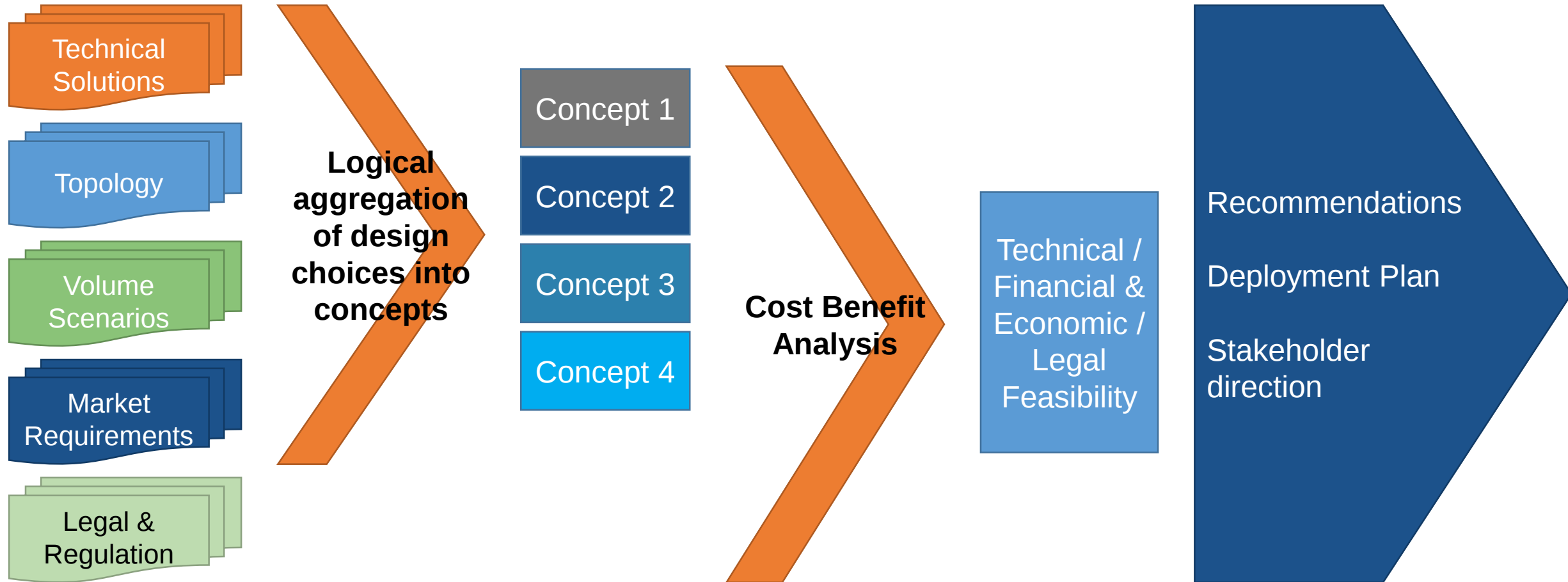


Towards meshed off shore grids – Development of a roadmap

6th June 2018, Amsterdam, *Michiel de Schepper*

Intuitively a Meshed & Coordinated Offshore Grid will deliver measurable benefits to the Offshore (Wind) Supply sector



What do we need to achieve?

	Premise	Meaning	Who
A	Acceptance of a joint approach	<i>Do we want to – are we interested and what do we expect/want it to do</i>	EU / Member states
B	Is it technologically feasible	<i>How can we do it (what & when)</i>	R&D / market ready
C	Is it feasible; legal & regulation	<i>How to ensure that we are we allowed to do it</i>	EU & National law & regulations
D	Is it economically feasible	<i>Is it attractive to do it – are (social) benefits > costs</i>	EU / Member states
E	Is it organisationally feasible	<i>How to organise, cooperation model</i>	EU / Member states Operator / owner
F	Is it financially feasible	<i>How to enable a bankable business case we make an investable case</i>	Operator / owner Market / Equity funders



An aerial photograph of a steep, green mountain slope. A winding asphalt road with white dashed lines curves through the landscape. The road starts from the bottom left, goes up, then down, then up again, and finally down towards the bottom right. The surrounding terrain is covered in lush green vegetation, with some rocky patches. In the background, a deep valley is visible, and a small stream flows through it. The sky is blue with some light clouds.

