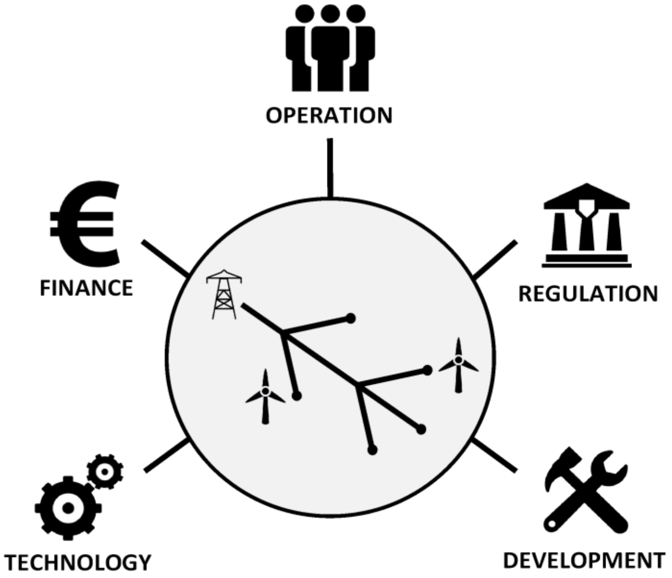
Offshore grid development plans in the PROMOTioN project

Pierre Henneaux (Tractebel) – September 13, 2017

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

Challenges for deployment of meshed offshore HVDC grid

- Cost effective and reliable converter technology
- Grid protection systems
- Financial framework for infrastructure development
- Regulation for deployment and operation
- Agreement between manufacturers, developers and operators of the grid



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Objectives of PROMOTioN

- Identify **technical requirements** and investigate possible **topologies** for **meshed** HVAC/DC **offshore grids**
- Develop **protection components** and **schemes for offshore grids**
- Establish components **interoperability and initiate standardisation**
- Develop recommendations for a coherent EU and **national regulatory framework** for DC offshore grids
- Develop **recommendations for financing mechanism** of offshore grid infrastructure deployment
- **Demonstrate cost-effective** Offshore HVDC equipment
- Develop a **deployment plan** for HVDC grid implementation

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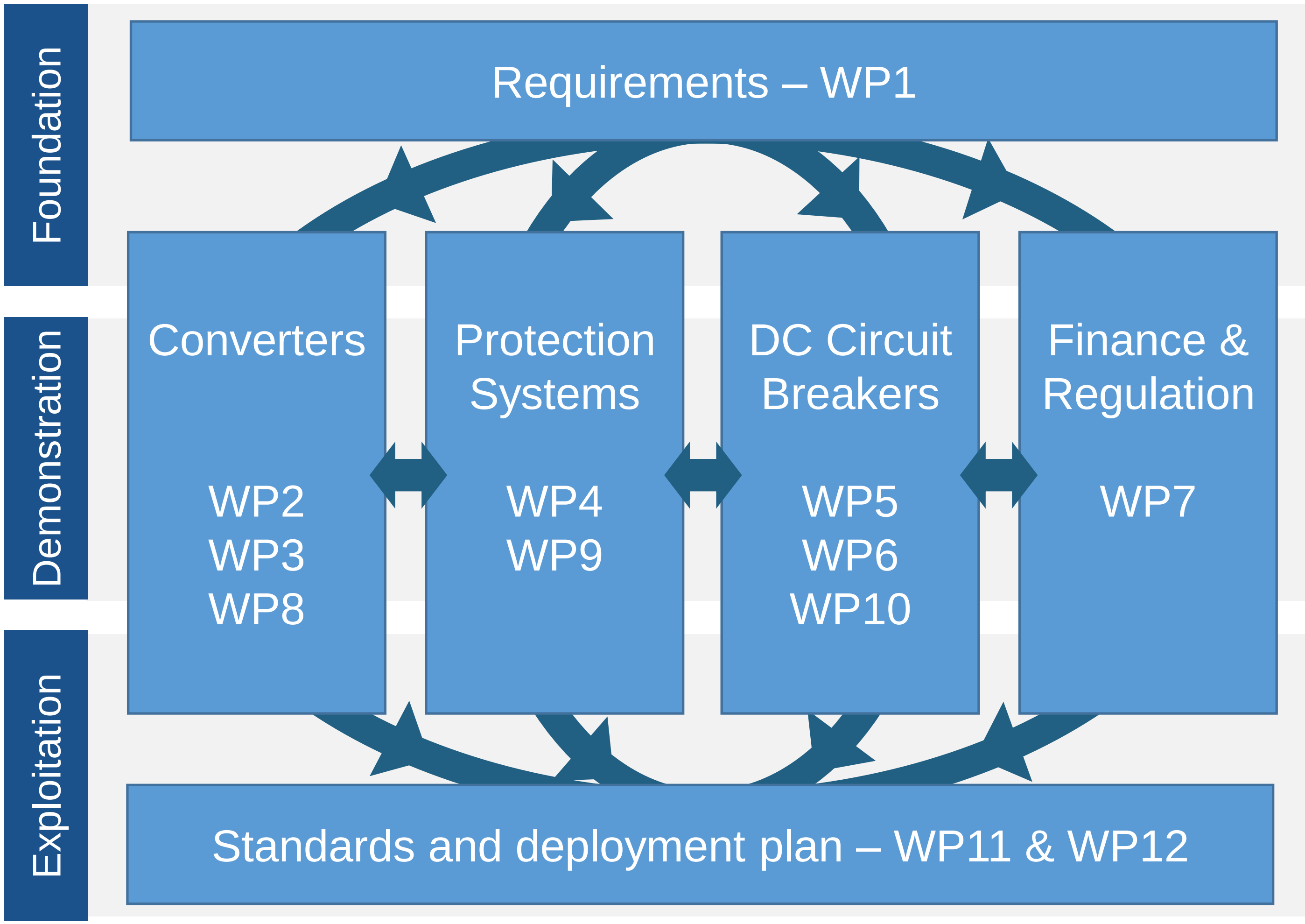
PROMOTioN – Project Structure



