Statnett
FoU og Teknologiutvikling
Center for RD&I

EU Green Deal

Dess inverkan på elkraftsystemen

Ludvika 9 november 2020 - prof.dr.techn.ir. Sonja Monica Berlijn MBA

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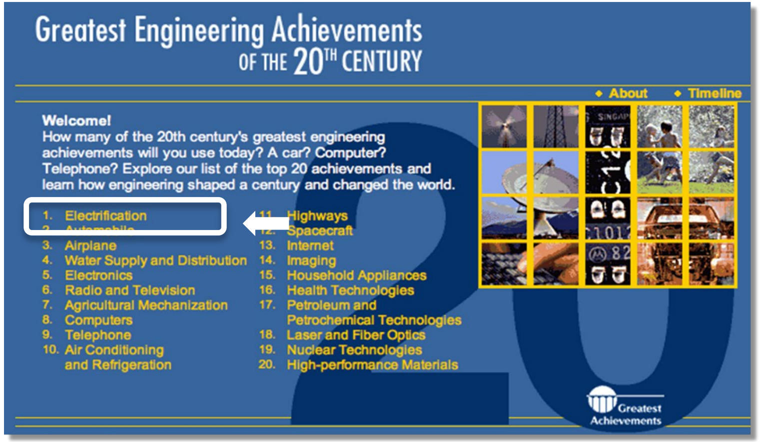
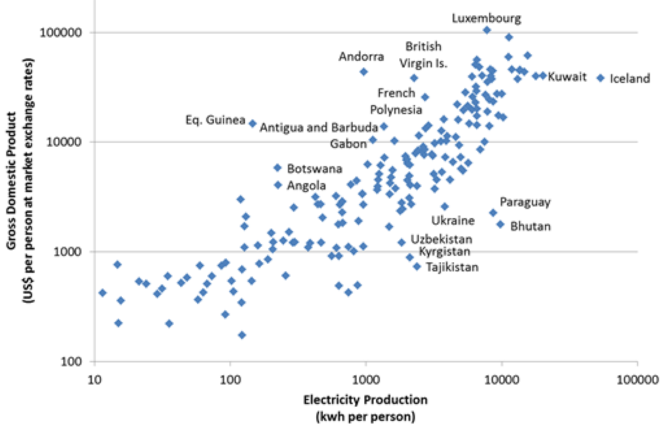
Elektrisitet

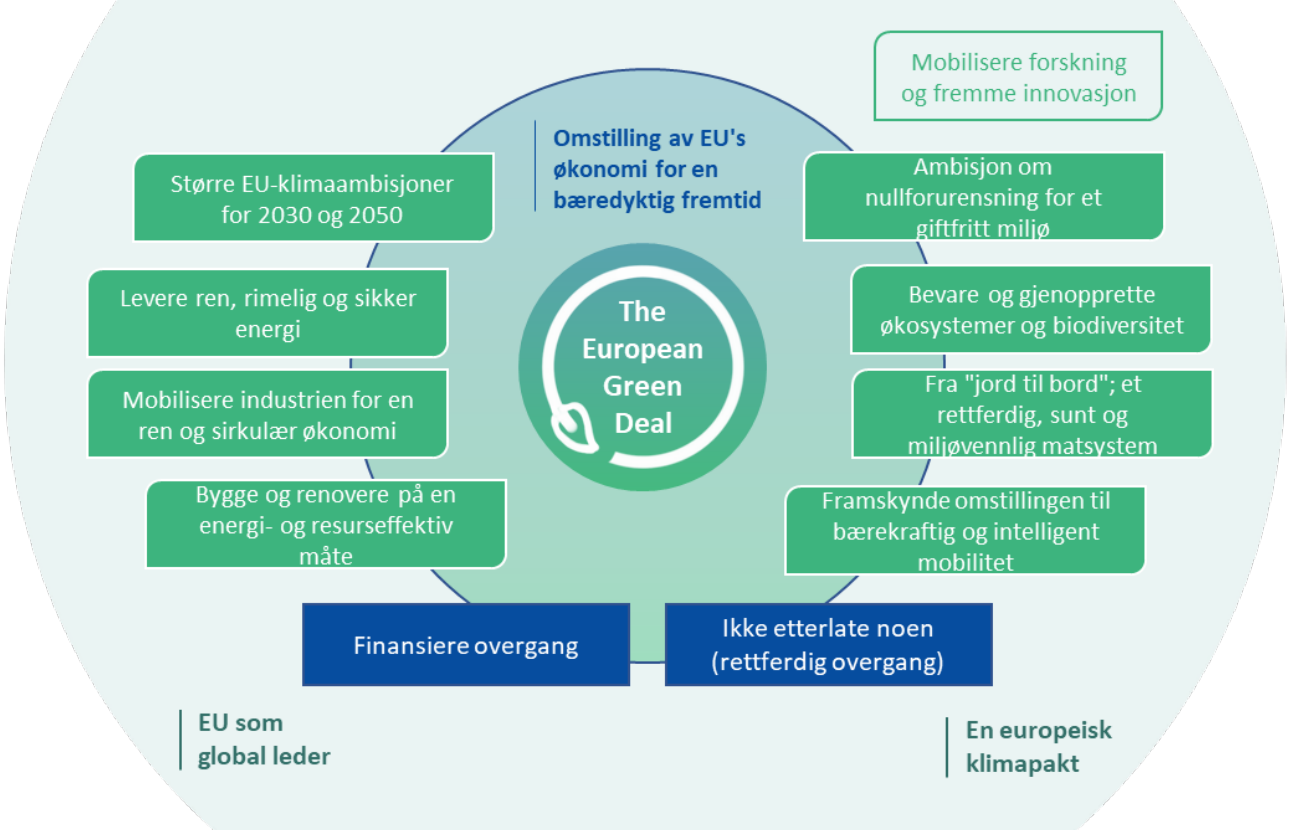
- Tilgang til elektrisk har vært, er og skal forbli viktig for samfunnet, derfor trenger vi et elektrisk kraftsystem som blir mer og mer sentralt i de-karbonisering

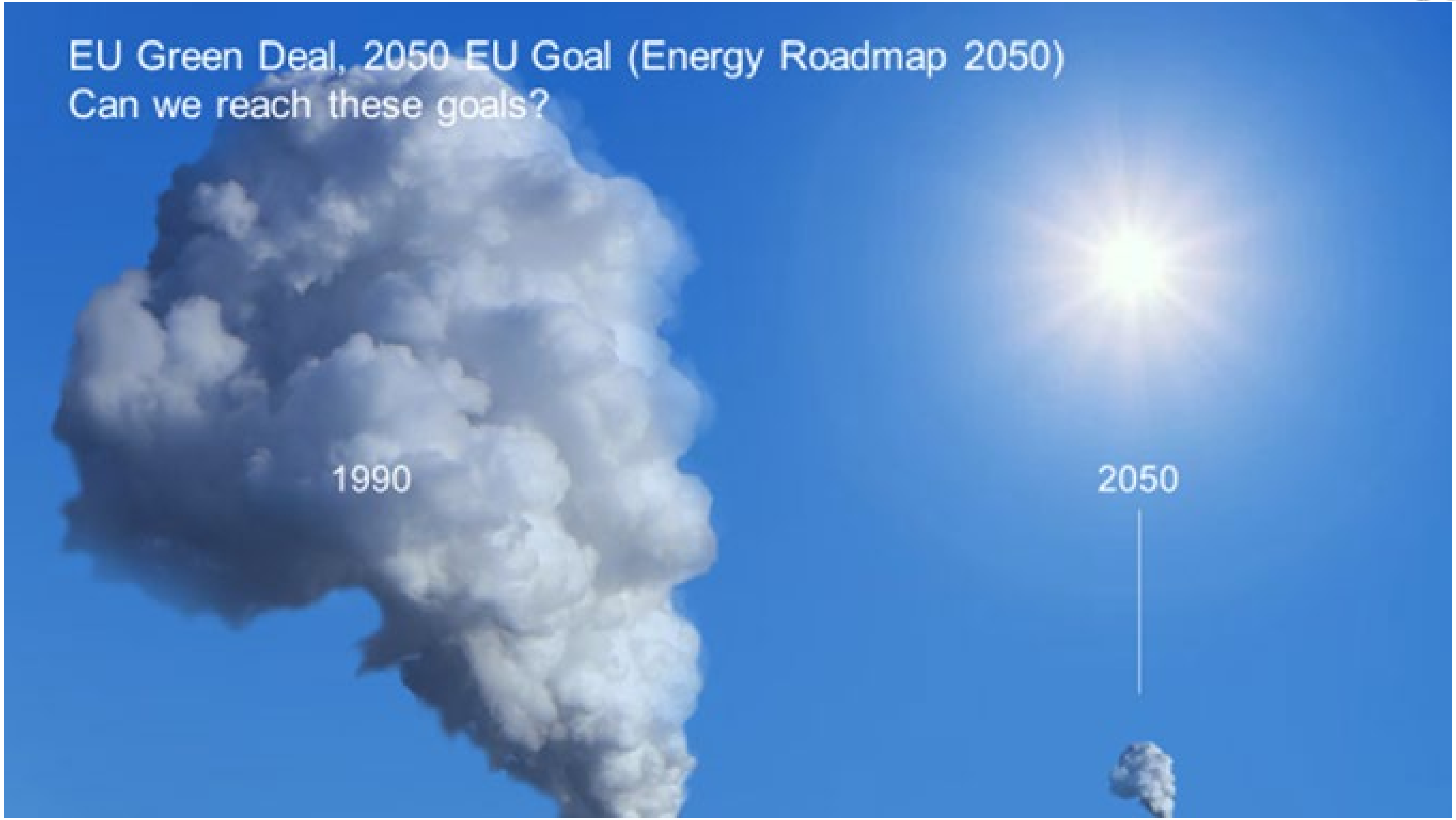




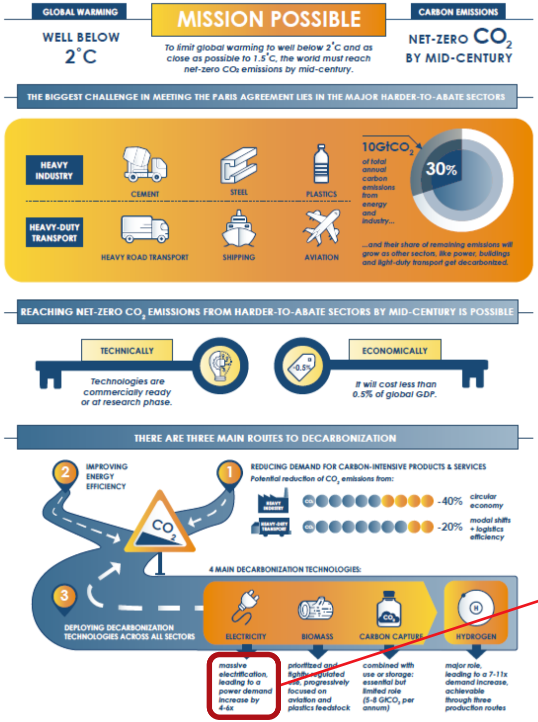
World bank 2009

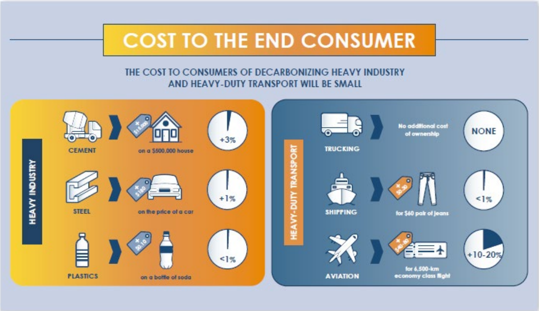
The European Green Deal

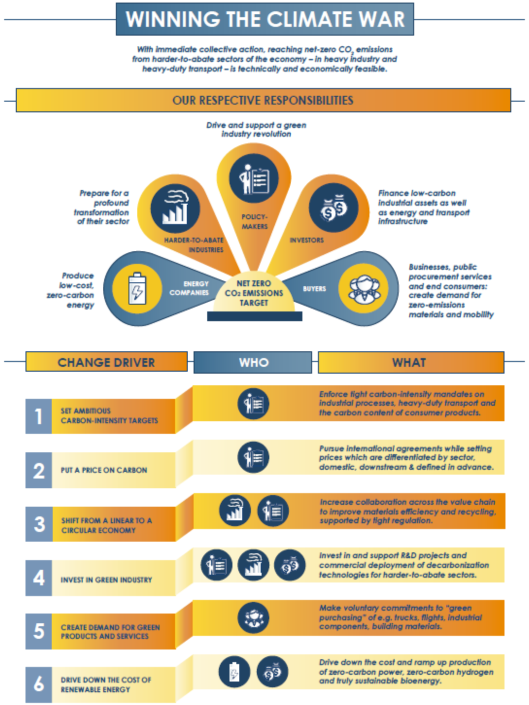



EU Green Deal, 2050 EU Goal (Energy Roadmap 2050)
Can we reach these goals?
1990
2050

Ja, det kan vi!







