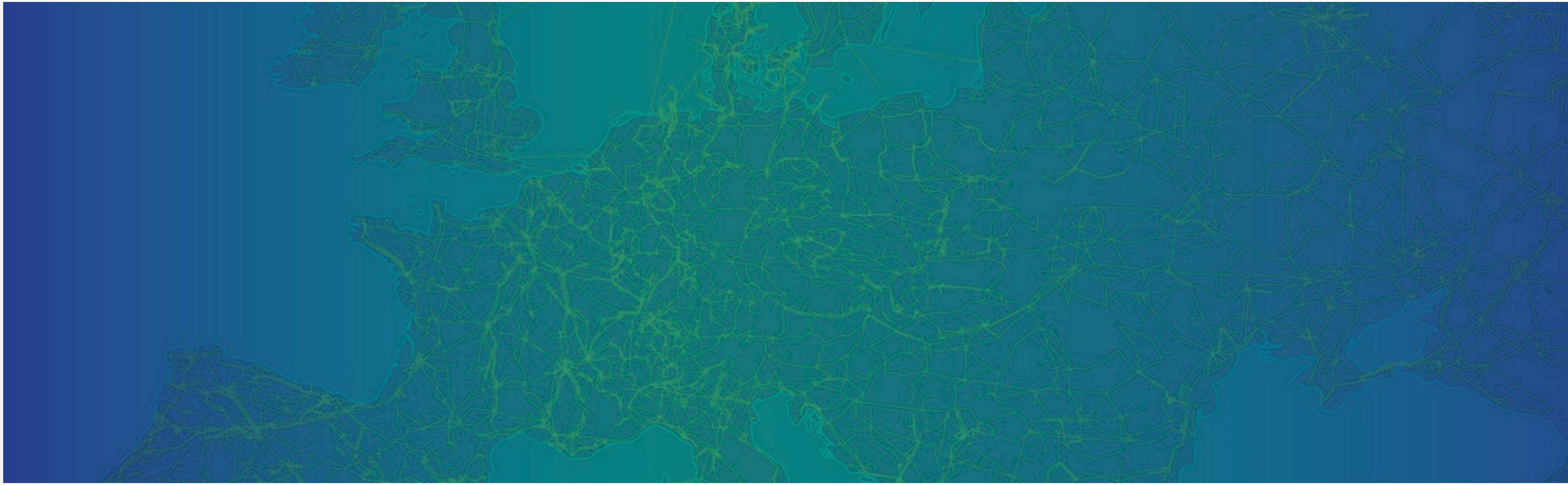
The innovation challenge and hybrid AC/DC networks

Webinar #5 of the ENTSO-E Vision 2030 series – 14 October 2020 – 10.00-12.00h



entsoe
Reliable Sustainable Connected

Housekeeping Rules

Video and audio

- Video and audio is allowed **only** for Speakers or Panellists
- Speakers or Panellists will be asked to switch video and audio OFF when not talking

Participants Questions

- Participants can place **their questions directly through sli.do (https://app.sli.do/event/jzscorhq)** and not through GoToWebinar.

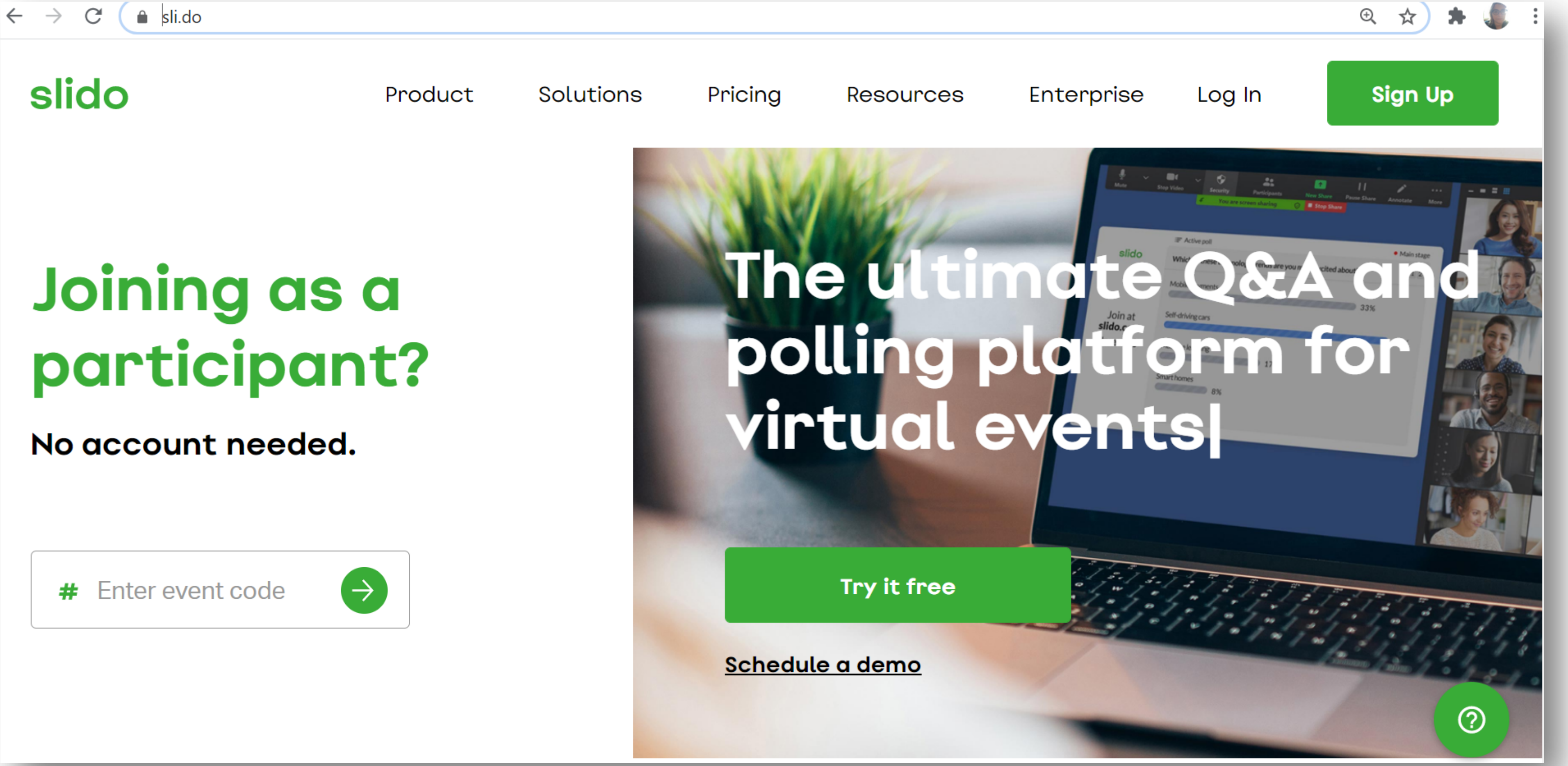
- In **Sli.do**, feel free to vote for most relevant questions posted.

- Indicate **your name and company/institution** when posting your question.

- Moderators will select a couple of questions and ask the relevant speakers or panellists to comment.

- Chat and raise the hand feature will not be used.

How to login to Sli.do



Go to www.sli.do and enter **EWeek-5** or scan the following QR with your phone to login