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Offshore grid development plans?

- Two activities are linked to the drafting of offshore grid development plans
  - Draft roadmap and reference offshore grid expansion plan
    - Deliverable 1.6, part of WP1
    - Preliminary analysis of the main challenges and of the factors impacting the business case (input for detailed studies within the various WPs)
  - Offshore grid development scenarios
    - Deliverable 12.2, part of WP12, i.e. part of the Deployment Plan
    - Will support quantitative analyses
- None of these activities aim to provide an actual offshore grid development plan
  - PROMOTioN is <u>NOT</u> a planning project
  - <u>Fictive</u> but realistic offshore grid development plans to support analyses and comparison of alternatives

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CONTENT

- Introduction
- Draft roadmap (WP1)
- Deployment Plan (WP12)
- Discussion

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Draft roadmap

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Objectives of the draft roadmap

- Derivation of a draft offshore grid development roadmap for the evacuation of offshore wind energy during the decade 2020-2030
  - Optimization of the grid topology
  - Identification of factors impacting the grid topology
  - Analysis of the economic viability
  - Preliminary step
    - To understand the complexity of the problem
    - To raise questions that must be addressed by the PROMOTioN project to reach the final objective
    - To prepare a relevant detailed work plan to issue a Deployment Plan
  - "Pave the way" for the Deployment Plan
- Not a "complete" draft roadmap
  - Several aspects ignored (technological, financial, regulatory)
  - They are currently under study within the PROMOTioN's project

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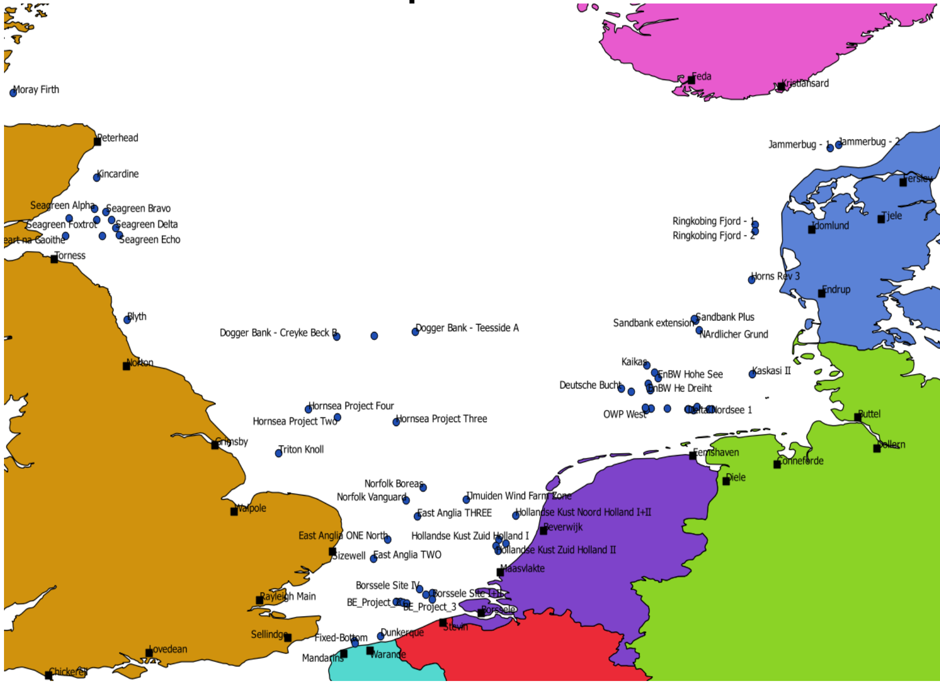
Draft roadmap