Massive electrification, leading to an electrical power demand increase in Europe by a factor 4 to 6

Kilde: Energy Transmissions Commission 2018

Elektrifisering er veien til de-karbonisering i Europa

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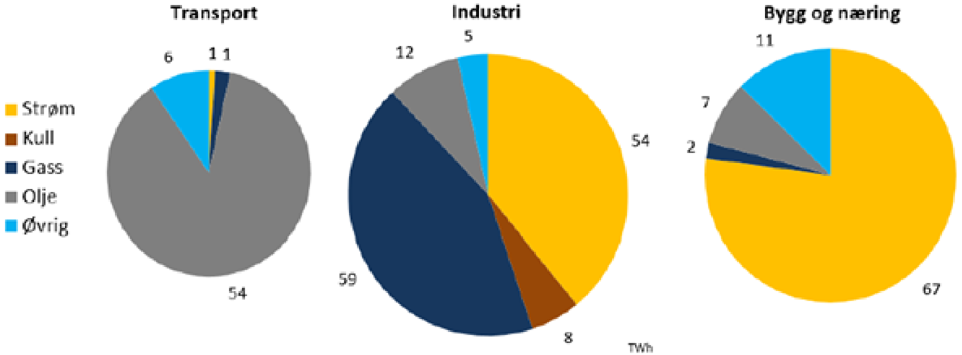
- Whatever the precise level of final energy demand, **electrification will be the dominant route to decarbonization**, with direct use of electricity accounting for 65-75% of final energy demand, and hydrogen and ammonia (in part produced from electricity) accounting for about 10-15%.
- Total electricity generation, whether for direct use, or for the production of hydrogen, ammonia or synthetic fuels, will need to **grow from around 20,000 TWh today to 85-115,000 TWh** by mid-century.
- This hugely increased electricity supply will have to be produced at 85-90% from direct zero-carbon electricity generation (i.e. renewables or nuclear) with only 10-15% coming from biomass or abated fossil fuel inputs.

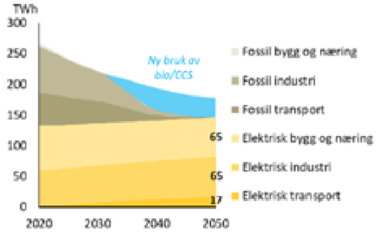
Hvordan blir det i Norge?

Figur 1: Fordeling av norsk energibruk i antall TWh basert på SSBs statistikk for 2017

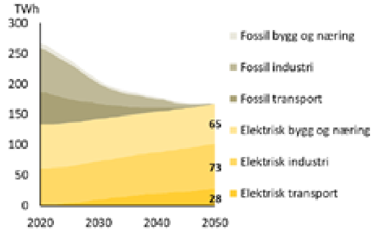


Elektrisitetsforbruket i Norge vil øke med ca. 25%

Fra 133 til 166 TWh



Figur 11: Fossil og elektrisk primær energibruk mot 2050 for Omfattende elektrifisering



Figur 12: Fossil og elektrisk primær energibruk mot 2050 for Fullelektrisk med hydrogen

Kilde: Statnett – Et elektrisk Norge – fra fossilt til strøm

Betydning av full elektrifisering av Norge

- Erstatter vi det meste av dagens fossile energibruk med elektrisitet, får vi en økning i kraftforbruket på 30-50 TWh per år. Med en tilsvarende vekst i fornybar kraftproduksjon gir dette en **halvering av klimagassutslippene i Norge.**
- Konsekvensene for transmisjonsnettet vil trolig være moderate.
- For å nå nullutslipp i energisystemet kan produksjon av hydrogen føre til ytterligere 40 TWh.
- Statnetts estimater tilsier at overgang til elektrisitet der dette er mulig vil bety at 40 TWh fornybar kraft erstatter 95 TWh fossil, altså mer enn en halvering av energibruken
- Dette vil gi store besparelser i energibruken og en samlet reduksjon i norske klimagassutslipp på rundt 25 millioner tonn CO2-ekvivalenter

Utenlandsk kraftproduksjon: vind, sol og termisk
Vannkraft-magasin
Distribuert produksjon med flere energibærere
Klimavennlig flyplass
Forbindelse til utland
Energismart nabolag
Mikronett
Vannkraftverk
Klimavennlig energi-stasjon
Bioenergi og biodrivstoff
Energilagre
Hydrogen - produksjon med CCS
Dyp geotermisk energi
Fjernvarme
Havvind
Smarte byer
Landvind
Klimavennlig energi-effektiv industri inkl. CO2-håndtering
Klimavennlig anleggsplass
Klimavennlige energi-teknologier til maritim transport
energi21

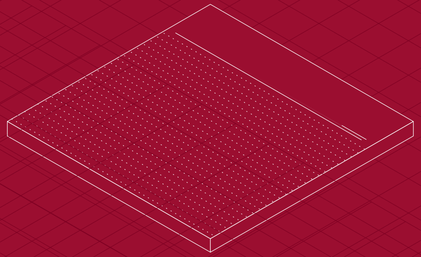
Havvind for et internasjonalt marked

Vannkraft som ryggraden i norsk energiforsyning

Solkraft for et internasjonalt marked

Klimavennlig og energieffektiv industri inklusive CO_2-håndtering

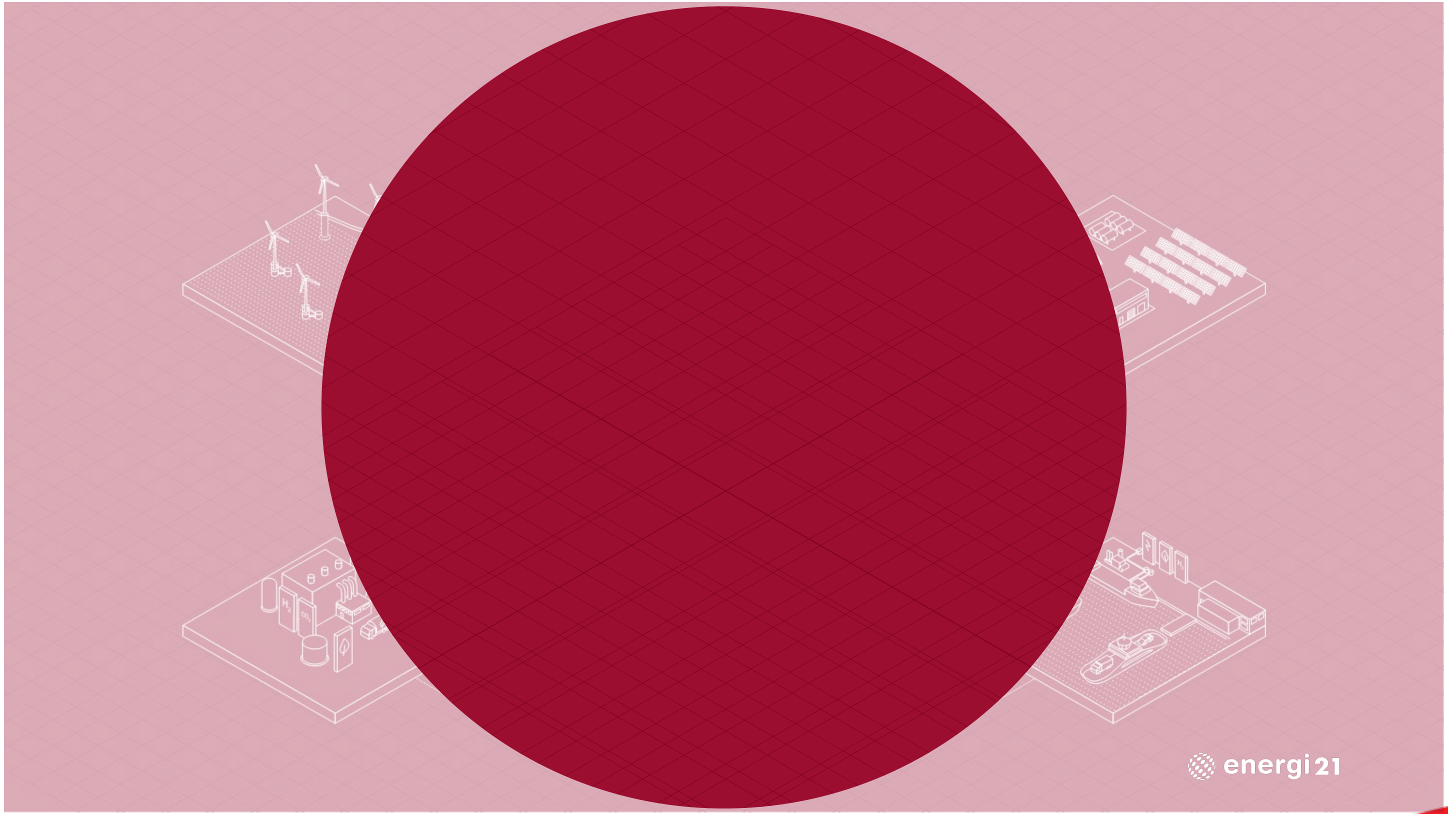
Klimavennlige energi-teknologier til maritim transport



Digitaliserte og integrerte energisystemer

energi21

Elektrisk kraftsystem blir ryggraden



Electricity grids are the enabler for de-carbonisation

Hvordan ser dagens nett i Europa, Norden, Nordsjø og Norge ut?

