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POWER FACTS EUROPE

Third edition | November 2019

One stop shop for TSO/ENTSO-E propriety data

Setting the scene

- Achieving climate neutrality objectives: TYNDP 2020 scenarios

3 Core Chapters

- Power network development: System planning for the energy transition
- Power system reliability
- Market integration

Focus Areas

- TSOs and digitalisation & innovation
- TSO-DSO interface and flexibility

This is the third edition of PowerFacts. It gathers facts from the year 2018 and 2019 when available.

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Data Sources

- Ten Year Network Development Plan
- Transparency Platform
- R&I Roadmaps and Monitoring reports
- Mid-term Adequacy Forecast
- Network Codes Updates
- Annual Reports
- Statistical Factsheets
- Incident Classification Scale report
- Market Coupling and Forward Capacity Allocation monitoring report
- etc.

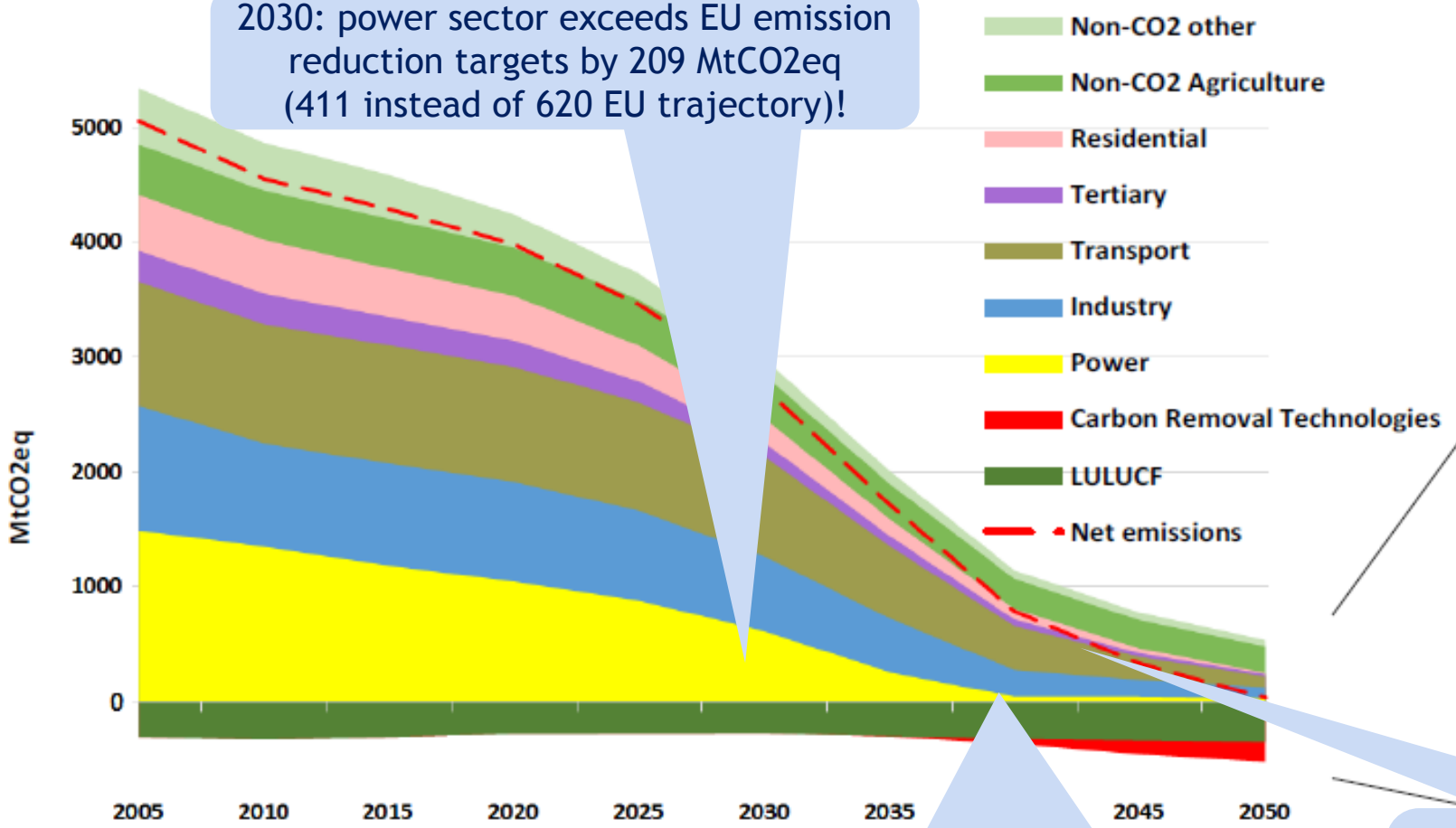
Setting the scene:
Achieving climate neutrality objectives

TYNDP 2020 scenarios

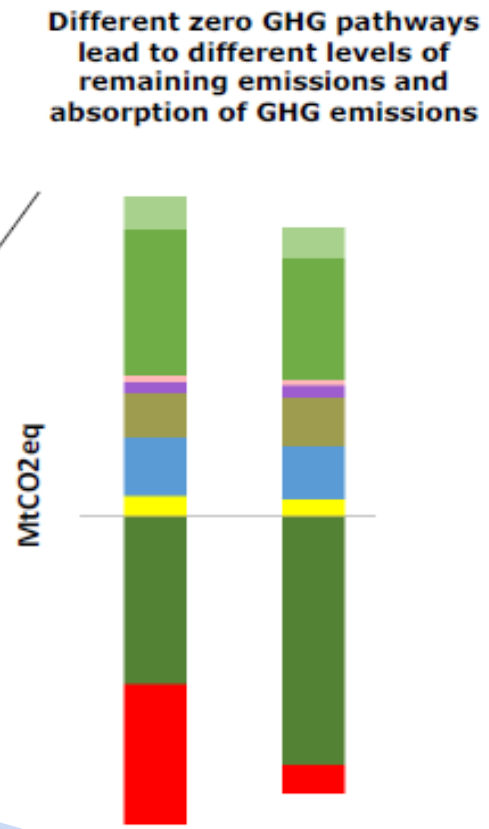
Setting the scene – What Green Deal?

GHG emissions in a 1.5°C scenario

2030: power sector exceeds EU emission reduction targets by 209 MtCO2eq (411 instead of 620 EU trajectory)!



2040: Carbon neutral power sector

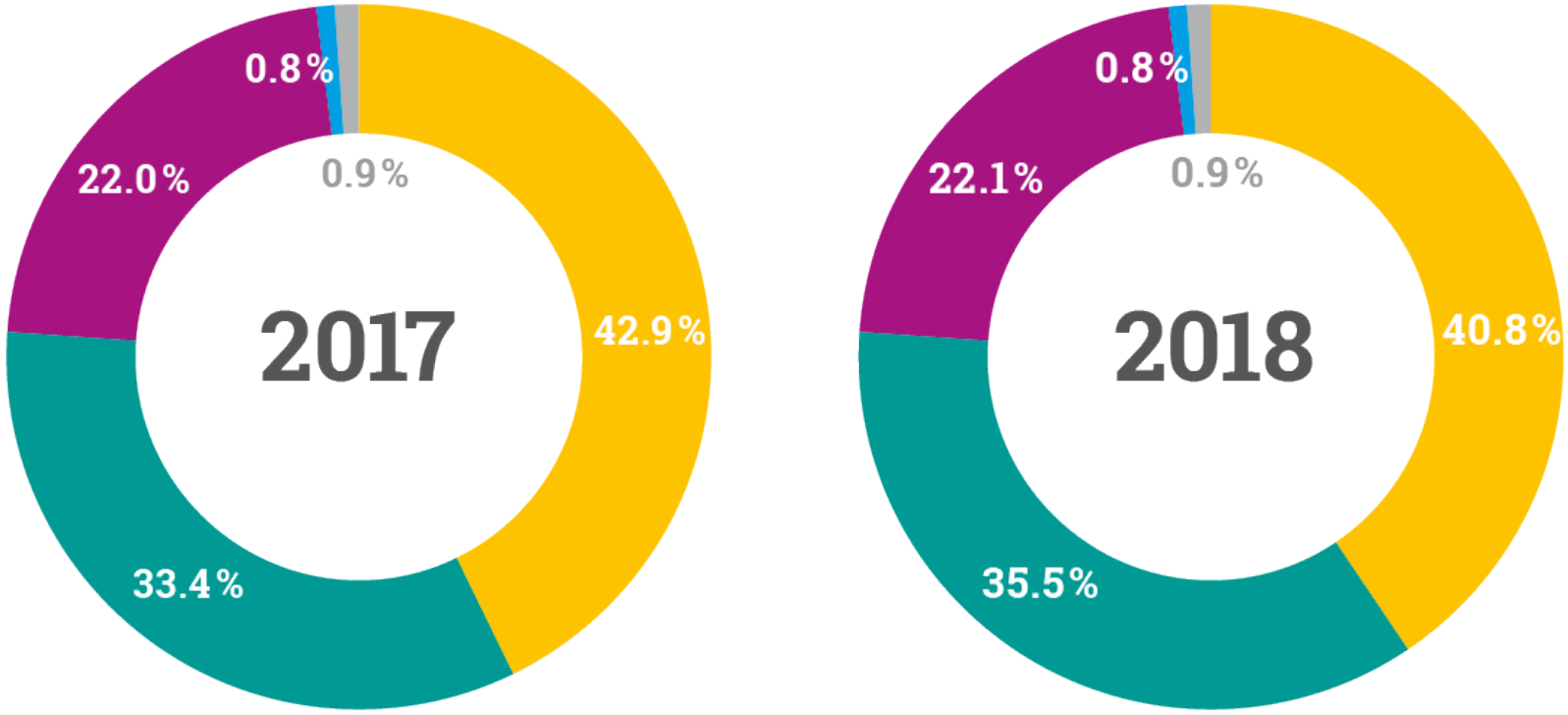


How to get other sectors clean?
- Transport/
- Heating/Cooling
- Industry

Source: EU Long term Strategy November 2018

More green electricity in the system

Evolution of electricity generation mix (TWh)



Fossil fuel in net electricity generation **has decreased by 2%** while **renewables increased by same amount** between 2017 and 2018

Source: ENTSOE Statistical Factsheets 2017 and 2018

More green electricity connected to the system

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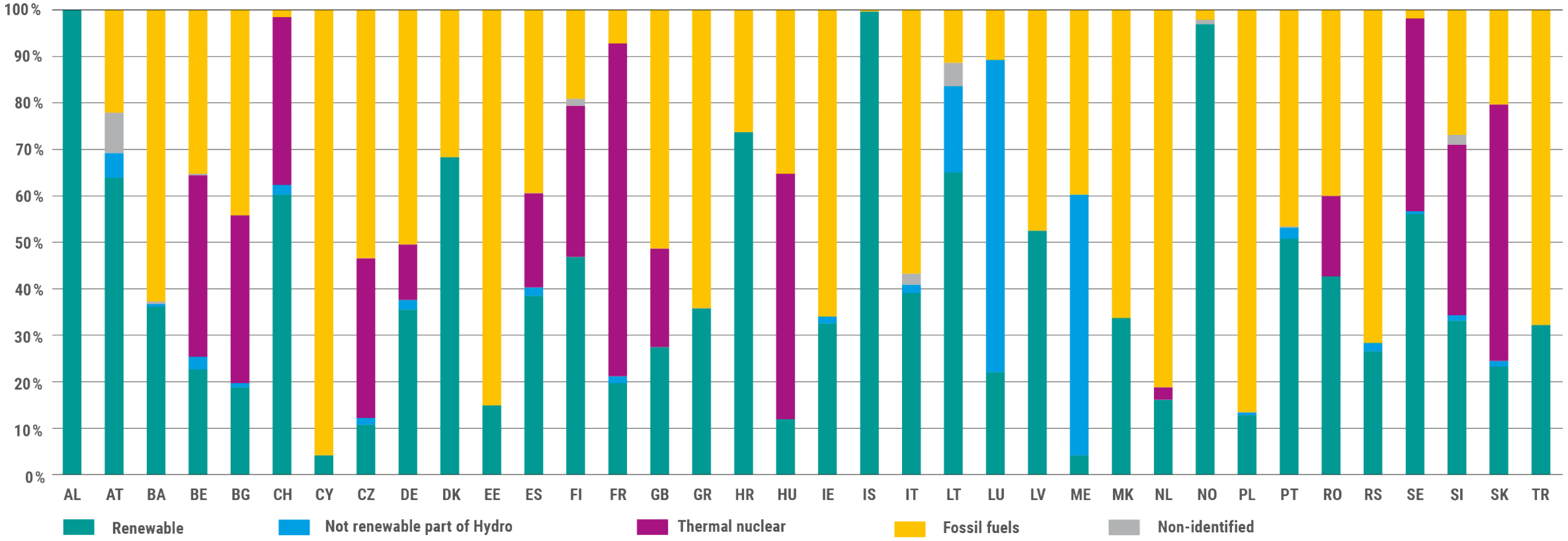
Share of energy produced of each member TSOs' country 2018

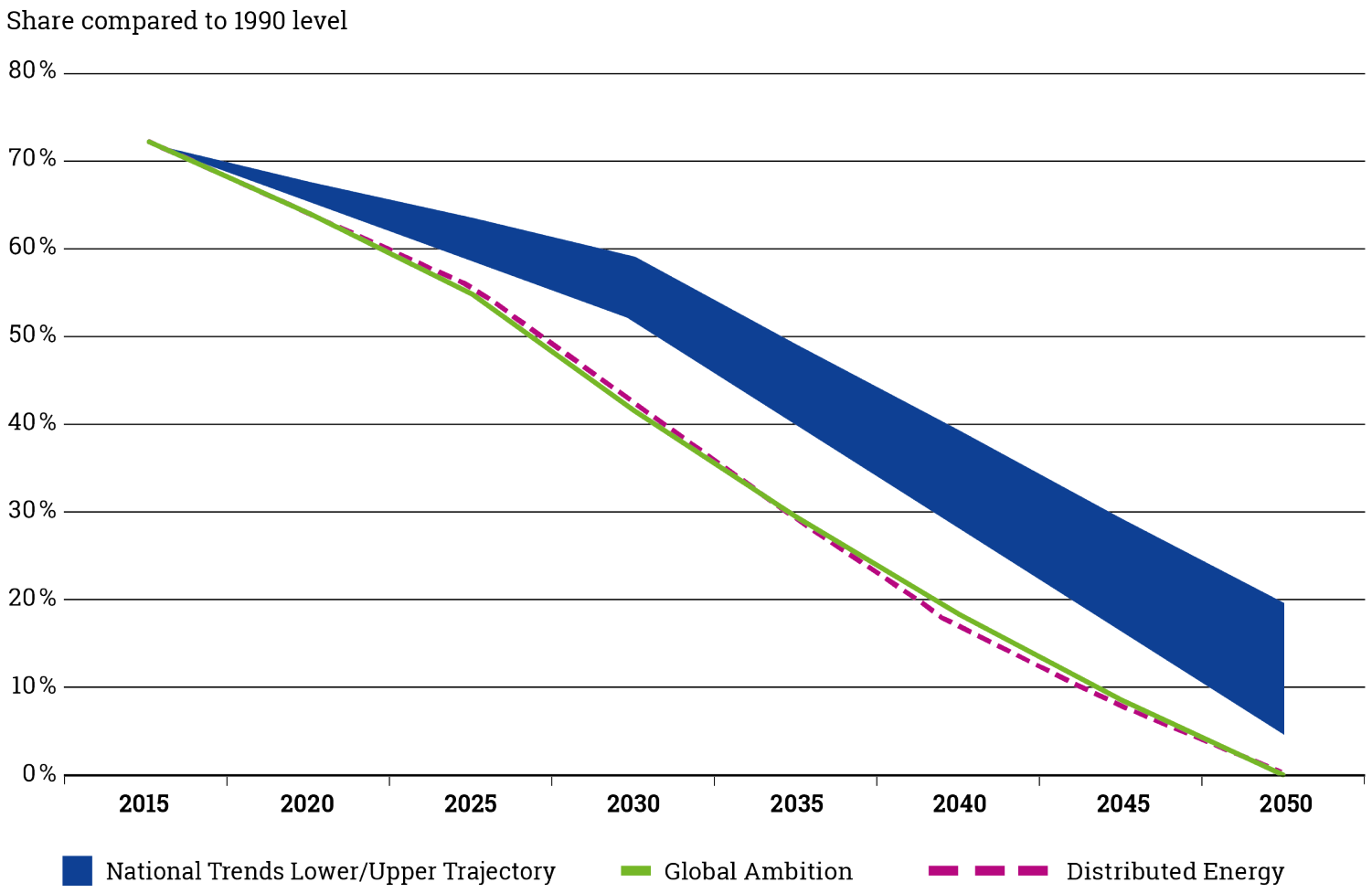
TSOs facilitated the integration of **19 GW extra** of wind and solar between 2017 and 2018.
This is about **25% less** than between 2016 and 2017 (25 GW extra)



Source: ENTSOE Statistical Factsheet 2018

Carbon neutrality can be reached by 2050 within a budget of 63.5 $GtCO_2$

GHG emissions compared to 1990 level

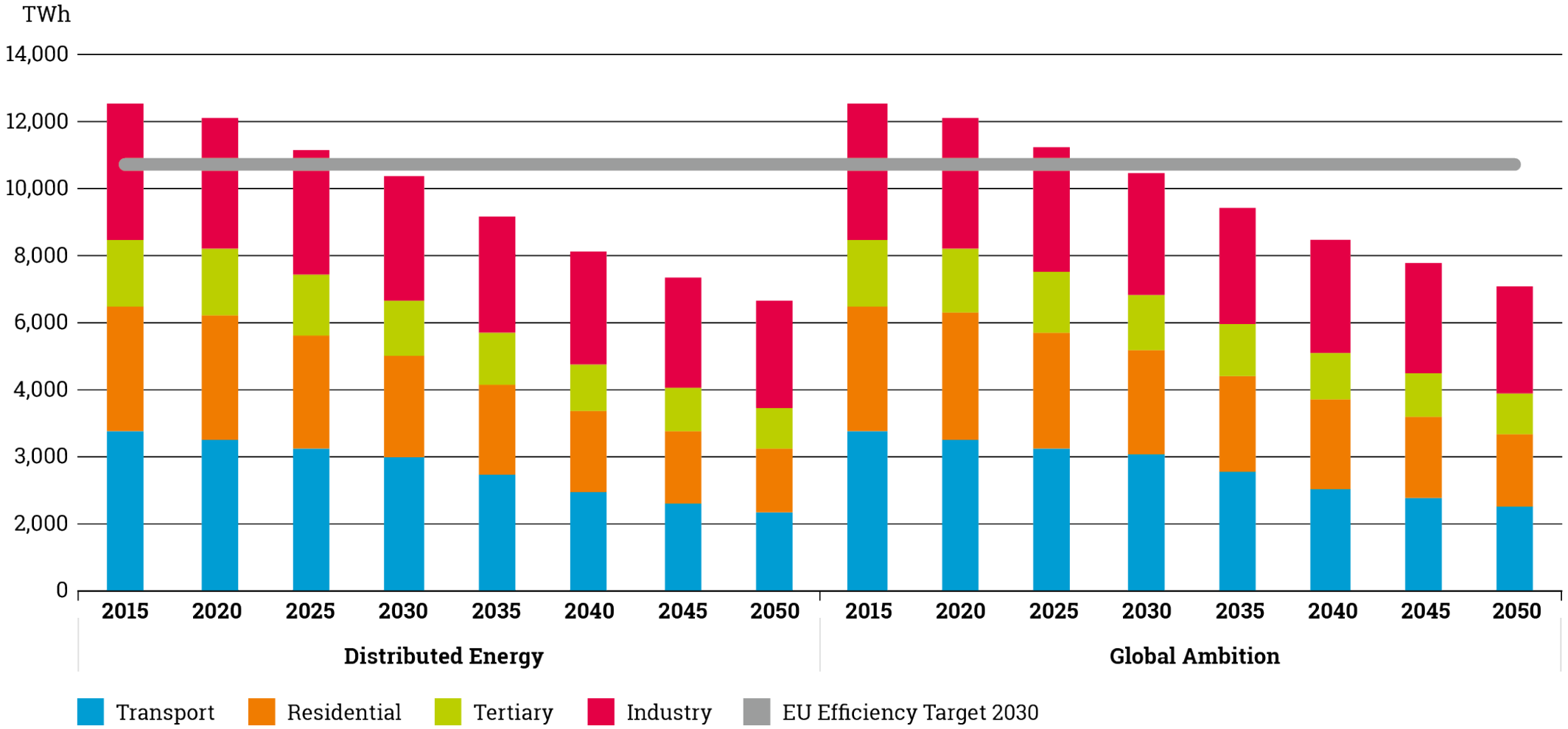


TYNDP2020 Scenarios show that the energy system can achieve carbon neutrality by 2050.

Considering different development of technologies, starting from 2018 onwards, the energy system can limit its emissions 63.5 $GtCO_2$ – 62.6 $GtCO_2$.

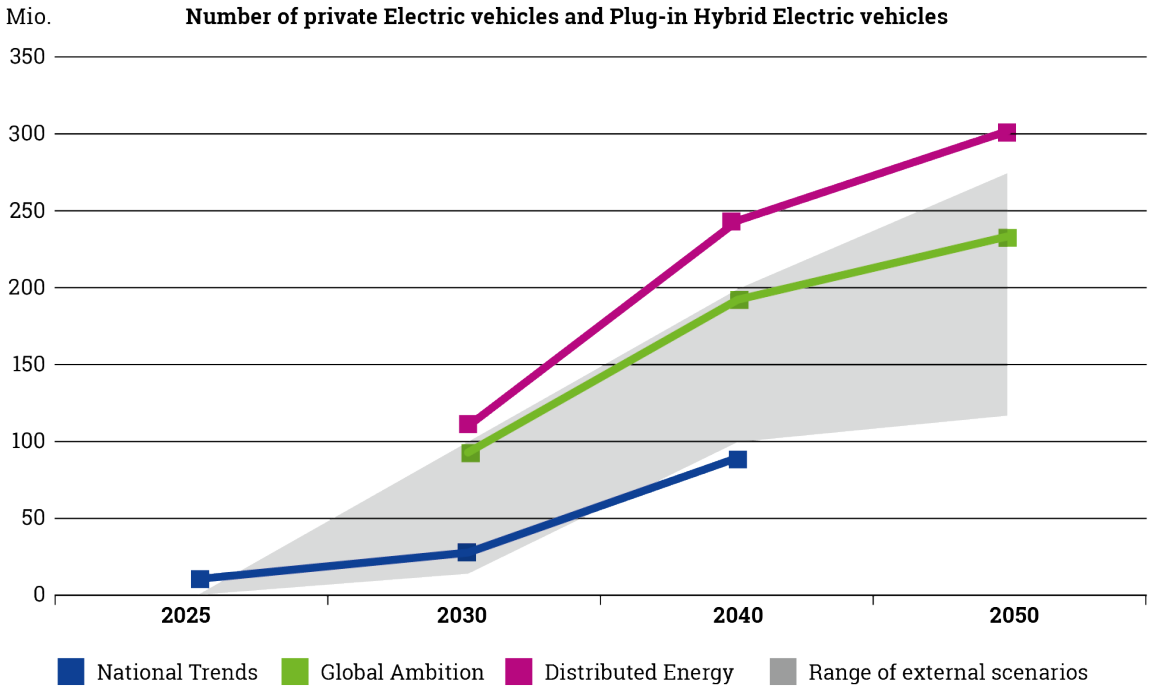
Source: TYNDP 2020 Scenario Report

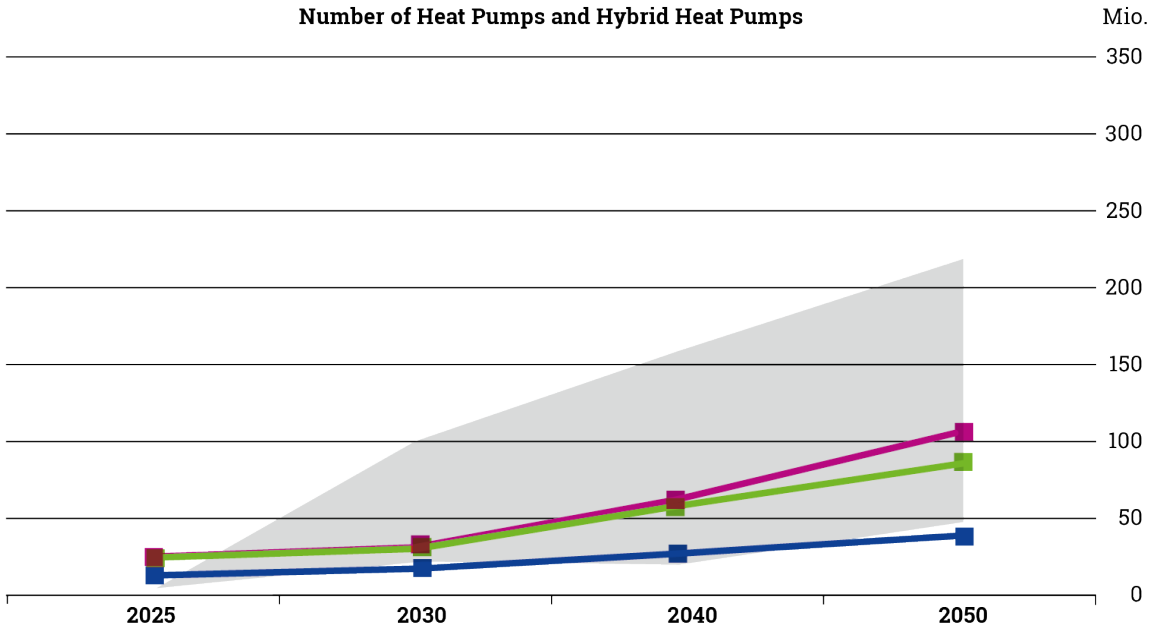
Final energy demand and efficiency can achieve ambitious reductions in energy volume



Source: TYNDP 2020 Scenario Report

Electric vehicles & heat pumps increase in all TYNDP2020 scenarios



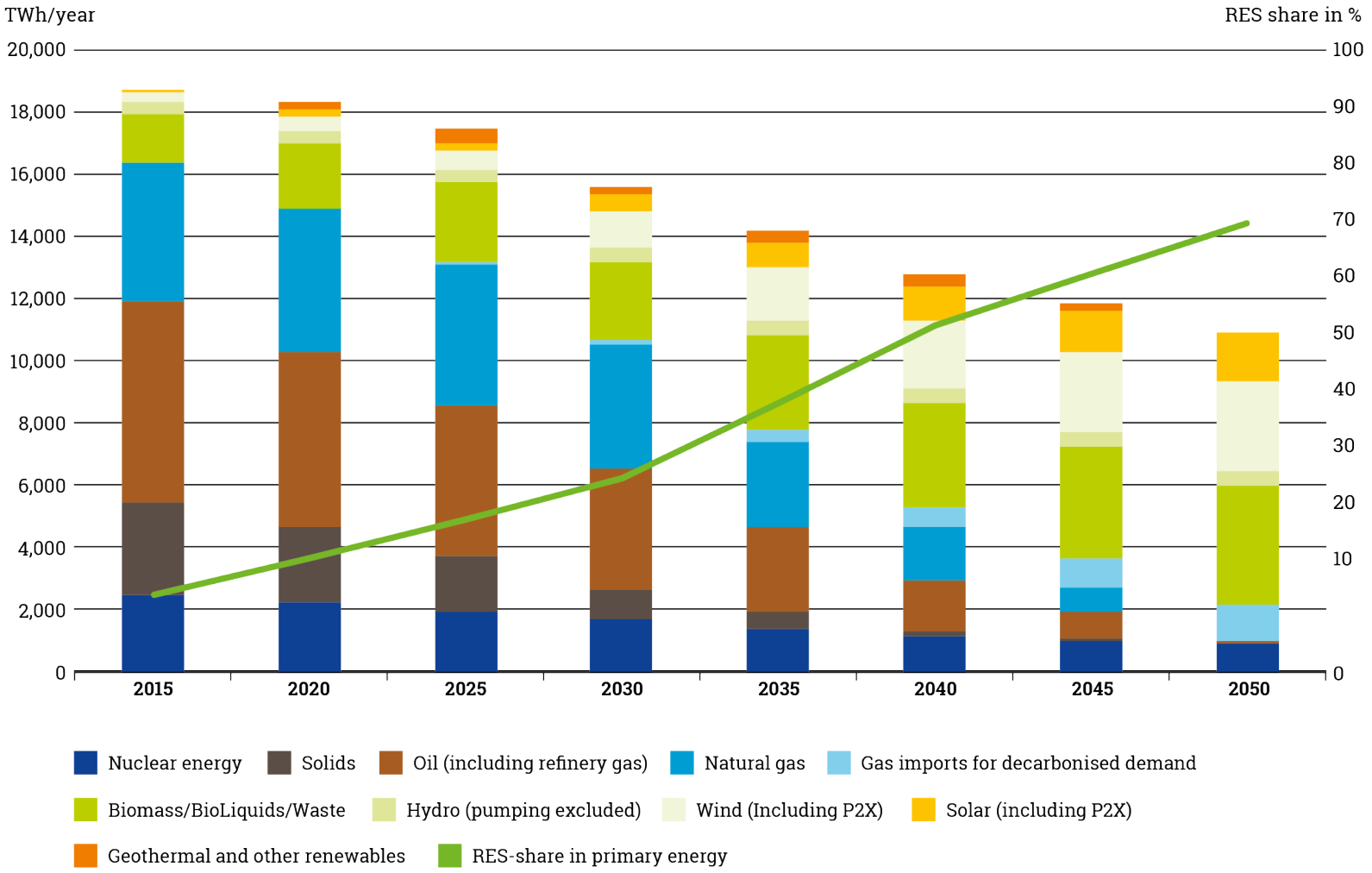


2040	Electric vehicles (million)	Heat Pumps (million)
Distributed Energy (DE)	240	50
Global Ambition (GA)	200	25
National Trends (NT) (TSOs)	100	60