*To Harvest the Benefits of a
Meshed Offshore Grid
(discussed this morning)
there is a long road to take to
get there...*

Source: cheshireboundstone.co.uk



© PROMOTiON – Progress on Meshed HVDC Offshore Transmission Networks
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

National ecosystems focus: Build vs Coordinate

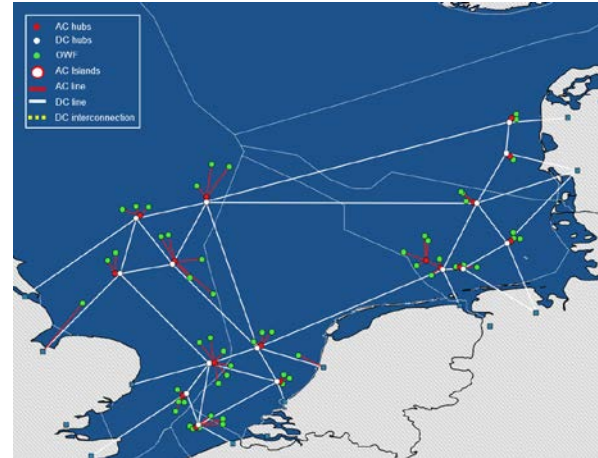
National ecosystems promote build of Offshore wind capacity, but coordination and forward thinking to facilitate a regionally optimal transmission solution are lacking.

- The situation today is largely uncoordinated internationally:
 - Different national regimes / starting points;
 - Different technical solutions;
 - Different National character / preferences.
- Currently the “easy” projects are being built, i.e. close to shore, existing technology.
- Timing /planned horizon (when can you influence future development [up to 10 years]).
- Distance to shore and density of infrastructure make a coordinated approach more logical.
- Benefit gained from combining the functions of interconnection and the evacuation of offshore wind energy
- Increased utilisation and cost optimisation of infrastructure
- Technology availability (new solutions HVDC meshing).
- Underlying Framework:
 - Legal
 - Regulatory → Business Model
 - Other

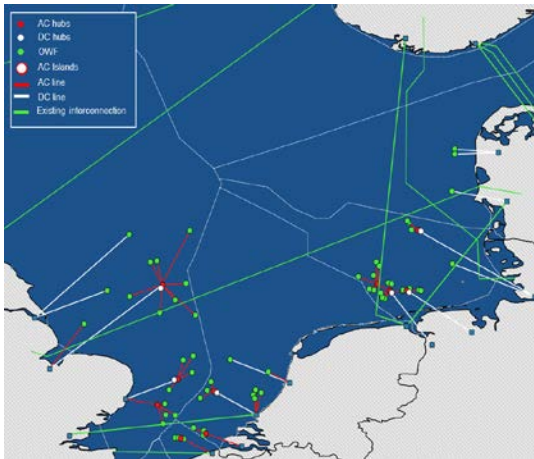


Initial Analysis focuses on Topology – “Concepts”

