FDP – Offshore Developments

Meeting with BOP

08-12-2022

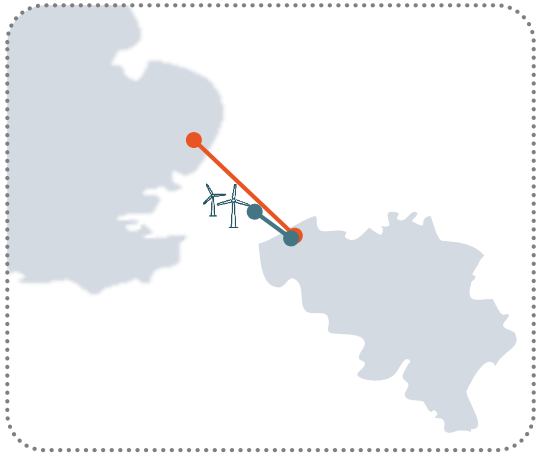
Why is Nautilus connected to the Princess Elisabeth island ?

FDP 2024-2034

Scopes of Nautilus and MOG2 have evolved these last years

From

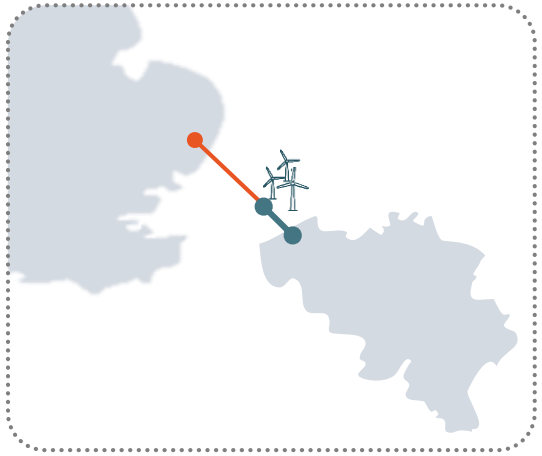
MOG2 : 1,75 – 2,1 GW
Nautilus Point-to-Point Interconnector



Federal Development Plan 2020-2030
(2019)

To

MOG2: 3,15 – 3,5 GW
Nautilus Hybrid to the Princess Energy Island[1]



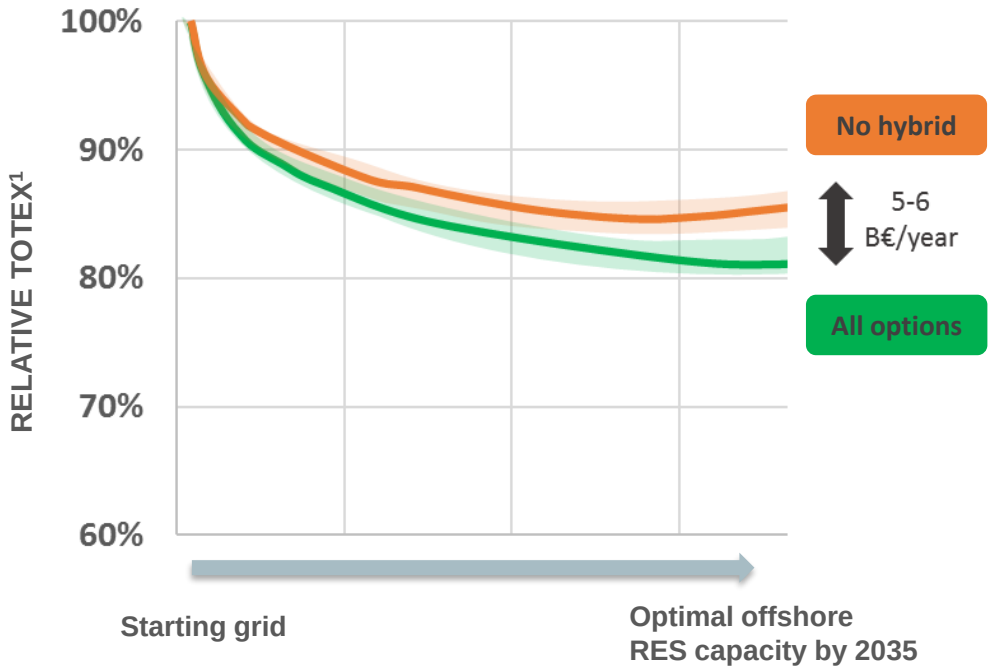
Federal Development Plan 2024-2034
(now)

Location of the UK connection point for illustrative purposes

1) An alternative with UK wind connected to Nautilus is still under analysis in the UK as part of the Offshore Transmission Network Review (OTRN)

Key message from FDP 2024-2034 Identification of System Needs

Hybrid systems & meshed offshore grid facilitate additional cost savings



- **5-6 B€ / year extra cost savings** can be achieved at EU level thanks to **hybrid systems** and meshed offshore grids
- Cheaper power system also imply **more realistic** to develop and **more environmental friendly** (less cables, less converter stations, less landing points,…)

.....

