EnergyVille

Status and concept of international grid connection

Market and Technical Requirements

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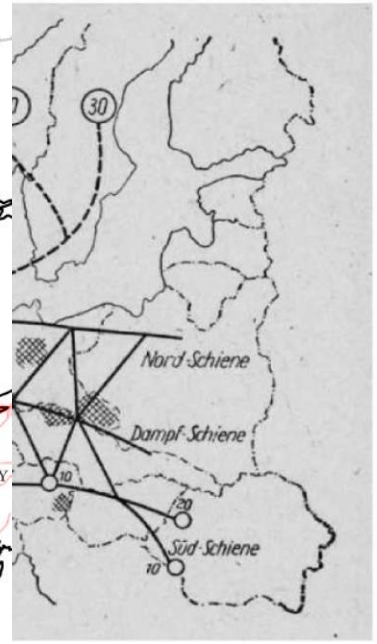
Agenda

- Overview of the European high voltage grid
- European market overview
- Planned expansions in Europe
- Obstacles for expansion / super grids
- An idea of European super grid: DESIGN GRID

The Supergr

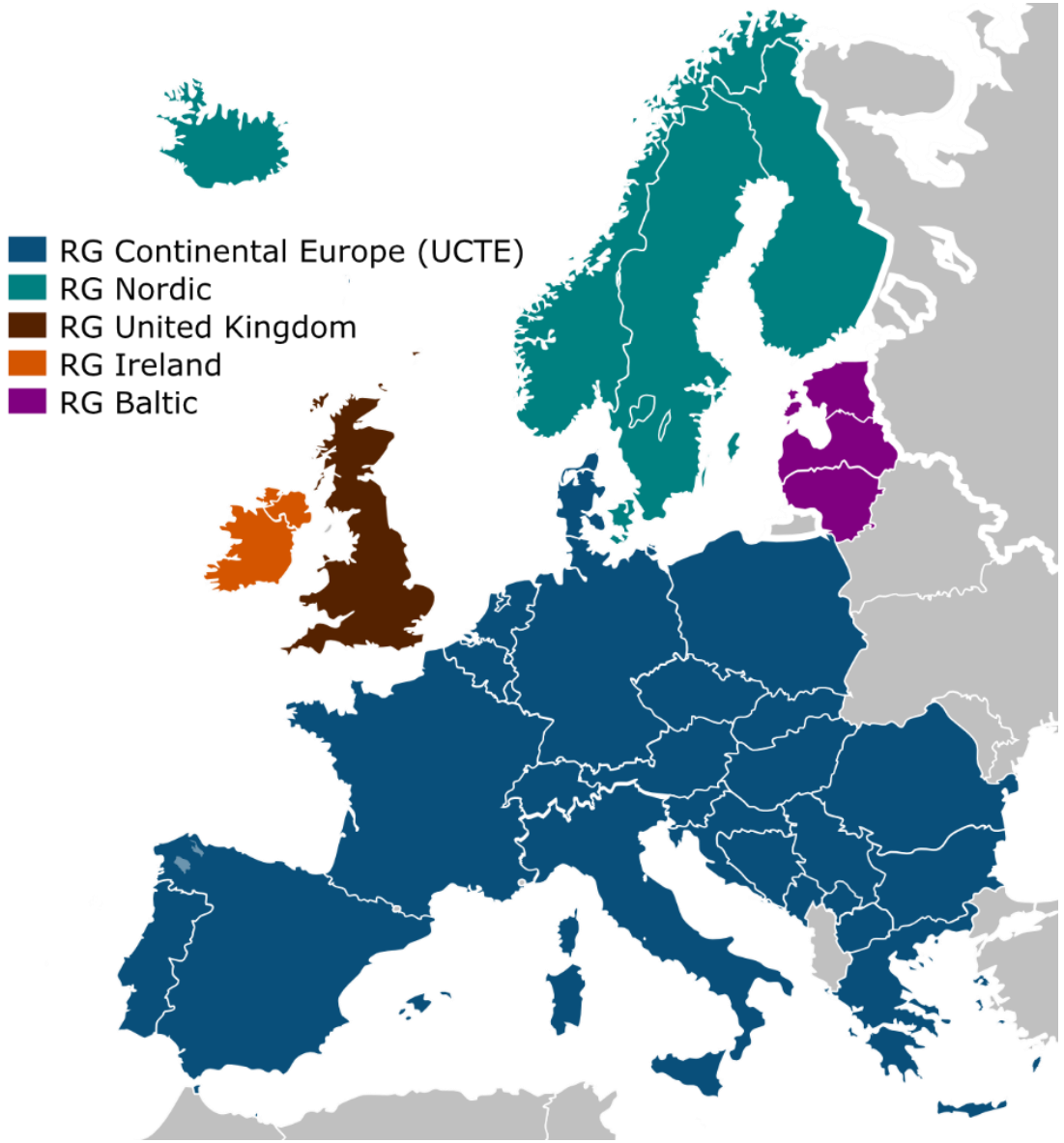
Today



1950

Synchronous zones in Europe

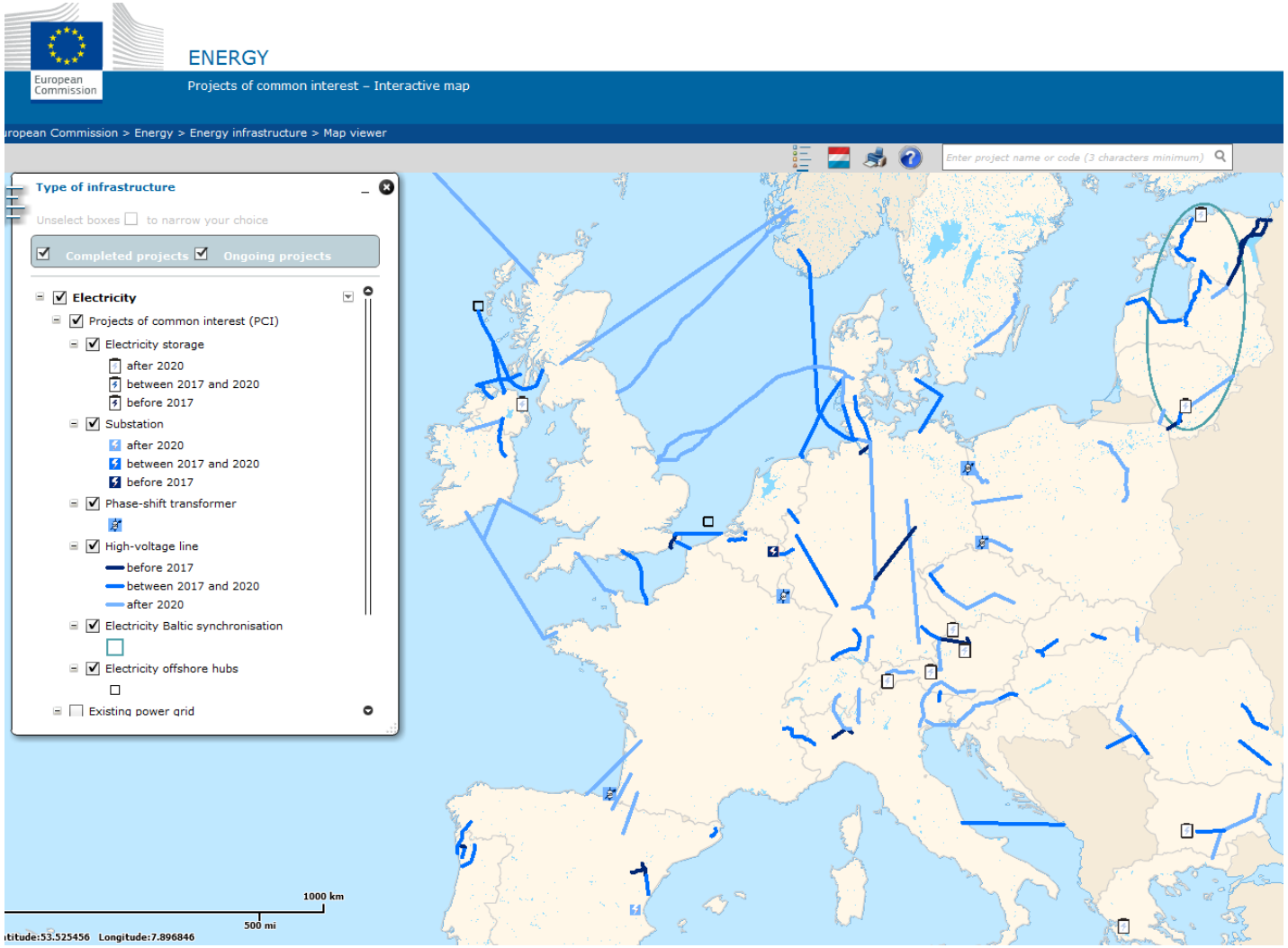
- Connected via HVDC cables or back-to-back converters
- For smaller zones (UK, Ireland, Baltic region)
  - Frequency stability is of major concern
  - Especially with decreasing inertia due to renewables
  - HVDC, especially VSC offers great flexibility and control



What is the Trend in Europe?

Projects of Common Interest

- Many PCIs between non – synchronous zones
- Many PCIs in vicinity of pumped hydro storage
  - Norway and Alps
- Offshore hub between UK, NL, BE part of PCI list!
- The development around the North Sea is the first step of the super grid.

