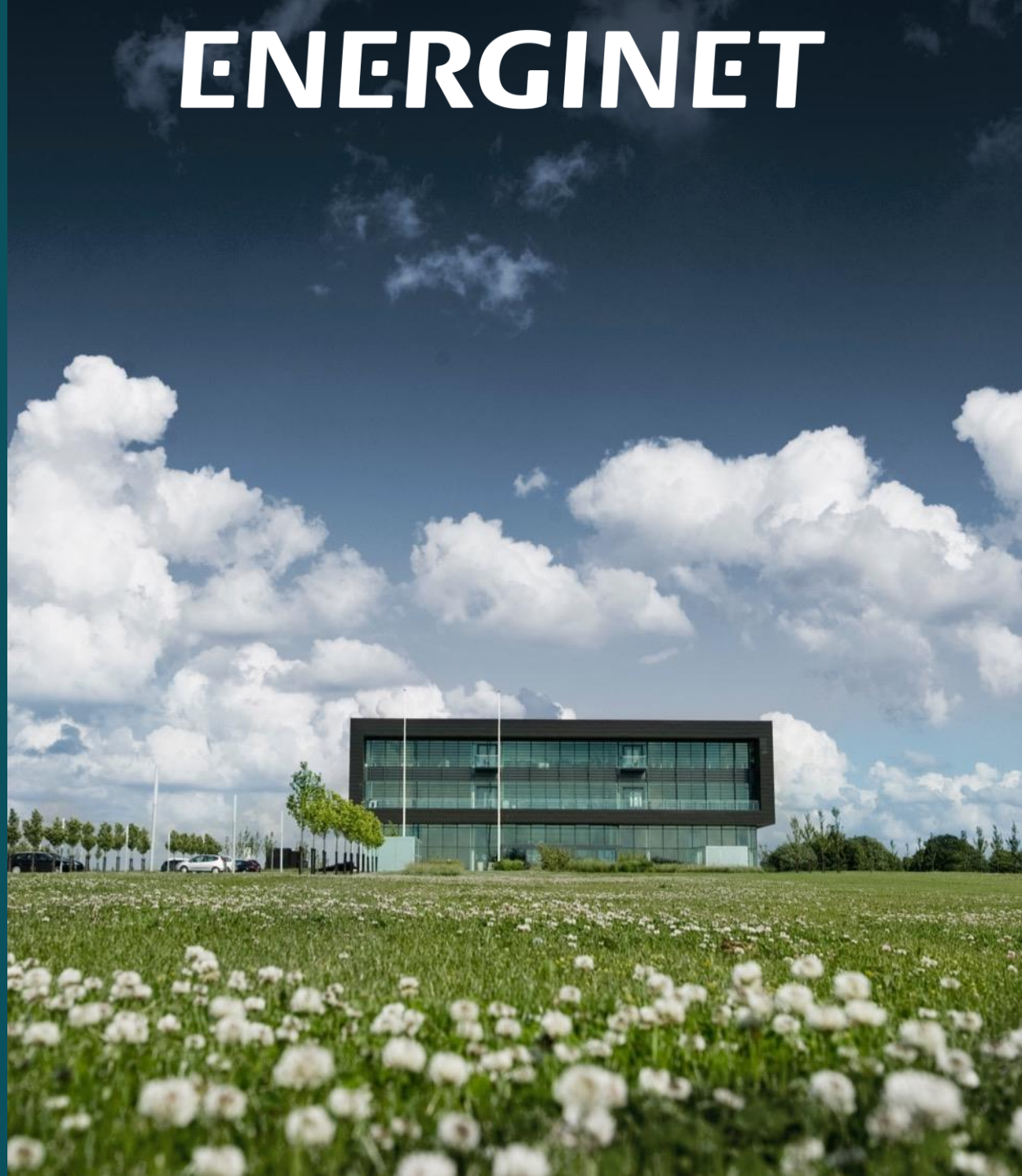
INTER-REGIONAL TRANSMISSION TARGETS IN EUROPE

28 November 2022

Peter Markussen, Senior director, Energinet Transmission System Operator, Denmark
(pmr@energinet.dk)



ENERGINET

THE ENERGY BACKBONE

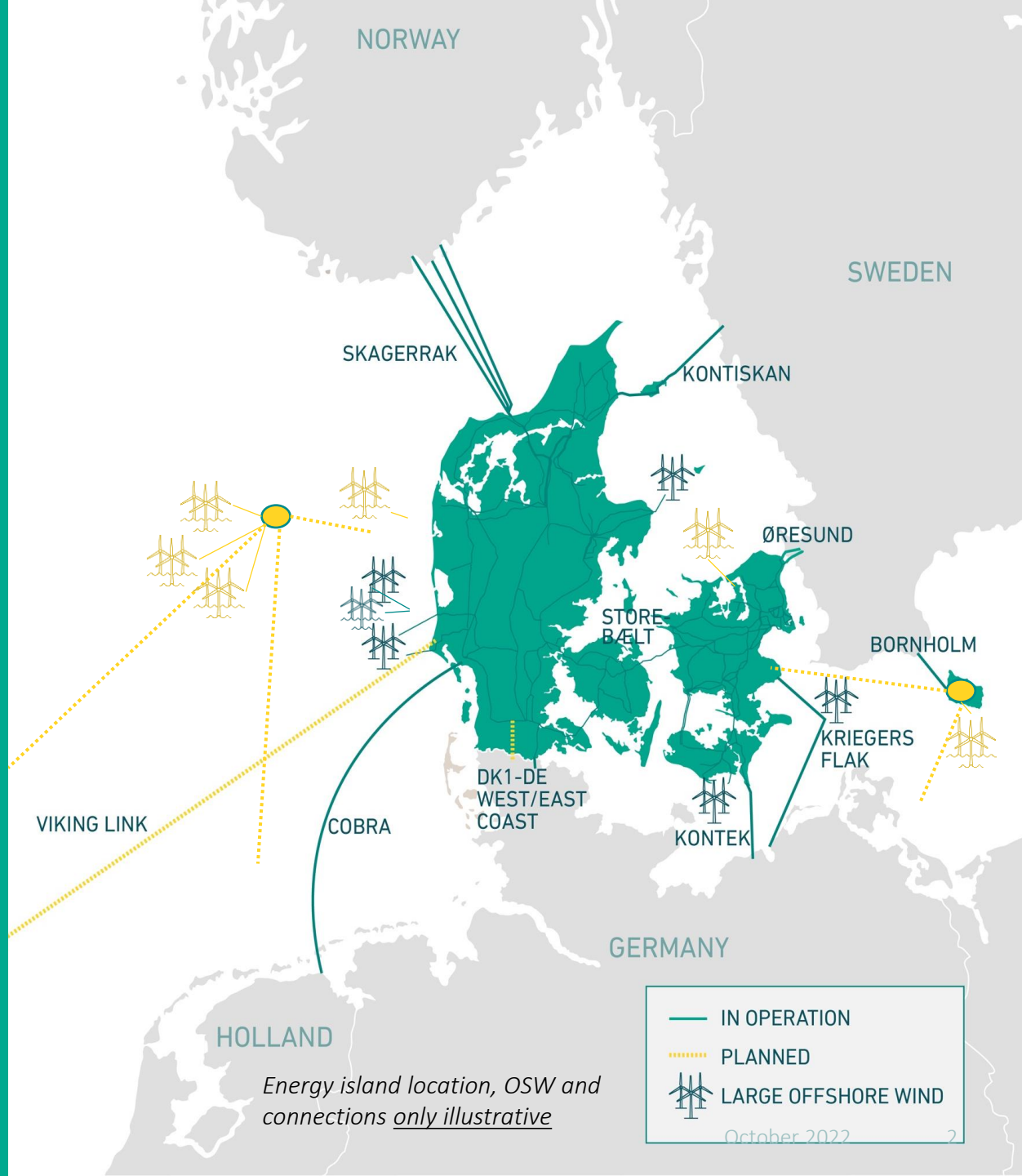
We operate and develop the transmission grids and gas pipelines in Denmark.

ENSURE BALANCE

We have the day-to-day and long-term responsibility for the overall electricity and gas system in Denmark.

WORKING FOR THE SOCIETY

Owned by the Danish Ministry of Climate, Energy and Utilities we safeguard society's interests as we move to a 100% green energy system.



Energy island location, OSW and connections only illustrative

WHY IS INTERREGIONAL TRANSMISSION IMPORTANT?

HIGH SECURITY OF SUPPLY

Lower risks for energy not served

Reduced dependency on imported fossil fuels

ACCELERATED GREEN TRANSITION

Reduced curtailment and CO2 emissions from fossil fuel

AFFORDABLE ENERGY

Annual 5-9 bill Euro reduced electricity production costs from common European electricity markets

Source: ENTSO-E, TYNDP 2022

HOW TO MAKE IT HAPPEN?

Focus for todays presentation

EUROPEAN LEVEL:

Harmonized system operation and electricity market

Coordination of short and long term grid planning to support national decisions

NATIONAL LEVEL:

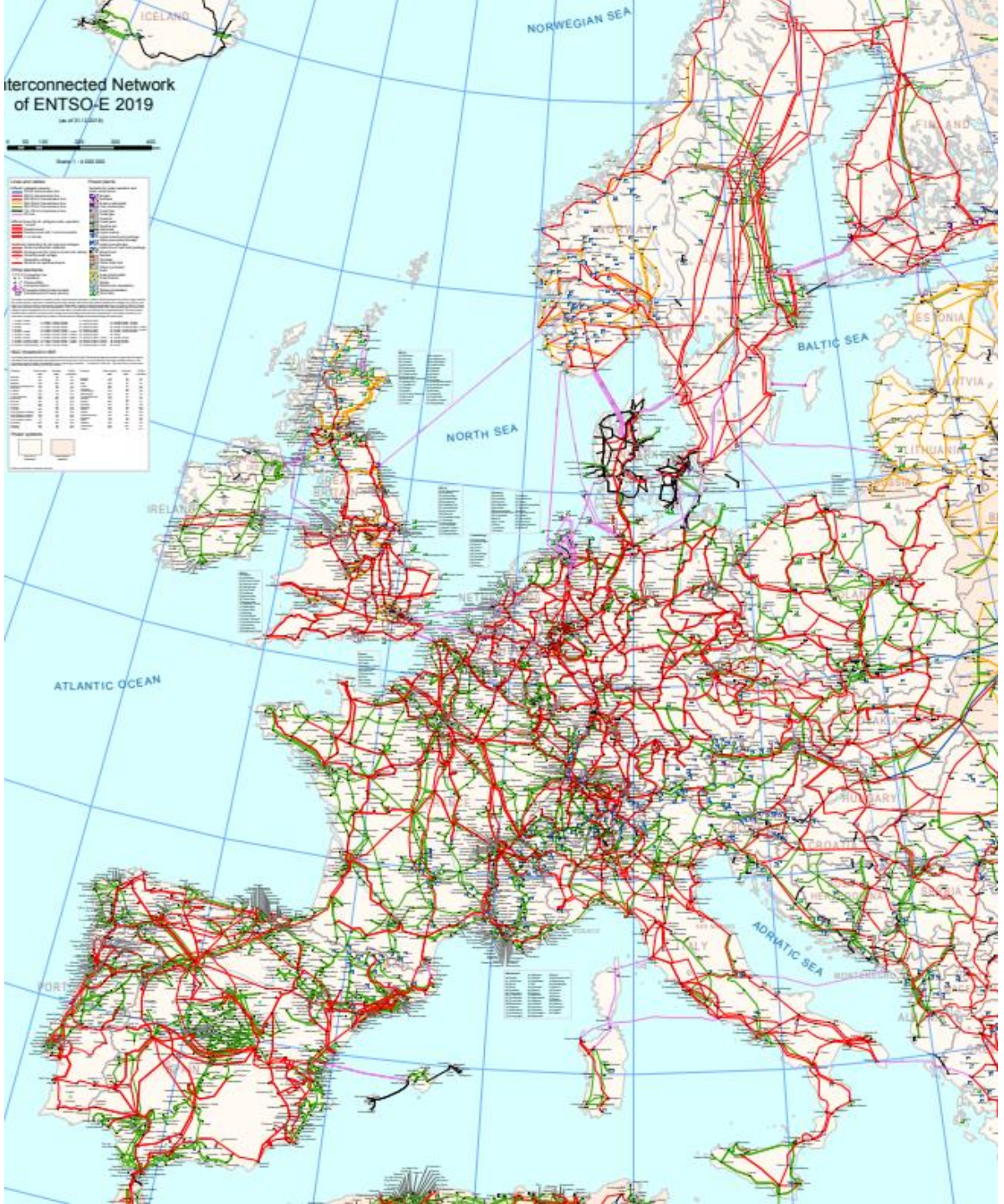
Approval of interregional transmission capacity

TRANSMISSION SYSTEM OPERATOR LEVEL:

Unbundling and clear roles and responsibilities of transmission system operators (TSO)

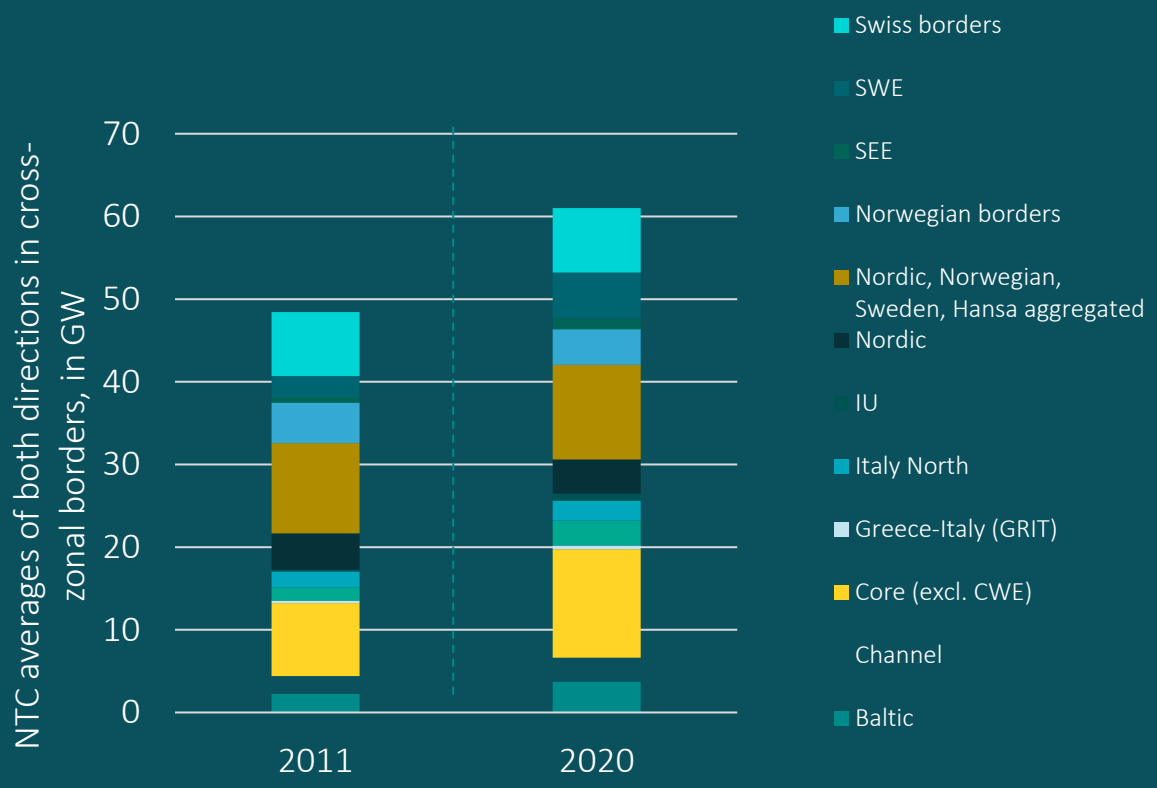
HISTORIC DEVELOPMENT

Today	Targets 2030	Target 2050
• ≈30% green electricity • ≈1000 GW VRE	• 40% green electricity • 55% CO2 reduction • 2000 GW VRE (indicative)	Climate neutral



INCREASE IN CROSS BORDER ELECTRICITY TRANSMISSION CAPACITY

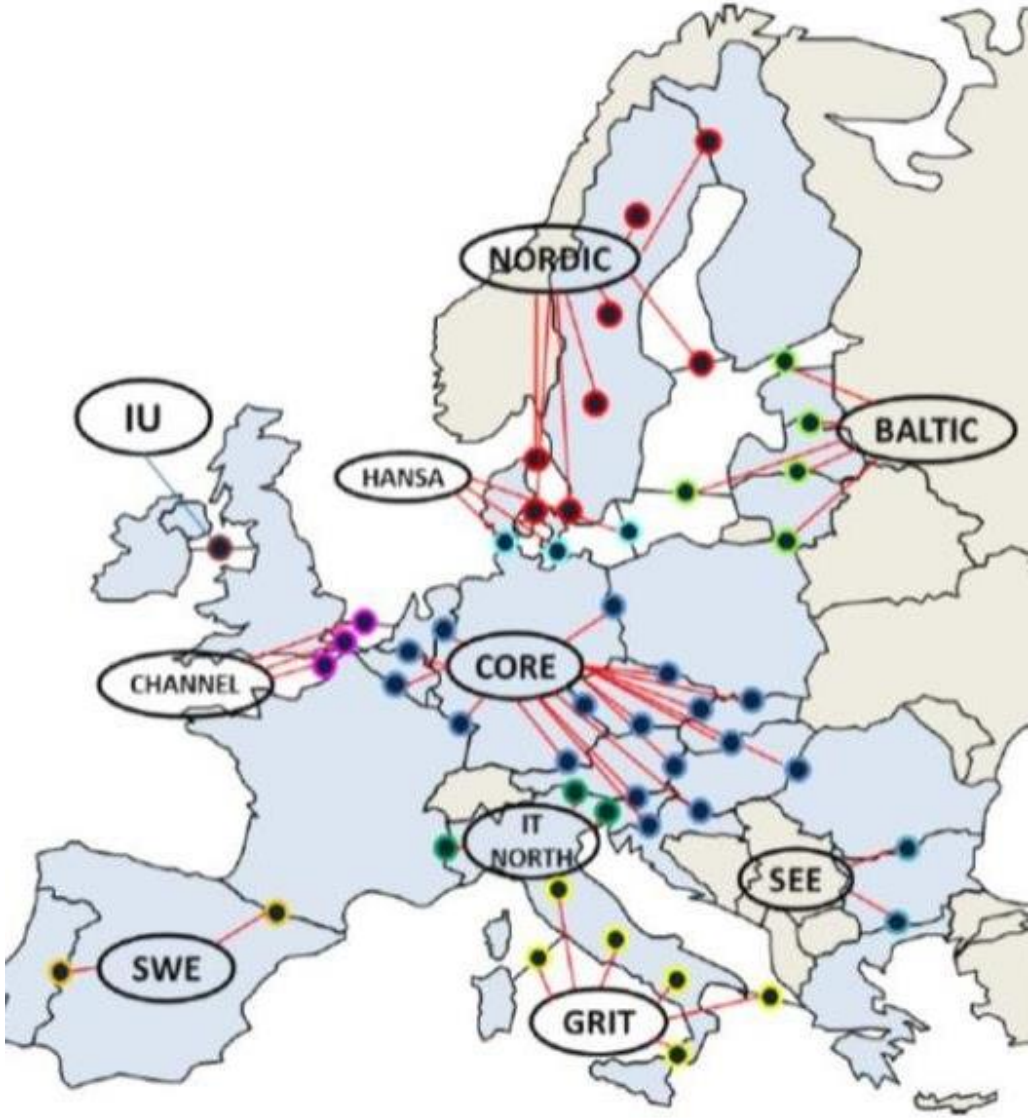
Net Transfer Capacity (NTC)



Source: Acer

ENERGINET

European Capacity Calculation Regions



Source: ACER.