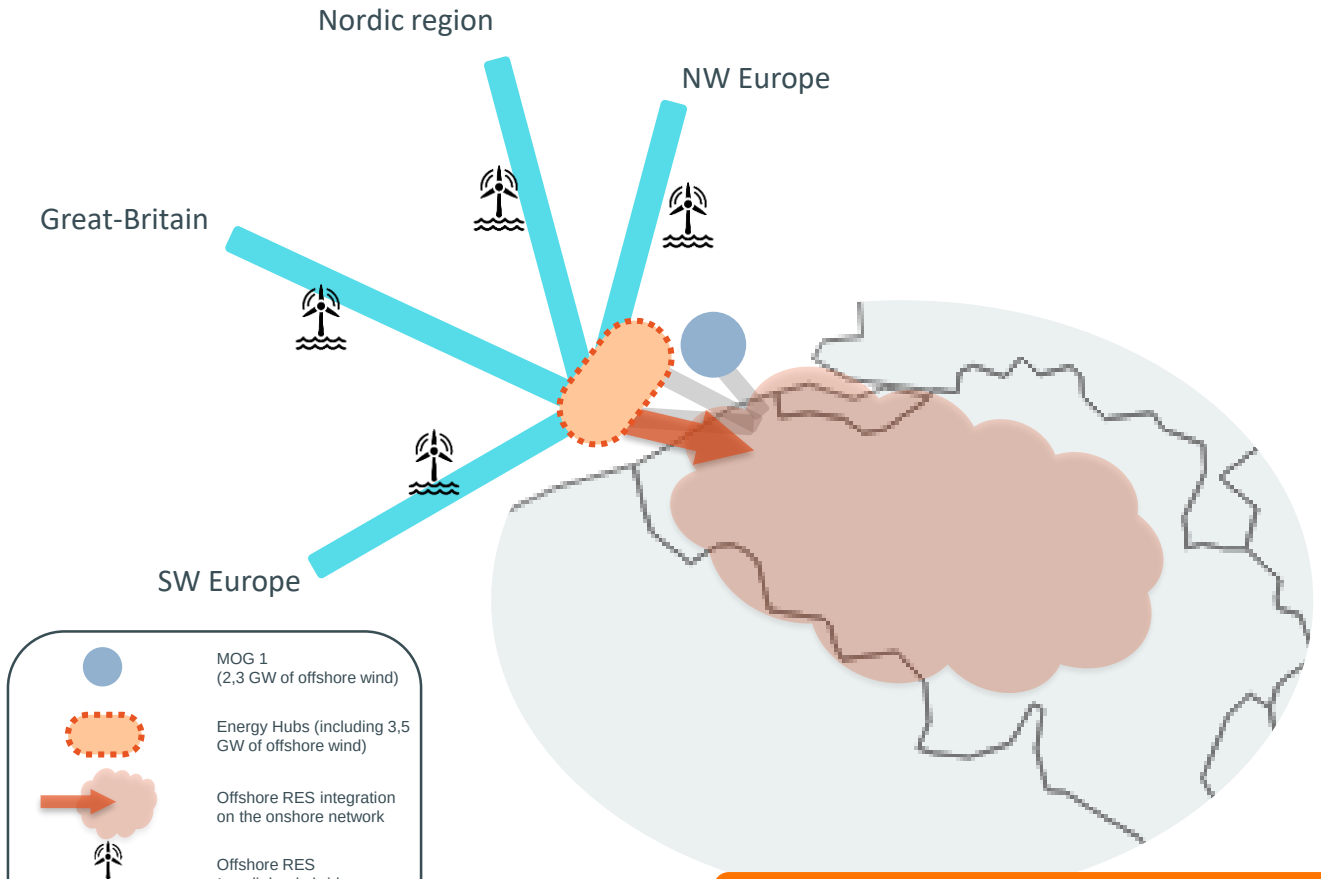
- Increased **coordination** at EU level is key
- **Future-proofness** is key to allow this coordination while not slowing down RES integration.

The timely development of the required technological solutions (multi-terminal HVDC, multi-vendor,…) is currently the biggest uncertainty and is an absolute condition to make offshore meshed grid happen.

(1) TOTEX = Operating cost of the system (fuel & CO2) + Investment cost in grid extension/RES connections
The analysis has been performed base on 1 scenario and 1 time horizon (Large Scale e-RES in 2035).

Key message from FDP 2024-2034 Identification of System Needs

Energy hub(s) off the Belgian coast are the corner stone of an efficient RES integration in EU & BE



- These **energy hub(s)** are chosen to be a major Belgian **access point**[1] **to the North Sea RES potential**. Doing so, RES energy is **optimally shared** between EU countries. ➔ Benefit from decorrelation effect at EU level
- Offshore cross-border interconnections will be **complementary** to the onshore cross-border reinforcements, as soon as they have reached their full potential.
- **Reinforcement needs** are identified between these hubs and the onshore network (-> link with Backbone IoSN)

