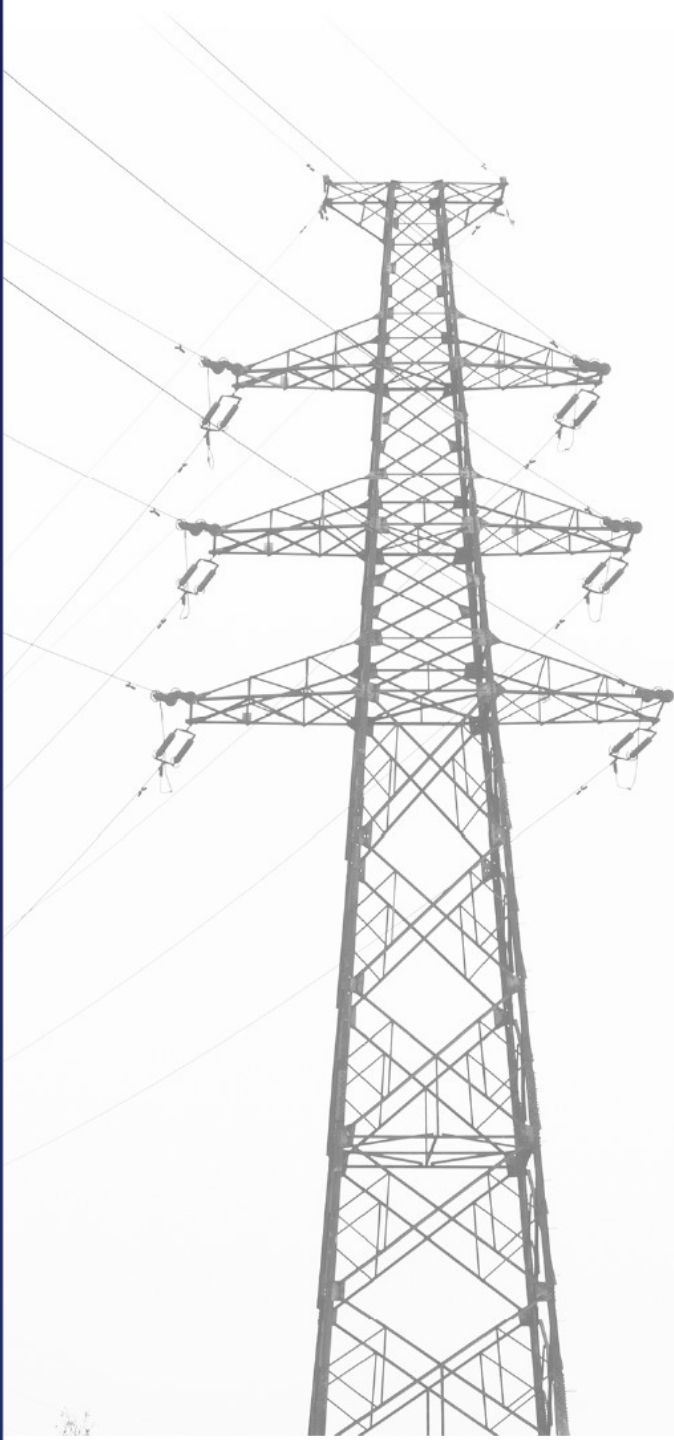




Large-Scale Transmission Development: Lessons from Europe

A PROJECT OF





Thank You

Advanced Energy Economy

Alberta Electric System Operator

Amazon Web Services

American Council on Renewable Energy

BP

California ISO

Calpine

Clean Energy Buyers Association

ClearPath

Constellation

Electric Power Supply Association

Electric Power Research Institute

Electricity Consumers
Resource Council

Enel Foundation

Energy Foundation

Equinor

GE Power

Google

Gridlab

ISO New England

LS Power

Meta

Microsoft

Midcontinent Independent
System Operator

National Hydropower Association

Natural Gas Supply Association

New York Independent
System Operator

New York Power Authority

NextEra

Niskanen Center

NRG Energy

National Hydropower Association

Nuclear Energy Institute

PJM Interconnection

Rocky Mountain Institute

Sustainable FERC

Tenaska

Vistra



Moderator and Featured Experts



Jennifer Curran
MISO



Leonardo Meeus
Florence School of Regulation



Konstantin Staschus
Guidehouse and ENTSO-E

Future Power Markets Forum

Prof Leonardo Meeus

Director of the Florence School of Regulation

Loyola de Palacio Chair



Evolution of the EU institutional framework

Each Member State required to design one or more competent bodies with the function of regulatory authorities

Each Member State required to designate a single national independent NRA

Establishment of an **Agency for the Cooperation of Energy Regulators (ACER)**

Enhancement of ACER and renaming of the “Agency” into a “**European Union Agency for the Cooperation of Energy Regulators**”



(National) Regulatory Authorities (NRAs)



Transmission System Operators (TSOs)

Management and accounting unbundling of national TSOs

Legal unbundling of national TSOs

Choice between three models of unbundling of national TSOs

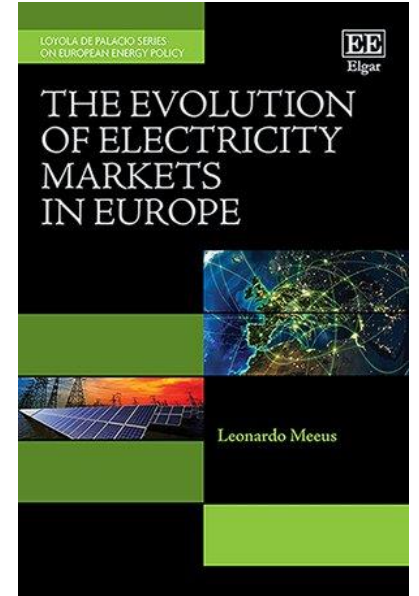
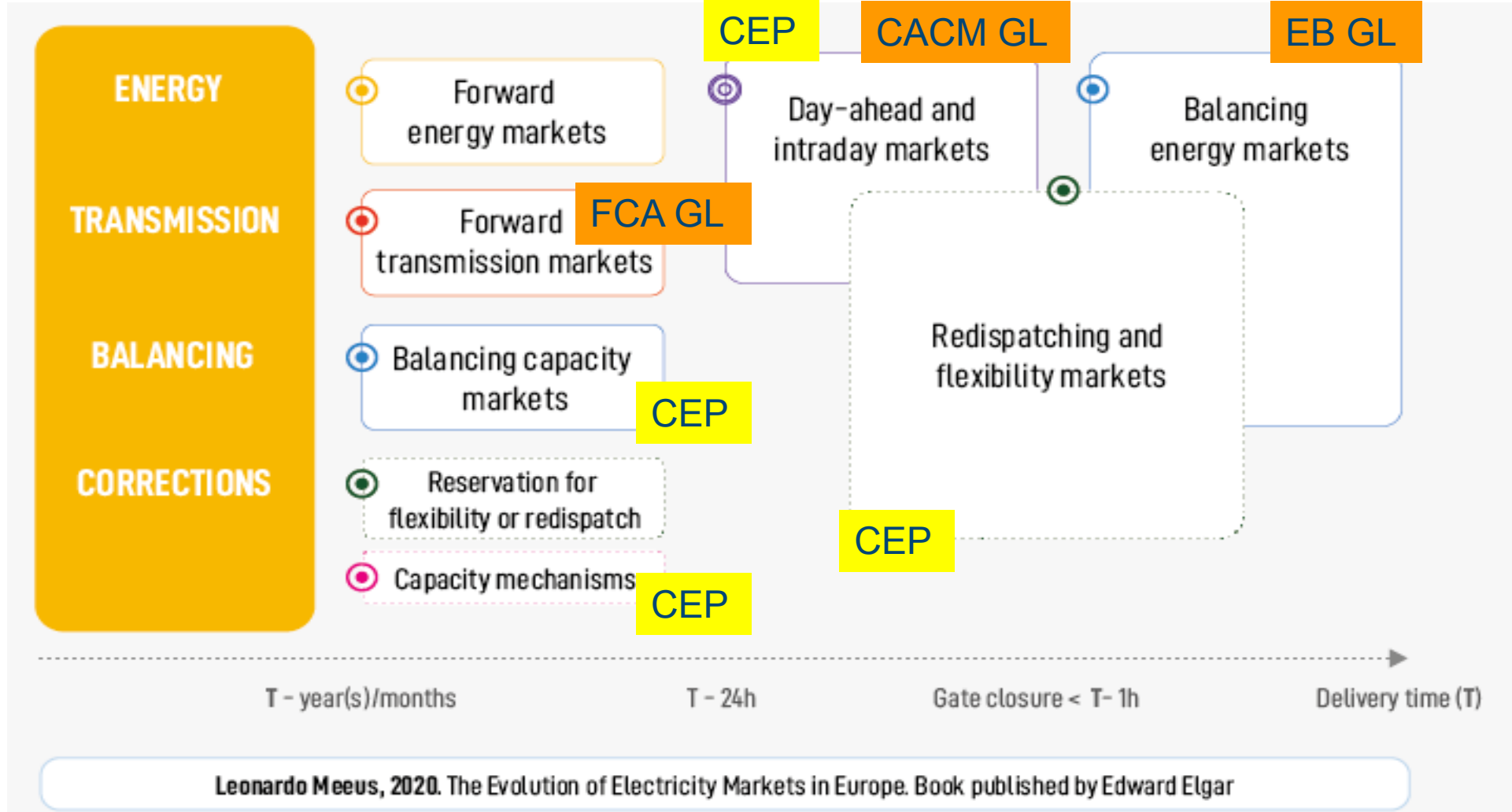
Enhancement of ENTSO-E’s tasks

Creation of the **European Network of Transmission System Operators for Electricity (ENTSO-E)**

Creation of the **EU DSO Entity** (distribution system operators)



Sequence of European electricity markets



Benefits of market integration

“Continued and strengthened efforts in the identified areas could deliver more than 300 billion Euros in benefits from EU energy market integration for the next decade.”