Source: TYNDP 2020 Scenario Report

Primary energy mix and its RES-share

E.g. in Distributed Energy scenario



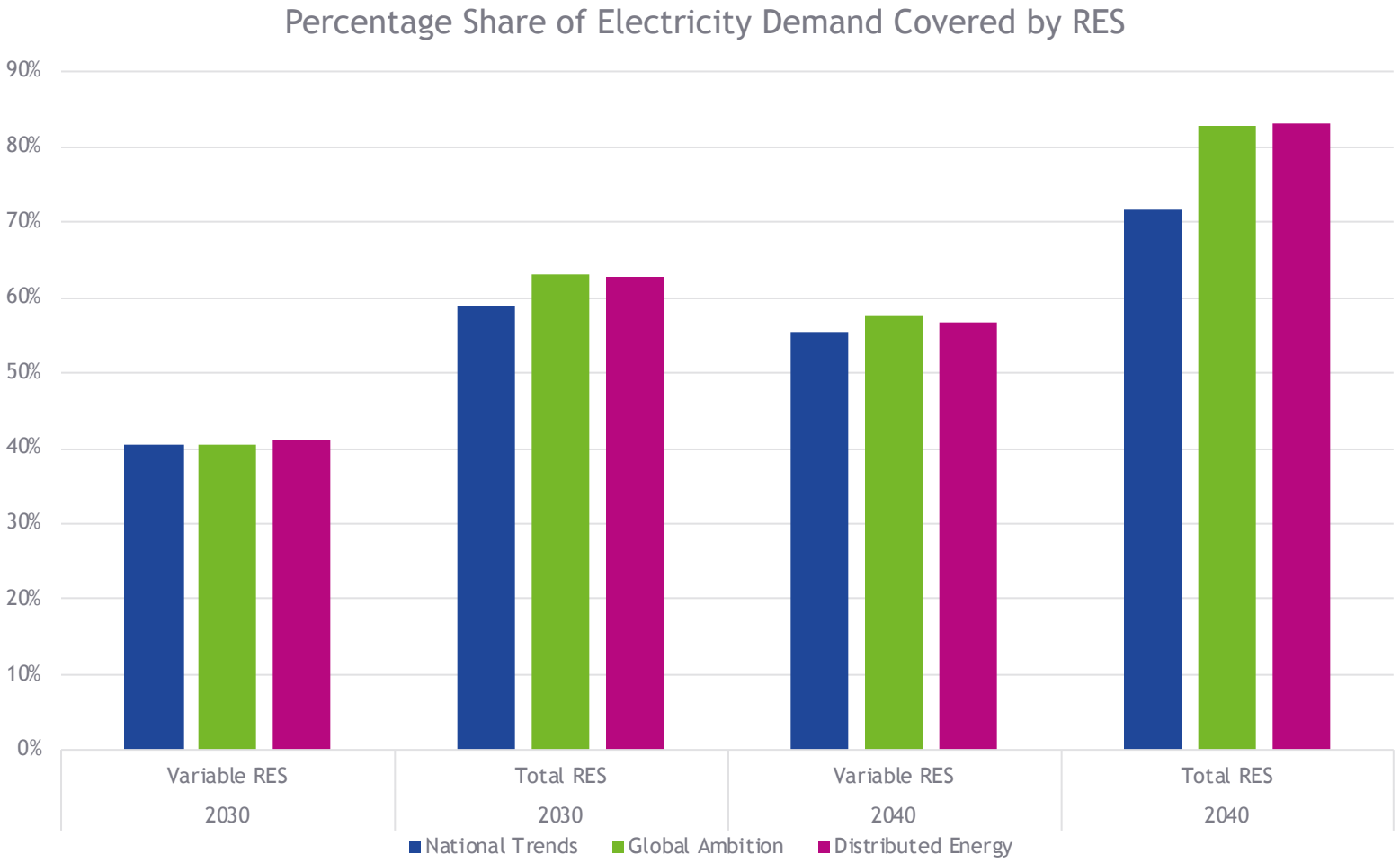
- Both COP21 scenarios are carbon-neutral by 2050.
- Both COP21 scenarios need significant increase in both renewables and further CO_2 removal technologies, while reducing primary energy demand

2050	Demand decrease	RES share
Global Ambition	42%	64%
Distributed Energy	43%	80%

Source: TYNDP 2020 Scenario Report

Power demand covered by RES: Wind and solar play a key role in all three TYNDP scenarios

With over 40% in 2030 and over 55% by 2040



In EU-28, electricity from renewable sources meets up to 63 % of power demand in 2030 and 83 % in 2040. Variable renewables (wind and solar) play a key role in this transition, as their share in the electricity mix grows to over 40 % by 2030 and over 55 % by 2040.

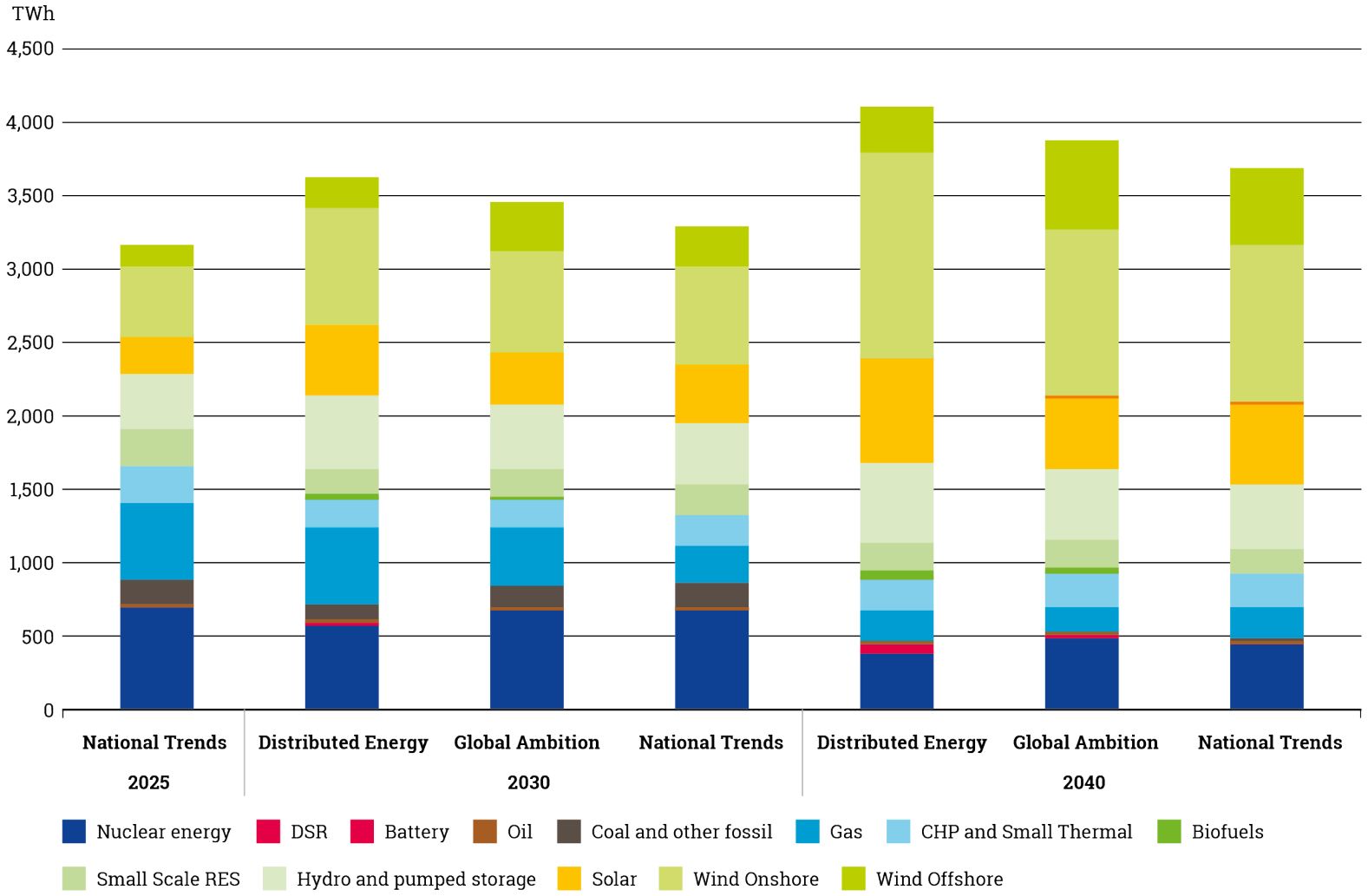
The remaining renewable capacity consists of biofuels and hydro.

*All figures stated above exclude power dedicated for P2X use, which is assumed to be entirely from curtailed RES, and newly build renewables that are not grid-connected, and therefore not considered in this representation.

Source: TYNDP 2020 Scenario Report

Generation mix and installed capacity

Generation Mix

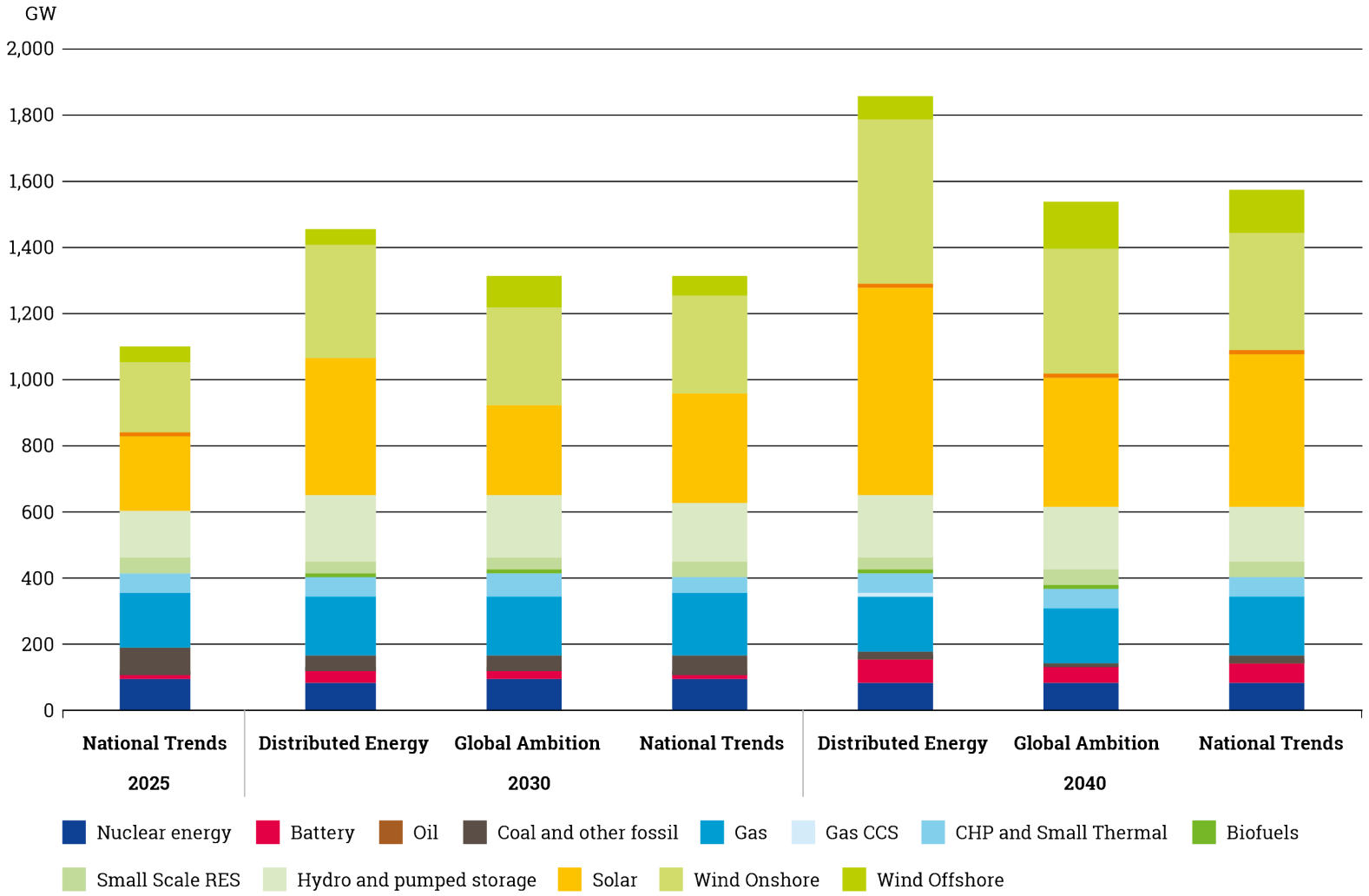


- **There is an increase in renewable capacity foreseen in all scenarios…**
- Shares of coal for electricity generation decrease across all scenarios
- Considerations on Other Non-Renewables source (mainly smaller scale CHPs) are important for decarbonisation
- The scenarios include repowering of renewable generation technologies from 2025 until 2040

Source: TYNDP 2020 Scenario Report

Generation mix and installed capacity

Installed Capacity



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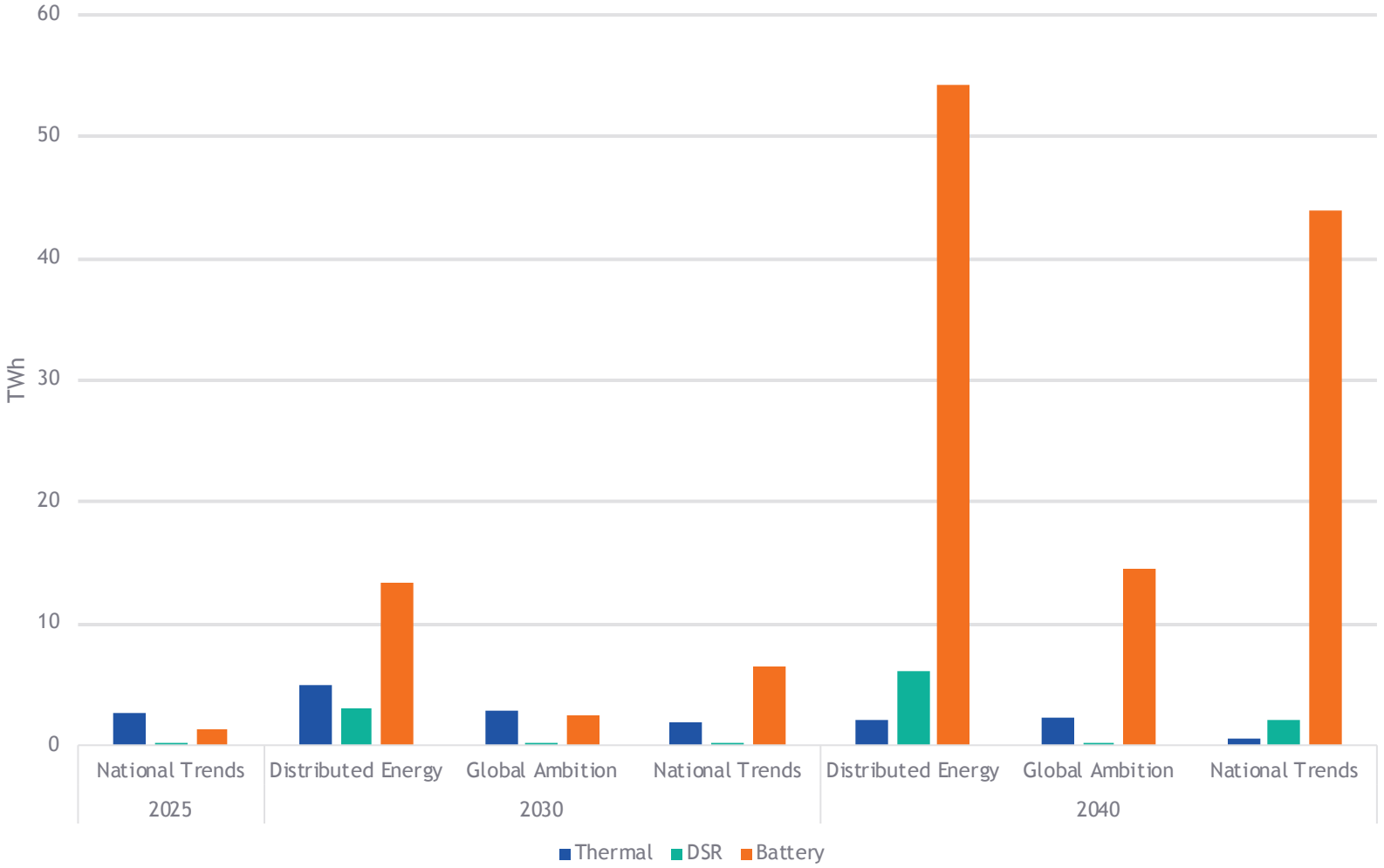
Source: TYNDP 2020 Scenario Report

Generation adequacy

Generation for Adequacy and Flexibility

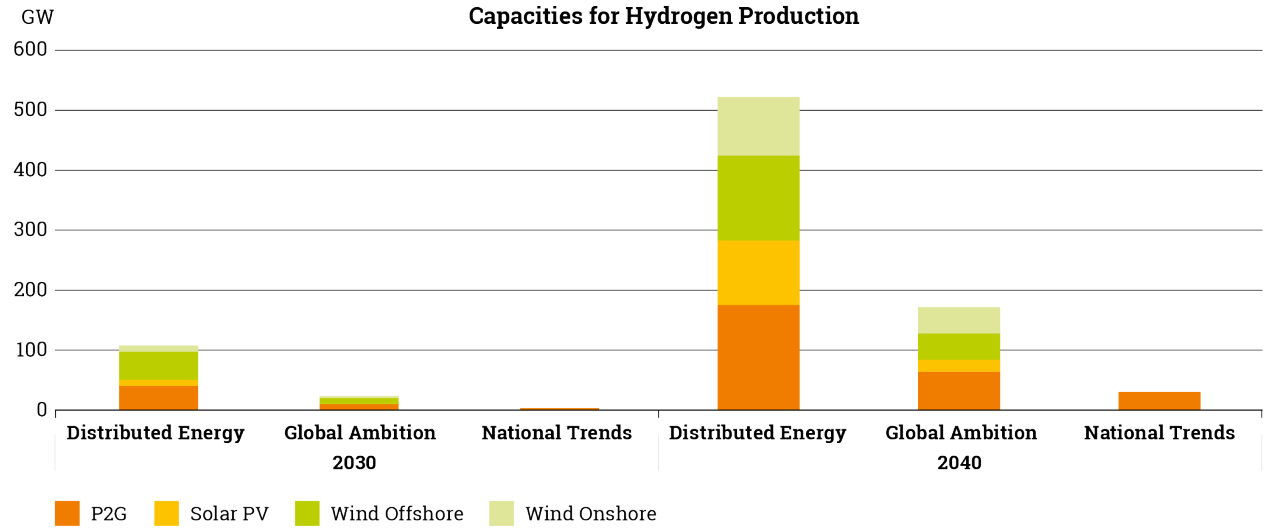


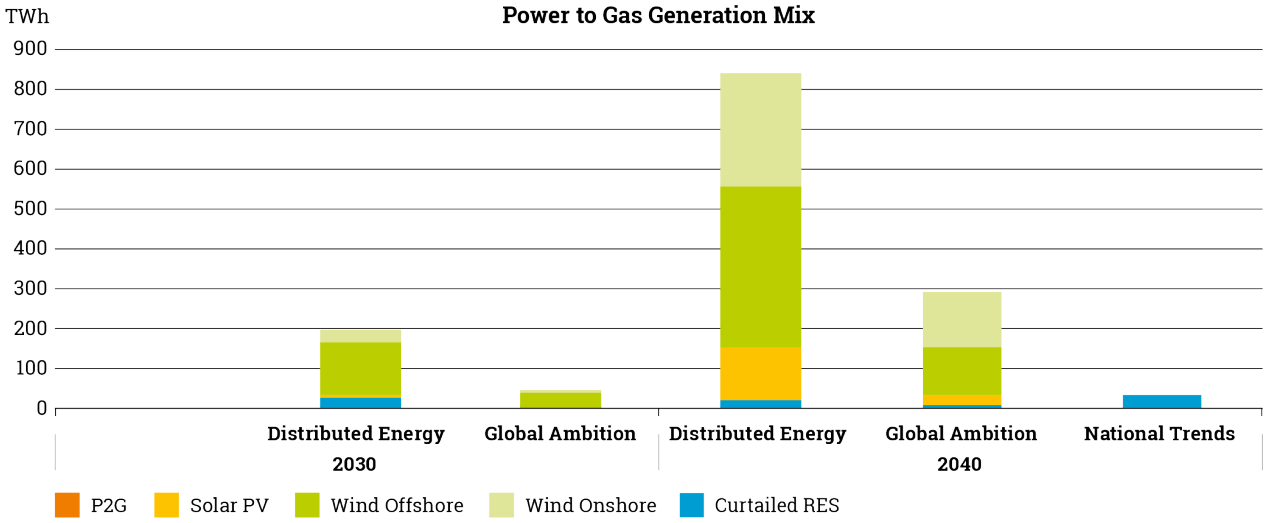
The scenarios show that there is potential for demand side technologies and batteries to take part in the market and help to smoothen demand peaks and level prices.

Distributed Energy shows the highest increase in usage of these, one reason is more solar is developed in the scenario. In 2040, there is a much larger increase in use of battery technologies in all scenarios.

Source: TYNDP 2020 Scenario Report

Capacities for hydrogen production





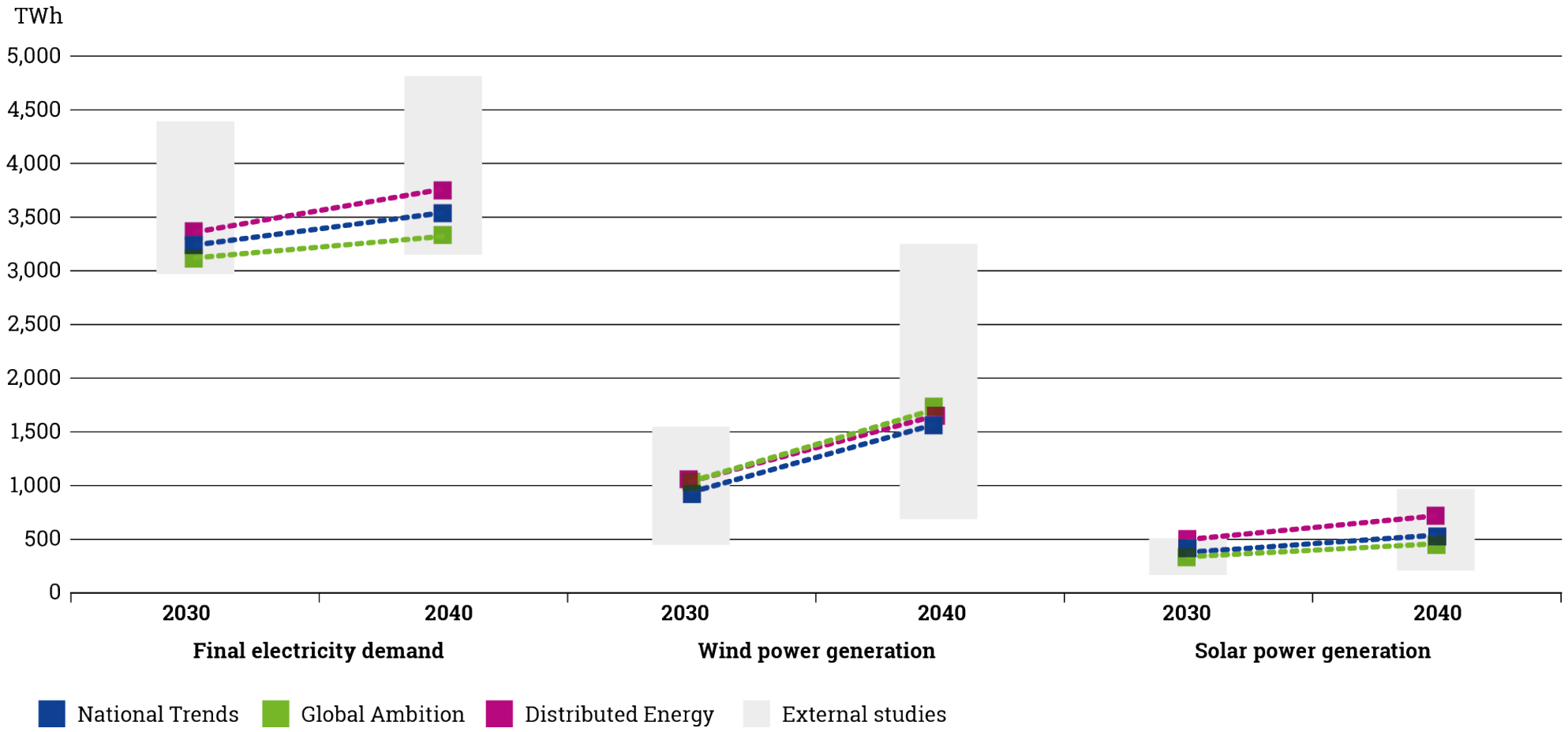
Distributed Energy has a significantly higher demand for EU produced hydrogen and synthetic methane than Global Ambition in the 2030 and 2040, as the storyline assumes a reduction of 70% of gas imports by 2050 (from 4,000 TWh in 2020 down to 1,200 TWh in 2050) combined with the decarbonisation of the gas supply.

In the COP21 scenarios, the main source used for electrolysis is offshore wind, but where regional constraints exist, onshore wind and solar PV will be the alternative.