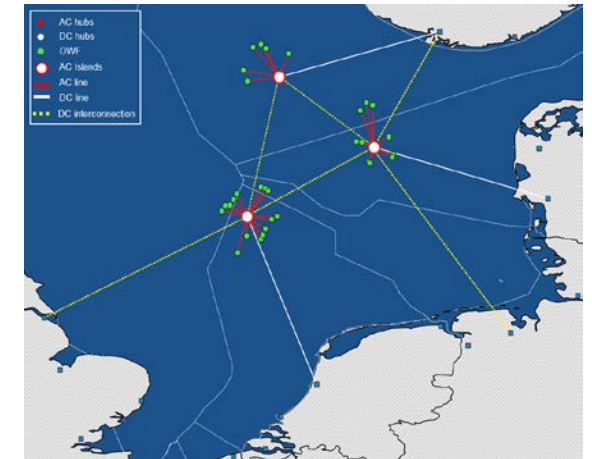
International
Distributed Hub
Concept



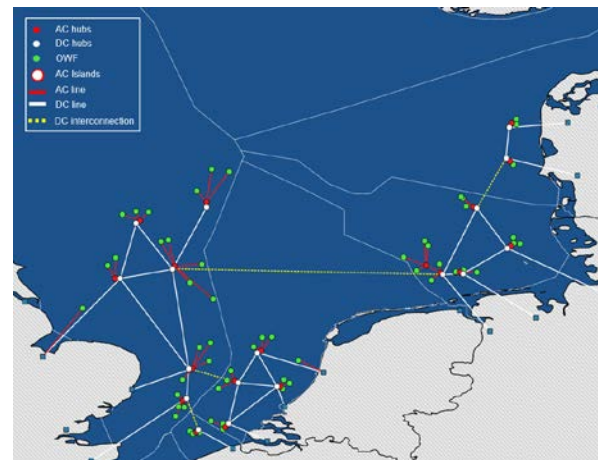
Business as Usual



Centralised International
Coordinated Hub Concept

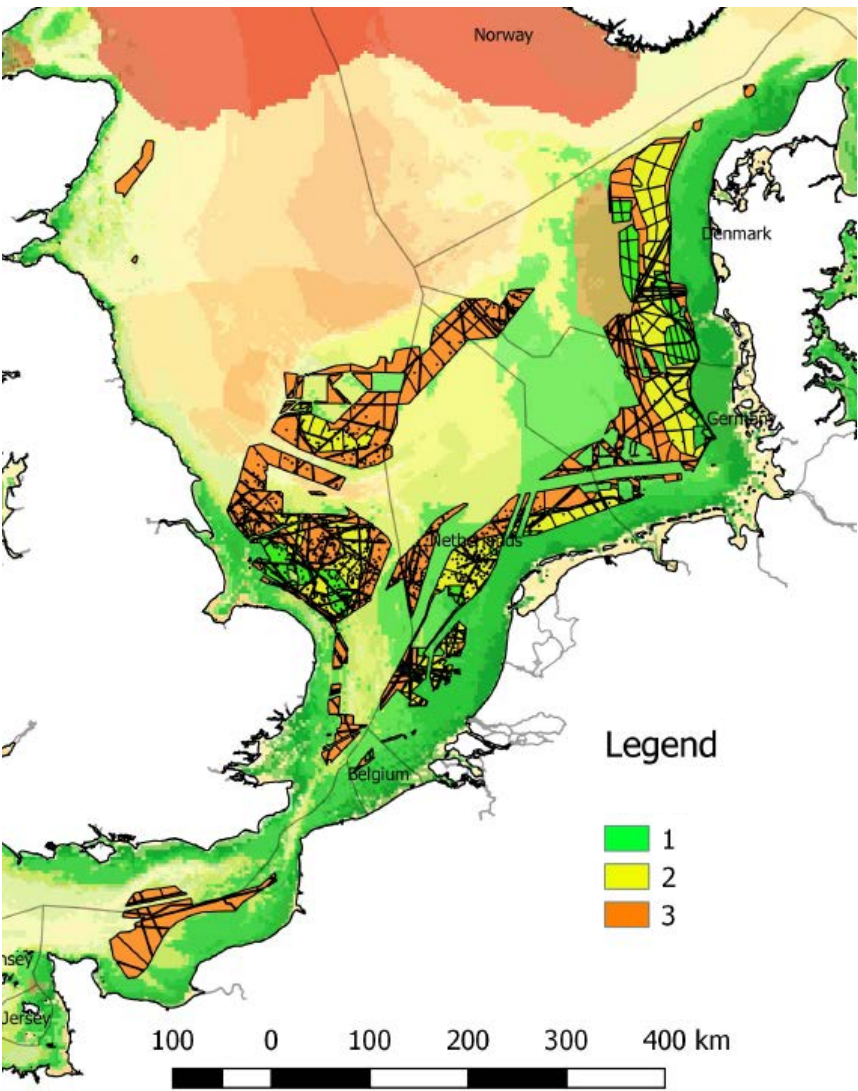


National Distributed
Hub Concept

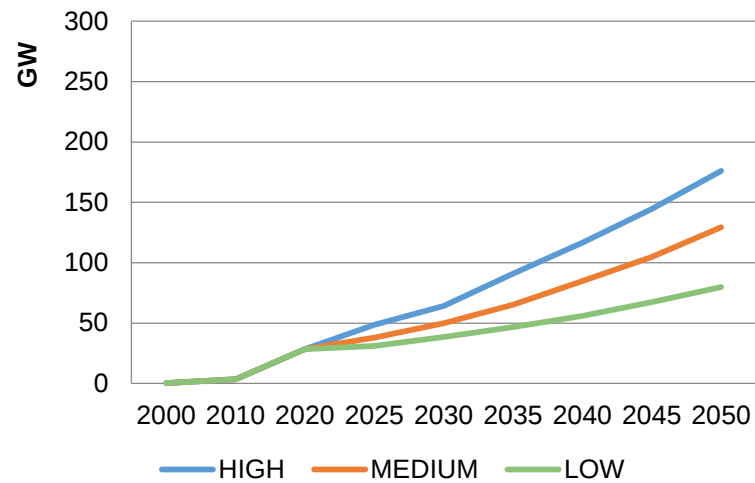




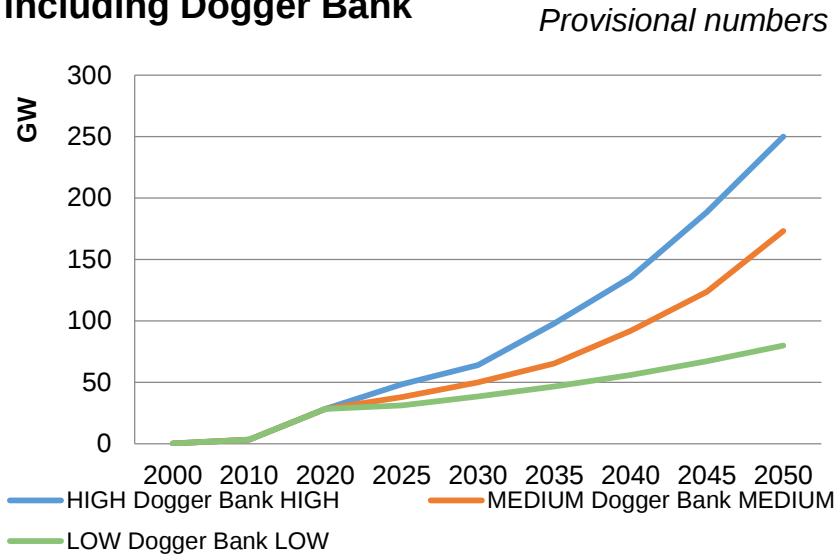
Scenarios integrate expected timing, volume and location of OWF roll-out



Cumulative Capacity
excluding Dogger Bank



Cumulative Capacity
including Dogger Bank



Prognosis of OWF capacity									
In Yellow additional capacity of Fixed in GW to install per 5 Years	2000	2010	2020	2025	2030	2035	2040	2045	2050
High	0,4	3	25,0	20,1	15,6	27,0	25,5	28,0	31,5
Central	0,4	3	25,0	9,6	12,0	15,3	19,6	20,0	24,5
Low	0,4	3	25,0	2,8	7,4	8,1	9,4	11,2	12,6
Dogger Bank (energy Island)	High	0	0	0	0	7	12	25	30
Dogger Bank (energy Island)	Central	0	0	0	0	0	7	12	25
Dogger Bank (energy Island)	Low	0	0	0	0	0	0	0	0



Operational design and its impact on technology

Market clearing does not drive an unique architecture for active elements in an offshore grid,

- Active power flows through each converter depend strongly on market clearing for each offshore wind generator
- For cross-border flows in line with the market clearing (e.g. in case several converters connect an offshore grid to a country)
- voltages (in both the AC and the DC grid).
- scheduling process is the link between the market system and the settings of the converters.