INCREASED CROSS BORDER EXCHANGE OF ELECTRICITY

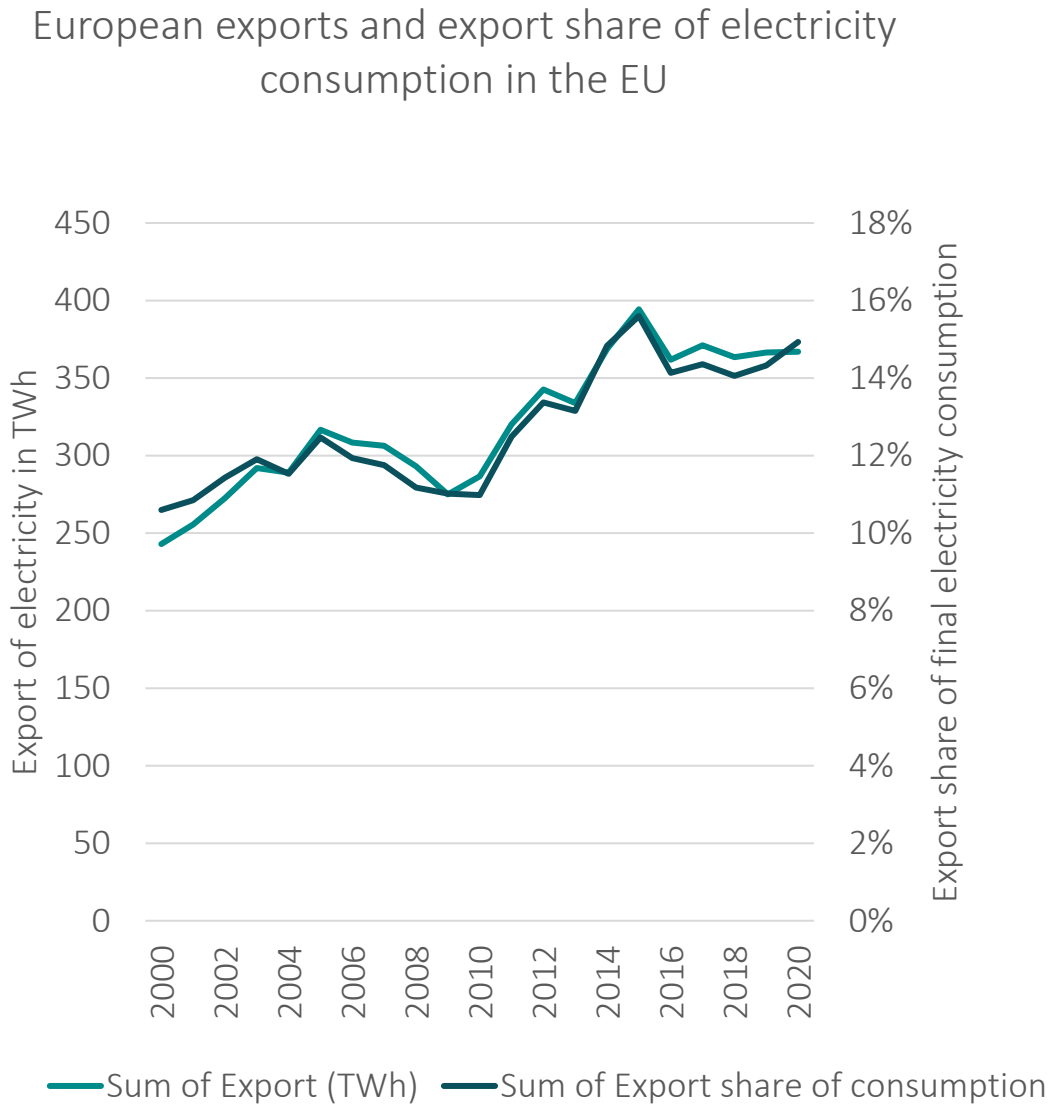
European Union (27 countries) electricity consumption

2000: 2,228 TWh

2008: 2,688 TWh (historic highest demand)

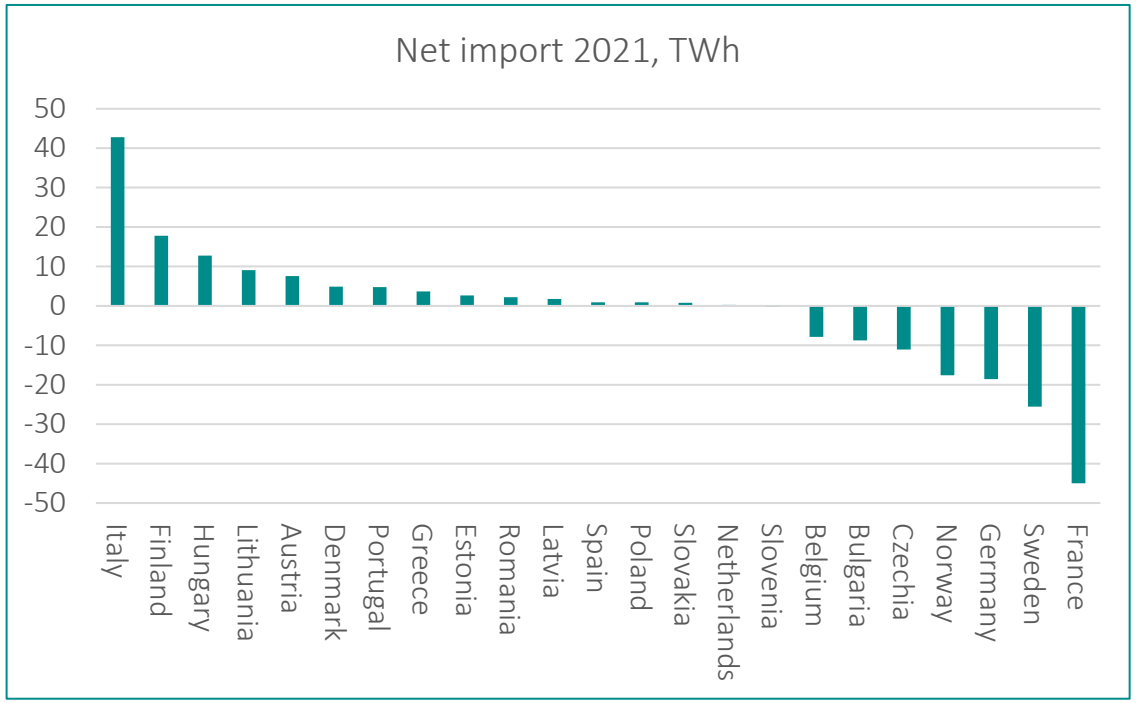
2020: 2,458 TWh

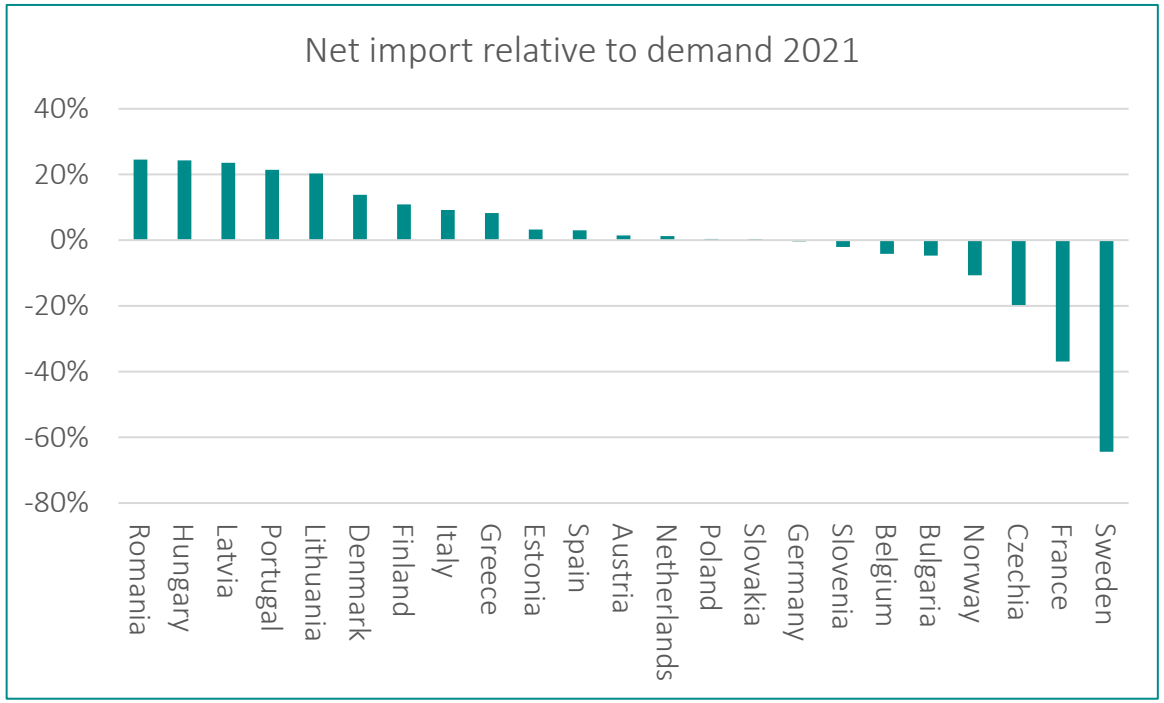
Source: Eurostat



LARGE DIFFERENCES IN NATIONAL IMPORT AND EXPORT

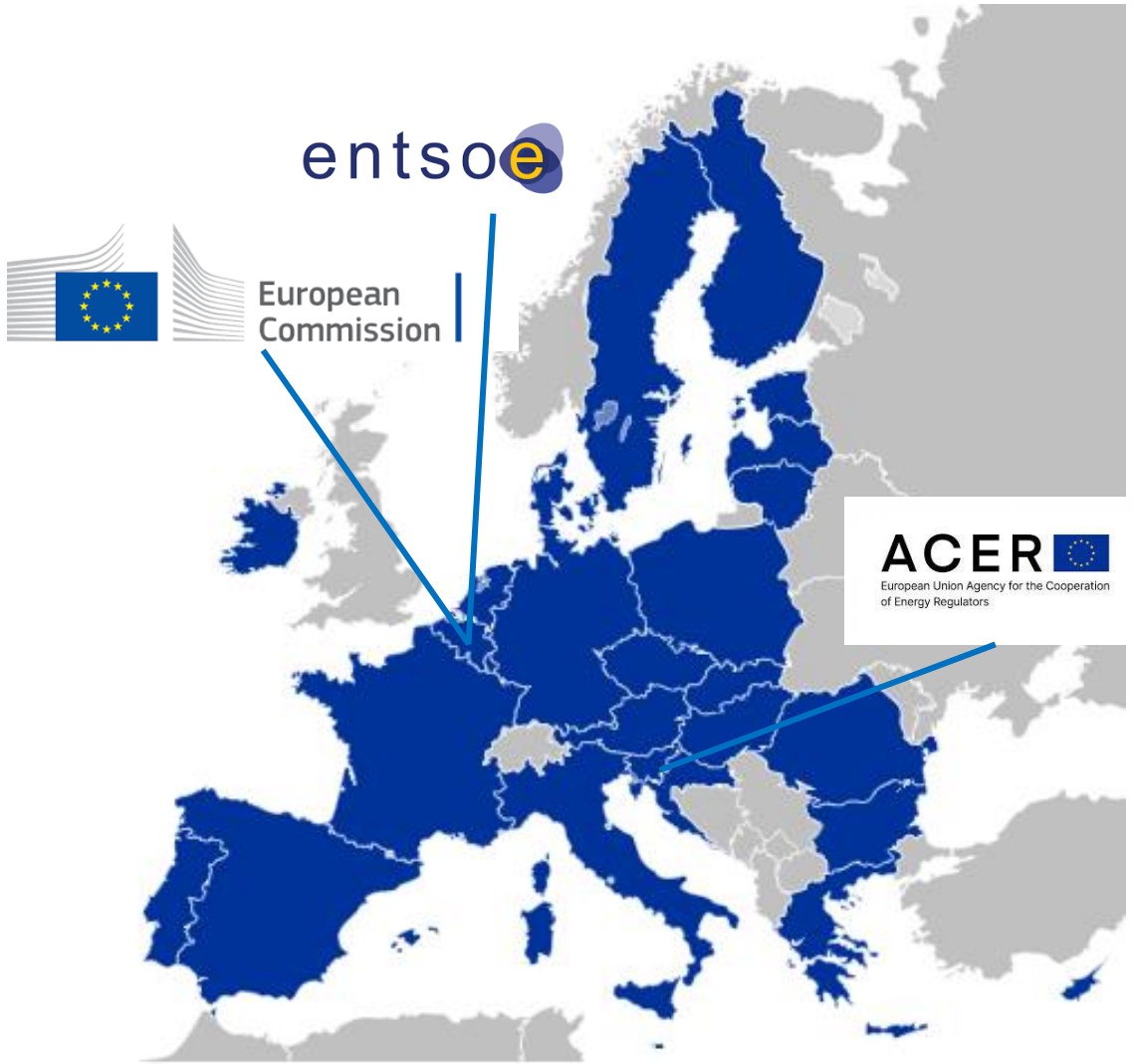
European regulation ensures reliability on cross border exchange and part of national security of supply assessments





Source: Eurostat

EUROPEAN REGULATION



EUROPEAN REGULATION FOR LIBERALIZATION

European electricity sector regulation has developed over the last 30 years

The Single European Act – establishment of Internal European market (1986)

Electricity Liberalization directives (law):

- 1996: unbundling and competition
- 2003: common electricity market
- 2009: harmonization of grid codes, ACER
- 2019: efficient integration of renewables (min. 70% capacity on interconnectors)
- 2021: continued development of markets and infrastructure