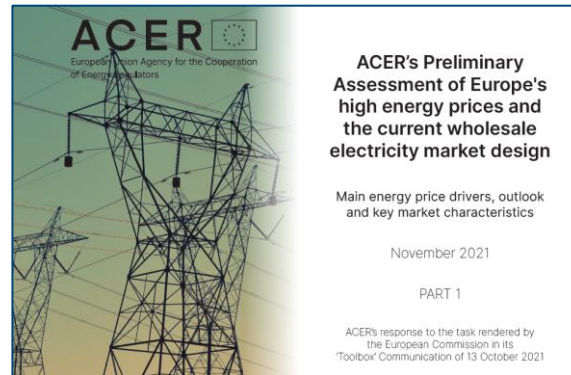
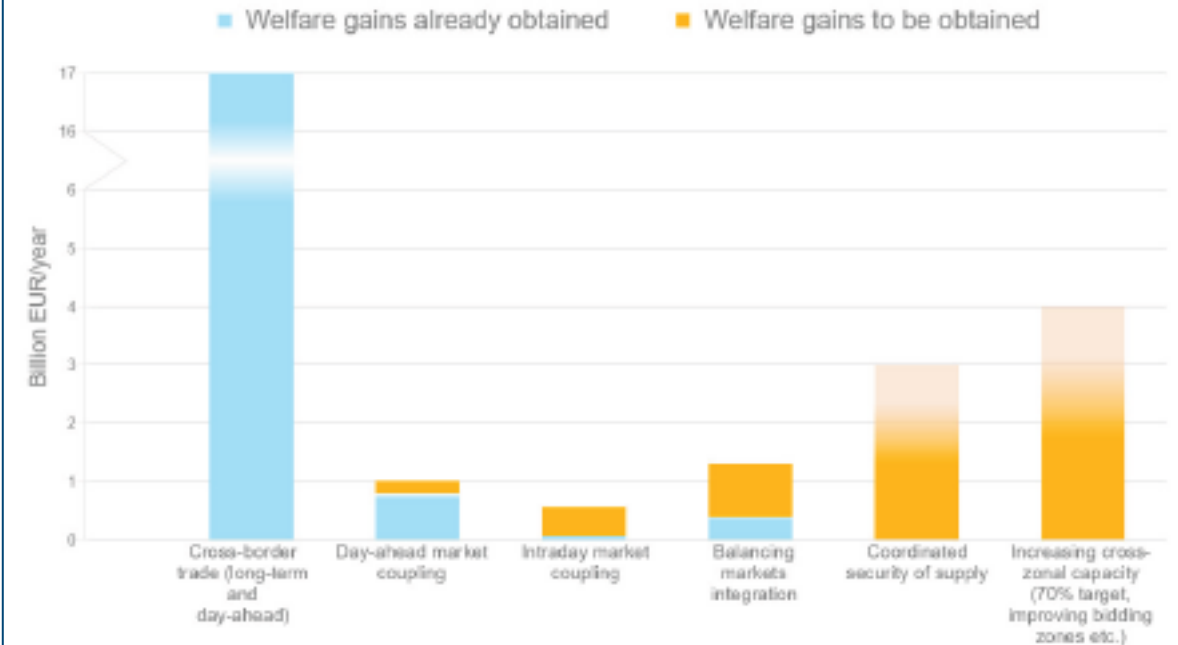


Figure 10: Social welfare benefits* already obtained and to be obtained from various actions intended to increase EU markets integration



Source: ACER Market Monitoring Report, various editions, available [here](#).

Note: *Gross benefits. The faded colour for some categories indicates that the welfare gains rely on third-party estimates and/or are subject to uncertainty.

Public statements



“We still have an electricity market that is designed in a way like it was necessary twenty years ago when we started to bring in the renewables [...] Today, the market is completely different and **this market system does not work any more.**” [Ursula von der Leyen, 8 June 2022](#)



“People are being charged for their electricity prices on the basis of the top marginal gas price, and that is frankly ludicrous. **We need to get rid of that system.**” [Boris Johnson, 25 June 2022](#)



“You have skyrocketing electricity prices that no longer have anything to do with electricity production costs, it follows gas, **it’s absurd**” [Emmanuel Macron, 28 June 2022](#)

Inspiration: ppt Lion Hirth

Gas prices



Ukraine invasion

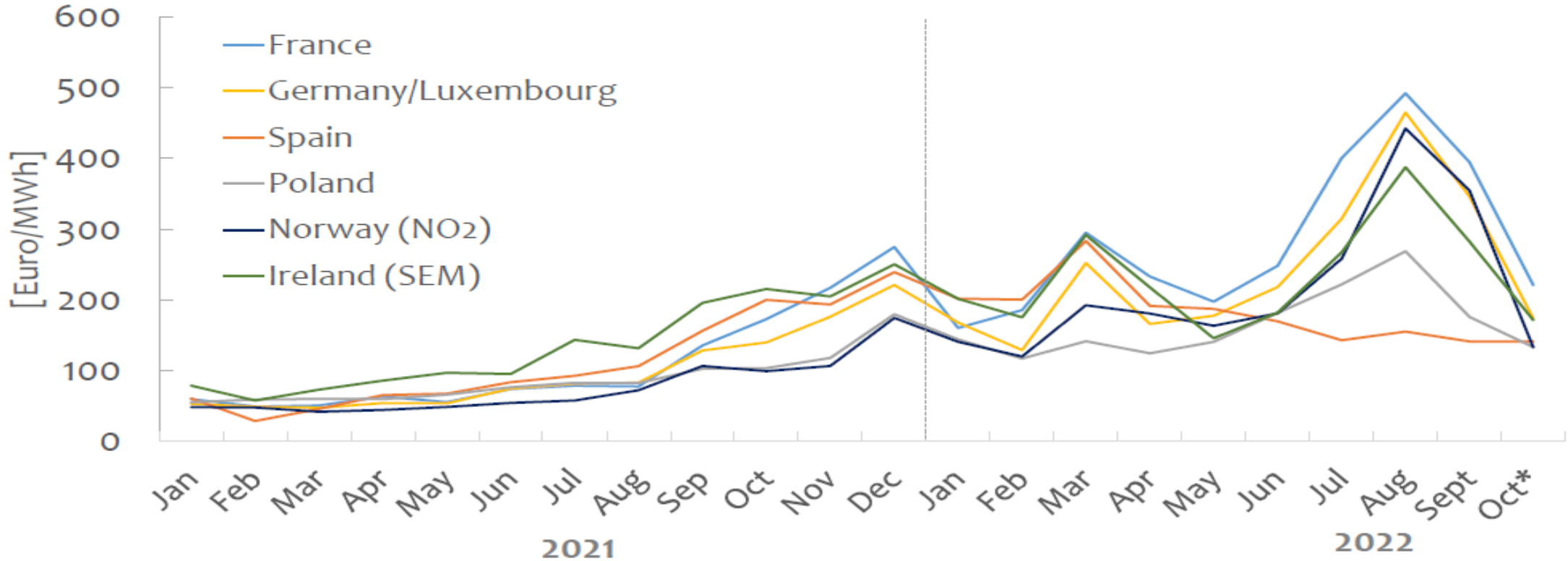


Source: ICE and tradingeconomics.com

Electricity prices



Monthly averaged day-ahead power prices



Source: ENTSO-E Transparency Platform

*Data until October 18, 2022

Government response (Status Sep 2022)

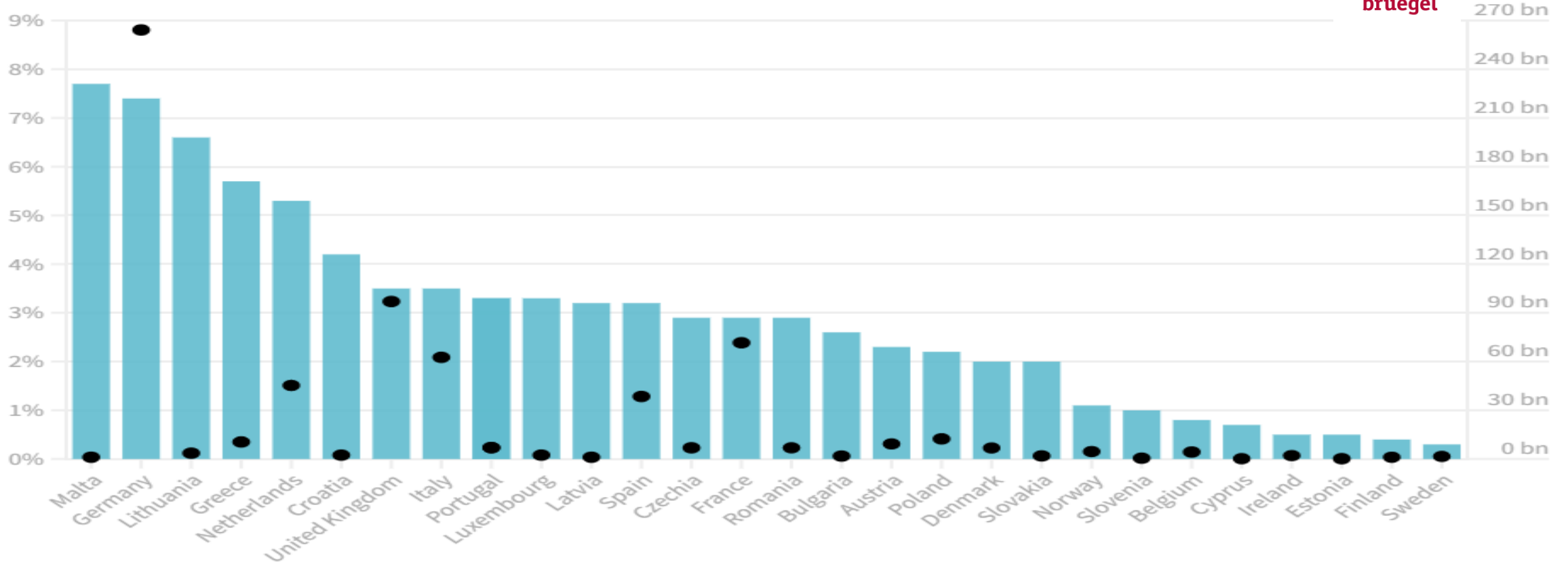
Country / Policy	Reduced energy tax / VAT	Retail price regulation	Wholesale price regulation	Transfers to vulnerable groups	Mandate to State-owned firms	Windfall profits tax / regulation	Business support	Other
Austria	✓	✓		✓			✓	✓
Belgium	✓	✓		✓		✗	✓	✓
Bulgaria	✓	✓		✓		✓	✓	
Croatia	✓			✓			✓	✗
Cyprus	✓			✓	✓			
Czech Republic	✓	✗		✓	✗		✓	✓
Denmark				✓				✗
Estonia	✓	✓		✓			✓	
Finland	✓			✓			✓	✓
France	✓	✓	✓	✓	✓		✓	✓
Germany	✓	✗		✓		✗	✓	✗
Greece	✓			✓	✓	✗	✓	
Hungary		✓				✓	✓	
Ireland	✓			✓				✓

implemented
 proposed



Government response (Status Oct 2022) = 674 billion

■ Percentage of GDP ■ Allocated funding (bn)



Proposals

- Iberian mechanism
- Greek proposal
- UK market splitting proposal

- EC Revenue cap proposal
- EC 5th electricity market reform

ENERGY & CLIMATE

The 5th EU electricity market reform: a renewable jackpot for all Europeans package?