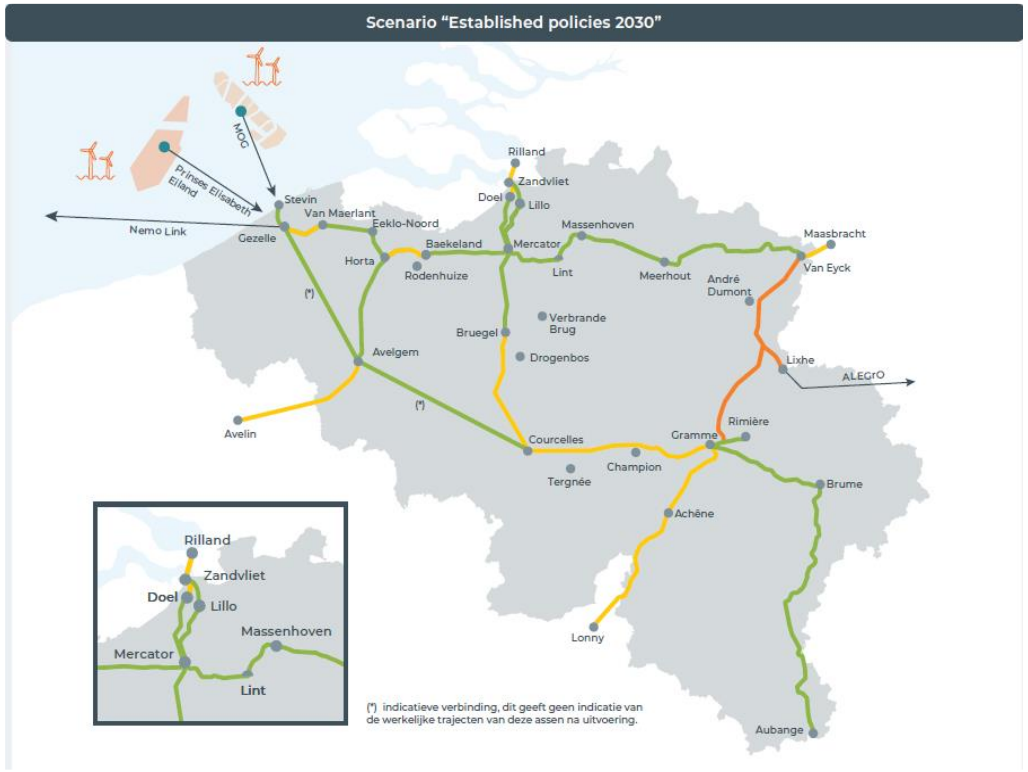
(1) Onshore cross border reinforcements are complementary

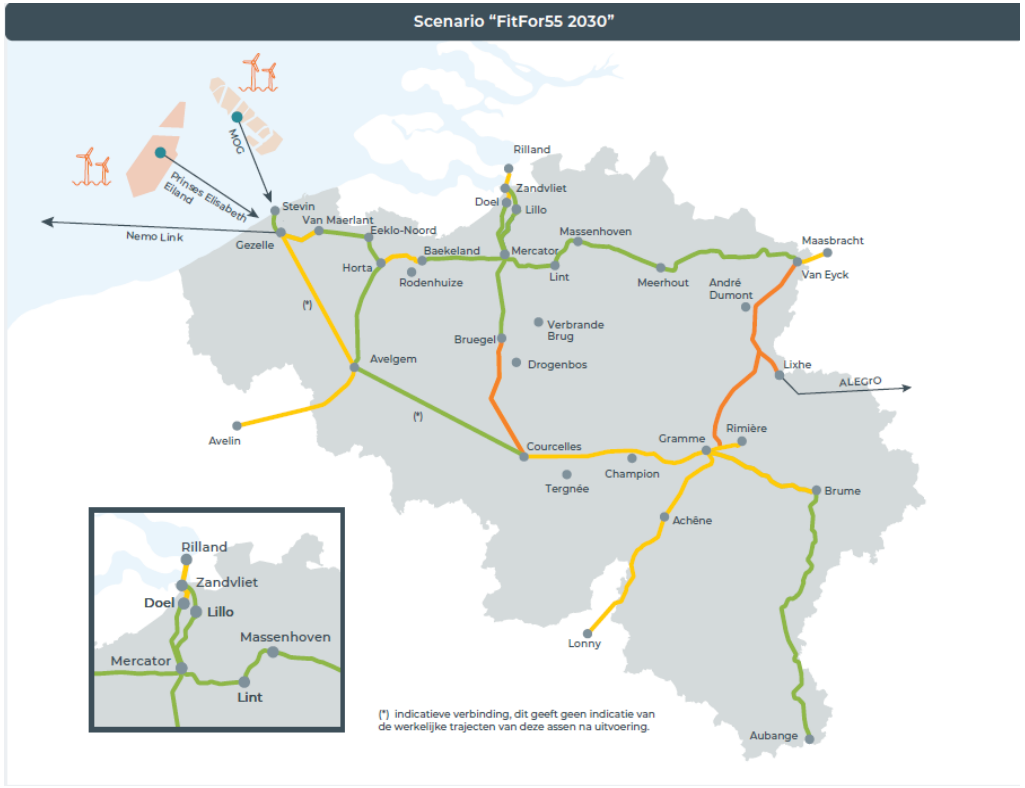
Hybrid systems and meshed grid allows both RES integration and new interconnections, via common infrastructure.

Key message from FDP 2024-2034 Identification of System Needs

Reinforcements needs are clearly identified on the onshore network

2030 vs. today	**Outer crown:** MOG II AC & DC, 1st PST Achêne. **Internal grid**: Brabo 3 + Ventilus & + de HTLS-upgrades van Bruegel – Mercator, MMVE en Mercator – Massenhoven **Power plants**: CCGT's Awirs & Seraing. No nuclear.





Onderstation 380 kV | Acceptabele belasting | Acceptabele hoge belasting | Gematigde overbelasting | Zware overbelasting