Welcome & Introduction

Håkon Borgen

Chair of ENTSO-E Research,
Development & Innovation Committee

Agenda

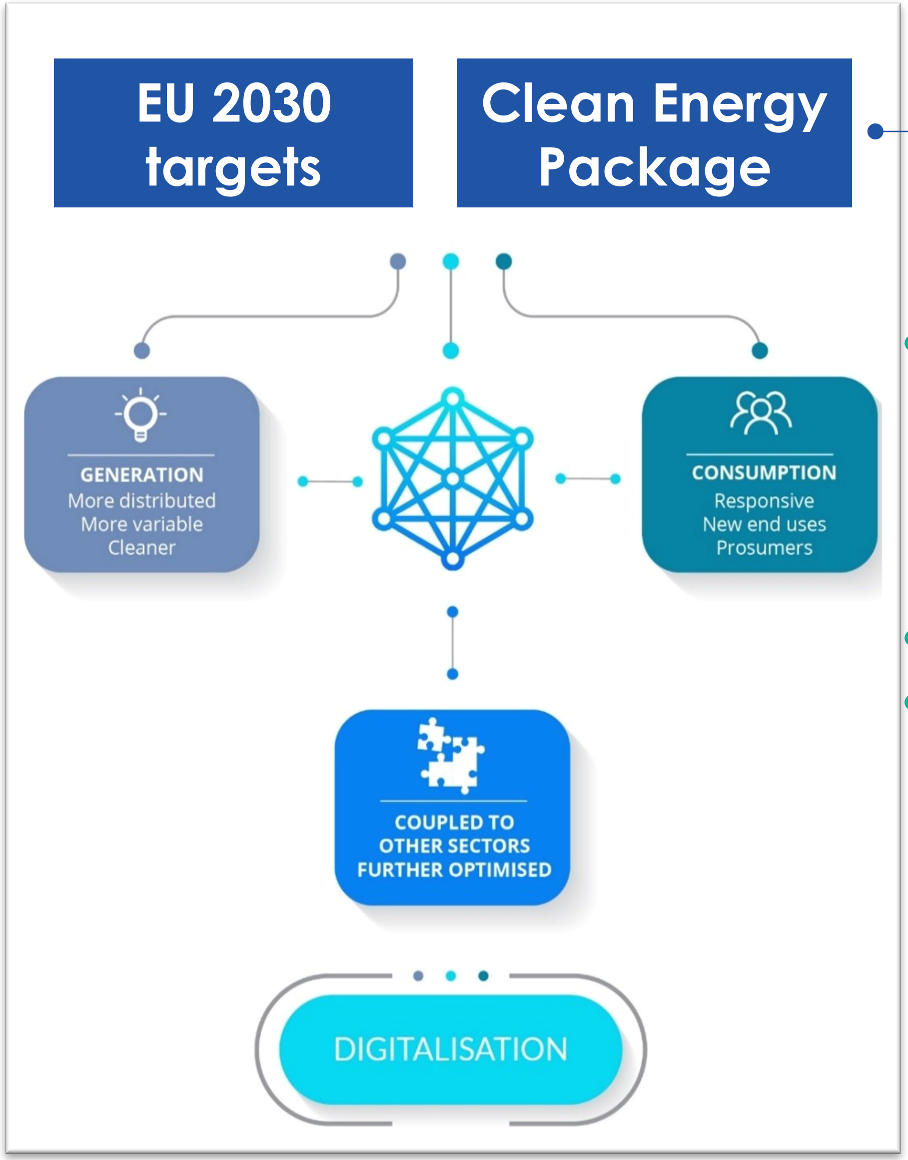
No	Subject	Time	Presenter
1	Welcome &Introduction ▪ ENTSO-E Vision for the future - overview ▪ ENTSO-E RDI Strategy & Roadmap for 2020-2030	10.00-10.05 10.05-10.25	**Håkon Borgen**, Chair of ENTSO-E Research, Development & Innovation Committee **Damian Cortinas**, Leader of ENTSO-E 2030 Vision Project
2	Regulation - a key enabler of innovation	10.25-10.40	**Jan Kostevc**, Team Leader of ACER Electricity infrastructure
3	Integration of power electronics and hybrid AC/DC networks	10.40-10.55	**Wilhelm Winter**, Convener of ENTSO-E RDIC Working Group - Security and system operation of tomorrow
4	Challenges of the System Operation	10.55-11.10	**Jens Jacobs**, ENTSO-E Project Manager of the RSC Project
5	Technology Innovations for Sustainable Green Power Systems - Stakeholders' view	11.10-11.25	**Frank Schettler**, Convenor of CENELEC and IEC WGs on HVDC Grids T&D Europe, Siemens Energy
6	Open Floor for Q&A discussion	11.25-11.55	**Moderator: Norela Constantinescu**, Research & Innovation Manager, ENTSO-E
7	Conclusions & next steps	11.55-12.00	**Håkon Borgen,** Chair of ENTSO-E Research, Development & Innovation Committee