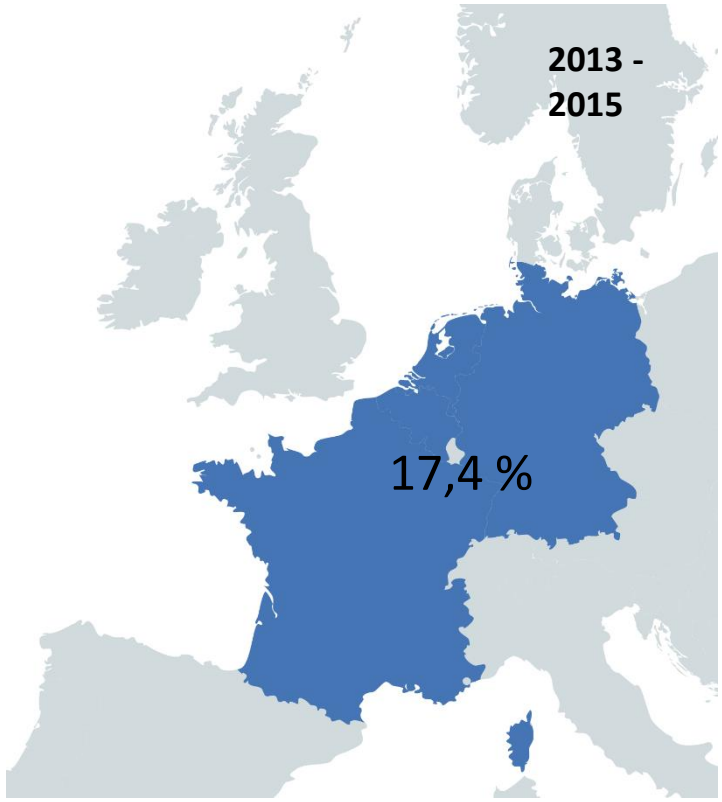


Average whole sale prices in Europe

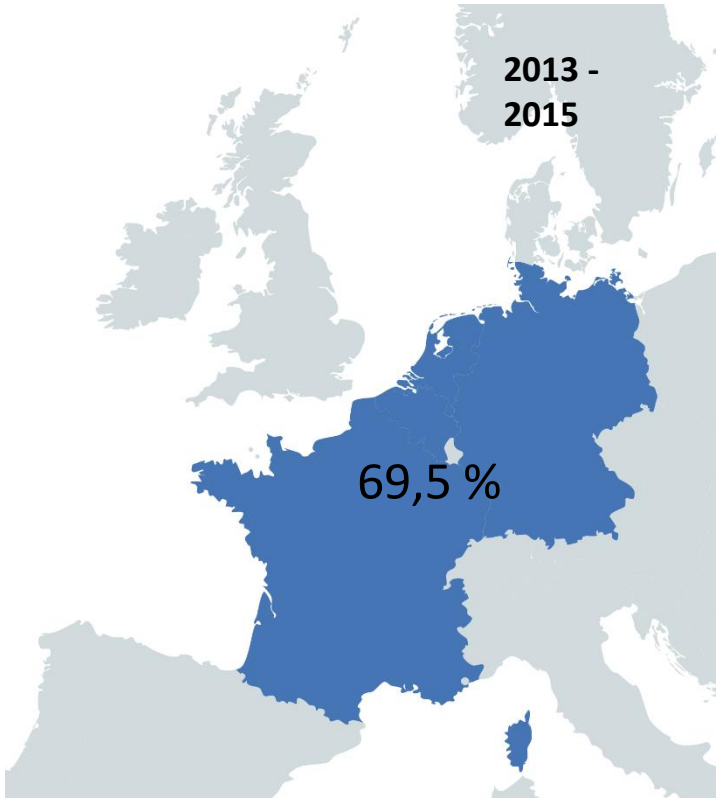
- Purely merchant lines are only viable between zones with high price difference
  - E.g. links to UK, Italy or Spain
  - Links from Scandinavia to rest of Europe
- In Central West Europe
  - Often price convergence on wholesale
  - Nevertheless, high balancing costs due to need for renewables
    - In 2015 roughly 1G€ for re-dispatch and other services for quality of supply in Germany
    - Grid expansion essential to increase social welfare and ensure security of supply!

Price convergence in CWE

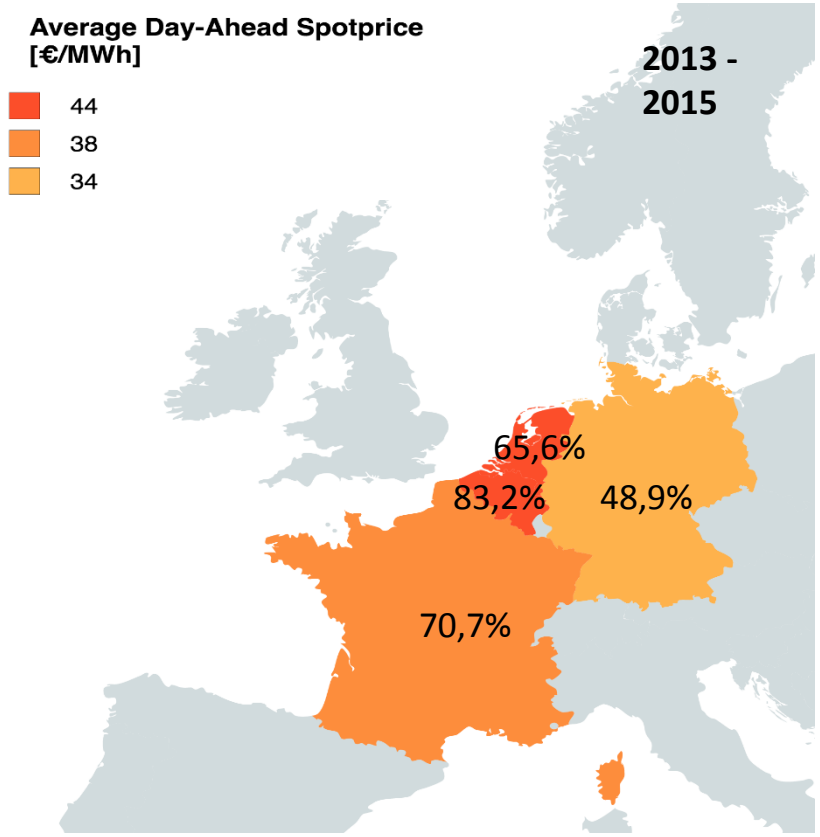
Full price convergence in CWE region (%)