EUROPEAN ENERGY AGREEMENTS

Lists not exhaustive

2013: Trans European Networks for Energy Regulation, TEN-E

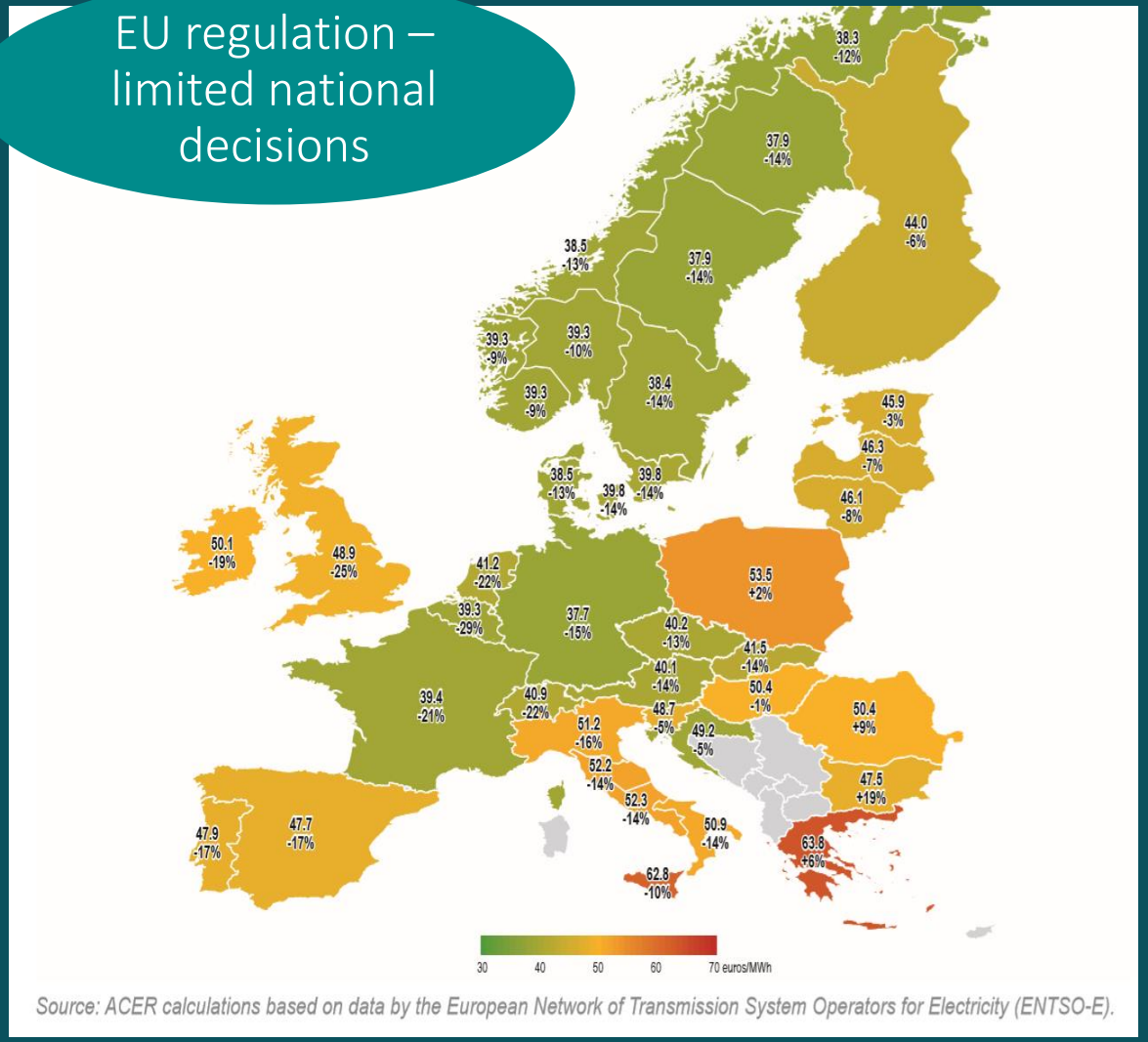
- European coordination of long term energy infrastructure planning (TYNDP)
- Identification and financing of Projects of Common Interest
- Non-binding target of minimum 10% (and in 2017 increased to 15%) of import capacity compared to total generation capacity

2019: European Green Deal

2021: RenewEurope

EUROPEAN COMMON ELECTRICITY MARKET AND SYSTEM OPERATION

EU regulation – limited national decisions



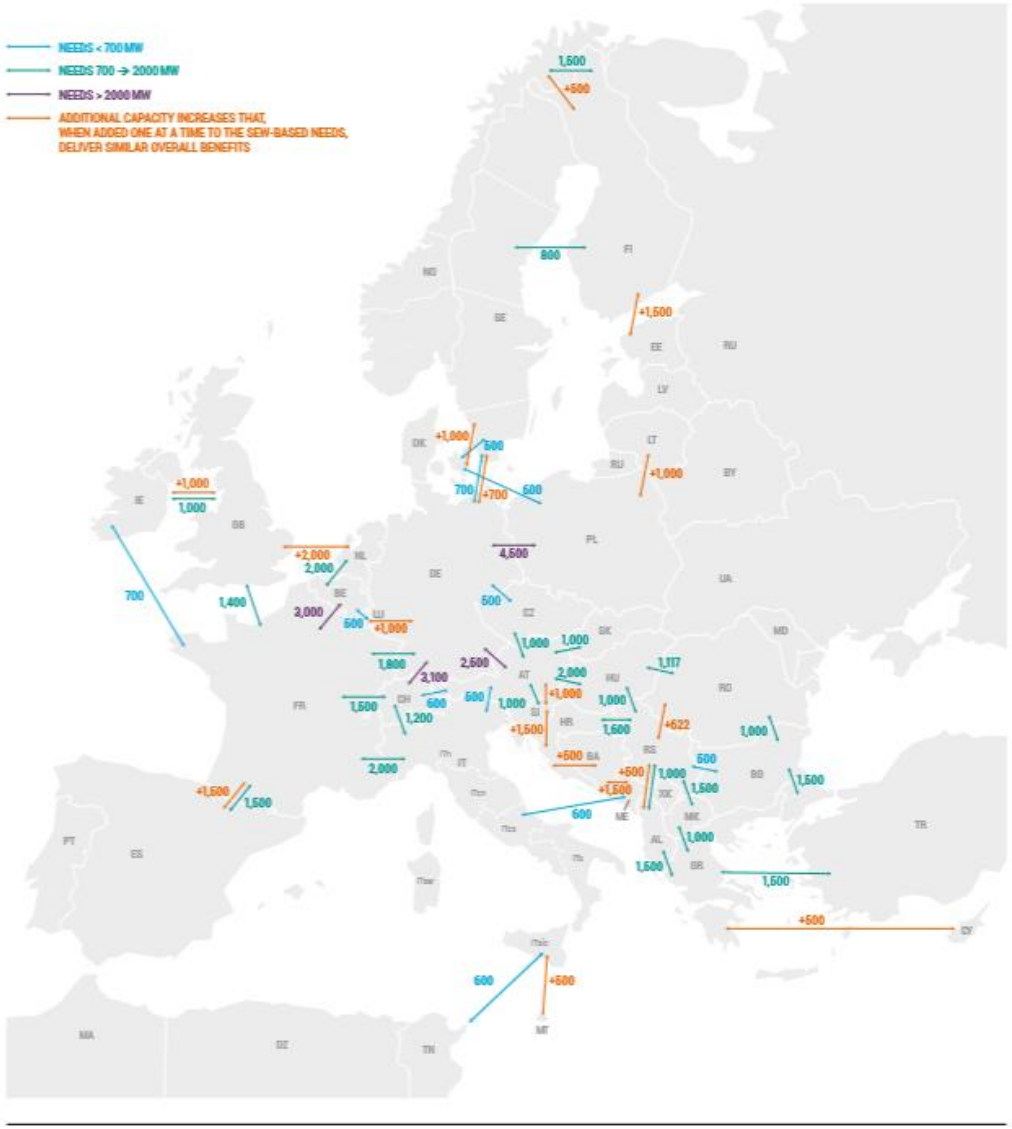
Source: ACER calculations based on data by the European Network of Transmission System Operators for Electricity (ENTSO-E).

EUROPEAN GRID DEVELOPMENT COORDINATION

EU coordination

National decision on grid investments

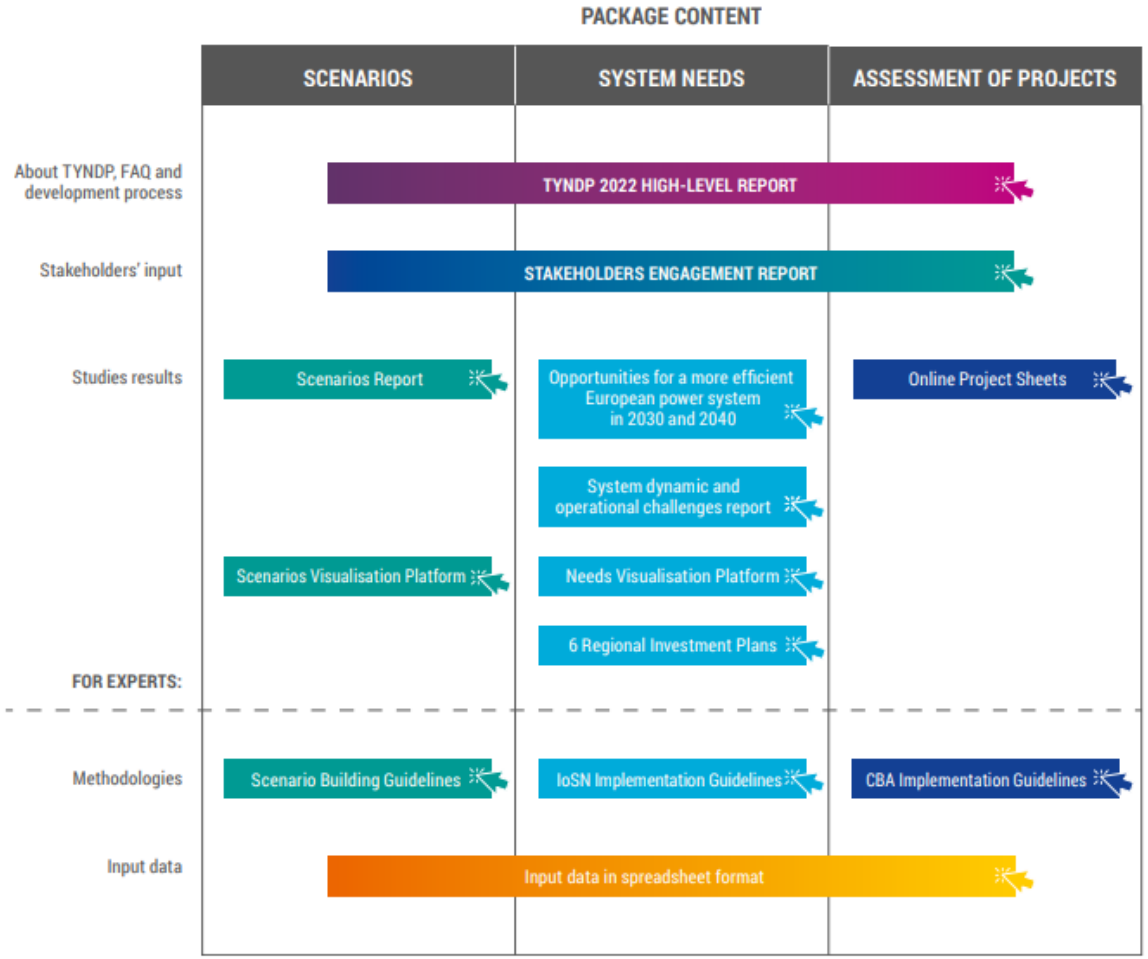
EUROPEAN ELECTRICITY GRID DEVELOPMENT



- Development of European electricity grid is coordinated between national TSOs
- The process is managed by ENTSO-E, European Network Transmission System Operators- Electricity
- Projects included can qualify as Projects of Common Interest (PCI)
- Every second year a new Ten Year Network Development Plan is published
- National decision to build out and no obligations to follow recommendations

- For mere information see: https://tyndp.entsoe.eu/

Content of the TYNDP 2022



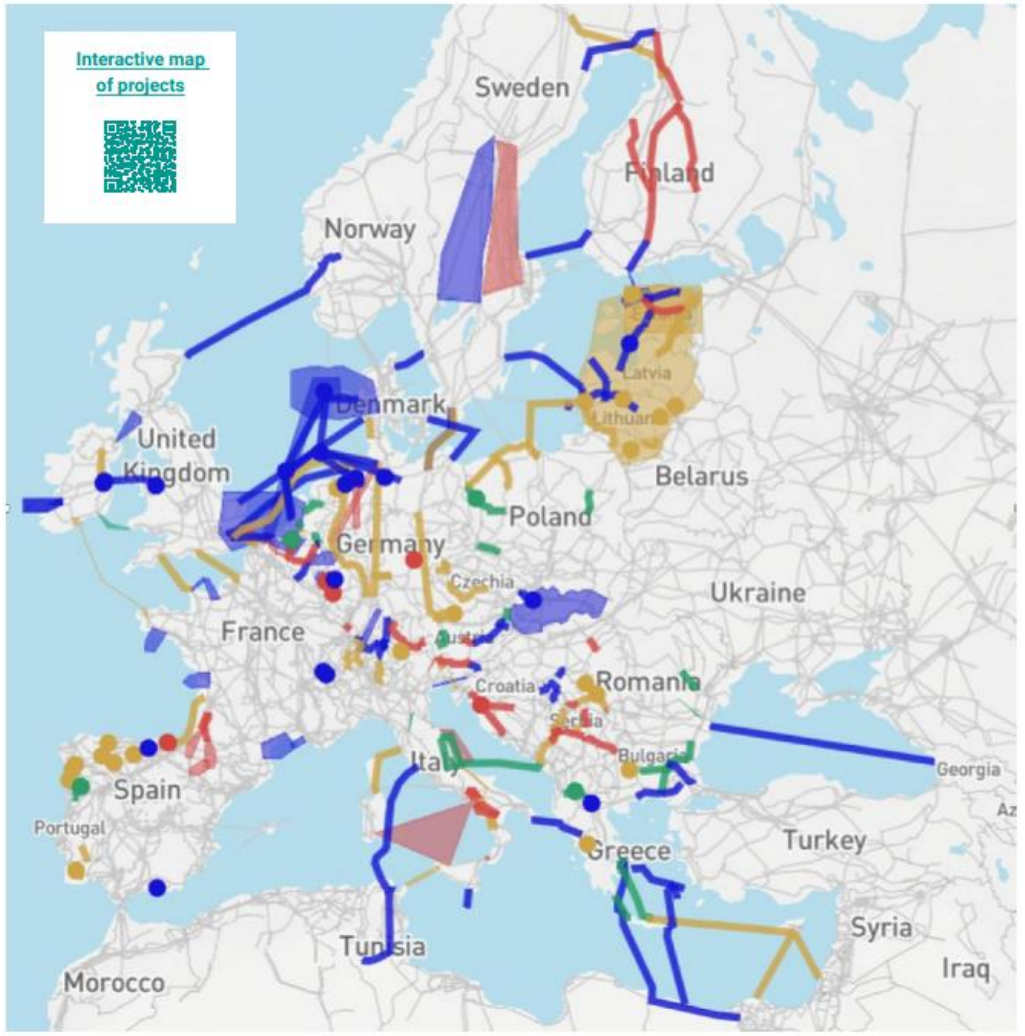


Figure 3 – Map of TYNDP 2022 transmission projects. Areas indicate projects for which the route is not yet known (green: under construction; yellow: in permitting; red: planned but not yet in permitting; blue: under consideration).

[ENTSO-E High-Level Report TYNDP 2022 (windows.net)]

PROJECTS OF COMMON INTEREST

Projects of common interest (PCI) are selected on the basis of 5 criteria:

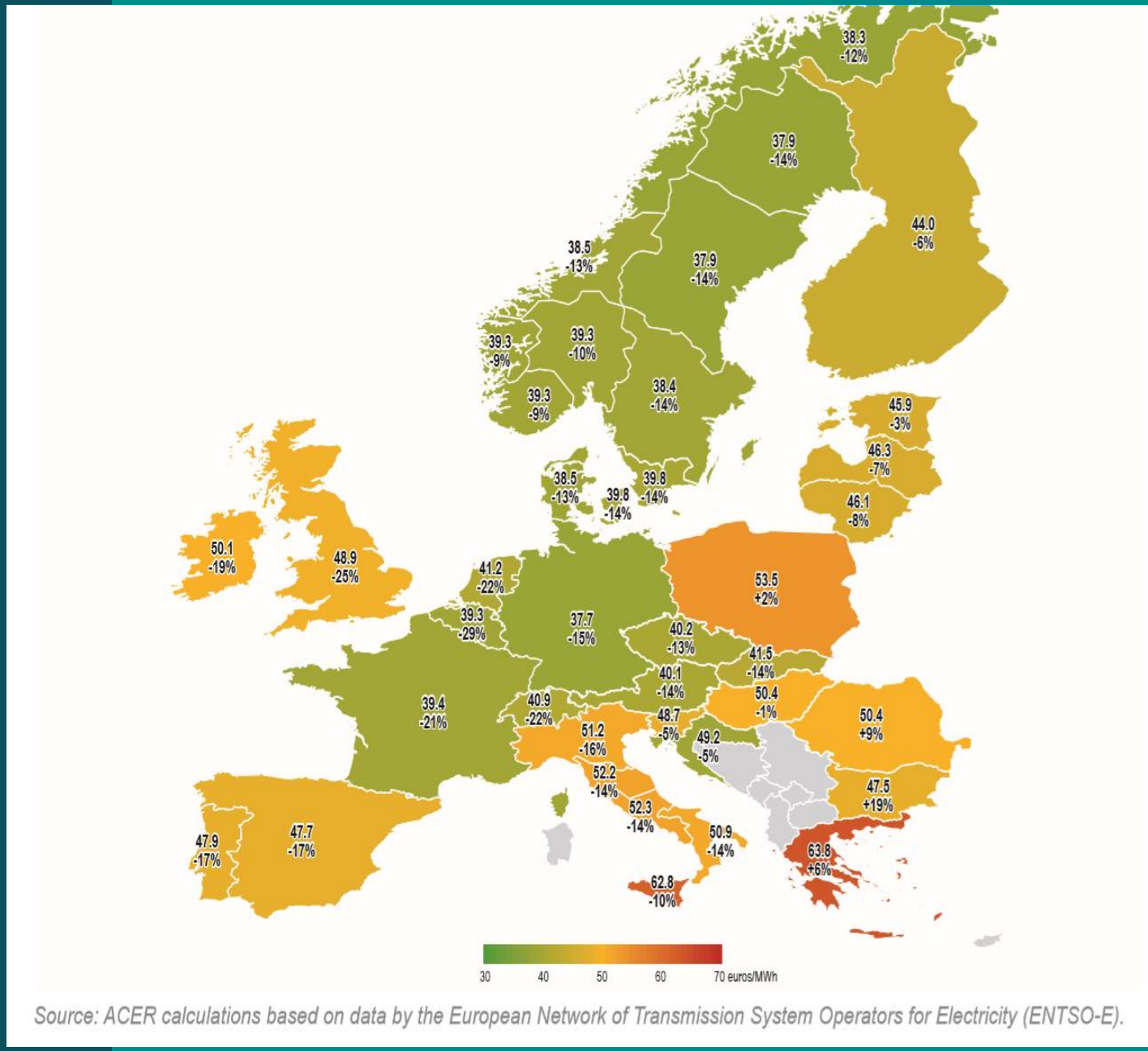
- Have a significant impact on at least 2 European Union member countries
- Enhance market integration and contribute to the integration of EU countries' networks
- Increase competition on energy markets by offering alternatives to consumers
- Enhance security of supply
- Contribute to the EU's energy and climate goals. They should facilitate the integration of an increasing share of energy from variable renewable energy sources.