Source: TYNDP 2020 Scenario Report

Benchmarking: variable RES and demand in TYNDP 2020 scenarios are within the range of external studies

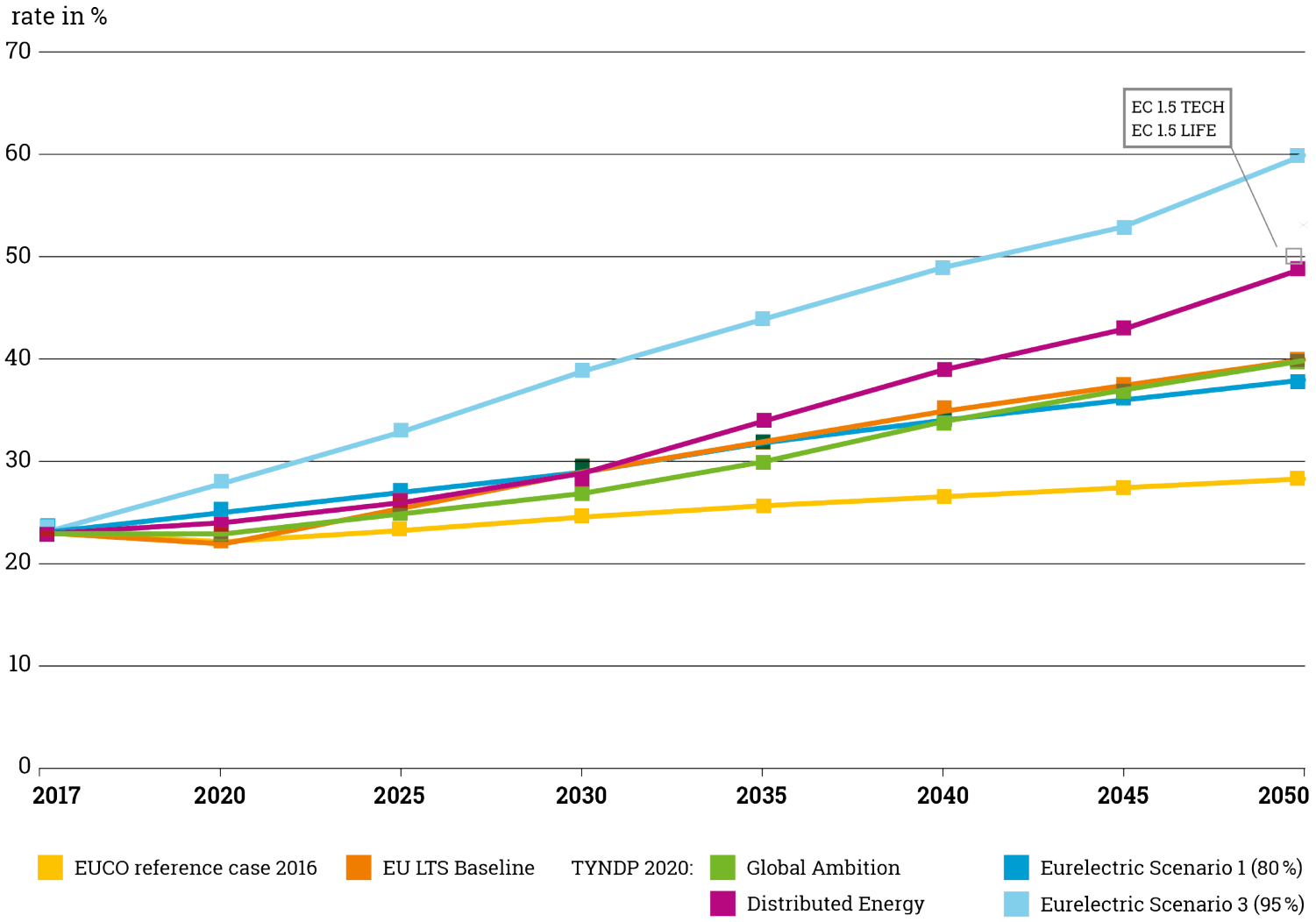
Projected Electricity Demand and Wind/Solar Generation for EU28



Source: TYNDP 2020 Scenario Report

Benchmarking: Electrification rate for EU28

Projected Electrification Rate for EU28



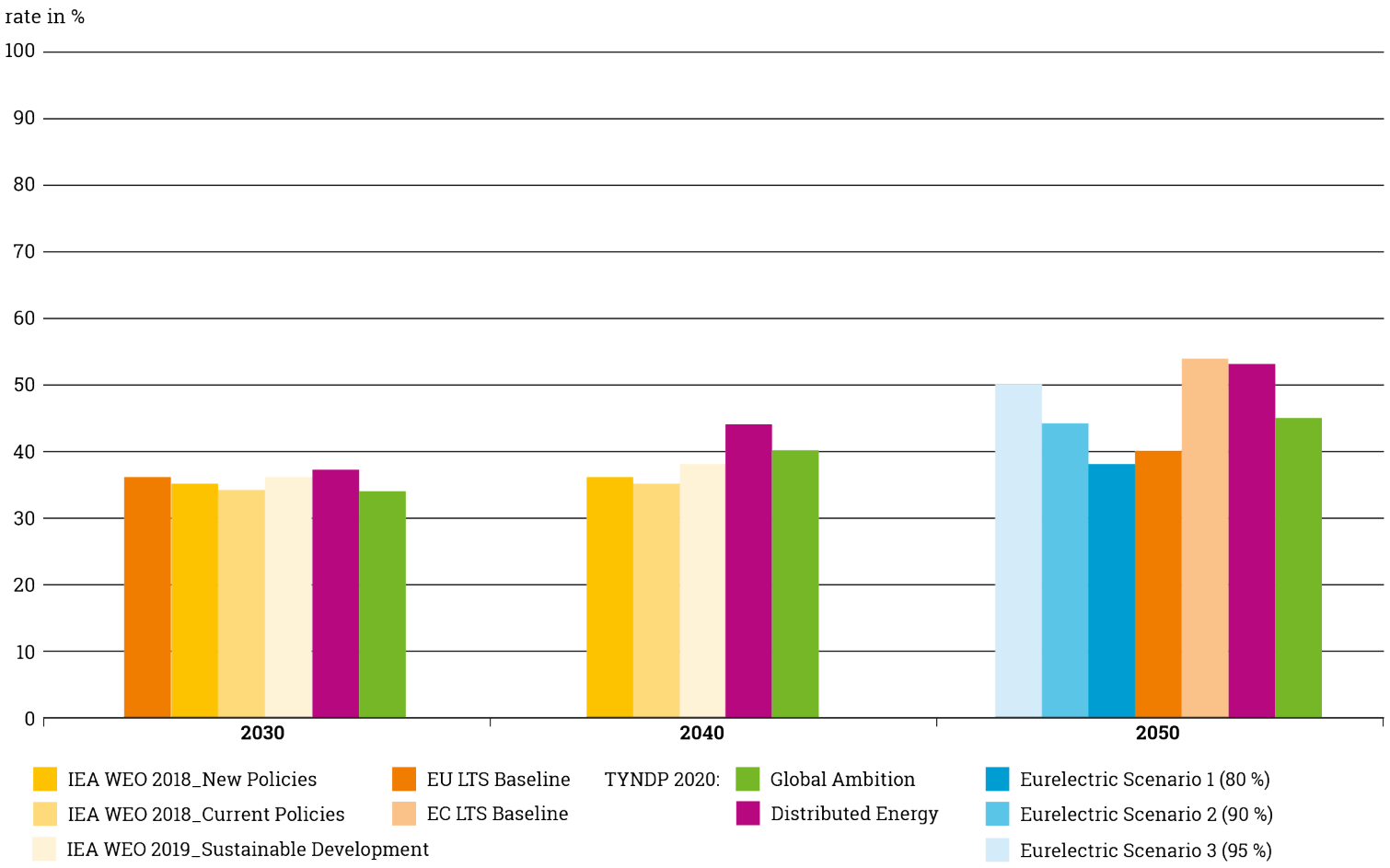
In 2050, the Distributed Energy scenario achieves roughly the same electrification rate as the EC 1.5 TECH scenario, which is close to 50 %.

The Global Ambition scenario follows approximately the same electrification path as the EU LTS Baseline scenario and additionally Eurelectric Scenario 1, which accomplishes the goal of 80 % emission reduction up to 2050.

Source: TYNDP 2020 Scenario Report

Electrification in industry in TYNDP 2020 scenarios is in line with other external scenarios

Projected electrification Rate for EU28

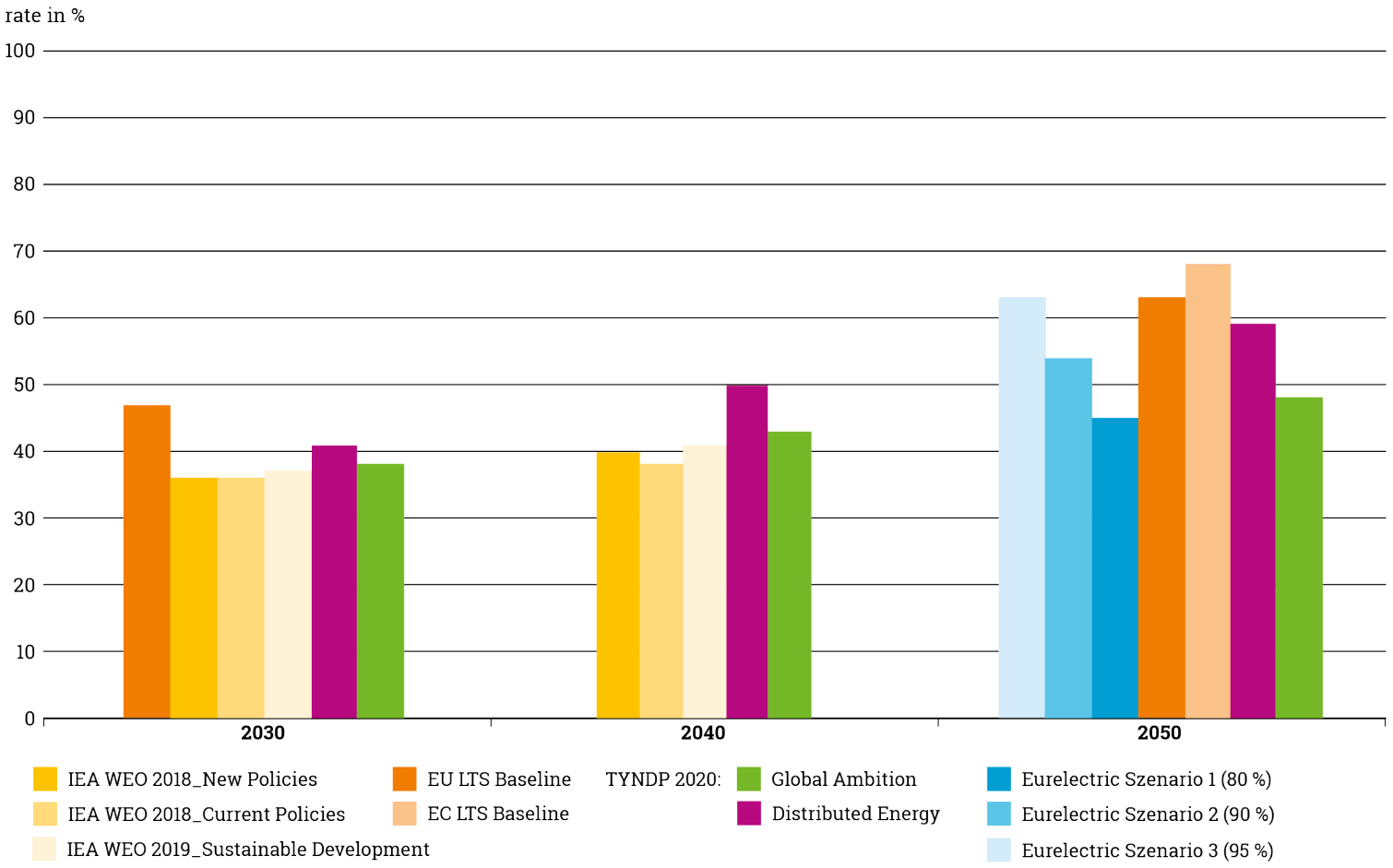


The sectorial breakdowns of the industry, residential and commercial sectors illustrate that the COP 21 scenarios are, with regard to electrification, in the order of magnitude compared to other external scenarios.

Source: TYNDP 2020 Scenario Report

Electrification in residential & commercial is similar in TYNDP 2020 with other external scenarios

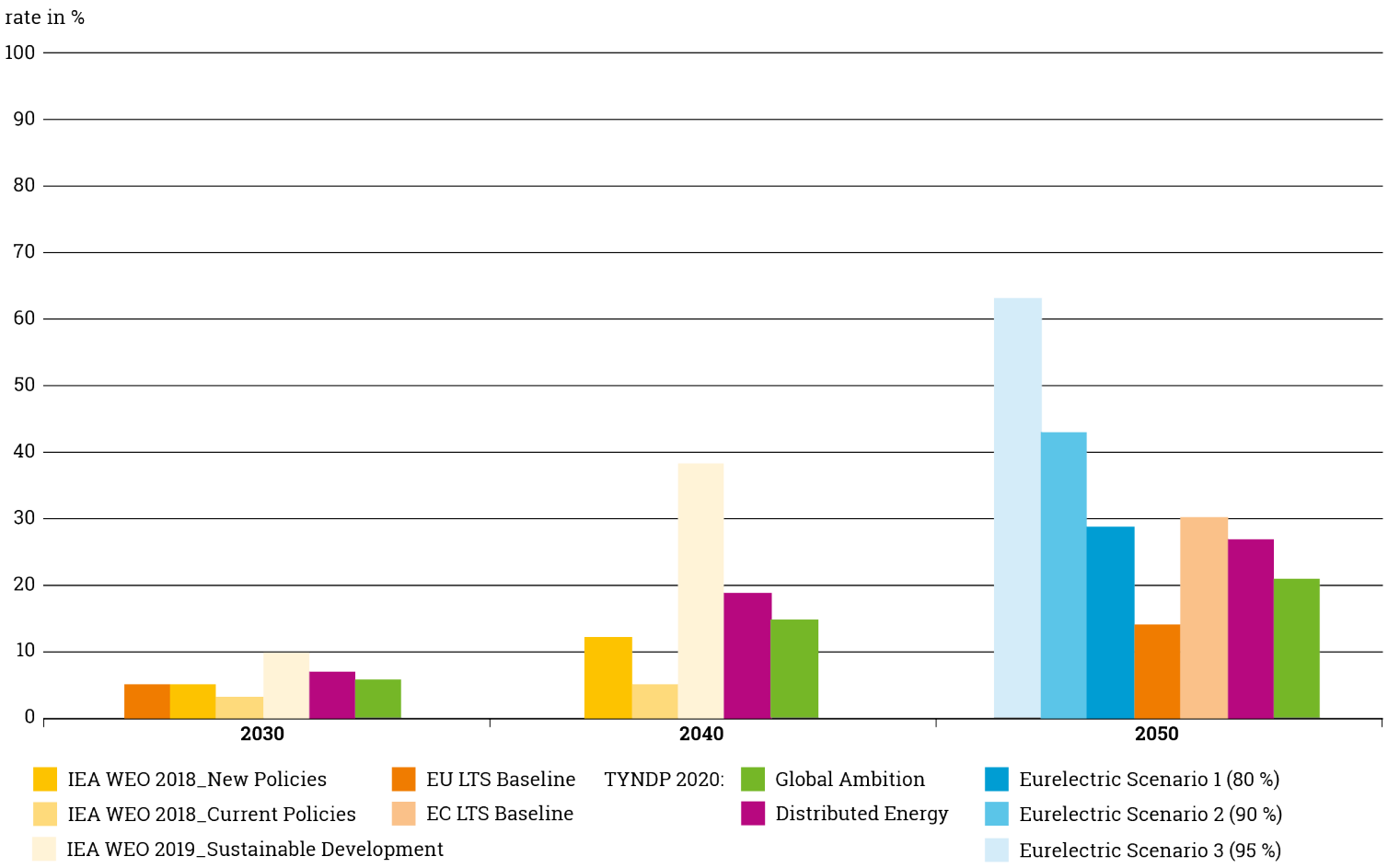
Projected electrification Residential and Commercial for EU28



Source: TYNDP 2020 Scenario Report

Benchmarking: Electrification in transport equivalent to EC 1,5 TECH scenario, but lower than Eurelectric

Projected electrification in Transport for EU28



The electrification in transport, is in the ballpark of other external scenarios. For 2050, the transport electrification in the ENTSOs' COP 21 scenarios matches the EC's 1,5TECH scenario, but is lower compared to Eurelectric's scenarios.

Source: TYNDP 2020 Scenario Report

Core Chapter 1: Power network development

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System planning for the energy transition

Optimal grid 2040 compared to “no-action” delivers…

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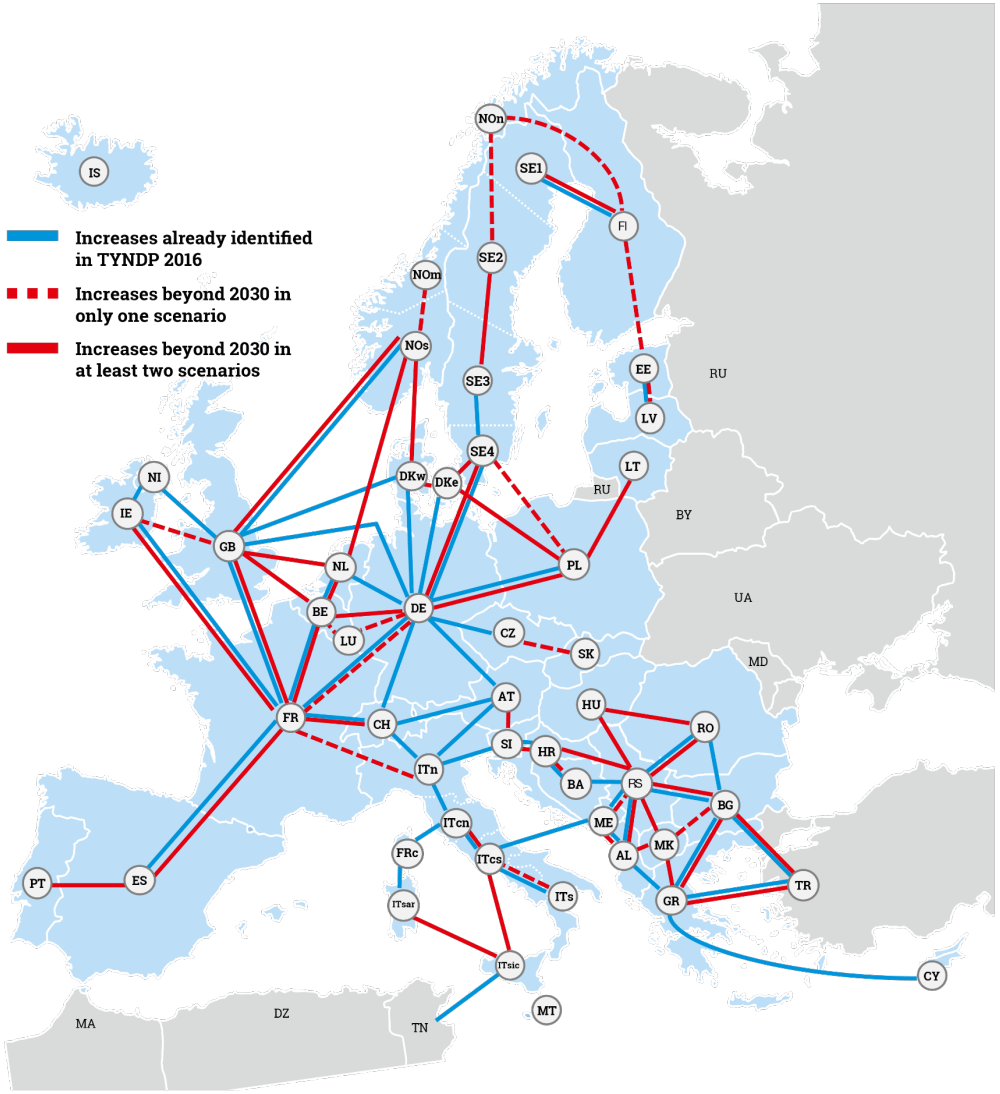

3 to 14 €/MWh
reduction in marginal costs of electricity generation

58 to 156 TWh
less curtailed renewable energy

37 to 59 Mton
reduction in CO_2

24 to 471 GWh
reduction in Energy Not Served

No new grid beyond 2020 hinders the integration of the European energy market

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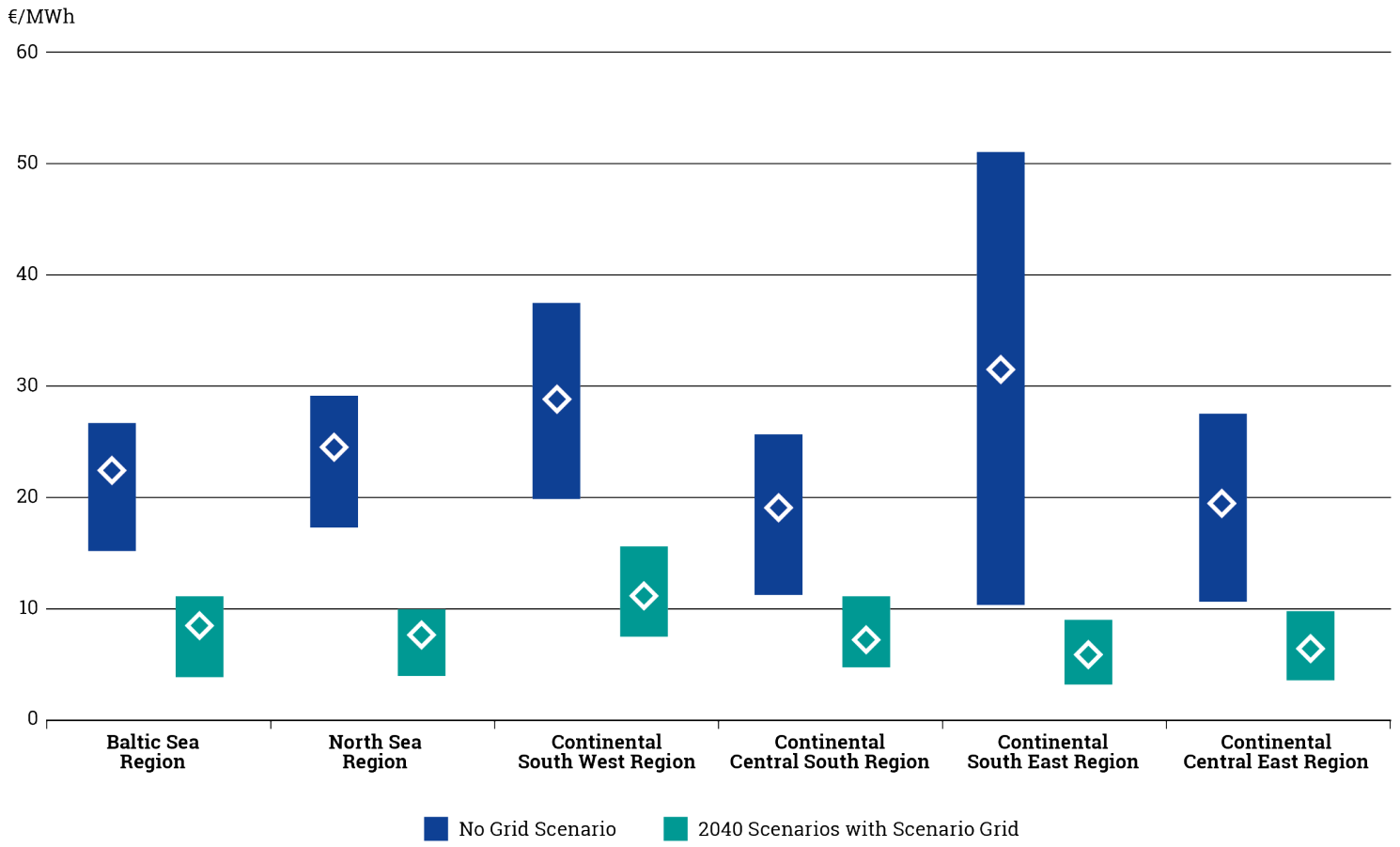
Annual marginal cost differences between neighbouring countries

(range and average of all scenarios and climate years)



43 bln €/year

Not reinforcing the transmission grid at borders and within countries would on average increase the total European market value by 43 billion euros per year by 2040 in an average case.

Source: ENTSO-E TYNDP 2018

The system in 2030: high price spreads can be mitigated by targeted solutions

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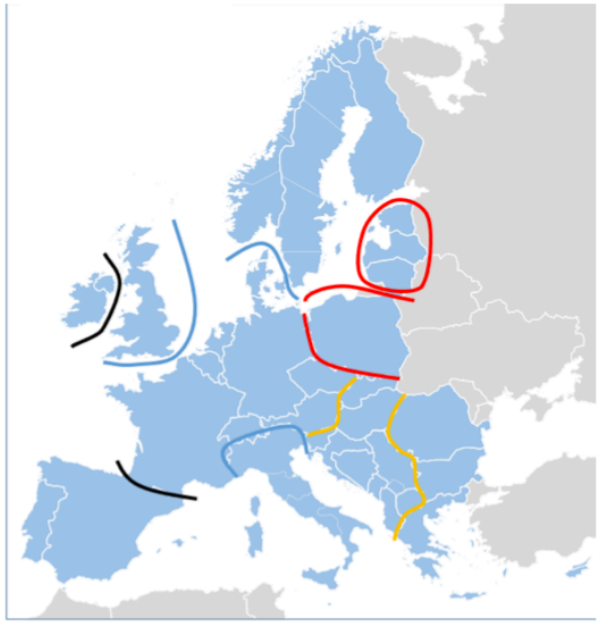
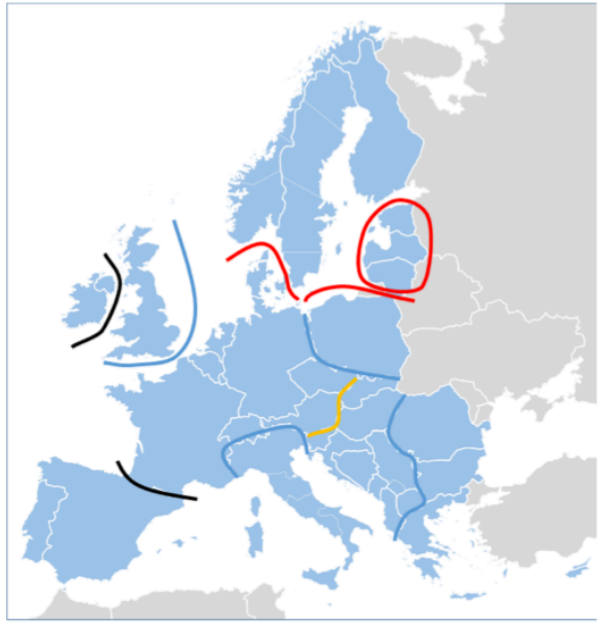
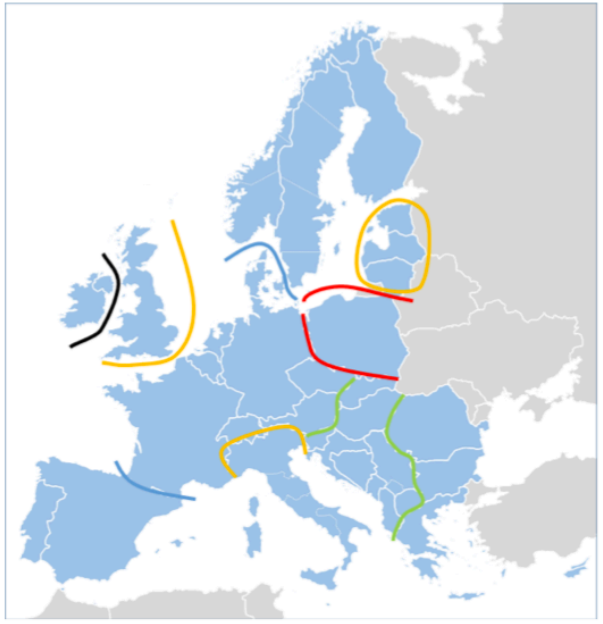
Impact of the implementation of existing mature projects (reference grid) by 2030 compared to a “no new projects” approach



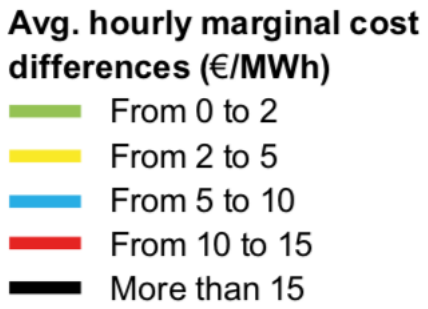
Sustainable transition 2030



Distributed generation 2030



EUCO 2030



Source: ENTSO-E TYNDP 2018

TYNDP 2018 key numbers – In 2030

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48 to 58% of the demand covered by renewables in TYNDP 2030 scenarios