This is the second instalment of the Topic of the Month: Reforming energy markets

AUTHORS
 **LEONARDO MEEUS**

TYPE
📌 **TOPIC OF THE MONTH**

DATE
🕒 **OCT 24, 2022**



RELATED

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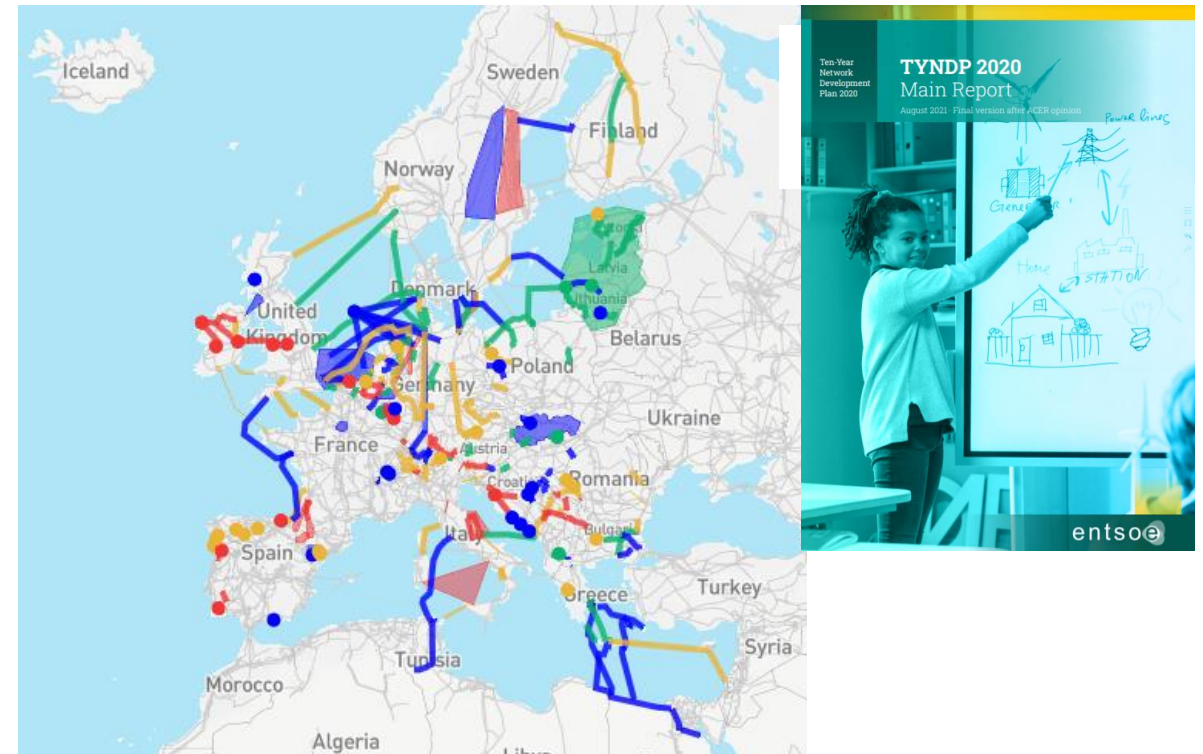
<https://fsr.eui.eu/the-5th-eu-electricity-market-reform-a-renewable-jackpot-for-all-europeans-package/>

Experience with Ten Year Network Development Plan for transmission grids (2010-2022: 7 reports)

Controversies

- Methodology, scenarios
- Transparency
- Trade-off grid expansion versus more efficient use of existing infrastructure (market design)
- Stakeholder engagement

2020 report



Distribution grids are next

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Capaciteitskaart invoeding elektriciteitsnet
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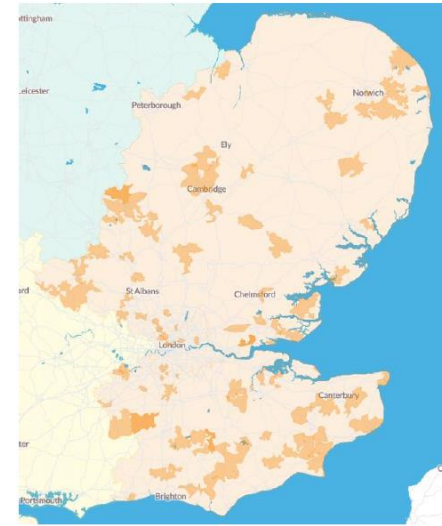
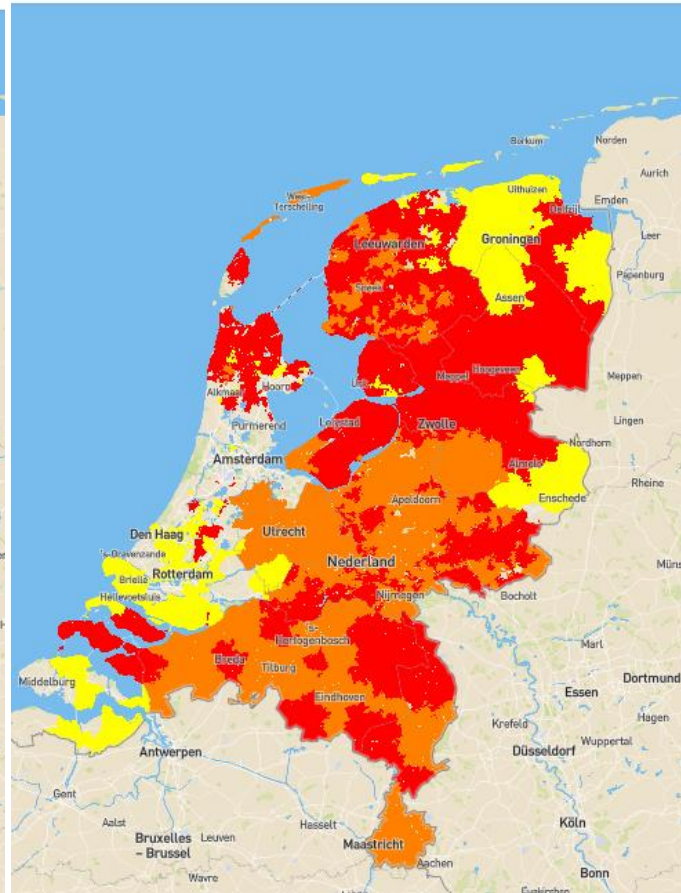
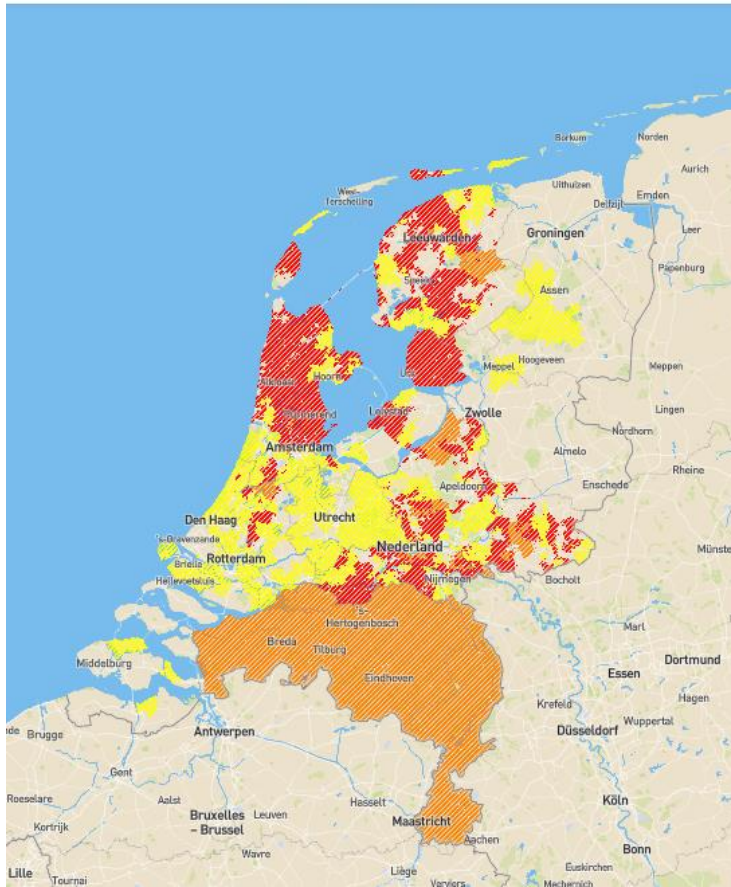
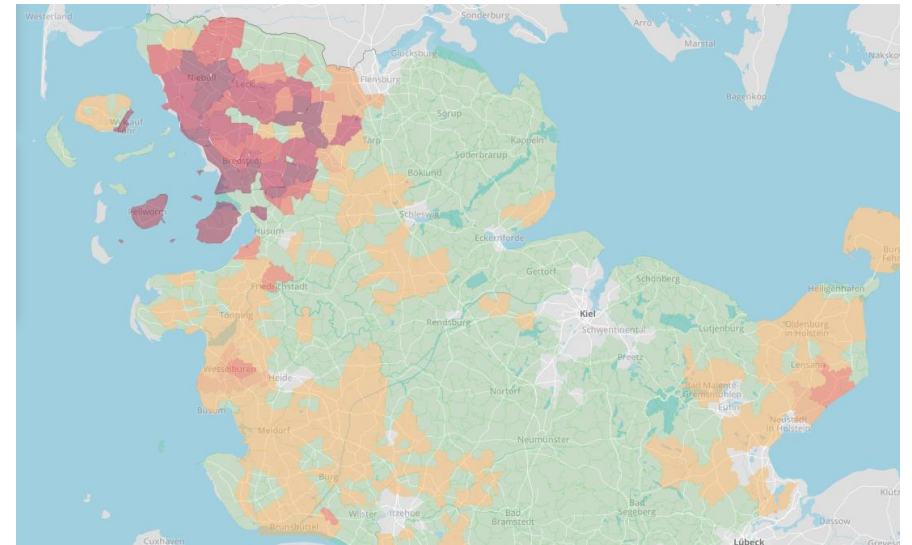
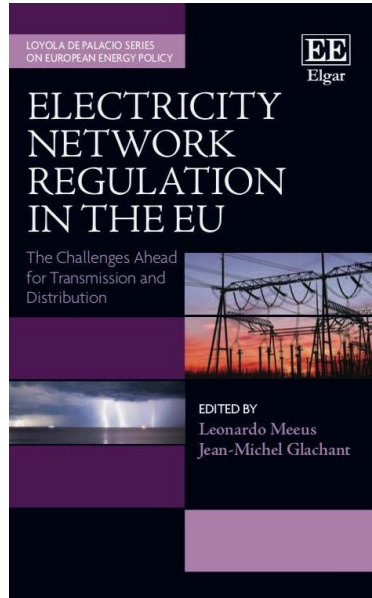
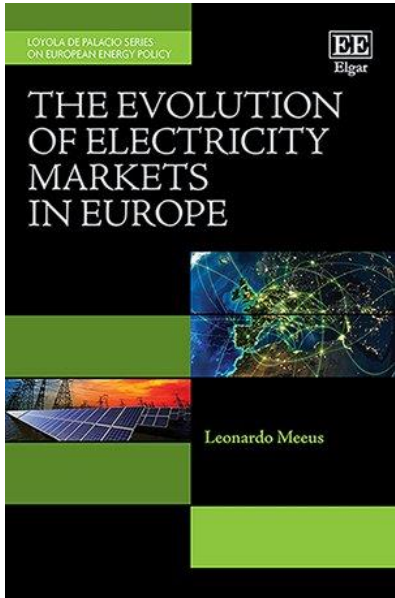