BENEFITS FOR PCI

The PCIs will benefit from:

- Faster and more efficient permit granting procedures
- Improved regulatory treatment
- Possible access to financial support from the Connecting Europe Facility (CEF) - €5.85 billion budget for the period 2021-2027)

ELECTRICITY MARKETS – EFFICIENT UTILIZATION AND FINANCING OF CROSS BORDER TRANSMISSION



Source: ACER calculations based on data by the European Network of Transmission System Operators for Electricity (ENTSO-E).

RELATION BETWEEN EUROPEAN ELECTRICITY SYSTEM AND MARKET AREAS

Synchronous area:

- Frequency regulation and dimensioning

Load frequency control (LFC) block (≈country)

- Dimensioning of balancing restoration reserves

LFC Area (≈ TSO):

- Ensuring balancing, 15 min for restoration
- Monitoring of balancing (ACE: Area control Error)

Market bidding area (≈ LFC area)

- Price areas in common European electricity market – in principle reflecting transmission congestions

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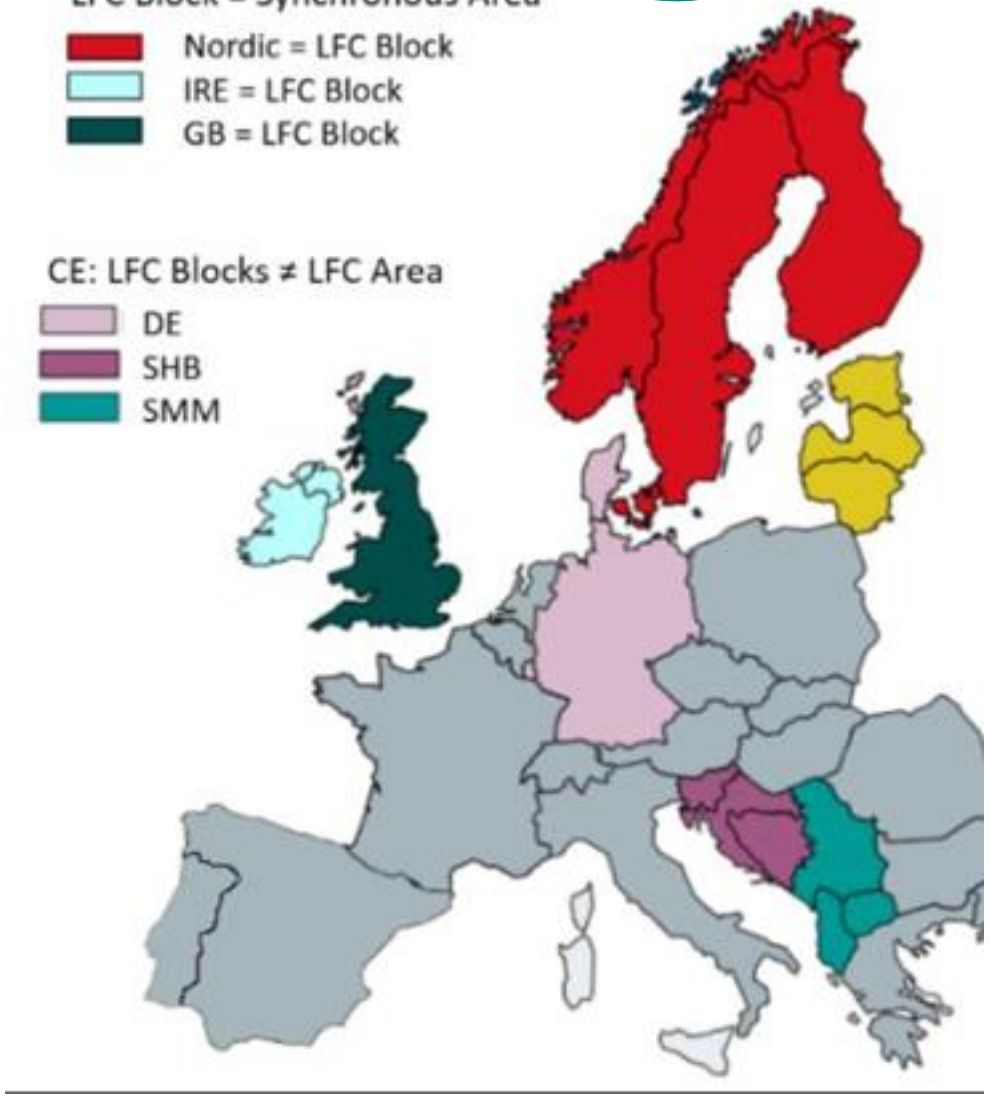
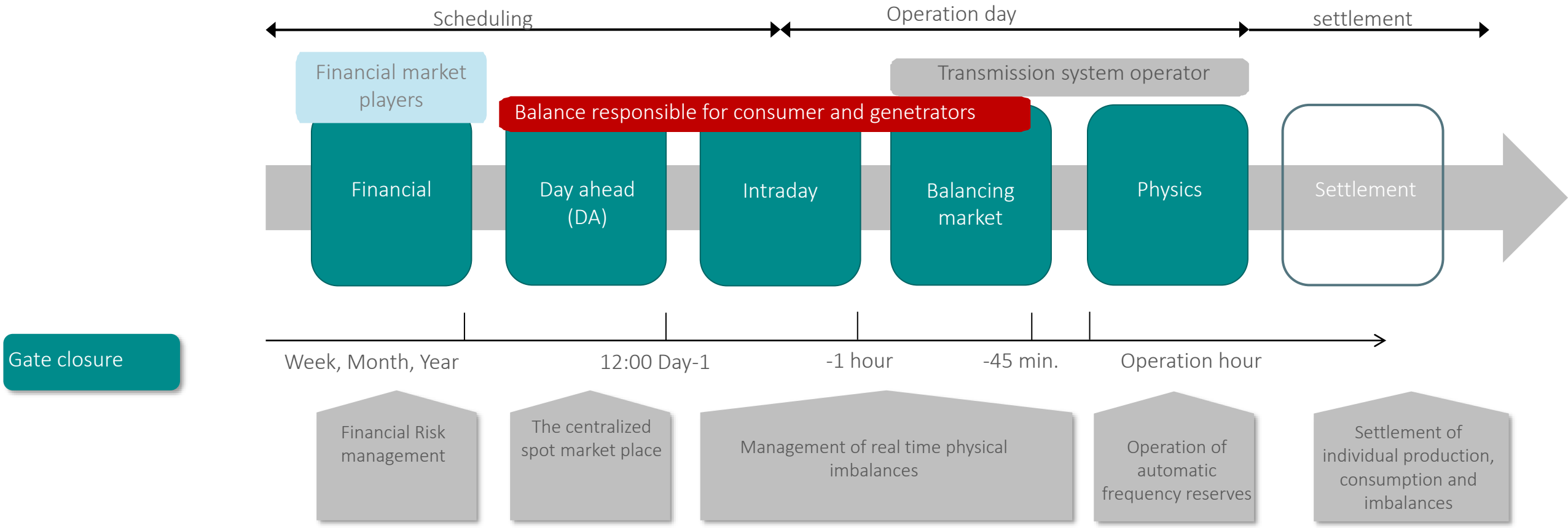
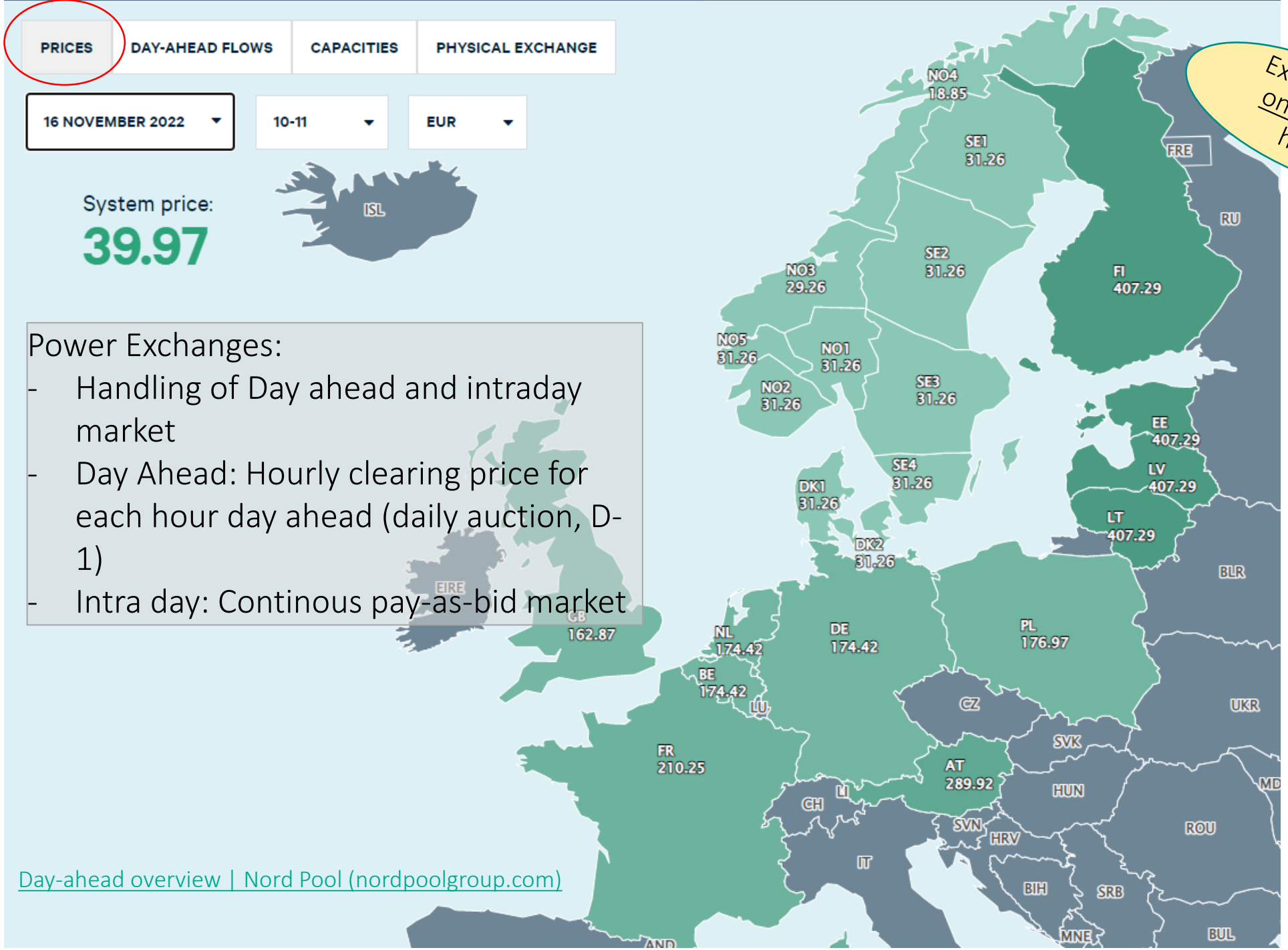
No rules without exemptions



MAIN MARKET OBJECTIVE IS EFFICIENT BALANCING OF EUROPEAN ELECTRICITY SYSTEM

The wholesale market is no just one market, but a number of markets based on zonal approach and marginal pricing





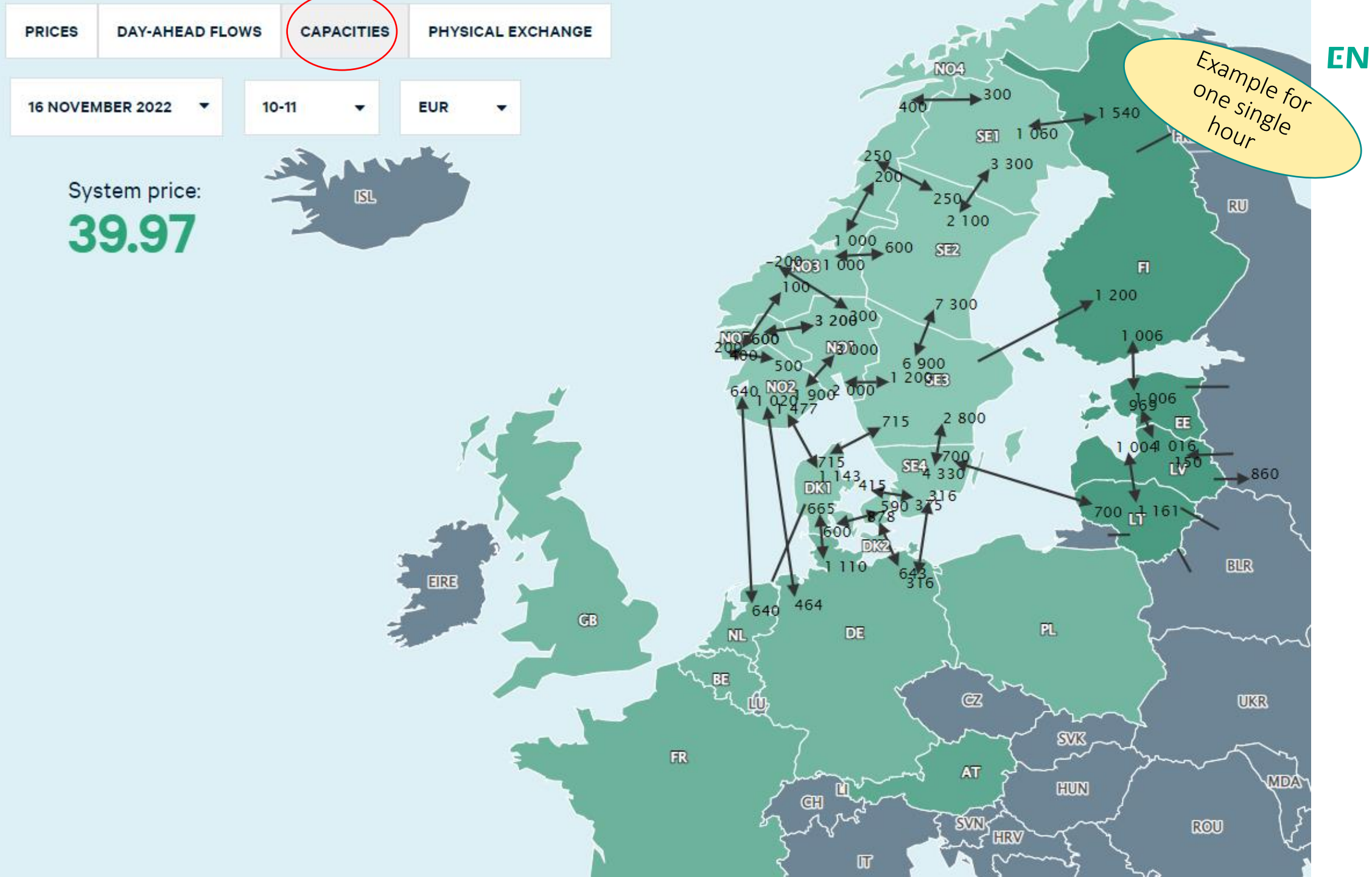
Example for one single hour

ENERGINET

Power Exchanges:

- Handling of Day ahead and intraday market
- Day Ahead: Hourly clearing price for each hour day ahead (daily auction, D-1)
- Intra day: Continous pay-as-bid market

Day-ahead overview | Nord Pool (nordpoolgroup.com)