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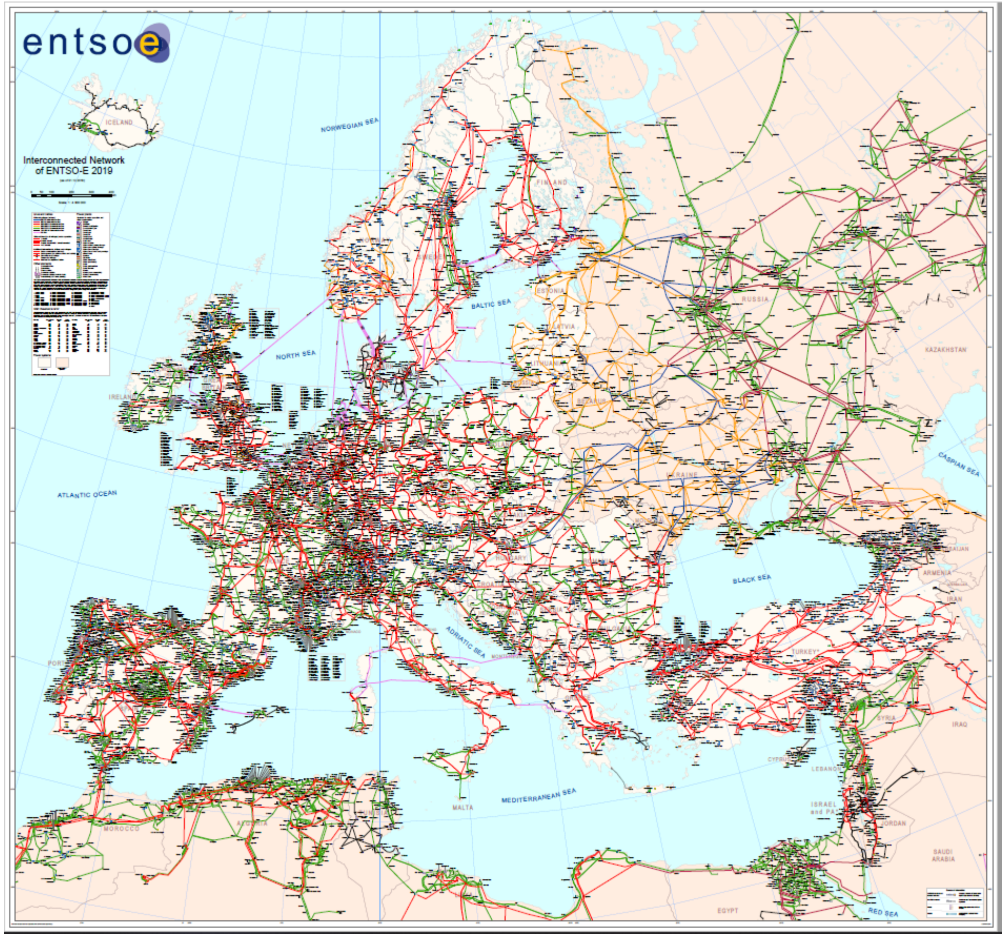
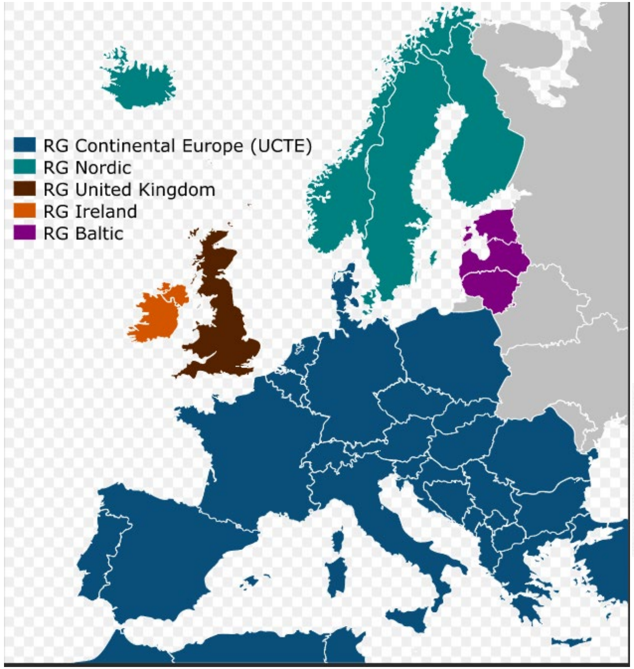
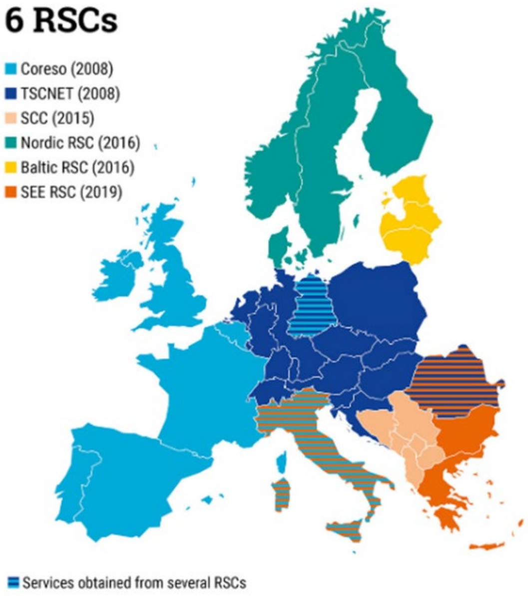


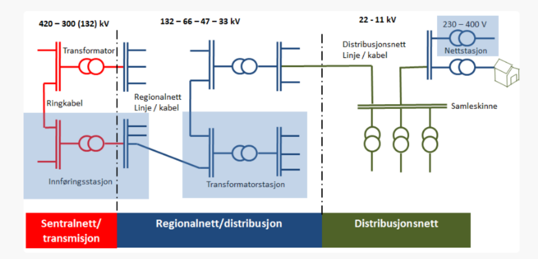
Synkronområder





Dagens nett i Norden

- Kraftnettet transporterer strømmen fra produsent til forbruker.
- Et velfungerende nett er en forutsetning for sikker strømforsyning.
- Kraftnettet er bygget opp på følgende måte:
    - Transmisjonsnett
    - Regional nett
    - Distribusjons nett



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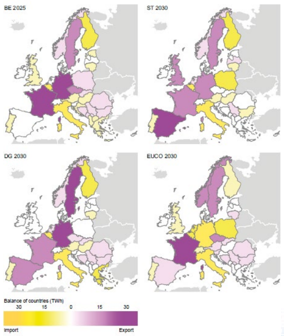
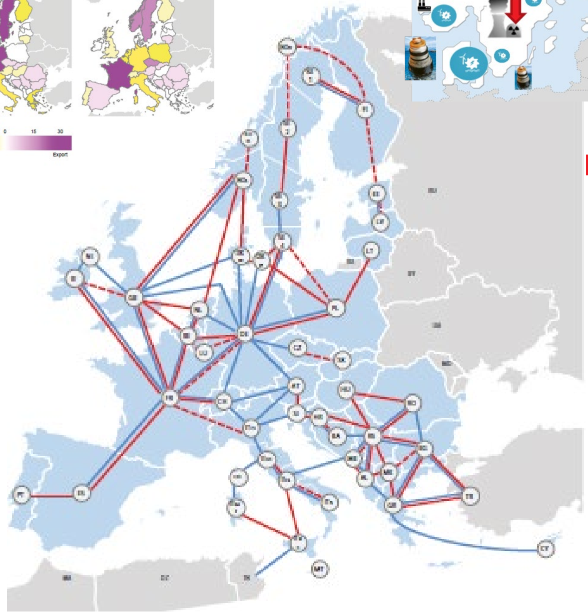
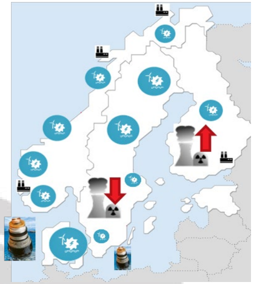
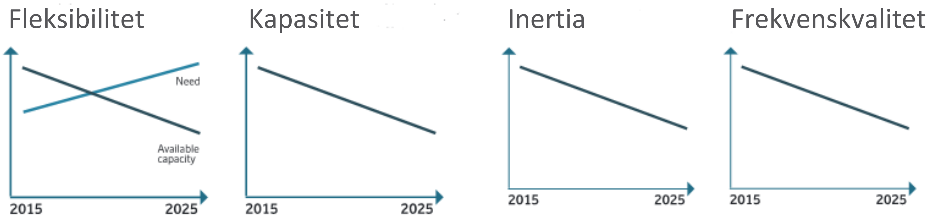
Klimamålene gir oss nye utfordringer i Norden









Norge er en del av det Nordiske synkronområdet

import + produksjon = eksport + forbruk + tap

Kilde: TYNDP 2018

Kilde: Nordic Challenges report 2017

Elektrifisering øker behovet for overføringskapasitet

- We need increased transmission capacity, storage, hybrid off-shore infrastructure, smart grids and Power toX
- 93 GW cross border exchange is needed
- Investing 3,4 bnEuro/year between 2025 and 2040 decreases generation costs by 10 bnEuro/year

entsoe

Home Scenarios System needs European projects Documents Promoters corner Data

93GW of additional solutions for cross-border electricity exchange needed by 2040 to achieve the EU Green Deal

Needs have been identified everywhere in Europe, with a total of 50GW of needs on close to 40 borders in 2030 and 43 additional GW on more than 55 borders in 2040. Projects promoters are welcome to submit projects addressing the identified system needs to the TYNDP 2020 until end September.

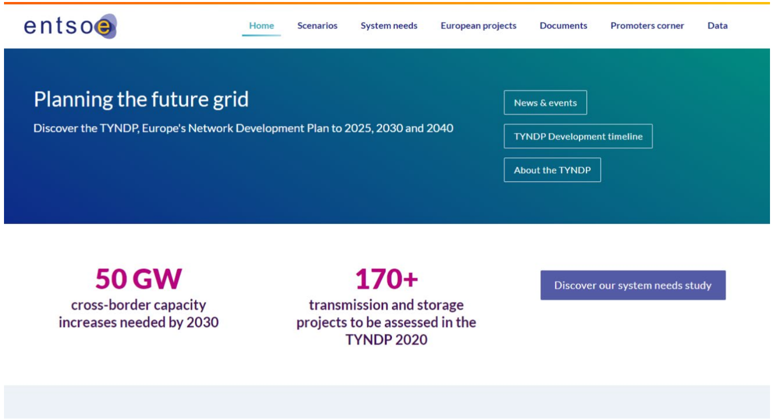
ENTSO-E's System Needs study released today shows borders or areas where new solutions for electricity exchange are needed to reach climate neutrality while keeping security and costs under control. Beyond the next wave of anticipated cross-border grid investment (35GW by 2025), needs have been identified everywhere in Europe, with a total of 50GW of needs on close to 40 borders in 2030 and 43 additional GW on more than 55 borders in 2040.

Addressing system needs puts Europe on track to realize the Green Deal, with 110 TWh of curtailed energy and 53 Mtons of CO2 emissions avoided each year until 2040. Market integration would progress, with price convergence increasing between bidding zones thanks to an additional 467 TWh/year of cross border exchanges by 2040. Investing 1.3 bn€/year between 2025 and 2030 translates into a decrease of generation costs of 4 bn€/year, while investing 3.4 bn€/year between 2025 and 2040 decreases generation costs by 10 bn€/year. Addressing the identified needs by 2040 would represent 45 bn € of investment, translating directly into jobs and growth for Europe.

Towards a system of systems

Europeisk nettplanlegging

- På Europeisk nivå koordineres nettplanlegging via ENSTO-E
- Det utvikles en TYNDP (Ten Year Network Development Plan) hvert annet år



What is the Identification of System Needs?

The identification of system needs study investigates where improving the electricity flow throughout Europe could bring benefits to Europeans. The present report investigates needs in the 2040 and 2030 horizons. For example: where could CO_2 emissions be reduced? Where could the curtailed electricity from renewable energy sources be used? Where could the electricity price between neighbouring countries be more aligned? The study also assesses the cost of not investing in the needed infrastructure. The System needs study is carried out by ENTSO-E biannually and forms part of the Ten-Year Network Development Plan (TYNDP) 2020 package.