Figure 1: Tender 1 locations openly published on Pico Flex⁹





www.leonardomeeus.com



Continent-wide transmission planning, and Europe's experience with it

Konstantin Staschus, PhD
ENTSO-E Chief Innovation Officer
Director, Guidehouse

Future Power Markets Forum, Large-Scale Transmission Development: Lessons from Europe, 17 Nov. 2022

Decarbonization 2050 needs targeted planning, markets, IoT, TSO-DSO interaction and especially grids

Climate protection / renewables

- Electricity saves energy + CO₂ in heating, transport, large parts of industry (rest: H₂)
- Solar/wind volatile, low capacity factor
- Installed capacity >> load
- When wind blows/sun shines: Curtail, store (incl. H₂) or transport to where value higher



Markets

- Generation no longer natural monopoly
- Wholesale markets dispatch generation well, especially over multiple systems
- Investment incentives difficult but DG investment in reach of retail customers



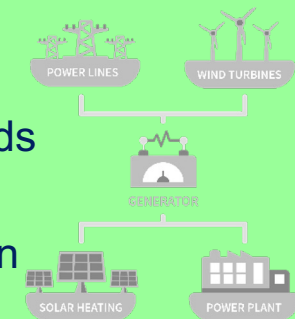
Continental grids + markets

- Reliability and trading benefits from large interconnections, esp'ly for regional temporary RE surplus/deficit
- Transport RE surpluses often cheaper than storing/curtailing/VoLL
- Local markets for local congestion, but integrated with continental wholesale markets



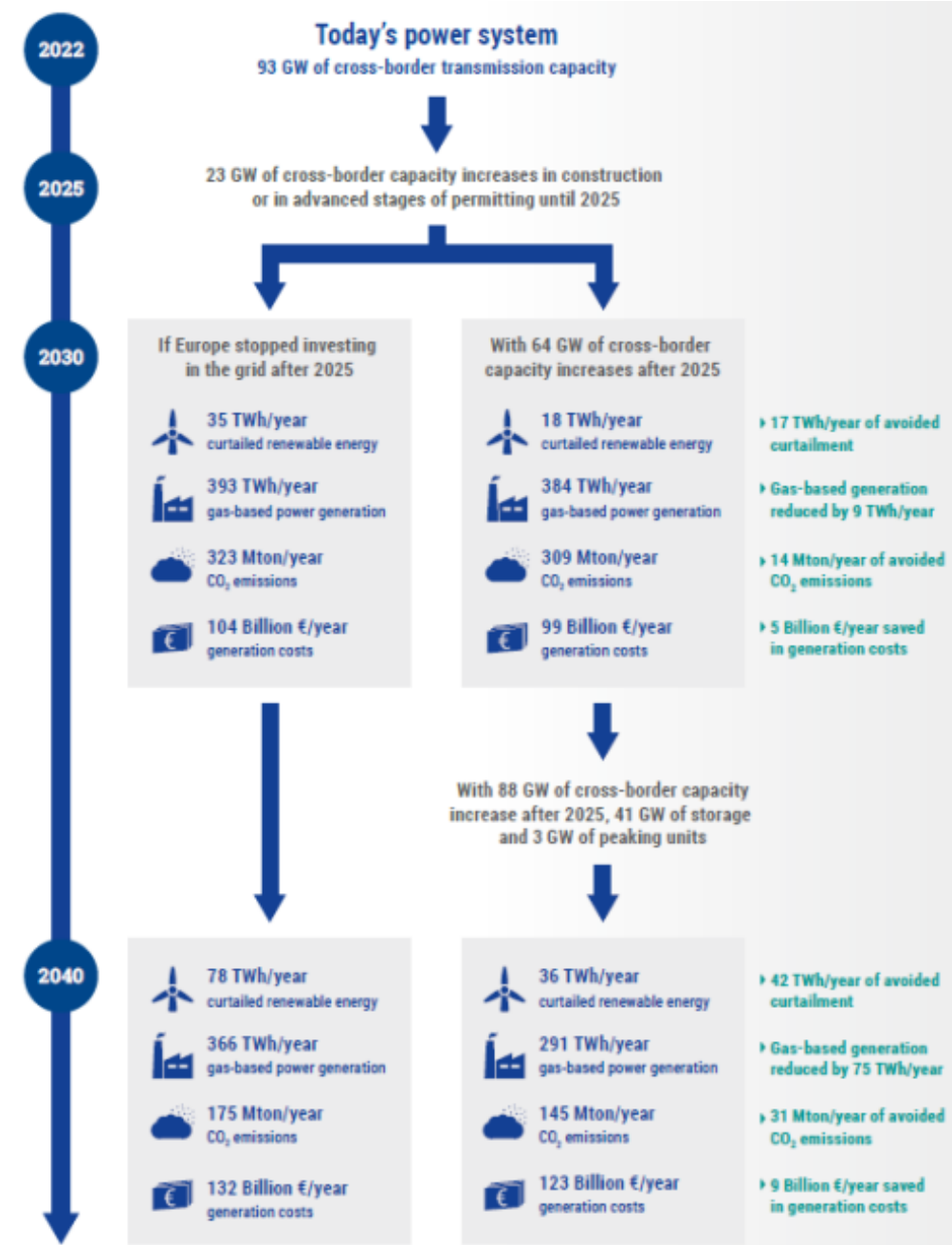
Internet of Things / smart grids

- Empowered customers, reliability
- Smart cities, appliances, meters, grids
- Even microgrids normally grid-connected, good electrification option



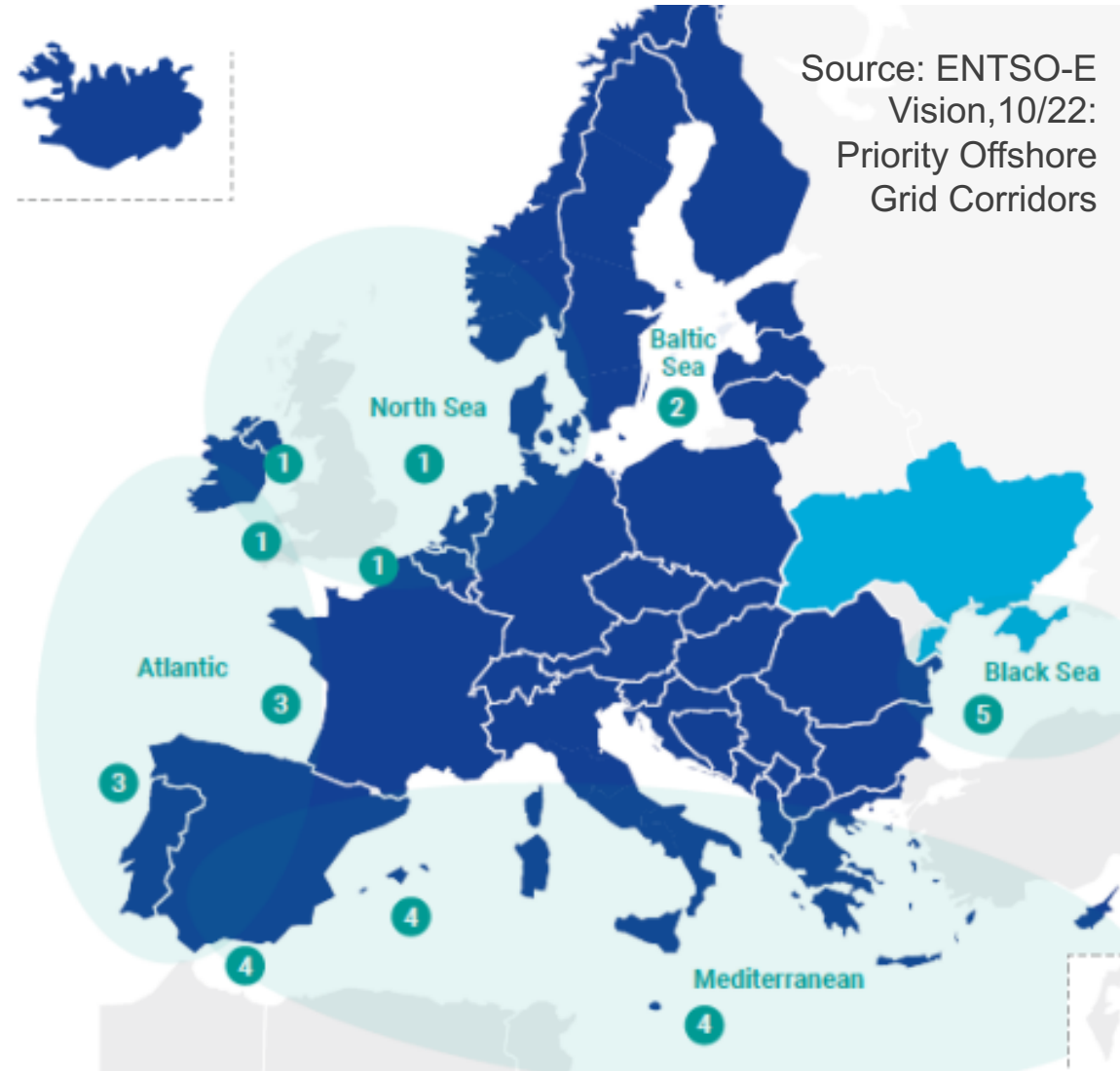
Why continent-wide transmission planning?

- Much more expensive and risky to decarbonize without making use of continental-scale weather diversity
- Strong solar or wind resources in different regions generally, different weather at any given time
- Without continental grid, need much more reserves, curtail RES more
- Strong grid pays for itself in generation cost savings, reliability 1.5-2x over
- Needs joint planning with storage, flex generation, hydrogen



Continent-wide transmission planning: Who

- Association (non-profit, member-financed) in Brussels
- EU TSOs (mandatory) + other founding members
- 39 TSOs from 35 countries + observer member Ukrenergo
- Very rare role of legally mandated tasks from EU laws:
 - Development + implementation of standards, network codes, platforms, tools, to ensure secure system and market operation, integration of renewable energy;
 - Assessment of system adequacy in different timeframes;
 - Coordination of the planning and development of infrastructures at the European level (Ten-Year Network Development Plans, TYNDPs);
 - Coordination of RD&I activities of TSOs;
 - Development of platforms to enable the transparent sharing of data with market participants.
- Founded 2009 in anticipation of 3rd IEM Package requirement, prepared by TSOs with EC for years



Source: ENTSO-E
Vision, 10/22:
Priority Offshore
Grid Corridors

Continent-wide transmission planning: How (1. scenarios)

Strong methodological evolution every 2 years; an entire library of publications + data



TYNDP 2022 **Scenario Report**, 4/22: Joint ENTSO-E – ENTSOG report on demand for electricity, methane, hydrogen; supply mixes and costs incl. electrolysers and flexible resources; CO₂ emissions