PRICES
DAY-AHEAD FLOWS
CAPACITIES
PHYSICAL EXCHANGE
16 NOVEMBER 2022
10-11
EUR
System price:
39.97
Example for one single hour
ENERGINET
ISL
NO4
NO3
NO2
NO1
SE1
SE2
SE3
SE4
FI
RU
EE
LV
LT
DK1
DK2
EIRE
GB
NL
DE
PL
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CH
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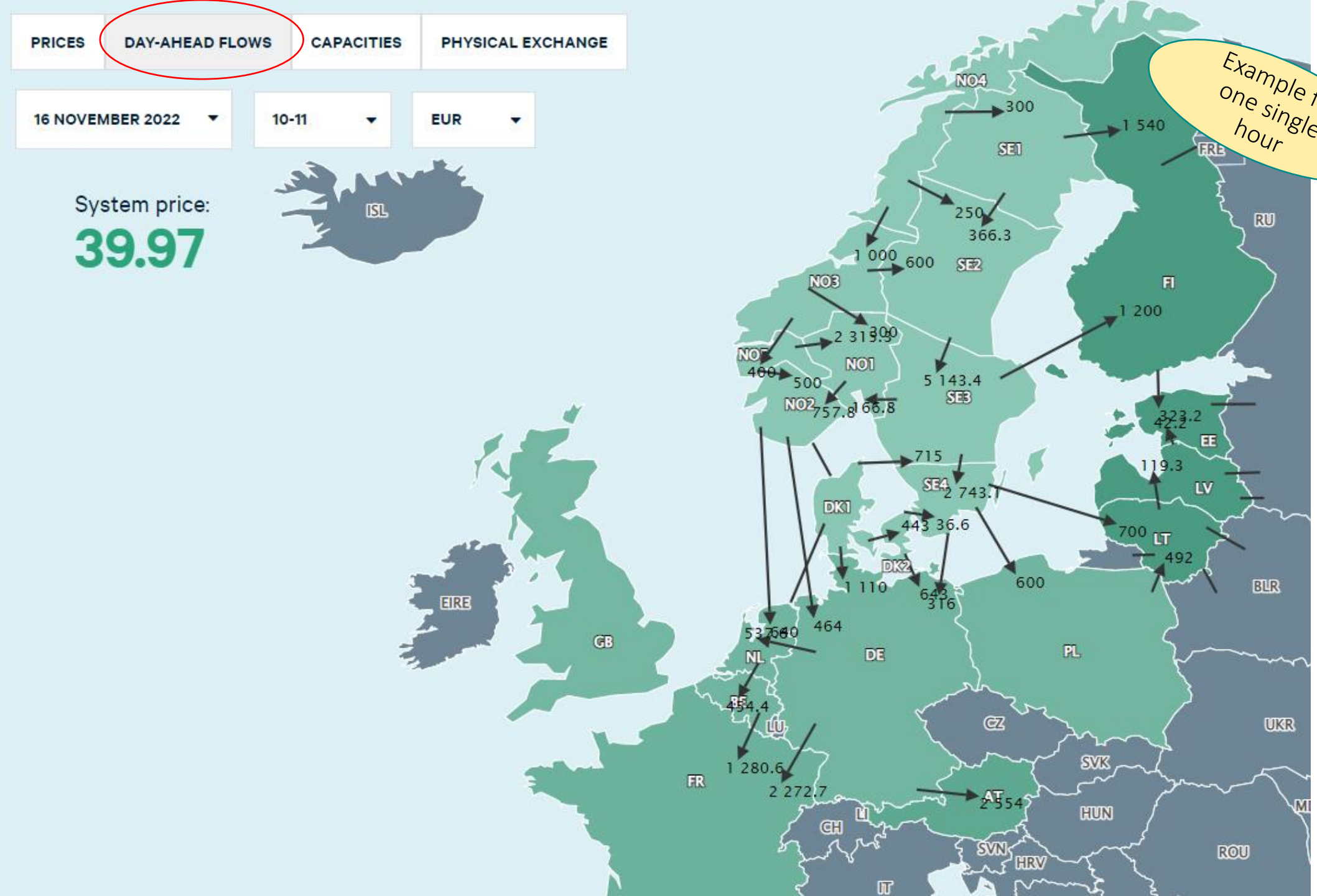
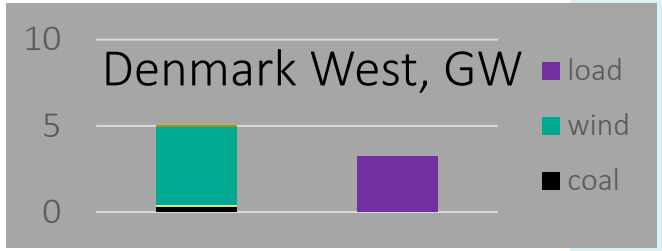
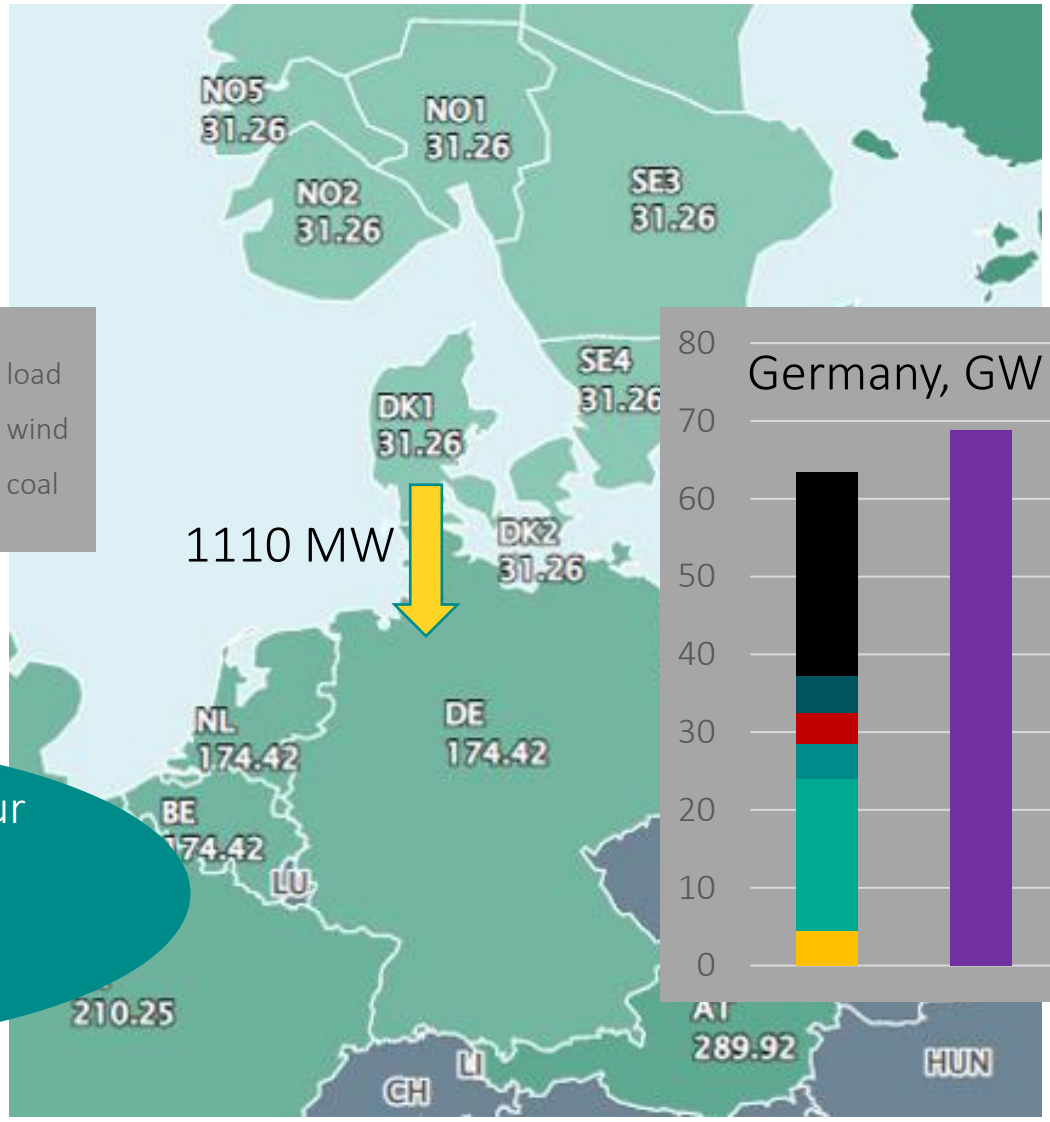
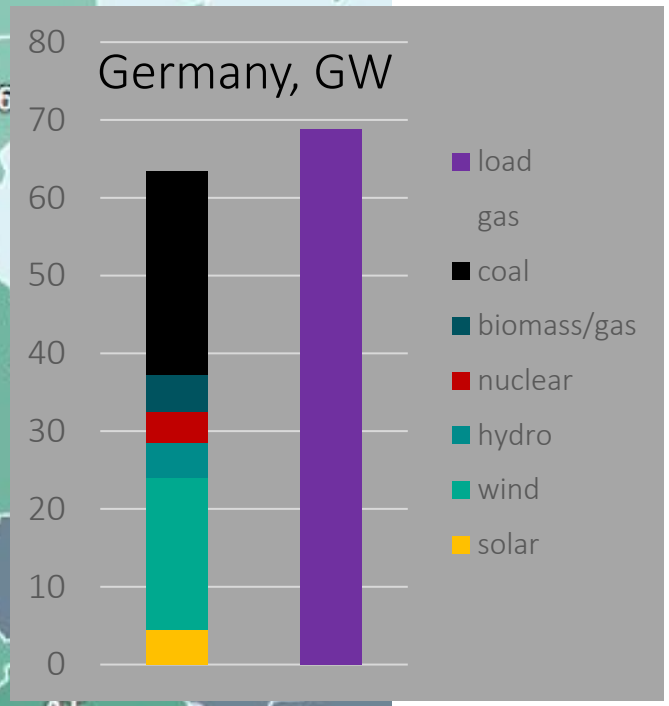

PRICES
DAY-AHEAD FLOWS
CAPACITIES
PHYSICAL EXCHANGE
16 NOVEMBER 2022
10-11
EUR
System price:
39.97
Example for one single hour
ENERGINET
ISL
NO4
300
1 540
SE1
FRE
250
366.3
1 000
600
SE2
RU
NO3
FI
1 200
300
2 319.5
NO5
NO1
460
500
5 143.4
SE3
NO2
757.8
166.8
323.2
42.2
EE
715
119.3
SE4
2 743.1
LV
DK1
443
36.6
700
LT
492
DK2
1 110
643
316
600
BLR
EIRE
GB
464
NL
DE
PL
454.4
BE
LU
CZ
UKR
SVK
1 280.6
FR
2 272.7
AT
2 554
HUN
LI
CH
SVN
HRV
ROU
IT

CONGESTION RENT – FINANCING OF INTERCONNECTORS

Example for one single hour



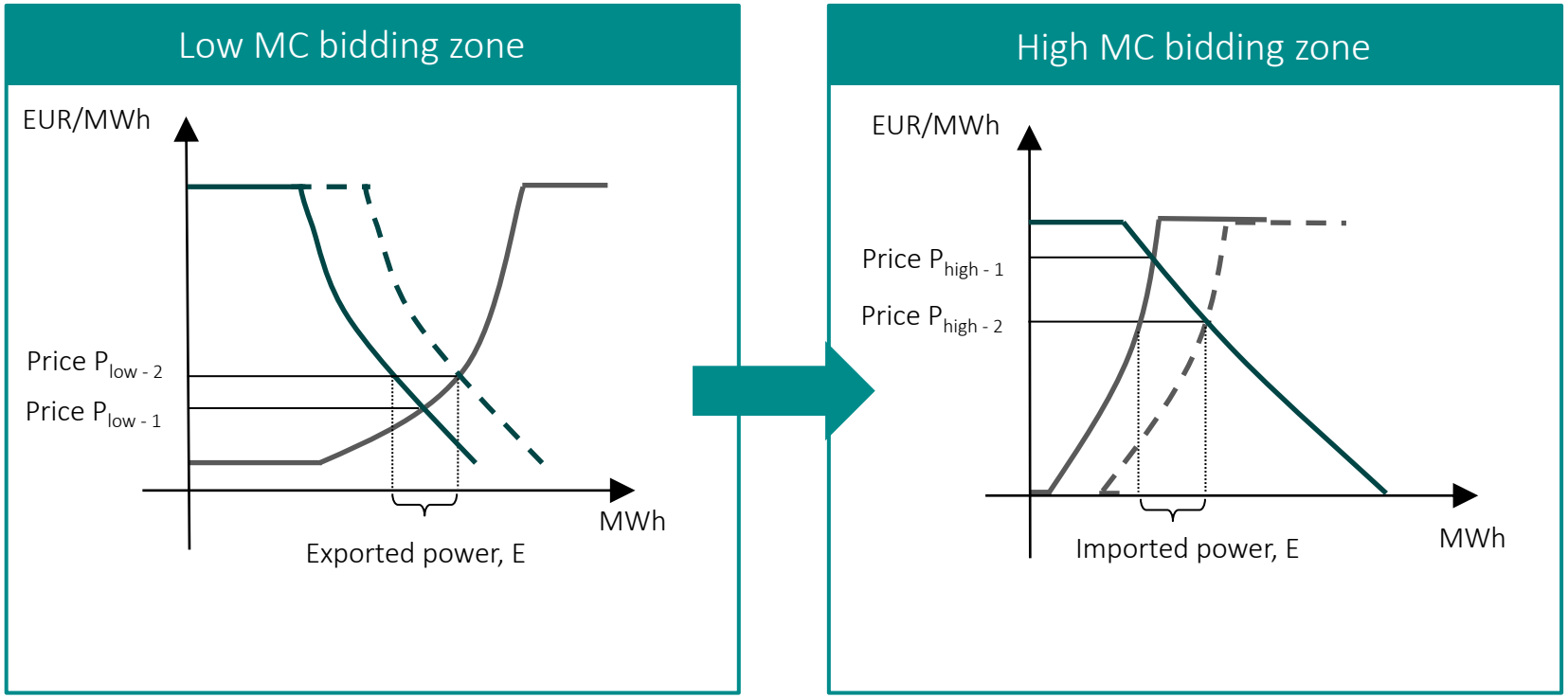




Congestion rent in one hour
16 Nov 2022:
1110* (174,42-31.26)=158.907 Euro

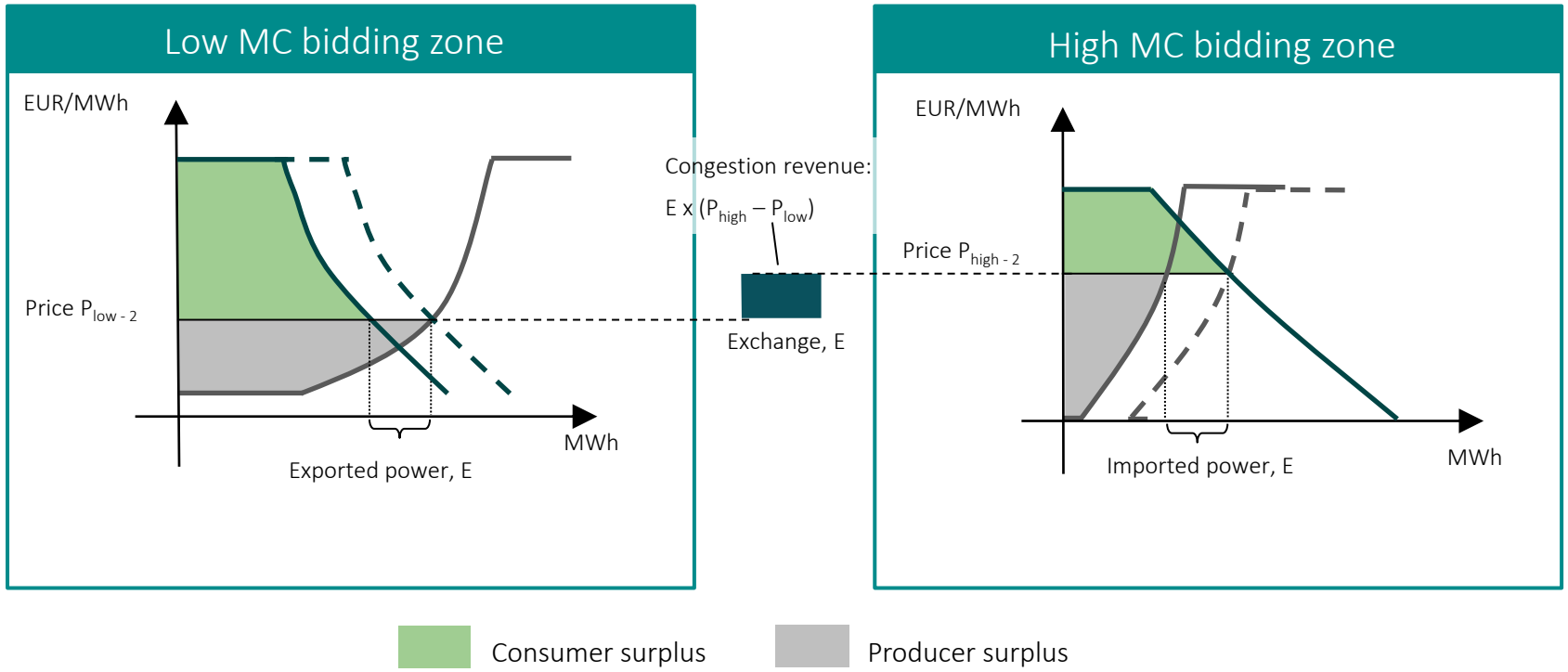
The economic theory

MARKET COUPLING IN THE DAY-AHEAD MARKET



Interconnector capacity is automatically allocating to those with highest willingness to pay

CRITERIA FOR FINDING THE EQUILIBRIUM

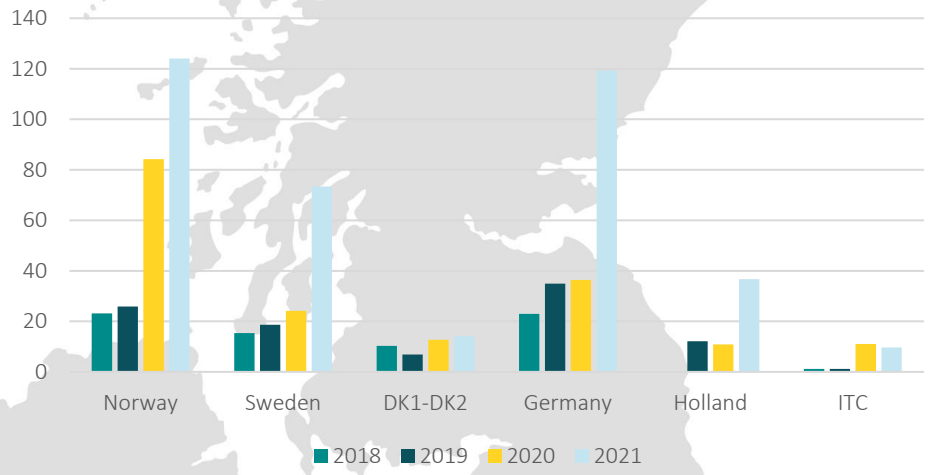


- Algorithm maximizes socioeconomic welfare taking capacity constraints into account
- Socioeconomic welfare is here the sum of consumer surplus, producers surplus and congestion revenue

