE needs to behave as a voltage source, synchronize with others, behave properly in islanded mode, take care of overcurrent limitation, be compatible with conventional machines and other grid following PE.
- **Develop adaptive protection system** - capable of correctly operating in different operating conditions (e.g. with high PE penetration and low short circuit power levels)
- **Adequate network models**

Power-to-X offshore



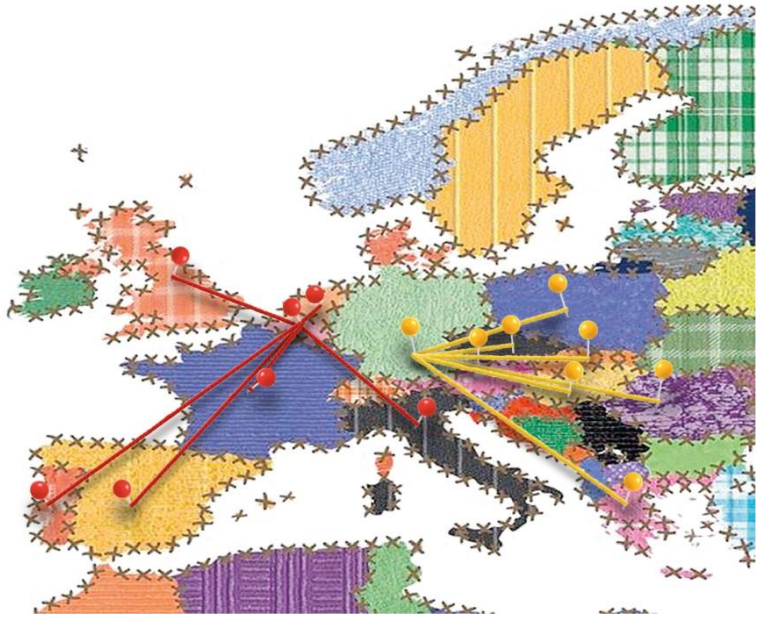
Harmonised Legislation and Regulatory Framework

- Currently differences in national rules and laws are binding the respective TSOs.

- TSOs are working together as closely as possible in this framework.

- To enable better cross-border system operations

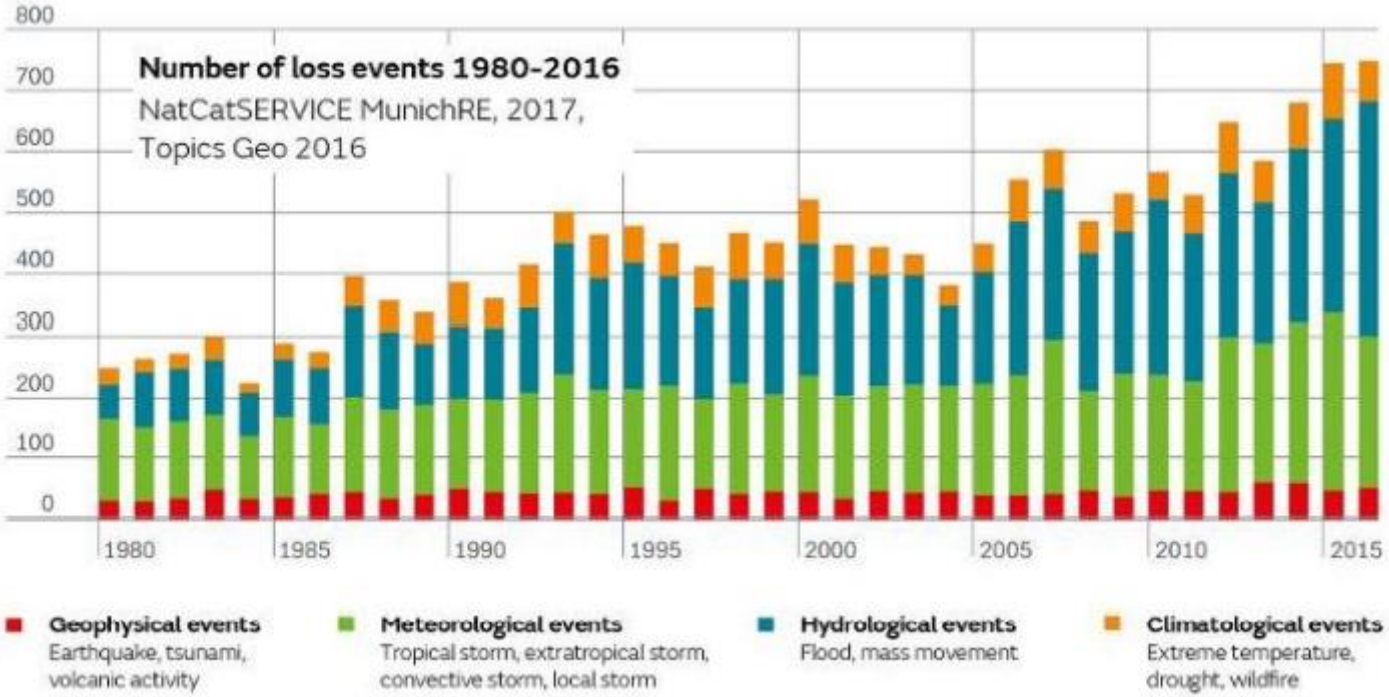
- missing infrastructure has to be built
- national rules and regulations have to be harmonized
- Impact analysis in neighbouring networks has to be developed (optimisation of remedial actions)