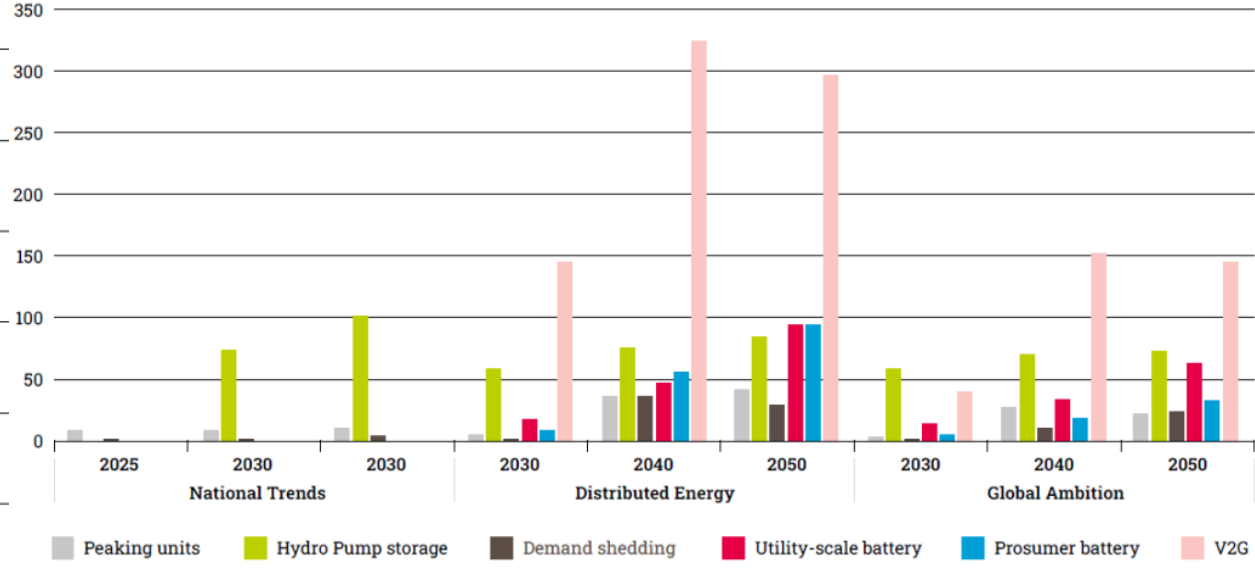
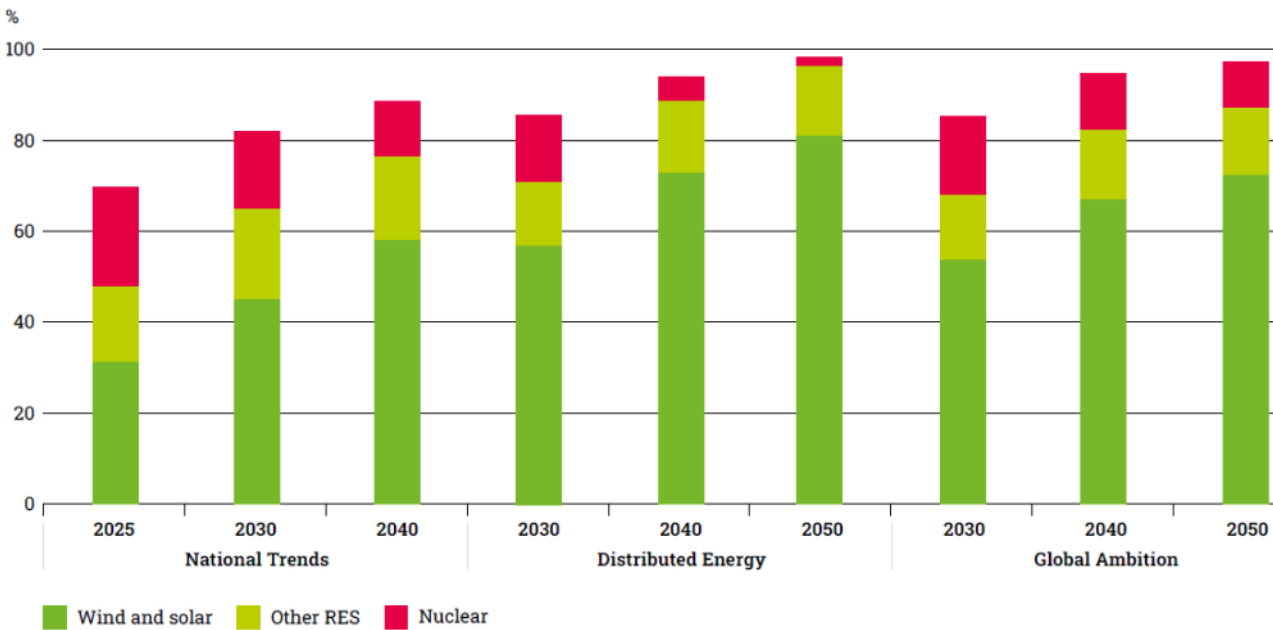


Figure 28: Main flexibility sources for adequacy for EU27 (Peaking units are to be understood as methane-fired open cycle units and peakers as resulting from the new adequacy step. Battery cover utility-scale and prosumer installation)

Figure 23: Share of electricity demand covered by low carbon generation in EU27

Continent-wide planning: How (2. system needs)

TYNDP 2022 **System Needs Study**, 7/22, based on TYNDP 2022 System Needs Implementation Guidelines, 7/22: Starting network, 2030/40 inputs, investment candidate links, market modelling + expansion optimization tool (Antares), planning zone design via clustering, climate years from pan-European climate data base, etc.

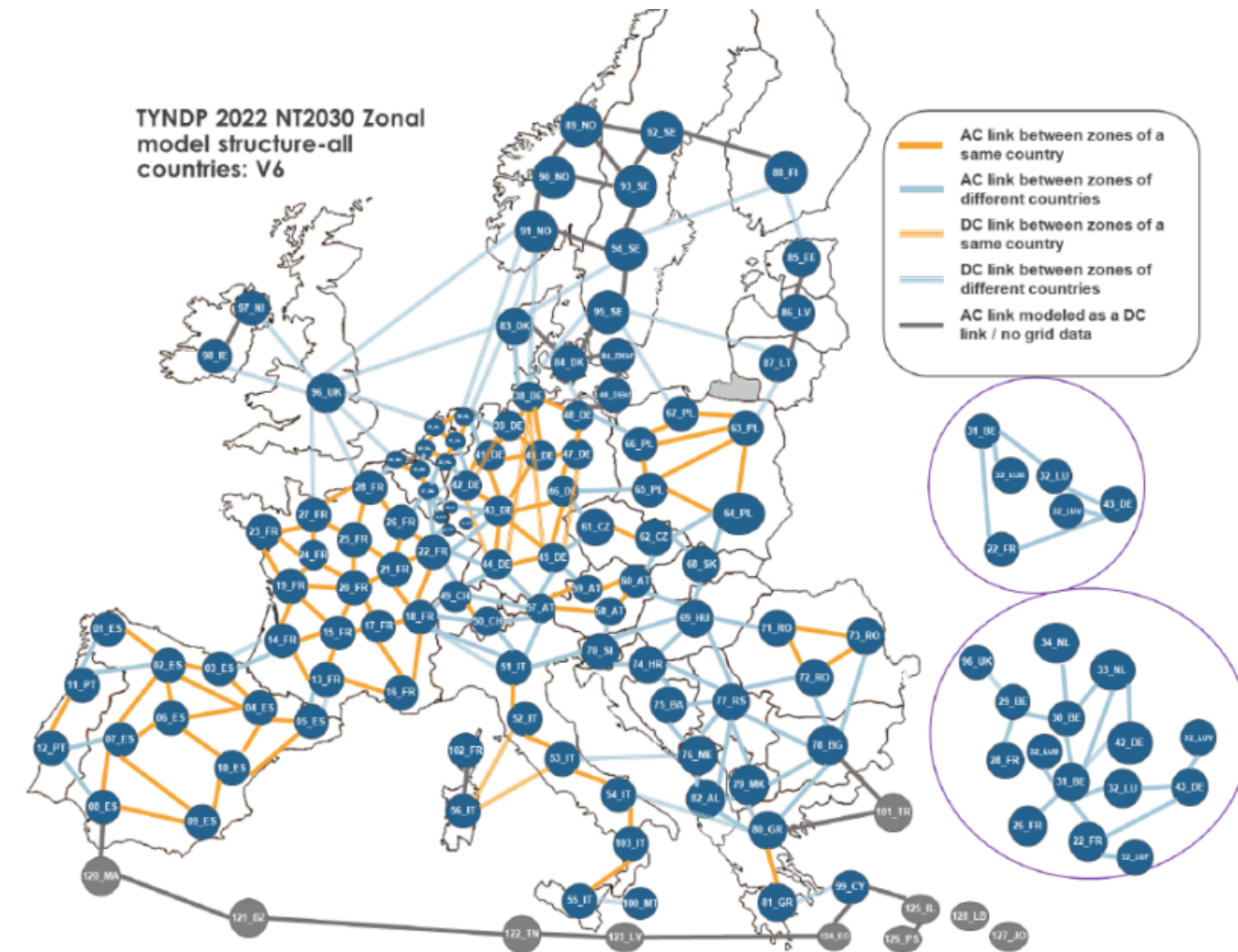


Figure 10. TYNDP 2022 Zonal clustering

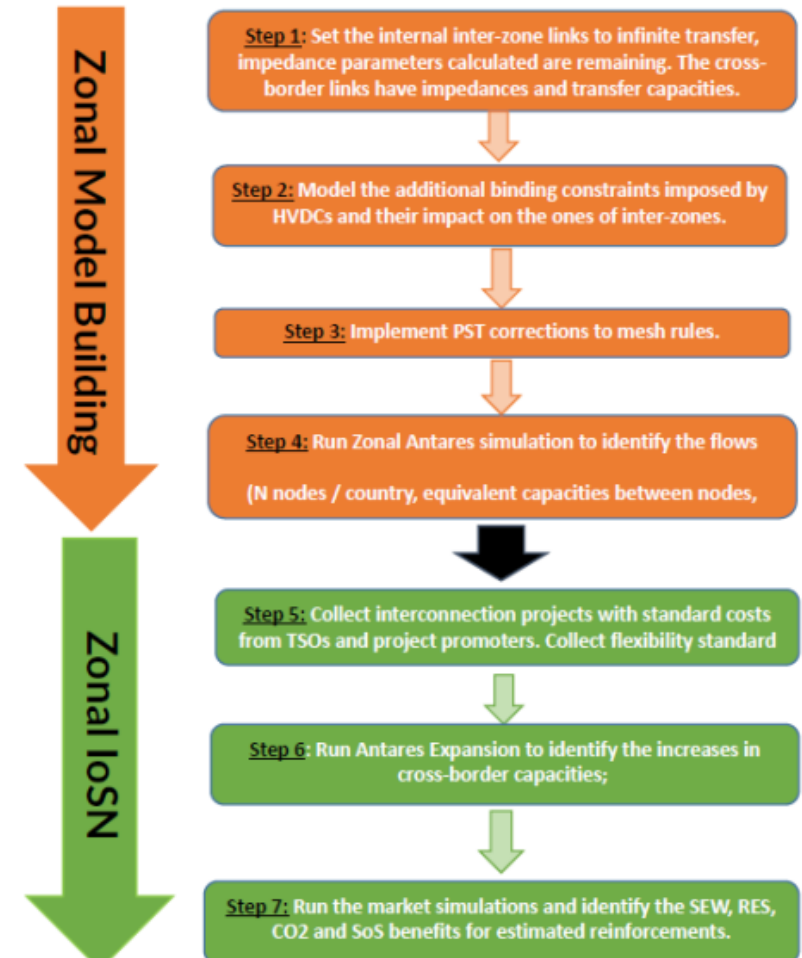


Figure 15 Step-by-Step IoSN Implementation phase process diagram

Simplified backup: Continent-wide planning: How (2. system needs)