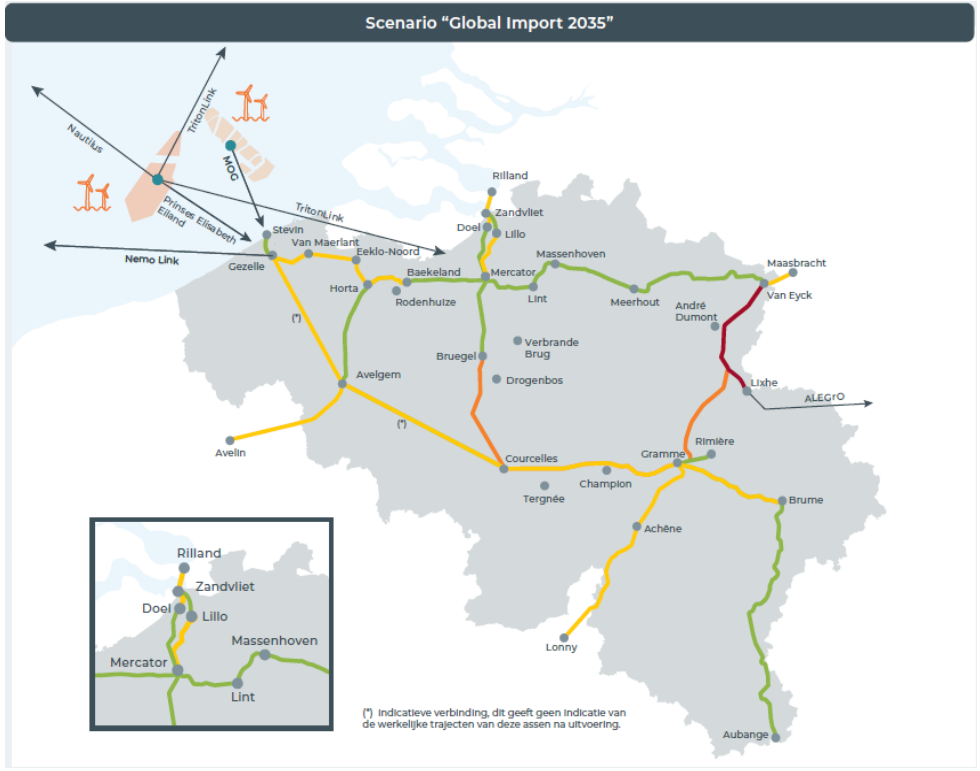
By 2030, the backbone network already reaches its limit on several axis with the Energy Island.

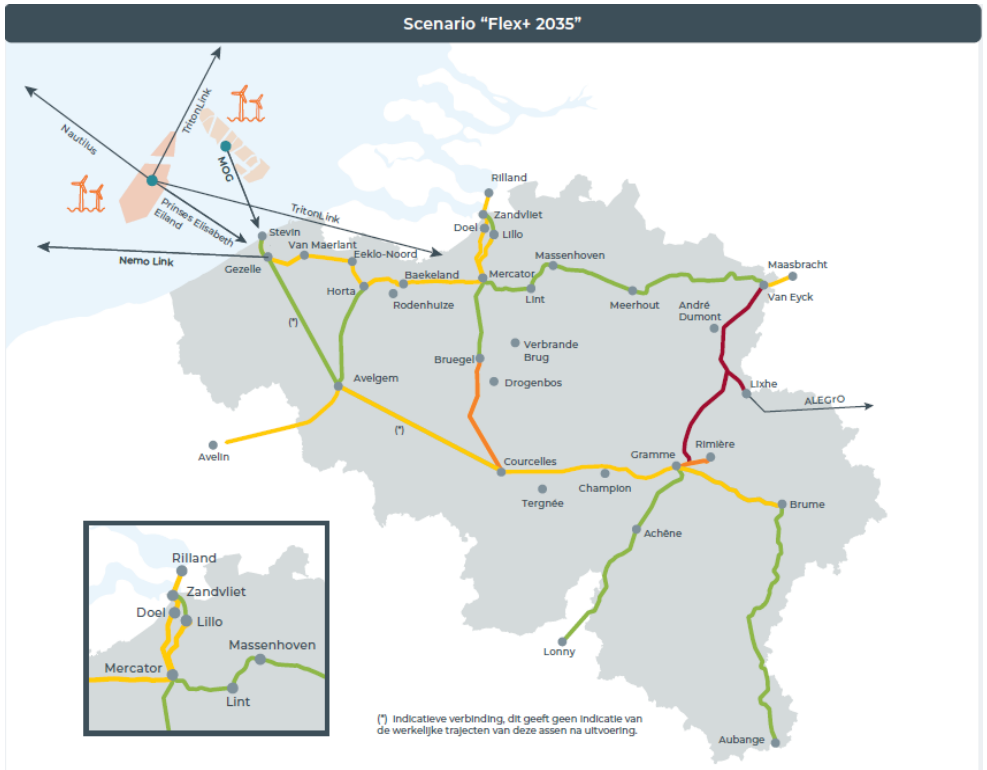
Note: Overloads on GRAMM-VANYK are even more severe assuming nuclear prolongation.

Key message from FDP 2024-2034 Identification of System Needs

Reinforcements needs are clearly identified on the onshore network

2035 vs. 2030	**Outer crown:** incl. HTLS-upgrade LAG, TritonLink on MERCA, Nautilus (upgrade VANYK – MAASB or BE-DE 2 not yet !!) **Internal grid**: idem as in 2030 **Power plants**: Idem as in 2030. No nuclear.





Onderstation 380 kV | Acceptabele belasting | Acceptabele hoge belasting | Gematigde overbelasting | Zware overbelasting

By 2035, with Nautilus Hybrid and TritonLink, even more axis are reaching their limits.

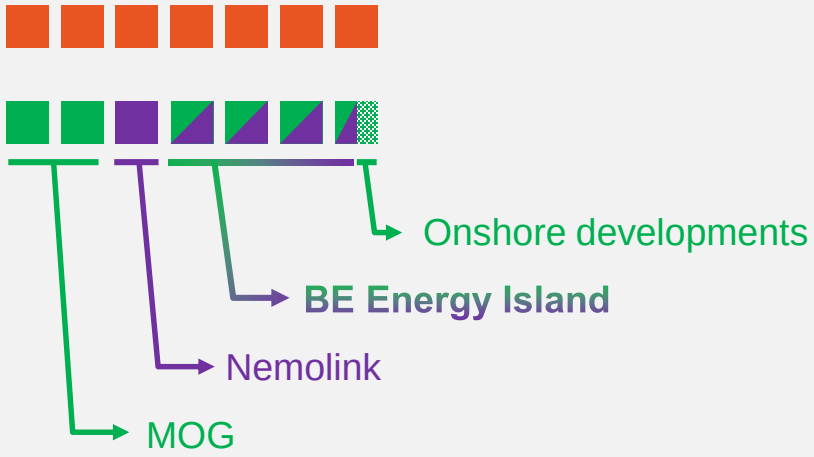
Note: Overloads on GRAMM-VANYK are even more severe assuming nuclear prolongation.