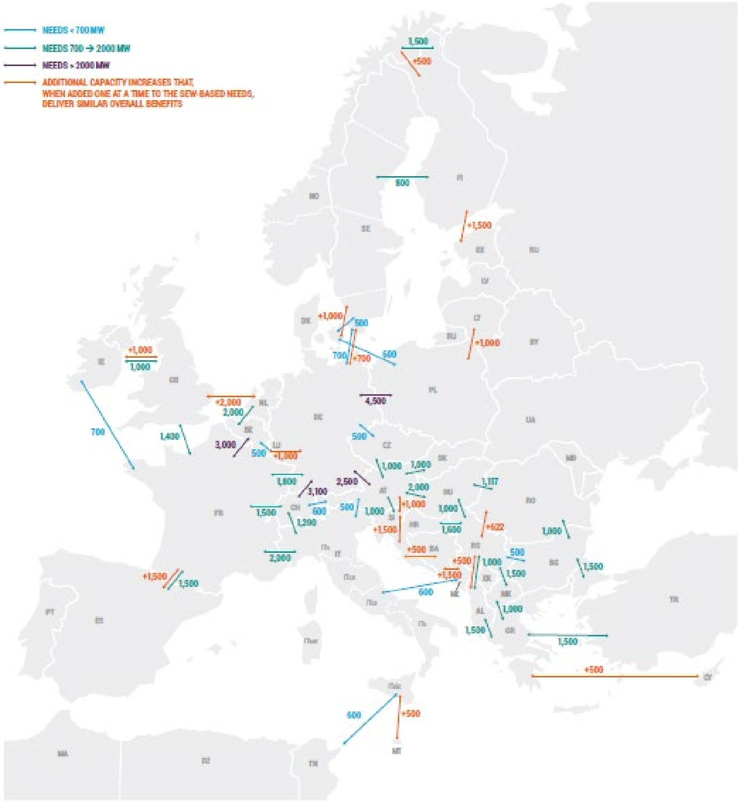
An essential step in Europe's long-term electricity infrastructure planning

The TYNDP is a long-term plan on how the electricity transmission grid is expected to evolve in Europe to implement the EU energy. Identifying the system needs is the second step in the development of the TYNDP.

The TYNDP 2020 scenarios developed jointly by ENTSO-E and its gas counterpart ENTSOG are described in the Scenarios report published in June 2020. Following the collection of projects from project promoters in November 2019, the TYNDP 2020 will perform a cost-benefit analysis of 171 transmission and storage projects and evaluate how they contribute to meeting the system needs for 2030.

Figure 0.1 – The three main steps of the TYNDP process

Identified need for capacity increase 2030 and 2040



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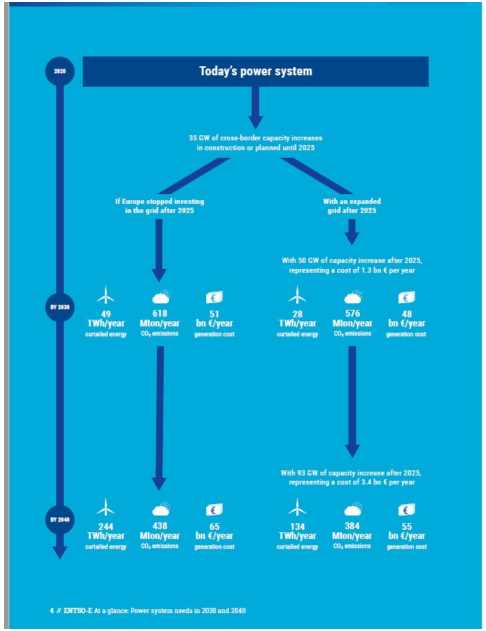
Hvorfor investerer vi i nett?

- Green Deal realisation 53 Mtons of CO2 avoided each year
- Investing will be the key to support the economy post COVID. It will support European industry.
- Addressing the identified needs by 2040 would represent 45 bn € of investment, translating directly into jobs and growth.



What if we do not invest:
High price differences between market areas

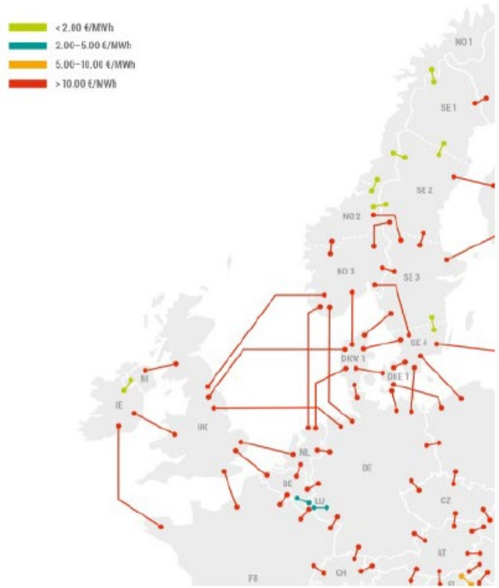


Figure 3-20: Difference in marginal costs between neighbouring bidding zones in 2040, in 'No investment after 2025'

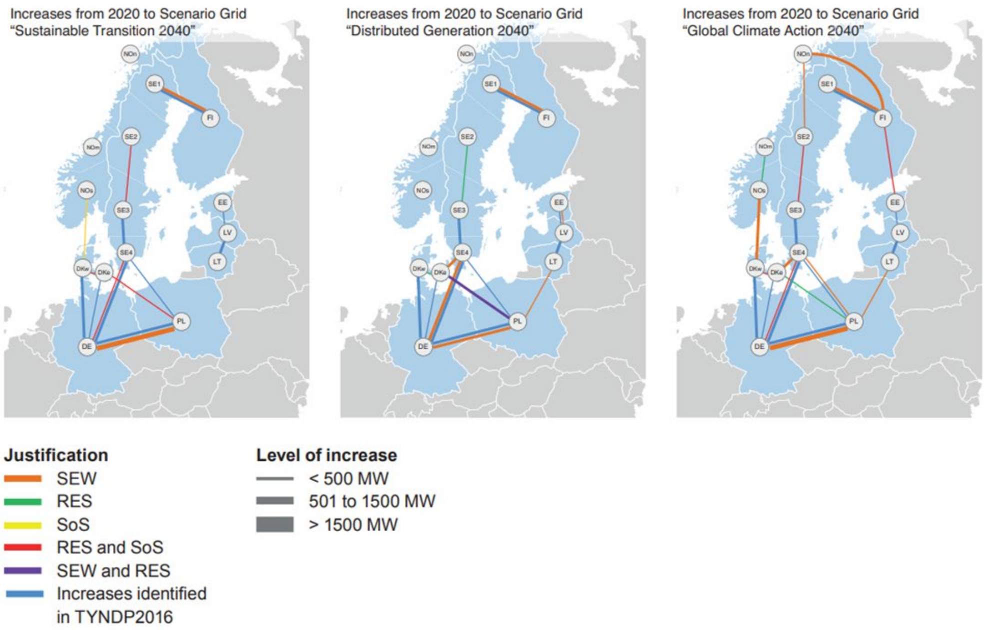
Regional nettplanlegging

- Kompleterende til Europeisk plan utarbeides det 6 regionale plan
- Norge inngår i hvert fall i 2 av de

Nettplanlegging i 'Baltic Sea'

- Også denne rapporten viser økt behov for kapasitet

Figure 6: Identified capacity increase needs in the three 2040 scenarios studied in BS region[5]



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Nettplanlegging i 'Northern Sea'

- Off-shore grid er i utvikling

The grid developments of the Northern Seas may serve as an example. These above developments could evolve in the Northern Seas to something like what is shown in the principle map below (Figure 5-6):

i. Country-to-country subsea interconnections,

ii. Radial offshore wind connections (single park) to shore,

iii. Radial offshore wind connections (several parks via hubs) to shore,

iv. Hybrid projects, (combination of offshore wind connections and interconnections) and

v. Multiterminal offshore platforms combining interconnections (with or without offshore wind being connected).

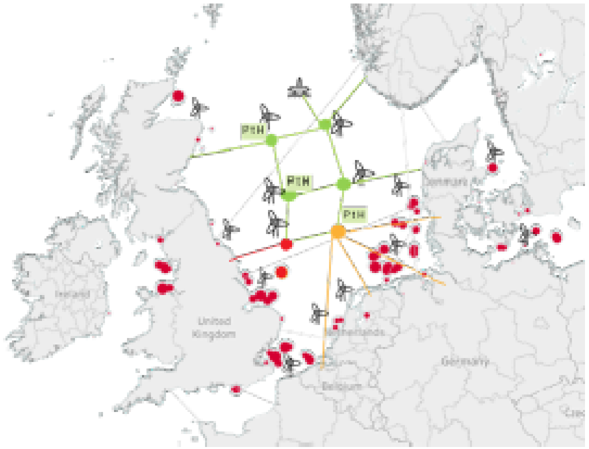
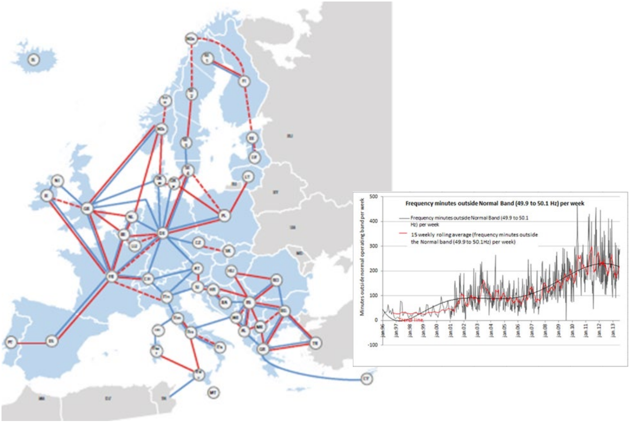
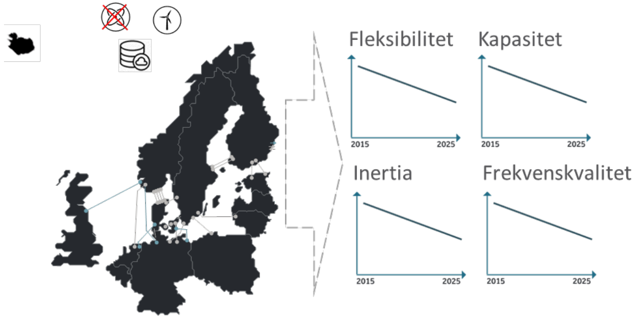


Figure 5-6: Potential development of offshore grid infrastructure (principle sketch, red dots represent existing OWFs).