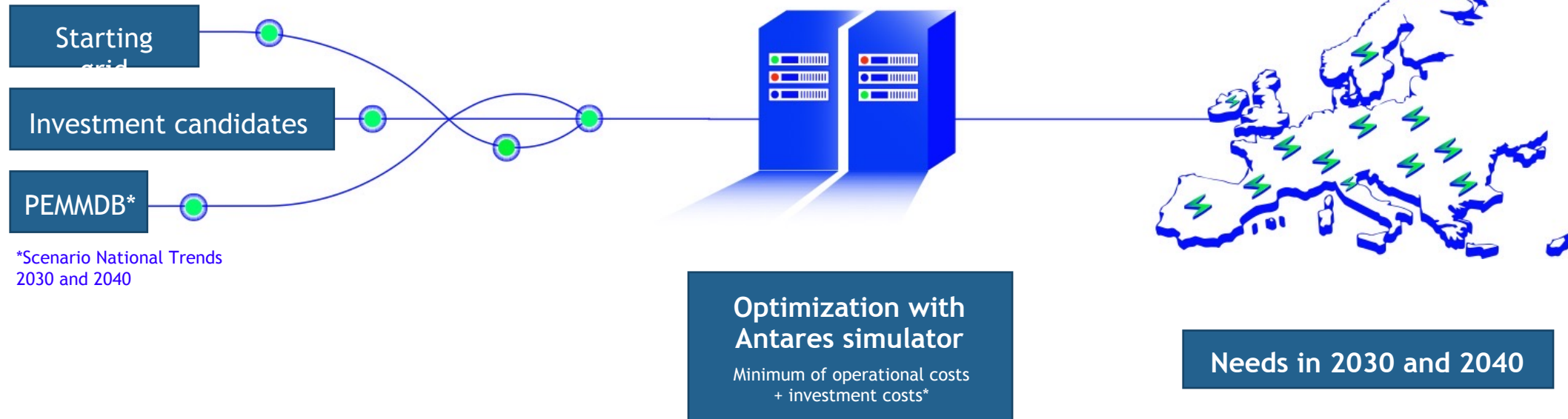
Identification of Needs

Study process overview

Input

Calculation

Output



*Scenario National Trends
2030 and 2040

**Optimization with
Antares simulator**
Minimum of operational costs
+ investment costs*

*Zonal market study 2030,
NTC market study 2040

Needs in 2030 and 2040

Continent-wide planning: How (3. project CBAs)

Assessment of 141 pan-European electricity transmission projects and 23 storage projects according to an ENTSO-E CBA Guideline approved by EC. Includes key info, project description & context incl. costs, socio-economic welfare in different scenarios, CO₂, RES integration, grid losses, security of supply, as much as possible in €

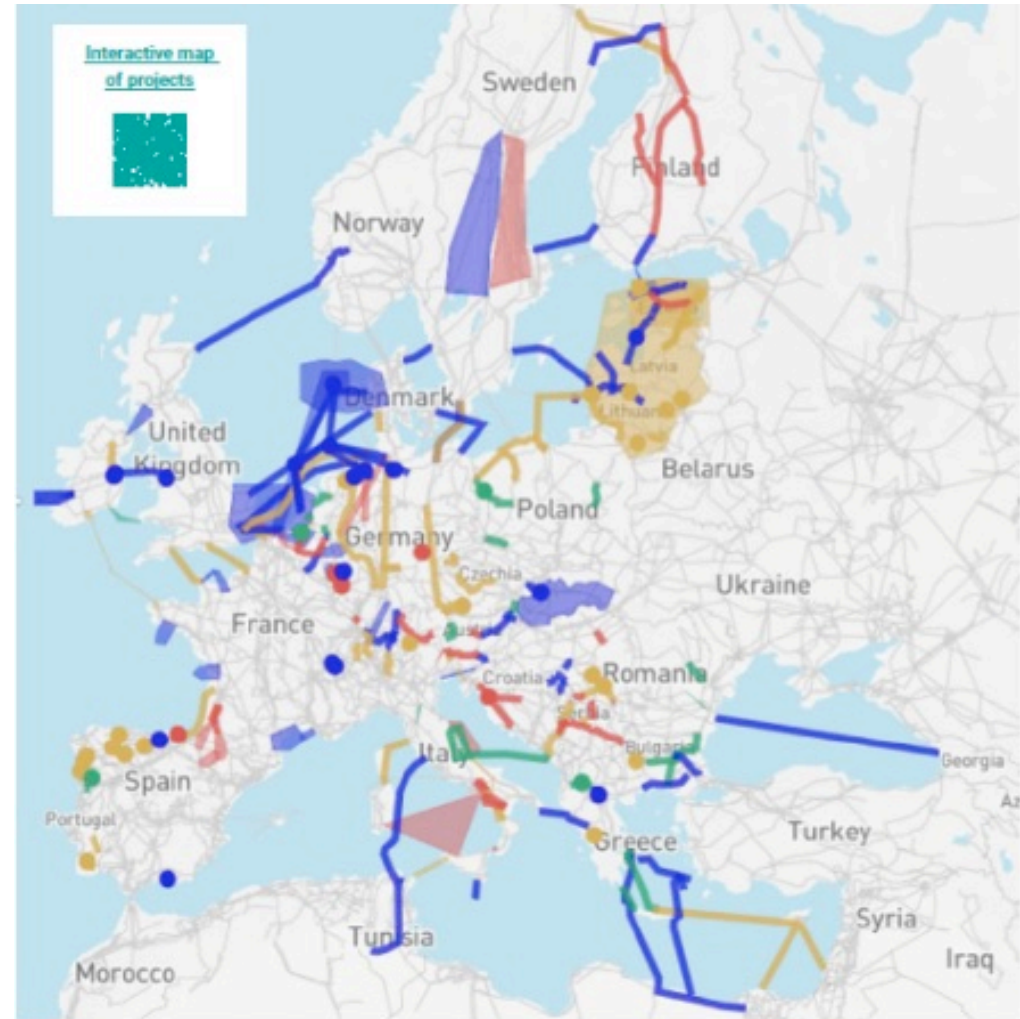
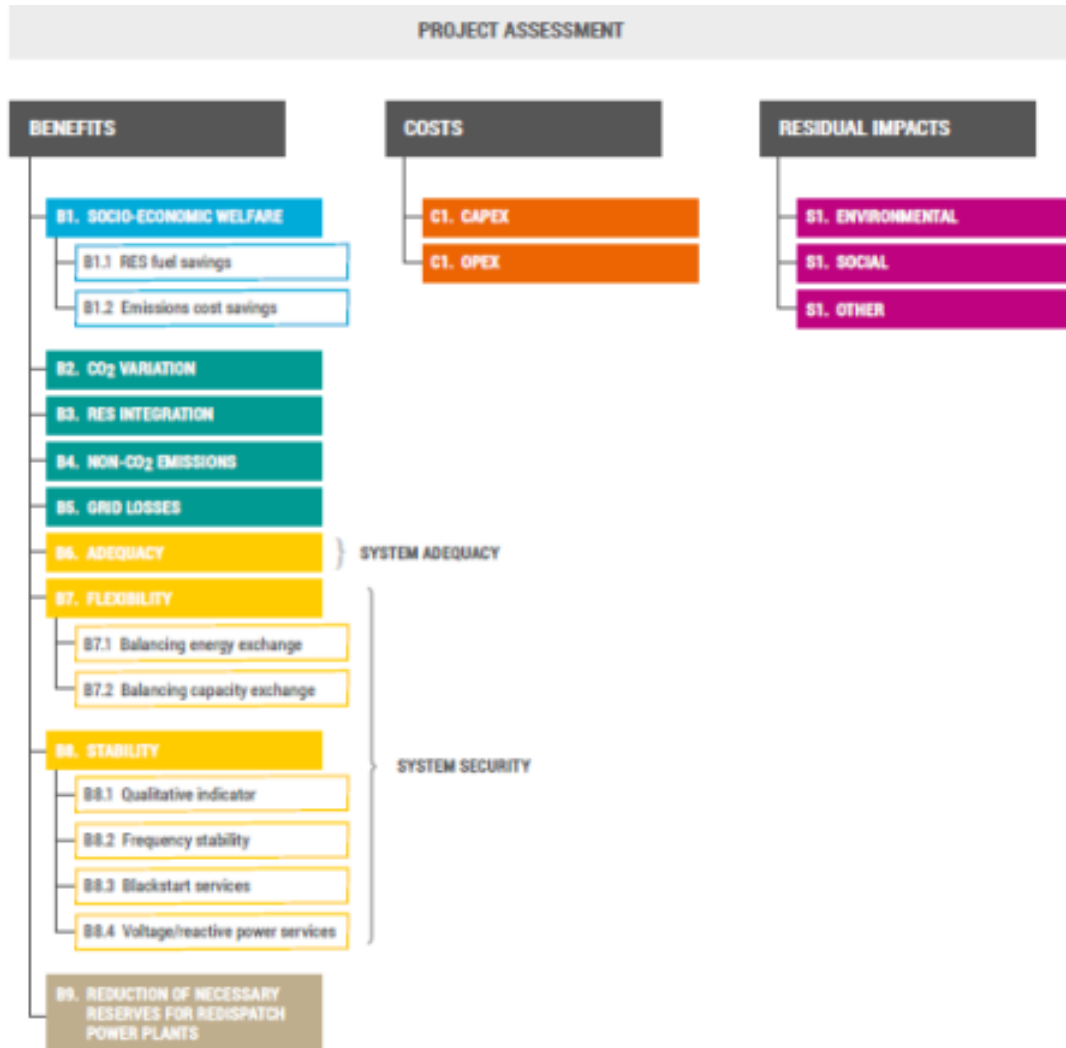


Figure 3 – Map of TYNDP 2022 transmission projects. Areas indicate projects for which the route is not yet known (green: under construction; yellow: in permitting; red: planned but not yet in permitting; blue: under consideration).