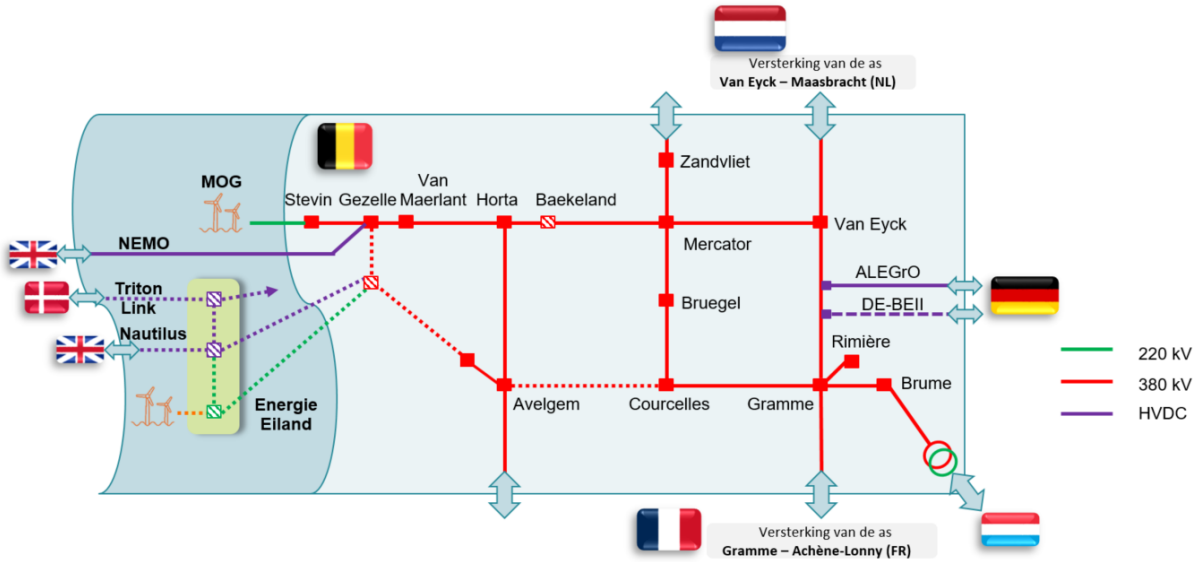
These general trends are also valid locally on MOG2/Nautilus

1. The hybrid system is the cheapest and fastest way to connect both 3,5 GW of wind in the Princess Elisabeth Zone and an interconnector with Great-Britain.

   ► Ventilus and BdH provide an additional 3,5 GW grid hosting capacity on the coast, for new offshore developments.

Backbone capacity up to Avelgem/Horta after Ventilus & BdH: **7 GW**





1. Draft Federal Development Plan 2024-2034
2. eef_guidelines_ref_tbc.pdf (europa.eu)

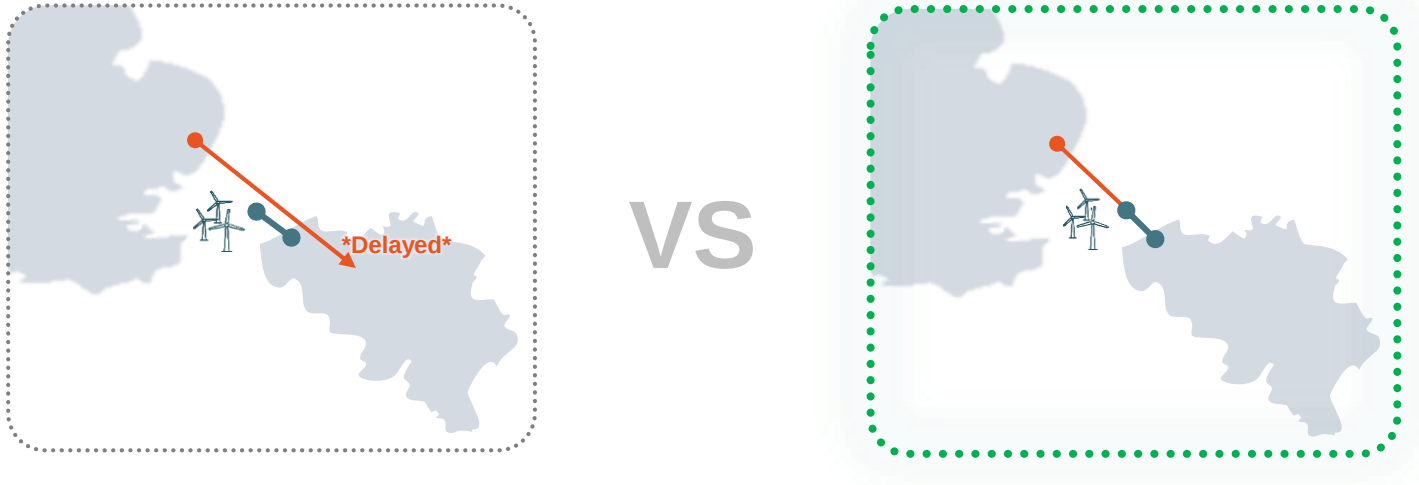
These general trends are also valid locally on MOG2/Nautilus

2. The hybrid system (formed by Nautilus & MOG2) allows significant savings for society

- CAPEX savings:
  - 1 shared converter station onshore instead of 2 independent converter stations.
  - 1 offshore HVDC cable system instead of 2 independent HVDC cable systems in parallel
  - Additional CAPEX costs to reach a further inland connection point.