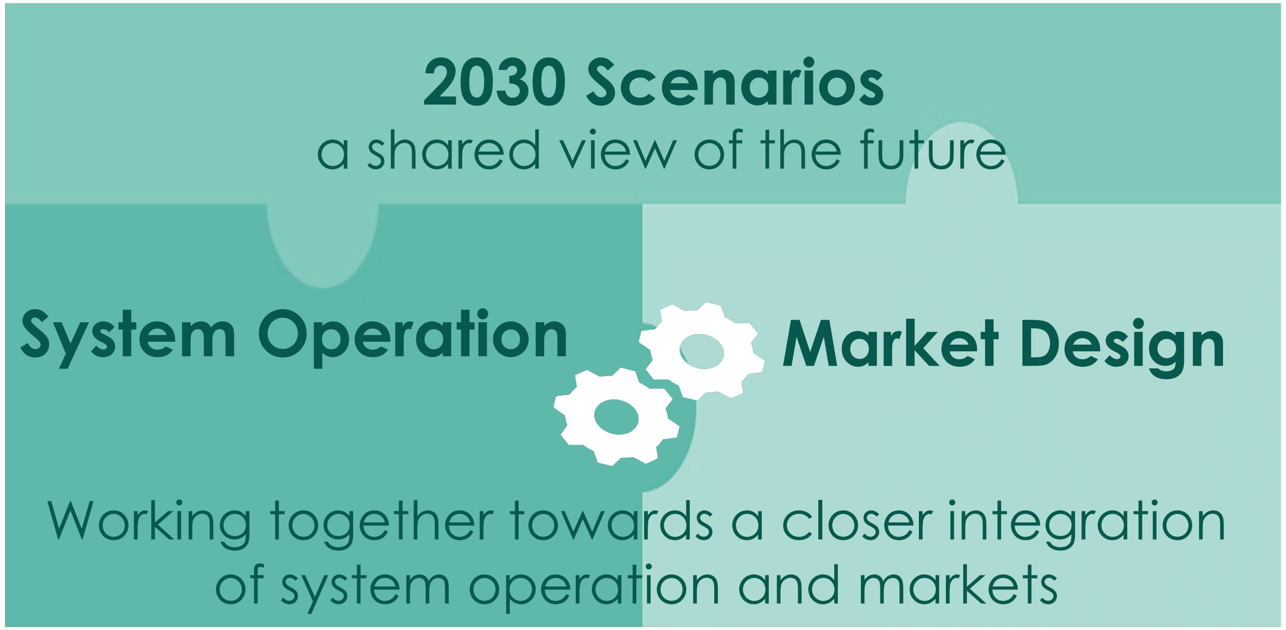
ENTSO-E Vision 2030

Damian Cortinas

ENTSO-E Vision 2030
Project Manager

A Vision reconciling political objectives and technical reality





A robust and resilient expert-based 2030 vision
adapted to a **dynamic future**

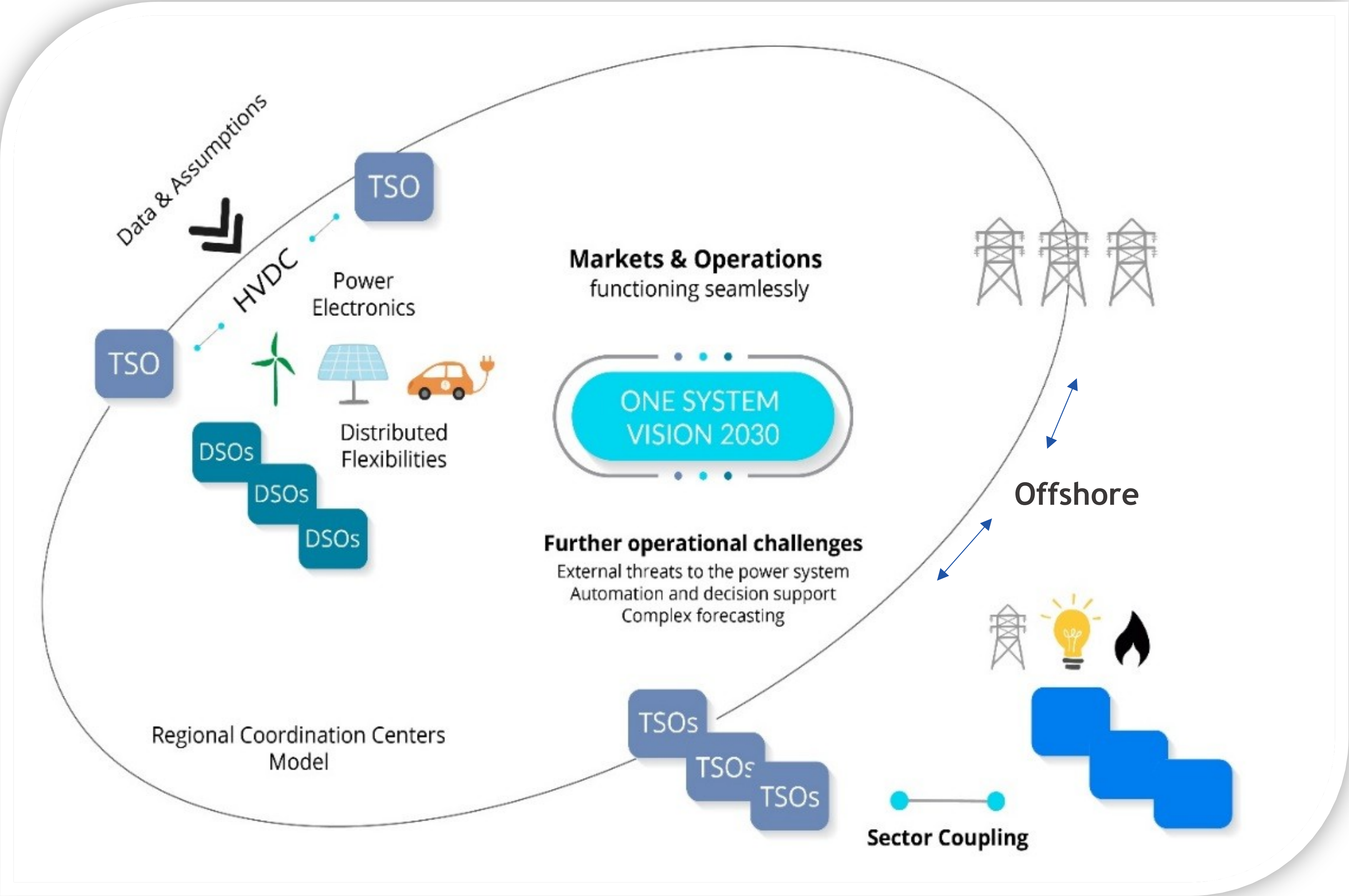
Green Deal | **Climate law**

Key drivers and major trends in the power system towards 2030

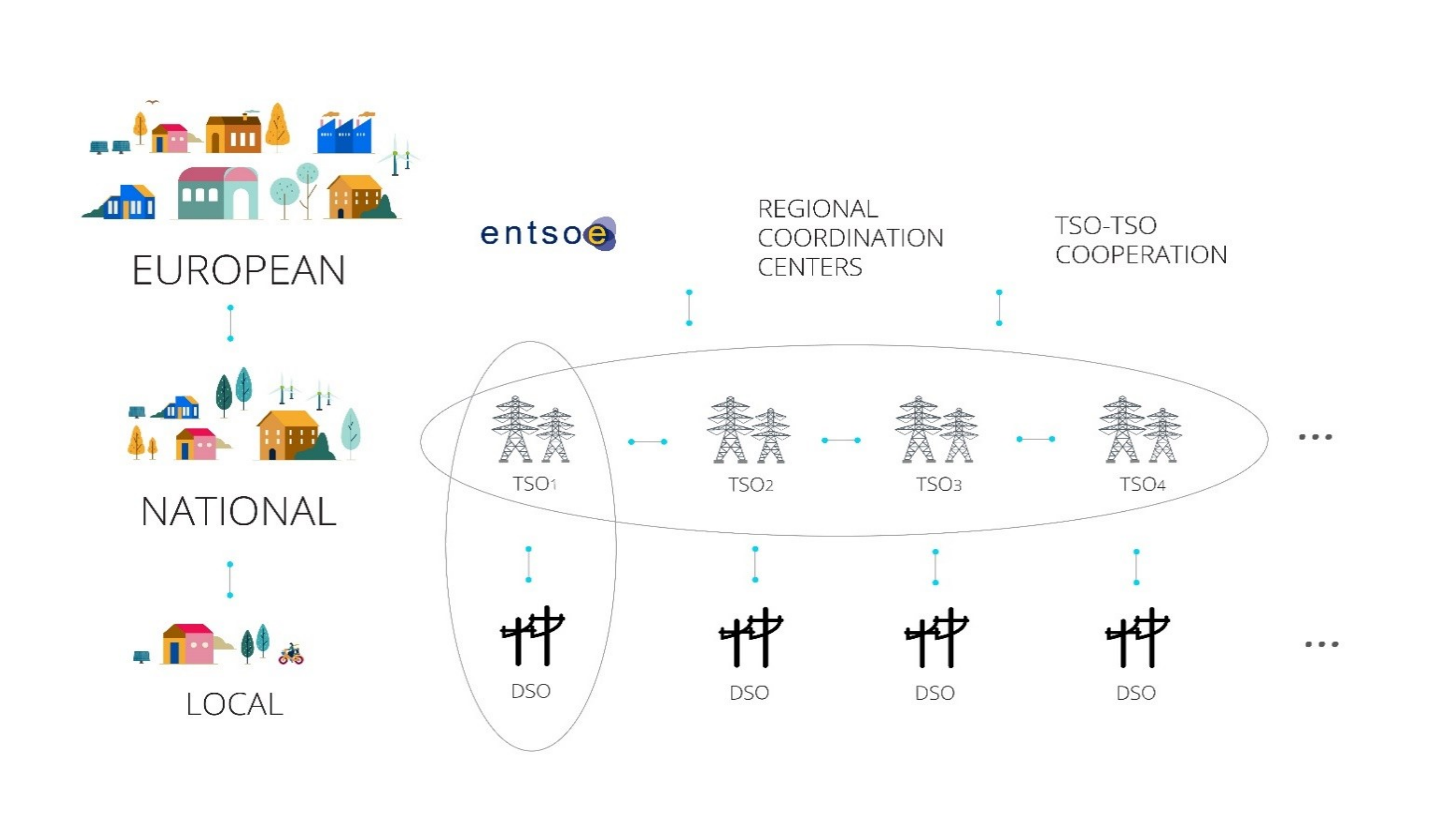
- **Distributed flexibilities** with close TSO & DSO cooperation
- **Power Electronics** towards hybrid AC / DC systems
- **Markets and Physics** seamlessly integrated
- Wind generation and interconnections in the seas, **Offshore Grids**
- **Energy Systems Integration**, beyond power
- **Mastering operational challenges** - resilience, forecast, automation, artificial intelligence

A true System of Interconnected Systems

For the benefit of all European consumers



Building a ‘System of Systems’



- Geographical scales
- Multilateral interfaces
- Interoperability
- System operators = key facilitators
- Governance involving stakeholders
- Putting consumers at the heart of the Energy Transition

Taking up the EU Green Deal challenge: ENTSO-E RDI Strategy &Roadmap 2020-2030

Håkon Borgen

Chair of ENTSO-E Research,
Development & Innovation Committee

The ENTSO-E R&I Roadmap 2020-2030: towards a pan-EU energy system with no net emissions of greenhouse gases in 2050

OS
One System of integrated systems

PG
Backbone of an energy system

CP
Cyber-Physical Systems

ONE SYSTEM OF INTEGRATED SYSTEMS (OS)

- F1 – Optimise cross-sector integration
- F2 – Develop an ecosystem for deep electrification

Breakthrough innovation opening new opportunities for system users

POWER GRID – BACKBONE OF AN ENERGY SYSTEM (PG)

- F3 – Enhanced grid use and development for a pan-EU market

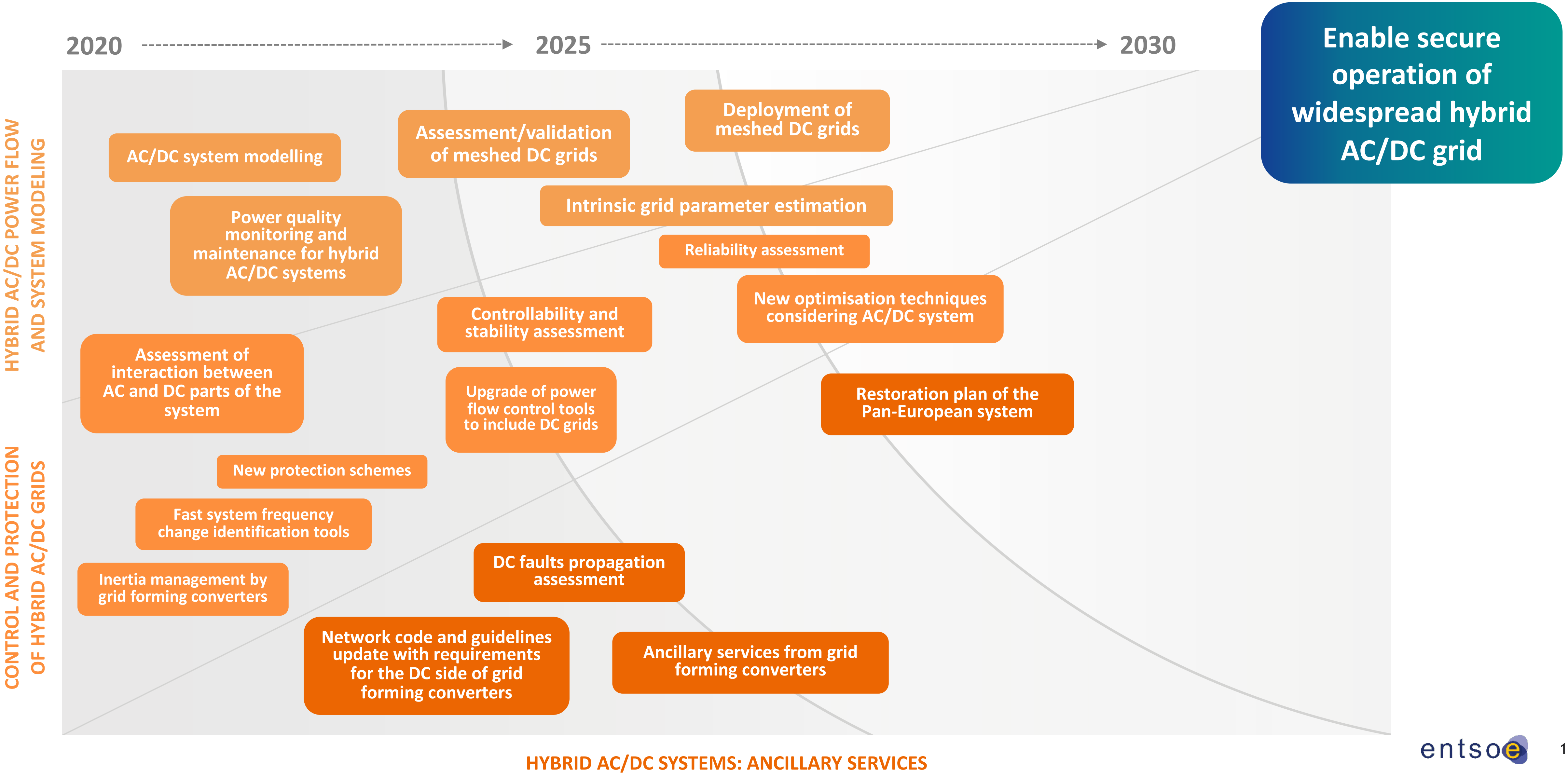
Better usage of a current assets and new solutions at system level

CYBER-PHYSICAL SYSTEMS (CP)