Continent-wide planning: Results

Opportunities for increases in cross-border transmission, storage and peaking units capacity in 2040

CROSS-BORDER CAPACITY INCREASES NEEDS IN MW (ADDITIONAL TO THE STARTING GRID 2025)

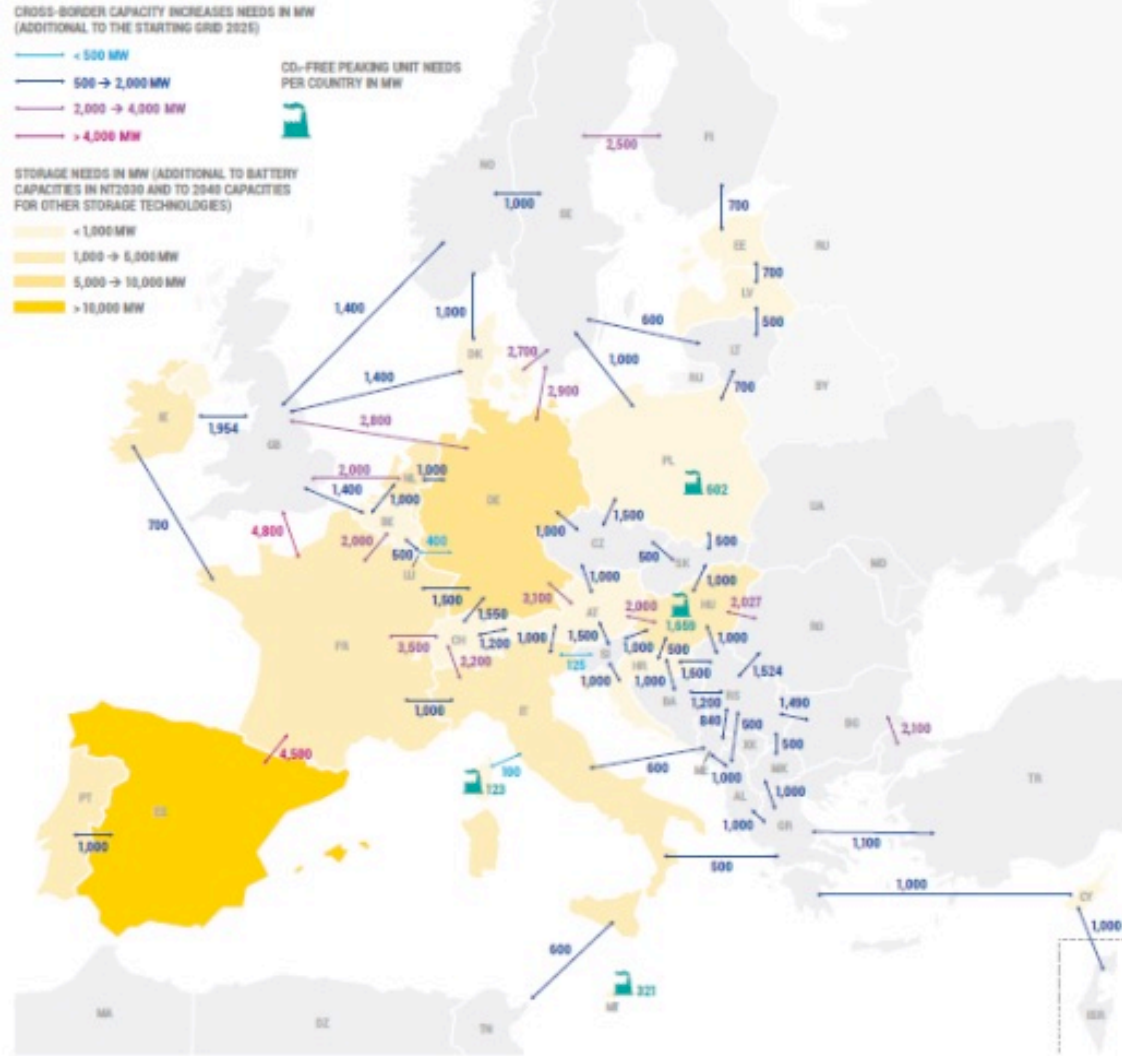
- < 500 MW
- 500 → 2,000 MW
- 2,000 → 4,000 MW
- > 4,000 MW

CO-FREE PEAKING UNIT NEEDS PER COUNTRY IN MW



STORAGE NEEDS IN MW (ADDITIONAL TO BATTERY CAPACITIES IN NT2030 AND TO 2040 CAPACITIES FOR OTHER STORAGE TECHNOLOGIES)

- < 1,000 MW
- 1,000 → 5,000 MW
- 5,000 → 10,000 MW
- > 10,000 MW



System needs in 2040

With storage and peaking units candidates

- Cross-border capacity increases 88 GW
- Storage 41 GW
- Peaking 3 GW
- Investments 5.6 Bn€/y

System benefits

- Increase in socio-economic welfare 9.4 Bn€/y
- Avoided CO₂ emissions 44 Mton/y
- Avoided curtailment 68 TWh/y
- Avoided energy-not-served 1,7 TWh/y

Number of KMs laid

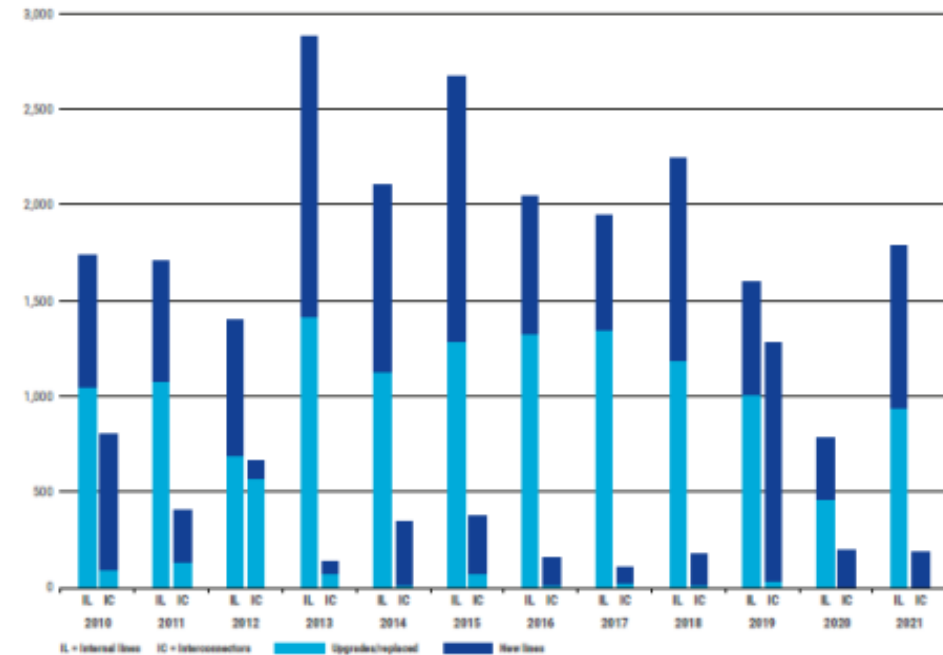


Figure 13 – Economic needs grid in 2040, additional to the starting grid 2025 for cross-border transmission, and to capacities in the National Trends 2030 scenario for battery storage and peaking units. To not overcharge the map,

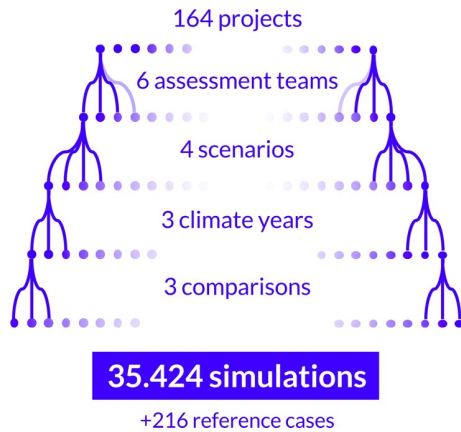
Figure 10 – Projects commissioned each year from 2010 to 2021 in km of line

Backup: Continent-wide planning: CBA simulations

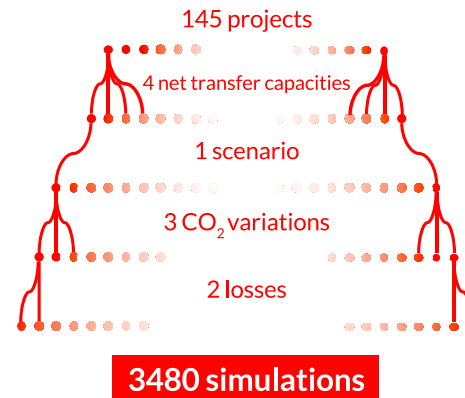
Cost Benefit analysis

TYNDP 2022 Cost-benefit analysis of projects – Simulation details

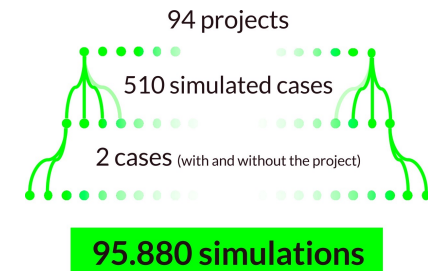
Market studies



Network studies



Security of supply studies



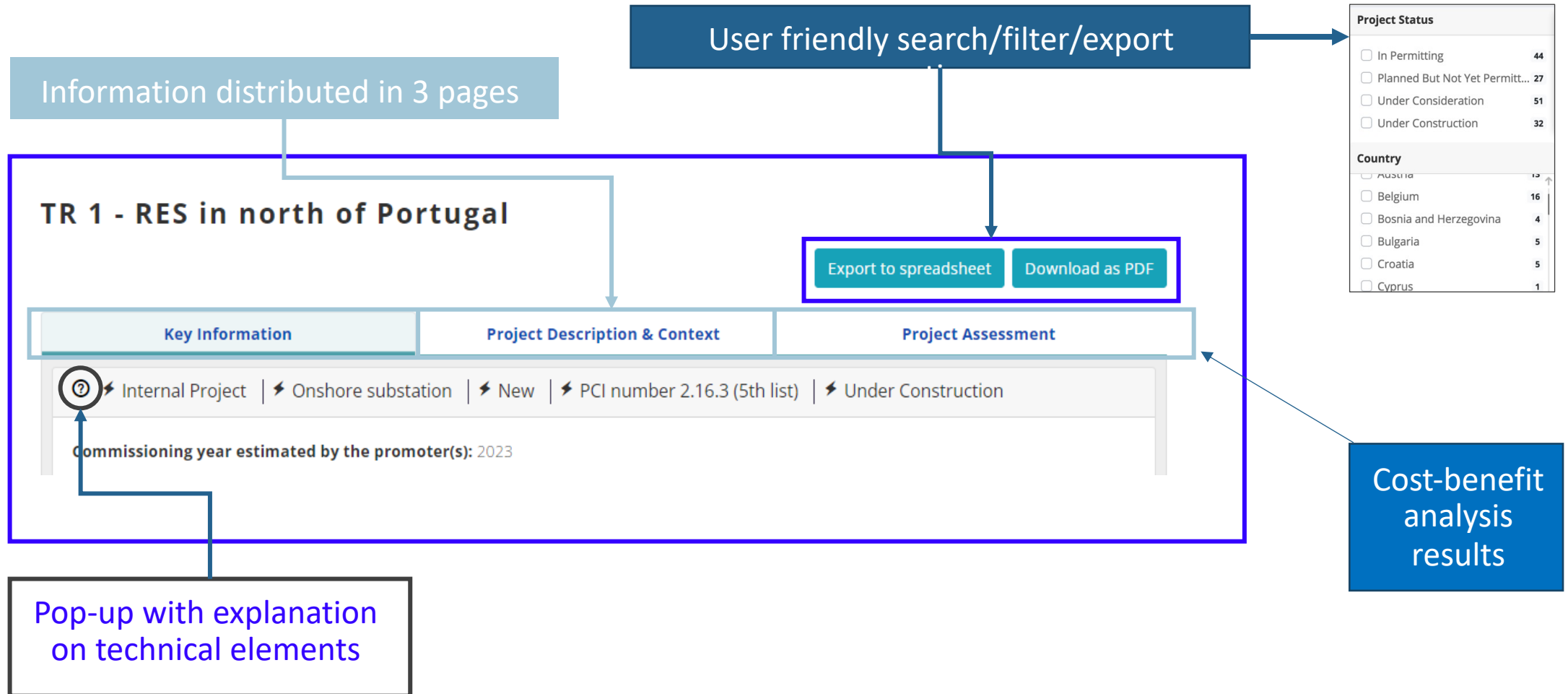
Each simulation is conducted for the entire continent over a year, ie. 8 760 hours.