  } ~ 650 – 750 MEUR

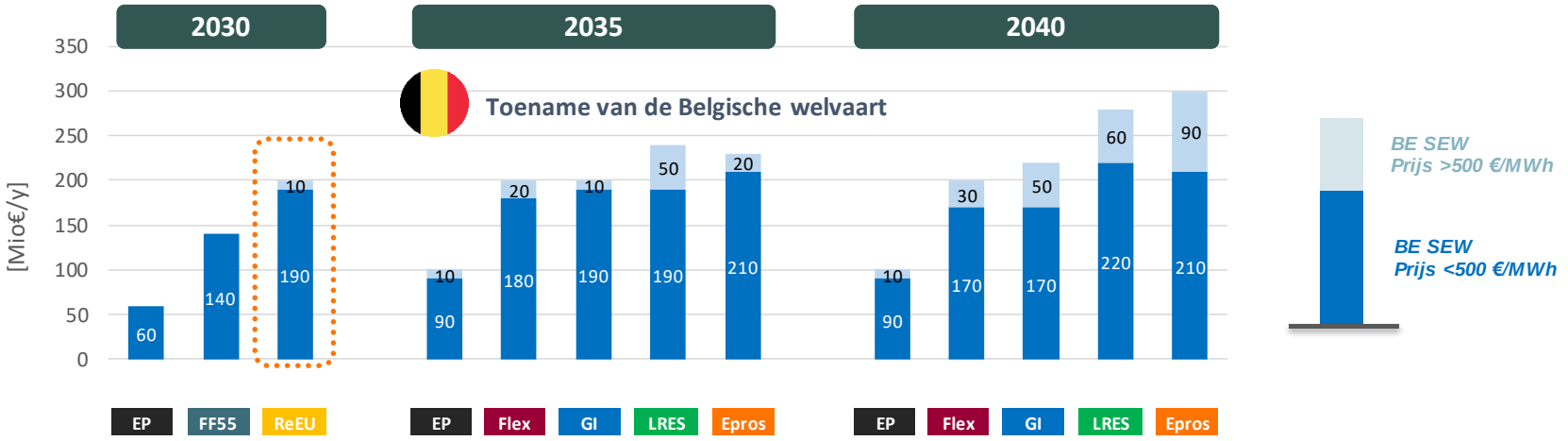
- OPEX savings as additional (complex) infrastructure also means additional OPEX on the whole lifetime.



These general trends also verifies locally on MOG2/Nautilus

3. An early connection of Nautilus comes with significant benefits

- Benefits for Belgium of Nautilus ranging from 60 and 200 MEUR/year depending on the scenario as of 2030[1]



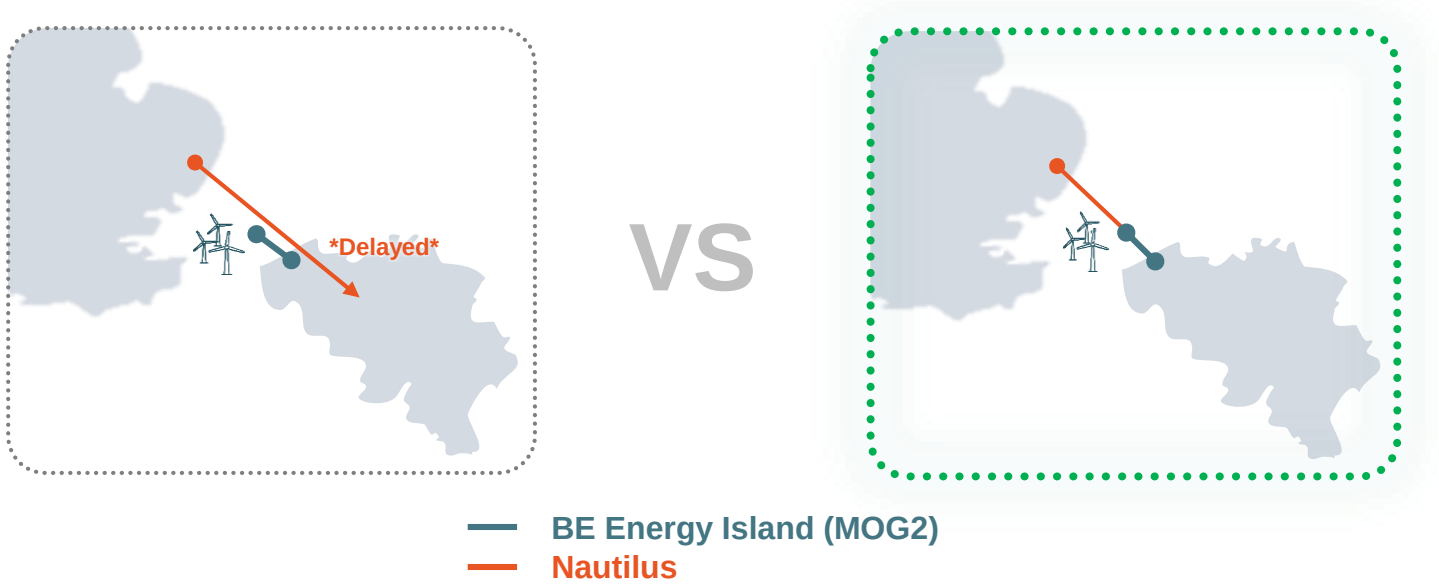
Connecting Nautilus on the BE Energy Island is faster and every year gained comes along with significant benefits for the Belgian society.