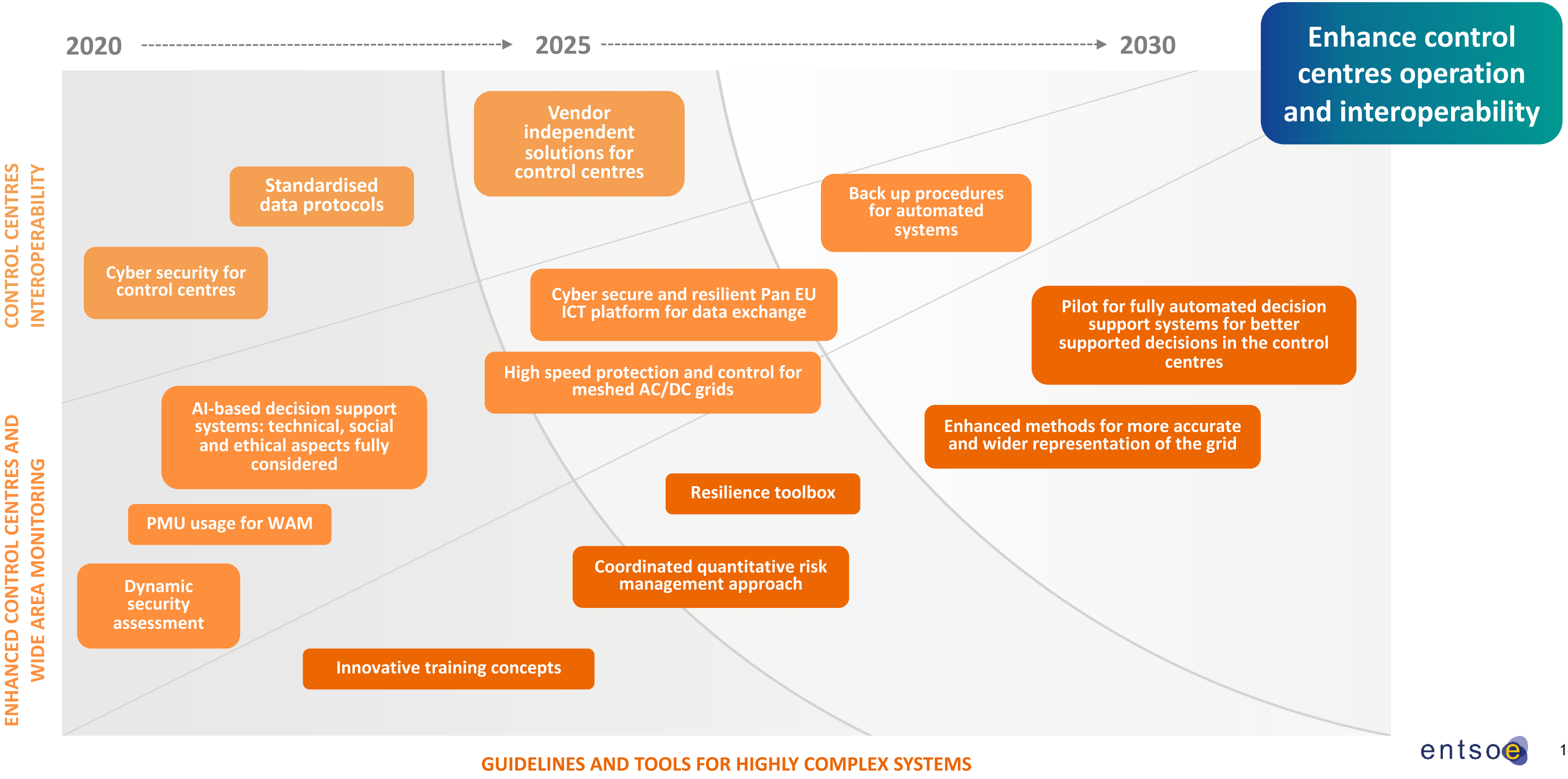
- F4 – Enable large-scale offshore wind energy into the grid
- F5 – Enable secure operation of widespread hybrid AC-DC grid
- F6 – Enhance control centers operation and interoperability

Further developing the core of the electrical system

Flagship 5: Enable secure operation of widespread hybrid AC/DC grid



Flagship 6: Enhance control centres operation and interoperability



Summary

- 2030 towards 2050: system of interconnected systems is in the center of ENTSO-E Vision 2030 which will play a key role in the European energy transformation
- ENTSO-E RDI Roadmap 2020-2030 aims to accelerate innovation for TSOs to reach climate neutrality
  - use cases approach to prioritise: 6 Flagships
  - implementation, integration and interoperability of technologies and solutions
  - progress through the milestones
- Next steps: TSOs to develop an implementation plan, enhance their commitment and cooperate with stakeholders
- Horizon Europe and other financial instruments such as CEF need to remain strong instruments for green transition
- Regulation plays a crucial part to facilitate faster uptake of innovations

Innovation in regulation

Jan Kostevc

Team Leader, ACER Electricity Infrastructure

ACER
Agency for the Cooperation of Energy Regulators

TSOs & Innovation

- **Why should TSOs be innovative? And why they aren't (at least not enough)?**

Identifying the problem

- **Across Europe NRAs approved approx. 80% of TSO proposed R&I projects.**
  - **Should TSOs propose more projects ?**
  - **NRA “blank check” to facilitate R&I ?**
  - **Regulatory frameworks should incentivise, but…**
  - **Benefit ? CBA is needed.**

ACER
Agency for the Cooperation of Energy Regulators

ACER leading the way forward

- **ACER and NRAs investigating best regulative practices**

- **Regulatory frameworks should not only allow, but also stimulate innovation!**

- **TSOs and NRAs need to work together**

Conclusions

- **Regulatory frameworks are the basis of TSO behaviour**
- **Identifying best practices (and beyond) …**
- **Bridging the gap between "classical" and "smart" solutions**
- **TSO/NRA cooperation is key !**

The opinions expressed in this presentation are those of the author(s) and do not necessarily represent the official views of the Agency for the Cooperation of Energy Regulators unless explicitly stated otherwise. The presentation is intended to help interested parties understand the Agency's functions and facilitate the accomplishment of the Agency's mission.

Thank you for your attention!

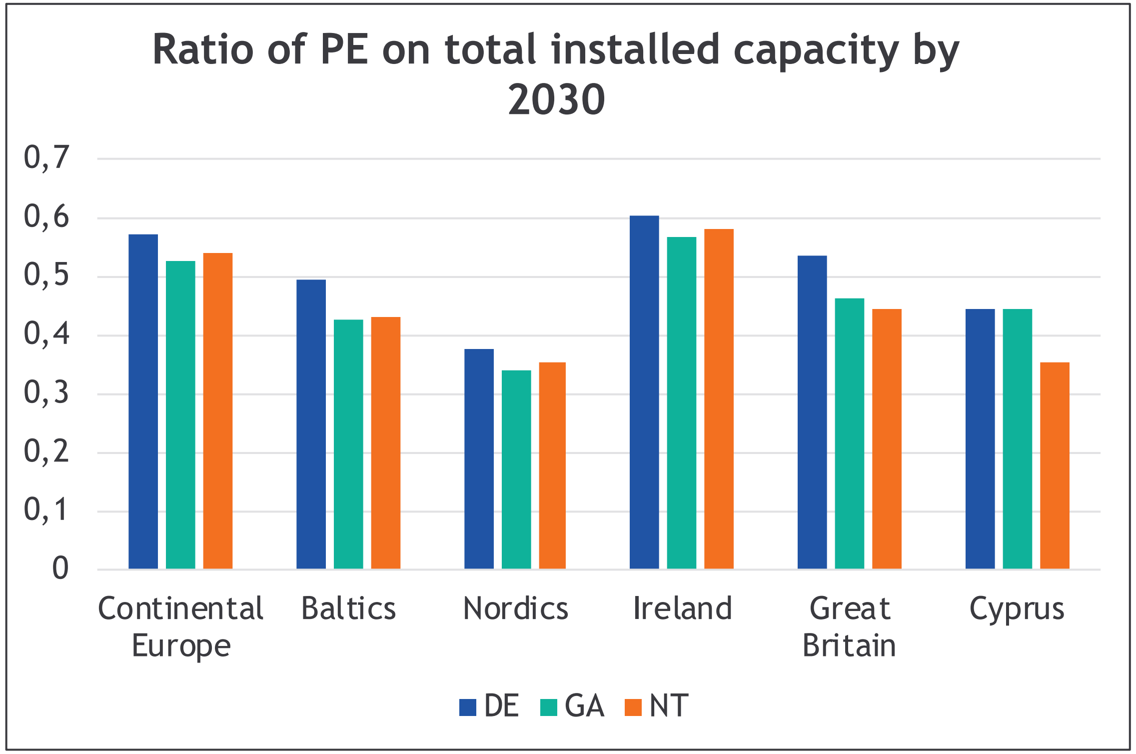
www.acer.europa.eu

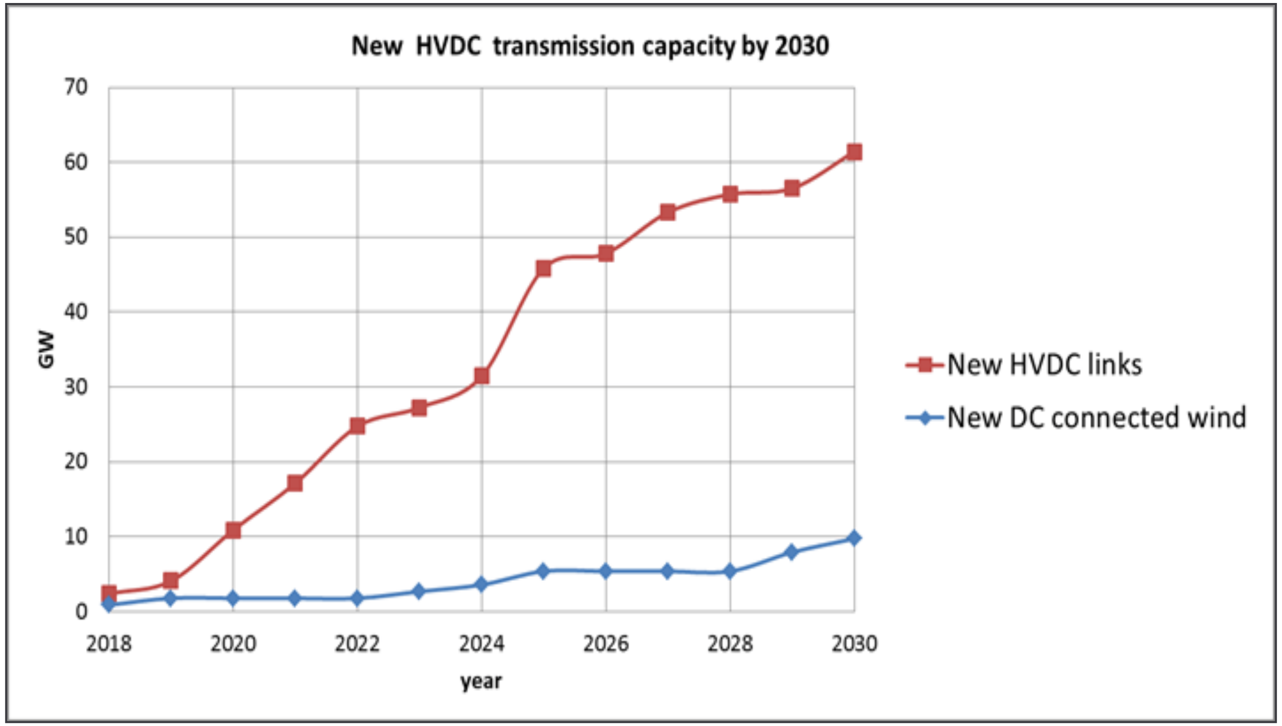
Integration of power electronics and hybrid AC/DC networks