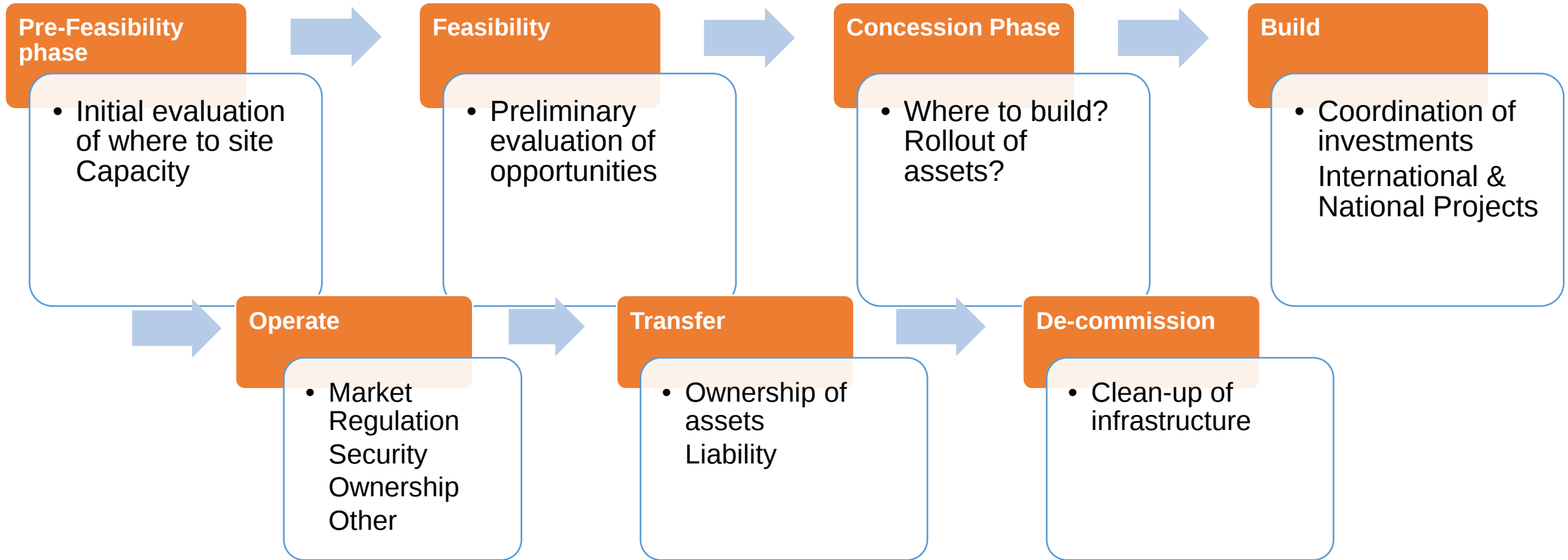
Several practical aspects will be considered, driving the analysis and the tech choices:

- **Controlling power flows**
- **Optimizing the DC grid topology**
- **Consideration of AC and DC constraints**
- **Compensating imbalances**
- **Operational security of the grid**
- **Partial restoration of the grid after a fault**