166 Transmission Projects proposed: Consisting of 357 Investments, 201 Overhead Lines, 67 Subsea, 23 Underground Cables

€114bn proposed investments by 2030

65 to 75% CO_2 emissions reduction in TYNDP 2030 scenarios compared to the 1990 levels

15 Storage Projects proposed: 12 Hydro Pumped Storage, 3 Compressed air

€2bn to 5bn annual savings in generation costs due to TYNDP projects

Source: ENTSO-E TYNDP 2018

The vast majority of projects are expected to be in service by 2027

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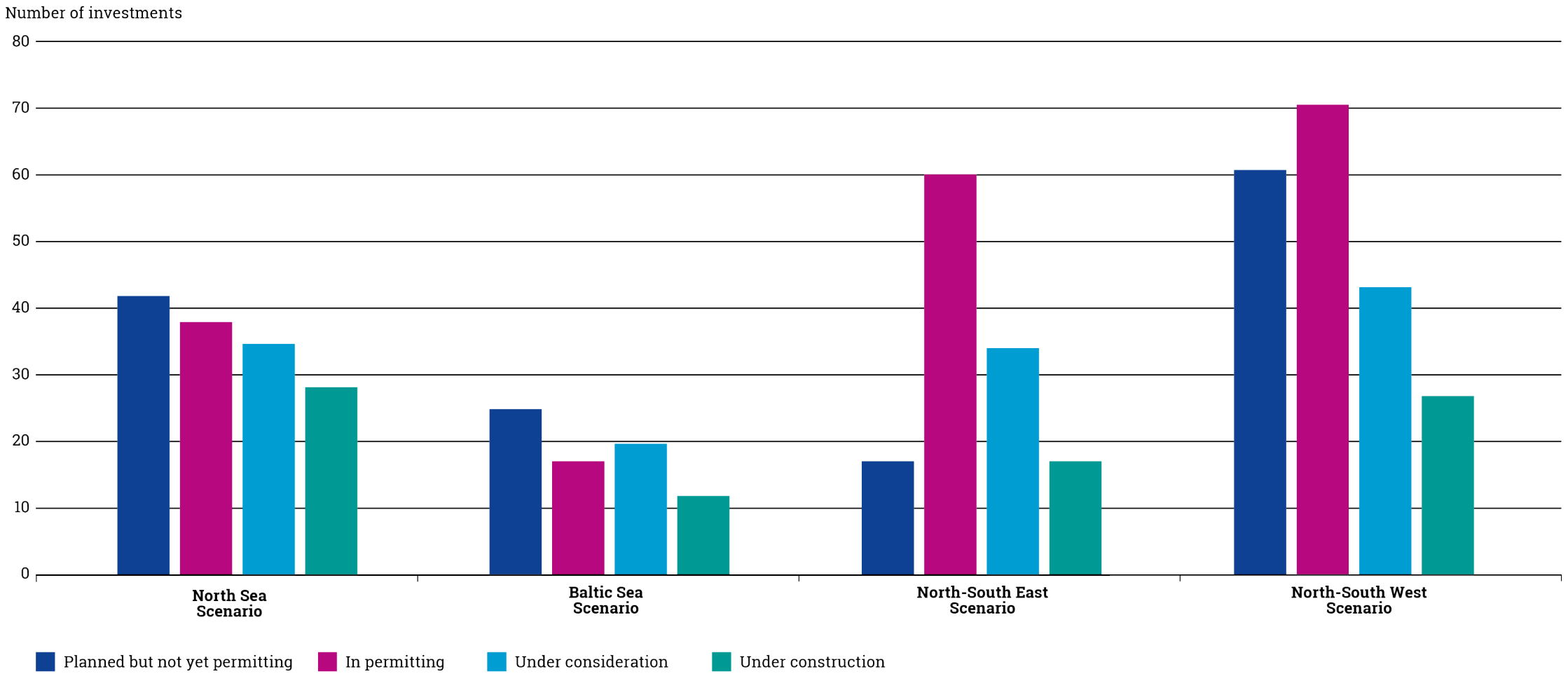
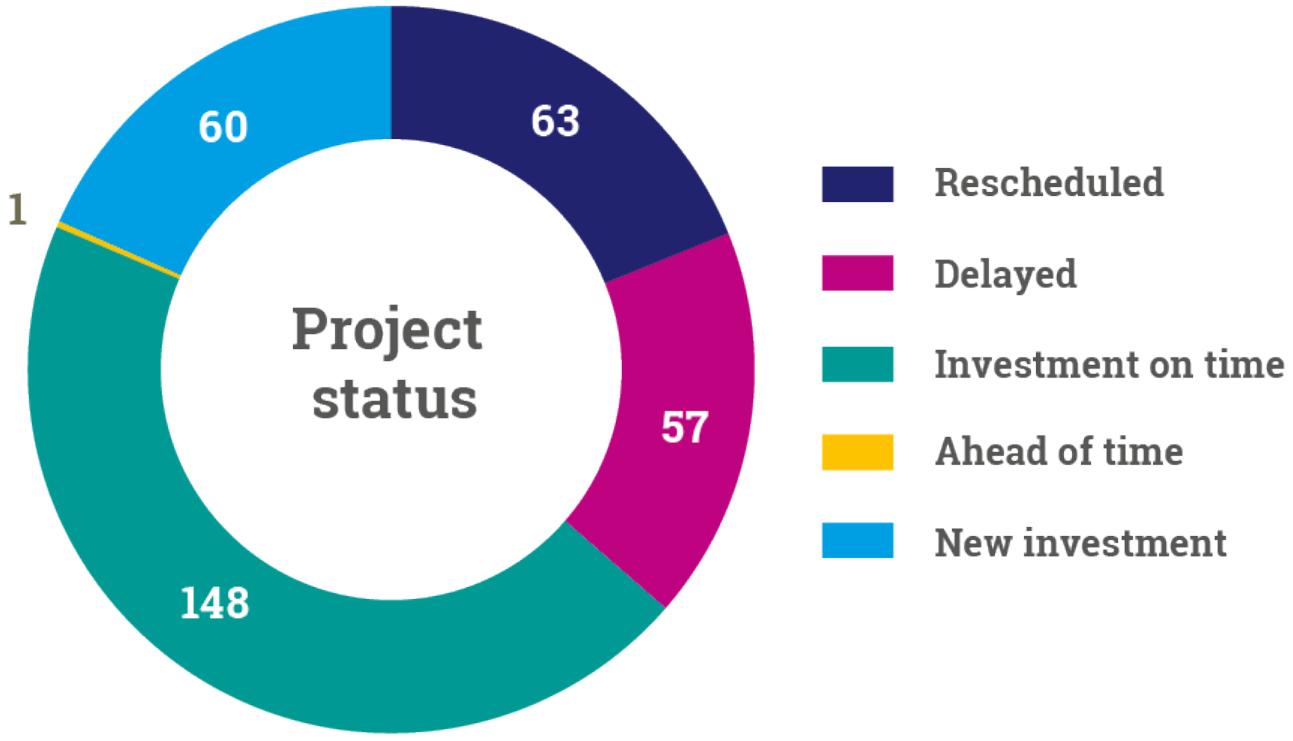
Project portfolio status for each European corridor



Source: ENTSO-E TYNDP 2018

Complex implementation for complex projects

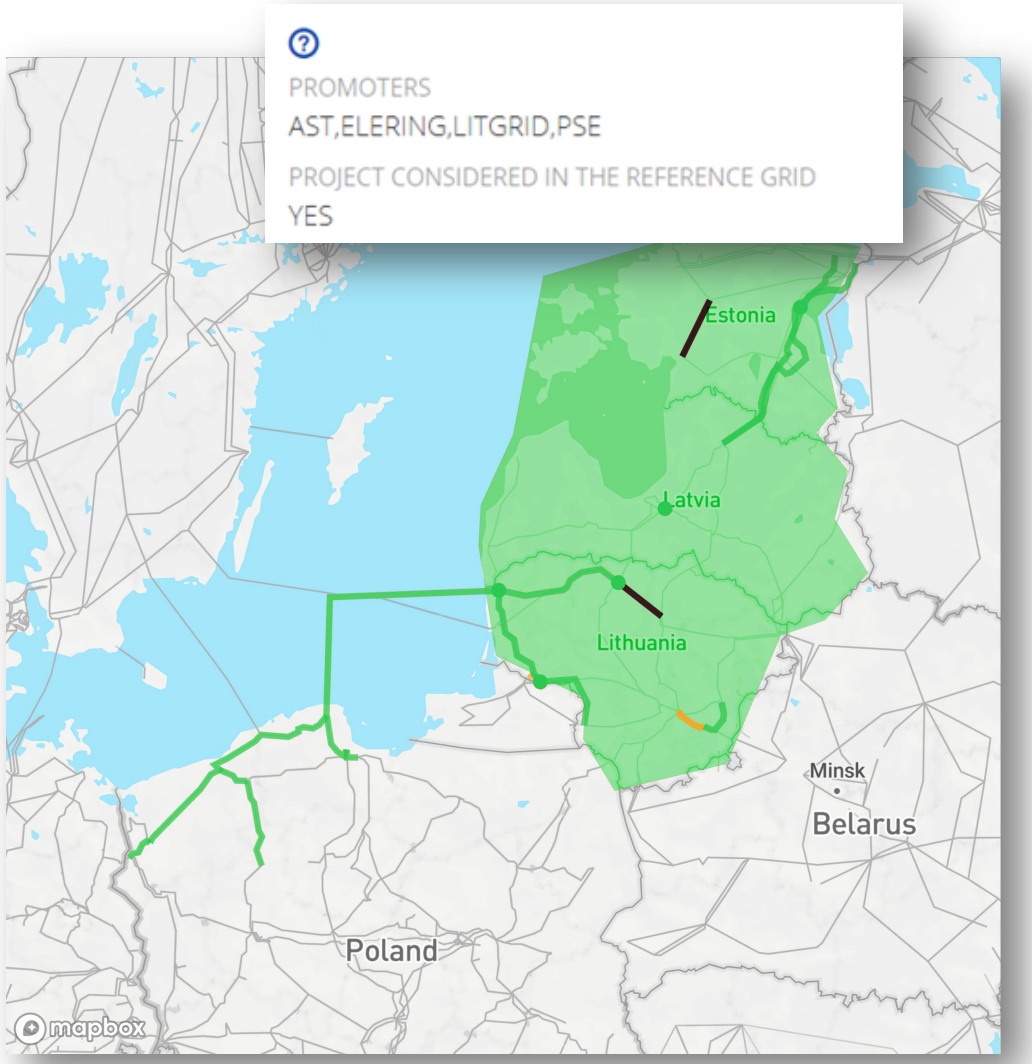


17% of TYNDP investments suffered delays in the past two years (compared with 25% in 2018)

One key element often generating delays and expensive redesigning of projects is their local acceptability.

Source: ENTSO-E TYNDP 2018

Grids for security of supply and markets
Zoom on the Baltics



- The three Baltic TSOs are preparing for desynchronisation from IPS/UPS and synchronisation with the Continental European Network (CEN) through current interconnection between Lithuania and Poland.
- Synchronisation of Baltic countries with CEN will ensure energy security by connecting to grid, which is operated following the common European rules.
- Baltic synchronisation project covers a lot of new projects for internal grid reinforcements required for synchronisation and separation of Baltic grid from IPS/UPS system, DC convertor stations on borders with Russia, Belarus and Kaliningrad area, additional studies.

Source: ENTSO-E TYNDP 2018

Grids for security of supply and markets
Zoom on offshore grid

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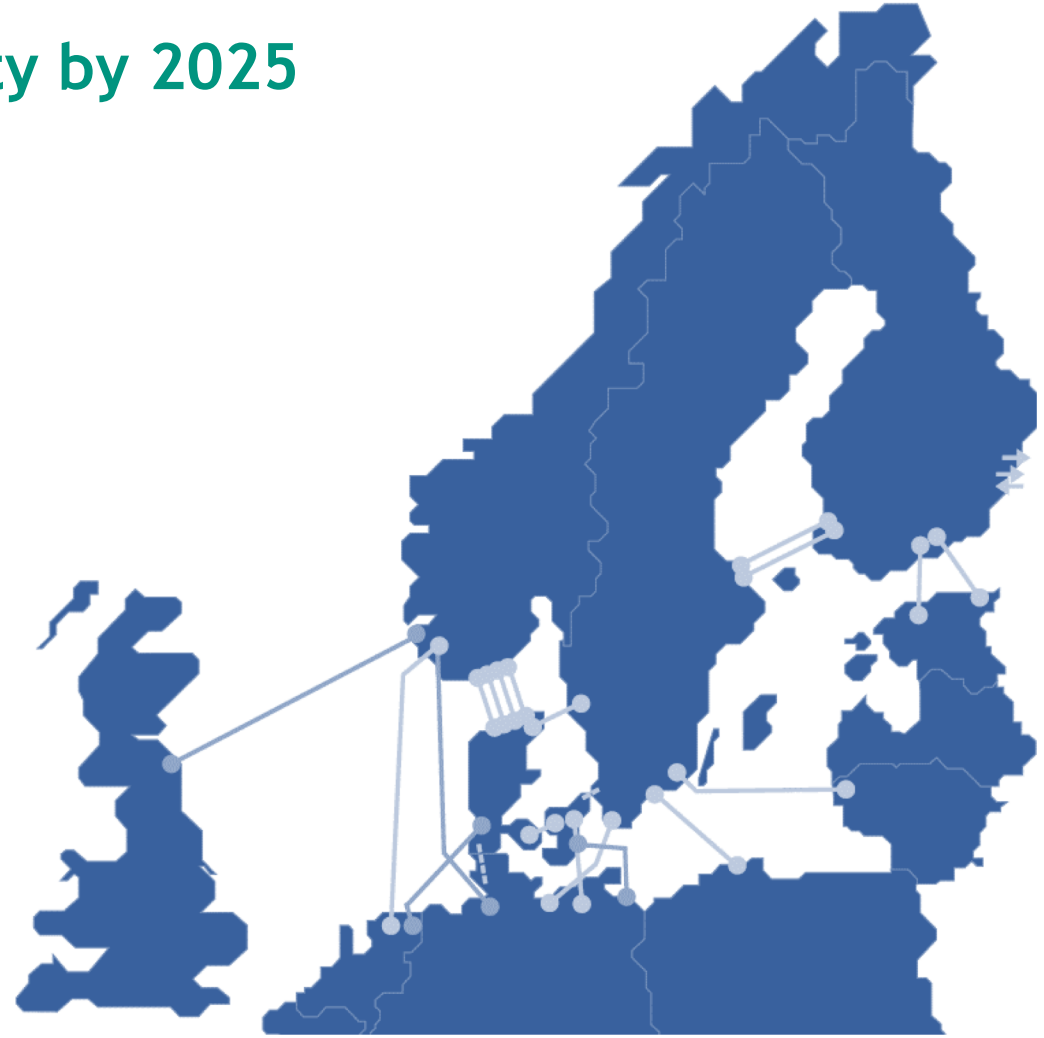
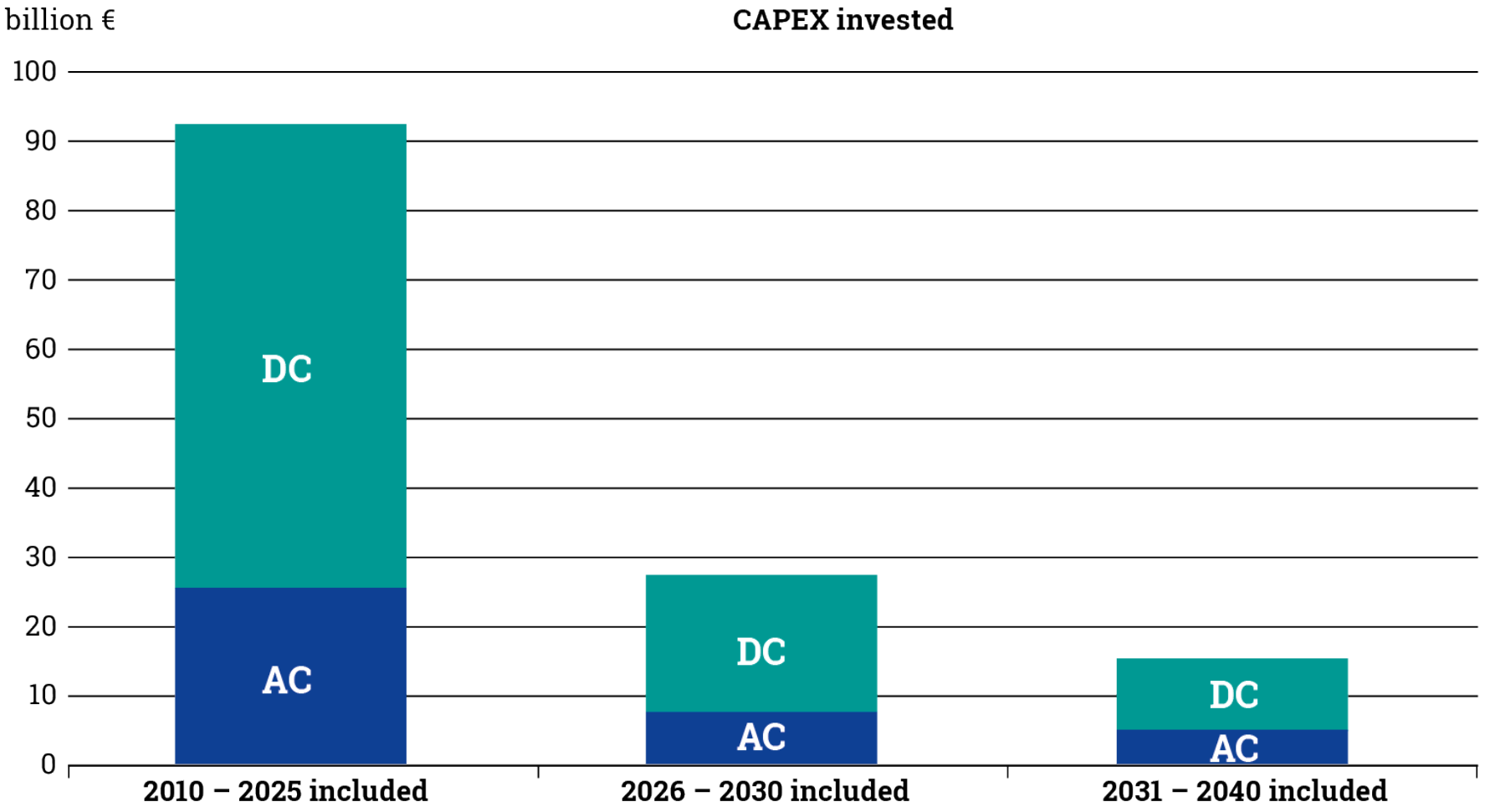
60% increase in interconnector capacity by 2025 between the continent and the Nordic

Cobra	700 MW
Kriegers Flak	400 MW
Nord Link	1,400 MW
North Sea Link	1,400 MW
Viking Cable	1,400 MW
Hansa Power Bridge	700 MW
Jutland-Germany	1,000 MW
Total	**7,000 MW**



Source: ENTSO-E TYNDP 2018

Grids for security of supply and markets
Investments in grid: AC/DC

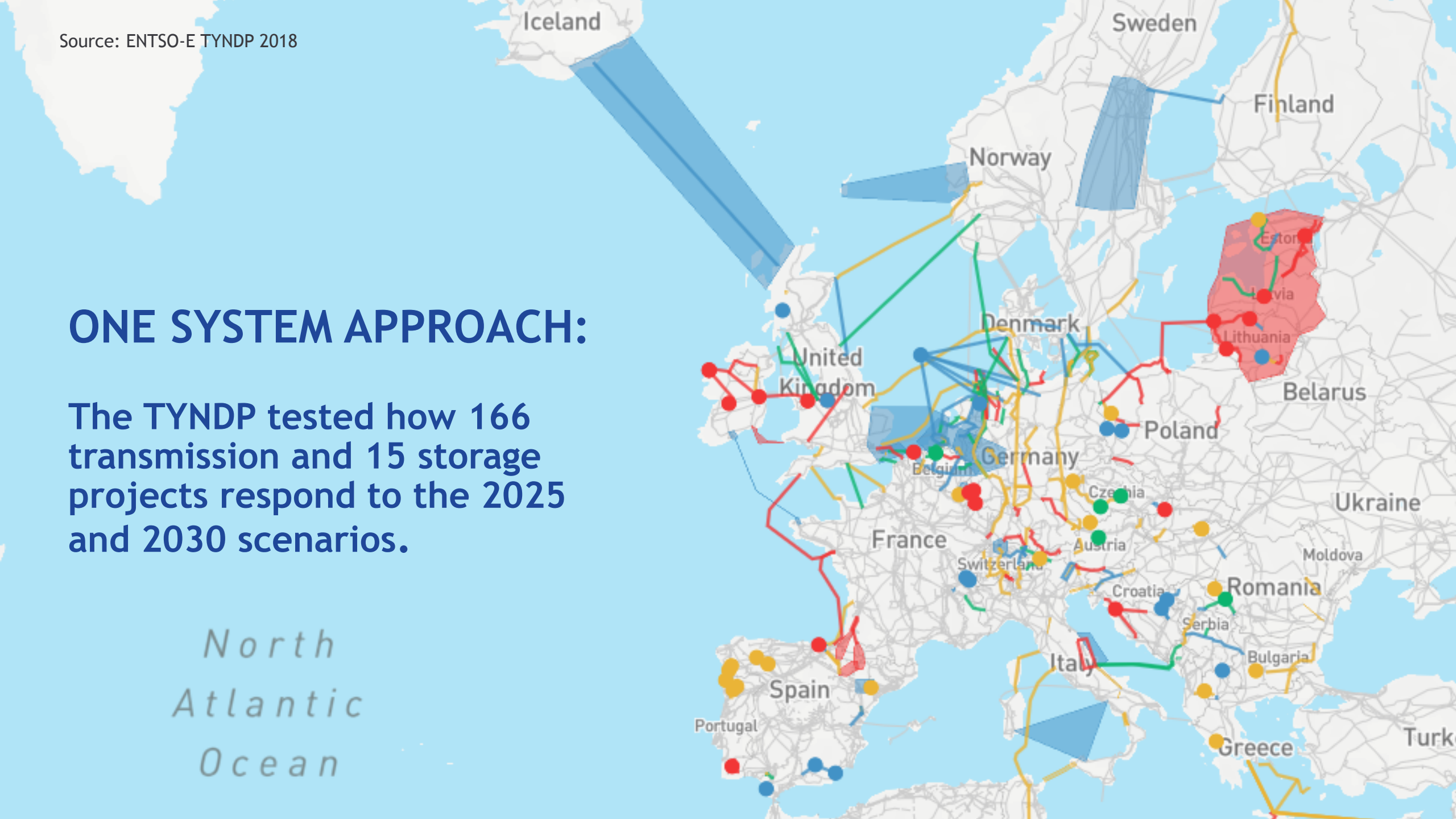


Source: ENTSO-E TYNDP 2018

Source: ENTSO-E TYNDP 2018

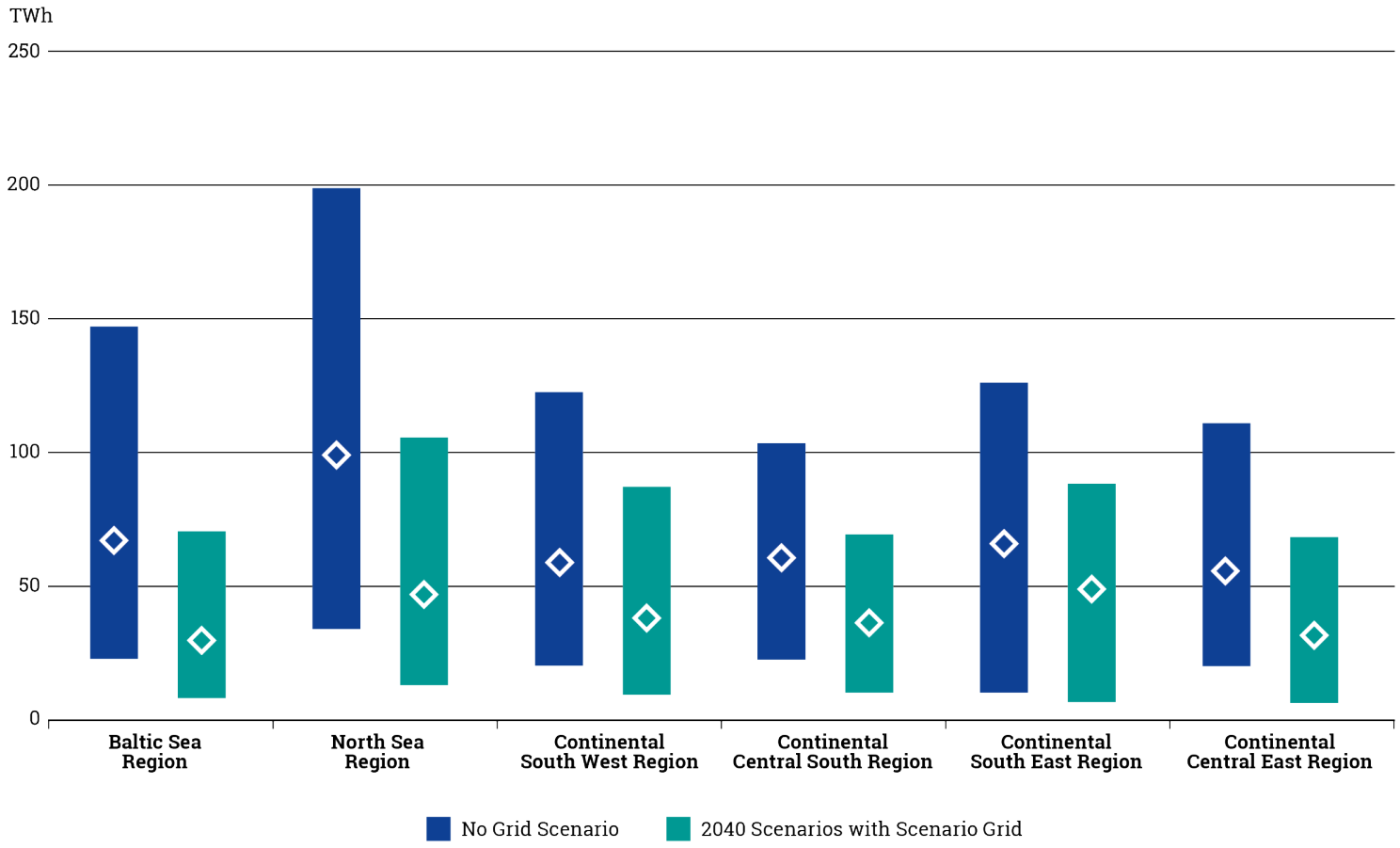
ONE SYSTEM APPROACH:

The TYNDP tested how 166 transmission and 15 storage projects respond to the 2025 and 2030 scenarios.