Wilhelm Winter

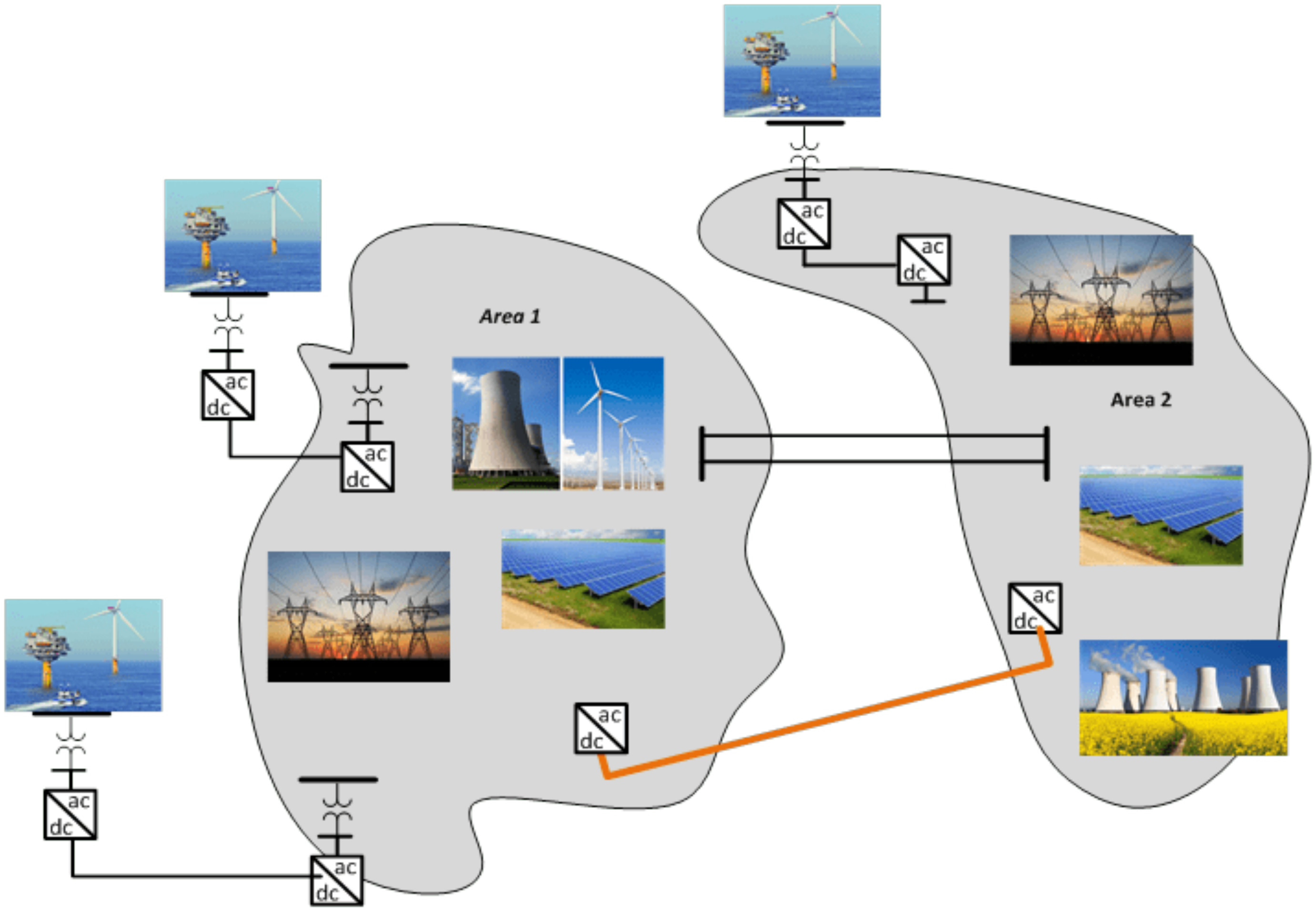
Convener of ENTSO-E RDI Committee
Working Group Security and System
Operation of Tomorrow

Grids with high penetration of PE based generation and transmission





Change in power generation structure

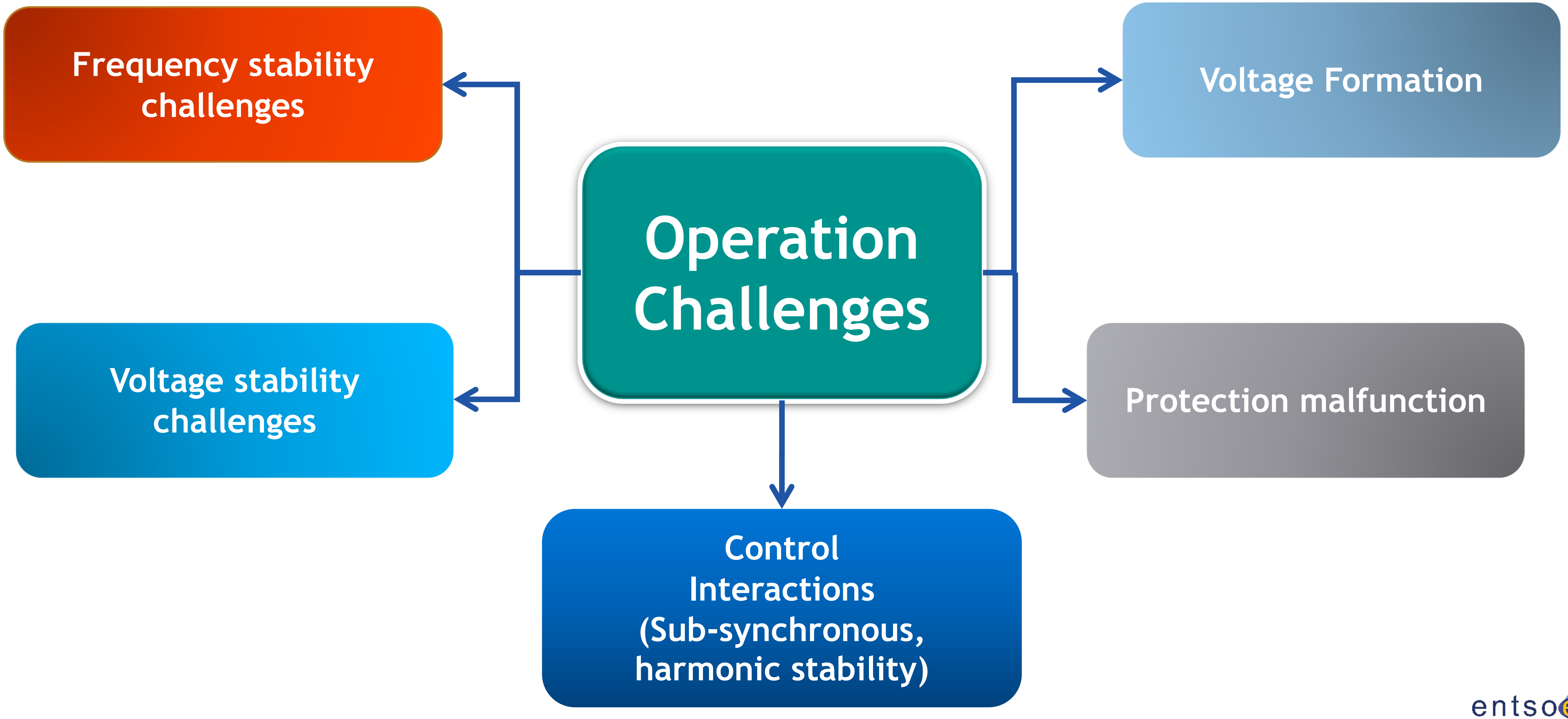


- Increasing share of power electronic interfaced generation (PEIG) in the grids
- Decreasing share of synchronous generation