Scope and main assumptions

- Geographical scope: North Sea
- Temporal scope: 2020-2030
  - Need for an offshore grid is expected to begin in that decade, but should increase after → the period 2020-2050 will be considered in the final Deployment Plan
- Reference scenario for potential installed wind capacities in the North Sea: TYNDP2016 Vision 3
  - 2020-2030: +37 GW

COUNTRY	ADDITIONAL OFFSHORE WIND GENERATION
Belgium	+1,700 MW
The Netherlands	+4,444 MW
France	+3,005 MW
Germany	+7,389 MW
Denmark	+1,310 MW
United Kingdom	+19,360 MW



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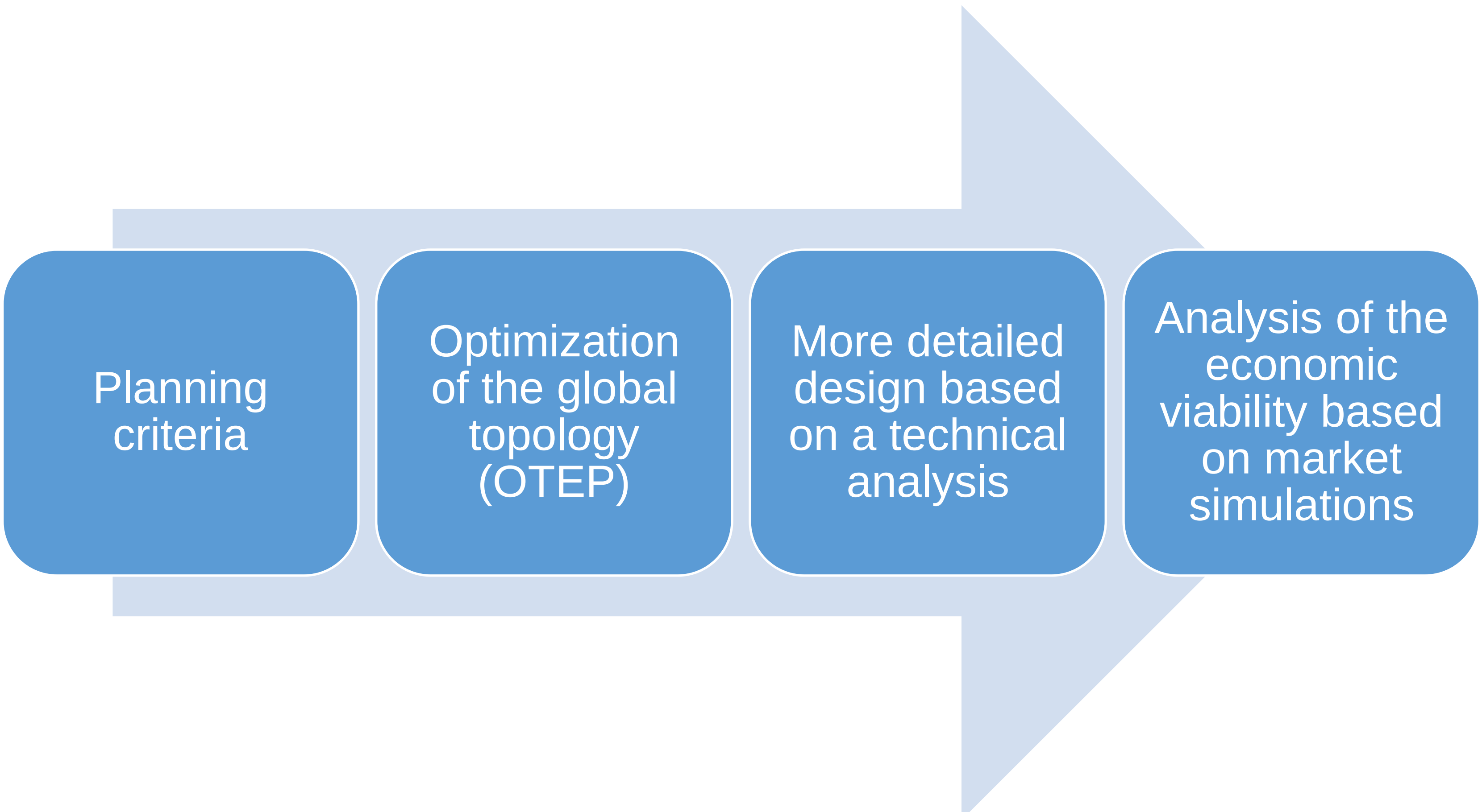
Draft roadmap

Main steps



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What are planning criteria?