Electricity grids are the enabler for de-carbonisation
This gives both opportunities and challenges



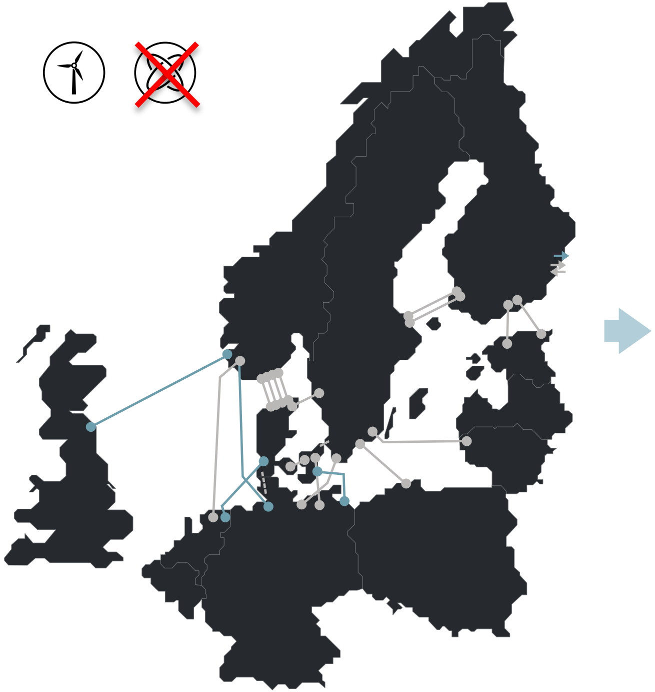


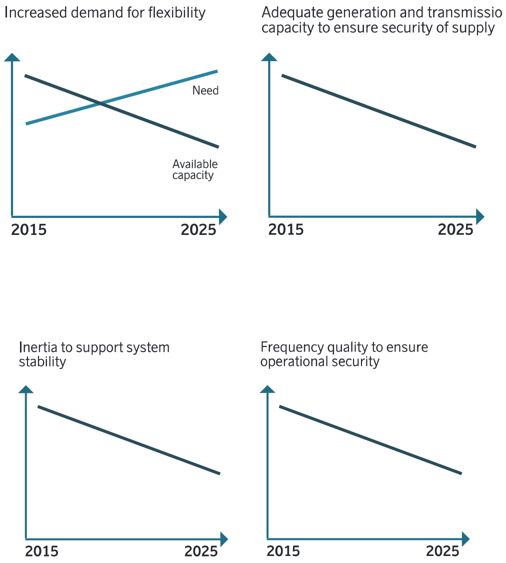
it is all about keeping the lights on..
and this is getting more difficult

Challenges and opportunities for the Nordic power system

Statnett FINGRID ENERGINET.DK SVENSKA KRAFTNÄT SWEDISH NATIONAL GRID

The changes challenge the way the Nordic Power System is planned and operated





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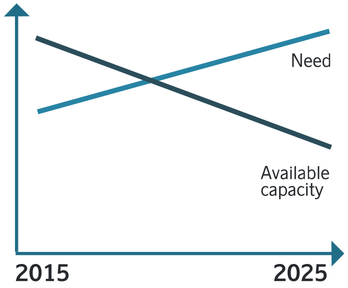
Increased demand for flexibility

- The demand for flexibility is increasing, both in the day-ahead market and in the operational hour.
- At the same time, the flexibility provided by existing hydro plants is limited and the thermal production capacity is declining

Increased demand for flexibility



Challenges

- A risk of having hours without price formation in the day-ahead market
- Periods of insufficient balancing resources available in the operational hour

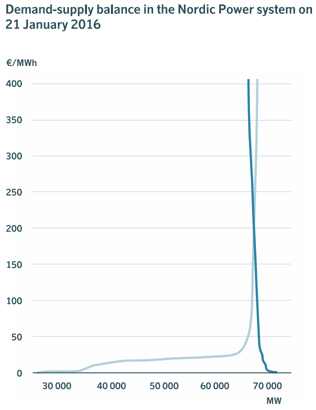
Possible solutions

- A finer time resolution in the day-ahead, intraday and balance market
- Utilize the transmission capacity more efficiently
- Ensure that the rules and regulation of the market facilitates the most cost effective development and utilization of available flexibility
- Utilising the information provided by the AMS-meters to introduce demand response

Generation to ensure security og supply

Challenges

1. Ensuring flexible capacity with market signals
2. Lack of adequate assessment and methodologies



Demand-supply balance in the Nordic power system on 21 January 2016. The figure shows that on this date the demand-supply balance was very tight. Market Data from Nord Pool Spot.

Possible solutions

- Develop harmonized Nordic common probabilistic methodologies
- Identify mitigation measures to address adequacy in a Nordic perspective, although the implementation can be both national and regional.
- Common definitions on generation adequacy that focus on defining a socioeconomically efficient level of security of supply.

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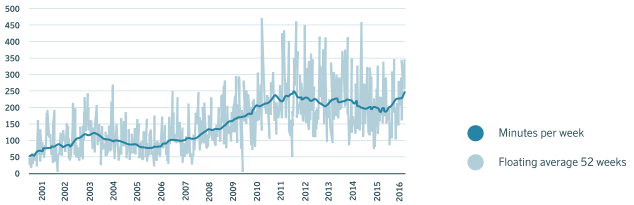
Maintain good frequency quality to ensure operational security

Challenges

- Larger imbalances caused by ramping
- More unpredictable power generation will increase the forecast errors
- Increased need for, but reduced access to, reserve capacities
- Availability of transmission capacity for frequency and balancing reserves

Development in frequency quality 2001 - Q1 2016

Minutes per week outside the normal frequency band (49.9-50.1 Hz)



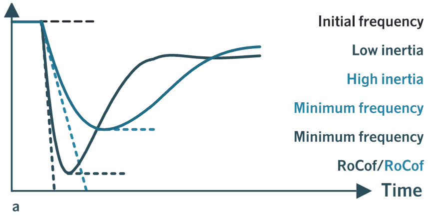
Possible solutions

- A common Nordic specification for the frequency quality
- Further develop joint Nordic ICT-solutions
- Introduce higher time resolution
- Stronger incentives for the Balance Responsible Providers to keep the balance
- Introduce efficient solutions for allocating transmission capacity to the reserve markets.
- Harmonize products and market solutions for frequency and balancing regulation

Sufficient inertia to support system stability

Challenges

- Having sufficient inertia in the system to ensure operational security
- Lack of minimum requirements i.e. a common understanding of how low level of inertia the system can handle and what is expected in the future Nordic power system



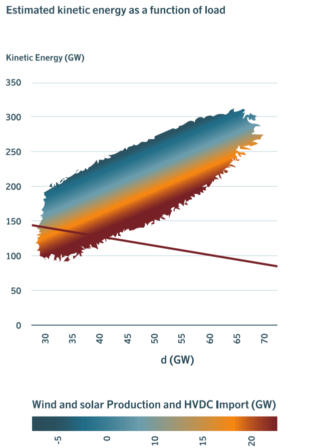
Frequency and power responses after a generator trip. a) Initial frequency and frequency responses after a generator trip with high and low

Possible solutions

- Market solutions or incentives to ensure that enough inertia is maintained in the system at all times

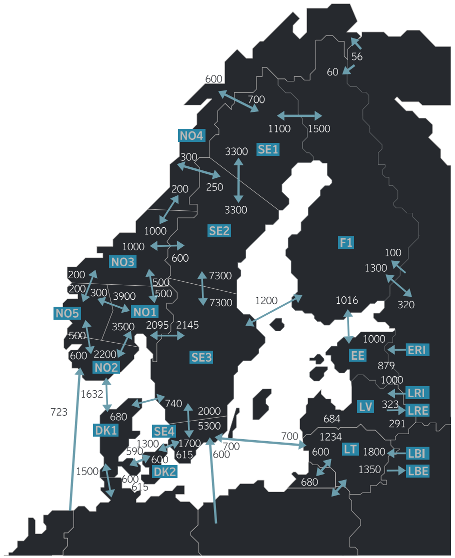
Technical solutions

- Installing system protection schemes
- PMU and the use of HVDC links/converters
- Increasing inertia from existing production units
- Add more frequency containment reserves



Estimated kinetic energy in 2025 as a function of total load in the synchronous area with wind and solar production and HVDC import including all climate years (1962–2012) of the market simulation scenario. The percentage of time when the estimated inertia measured by kinetic energy in 2025 is below the estimated required amount (shown by the red line) is 7.7 % (673 hours per year)

Transmission adequacy to ensure security of supply



Challenges

- Using correct assumptions and value all benefits when planning the transmission net
- Maintain operational security and an efficient market while reconstructing the grid

Possible solutions

- Develop the grid and addition transmission capacity can alleviate the challenges with flexibility and real-time balancing
- Improve modelling tools and a common understanding in the interpretation of findings, and a robust scenario strategy
- Clarify differences and common goals in the Nordics for grid development

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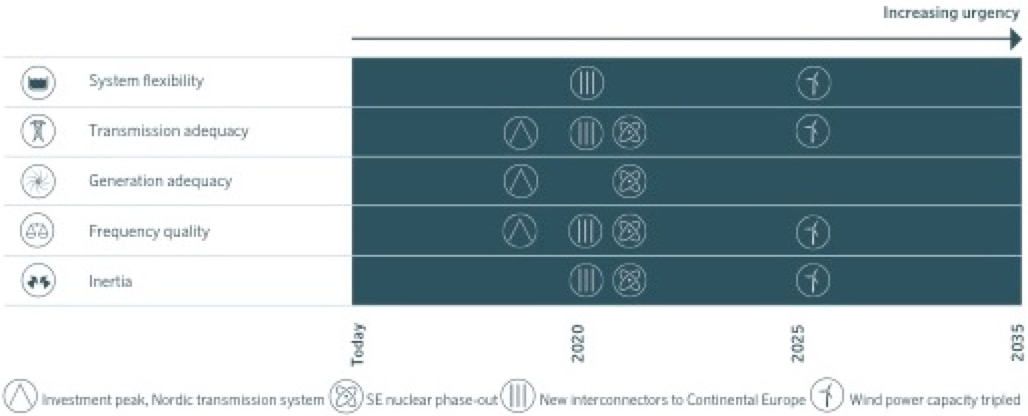
The way forward – there is an urgency to deal with the challenges



- The Nordic TSOs will follow up with a "solution report" 2016-2017 where the different solutions / alternatives are compared
- But an extended cooperation across the power sector is also needed!

Technical challenges in Baltic Sea

- Technical challenges brought forward by increases in RES generation, which are identified by TSO experts include:
  - Frequency stability issues, due to reduced inertia, increased deviation range and ramp rate of generation and larger contingencies;
  - Voltage stability issues, due to longer transmission paths and reduced voltage control near load centres; and
  - Angular stability issues, due to reduced minimum short-circuit current levels.

Challenges in Northern Sea

- Fundamental change of the generation portfolio
- Need to satisfy increasing electricity demand and security of supply
- Need to integrate huge amounts of offshore wind generation
- Change in the flow across the region – grid congestions
- High price differences between market areas
- High amounts of RES curtailment and CO_2 emissions
- Ensuring flexibility in the energy system

Wow – that is a lot!?

- Both significant investments and new solutions are needed and they are needed fast!


Siemens

ANNONS

Stor andel väderberoende elproduktion skapar utmaningar


Utmaningen: Hur ska elnäten räcka till för hela Sverige?

2020-08-18 06:00 Av: Linda Nohrstedt 19 kommentarer

Aktivera Talande Webb

Det är trångt i elnäten, både runt storstäderna och mellan olika landsändar. Här är sju artiklar om Sveriges kapacitetsutmaning – med några lösningar.


NyTeknik

Premium / Automation / Digitalisering / Energi / Fordon / Startup / Ingenjörskarriär / Lediga j

OPINION

”Därför är det inte ’ren idioti’ att bygga datacenter”

2020-11-04 07:00 23 kommentarer

Det här är en debattartikel. Åsikterna som framförs är skribentens egna.

Aktivera Talande Webb

DEBATT. Etablering av datacenter kritiseras på grund av elförbrukning och för att de inte ger många arbetstillfällen. I själva verket har datacenter en positiv klimateffekt – och leder till jobb, skriver forskare och


OPINION

”Utsläppen måste ned till noll – det här krävs av tekniken”

2020-10-30 08:01 83 kommentarer

Det här är en debattartikel. Åsikterna som framförs är skribentens egna.

Aktivera Talande Webb

DEBATT. Alla fossila bränslen måste avvecklas, flygandet minska rejält och kött- och mejerikonsumtion kapas kraftigt. Men det finns tekniska lösningar för att nå nollutsläpp i samhället, skriver Göran Finnveden, KTH.