12.1 Opens the discussion of these issues

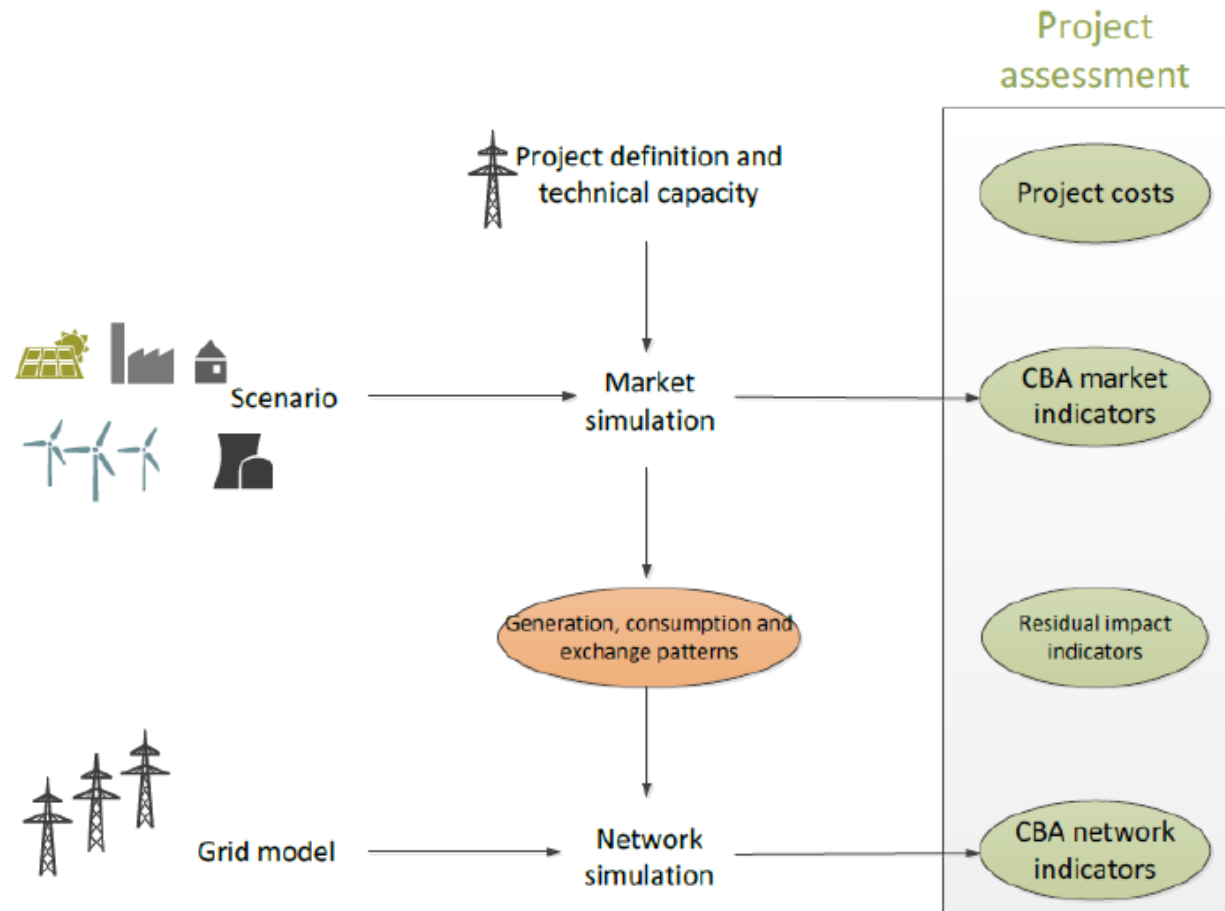
12.2 Considers appropriate technical solutions to satisfy the market constraints.

Regulatory framework & governance



WP7.1 has analysed the current legal framework, WP7.6 makes global recommendations for each scenario. These are validated in WP12.2

Economic feasibility and business model



CBA methodology is based on ENTSO-E technique and publically available literature. It will be applied in WP12.2 to make:

1. CBA of technical choices within each Concept
2. CBA of different Concept-Scenarios
3. Conclude on Economic feasibility of each Concept-scenario

Financeability

Subsidies

- Support for national and International offshore projects
- Anticipatory investment (like Airbus, JSF or Boeing)
- Loan Structures

Private Strategic Investment /TSO

- Limits to investment capacity
- Ownership and management issues

Private Investment Banks and Funds

- Amount of required investment
- Timing
- Perceived risks
 - Stability of cash dividends
 - Priority
- Required return on investment

National preferences

- Cultural inclination towards or away from central coordination / regulation?
 - UK (Anglo Saxon values, organic, financially efficient) vs Germany (Planned, central coordination, technically strong)
- Refer to precedents
 - Oil & gas infrastructure (pipeline, tunnel infrastructure)
 - Communication
- Can non-Northern Sea member states contribute to Norths Sea wind power development?
 - What if finance derived from non-Northern Sea member states?
 - Can such a country finance and build capacity in designated areas?
 - If yes, who gains the RES credits?