> **1 Billion instant renderings** of the European electricity system

Backup: Continent-wide planning: CBA result formats

Cost Benefit analysis

What is in the project sheets?



Taking a step back: Experiences, difficulties, advantages

- **Clear legal framework for ENTSO-E and TYNDP (and projects of common interest) with strong Europe-wide federal aspects but also national/state liberties.**
 - Before/without the binding legal framework and before the mandatory ENTSO-E, there was no TYNDP.
- **Clear focus on EU socio-economic welfare as opposed to company bottom lines or national interests.**
 - This evolved better and better over 12 years.
 - The socio-economic welfare orientation of TSO planning and the will to make renewables integration work were already strong in 2009, so generally EC and TSOs pulled in same direction.
 - The TSO bottom line still counts for them, and the dual role of ENTSO-E as neutral, public service and EU-focused body and voice of the national TSOs requires clear identification when its representatives speak in the first vs. the second role.
 - Also TSOs listen a lot to their national governments, and those do not always support EU integration agendas by the Commission.
- **Cannot manage a successful energy transition and societal decarbonisation without this**
 - The money wasted would make opposition to new lines worse.
 - Needs commitment from all EU Member States and all TSOs to energy transition and decarbonisation.
 - In fact, because TSOs saw the risks to secure system operation from renewables as hard to handle without binding network codes and EU TYNDPs, they lobbied for ENTSO-E. EC, European Parliament and even the Council saw the case for security of supply and renewables integration and supported it.

General role of ENTSO-E; comparability to US

- Network code role similar to NERC, but broader scope of codes, less details, no penalty power
- TYNDP, operational rules, market and connection codes, RD&I, Transparency Platform broader than at NERC
- Note that most TSOs own and manage the assets, are responsible for all aspects of system operation; those are complemented by PXs (with EU-wide natural monopoly roles - market coupling), regional (operational) coordination centers)
- Joint planning can work a-ok with some differences in market structure – when will US do it?
- Power market differences between states seem bigger than with Canada (and Mexico?) – given diversity of climates, time zones, hydro in Canada etc., North American continental planning seems to offer advantages

THANK YOU FOR YOUR ATTENTION



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+49 176 2269 8552



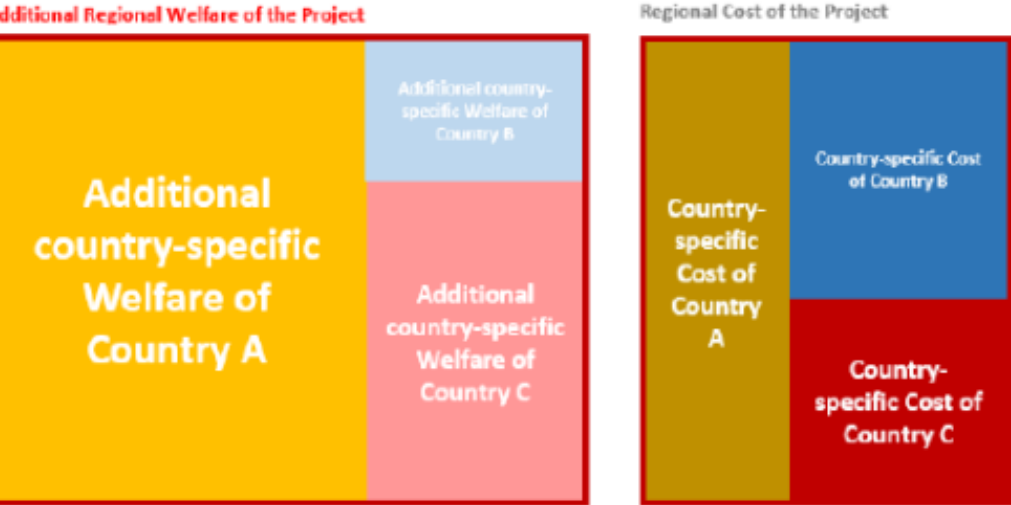
For more information:
<http://www.entsoe.eu>
[Planning the future grid - TYNDP \(entsoe.eu\)](#)



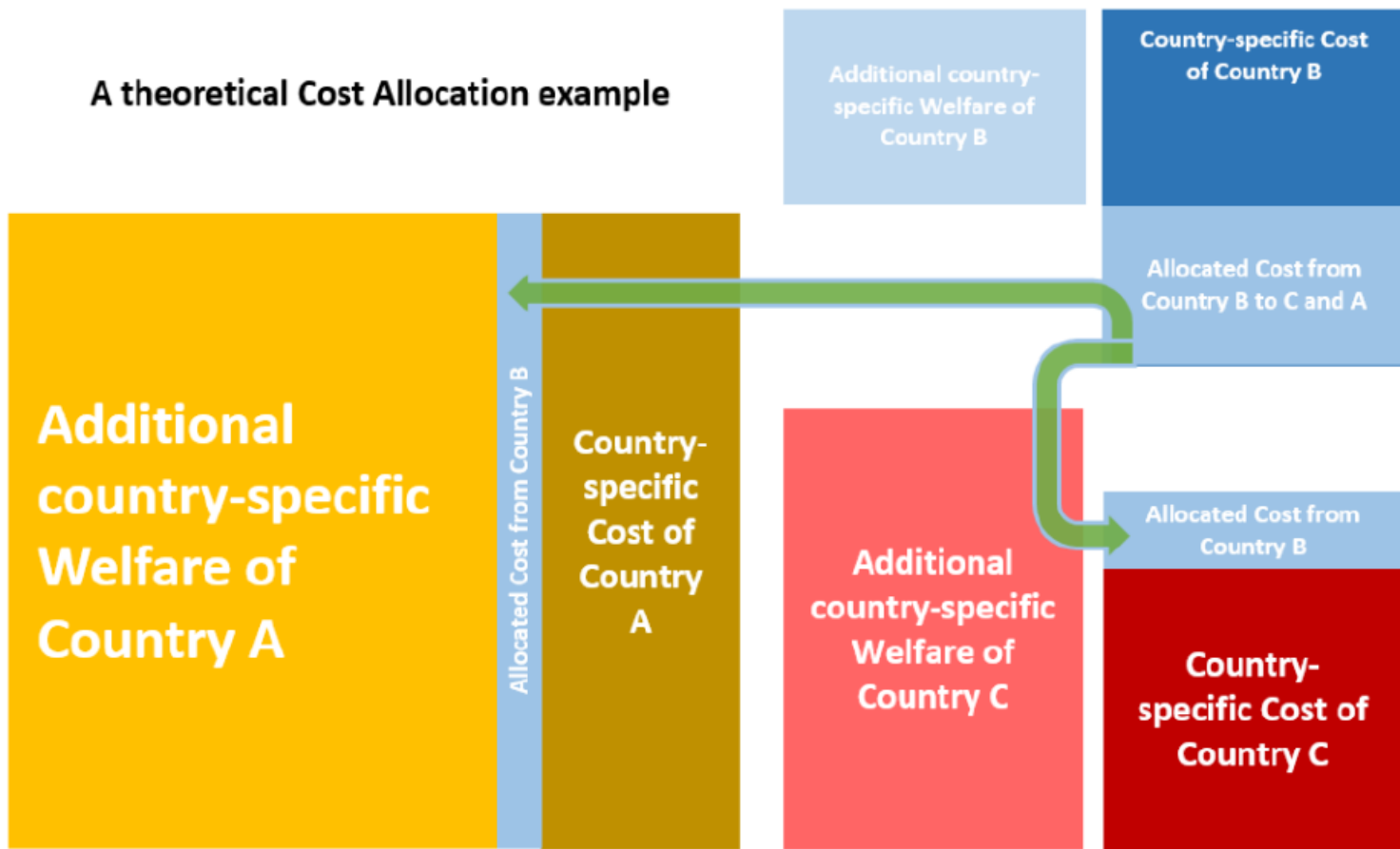
**ENTSO-E | Rue de Spa, 8
1000 Brussels, Belgium**

**Guidehouse Germany GmbH | Albrechtstr. 10c
10117 Berlin, Germany**

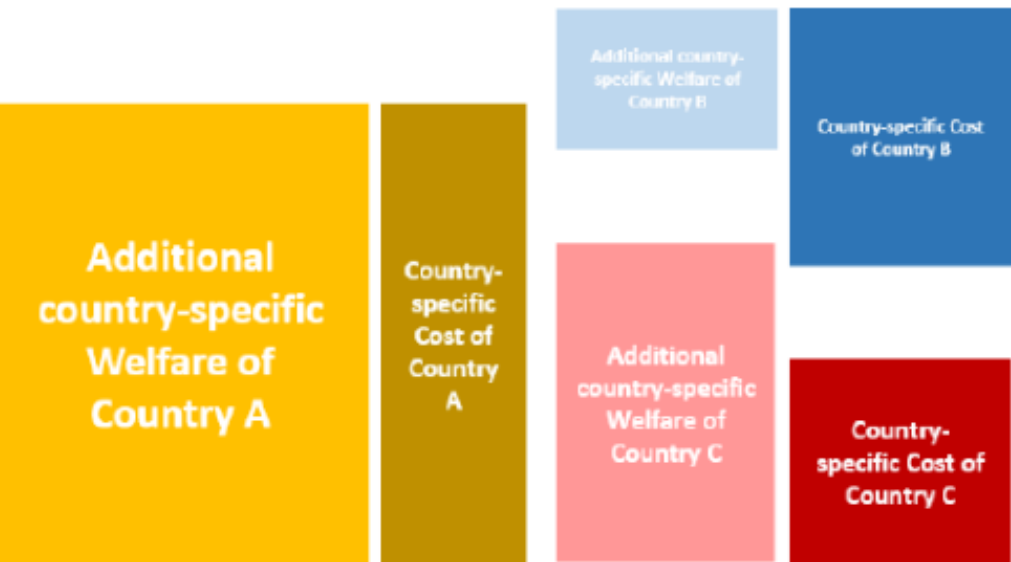
Backup: CBCA cross-border cost allocation



A theoretical Cost Allocation example



Comparison of country-specific Benefits and Costs



Note this requires consensus on complex and uncertain benefit calculations and possibly overall less asset base with RoR.





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