- In a nutshell: reliability (adequacy & security) requirements
  - The power system must be able to accommodate power flows and endure contingencies while staying within acceptable working conditions
- Transmission planning criteria typically cover
  - The system states and the contingencies (including faults) to study
  - The acceptable system operating limits in normal operation (pre-contingency) and post-contingency states
  - The acceptable response of the system to outages and to fault disturbances
- The choice of planning criteria impacts the CBA
  - E.g. N-1 security (and its exact definition)

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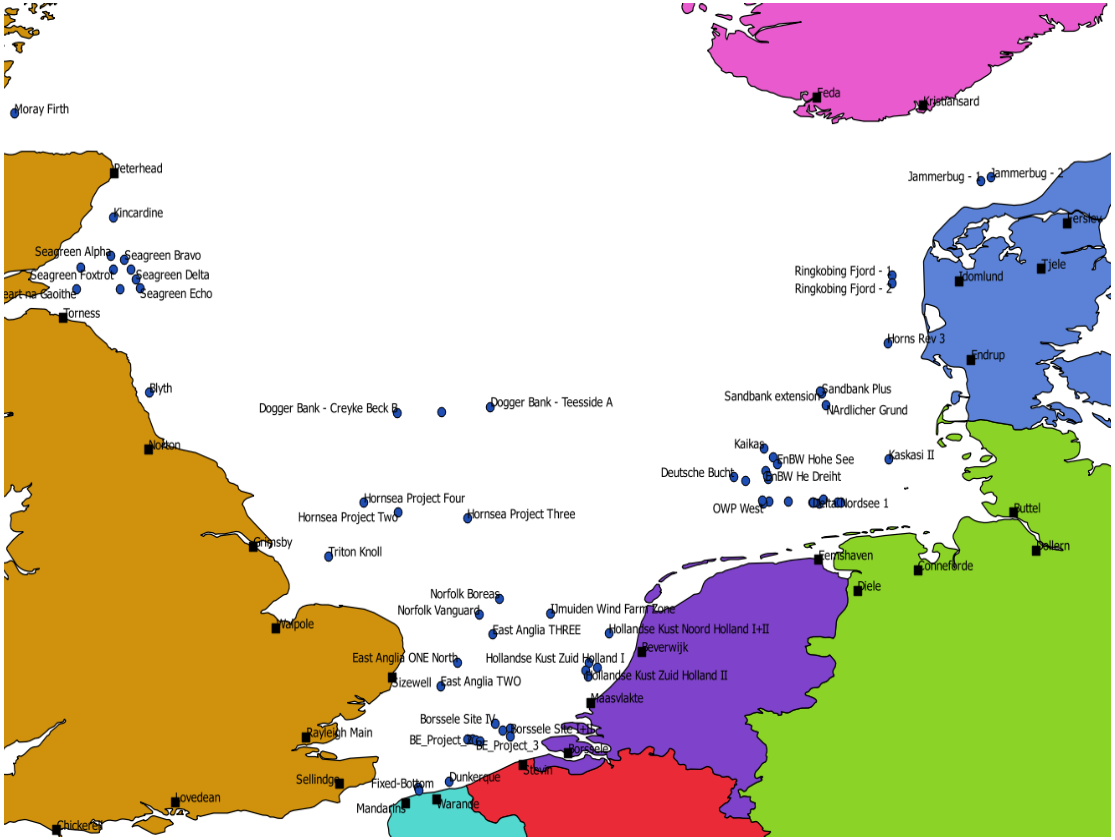
Draft roadmap

Optimization of the global topology

- Optimization of the connections of offshore wind farms to the shores such that
  - The cost of cables (and offshore platform extensions) is minimal
  - All the offshore wind energy can be evacuated



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Draft roadmap

More detailed design

- The optimization of the global topology
  - Does not optimize
    - The placement of HVDC circuit breakers
    - The use of DRU/VSC converters for offshore wind farms
  - Model the offshore grid in a simplified way
- Need of a technical analysis
  - Determine where HVDC circuit breakers are needed, using a very simple policy
    - Smarter strategies are analysed within the PROMOTioN's project
  - Other adaptations
  - Guarantee the technical viability

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Analysis of the economic viability