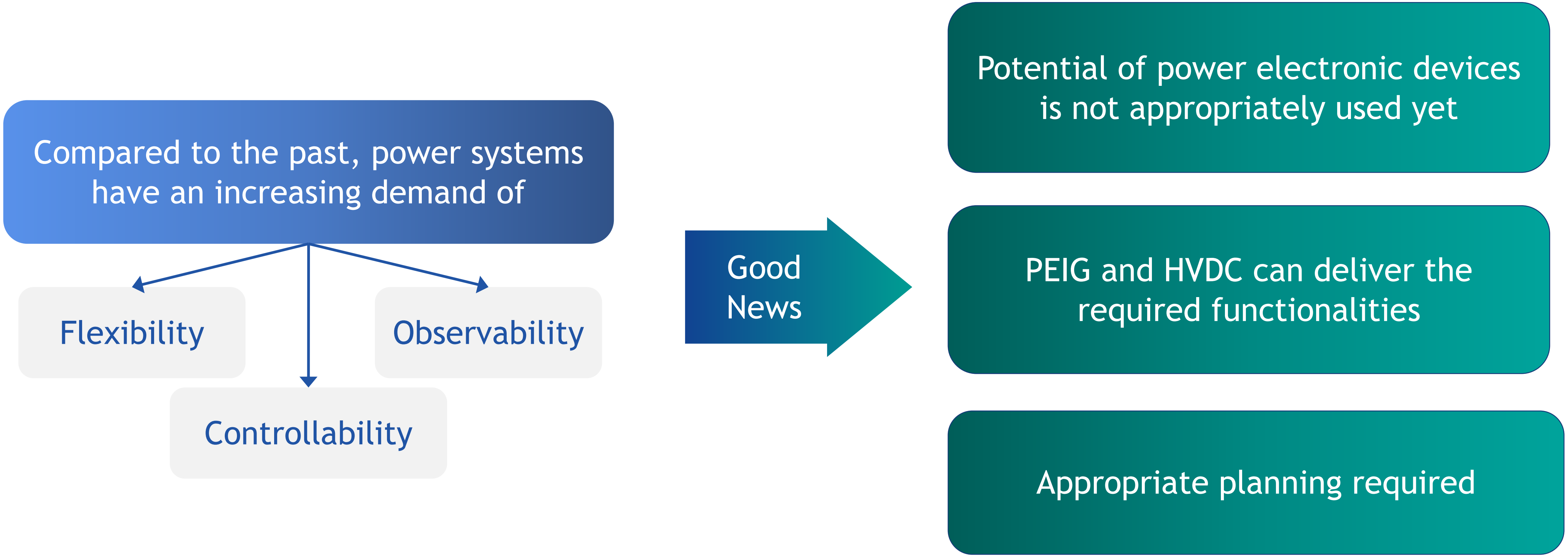
Key questions:

- How to accommodate more PEIG in the power system?
- What do we do to maintain the same levels of security of supply?

Main Operational challenges due to massive penetration of PEIG



Future System Needs



Roadmap towards PE-Dominated Power Systems in hybrid AC DC Systems

Enhancement of system stability

Enhancement of system observability

Enhancement of flexibility

Tools and advanced models

Enhancement of coordination

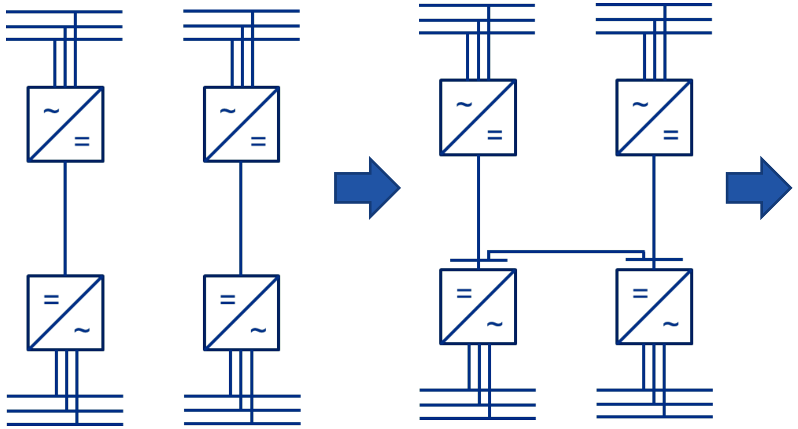
Roadmap towards PE-Dominated Power Systems in hybrid AC DC Systems

Damping and Flexibility

HVDC systems offer required flexibility for large scale integration of PEIG and grid forming control

HVDC systems can improve the overall AC/DC grid operation

HVDC systems can contribute to grid stabilization



Today: Single Point-to-point connections

Multiterminal Systems

Source:
PEI, European grid vision

DC grids as a backbone system for AC?

Roadmap towards PE-Dominated Power Systems in hybrid AC DC Systems

Tools and advanced models

The dynamic security assessment of power electronic dominated networks will require both for accurate and computationally efficient models

The complexity of HVDC systems and PEIG in the grid requires for advanced modelling methodologies

The data exchange between TSOs and a common library of advanced models will enable effective network studies both regional as well as on a pan-European level

Roadmap towards PE-Dominated Power Systems in hybrid AC DC Systems

Coordination between TSO and DSO

Significant generation capacity embedded in distribution level
- Might provide ancillary services (e.g. active participation in frequency control)
- Expected increasing impact on stability issues

Cooperation required for gathering data for grid models

Summary and Conclusion

- The power system is migrating from the traditional conventional generation-based AC system to a hybrid AC/DC system which will accommodate a high level of PEIG
- The operational challenges due to the high penetration of PEIG are identified
- HVDC interconnectors and FACTs introduce a higher level of control possibilities, which can be used to enhance system security of supply
- In addition, the utilisation of novel control concepts to effectively use the technologies available will have a significant impact on how to operate the electrical energy system
- In order to cope with all the challenges, innovation, research and development in the electrical energy business is crucial (interoperability and demonstration will become more important)
- Cooperation with various stakeholders is essential from the early stage

Challenges of the System Operation

Jens Jacobs

ENTSO-E Project Manager
of the RSC Project

Identified further operational challenges in SO Vision 2030

One System Vision for the year 2030 encompasses **Further Operational Challenges**:

- ➢ important drivers of the future that are not dealt with in specific parts of the vision.

Three main areas were identified

1. Managing and coping with threats to the power system
2. Automation and decision support
3. Complex forecasting

These three areas do not cover all the challenges TSOs will face in the future, but they are considered as the most important drivers and TSOs have a clear plan to meet the challenges through innovation and cooperation, in One System.

How TSOs are handling or intend to handle these areas?

- ➢ **Linking** the areas with mainly the **RDIC Roadmap Flagship 6** (Enhanced control operation and interoperability) while there are also close links with Flagship 3 (Enhanced grid use and development for pan EU market)

Managing and coping with threats to the power system

Which challenges effect TSOs?

The general topic of “threats” can be broken down to three main areas

- Risk Preparedness, System resilience and System restoration
  - anticipation, preparation, absorption, adaptation, rapid recovery and sustainment of critical system operation
- All these threats are linked to physical as well as cyber threats

How TSO’s are going to face these challenges?

- Ensuring **Cyber security for control centres**
- Developing **cyber-secure and resilient pan-EU ICT platform for data exchange**
- **Resilience toolbox** to assist system operators
- Developing a **Coordinated quantitative risk management approach**
- Development and deployment of **High-speed protection and control for meshed AC/DC grids**

Automation and decision support

Which challenges effect TSOs?

- Digitalisation impacts the energy systems due to
    - More and more market players participate
    - The amount of data is growing tremendously
- Big data is becoming increasingly important but also challenging to create a reliable picture of the situation of the system.
- Automated systems need to support the operators
    - creating a complete picture of the situation
    - providing best possible option to deal with the situation

How TSO's are going to face these challenges?

- Develop a **Pilot for fully automated decision support systems for better supported decisions in the control centres**
- Developing **Standardized data protocols**
- Development and training of **AI-based decision support systems: technical, social and ethical aspects fully considered**
- Develop and deploy **Back up procedures for automated systems**
- *From Flagship 3 e.g Coordinated planning of pan EU market highly controllable power grid including HVDC and Load Flow Control*

Complex forecasting

Which challenges effect TSOs?

- Quality of the process results depends strongly on the quality of the forecast-data.
- Minimising the forecasting error leads to more reliable process results
- Increasingly critical to gain all the necessary information, e.g. out of forecasts, into one big picture.
- The high volatility of the infeed and consumption in the future will challenge the operators to make the right decisions.
- Finding a suitable solution from days-ahead to real-time, hence maximising the accuracy of the short and medium term forecast is of utmost importance.

How TSO's are going to face these challenges?

- Development and deployment of **Enhanced methods for more accurate and wider representation of the grid**
- Fostering and enhancing **PMU usage for Wide Area Monitoring (WAM)**
- *From Flagship 3 e.g. Improved, self-learning renewable power forecasts*

Operational challenges and how they are going to be faced by TSOs

1. Managing and coping with threats to the power system
   - Ensuring **Cyber security for control centres**
   - Developing **cyber-secure and resilient pan-EU ICT platform for data exchange**
   - **Resilience toolbox** to assist system operators
   - Developing a **Coordinated quantitative risk management approach**
   - Development and deployment of **High-speed protection and control for meshed AC/DC grids**
2. Automation and decision support
   - Develop a **Pilot for fully automated decision support systems** for better supported decisions in the control centres
   - Developing **Standardized data protocols**
   - Development and training of **AI-based decision support systems**: technical, social and ethical aspects fully considered
   - Develop and deploy **Back up procedures for automated systems**
3. Complex forecasting
   - Development and deployment of **Enhanced methods for more accurate and wider representation of the grid**
   - Fostering and enhancing **PMU usage for Wide Area Monitoring** (WAM)

Technology Innovations for Sustainable Green Power Systems - View of the stakeholders

Dr. Frank Schettler

Convenor of CENELEC and IEC WGs on HVDC Grids
T&D Europe, Siemens Energy

Europe's Grid Technology Providers

T&D EUROPE is the European association of the **electricity transmission and distribution** equipment and services industry

Our scope includes the **complete range of products and services** necessary to transport and distribute electricity in high and medium voltage

T&D Europe is working towards **future-proofing the electricity networks** in Europe by means of policy, technology and investments

The companies represented by T&D Europe account for a production worth over €25 billion, and employ over 200.000 people in Europe

National trade association members

Corporate members

Associate members

Opening Notes

- T&D Europe welcomes the ENTSO-E Vision on Market Design and System Operation towards 2030.
- Transferring Europe‘s energy system towards a sustainable, carbon-free future requires new approaches as addressed by ENTSO-E‘s „True System of Systems“ concept.
- From T&D Europe perspective, the transition needs:
  - Innovative, reliable and cost efficient technologies developed by the industry in line with the market requirements
  - Attractive conditions for all players in the market to invest in new technologies
  - Effective regulatory frameworks for operating the power systems of the future as one integrated system
- As a representative of the industry, T&D Europe is already contributing to several activities supporting this transition process.