ONE SYSTEM APPROACH
2040: grid improves system efficiency

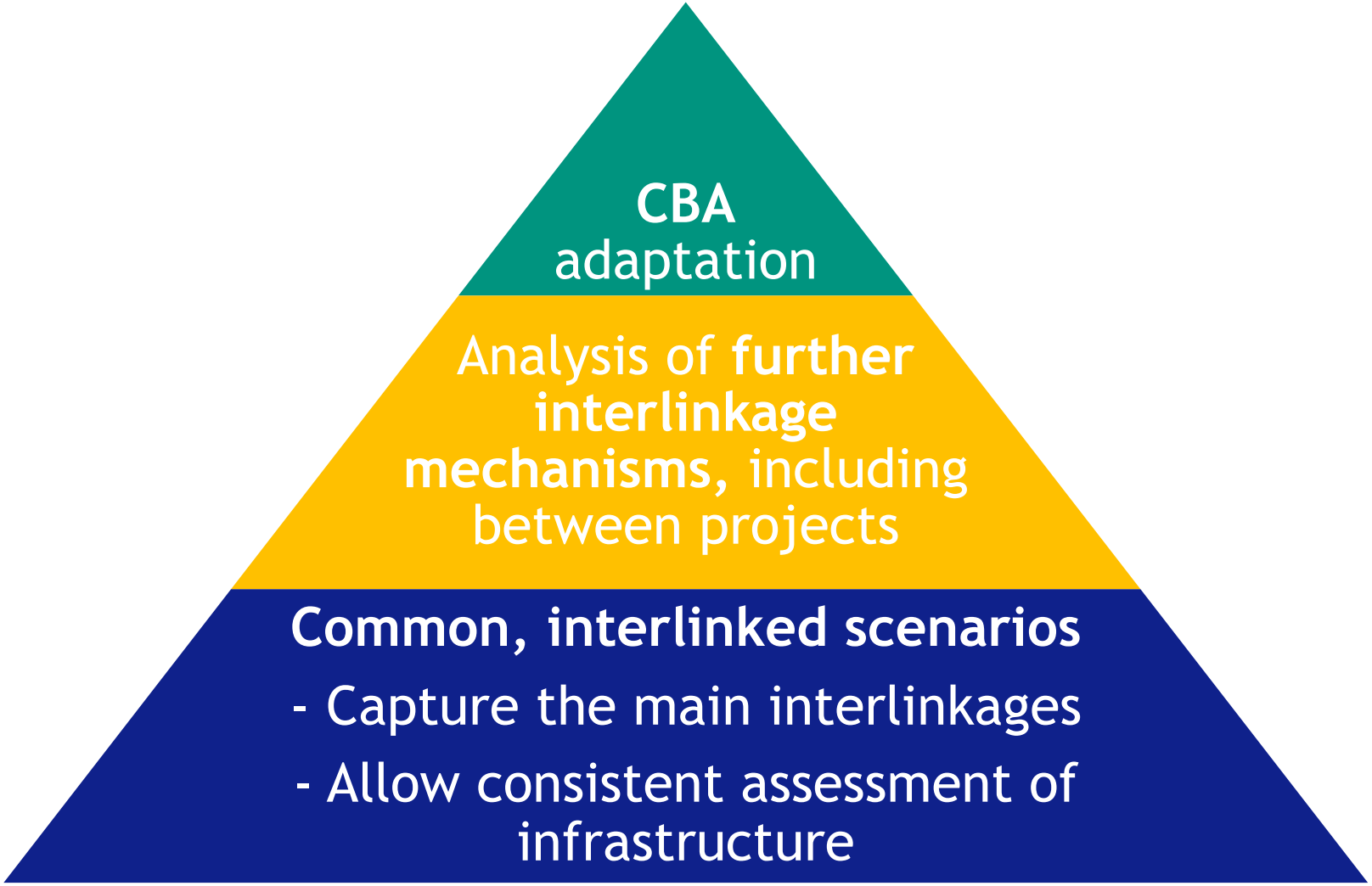
European Curtailed Energy Range and average of all scenarios and climate years



156TWh/year
of RES electricity not curtailed

Source: ENTSO-E TYNDP 2018

ONE SYSTEM APPROACH
Sector coupling: focus Power to Gas



Source: ENTSO-E

Key takeaways

The TYNDP 2020 scenarios go all beyond the 40% EU emissions reduction trajectory.

Grids are essential to deliver the energy transition: the cost of no-grid amounts to 43 bn EUR per year as of 2040; € 140 bn EUR investment in transmission grids are needed to enable the energy transition by 2040. Investments will focus largely on DC until 2025.

ONE SYSTEM APPROACH: We need a grid+ approach: a combination of flexibility solutions and that include grids and storage, demand side response, sector coupling and many more. This approach is the basis for our TYNDP.

We need sector integration for achieving climate neutrality: this includes P2G, PtX and has one system in mind.

Core Chapter 2: Power system reliability

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Limited number of incidents recorded on the grid

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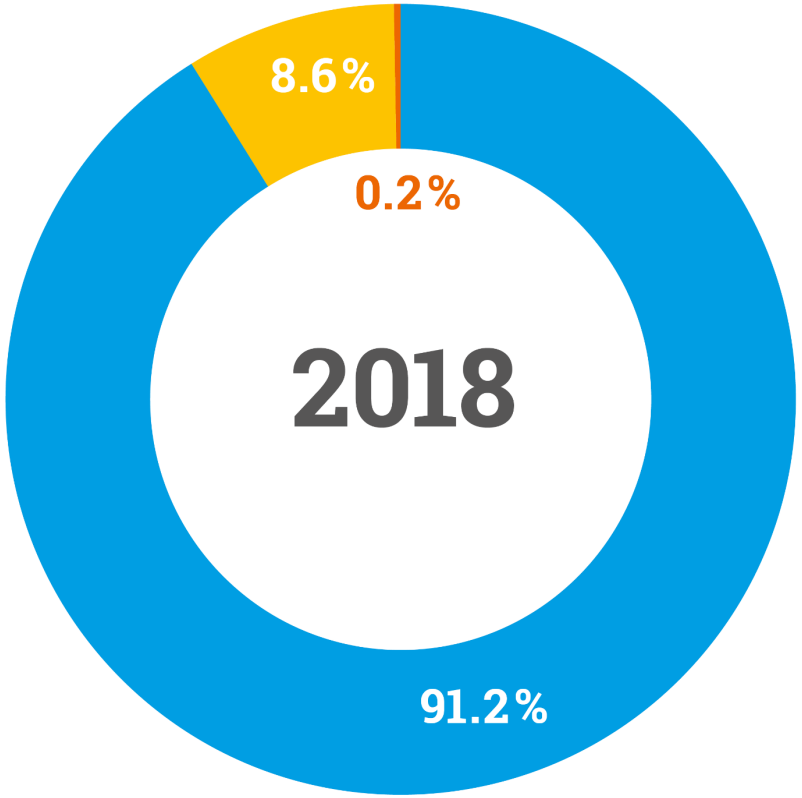
Number of recorded incidents per scale in 2018 and the percentage distribution



Scale of incident	Number of incidents	Percentage
Scale 0	2,762	91.2 %
Scale 1	262	8.6 %
Scale 2	6	0.2 %
Scale 3	0	0.0 %
Grand Total	**3,030**	**100.0%**

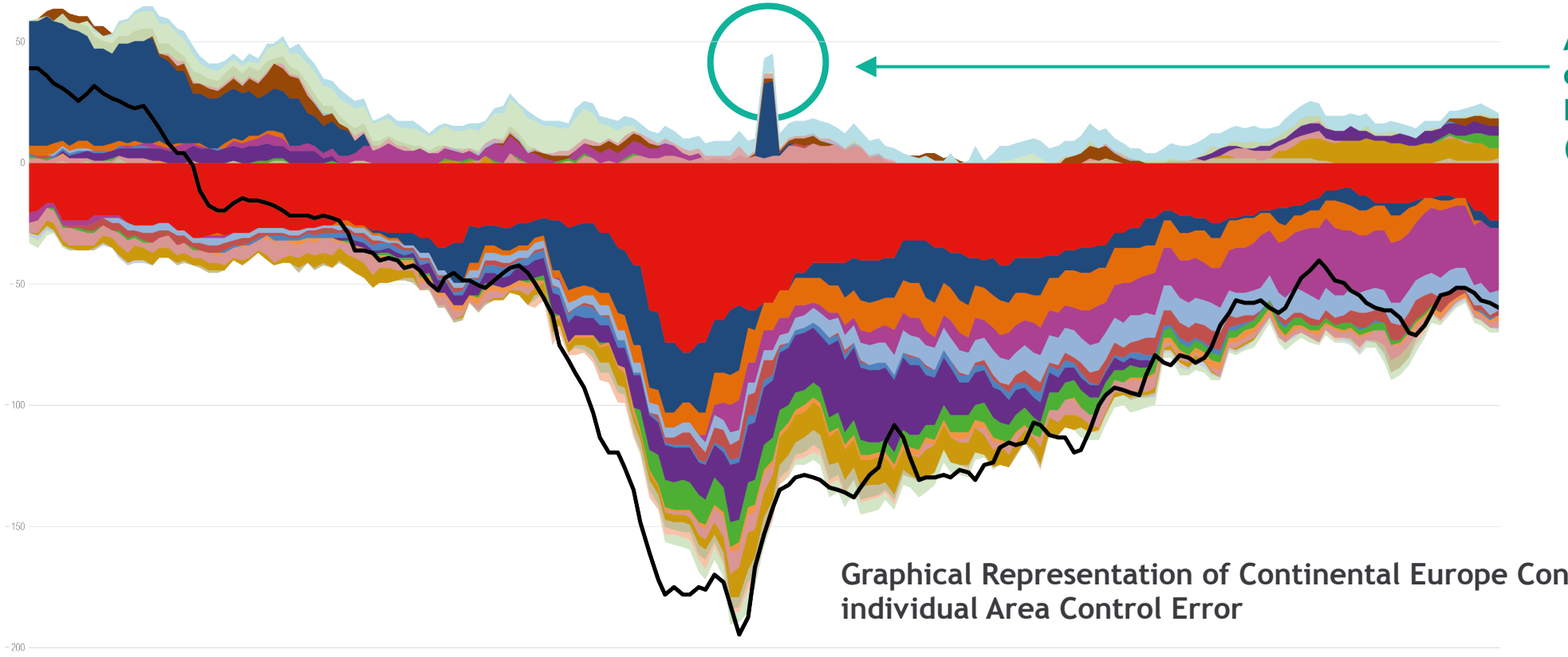
- Scale 0: Anomaly
- Scale 1: Noteworthy incident
- Scale 2: Extensive incidents
- Scale 3: Wide area incident or major incident / 1 TSO

Source: ENTSO-E Incident Classification Report 2019 on incidents reported by TSOs in 2018

However, impact of energy transition on the system is a reality

Zoom on 10 January 2019 significant frequency deviation

- European power system resilience and solidarity was tested in January 2019
- Fast and coordinated response from TSOs to avoid disconnection of non-interruptible load



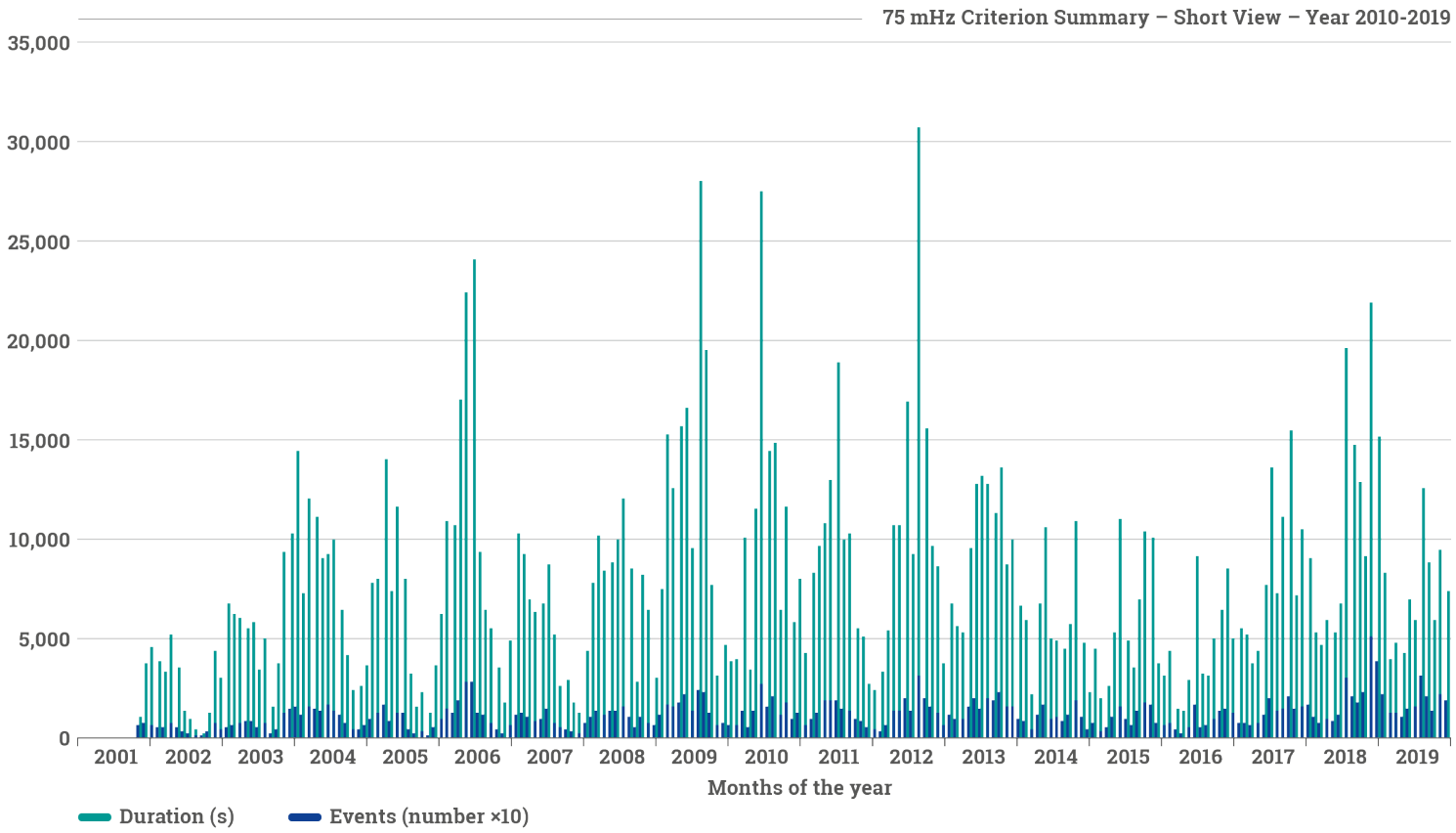
Automatic activation of the Industrial Interruptible Service (1,700 MW) in France

Graphical Representation of Continental Europe Control Block individual Area Control Error

Source: ENTSOE report on January 2019 frequency deviations

Zoom on 10 January 2019 significant frequency deviation

Number and duration of 75 mHz criteria violation

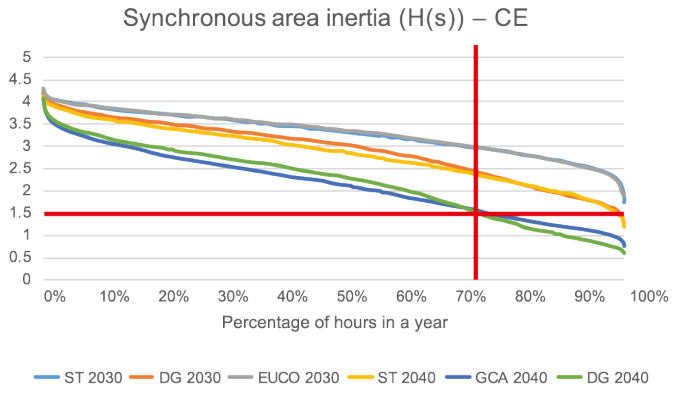


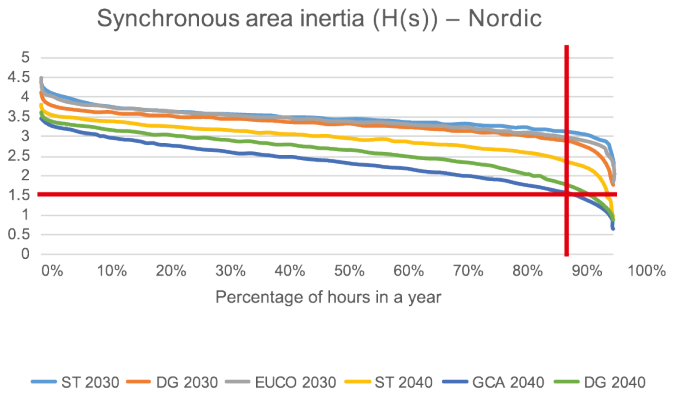
- The quality of frequency in the Continental Europe Synchronous Area has decreased during the last years. The Figure shows, monthly, the number and duration of periods when frequency deviation was greater than 75 mHz
- A very high percentage of the frequency deviations are caused by Deterministic Frequency Deviations (DFDs)
- Approximately 85% of the deviations are deterministic with respect to the 75mHz limit

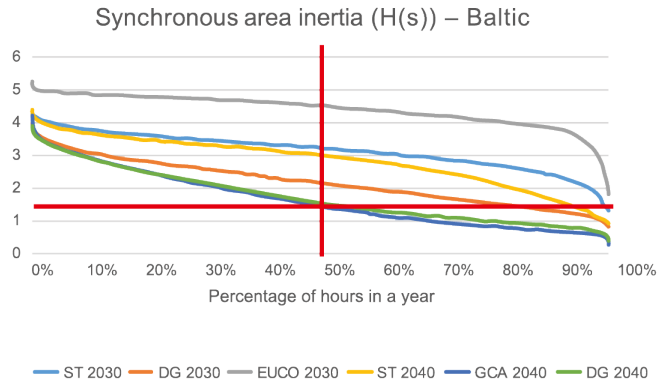
Source: ENTSOE report on January 2019 frequency deviations

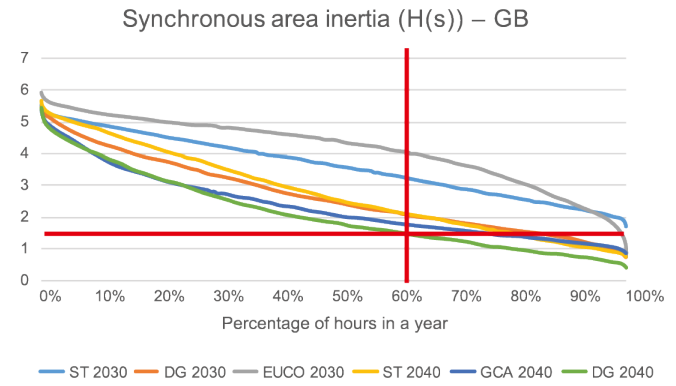
System strength 2030/2040 - Inertia indicator

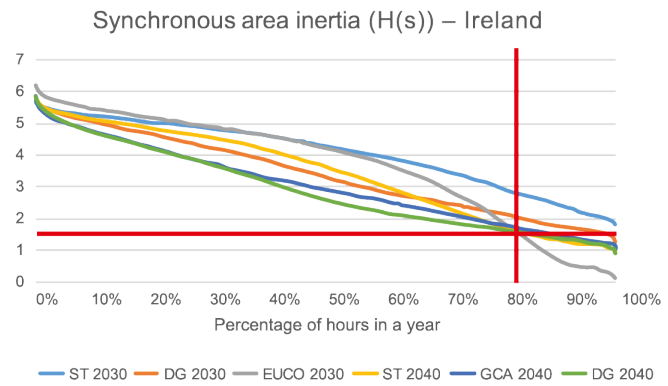
All Synchronous Areas will become prone to a lack of inertia, which will cause large frequency excursions in cases of relatively low mismatches between generation and demand.











Source: ENTSO-E TYNDP 2018 System Needs Report: European Power System 2040 – Completing the map

Decrease in dispatchable versus increase in non-dispatchable generation

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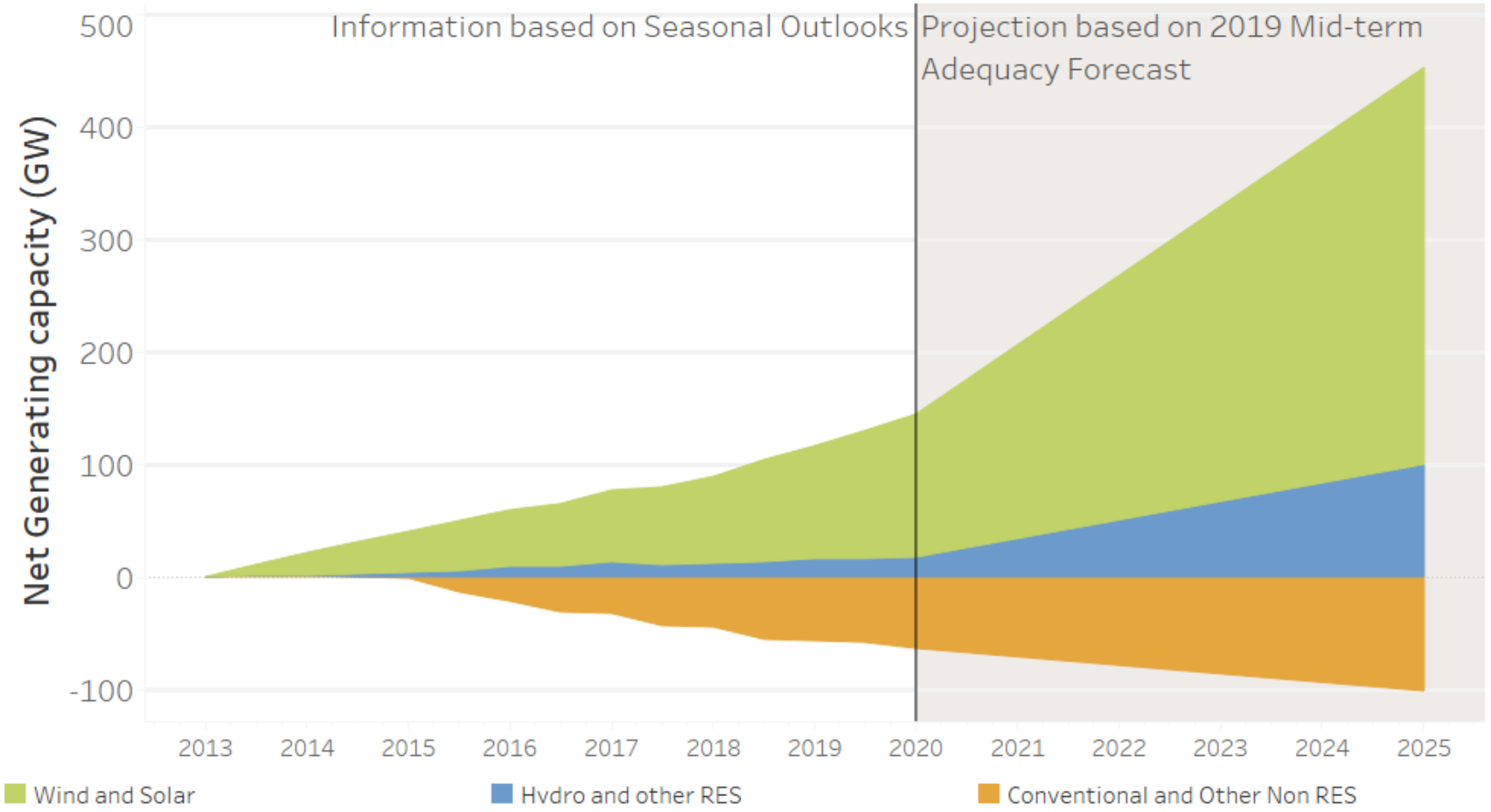
Cumulated capacity change



Source: ENTSO-E Seasonal Outlooks and MAF

Phasing out of conventional generation

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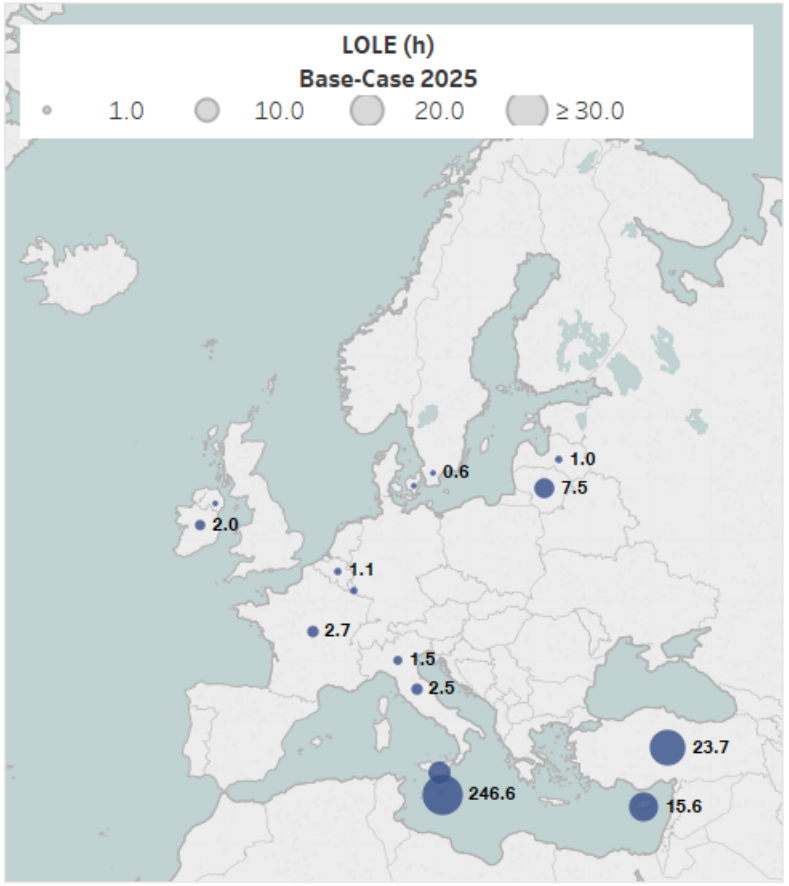
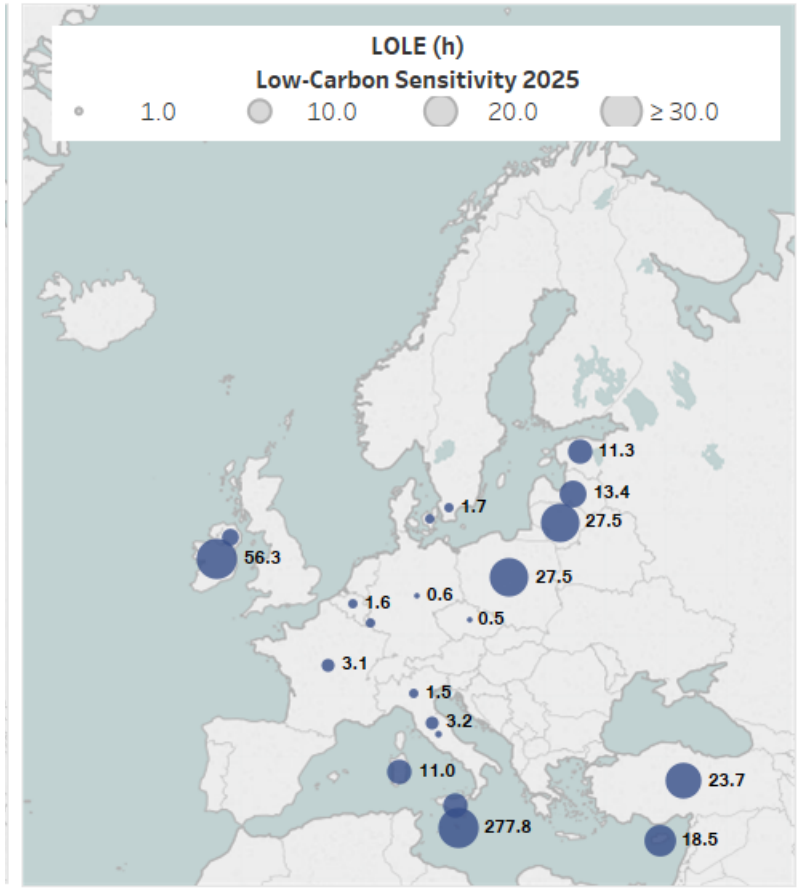
A *stress-test scenario* with further reduction of conventional thermal generation in 11 countries for 2025





Comparison of LOLE* between the base-case and the low-carbon sensitivity in 2025. The circled and the corresponding values used in the legend are only indicative and do not cover the whole range of circle radius and LOLE values that are represented in the maps – e.g. only circles corresponding to radii above 0.5 h are presented.