1. Draft Federal Development Plan 2024-2034

These general trends also verifies locally on MOG2/Nautilus

4. The hybrid system is fully in line with the “energy efficiency first” principle[1] developed in the EU regulation.

- It significantly lowers the amount of (raw) material and in turns the spatial and environmental impacts while providing significant benefits to the society, thanks to a higher (more efficient) utilization rate of the infrastructure.



The hybrid system allows to use the HVDC system between the energy island and TBD during no or low wind periods.

1. eef_guidelines_ref_tbc.pdf (europa.eu)

Main take-away :

The vision is to use the Princess Elisabeth island as an offshore hub, to which both offshore wind and interconnectors will converge.

- This vision is **realistic**: a radial only strategy is neither cost-efficient nor realistic given the speed of integration required.
- This vision is **coherent** with the development of the onshore network, which prevents the emergence of structural congestions.
- This vision **supports the electrification** of Belgian society as it allows trade of clean energy between the North Sea countries without uselessly overloading the onshore network.
- This vision is **ambitious** given the technological challenges it raises and is in line with the **energy efficiency-first** principle: only the infrastructure really needed is installed.

➔ Nautilus is the first candidate hybrid system identified that fits with this vision.

➔ Other candidates will emerge anyhow.

BOP’s Grid Design proposals

Remarks per idea

Idea 1: Connecting Nautilus further inland

Significant CAPEX and OPEX increase

- 1 additional converter station is required onshore.
- 1 additional HVDC cable system offshore (~60km) and onshore (>100km) is required, including an additional cable landing point.

Additional delay

- To reinforce the internal grid accordingly.
- To obtain the permits for the additional infrastrucrure
- To install the additional infrastructure.

Additional environmental impact

- Both offshore and onshore

Conclusion:

Connecting the Princess Elisabeth Island also further inland is indeed a good option, which is envisaged via TritonLink (FOP ID 4) and the Offshore Energy Hub (FOP ID 5), thereby increasing system efficiency even further. A further reinforcement of the interconnection capacity between the Belgian EEZ and the onshore backbone will be studied, in the framework of the revised Belgian offshore ambitions.

Idea 2: Connecting MOG2 exclusively via AC

Significant CAPEX and OPEX increase

- No possibility to spare the HVDC cable system as the AC cables of MOG2 can not be used in a hybrid context (serving both BE wind-infeed and Nautilus).

Additional environmental impact

- Significant increase of total AC cable length both offshore and onshore.
- No possibility to spare the HVDC cable system

4 additional landing points

- Can be considered as almost impossible.
- Securing 7 landing points is already a challenge today

Additional delay on Ventilus

- Rescoping of the project would be required
- Unacceptable delay, directly impacting the connection of MOG2. Securing 7 landing points is already a challenge today

Increased risk of system instability

- Connection of 3,5 GW IBRs in antenna on 10 AC cables comes with a risk of transients an/or resonance in case of loss of one or several network element(s).
- With 3,5 GW AC-connected wind + a HVDC system in the same area, the amount of IBRs seen by the network will significantly increase compared to the hybrid solution. This will further reduce the apparent system strength (weighted short-circuit ratio) which increases the risk of system instability, for which the currently planned mitigation measures are not sufficient (see next slides)

Conclusion:

Connecting MOG2 exclusively via AC is not relevant as it doesn't offer any perspective for further extensions, which leads to increased costs, risks and delays to meet similar objectives in terms of RES integration and development of interconnections.

Context

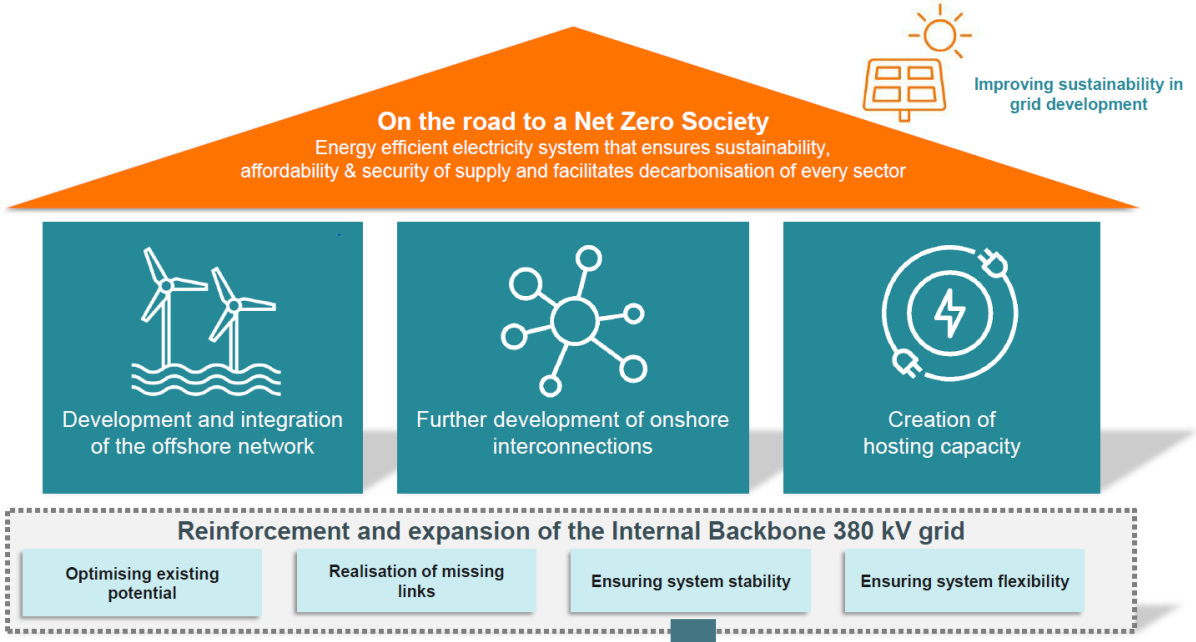
Dynamic stability in Belgian coastal area