- Purposes of an offshore meshed grid
  - Not only to evacuate offshore wind energy
  - But also to exchange energy between countries
- Additional benefits brought by the offshore grid
  - Increase of the Socio-Economic Welfare (SEW)
  - Integration of Renewable Energy Sources in the North Sea countries (possibility to exchange RES surplus)
  - …
- Economic viability: linked to the SEW increase
- Estimation of the SEW increase
  - “Market simulation”: estimation of the hourly dispatch of generating units for an entire year in the North Sea countries
  - SEW increase = Reduction of the generation cost with the meshed grid compared to a purely radial solution

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Limitations of the current methodology

- Only HVDC connections considered in the optimization problem, but importance of HVAC connections
- Offshore wind farms separated by short distances are connected individually, but in reality they could be clustered to be connected together
- Need for DCCBs not considered in the optimization problem, but could impact drastically the topology
- Exchanges of energy between different market areas should be considered in the sizing of the grid
- Countries might require that wind generated in their economic zone is connected to their onshore grid

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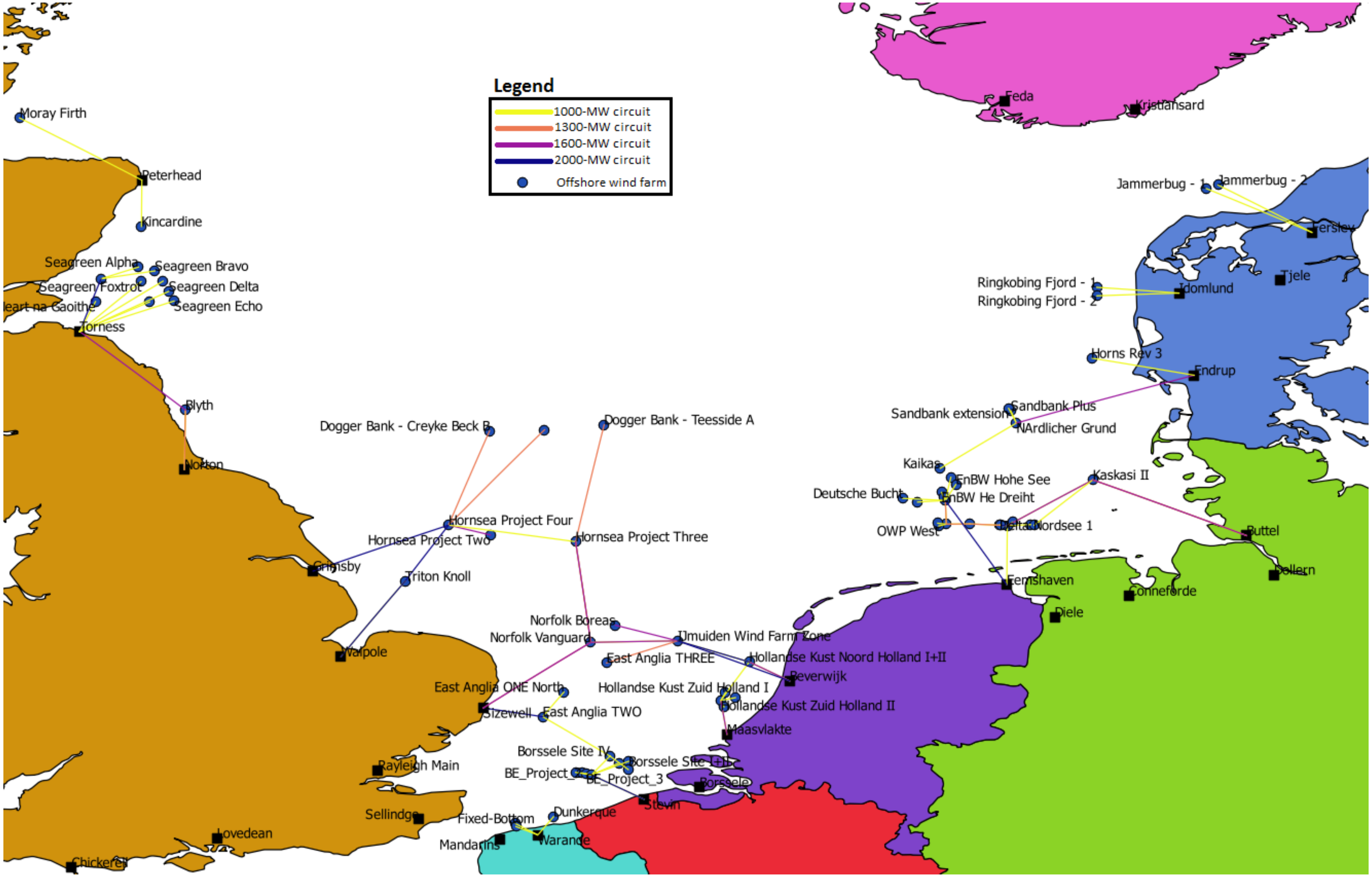
Resulting coordinated topology in 2030