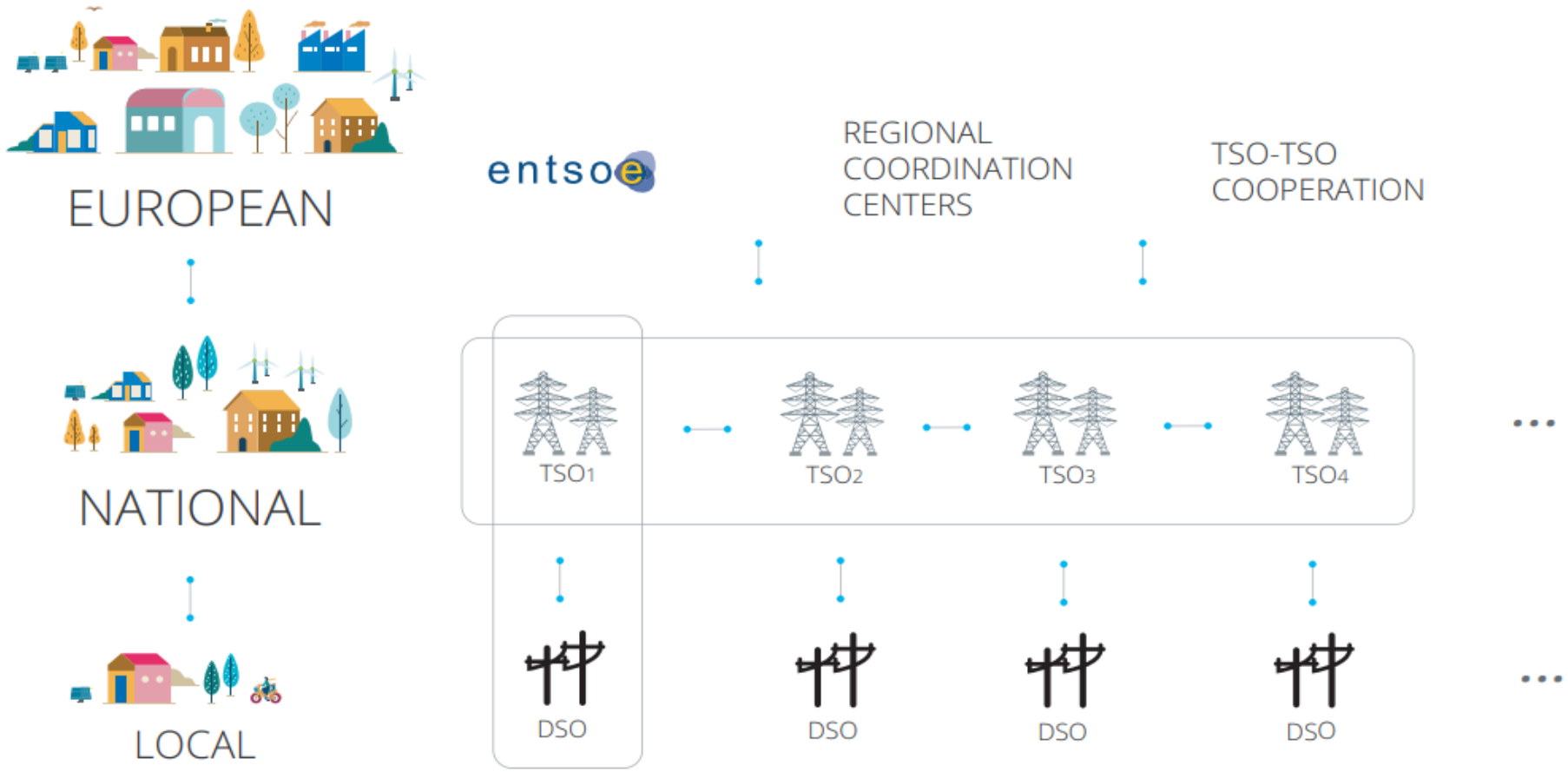
Resilience

Power system resilience is the ability to limit the extent, severity, and duration of system degradation following an extreme event.