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

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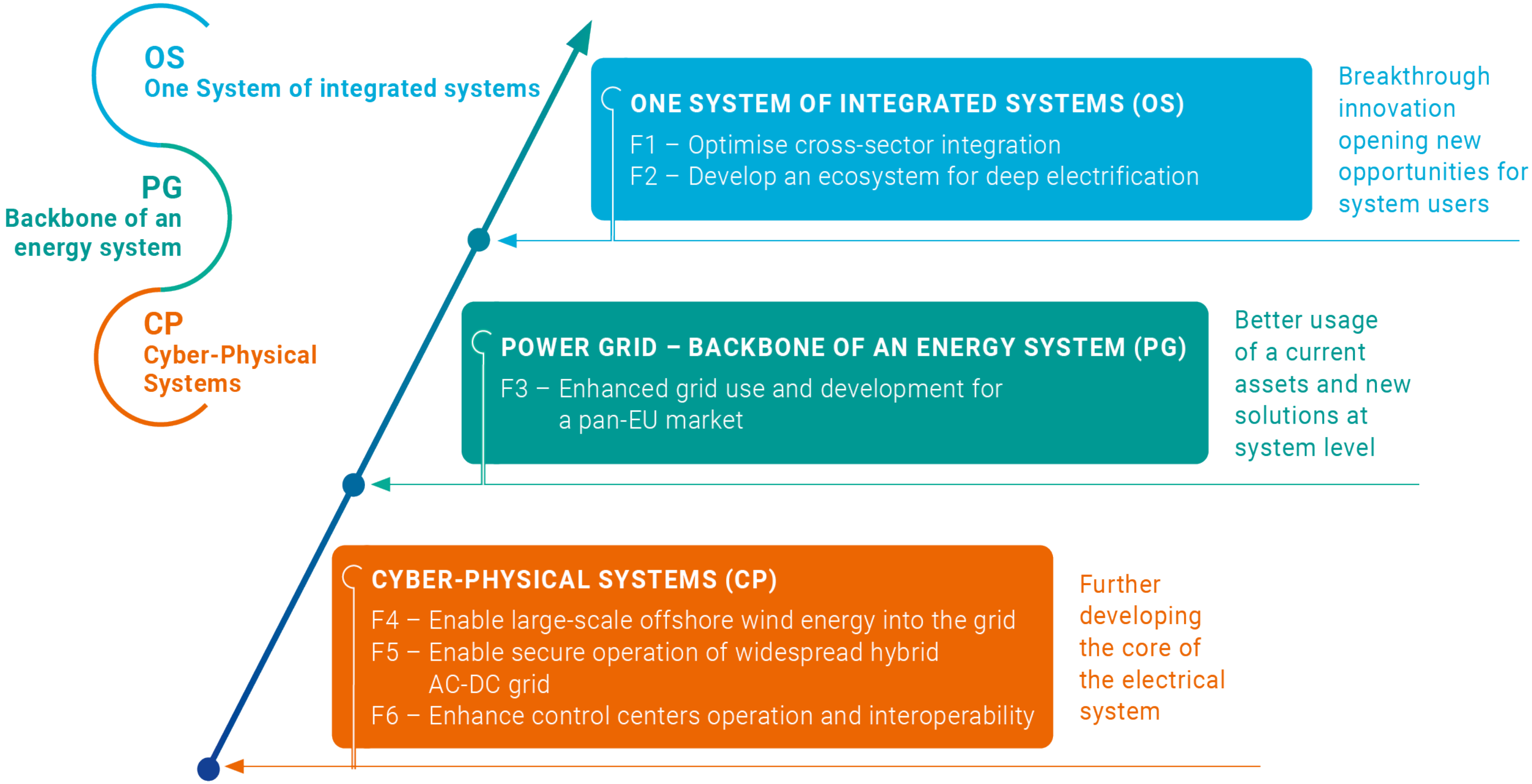

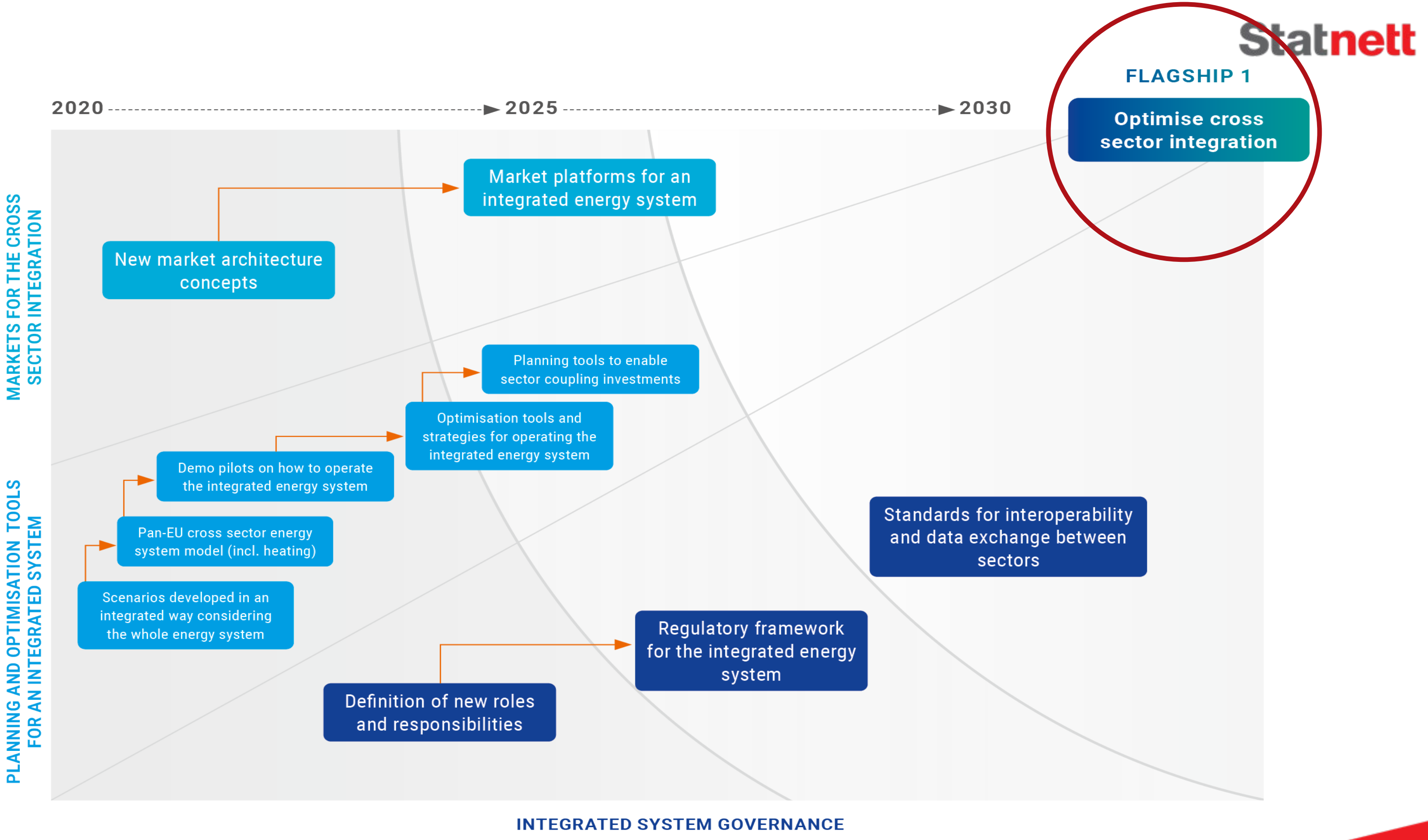
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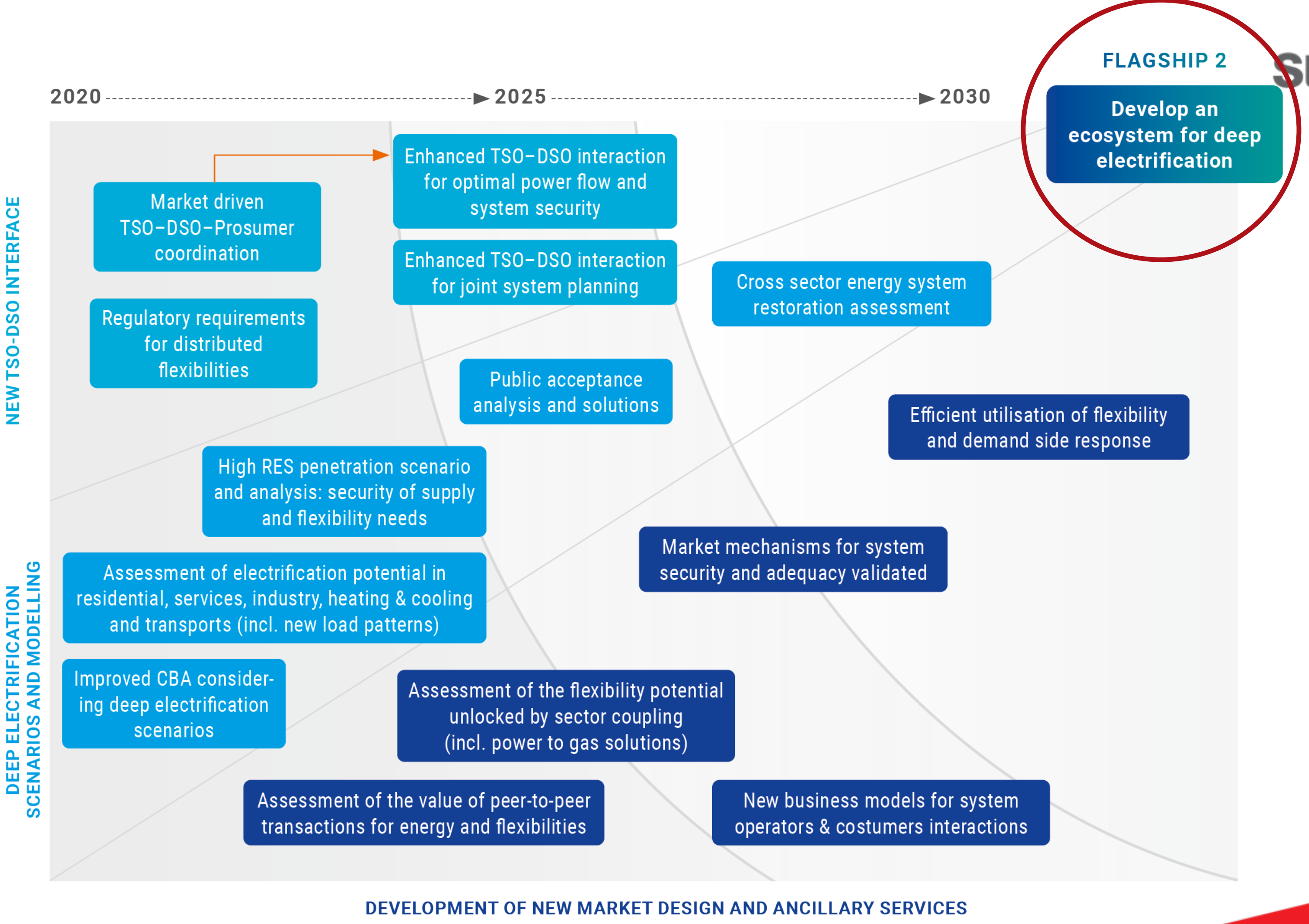
FLAGSHIP 1
Optimise cross sector integration
2020
2025
2030
MARKETS FOR THE CROSS SECTOR INTEGRATION
PLANNING AND OPTIMISATION TOOLS FOR AN INTEGRATED SYSTEM
INTEGRATED SYSTEM GOVERNANCE
New market architecture concepts
Market platforms for an integrated energy system
Scenarios developed in an integrated way considering the whole energy system
Pan-EU cross sector energy system model (incl. heating)
Demo pilots on how to operate the integrated energy system
Optimisation tools and strategies for operating the integrated energy system
Planning tools to enable sector coupling investments
Definition of new roles and responsibilities
Regulatory framework for the integrated energy system
Standards for interoperability and data exchange between sectors