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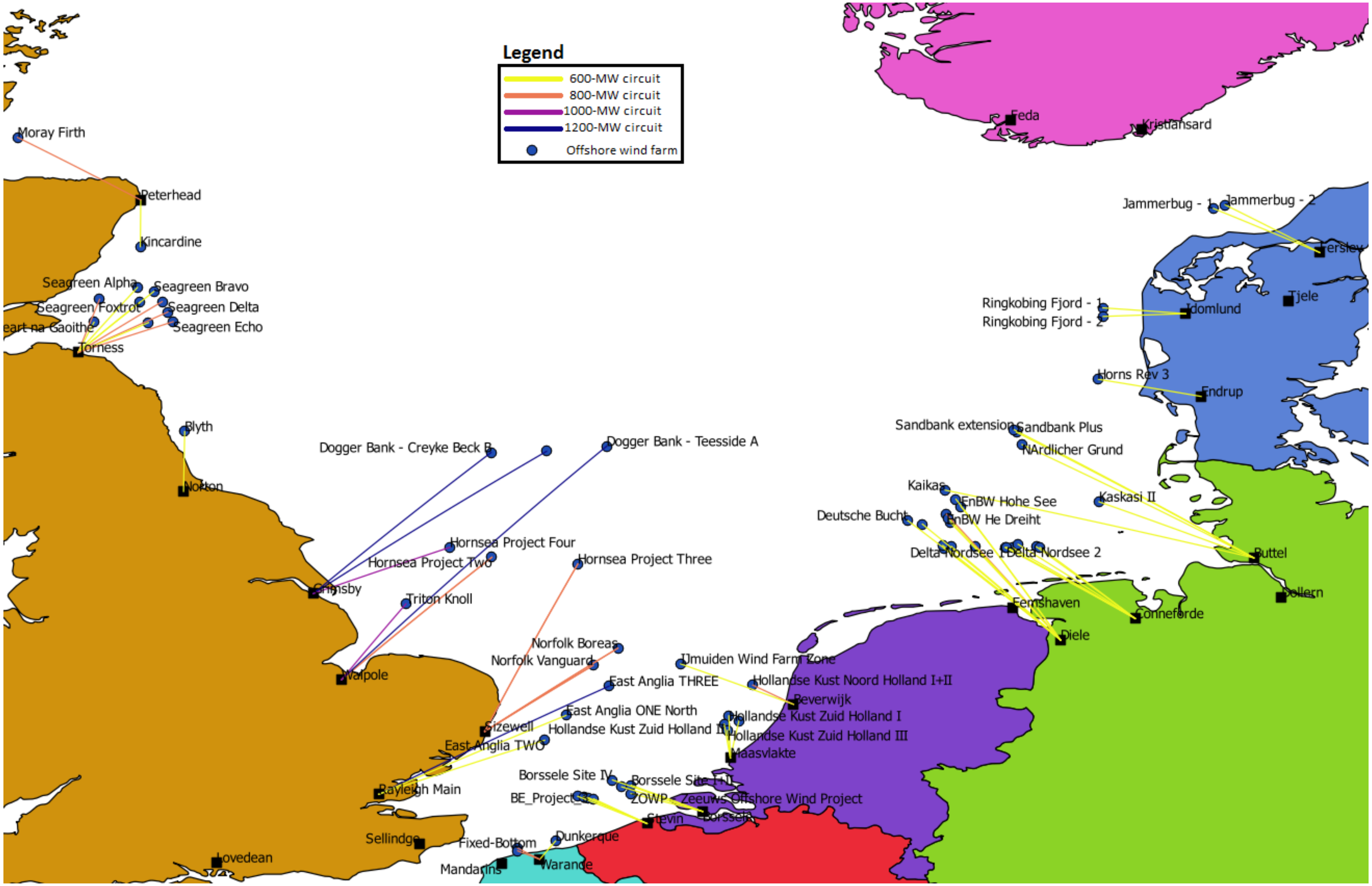
Main results

Resulting radial topology in 2030 (comparison)



Different sets of assumptions

- Main sources of uncertainties
  - Technical capabilities of Diode Rectifier Units (DRUs)
  - Technical capabilities of HVDC Circuit Breakers (DCCBs)
- Four different sets of assumptions

	Availability of DRUs, but only for radial, point-to-point connections	**Possibility to use "cheap" DCCBs (cost of a DCCB negligible compared to the cost of a converter)**
Base case	✗	✗
Variant 1	✓	✗
Variant 2	✗	✓
Variant 3	✓	✓