The Potential of HVDC

Technology is available today, optimized for different purposes, e.g. Cable and Overhead Line

Broad worldwide operational experience
with more than 10 GW transmission capacity alone to offshore wind parks in operation or under construction

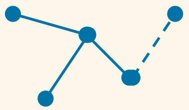
Most efficient means for energy transport over long distances and for subsea applications

“Multi-Purpose” HVDC applications serve:

- as interconnectors between different synchronous AC zones
- strengthening AC zones as embedded systems
- connecting remote generation and demand

Today's European Design Approach

HVDC today is point-to-point with the DC side being coordinated by the HVDC system vendor (with a few exceptions)



Multi-Purpose HVDC Systems will tend to be multi-terminal, developing stepwise with the perspective to add new links to the existing DC circuit

- First Multi-Terminal Projects are under execution or under development in Europe

MTDC ready

- Some HVDC systems are already prepared to become Multi-Terminal
- **With the present design approach, future system expansions will have vendor-specific requirements**

A new Approach is needed

T&D europe

HVDC grids consist of individual stations (e.g. AC/DC converter stations, switching stations) typically provided by different vendors and connected via transmission lines

Interoperability needs to be assured based on:

- standardized functional requirements for all necessary station interfaces at the AC and DC side
- HVDC grid code for the DC circuit

System integration risks can be minimized by comprehensive testing; Testing should be Hardware-in-the-Loop until sufficient experience is available.

The development of HVDC grids is a European endeavor, which needs real industrial size projects to materialize.

Interoperability: Ability of a system to work together with other systems, now or in the future, without restrictions

system: defined by its boundaries and expected function,

without restrictions: performance according to specifications,

in the future: multi-stage development

together with other: multi-vendor design

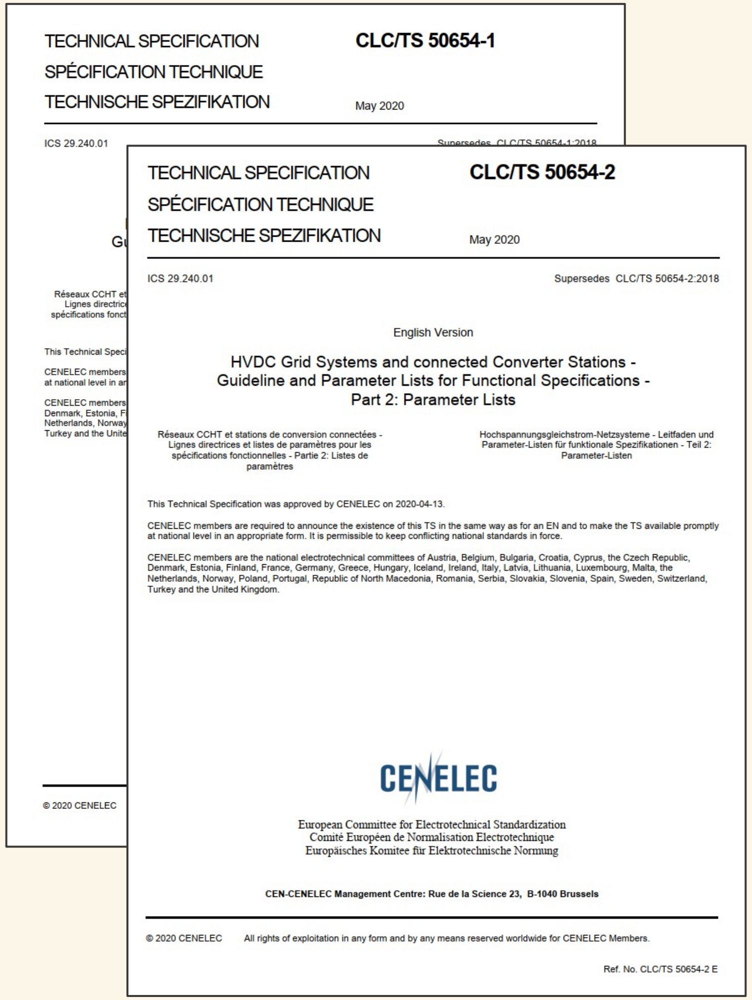
The Technical Framework is Available

CENELEC TS/50654:

HVDC Grid Systems and connected Converter Stations – Guideline and Parameter Lists
for Functional Specifications, May 2020

The Standard addresses all HVDC grid specific aspects:

- **Coordination with the AC system(s)**
- Main circuit design
- HVDC grid controls
- HVDC grid protection
- Models
- Testing



TECHNICAL SPECIFICATION CLC/TS 50654-1
SPÉCIFICATION TECHNIQUE
TECHNISCHE SPEZIFIKATION
May 2020
ICS 29.240.01

© 2020 CENELEC

TECHNICAL SPECIFICATION CLC/TS 50654-2
SPÉCIFICATION TECHNIQUE
TECHNISCHE SPEZIFIKATION
May 2020

ICS 29.240.01 Supersedes CLC/TS 50654-2:2018

English Version

HVDC Grid Systems and connected Converter Stations - Guideline and Parameter Lists for Functional Specifications - Part 2: Parameter Lists

Réseaux CCHT et stations de conversion connectées - Lignes directrices et listes de paramètres pour les spécifications fonctionnelles - Partie 2: Listes de paramètres

Hochspannungsgleichstrom-Netzsysteme - Leitfaden und Parameter-Listen für funktionale Spezifikationen - Teil 2: Parameter-Listen

This Technical Specification was approved by CENELEC on 2020-04-13.

CENELEC members are required to announce the existence of this TS in the same way as for an EN and to make the TS available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

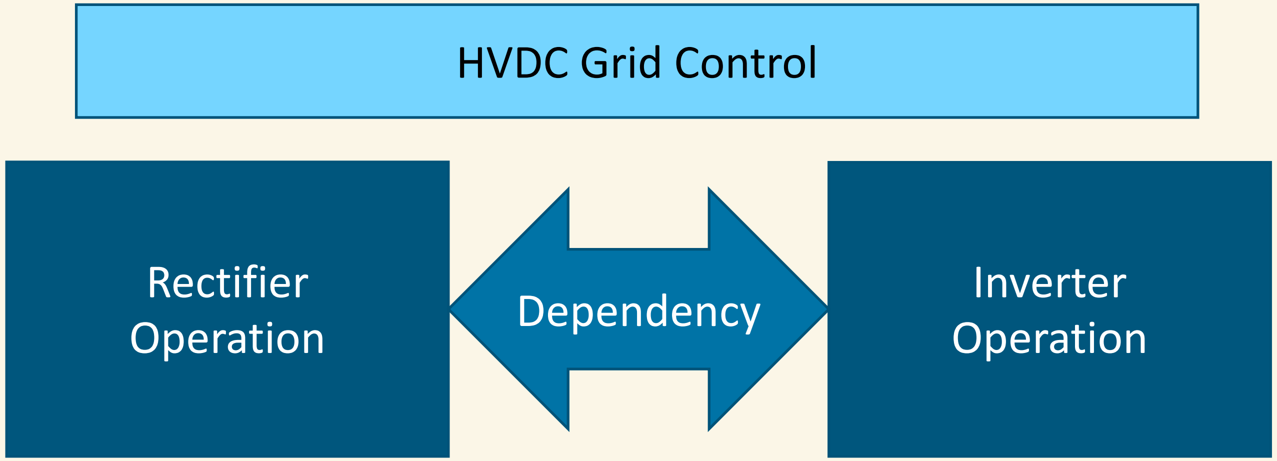
CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

© 2020 CENELEC All rights of exploitation in any form and by any means reserved worldwide for CENELEC Members.

Ref. No. CLC/TS 50654-2 E

AC/DC System Integration at Grid Level

- HVDC is a power transmission system
- Active power fed to or taken from the DC circuit needs to be balanced at all times

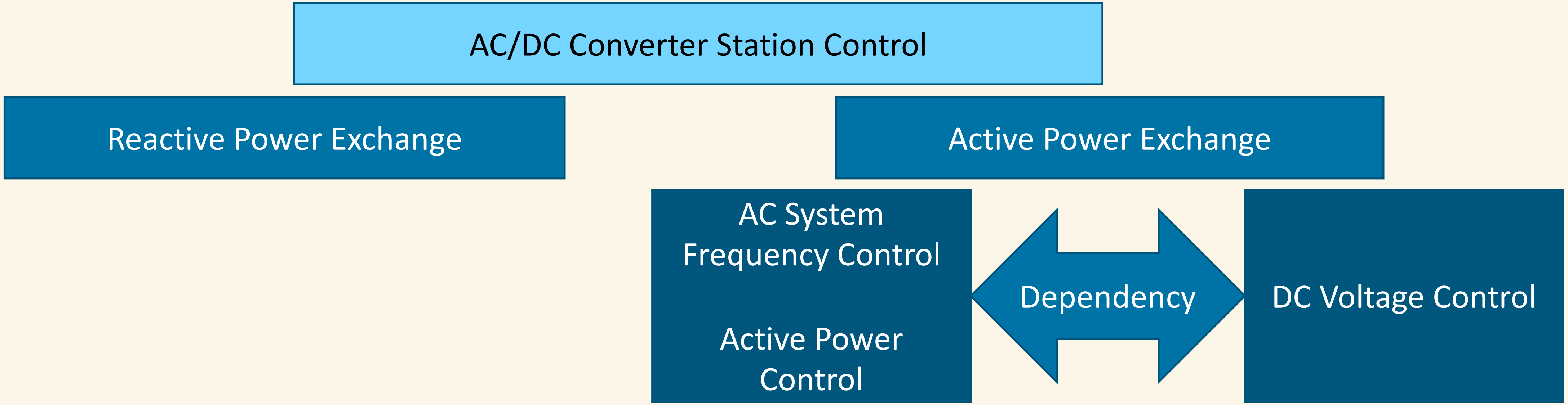


CLC/TS 50654 describes how the coordination of power flows associated with primary frequency control shall be specified

AC/DC System Integration at Station Level

HVDC allows flexible grid integration providing system ancillary services including fast frequency support, AC voltage control, System Recovery Ancillary Services (SRAS), etc.