FLOW ON DANISH INTERCONNECTORS

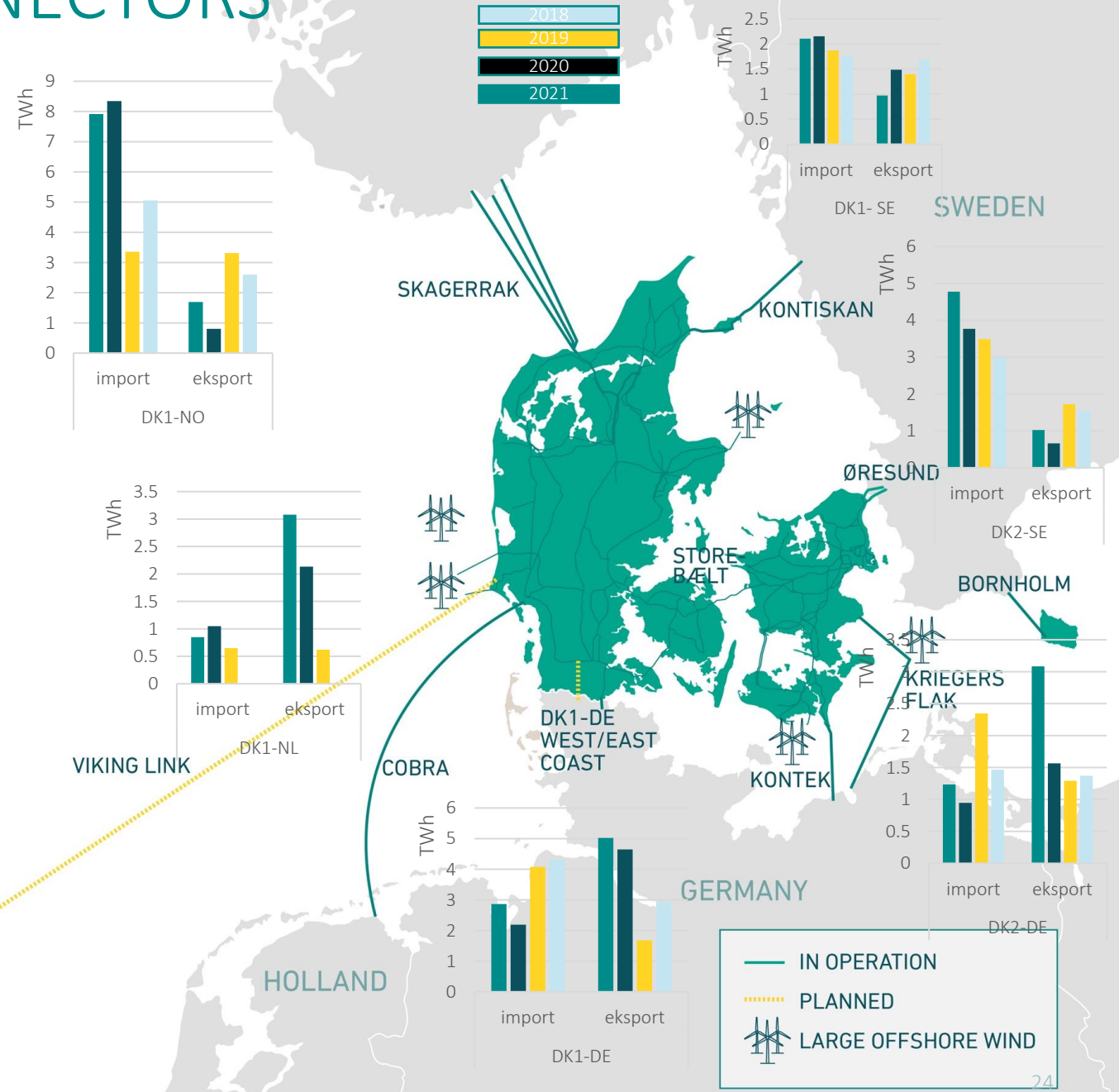
– DIRECTION CAN CHANGE FROM HOUR TO HOUR

Energinet share of congestion income from interconnectors, mio. Euro



Danish interconnectors mainly financed by congestions rent from price differences between market areas in the common European electricity market

Interconnectors also contribute to delivery of ancillary services, real time balancing and ressource adequacy



70% RULE – EFFICIENT UTILISATION OF TRANSMISSION

Each TSO deliver annual report to ACER on fulfillment of 70% criteria (at the latest in 2025) respecting operational security levels)

If objective not fulfilled deliver report on background and actions and derogations and to be assessed by ACER

ACER to take dialogue with TSO and identify initiatives and solutions

ACER Q&A - 70 percent target.pdf (europa.eu)

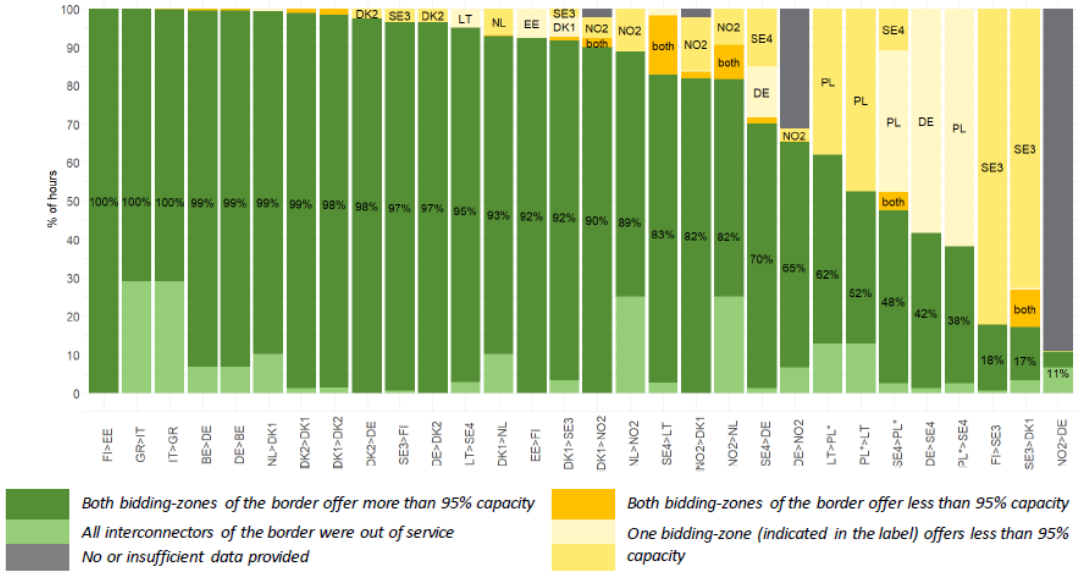
CALCULATION METHODOLOGY

- Each market bidding zone border is calculated seperately (main rule)
- Based on Net Transfer Capacity (NTC) made available to the market
- Planned and Unplanned outage not included
- Calculated as hour-by-hour availability

ACER Recommendation 01-2019.pdf (europa.eu) – 39 pages!

ACER – MONITORING OF 70% RULE (AND MANY OTHER INDICATORS)

Figure 3: Percentage of the time when the margin made available is below 95% of the maximum admissible flow at the border – 2021 (% of hours)

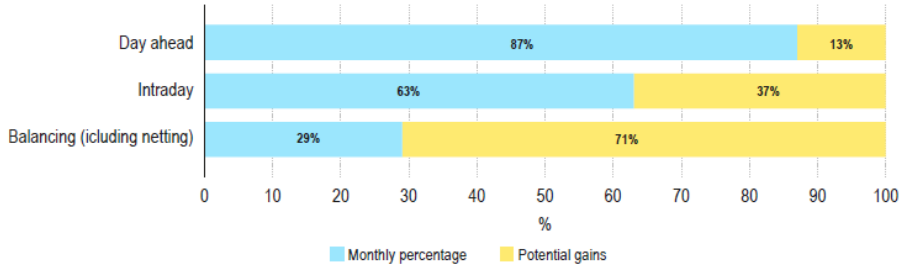


Source: ACER calculation based on TSO data.

[ACER-CEER Market Monitoring Report (MMR) | www.acer.europa.eu]

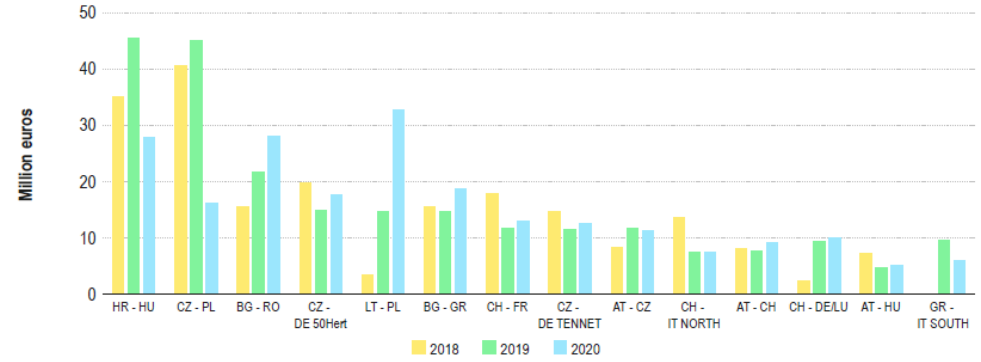
INCREASING THE COMMON SOCIO ECONOMIC BENEFIT

Figure ii: Level of efficiency in the use of interconnectors in Europe in the different timeframes – 2020 (% use of available commercial capacity in the 'right economic direction')



Source: calculations based on national regulatory authorities, ENTSO-E and Vulcanus data.

Figure 25: Estimated social welfare gains still to be obtained from further extending DA market coupling per border – 2018–2020



Source: ACER calculations based on ENTSO-E, NRAs and Vulcanus data.

Note: Only non-coupled borders are shown. The borders within the Core (excl. CWE) region with 'multilateral' technical profiles are not included in this figure, because the methodology applied to the other borders, based on NTC values, is not applicable to these (excl. CWE) borders for this calculation (DE/LU-CZ, DE/LU-PL, PL-SK).

SHORT TERM ADEQUACY FORECAST, SUMMER 2022

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Example

- With increased interdependency in Europe adequacy assesments on European level
- Level of security of supply a national decision
- Capacity markets/strategic reserves approved by EU Commission

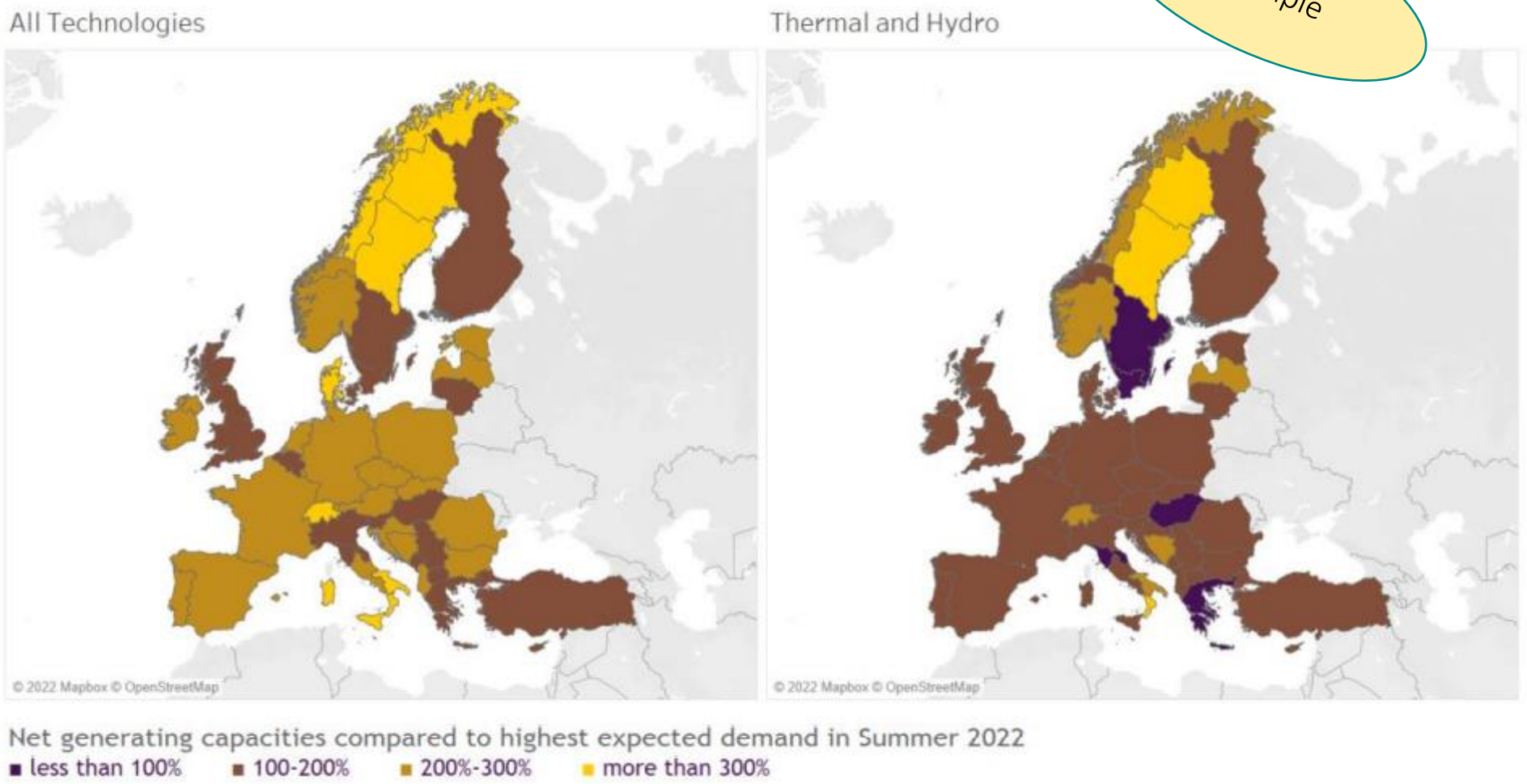


Figure 1: Net generating capacity overview – comparison with highest expected demand

1_Summer-Outlook-Report_2022.pdf (windows.net)