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Draft roadmap

Cost-Benefit Analysis

- The initial investment of the radial and the coordinated solutions can be different
- But the coordinated solution is expected to bring additional benefits
  - Exchange of energy between countries
- Benefits valued through the increase of the Socio-Economic Welfare (SEW)
  - Estimation of that increase through market simulations

	Additional investment compared to the radial solution (M€)	Actualized increase of the SEW over the lifetime (M€)	Net Present Value (M€)
Base case	4,878	-2,211	-2,667
Variant 1	5,981	-2,211	-3,770
Variant 2	-3,308	-2,211	5,519
Variant 3	-2,206	-2,211	4,417

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Conclusions of the draft roadmap

- The DCCBs capabilities and costs will drastically impact the business case of coordinated solutions such as meshed grids
  - If need of expensive DCCBs, only offshore wind farms far from the shore will be part of the offshore grid
- The DRUs capabilities and costs will drastically impact the business case of coordinated solutions such as meshed grids
  - If they can be used only for radial point-to-point connections and if they are cheap, only the cost of radial solutions decrease
- The hosting capacity of the onshore grid could strongly impact the grid topology, but possible onshore grid reinforcements
  - Importance of coordinated planning
- Uncertainties about the way the grid will be operated (e.g. security rules, market rules) – they also impact the business case

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Deployment Plan

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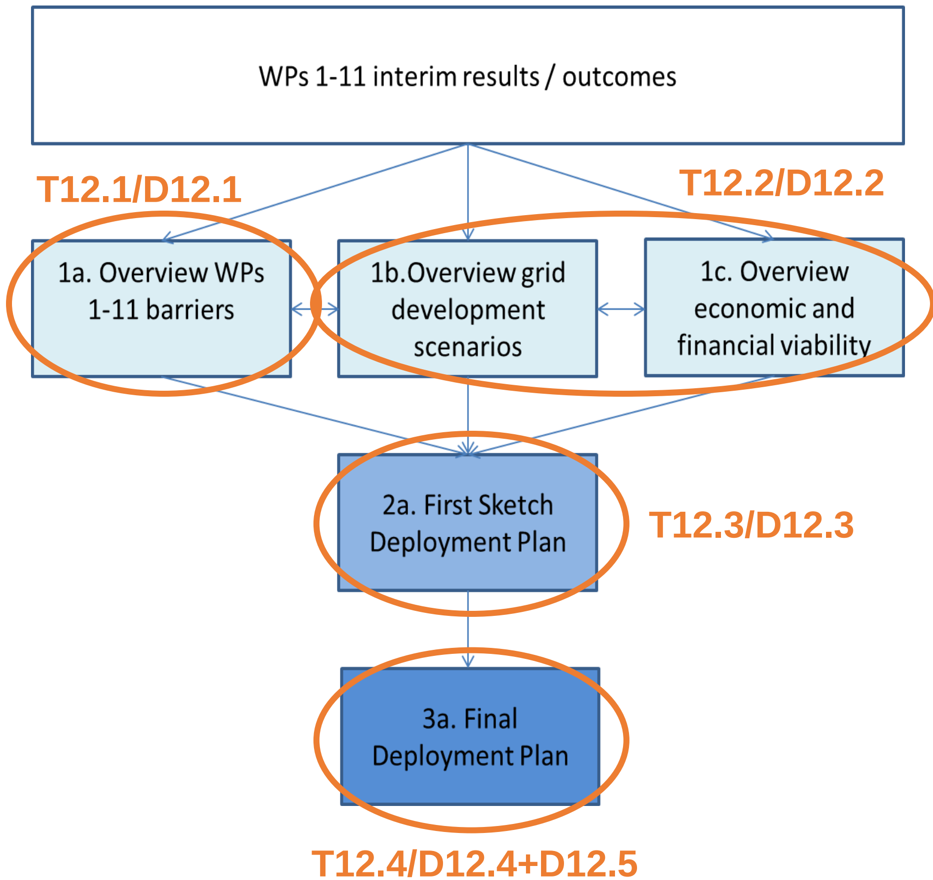
Overall structure of WP12

- Four tasks in WP12
  - T12.1: Preliminary analysis and project involvement
    - D12.1 due in December 2017
  - T12.2: To develop an “Optimal scenario”
    - D12.2 due in June 2018
  - T12.3: First sketch of the deployment plan
    - D12.3 due in December 2018
  - T12.4: Final deployment plan
    - D12.4&D12.5 due in December 2019



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What is the Deployment Plan (DP)?