Power system resilience is achieved through a set of measures to be taken before, during, and after extreme events.

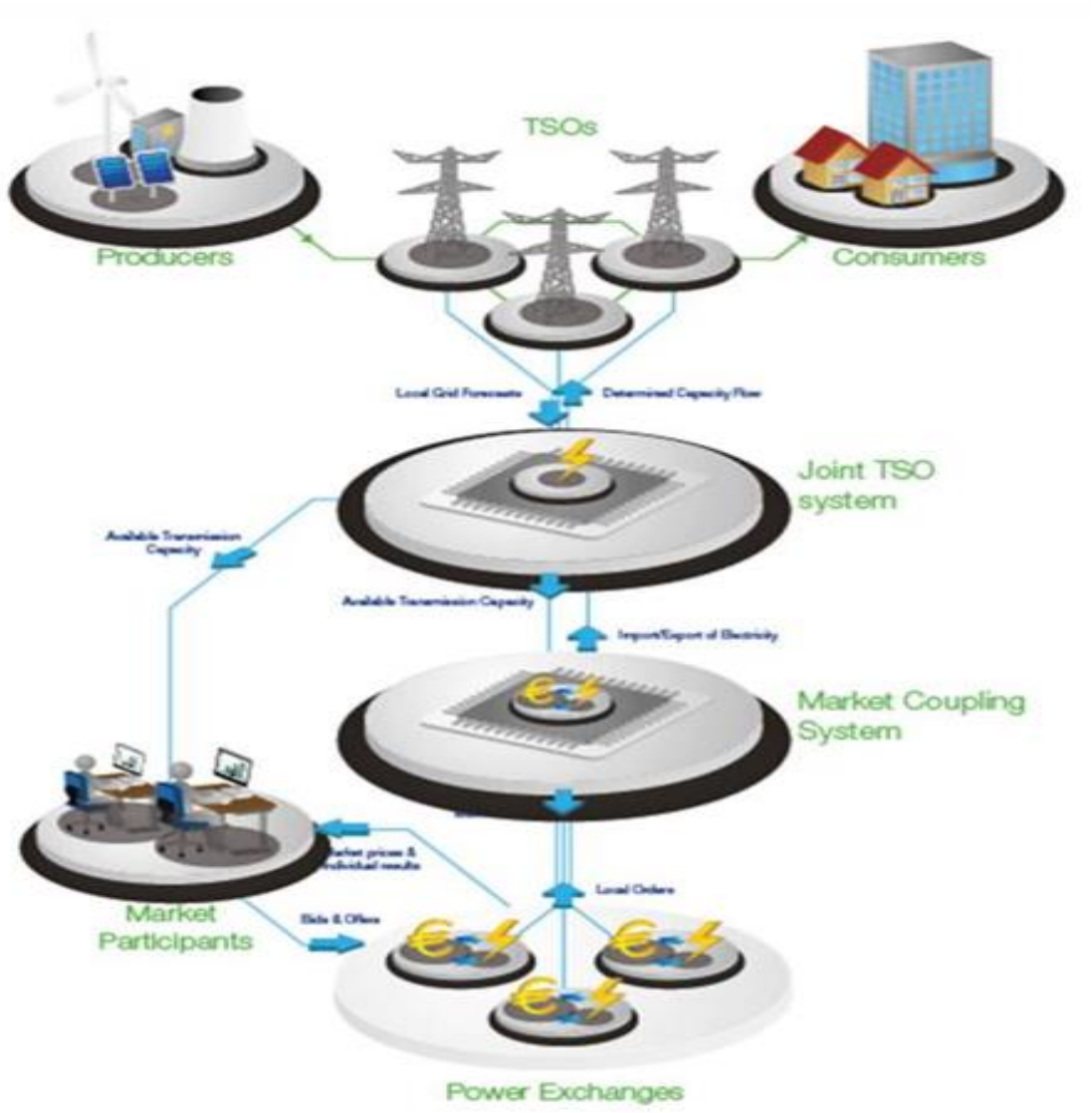


Coordination (vertical and horizontal)