** Loss of Load Expectation (LOLE) is the expected number of hours per year with adequacy risk*

Source: ENTSO-E MAF 2019

Power systems in need of flexibility

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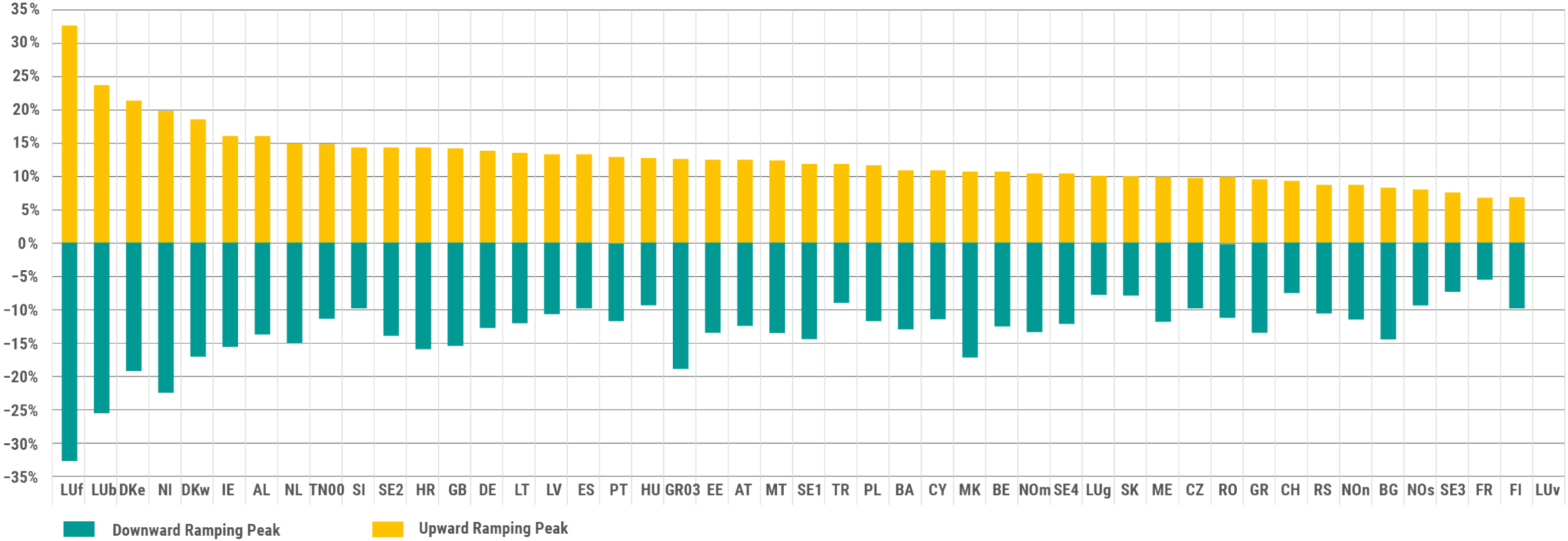
Power systems ramping needs calculated for Year 2025

- Hourly residual loads indicate high flexibility needs
- Need for flexibility increases to cope with the variability of RES



Source: ENTSO-E

TSO regional coordination supporting a smoother transition

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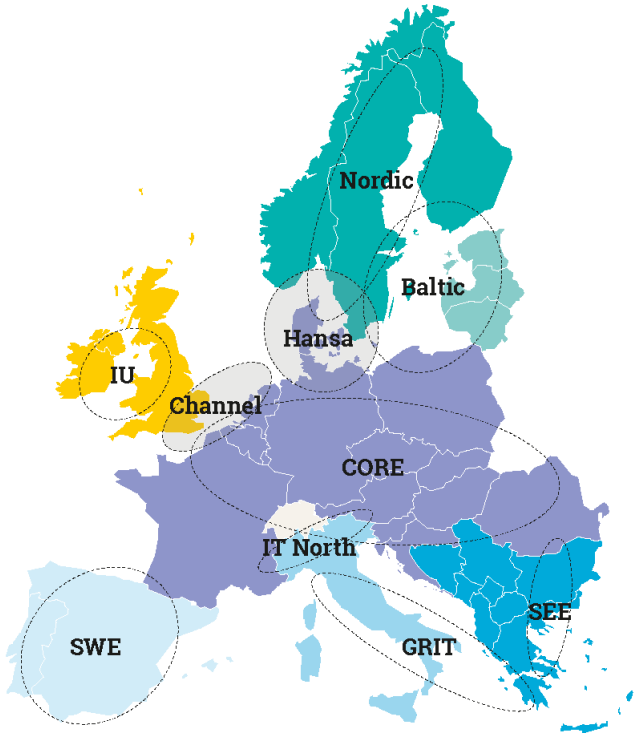
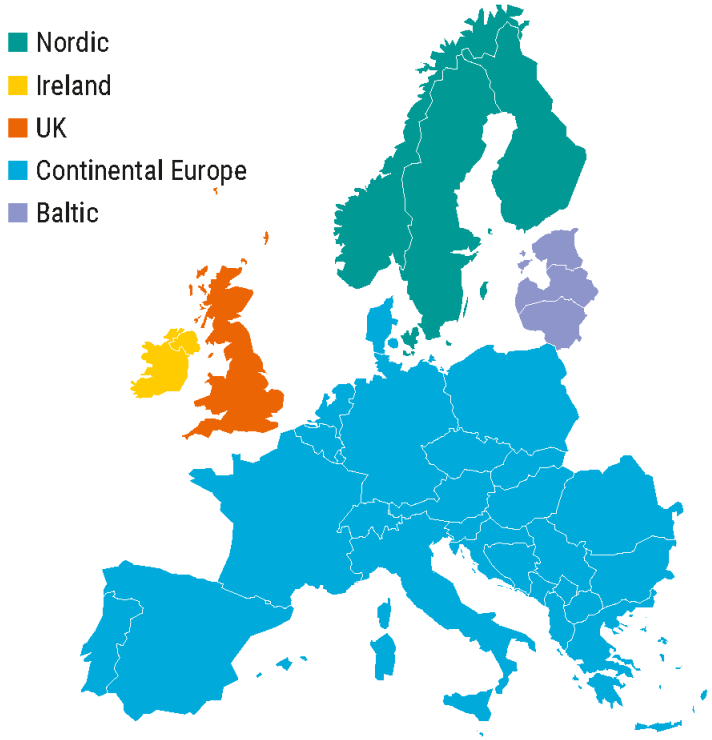
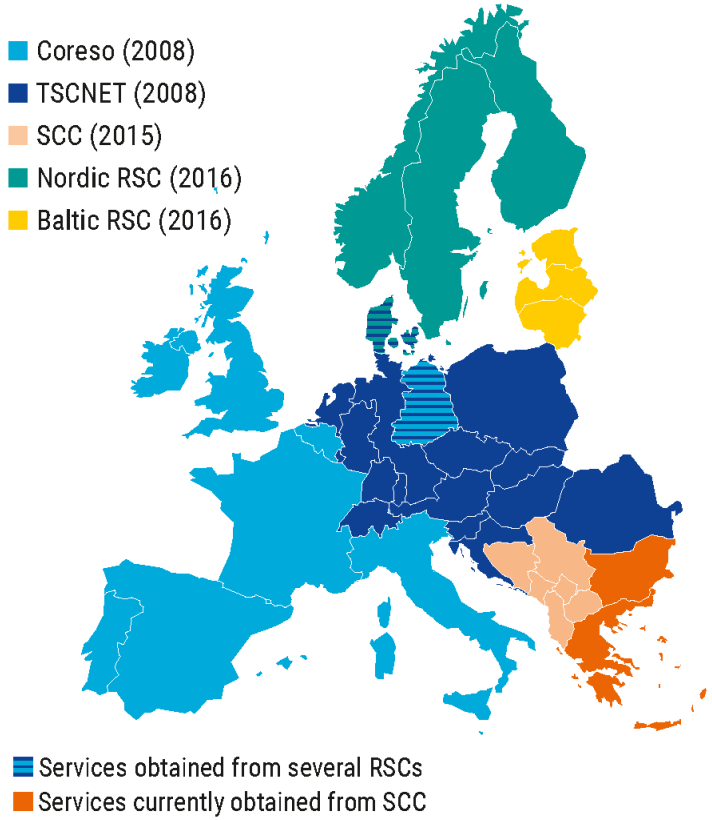
10 CCRs



5 Synchronous Areas



5 RSCs



State of play of TSOs' regional coordination in markets and system operations.

Source: ENTSOE report Enhanced TSO Regional Coordination for Europe

TSO coordination supporting operations and markets

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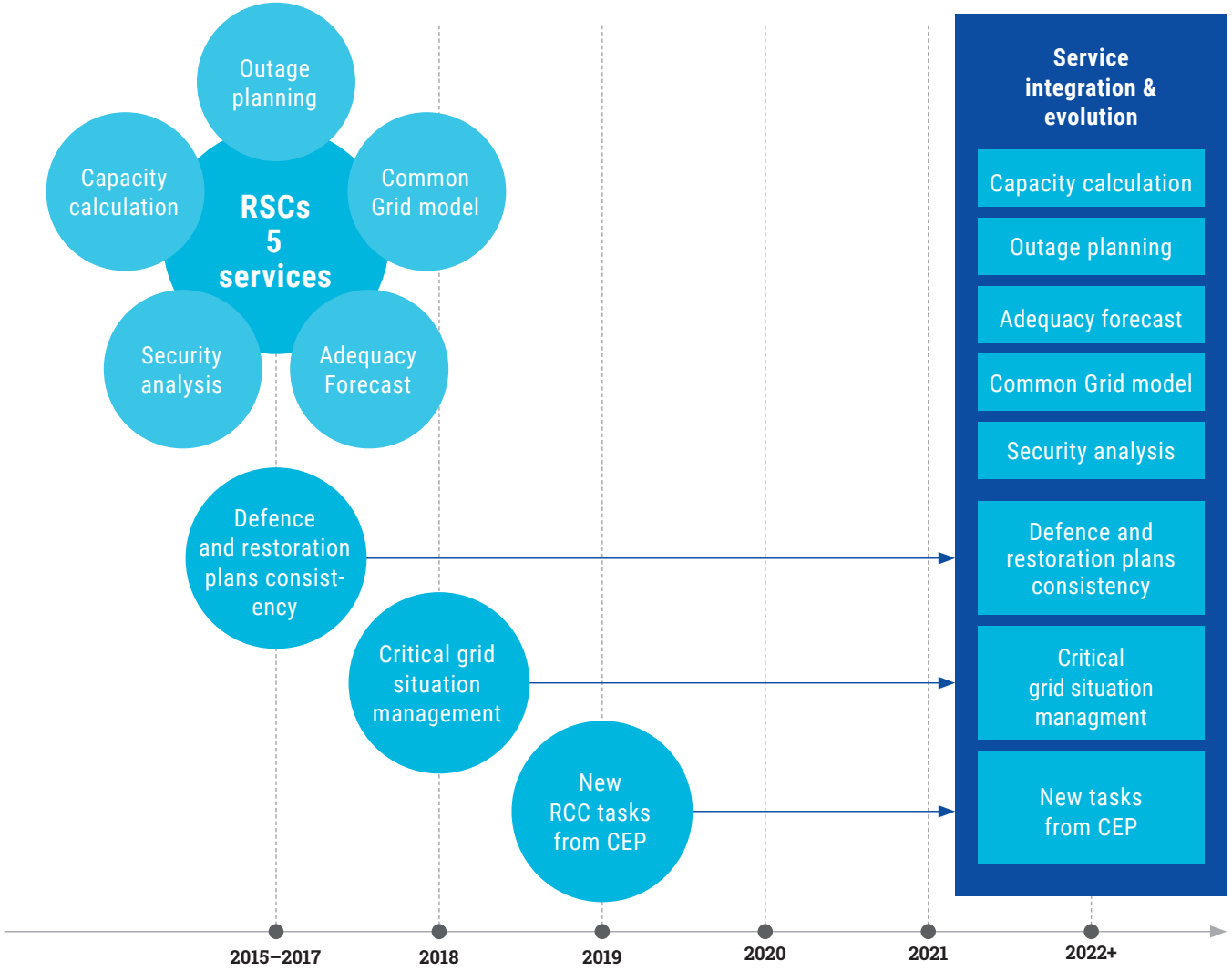
Timeline refers to entry into force and implementation of relevant network codes, all TSO decisions, and CEP regulation.



Source: ENTSOE report Enhanced TSO Regional Coordination for Europe

Zoom on Common Grid Model

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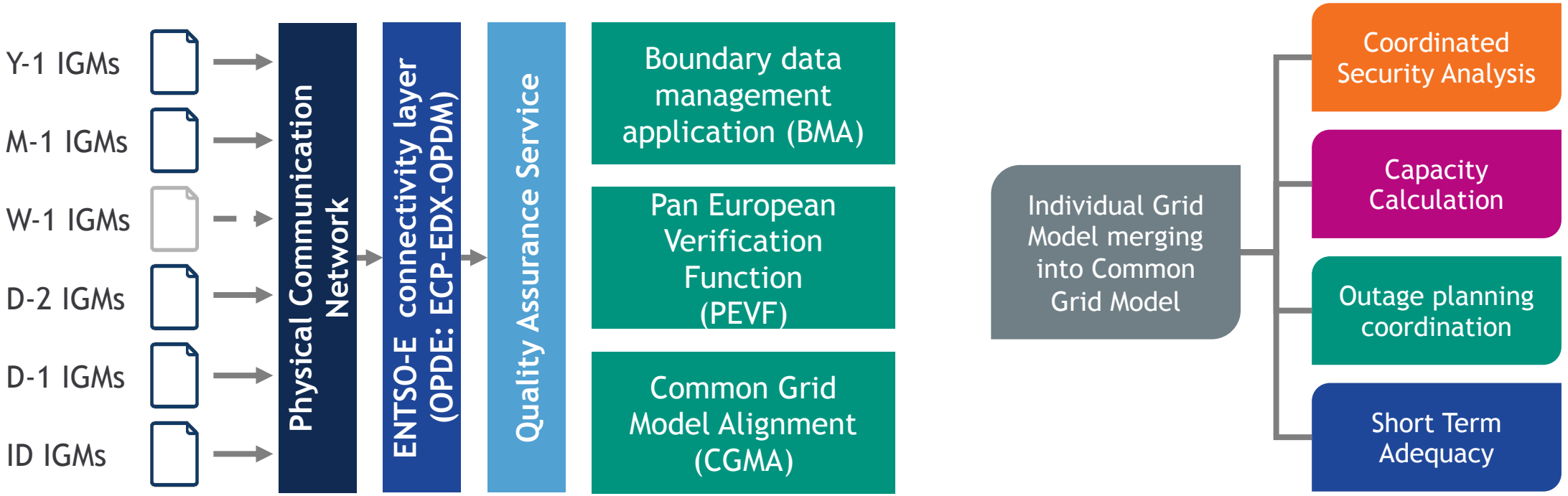
Integration of CGM Programme, TSOs and RSCs is key for an integrated system for a more secure, cleaner and cost efficient European energy market



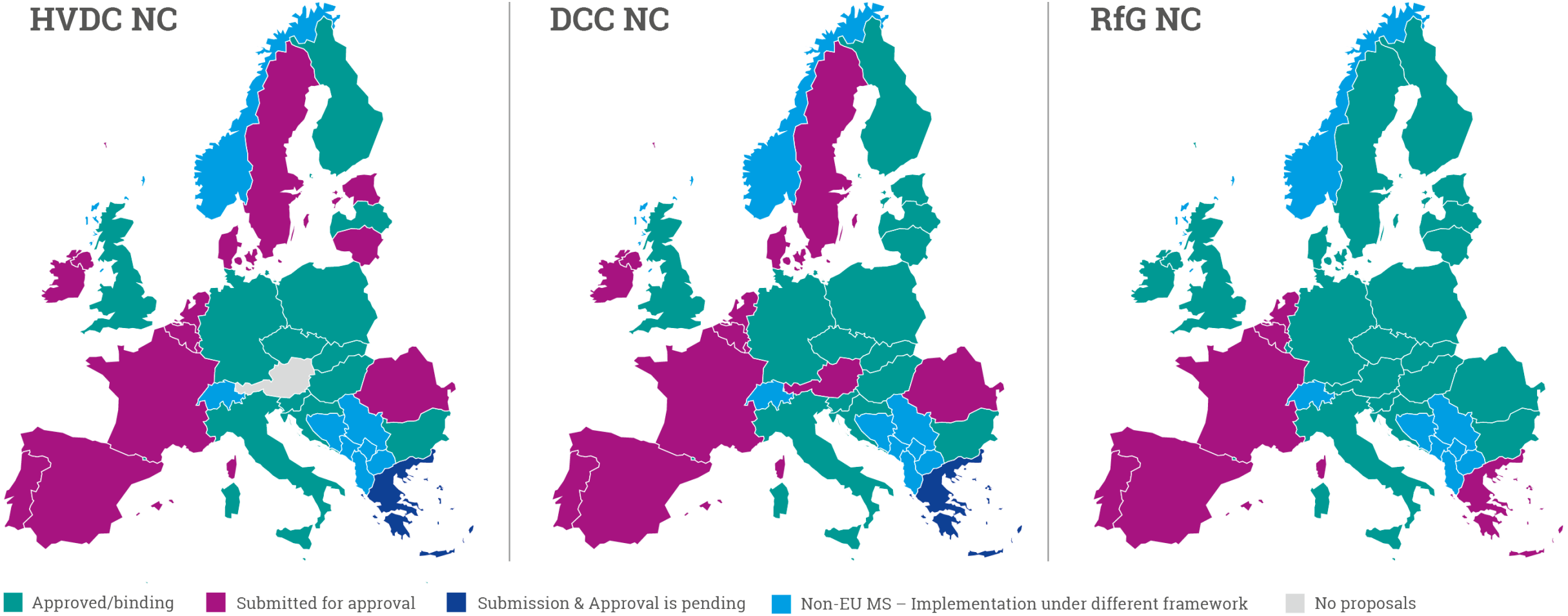
TSOs

CGM Programme

RSCs

Zoom on Connection Codes

Implementation of network codes support system reliability



Source: ENTSO-E Active Library

Key takeaways

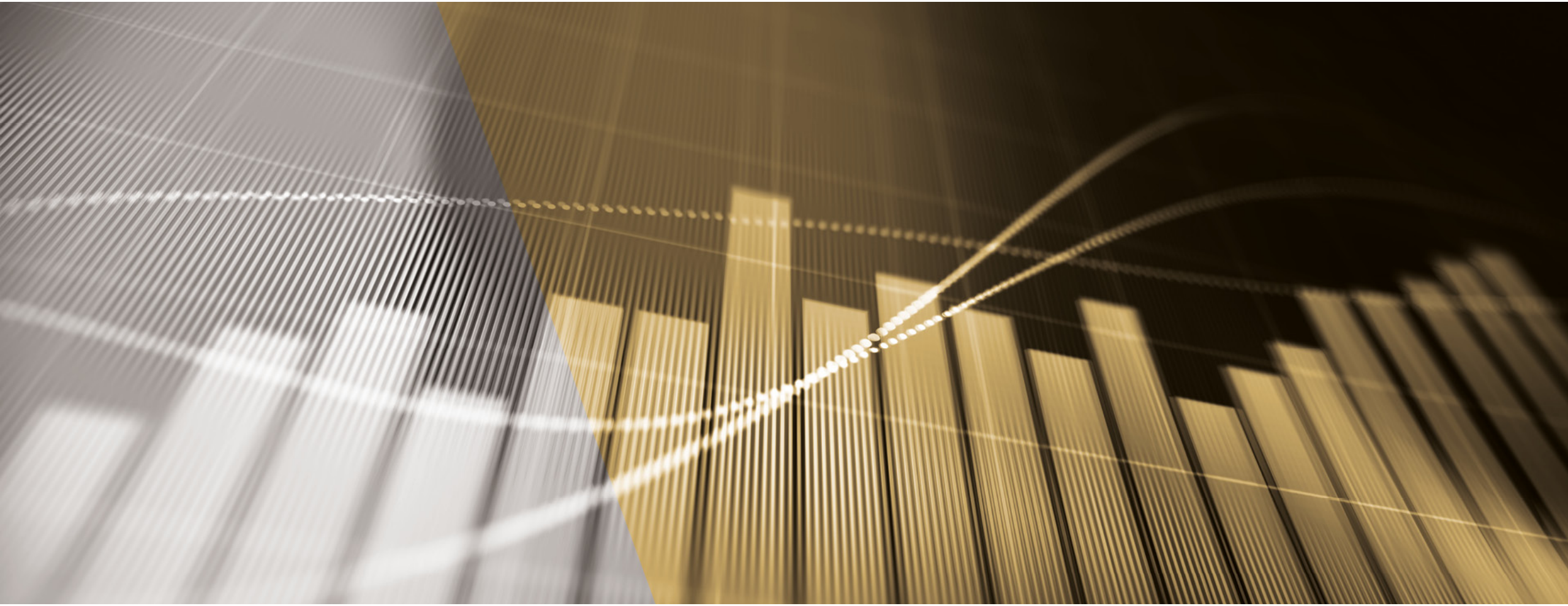
Variable generation integration & decommissioning of conventional generation are challenging for the system, for example with respect to the availability of inertia.

The transparency on incidents increased, like the 10 January 2019 example shows, demonstrating rapid and efficient reaction and coordination by TSOs and role of flexible demand

Regional TSO coordination is a building block for more secure operations and efficient markets in Europe & RSCs are increasing in maturity, developing new services in line with the CEP

Network codes implementation is progressing and is increasing security of the system as a whole

Core Chapter 3 - Market Integration



Massive physical energy flows across Europe

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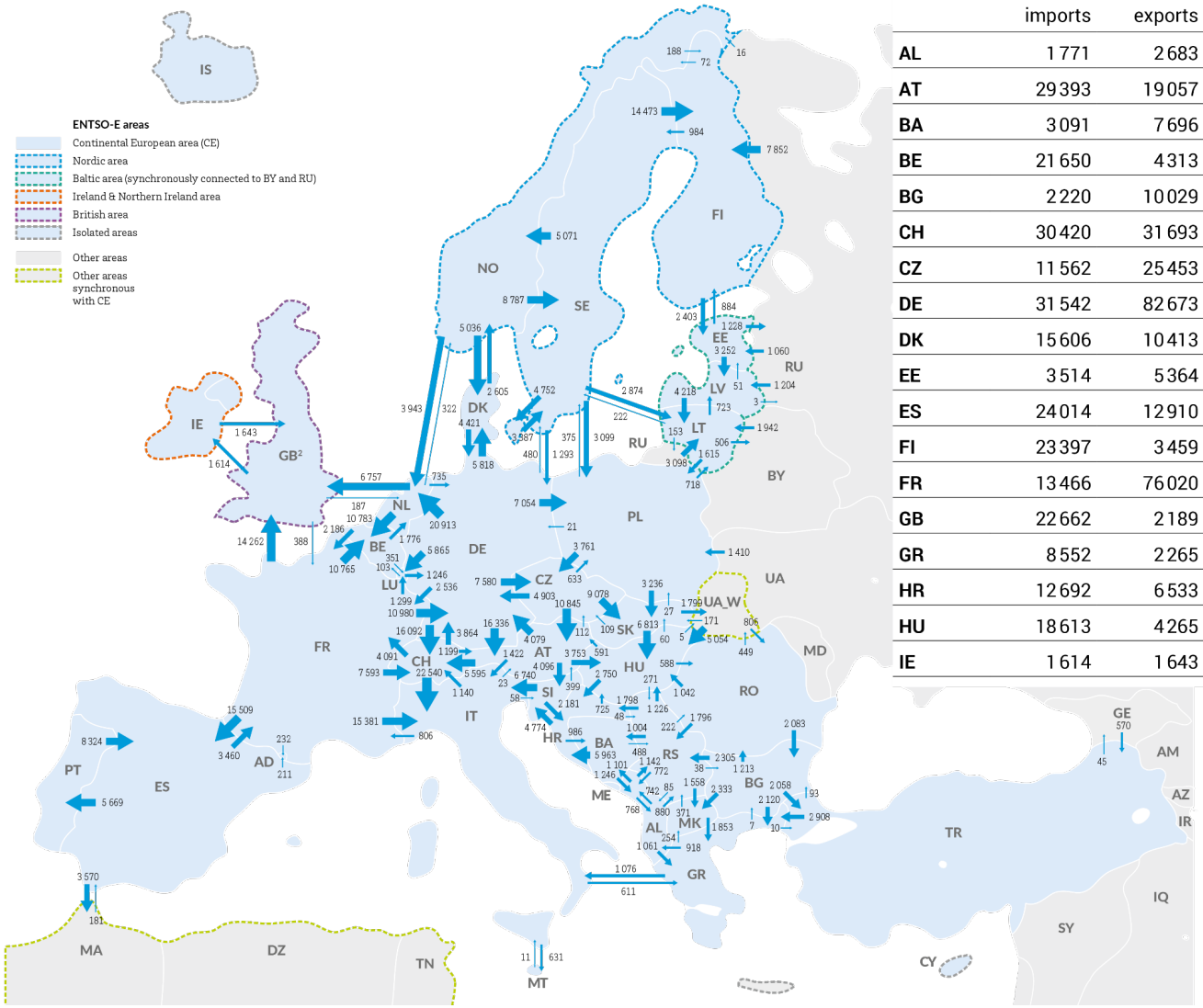
GWh average over the year



	Sum of imports	Sum of exports	Balance (imp – exp)
AL	1 771	2 683	−912
AT	29 393	19 057	10 336
BA	3 091	7 696	−4 605
BE	21 650	4 313	17 338
BG	2 220	10 029	−7 809
CH	30 420	31 693	−1 274
CZ	11 562	25 453	−13 891
DE	31 542	82 673	−51 131
DK	15 606	10 413	5 193
EE	3 514	5 364	−1 850
ES	24 014	12 910	11 104
FI	23 397	3 459	19 938
FR	13 466	76 020	−62 554
GB	22 662	2 189	20 473
GR	8 552	2 265	6 288
HR	12 692	6 533	6 160
HU	18 613	4 265	14 348
IE	1 614	1 643	− 29

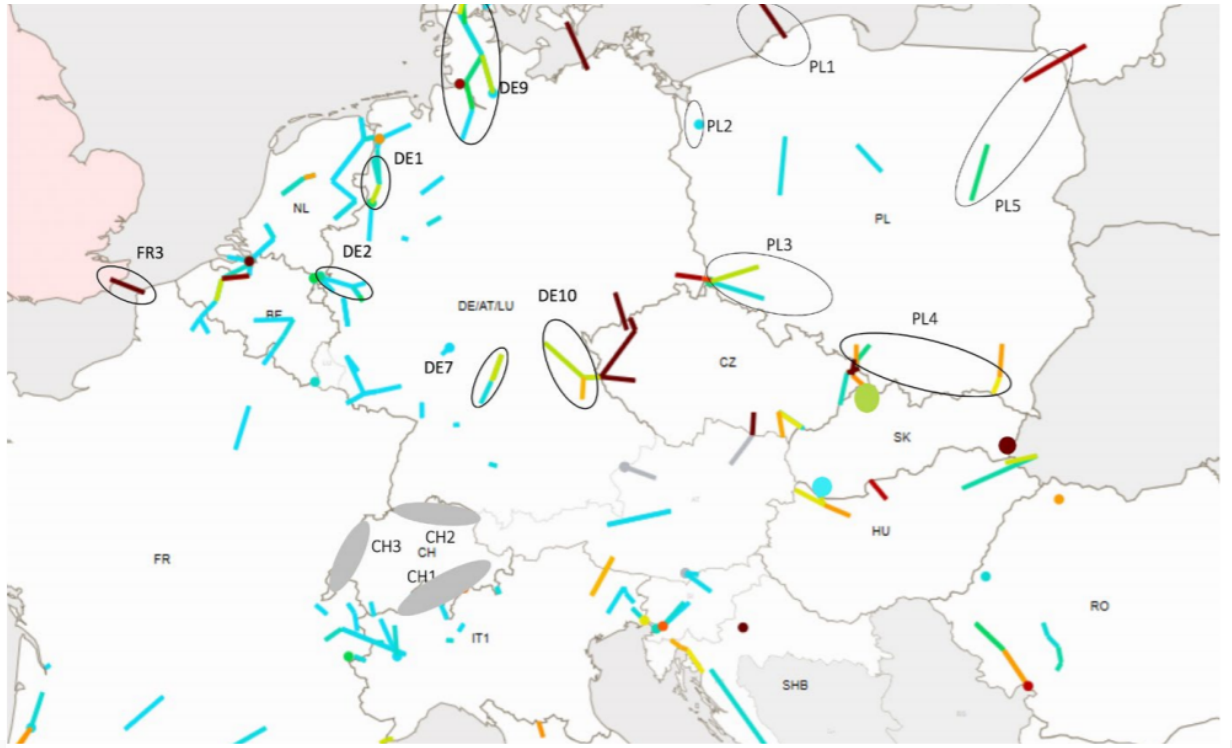
	Sum of imports	Sum of exports	Balance (imp – exp)
IT	47 169	3 268	43 902
LT	12 850	3 219	9 631
LU	7 514	1 349	6 166
LV	5 179	4 272	907
ME	2 760	3 011	−251
MK	4 144	2 224	1 921
NL	26 818	18 596	8 223
NO	8 085	17 954	−9 869
PL	13 839	8 121	5 718
PT	5 669	8 324	−2 655
RO	2 829	5 370	−2 541
RS	7 300	6 703	597
SE	14 234	31 561	−17 328
SI	8 928	9 320	−392
SK	12 544	8 747	3 797
TR	2 638	3 046	−408
ENTSO-E	**458 274**	**443 734**	**14 540**