FLAGSHIP 2
Develop an ecosystem for deep electrification
2020
2025
2030
NEW TSO-DSO INTERFACE
DEEP ELECTRIFICATION SCENARIOS AND MODELLING
Market driven TSO–DSO–Prosumer coordination
Enhanced TSO–DSO interaction for optimal power flow and system security
Enhanced TSO–DSO interaction for joint system planning
Regulatory requirements for distributed flexibilities
Cross sector energy system restoration assessment
Public acceptance analysis and solutions
Efficient utilisation of flexibility and demand side response
High RES penetration scenario and analysis: security of supply and flexibility needs
Market mechanisms for system security and adequacy validated
Assessment of electrification potential in residential, services, industry, heating & cooling and transports (incl. new load patterns)
Improved CBA consider-ing deep electrification scenarios
Assessment of the flexibility potential unlocked by sector coupling (incl. power to gas solutions)
Assessment of the value of peer-to-peer transactions for energy and flexibilities
New business models for system operators & costumers interactions
DEVELOPMENT OF NEW MARKET DESIGN AND ANCILLARY SERVICES

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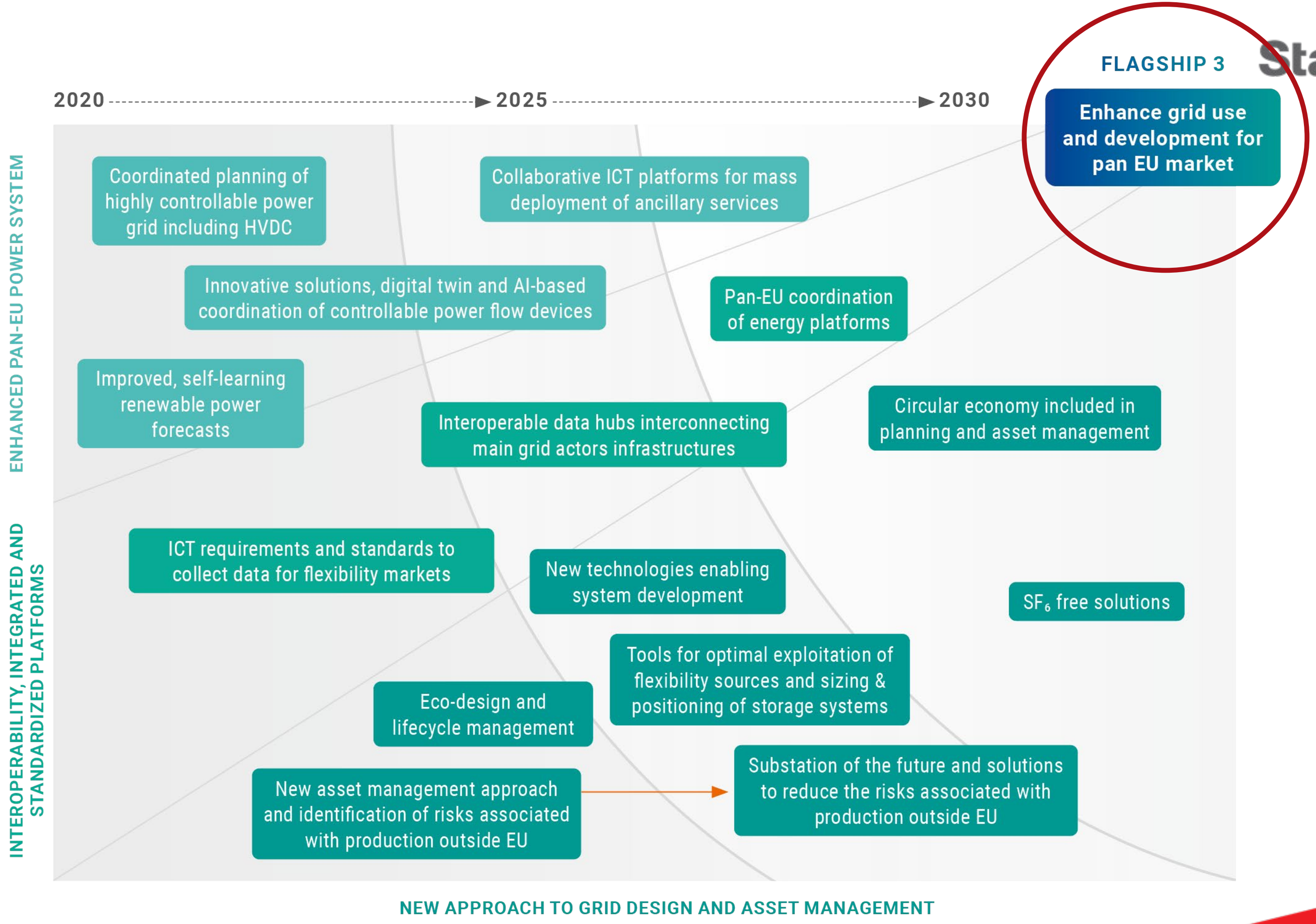
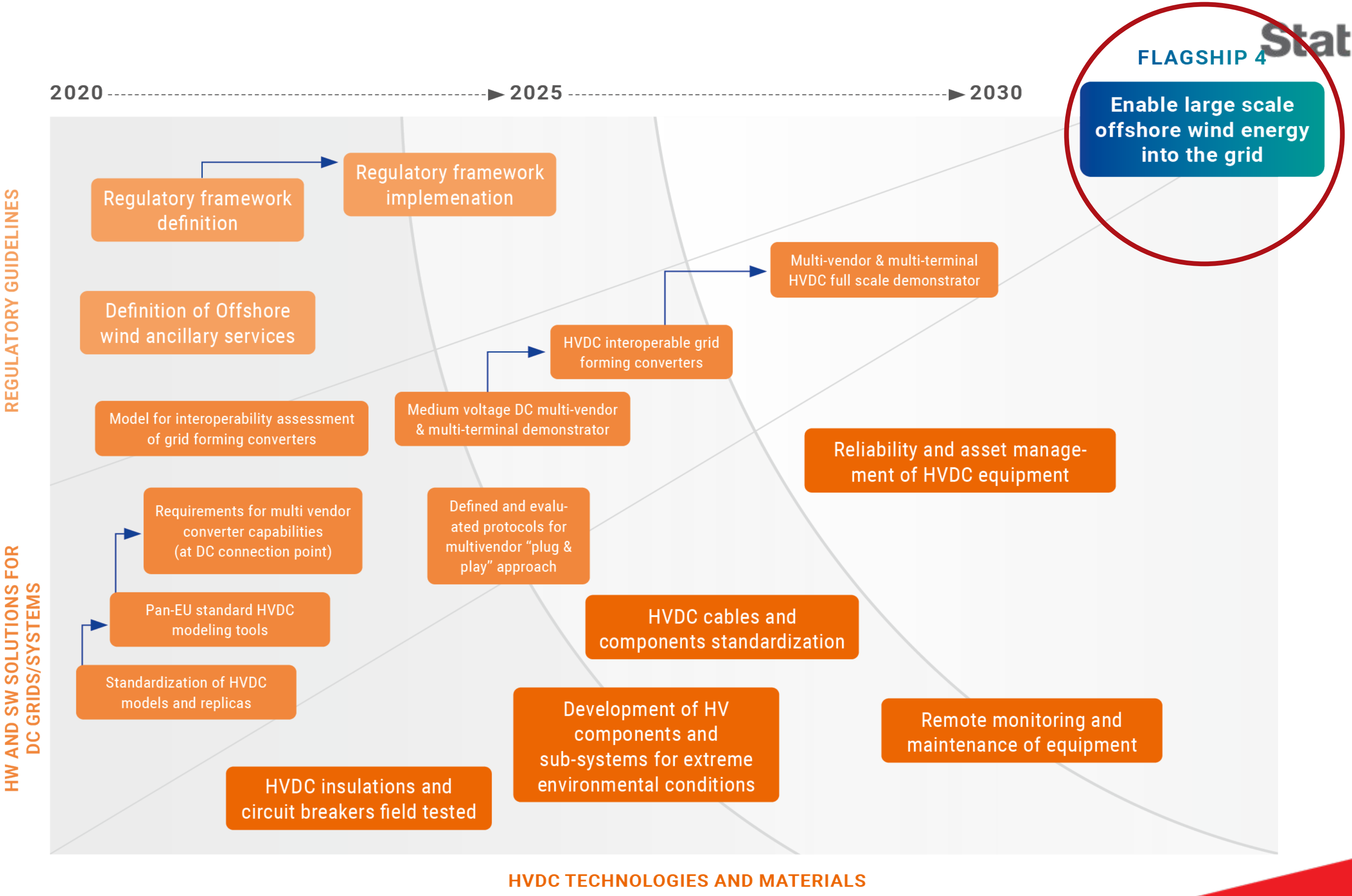
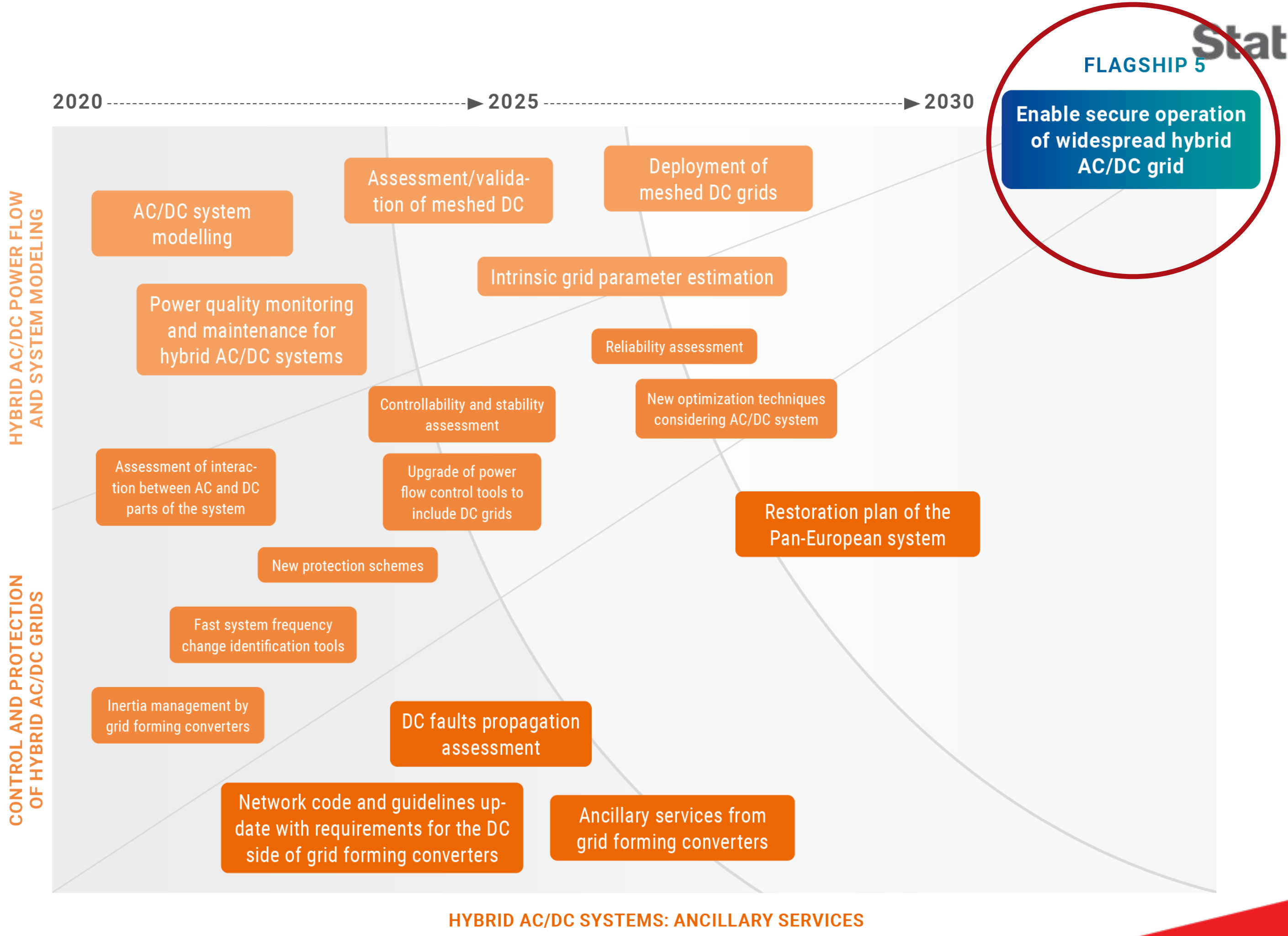
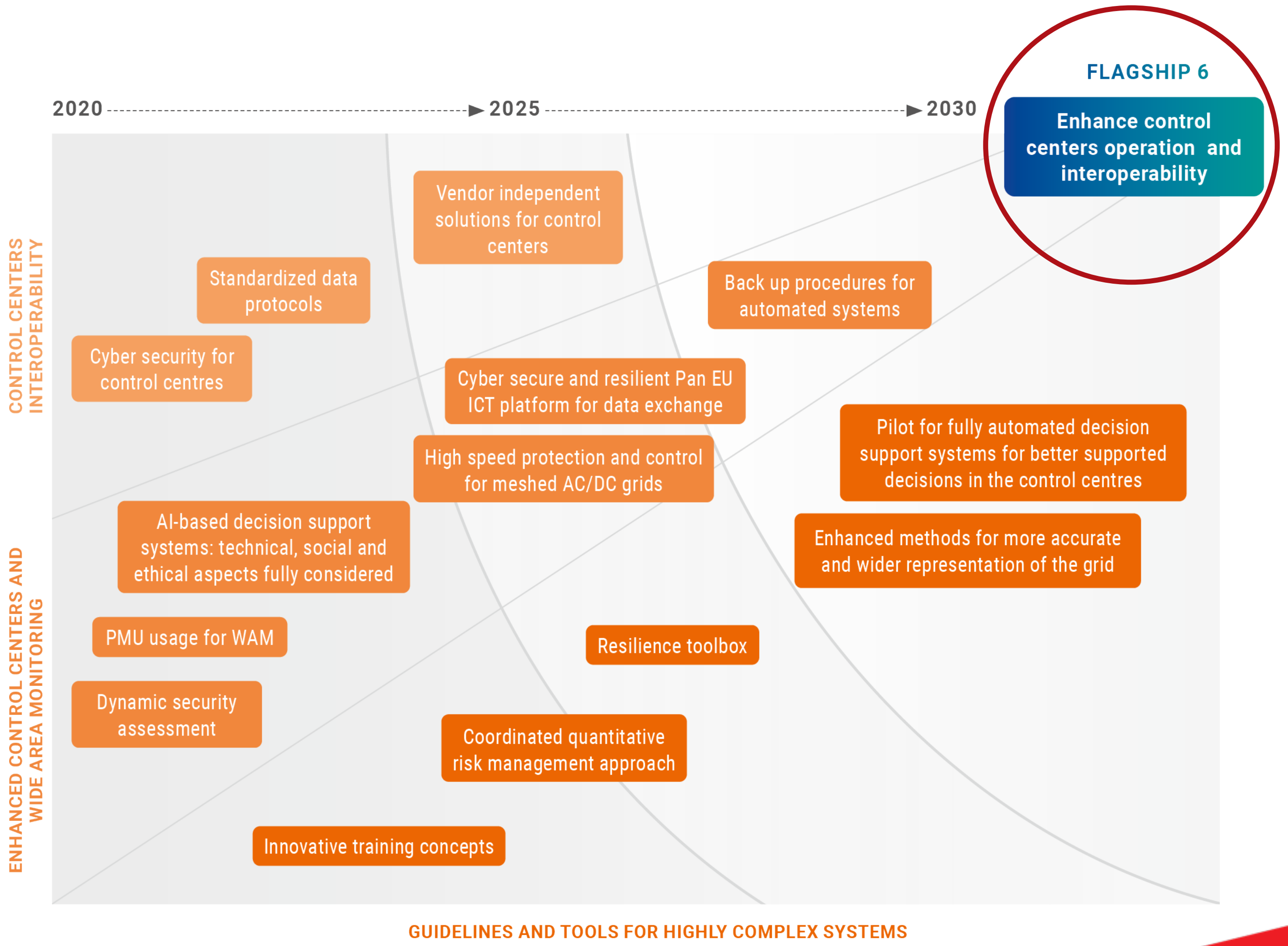