Partial price convergence in CWE region (%)



Price convergence to at least one other CWE country (%)

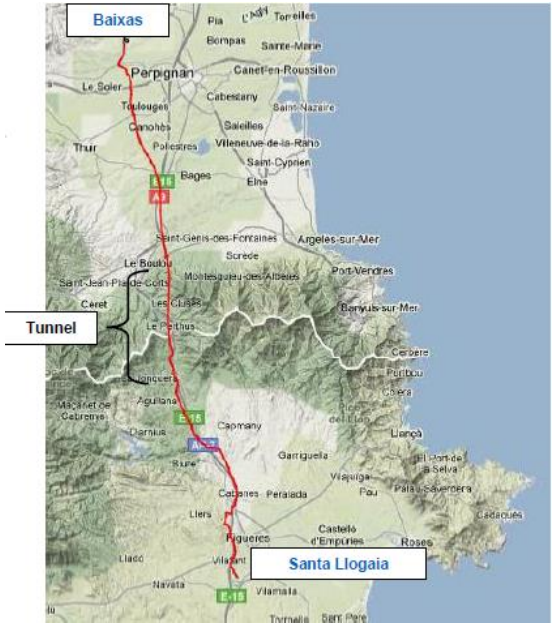


What is the Trend in Europe?

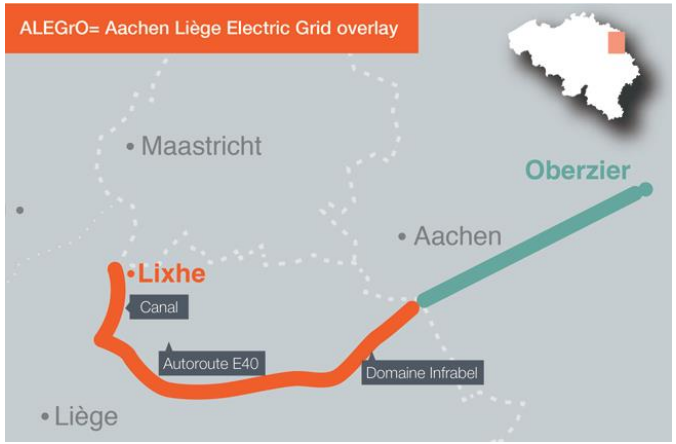
Embedded HVDC

- More and more HVDC links within the same synchronous zone
  - Increased power flow control
  - Reactive power support
  - Increased stability