- The DP is <u>NOT</u> a grid development plan indicating the infrastructure to build
- The DP is supposed to be a set of recommendations with concrete insights on different strategies to develop an offshore grid (pros/cons, indicative costs, indicative benefits, related regulatory frameworks, possible ways to finance such a grid, etc.)
- In order to provide detailed recommendations, fictive offshore development scenarios must be obtained, to allow rough quantitative estimations (e.g. level of CAPEX, OPEX, benefits, etc.)
- Purpose of task 12.2: provide a quantitative assessment for the DP
    - Grid development scenarios
    - Economic and financial viability
    - Technical aspects

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Offshore grid development scenarios (T12.2)

- Different alternatives to development the offshore grid will be analysed
  - Small HVDC hubs – large HVAC hubs (i.e. energy islands)
  - National policy – European policy
  - Integration of DCCBs – no DCCB
  - …
- Different scenarios for the development of offshore wind farms
- Limitations of the draft roadmap will be addressed
  - Mixed HVDC/HVAC offshore grid, in particular to connect close offshore wind farms to HVAC hubs
  - The offshore grid will not only be developed to evacuate offshore wind energy, but also for power trade between North Seas countries

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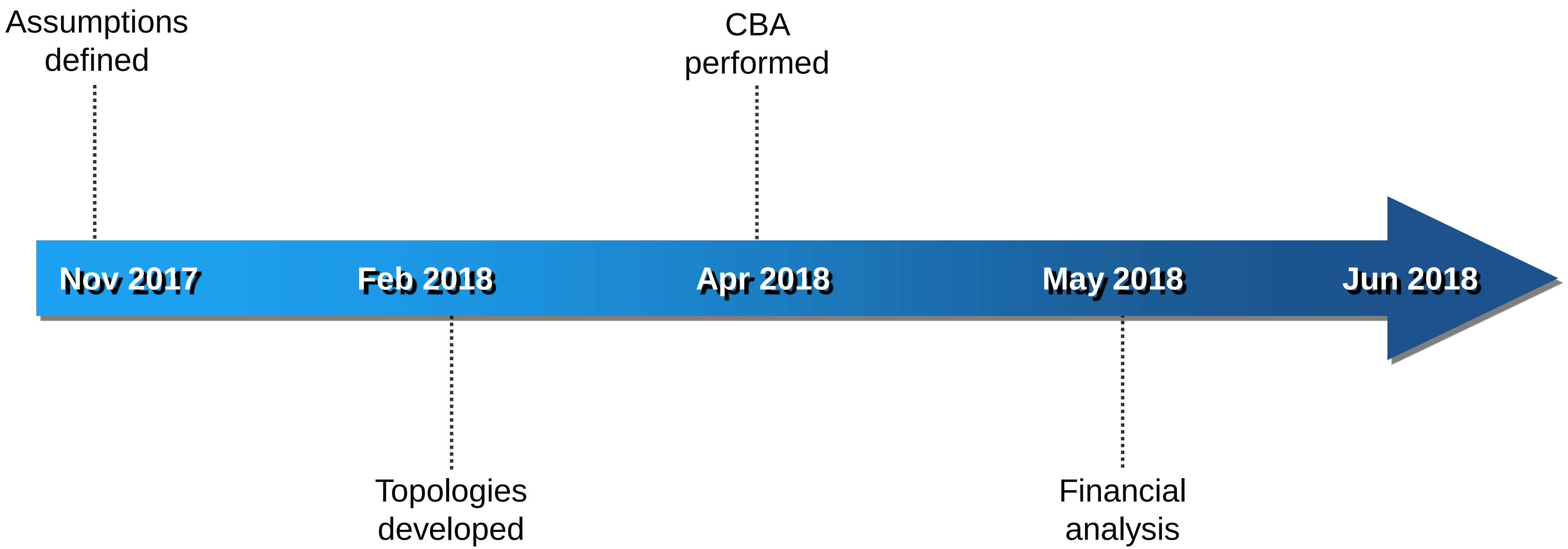
Deployment Plan

Timeline for Task 12.2



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Discussion

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Discussion

- Interactions between the PROMOTioN project and ENTSO-E RGNS?
- Bilateral interactions with specific TSOs?
  - In particular TSOs not present in PROMOTioN
- Possible interactions
  - Need of input from TSOs for “initial conditions”, i.e. decided (or nearly decided) infrastructure
  - Need of input from TSOs for “boundary conditions”, i.e. hosting capacity of the onshore grid
  - Global comments on assumptions will be welcome
  - Results of T12.2 should be of interest for the TSOs
    - Comparison of alternatives
    - Technical constraints
    - …
  - Interactions will be needed for the DP itself

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APPENDIX

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