What do we need to achieve...

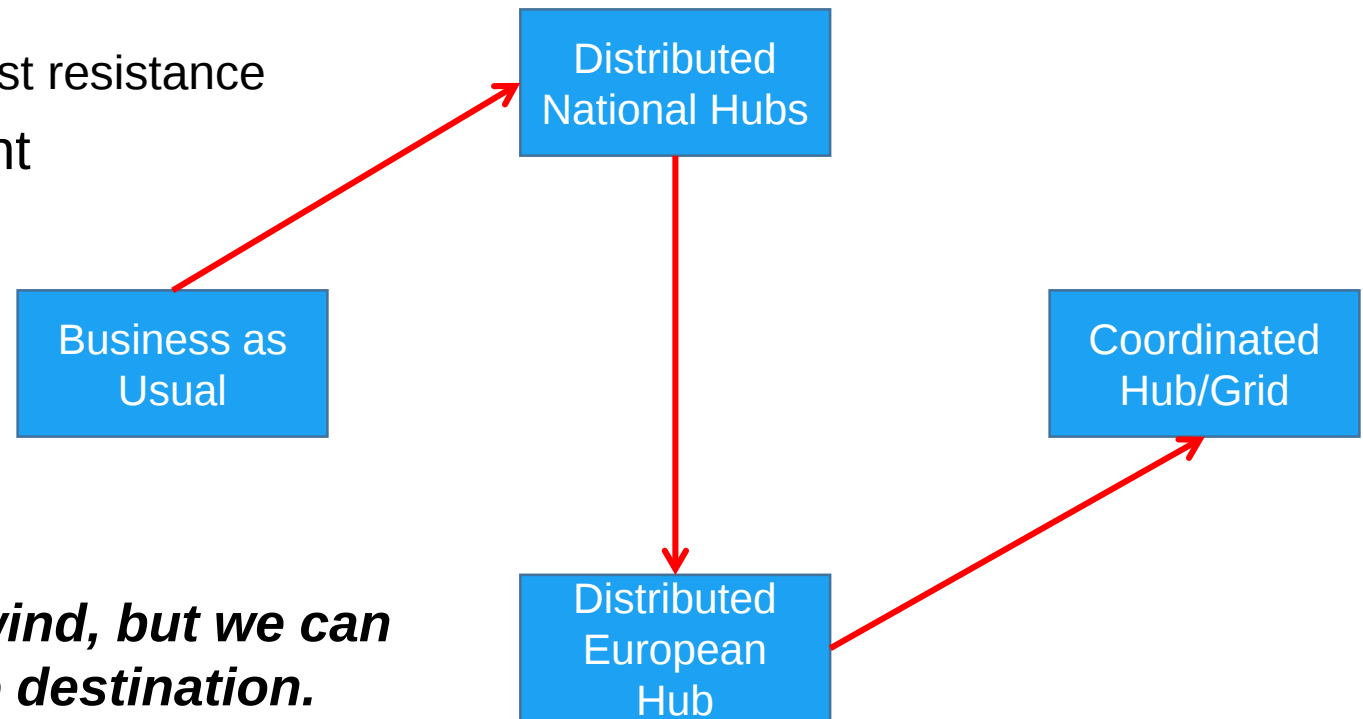
A potential way to summarise results *may* be:

Choice	Motivation	Options	Impact of each option	Recommended choice	Owner now	Ideal owner
Voltage levels	Assets with different voltage ratings cannot be connected together to form a grid. Due to the fact that high power HVDC-HVDC conversion is not yet developed	Cigre TB on recommended voltages	Amount of power Technical maturity Availability of manufacturers Cost ...	Some form of standardisation Future	In AC projects onshore, TSO determines voltage based on standardised voltage classes. In turn key HVDC projects often voltage level chosen by OEM to optimise link	IEC standards and TSOs

For reference only

Conclusions or summary

- Not one solution – many potential routes
 - Business as usual is real and today
 - May be expected to follow route of least resistance
- Make benefits of choices transparent



We can't change the direction of the wind, but we can adjust the sails to always reach the destination.

Jimmy Dean