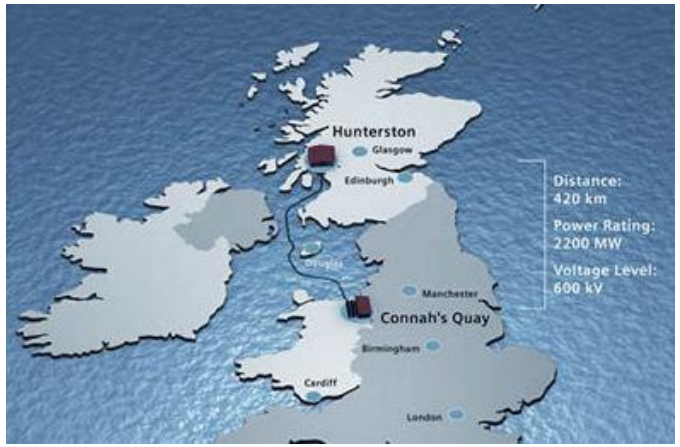
Sweden



France - Spain

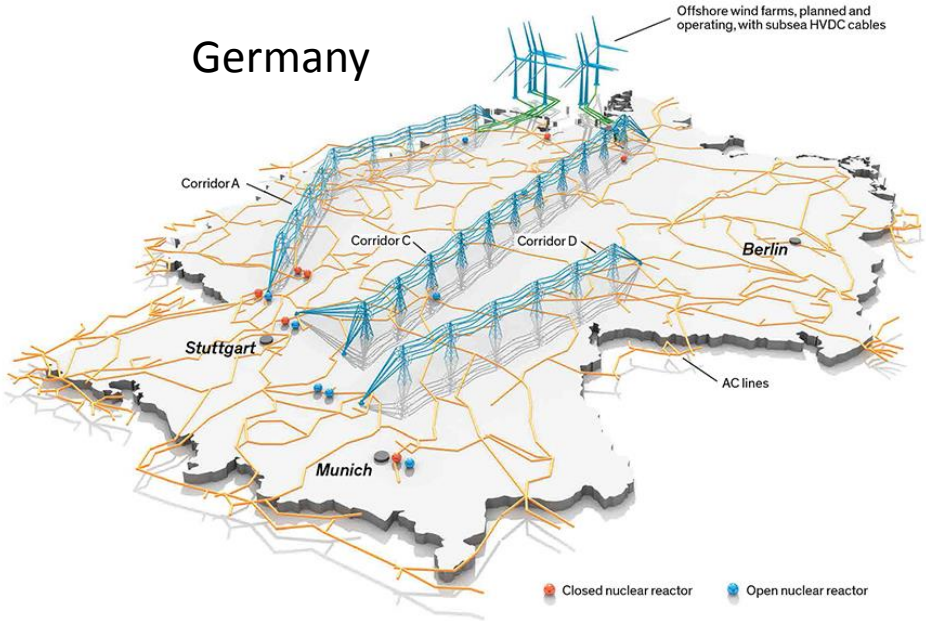


Belgium – Germany



UK - Westlink

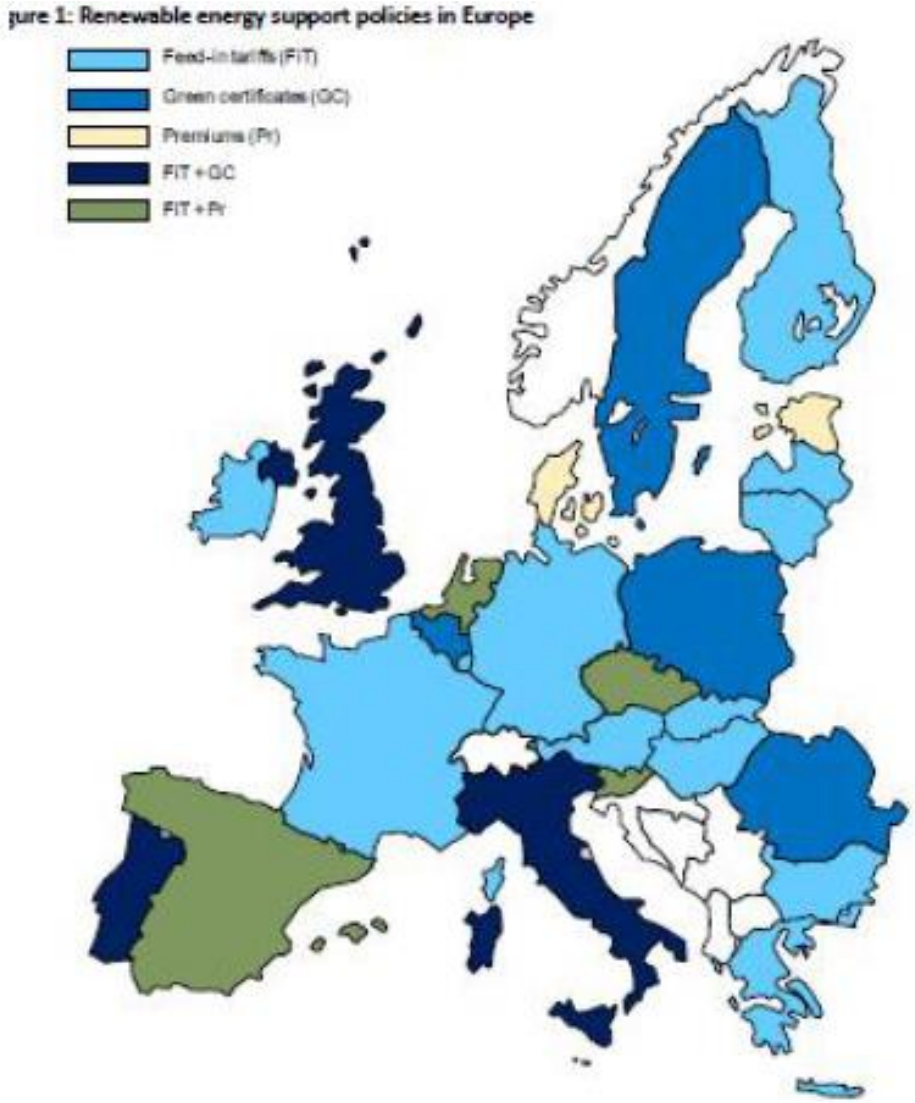
Germany



Challenges for coordinated planning

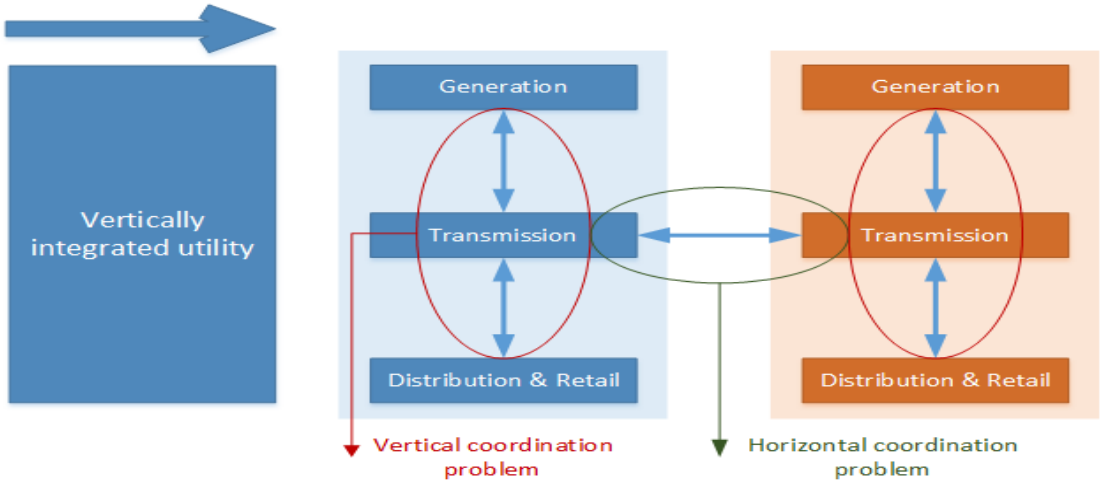
Not necessarily technical…

- Regulatory challenges for coordinated planning
  - Not aligned national frames
    - Swedish TSO is not responsible for connection of offshore wind farms
    - German TSO obligation makes cooperation difficult
  - Not aligned renewable support schemes
    - Integrating three national solutions where each country imports the offshore wind produced in its water is not necessarily the best design
    - In case of an interconnector, where does the wind go?
  - Capacity Remuneration Mechanisms