DEVELOPMENT BEYOND ELECTRICITY (ONSHORE) TRANSMISSION

Electricity for hydrogen in TYNDP 2022 scenarios

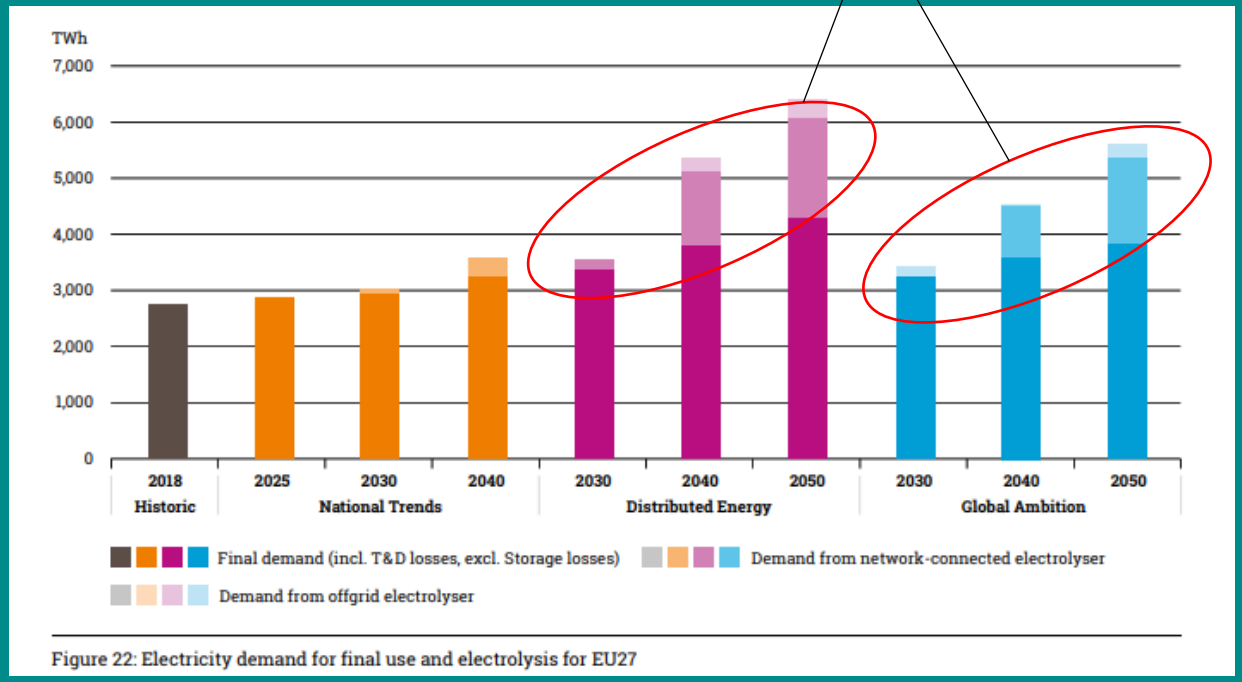


Figure 22: Electricity demand for final use and electrolysis for EU27

EUROPEAN COORDINATION INCLUDING GAS AND HYDROGEN

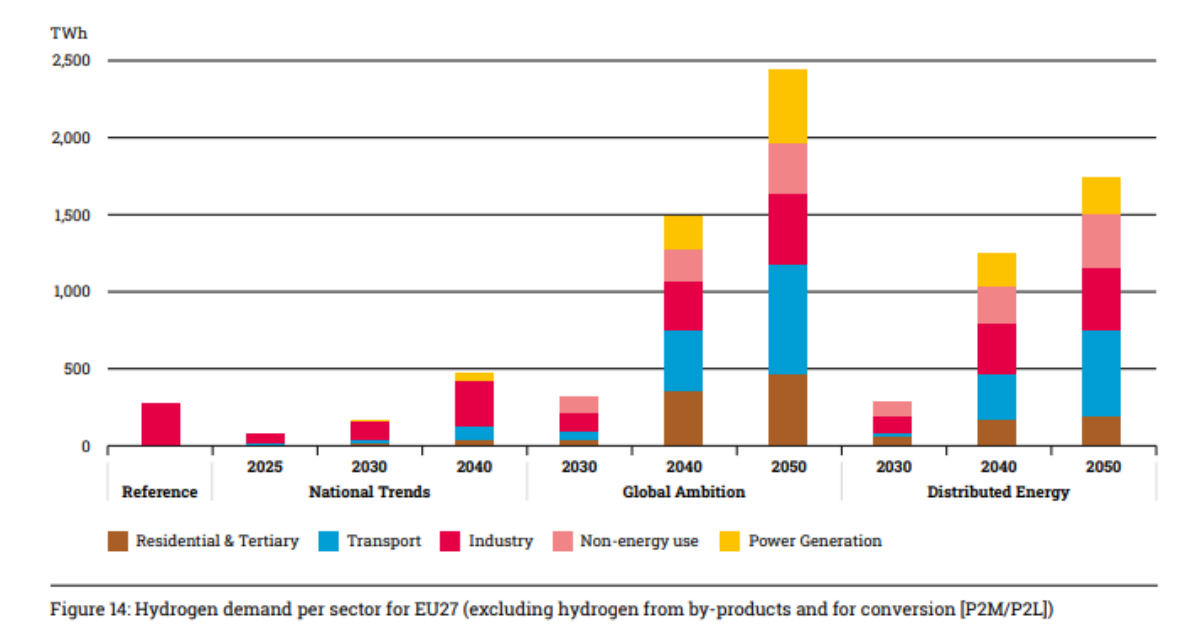
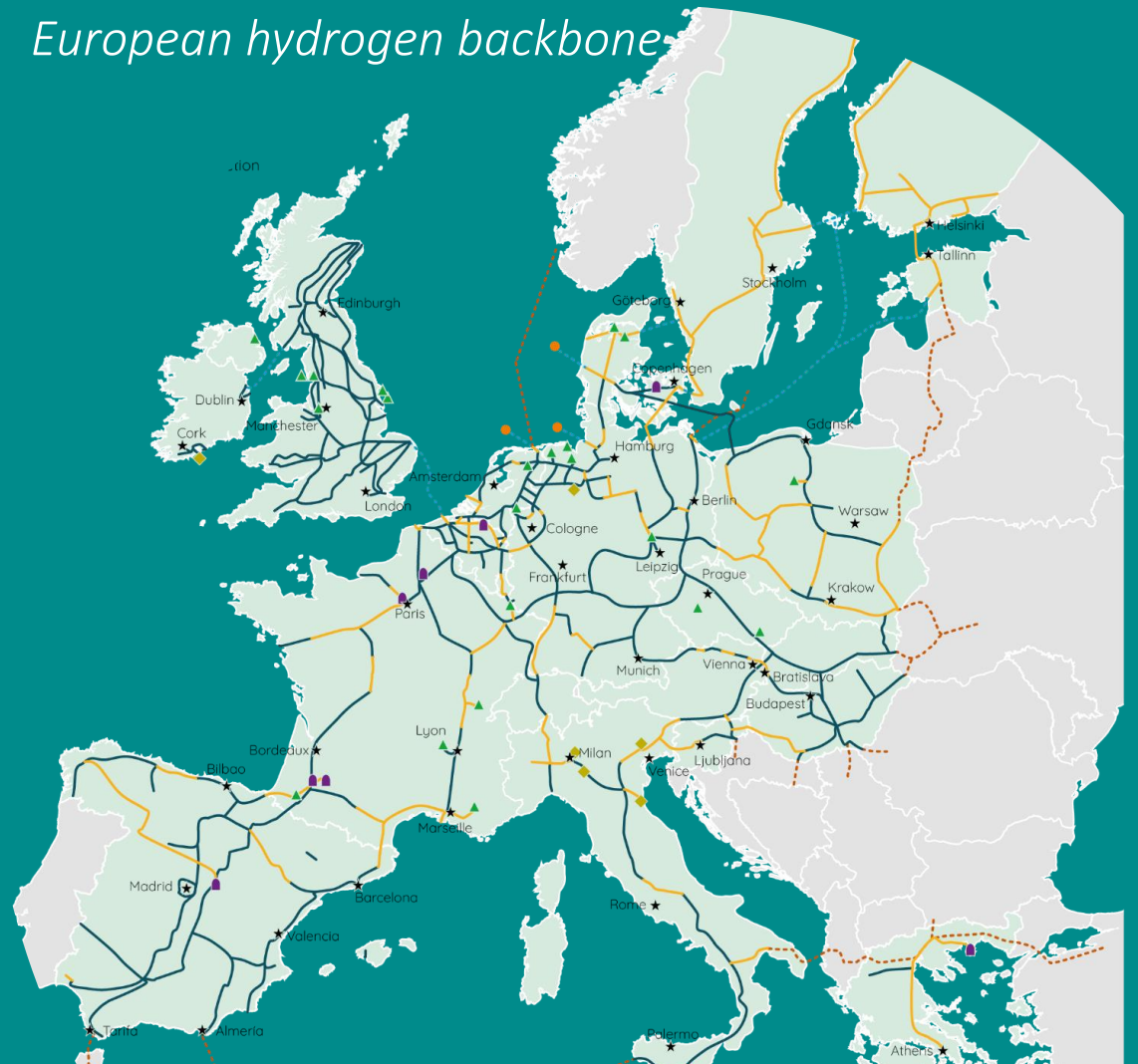


Figure 14: Hydrogen demand per sector for EU27 (excluding hydrogen from by-products and for conversion [P2M/P2L])

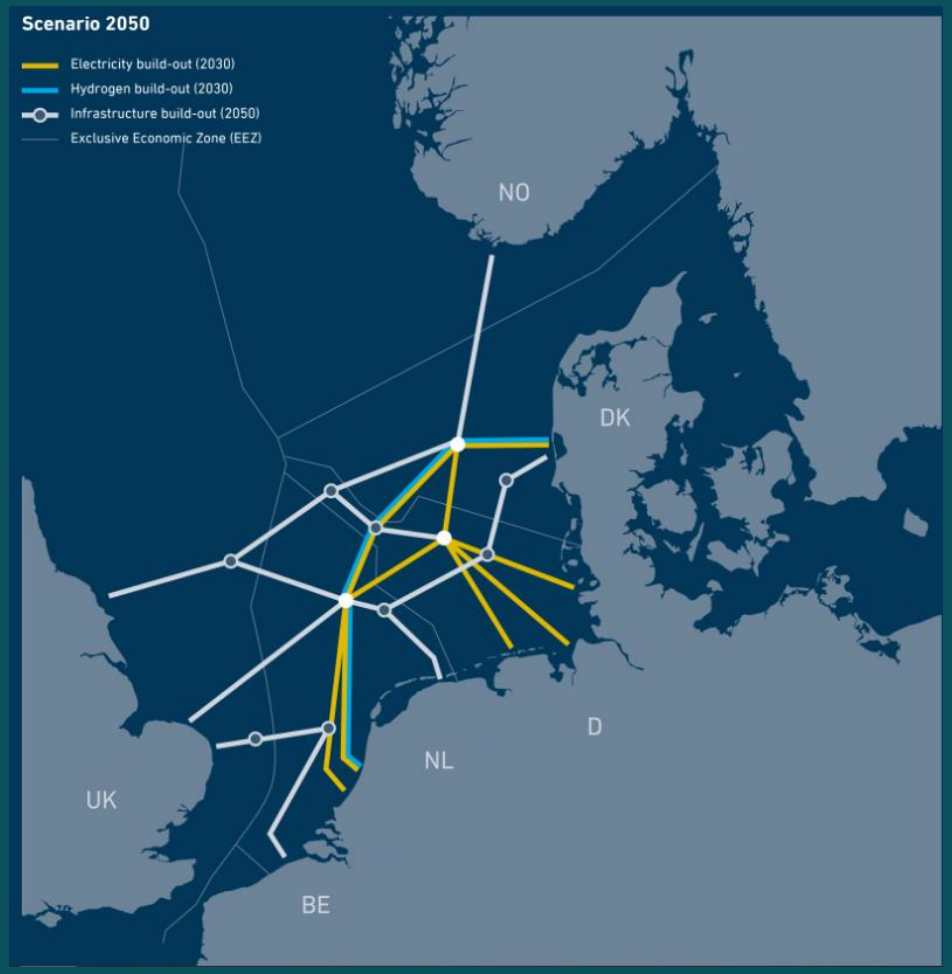
[TYNDP 2022 Scenario Report | Version. April 2022 (entsos-tyndp-scenarios.eu)]

FUTURE COORDINATION OF GAS, ELECTRICITY AND HYDROGEN INFRASTRUCTURE

European hydrogen backbone



OFFSHORE WIND CONCEPTS ANALYSED IN NORTH SEA WIND POWER HUB



North Sea Wind Power Hub

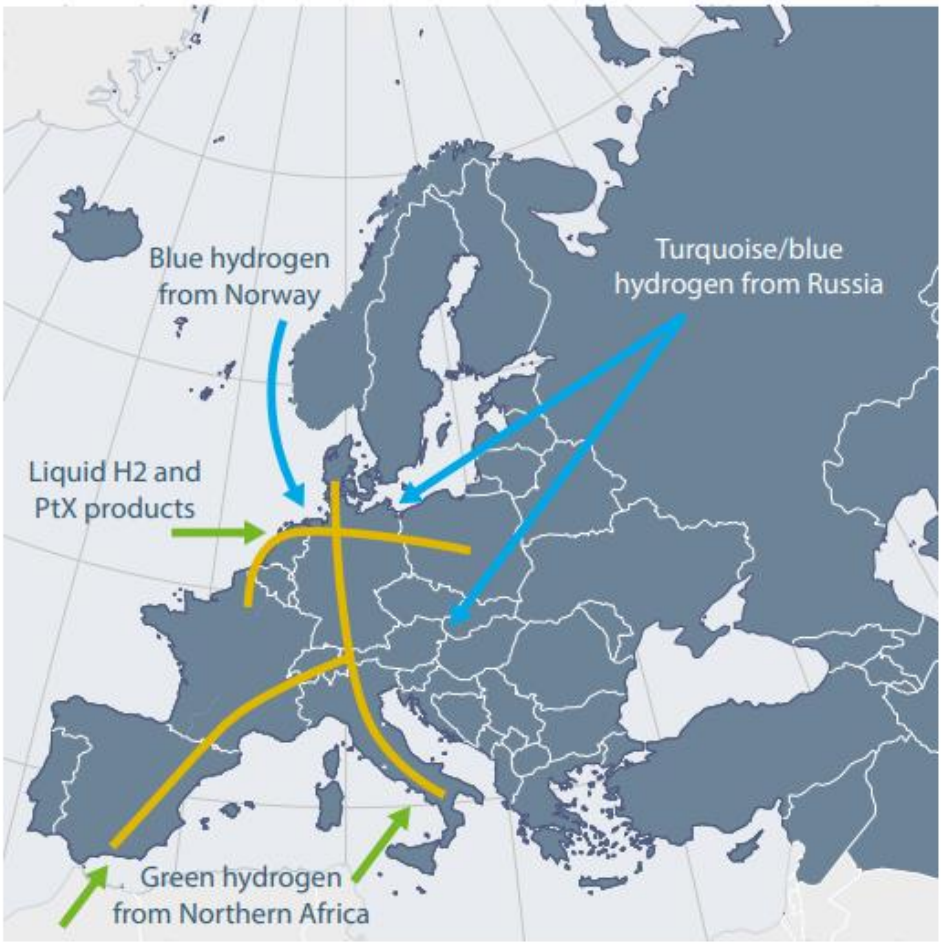


Illustration of possible hydrogen import routes for blue and green hydrogen to Europe via pipelines and ship. The yellow line illustrates one European 'hydrogen backbone".[17]

ALL SOLUTIONS NEEDED….

Types of solutions

- Construction solutions
- Operation solutions
- Market solutions
- Initiatives based on dialog with actors and third-party solutions

STORAGE AND FLEXIBILITY

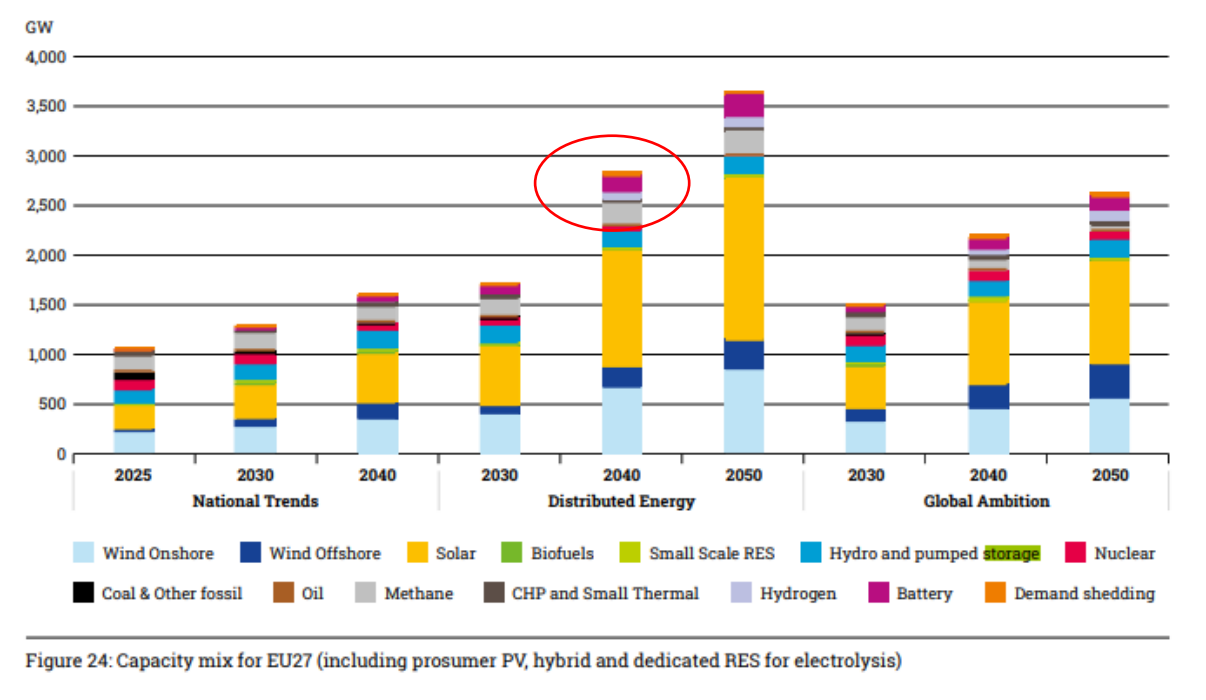
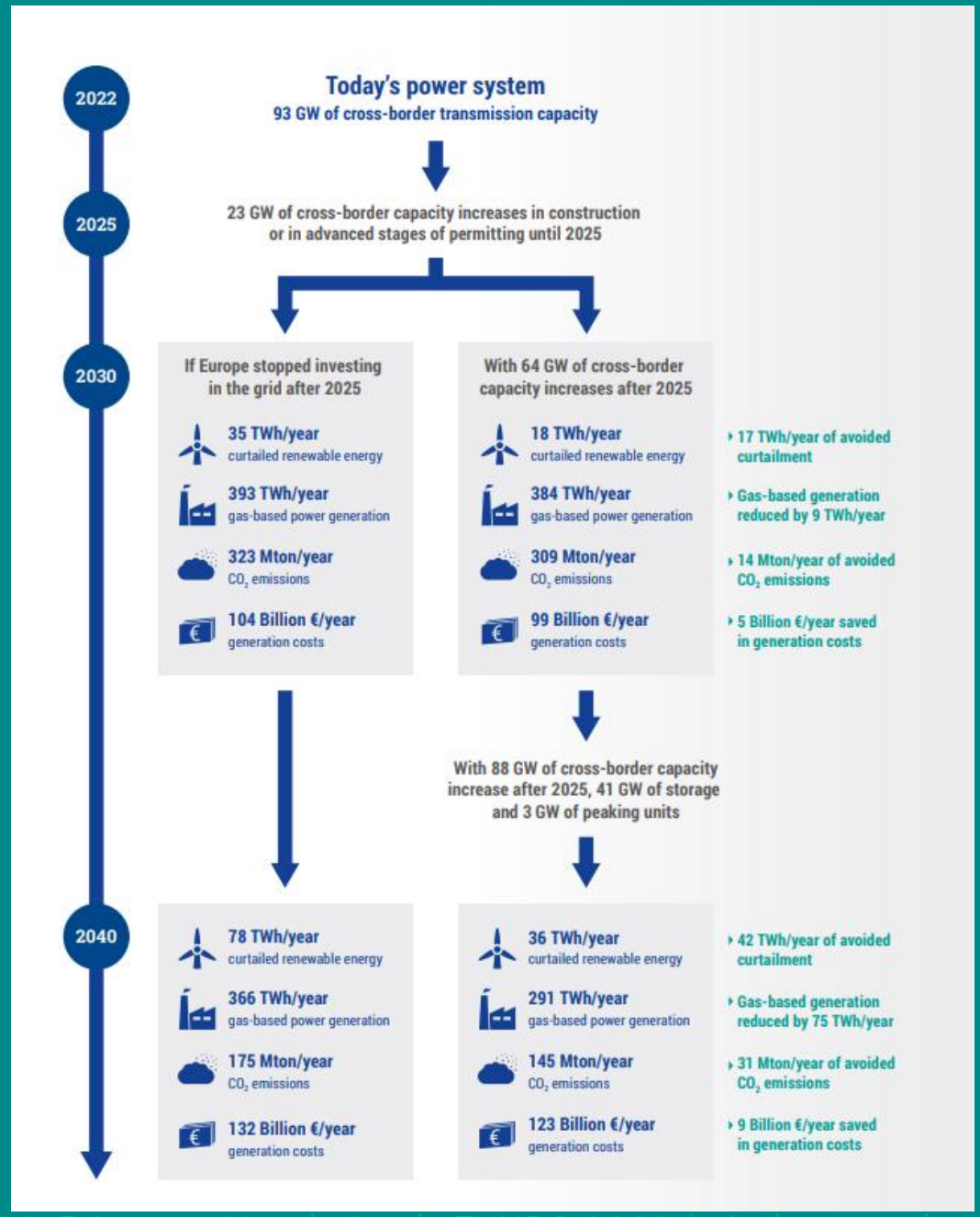