Source: ENTSO-E

Market coupling set up



Stakeholder management

European Commission

ACER
European Union Agency for the Cooperation of Energy Regulators

entsoe

CEER
Council of European Energy Regulators

Federal Ministry for Economic Affairs and Climate Action

Ministerie van Economische Zaken en Klimaat

EU DSO ENTITY

ETIP SNET

Bundesnetzagentur

Authority for Consumers & Markets

cigre
For power system expertise

smartEn
Smart Energy Europe

WindEurope

Renewables Grid Initiative

BEUC
The European Consumer Organisation

TU Delft
Delft University of Technology

T&D europe

eurelectric

Fraunhofer ISI

TU/e
Technische Universiteit Eindhoven University of Technology
Where innovation starts

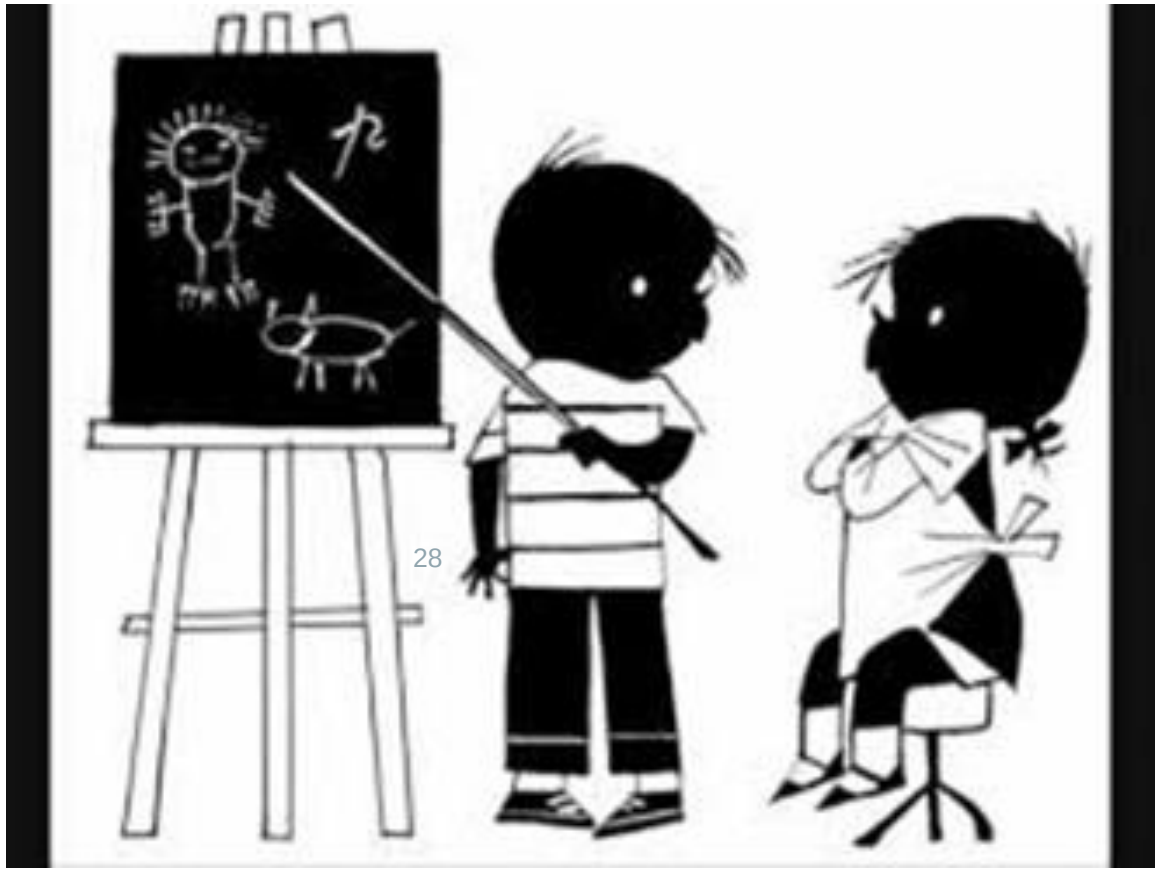
EASE
European Association for Storage of Energy

Hydrogen Europe

Consentec

Big challenge

- ***How to connect engineering, physics and politics?***
- The goal is to communicate complex topics in understandable, meaningful and intuitive ways.