Physical flow values in GWh

Source: ENTSO-E Statistical Factsheet 2018

Congestions are a reality

Capacity Calculation for the Day Ahead timeframe for the year 2017 and for Central Europe



Congestion frequency – percentage of total hours of the year

> 0 | 4 | 7 | 11 | 14 | 18 | 21 | 25 | 28 | 32 | >35 %

Grid

Coloured bubble – represents single or group of congestions (applied for ES, SK, CH and BG)

Coloured line or dot – represents single congestion
(line – transmission line, dot – transformer, substation or transmission line whose length is under 10 km)

Grey bubble, line or dot – congestion reported and frequency not available

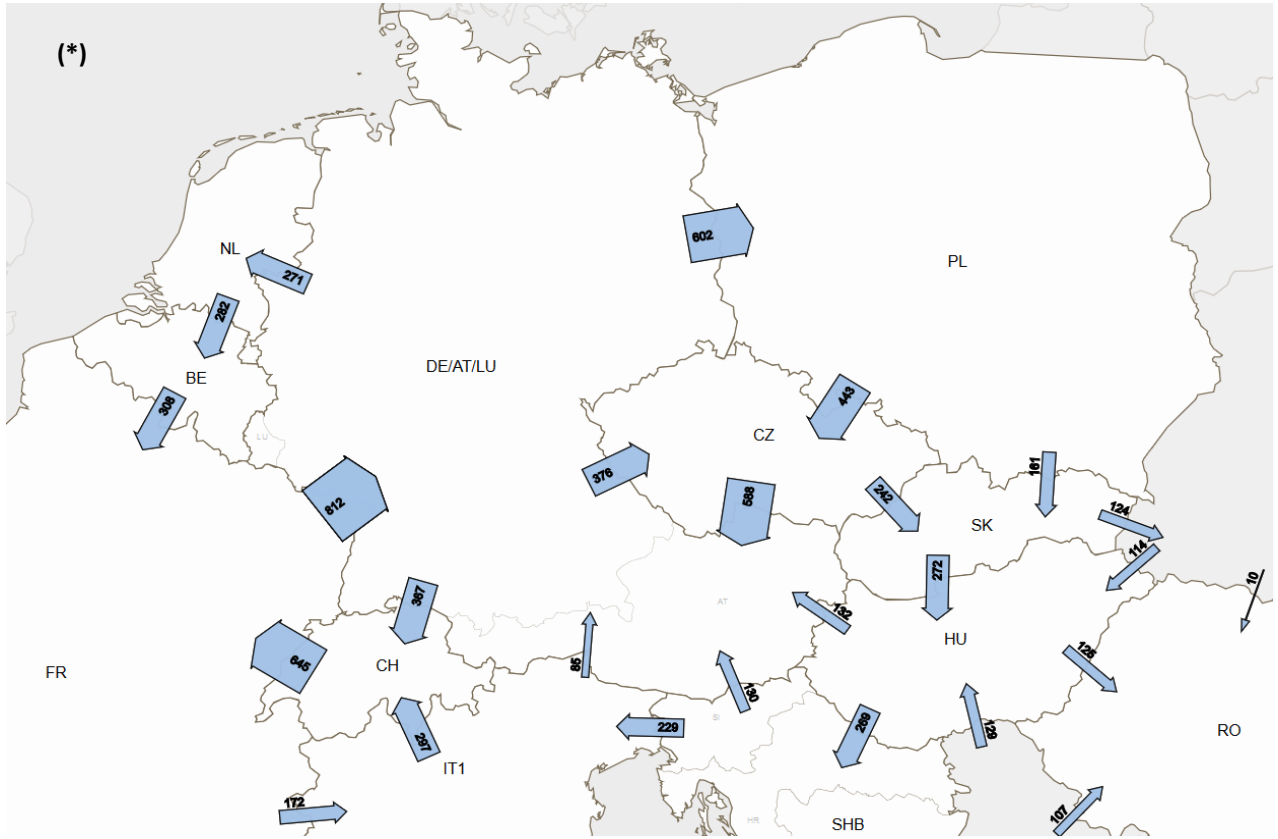
Countries

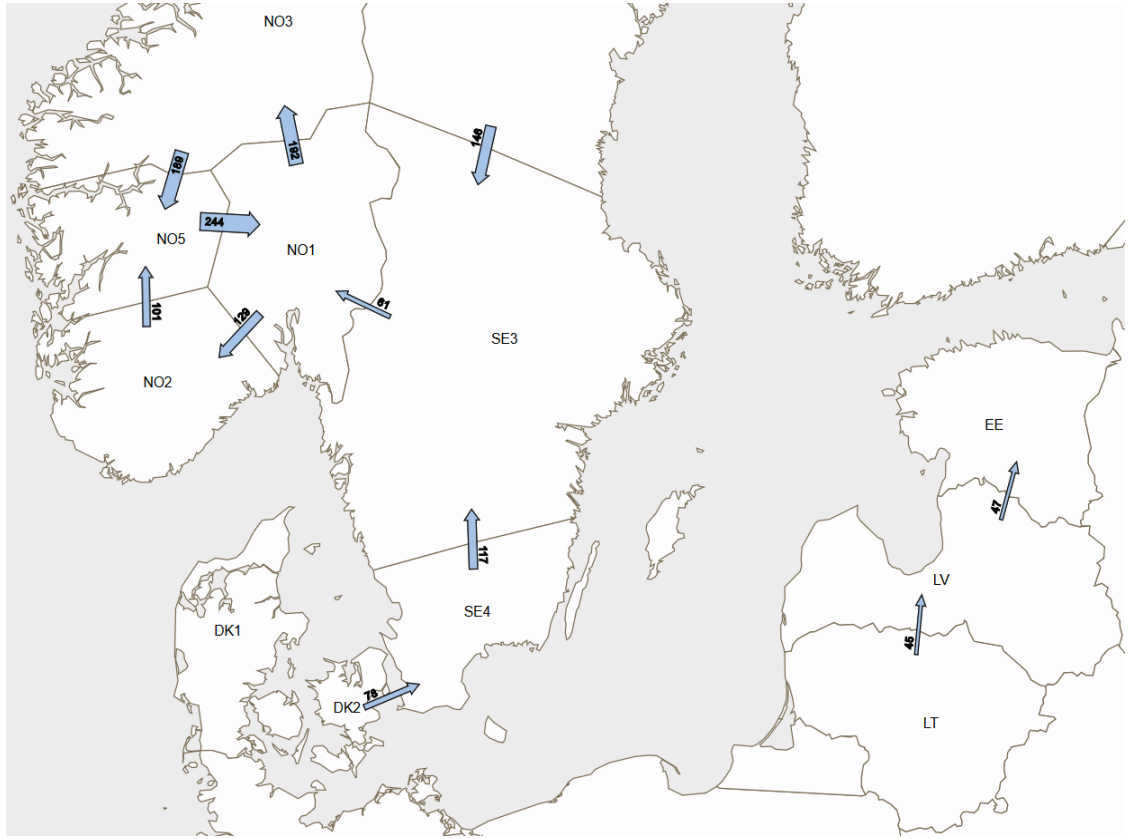
- Data available
- Data not available
- The concerned process is not performed
- Data is not complete

Source: ENTSO-E Bidding Zone Technical Report 2018

Flows not resulting from the capacity allocation

(loopflows and unscheduled flows)





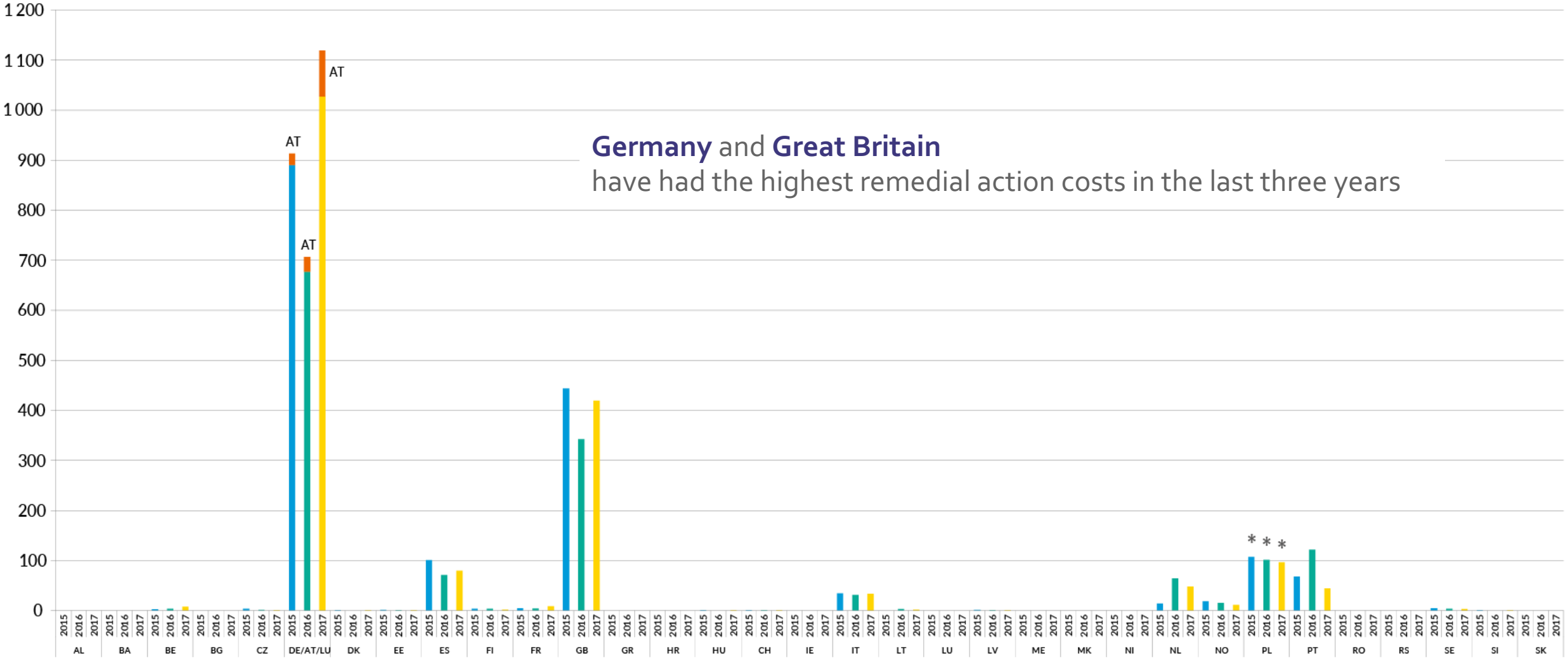
- Commercial transactions are physically realised by power flows distributed in the grid as per the law of physics
- Those power flows also include loopflows and unscheduled flows which cannot be ignored

*Average PTDF Flow Indicator for 2017 (in MW)

Source: ENTSO-E Bidding Zone Technical Report 2018

Transparency on costs related to congestions

Remedial action costs in 2017

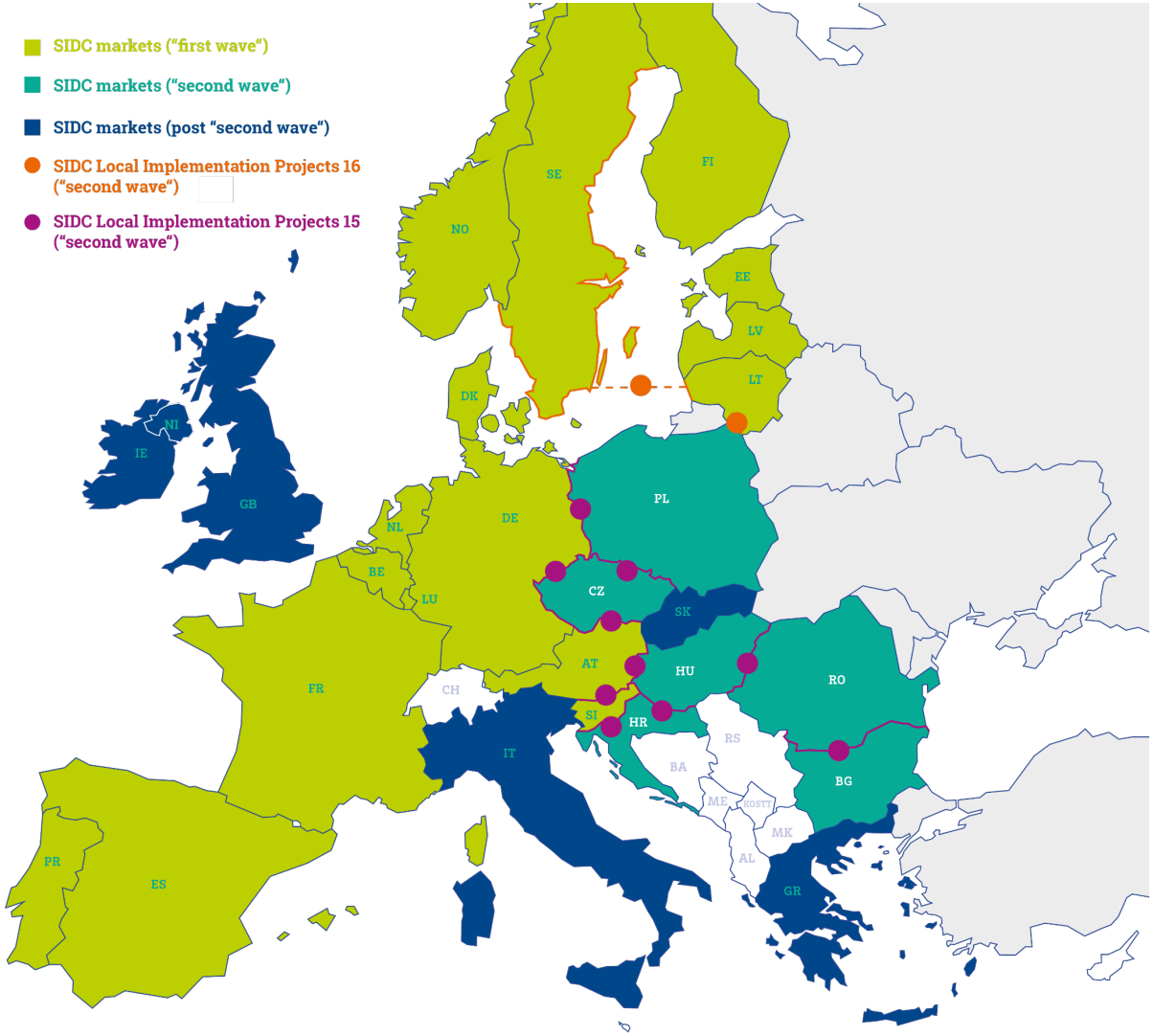


Germany and **Great Britain**
have had the highest remedial action costs in the last three years

Source: ENTSO-E Bidding Zone Technical Report 2018

Market integration: the Single Intraday Coupling

Current state-of-play of SIDC with the different waves depicted (as of July 2019)



XBID

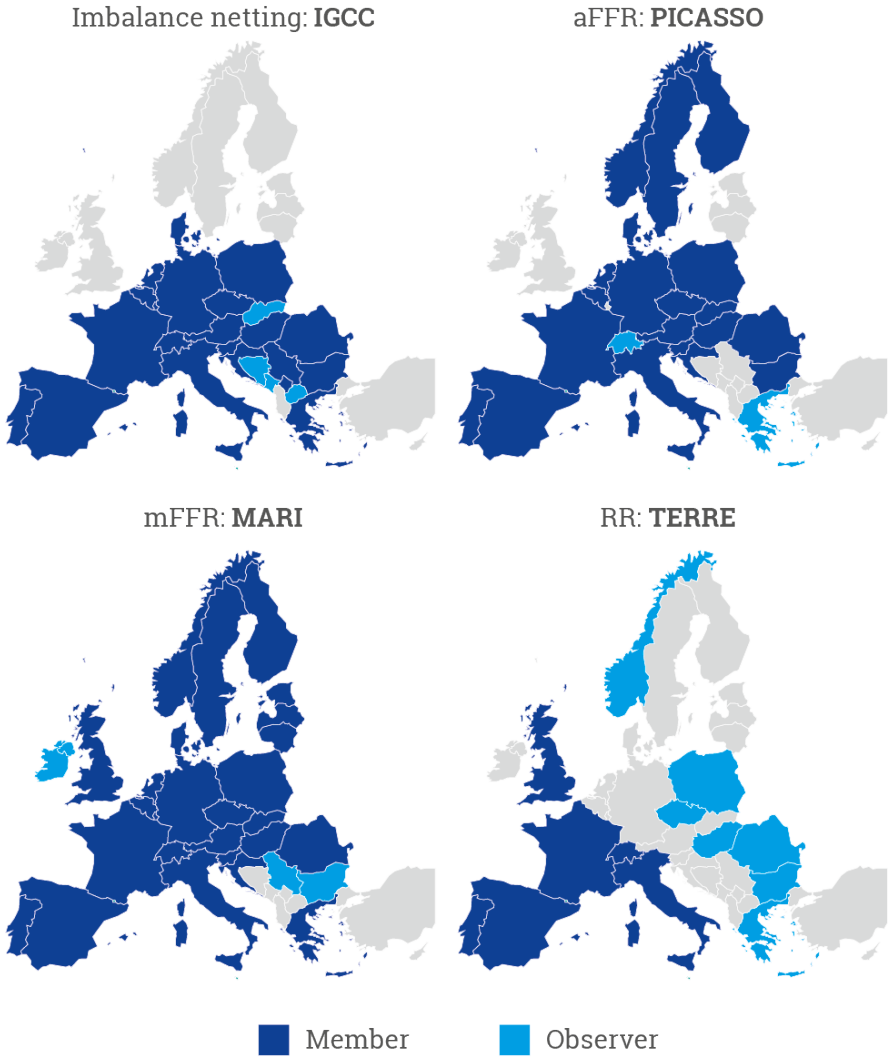
The SIDC was implemented through the **XBID (Cross-Border Intraday) project.**

The **first go-live in June 2018** included 14 countries: Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Latvia, Lithuania, Norway, The Netherlands, Portugal, Spain and Sweden.

Second go-live in November 2019 with 7 further countries – Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania and Slovenia.

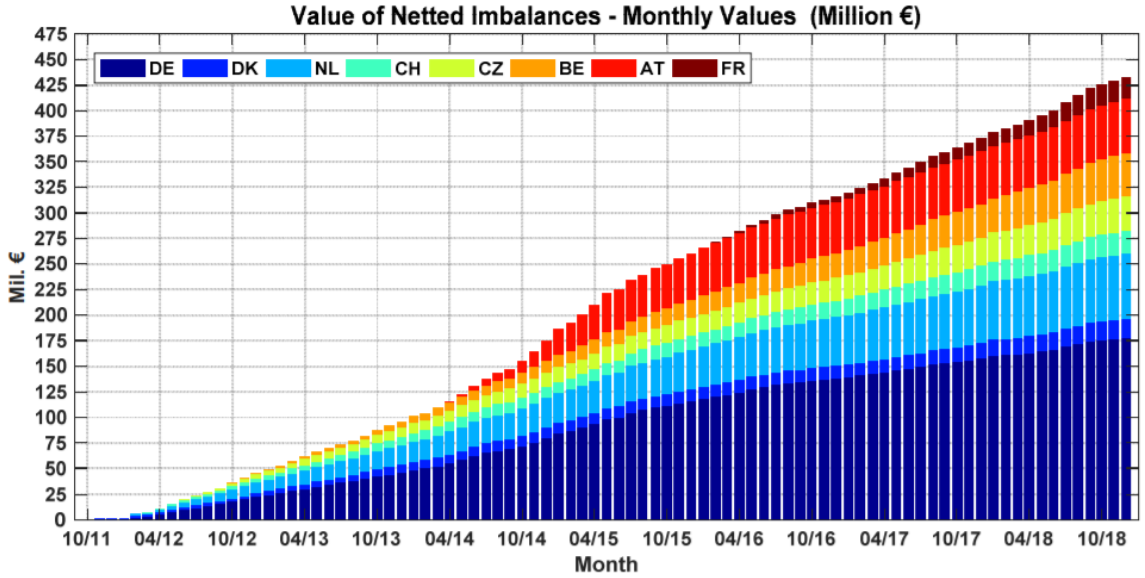
Source: ENTSO-E Market Report 2019

Market integration: Balancing markets



Major milestone achieved in 2018 in integrating balancing markets: TSOs submitted **eight proposals** establishing the high-level design of European platforms for the exchange of balancing energy products and for the imbalance netting process.

Substantial savings for consumers: the cumulative value of netted imbalances for 2018 through IGCC amount to approx. EUR 60 million.



Imbalance netting: IGCC
aFFR - Automatic frequency restoration reserve: PICASSO
mFRR - Manually activated frequency restoration reserve: MARI
RR - Replacement Reserves: TERRE

Source: ENTSO-E Market Report 2019

Balancing markets harmonization ongoing

Frequency Restoration Reserve (Automatic) – Energy-Procurement Scheme

Definiton of question

Procurement Scheme	Background to the offer, which is closest to the real operation time

Definition of answer

Hybrid	Combination
Mandatory only	Generators connected to the grid are obligated to reserve a certain amount of capacity in oder to meet TSO requirements, for a fixed price set by TSO, NRA or for free.
Market only	There is no contract or obligation for a grid user to offer the reserve (before the offer). The grid user can voluntarily participate in the market (e.g. tender, auction, market platform (like PX)) and bid a price or customise his offer (e.g. the volumes, timeframe). The market result may lead to a bilateral contract.

Missing data
N/A
Market only
Mandatory only
Hybrid

Source: ENTSO-E Survey on Ancillary services procurement, Balancing market design 2018

Network codes implementation milestones

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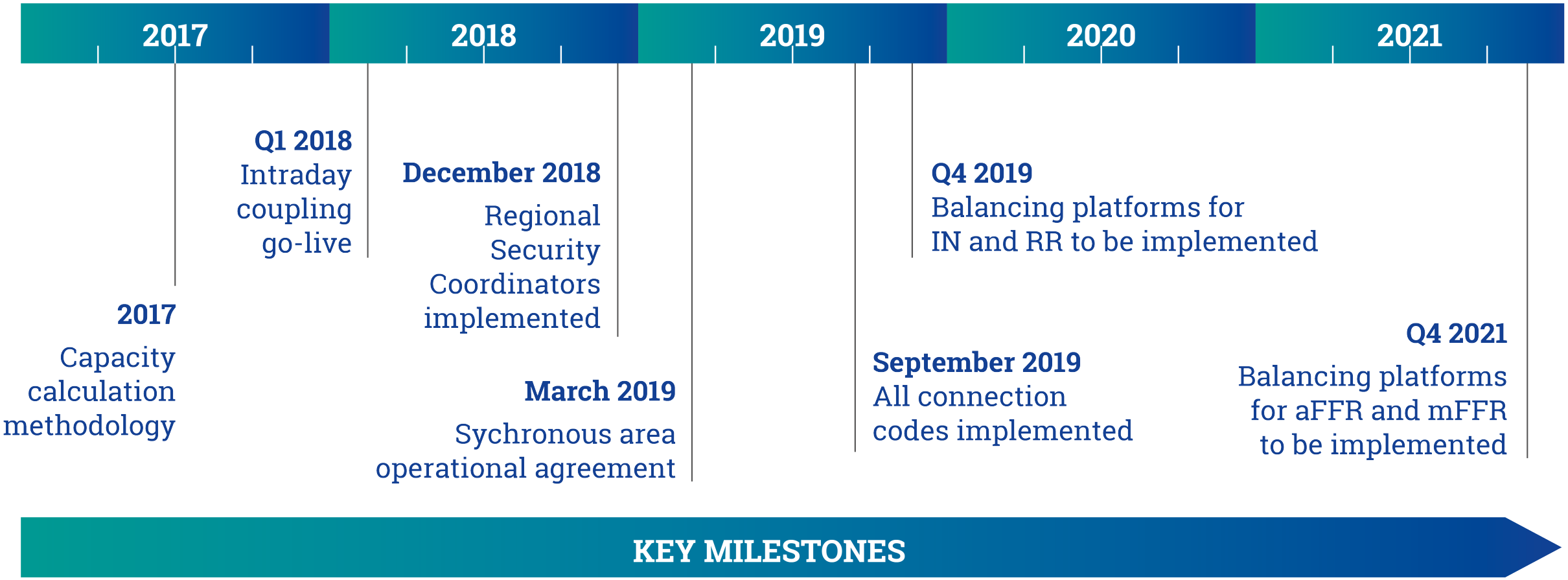
Network code implementation is ongoing



Source: ENTSO-E

Key takeaways

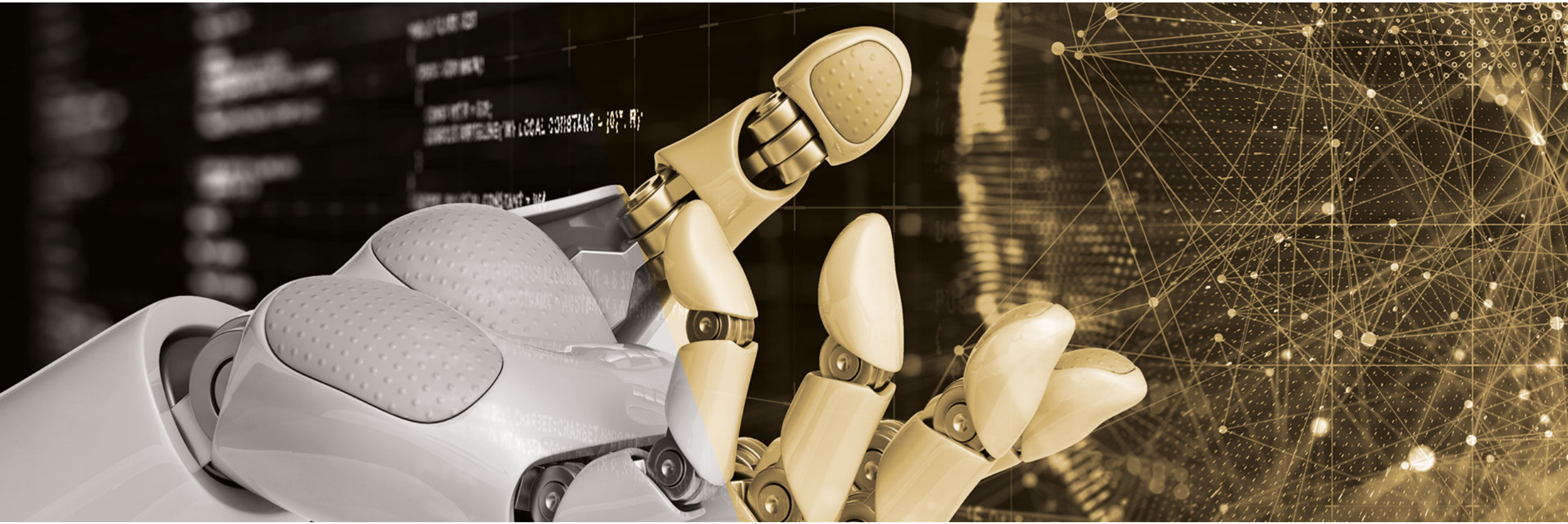
Several achievements have to be stressed for the Power Facts report period: the Transparency platform was upgraded, XBID was put in place, and balancing markets start to take off.