Cost allocation and Regulation (1)

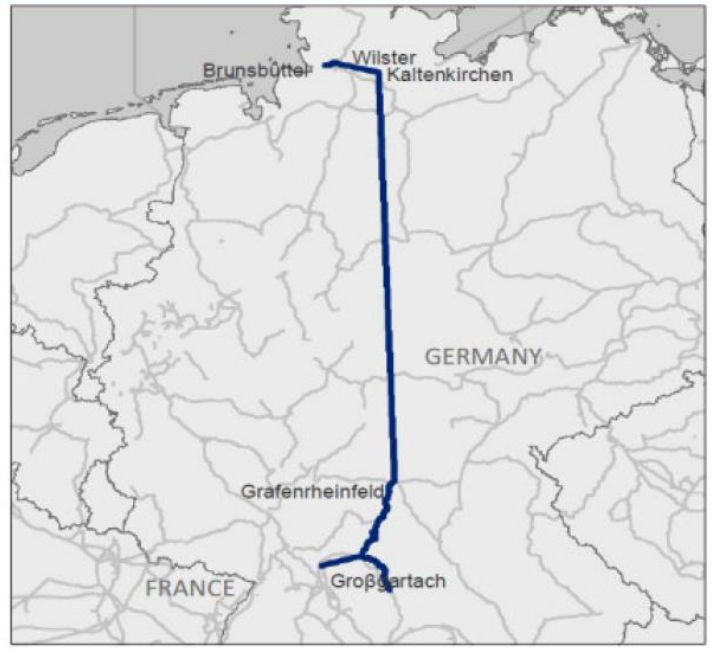
- New developments
  - Restructuring => Vertical coordination (VC)
  - EU energy policy objectives => Horizontal coordination (HC)



- Efficient cost allocation solutions required both at national and European level
  - Transmission tariff design
  - Cross-border cost allocation

Cost allocation and Regulation (2)

- Existing cross-border cost allocation solution in Europe
  - Relative to asset hosted
    - Does not reflect the welfare distribution effect
  - 50-50 rule
    - Does not reflect the welfare distribution effect
    - Limited application
  - Inter TSO Compensation (ICT)
    - Limited scope and precision
    - Welfare distribution effects ignored
  - Summarizing
    - ⚠ Not suitable for PCI type projects
    - ⚠ Other mechanisms based on Peak Demand – Installed Generation Capacity – RES Installed – TSO involvement – Distance – …



Source: PLATTS, GISCO, European Commission

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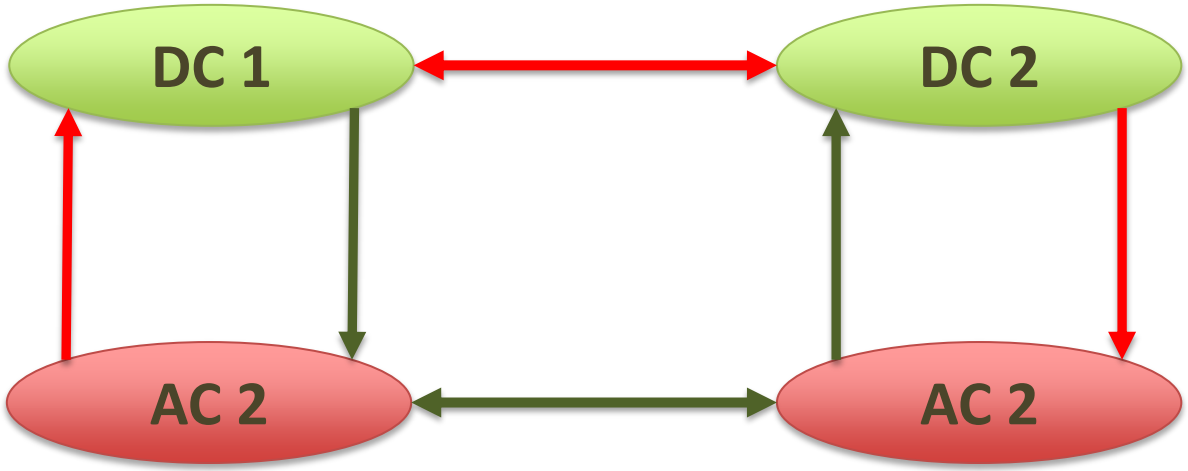
Operational Rules for HVDC GRIDS

- The control strategy influences the market
  - How to be neutral to all market participants?
- Ancillary services and operation
  - How to operate an overlay grid? Who is responsible?
  - Operational rules need to be considered in planning
    - But, many operational rules between AC and DC systems are not defined, yet (in red)