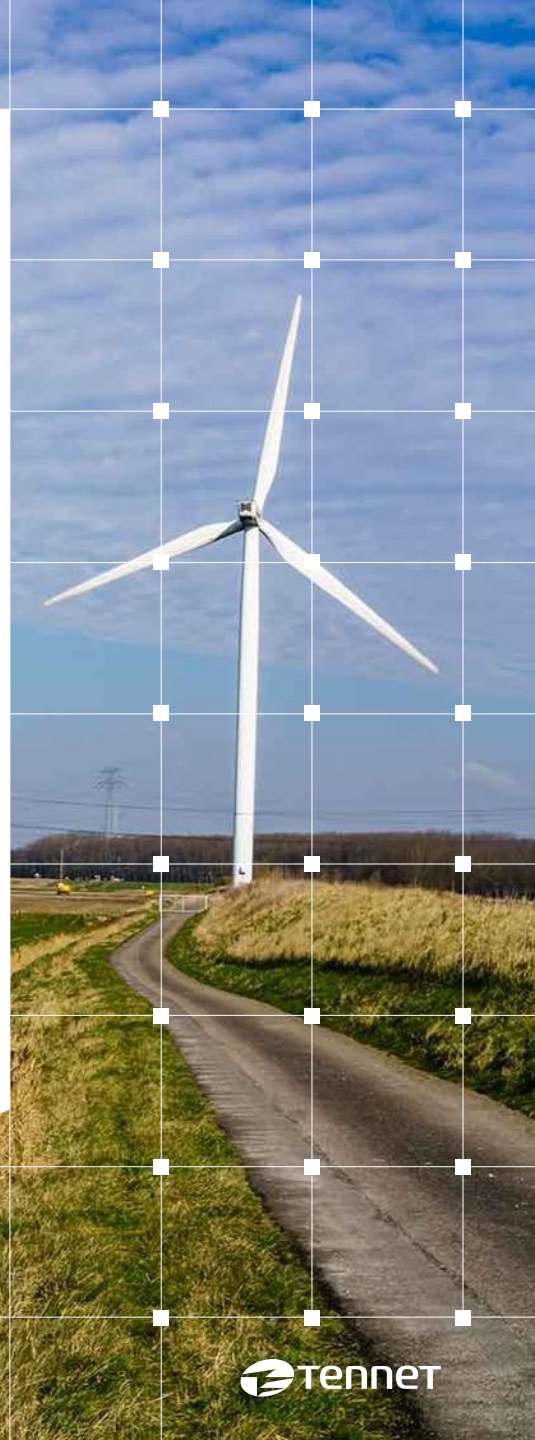


Conclusions

- ***System Operation is in a world-wide energy transition towards***
  - a more weather-dependent energy system
  - bigger dependency on quality of data exchange
  - deep digitalization with enhanced resilience (incl. cyber security)
  - increased cooperation and coordination among parties
  - integration of new technologies and environmental restrictions
- ***Coordinated decisions are better decisions supported by***
  - clear understanding of roles and responsibilities
  - common analysis and procedures with standardized rules
  - enhanced visibility, controllability and decision support tools resulting in an enhanced network security and cost efficiency
- ***Innovation and R&D in the energy business is crucial***

TenneT is a leading European grid operator. We are committed to providing a secure and reliable supply of electricity 24 hours a day, 365 days a year, while helping to drive the energy transition in our pursuit of a brighter energy future – more sustainable, reliable and affordable than ever before. In our role as the first cross-border Transmission System Operator (TSO) we design, build, maintain and operate 24,500 kilometres of high-voltage electricity grid in the Netherlands and large parts of Germany, and facilitate the European energy market through our 16 interconnectors to neighbouring countries. We are one of the largest investors in national and international onshore and offshore electricity grids, with a turnover of EUR 6.4 billion and a total asset value of EUR 32 billion. Every day our 6,600 employees take ownership, show courage and make and maintain connections to ensure that the supply and demand of electricity is balanced for over 42 million people.

Lighting the way ahead together



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