FLAGSHIP 3
Enhance grid use and development for pan EU market
2020
2025
2030
ENHANCED PAN-EU POWER SYSTEM
INTEROPERABILITY, INTEGRATED AND STANDARDIZED PLATFORMS
Coordinated planning of highly controllable power grid including HVDC
Collaborative ICT platforms for mass deployment of ancillary services
Innovative solutions, digital twin and AI-based coordination of controllable power flow devices
Pan-EU coordination of energy platforms
Improved, self-learning renewable power forecasts
Interoperable data hubs interconnecting main grid actors infrastructures
Circular economy included in planning and asset management
ICT requirements and standards to collect data for flexibility markets
New technologies enabling system development
SF₆ free solutions
Tools for optimal exploitation of flexibility sources and sizing & positioning of storage systems
Eco-design and lifecycle management
New asset management approach and identification of risks associated with production outside EU
Substation of the future and solutions to reduce the risks associated with production outside EU
NEW APPROACH TO GRID DESIGN AND ASSET MANAGEMENT


FLAGSHIP 4
Enable large scale offshore wind energy into the grid
2020
2025
2030
REGULATORY GUIDELINES
HW AND SW SOLUTIONS FOR DC GRIDS/SYSTEMS
HVDC TECHNOLOGIES AND MATERIALS
Regulatory framework definition
Regulatory framework implementation
Definition of Offshore wind ancillary services
Model for interoperability assessment of grid forming converters
Medium voltage DC multi-vendor & multi-terminal demonstrator
HVDC interoperable grid forming converters
Multi-vendor & multi-terminal HVDC full scale demonstrator
Reliability and asset management of HVDC equipment
Requirements for multi vendor converter capabilities (at DC connection point)
Defined and evaluated protocols for multivendor “plug & play” approach
Pan-EU standard HVDC modeling tools
Standardization of HVDC models and replicas
HVDC cables and components standardization
Development of HV components and sub-systems for extreme environmental conditions
Remote monitoring and maintenance of equipment
HVDC insulations and circuit breakers field tested



FLAGSHIP 5
Enable secure operation of widespread hybrid AC/DC grid
2020
2025
2030
HYBRID AC/DC POWER FLOW AND SYSTEM MODELING
CONTROL AND PROTECTION OF HYBRID AC/DC GRIDS
AC/DC system modelling
Assessment/validation of meshed DC
Deployment of meshed DC grids
Power quality monitoring and maintenance for hybrid AC/DC systems
Intrinsic grid parameter estimation
Reliability assessment
Controllability and stability assessment
New optimization techniques considering AC/DC system
Assessment of interaction between AC and DC parts of the system
Upgrade of power flow control tools to include DC grids
Restoration plan of the Pan-European system
New protection schemes
Fast system frequency change identification tools
Inertia management by grid forming converters
DC faults propagation assessment
Network code and guidelines update with requirements for the DC side of grid forming converters
Ancillary services from grid forming converters
HYBRID AC/DC SYSTEMS: ANCILLARY SERVICES



FLAGSHIP 6
Enhance control centers operation and interoperability
2020
2025
2030
CONTROL CENTERS INTEROPERABILITY
ENHANCED CONTROL CENTERS AND WIDE AREA MONITORING
Vendor independent solutions for control centers
Standardized data protocols
Cyber security for control centres
Back up procedures for automated systems
Cyber secure and resilient Pan EU ICT platform for data exchange
High speed protection and control for meshed AC/DC grids
Pilot for fully automated decision support systems for better supported decisions in the control centres
AI-based decision support systems: technical, social and ethical aspects fully considered
Enhanced methods for more accurate and wider representation of the grid
PMU usage for WAM
Resilience toolbox
Dynamic security assessment
Coordinated quantitative risk management approach
Innovative training concepts
GUIDELINES AND TOOLS FOR HIGHLY COMPLEX SYSTEMS

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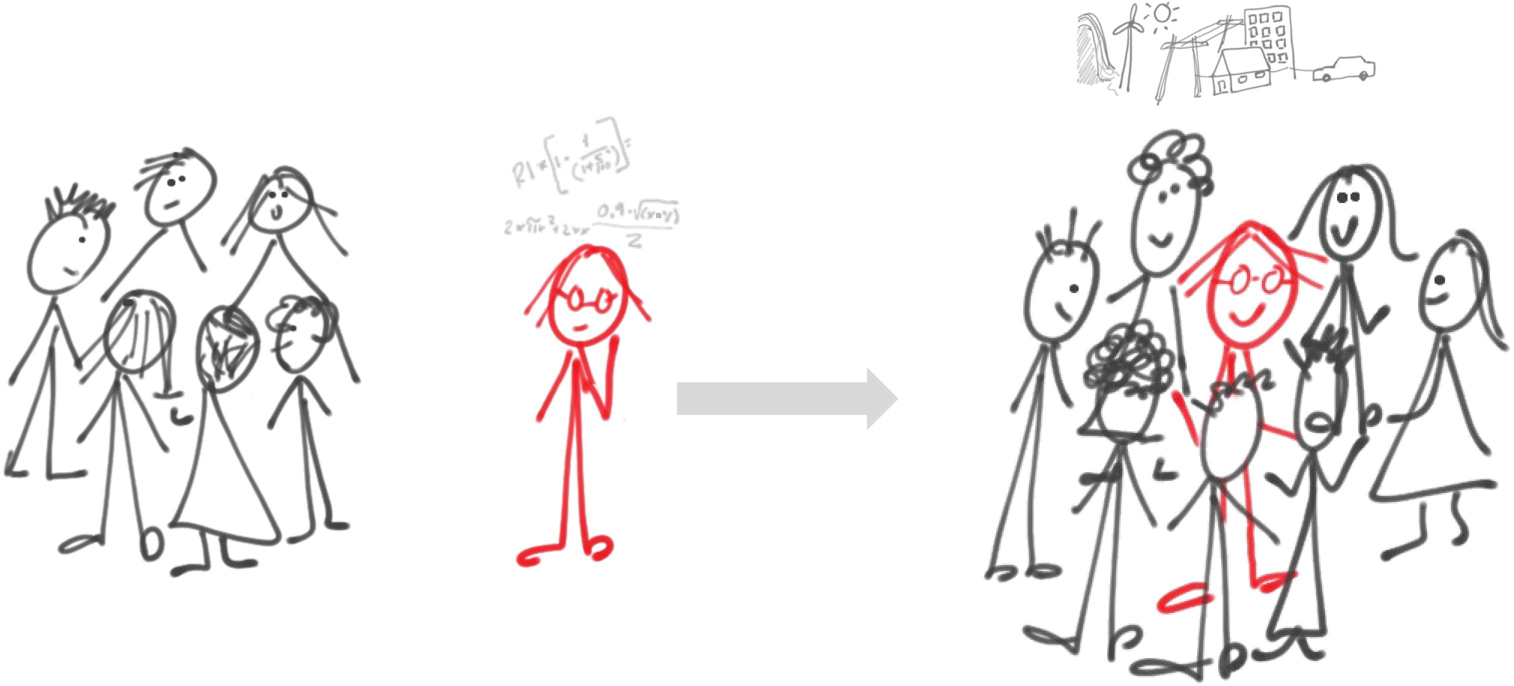
Store radikale endringer

Leder til store radikale utfordringer

Som trenger radikale innovasjoner

Fantastiske muligheter for bransjen



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