Figure 24: Capacity mix for EU27 (including prosumer PV, hybrid and dedicated RES for electrolysis)

SUM UP



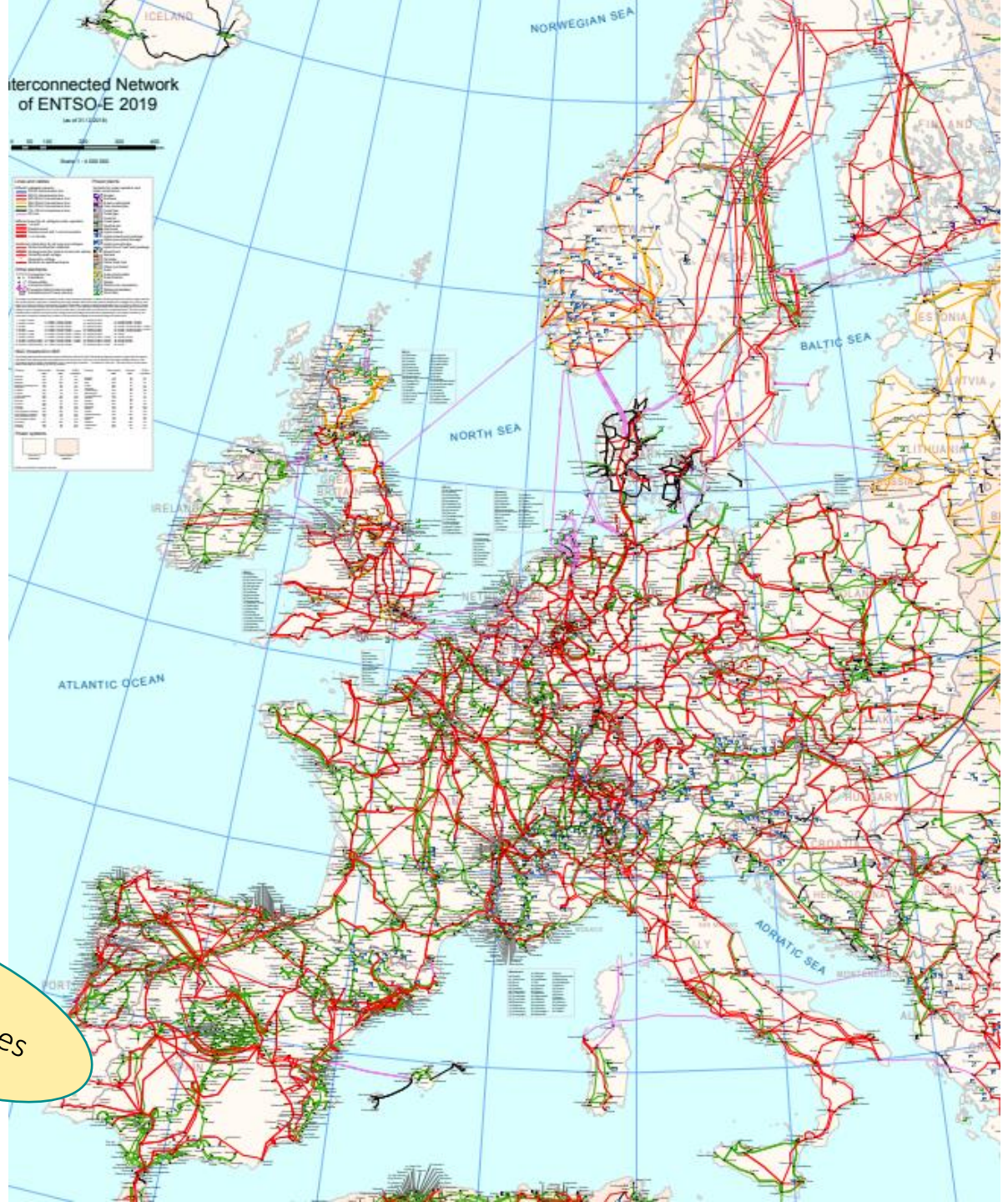
ENTSO-E System Needs Study TYNDP 2022 (windows.net)

SUM UP

- Increasing transmission capacity and cross border electricity exchange has been high EU priority for last 30 years
- Large socio economic benefit and improved security of supply from transmission across countries
- Most important regulation:
  - Electricity market and system operation guidelines gives financial incentives
  - European regulation and coordination creates transparency and platform of over-national agreements
- In green transition need to think energy systems and infrastructure together for security of supply and affordability

The challenges

- How to accelerate and support long distance transmission onshore and offshore?
- How to ensure internal national grid build out?
- How to support sector coupling and flexibility?



LEARNINGS BETWEEN US AND EUROPE

THE CHALLENGES ARE THE SAME – THE DIFFERENCES ARE THE INSPRIRATION

Examples for illustration

Organisation:

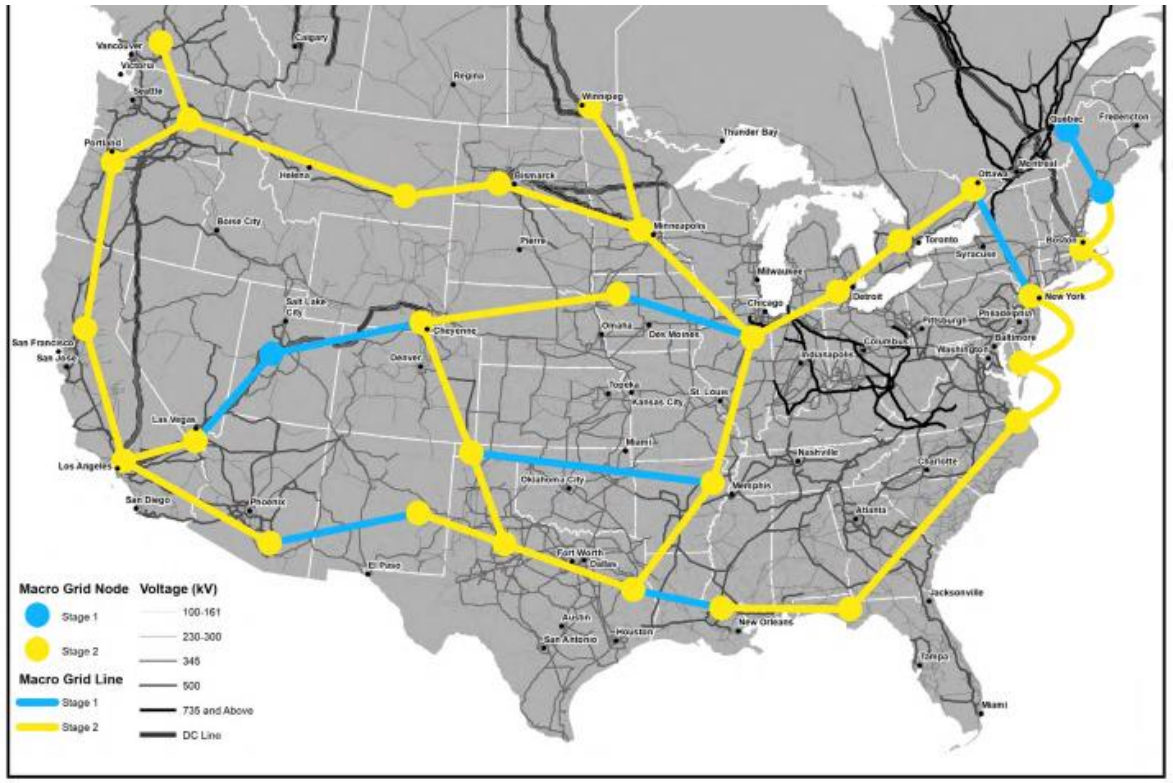
- US is a mix of RTO, ISO and national balancing authorities (room for many different solutions)
- Private owned transmission companies (move fast)

Financing:

- Federal regulation of tariffs (harmonized across the country)
- Inflation Reduction Actt – support for interregional transmission (financial support)

Planning:

- First step taken for national transmission development plan (long distance and not just cross border)



BACK UP

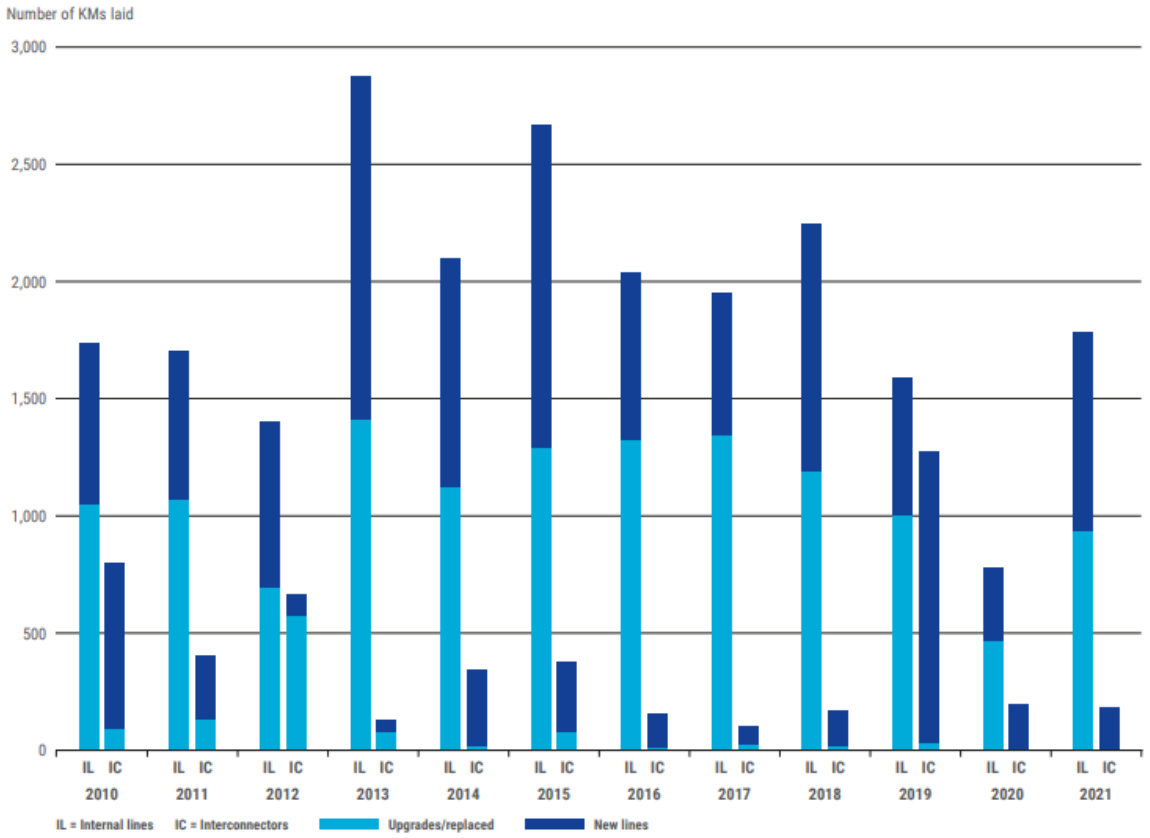


Figure 10 – Projects commissioned each year from 2010 to 2021 in km of line

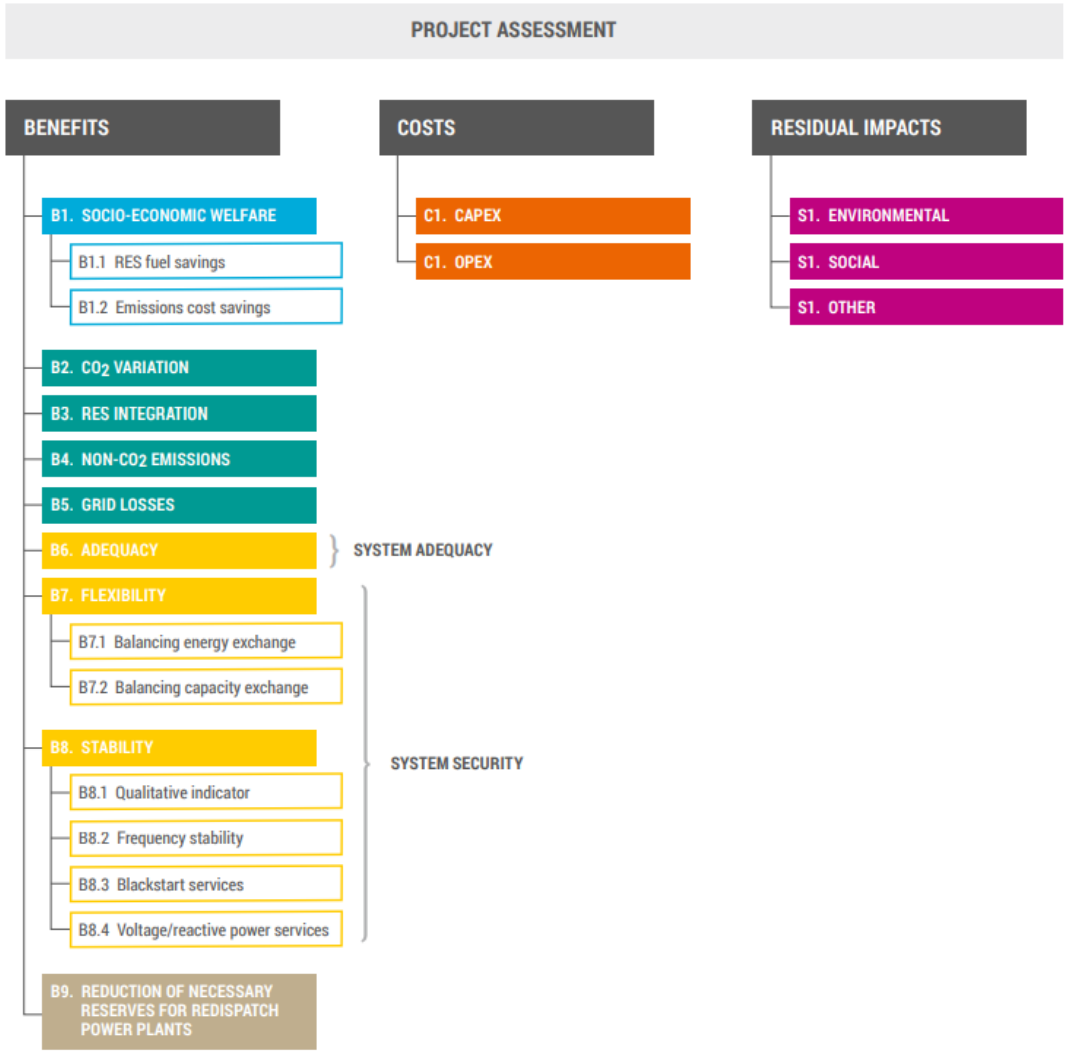


Figure 11 – Assessment framework categories of TYNDP projects

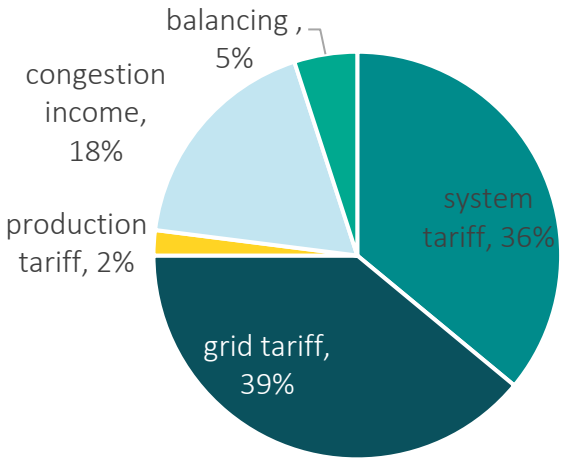
[ENTSO-E High-Level Report TYNDP 2022 (windows.net)]

ENERGINET - FINANCING OF GRID AND SYSTEM OPERATION

- Energinet electricity system operation and transmission grid are non-profit regulated
- Financed mainly by a electricty consumption tariff and congestion income from interconnectors.
- Tarif is appr. 14 Euro/MWh (appr. 30% of electricity market price in 2019)
- Tariff is divided in system tarif and grid tarif
- Tariff is expected to increase pr. MWh with increased grid investments and system costs.
- Grid investments are financed by bank loans and depriciated based on expected lifetime

ENERGINET

Financing, 630 mill. Euro, 2019



Costs, 630 mill. Euro, 2019