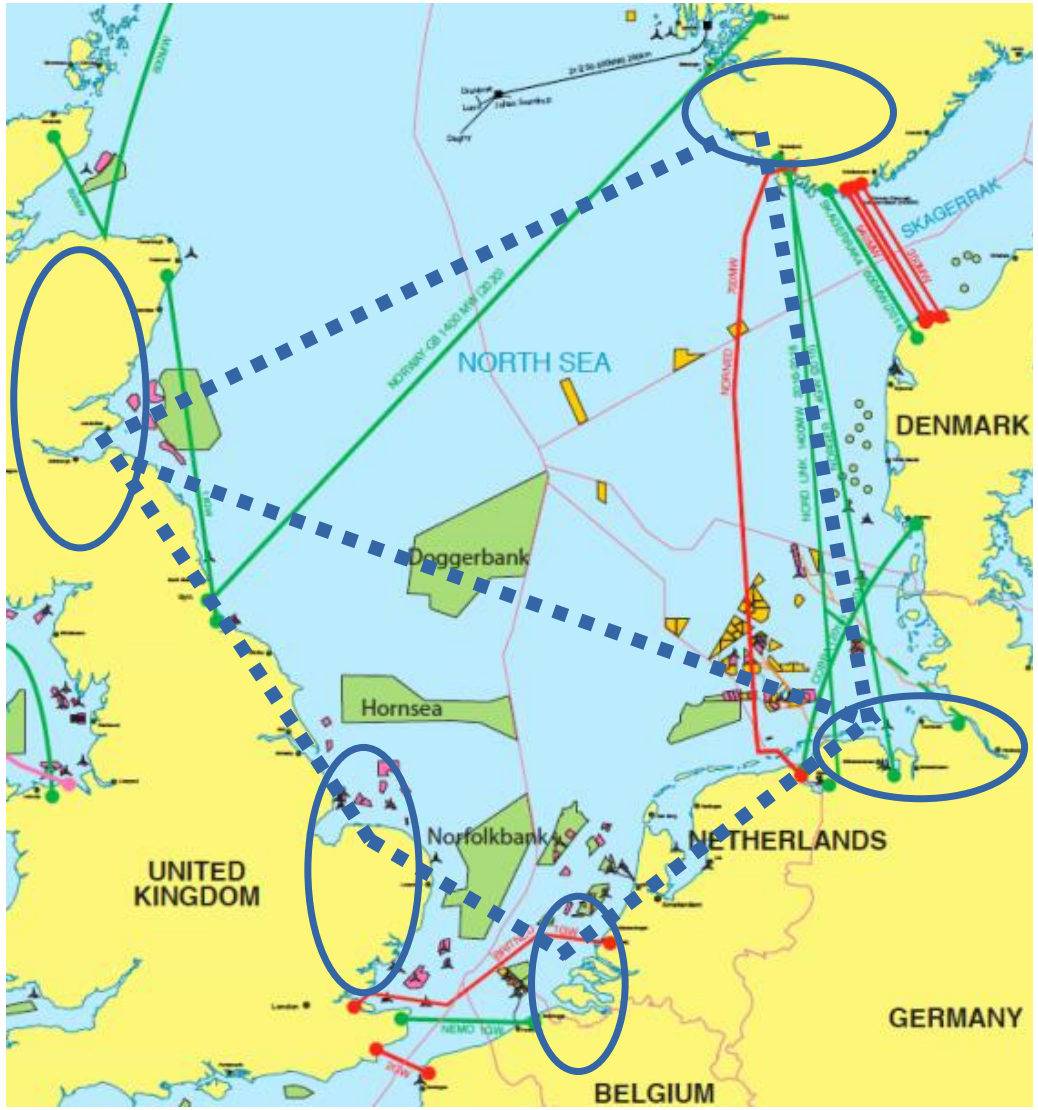


The way to the future – DESIGN GRID

An integrated offshore grid design for Europe

- A five line grid connecting:
  - Denmark
  - Belgium
  - Netherlands
  - Germany
  - Sweden
  - Iceland
  - UK
  - Norway

- Allowing integration North Sea offshore wind farms



DESIGN GRID

- **DESIGN Grid** will allow trade between different markets and price zones
  - Denmark, Belgium, Netherlands, Germany, Sweden, Iceland, UK, Norway
- This way, TSOs will develop new products and services, based on the possibilities offered by **DESIGN GRID**
- The coordinated operation of the DESIGN GRID links will allow
  - Optimal infeed of renewable energy
    - Reducing re-dispatch costs
  - Delivery of system services
    - Frequency support
    - Reactive power support
    - Black – start capability

How to get there?

- 1st STEP: Feasibility study
  - Identify technical and regulatory show stoppers and provide solutions
  - Risk level: low
  - Time horizon: 1-3 years
- 2nd STEP: Detailed engineering study
  - Subsea surveys, technical studies, legal advise, permits, etc….
  - Set up as a Newco -> **DESIGN GRID**
  - Acts as commissioning agent for construction
  - Risk level: Medium
  - Time horizon: ~ 3 years

How to get there?