The CEP has added several new mandates to the To-Do List of ENTSO-E and TSOs, such as CRM, bidding zone methodologies etc. TSOs supported by the RSCs are working hard to implement the Capacity Calculation Methodologies, the IT and monitoring developments, changes on the operational process, etc. It is a very busy period for TSOs with this very short and tight deadline.

Transparency has increased, as the example of transparency of congestion costs or capacity calculation in CWE shows. TSOs are regulated entities that are subject to NRAs scrutiny. NRAs had always access to all TSOs data and calculation.

Focus Areas

- TSO-DSO flexibility projects and integrated system management
- Cyber physical grid, innovation & transparency



TSOs contribute to many TSO-DSO flexibility projects and integrated system management pilots

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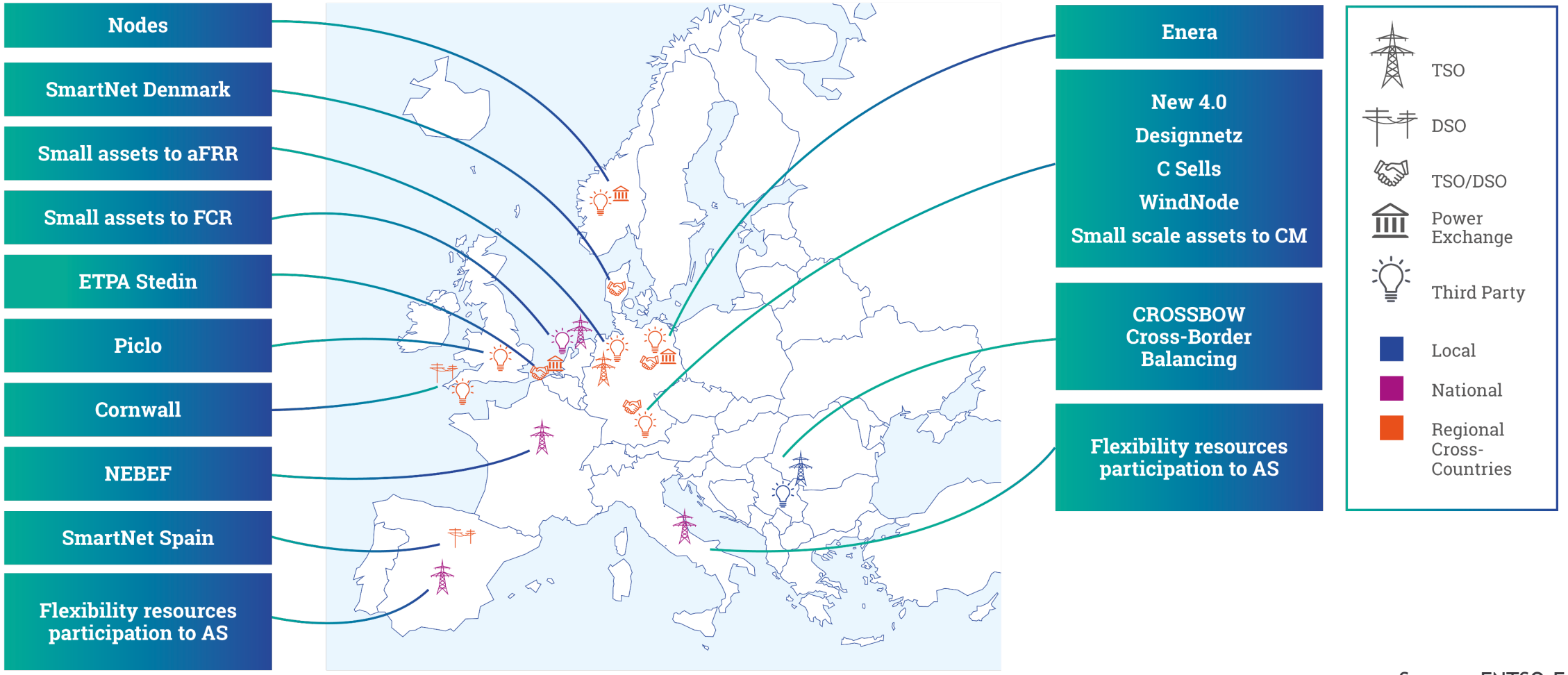
Distribution of the projects related to flexibility services



Source: ENTSO-E

TSO-DSO flexibility projects and integrated system management are a reality all across Europe and deal with markets, technical solutions, data management and aggregation

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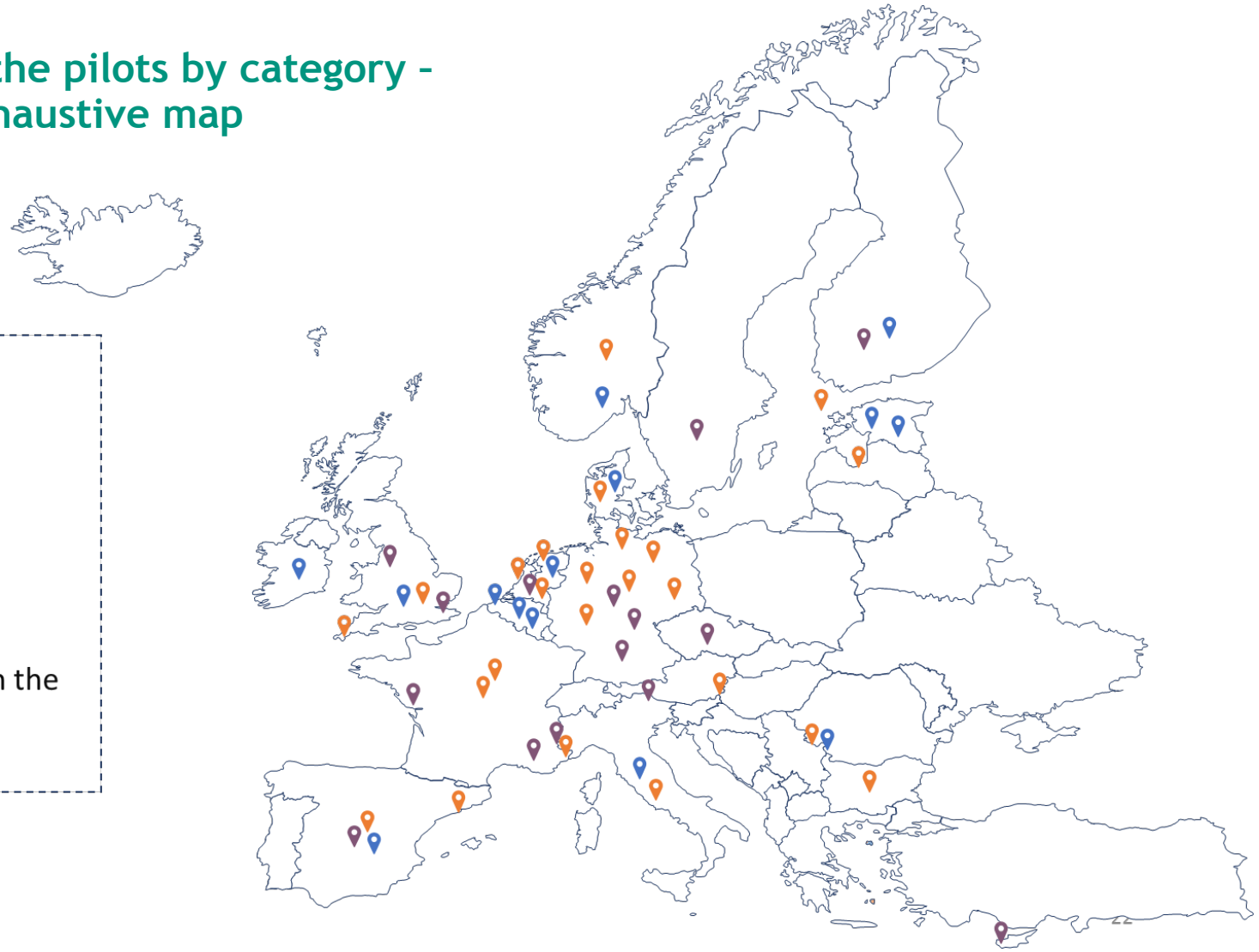
Geographical scope of the pilots by category - illustrative and non-exhaustive map



Categories of the pilots:

- Flexibility Market Places
- Data Exchange
- Technical Solutions
- Assets aggregation (not in the map as covering all European countries)

Source: ENTSO-E

TSOs bet on innovation on a European scale as their participation in EU projects show

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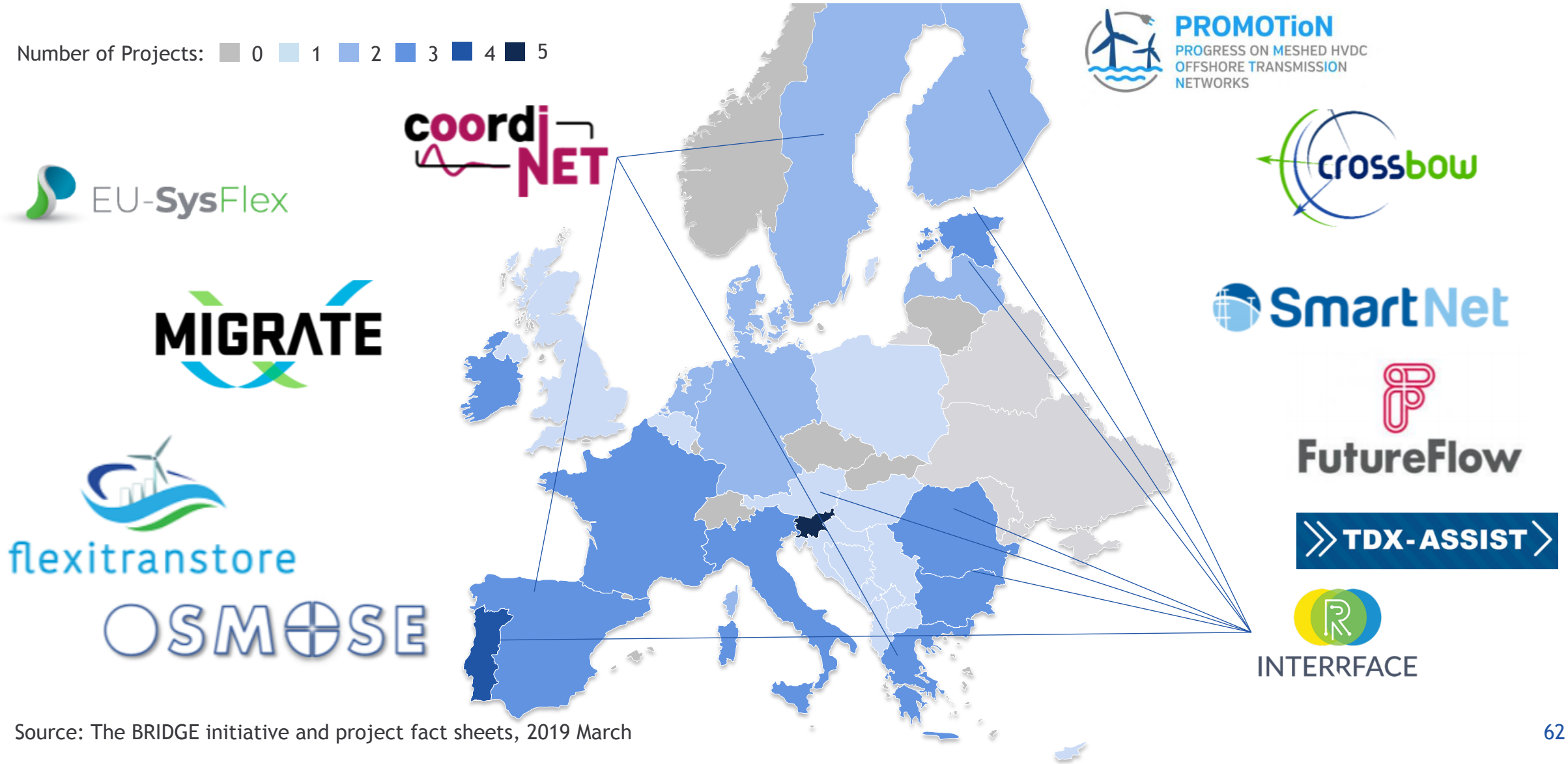
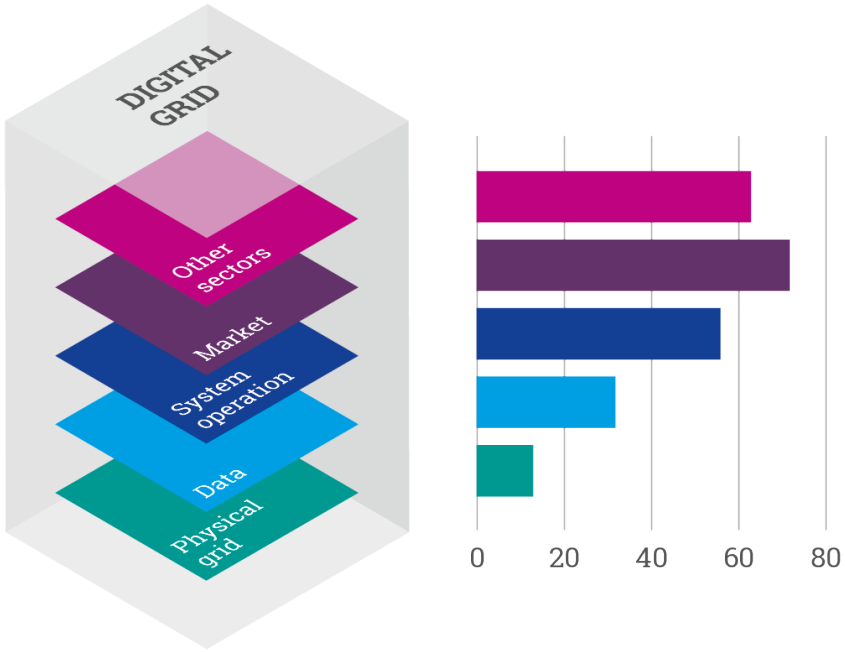


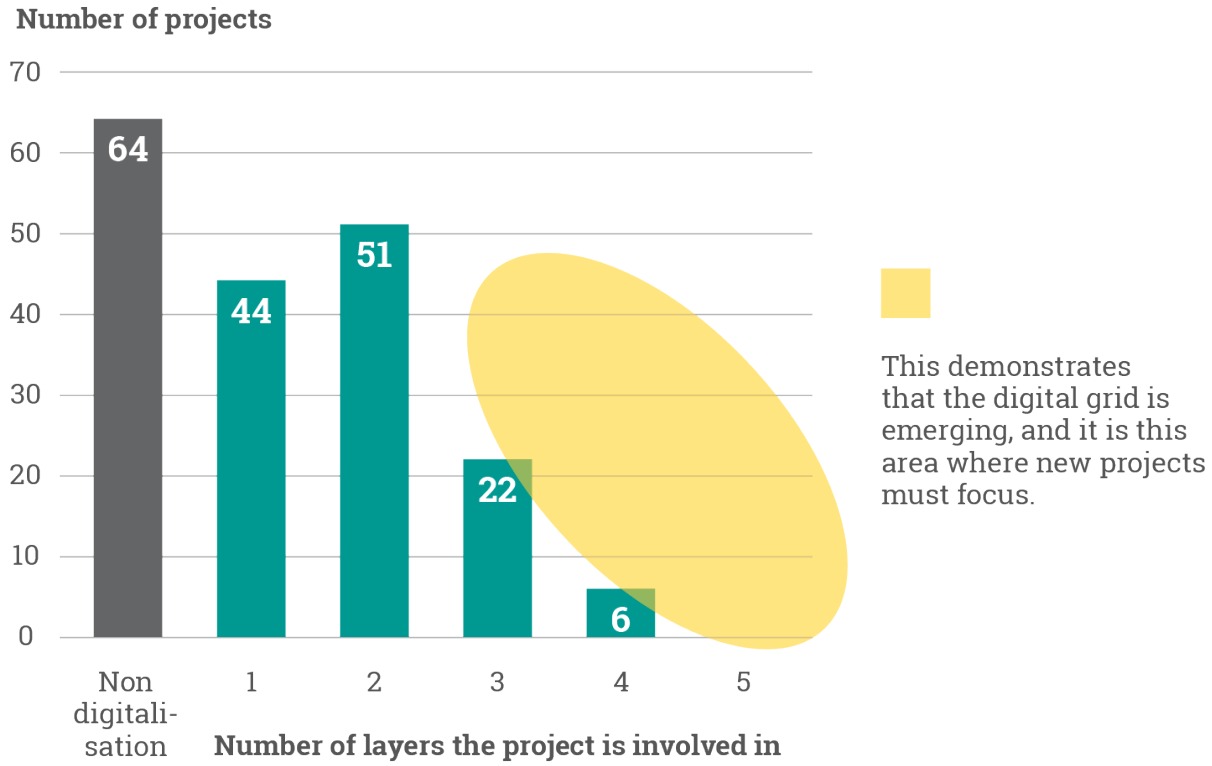
Source: The BRIDGE initiative and project fact sheets, 2019 March

The grid transforms into a Cyber Physical one

Number of digitalisation projects per layer of the Digital Grid

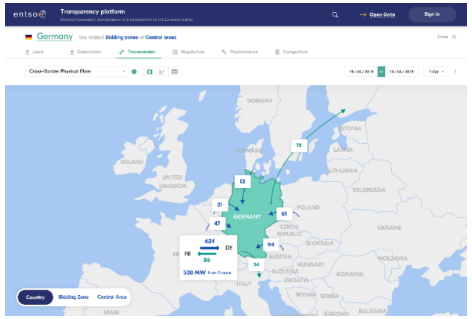
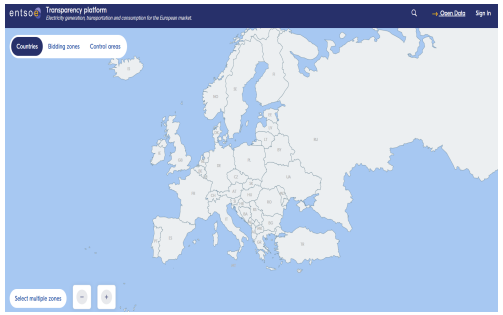
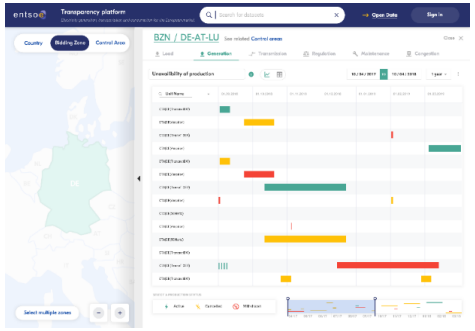
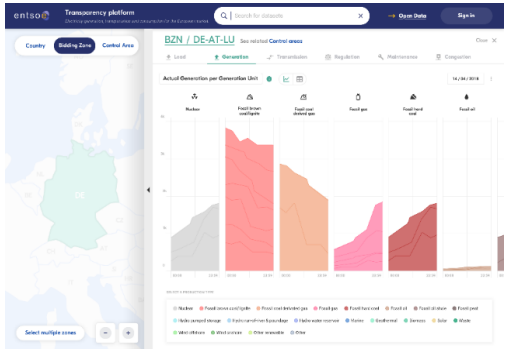
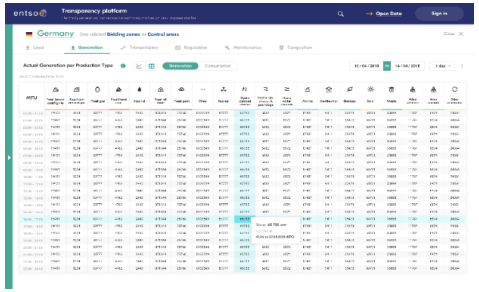
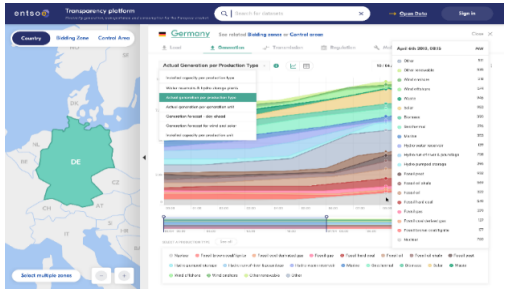


Number of digitalisation projects across Digital Grid layers



Source: ENTSO-E Digital Report

ENTSO-E Transparency Platform new user interface makes it more user-friendly and data easily accessible

Proof of Concept (PoC) for the new Graphical User Interface (GUI), named New Transparency open for user feedback on https://newtransparency.entsoe.eu

PoC is currently limited in terms of functionalities, in any case, there will more additions to it in future.

Following screens are accessible, under PoC:

Actual generation per production type	Unavailability of production and generation units	Cross-border physical flows	Actual generation per generation unit

Landing page and Load domain will be deployed by December 2019, and rest of the other domains by 2020.

Source: ENTSO-E Digital Report

The user community of the Transparency Platform is consolidating, after a steep increase

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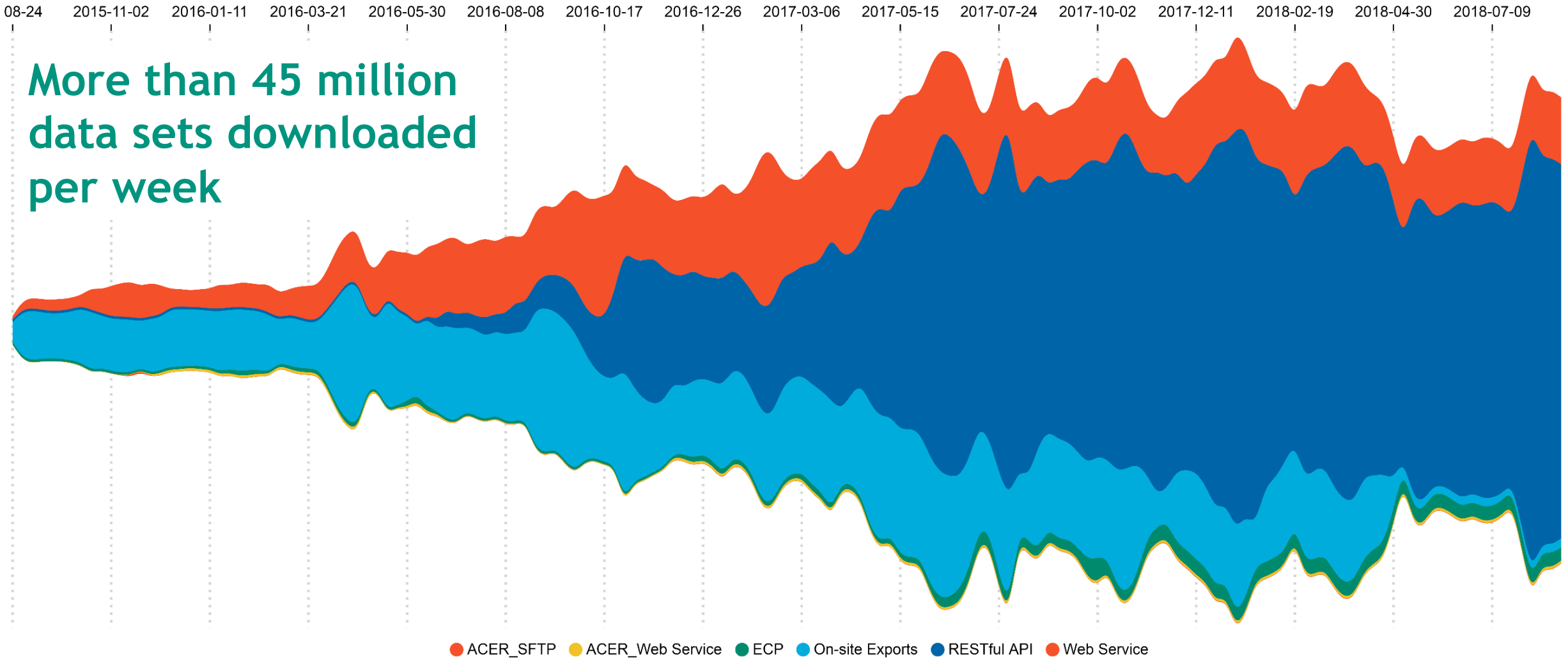
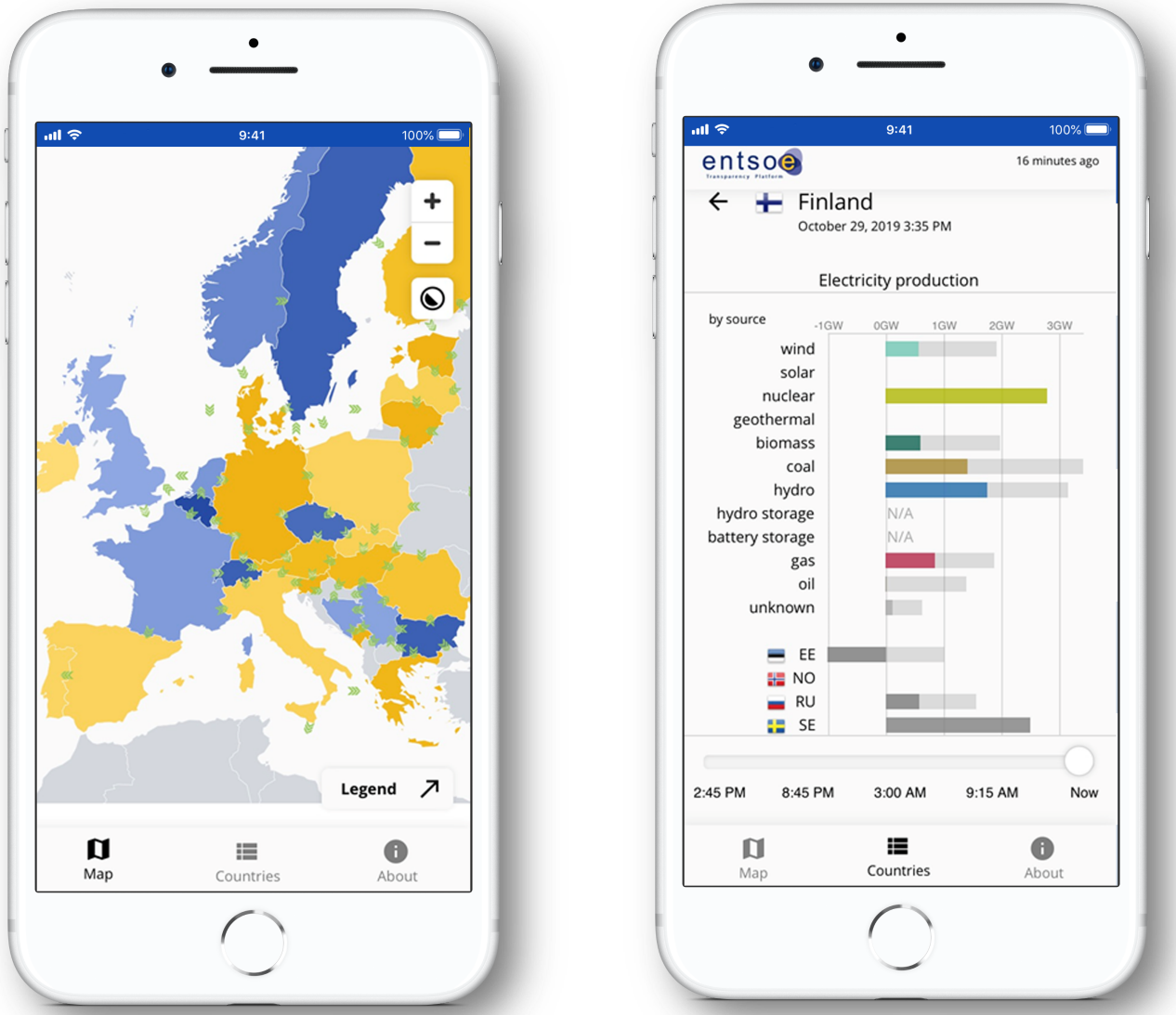


Source: ENTSO-E

ENTSO-E Transparency Platform App



Live access to a summary of the data from the ENTSO-E Transparency Platform:

- Generation mix
- Cross-border physical flows
- Day-ahead prices

Available in Apple App Store and Google Play store

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For more data, please visit

www.entsoe.eu/data