CLC/TS 50654 defines “basic operation functions” which need to be parameterized to achieve proper coordination between the AC and DC side



Changing Responsibilities for TSOs and Vendors

T&D europe

In present HVDC systems, all DC side functions are defined and coordinated by vendor

Multi-vendor HVDC Systems need a leading role of TSOs in defining functions on both the AC and DC side

HVDC System Vendors

support the TSOs in defining function

(proposal of possible solutions)

TSO Scope (AC)

review of existing AC related functions in relation to requirements emanating from the HVDC Grid

(AC network support functions)

TSO Scope (DC)

Detailed specification of:

central DC network coordination and protection functions

distributed control functions (i.e. DC node voltage control*) implemented in converter stations control systems

*) CLC/TS 50654

The Coordination with Distribution Networks

There is a high potential for climate-neutrality by shifting sectors traditionally relying on fossil fuels (transport, buildings, industry, etc.) to electricity.

Requirements are needed, defining what functions are essential for an efficient grid enabling a climate neutral future.

Distribution networks will have to become an integral part of AC and DC system operation, calling for a TSO-DSO cooperation.

Distribution grids need to provide the required level of observability and controllability to manage the increased volatility of the system, characterized by e.g. intermittency of renewable generation or decreasing inherent inertia.

Variable generation from solar and wind power requires flexible services for balancing supply and demand. Such services should be much stronger incentivized.

Summary

T&D europe

- HVDC and particularly HVDC grids in coordination with AC transmission and distribution grids will play a key role in reaching the European Green Deal targets.
- Being integral part of an automated overall grid control, HVDC grids can become the backbone of Europe’s power system interconnecting different synchronous zones, strengthening existing AC grids, connecting large scale renewables and remote loads.
- HVDC grids will change the roles of TSOs and vendors with respect to DC side requirements.
- Commonly agreed functional requirements will allow the industry to develop compatible solutions while keeping the freedom for technological developments.
- An appropriate regulatory framework should stimulate investments into new technologies and support attractive business models.
- Paperwork is not enough, industrial scale pilot projects are needed as a necessary step in ensuring scalable HVDC grids.

T&D europe

www.tdeurope.eu

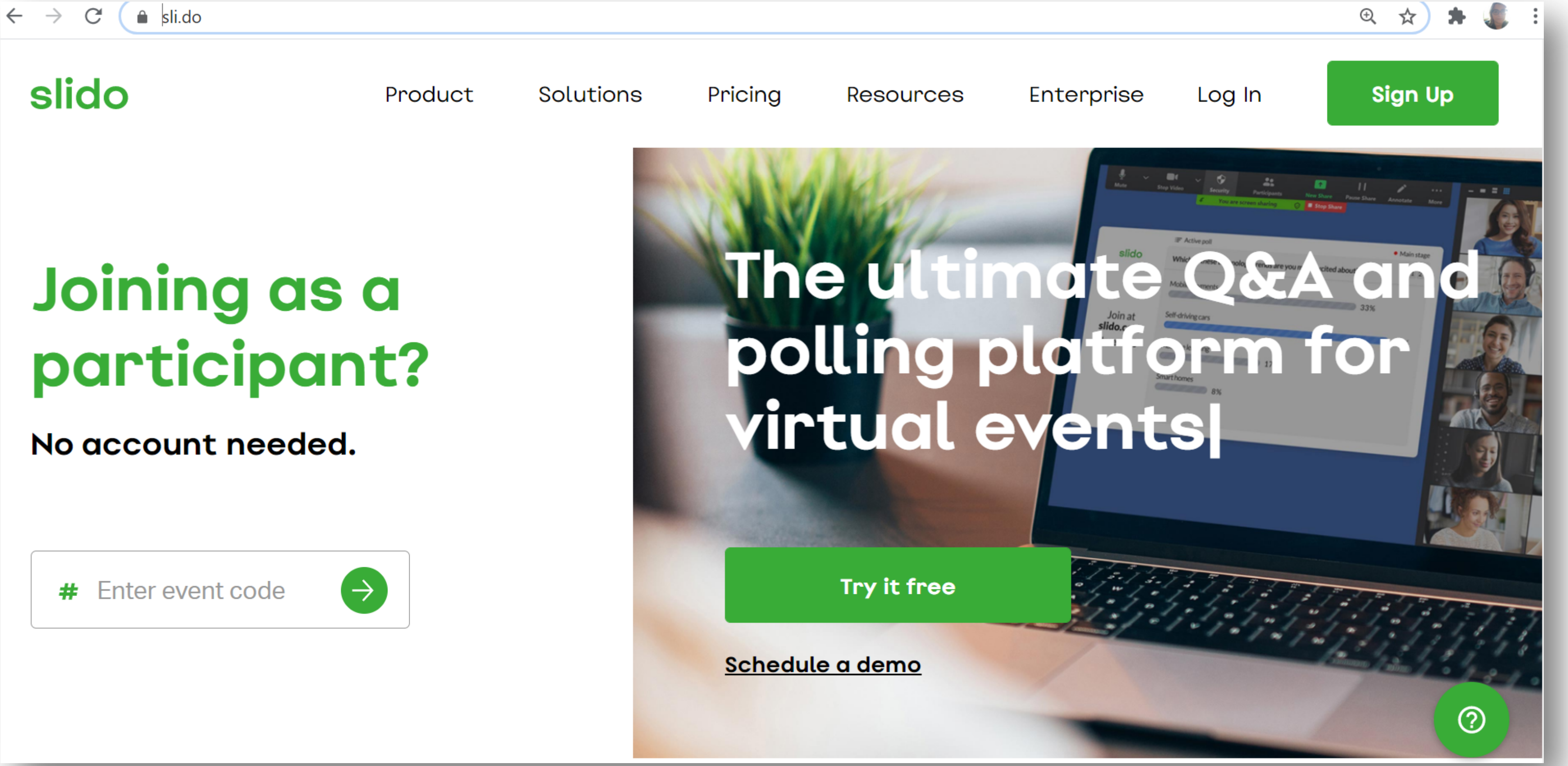
@BetterGrids

Open Floor for Q&A discussion

Norela Constantinescu

ENTSO-E Manager of
Research & Innovation

Open floor to Questions & Answers



Go to www.sli.do and enter **EWeek-5** or scan the following QR with your phone to login

Conclusions & next steps

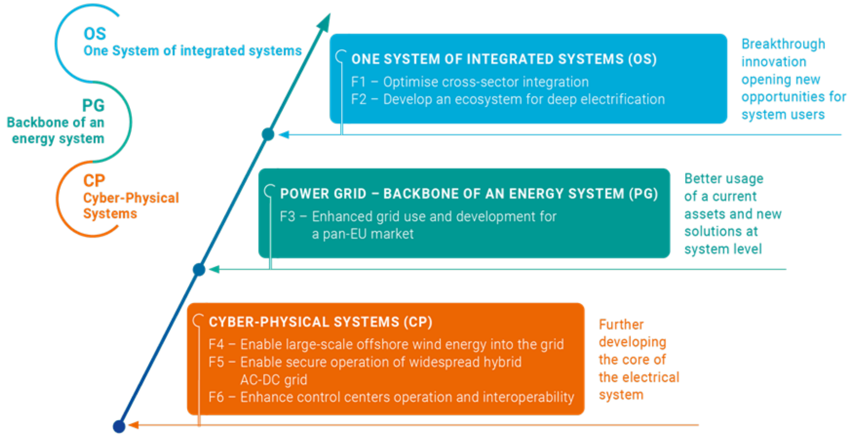
Håkon Borgen

Chair of ENTSO-E Research,
Development & Innovation Committee

Webinar 5 – Conclusions and next step

The innovation challenge and hybrid AC/DC networks

RDI Flagships



Hybrid AC/DC

- ❑ Operationally, large scale RES integration means the migration from traditional AC based to hybrid AC/DC system which requires commonly agreed functional requirements, interoperability and demonstrators
- ❑ Operational challenges will be coped with by TSOs, automation and decision support, complex forecasting are needed elements
- ❑ HVDC grid can/will interconnect Europe's power system different synchronous zones, strengthen existing AC grids, connect large scale renewables and remote loads

Accelerate innovation

- ❑ ENTSO-E RDI Roadmap 2020-2030 aims to accelerate innovation for TSOs in order to reach climate neutrality with high share of RES into the electricity system while keeping its security of supply
- ❑ Innovation in regulation is key to ensure that innovative solutions will become the choice in future developments of the power system reaching European climate neutrality by 2050
- ❑ Achievements and cooperation among stakeholders are fundamental to deliver on the energy transition and for reaching European climate neutrality by 2050

ENTSO-E and TSOs are committed to ensure the energy transition by building a system of systems with consumers at the heart

Inside the Vision 2030 – Join us for the next webinar!

Webinar #6

A system of systems – ENTSO-E's vision for the future

Don't miss the last piece! **14.00-16.00 CET Today**