- 3rd STEP: Stepwise Construction and Operation
  - Different companies can build parts of the grid
    - TSOs, insurance companies, pension funds, manufacturers, asset holders, ….
  - The operation is transferred to a commercial system operator -> “**DESIGN Operate**” (Newco)
  - Revenues are passed to **DESIGN GRID** determined in a specific regulatory scheme
  - Risk level: Medium
  - Time horizon: 2020 - 2030

Operation and Regulation

- Operation and maintenance in the hands of **DESIGN Operate**
  - Collecting grid fees
  - Maintenance
  - Scheduling and real time operation (ISO approach, e.g. CORESO)
  - Payment of concession holders
- Interaction with national grids is important
  - Although power transfer managed by **DESIGN Operate**, reactive power control can be given to national TSOs
- Fundamental rewrite of grid codes is required to coordinate interactions

Why are investments stalling?

- TSOs are hesitant to invest in a multinational offshore grid as long as there is not a harmonized regulation
- Regulators have no means to harmonize and improve regulation as long as there is no multinational offshore grid

Financing and Regulation

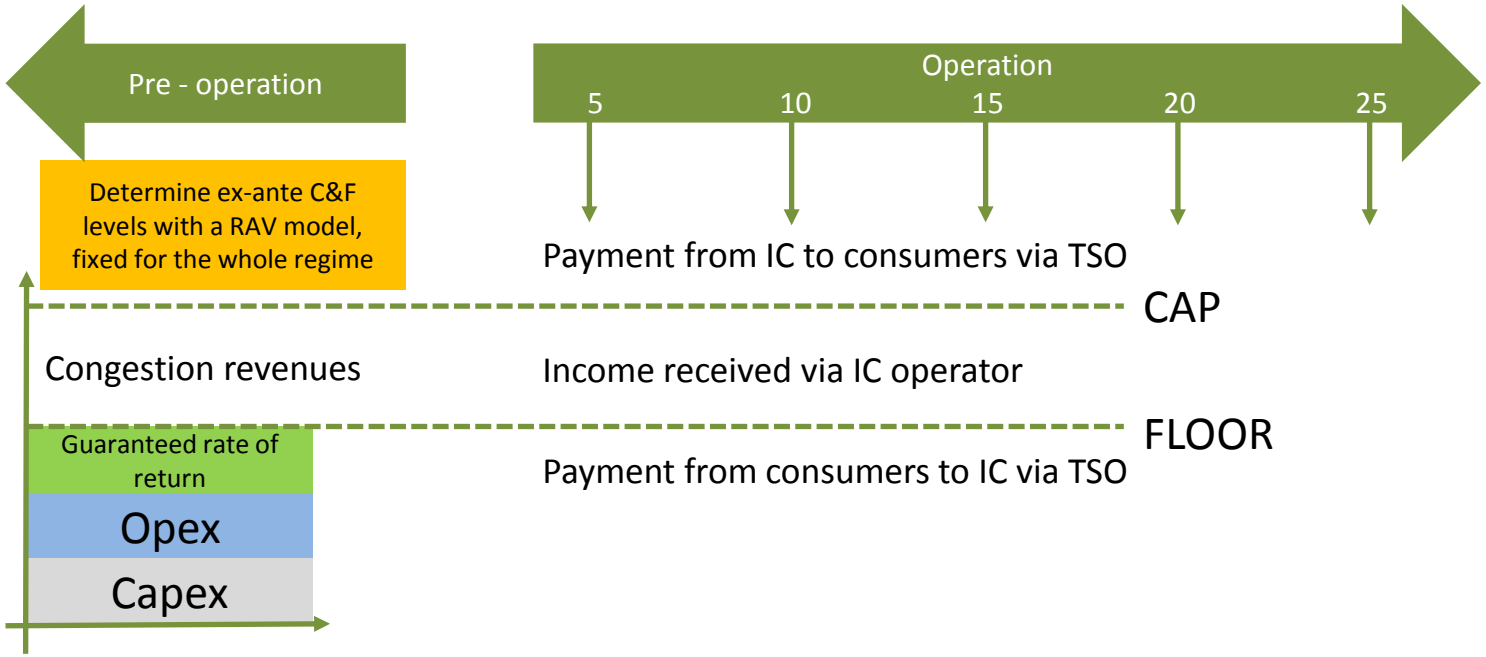
- Regulatory Framework determines feasibility of North Sea Grid Developments:
  - D: DKK, Danish Crown
  - E: EUR, Euro
  - S: SEK, Swedish Crown
  - I: ISK, Iceland Crown
  - G: GBP, British Pound
  - N: NOK, Norwegian Crown
- How to match national operational standards, regulatory and legal framework?

Building Blocks of a Regulatory Framework

Planning and Design	• Coordination of national and regional transmission expansions
Ownership	• Ownership by New Third Party Companies (Newco) • Impact monopoly of local TSO (parallel path)
Cost Allocation	• Distribution of the costs amongst regions: new cost allocation methods • New tariff schemes (cfr. national regulators)
Operation	• Network Codes to ensure compatibility local TSO and Newco • Redesign of Ancillary Services • Coordination maintenance, scheduling and dispatch of transmission assets owned by Newco

DESIGN GRID Revenue Model

- Cap & floor set based on:
  - CAPEX
  - OPEX
  - Cost of financing



- For the benefit of the **network users** and the **investors**:
  - Sharing of revenues in times exceeding the cap
  - Helps to being prepared for the time below the floor

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