- Ventilus and BdH will create a hosting capacity of 7 GW that will almost entirely be taken by IBRs (Inverter-based resources)
  - Massive RES integration
    - Offshore developments (5.8 GW in 2030)
    - Onshore developments, conditional on arrival of Ventilus/BdH
  - HVDC links (Nemo & Nautilus)
  - Emerging large-scale BESS projects (onshore)
- Inertia and system strength is limited, increasing the risk for stability issues given the high penetration of PE converters
- Dynamic instability risks must be mitigated, as they might lead to uncontrolled disconnection of IBR, potentially creating an imbalance > 3GW

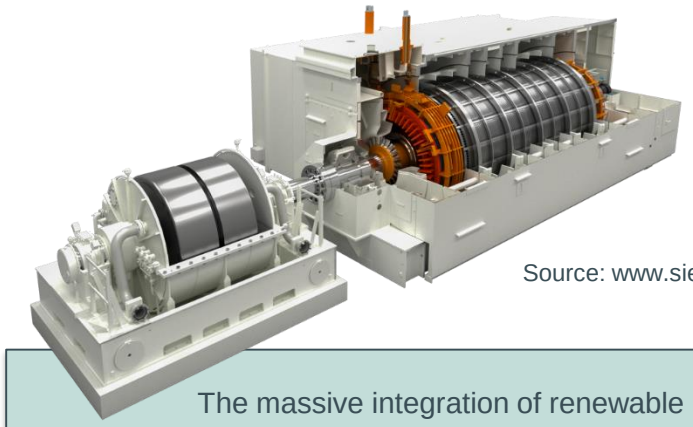
Dynamic stability must be assured when integrating the planned quantities of IBRs in the Belgian coastal area. If instability risk is not sufficiently mitigated, this can lead to cascading effects with continental European-wide consequences (blackout)

FDP 2024-2034

Ensuring system stability is key to realize our ambitions

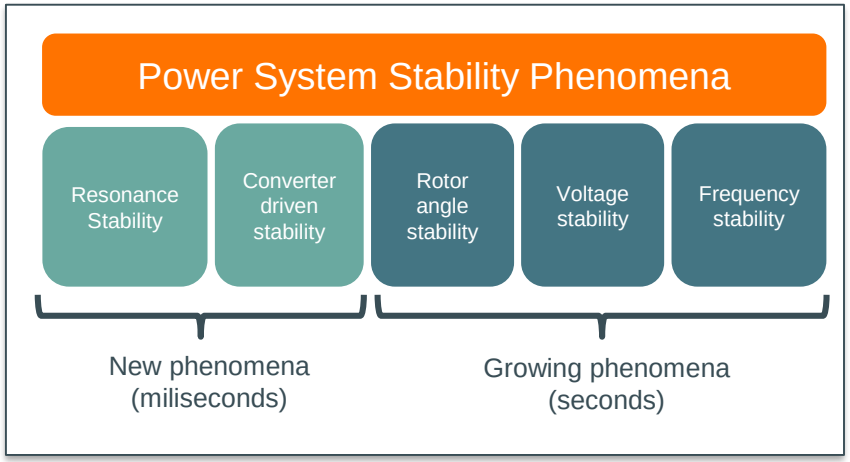


PROJECT	OMSCHRIJVING	ID FOP	VERMELD IN FOP 2020?	TYPE GOEDKEURING	GEPLANDE REALISATIE	PROJECTSTATUS
Synchrone com-pensatoren	Plaatsing van 2 tot 3 synchrone compensatoren voor het garanderen van de systeemstabiliteit bij de integratie van zeer grote hoeveelheden hernieuwbare energie	66	Nee	Ter goedkeu-ring	2028-2030	In studie



Source: www.siemens-energy.com

The massive integration of renewable energy and the decline of conventional thermal generating units is fundamentally changing the behavior of the electricity system. Traditionally, the stability of the transmission network is ensured by the presence of these conventional generating units. Renewable sources do not yet have the same or similar properties, which implies that it is necessary to take measures to guarantee grid stability at all times. In this context, Elia is considering the placement of **synchronous condensers**. These are synchronous machines which can provide voltage regulation, reactive power, short circuit power, and inertia to the grid. A strategic deployment of synchronous condensers in the Belgian coastal area strengthens and stabilizes the grid and hence helps to safely accommodate the planned amounts of IBR.



Idea 3: Eliminating faster GEZEL-MAERL bottleneck

4.5.2.3. Versterken van de as Gezelle – Van Maerlant

PROJECT	OMSCHRIJVING	ID FOP	VERMELD IN FOP 2020?	TYPE GOEDKEURING	GEPLANDE REALISATIE	PROJECTSTATUS
Gezelle-Van Maerlant	Plaatsen van bijkomende kabels 380 kV in het kader van bijkomende productie aan offshore wind	57	Nee	Indicatief	~2035	In studie

Limited potential in terms of grid hosting capacity increase

- This reinforcement can not support an increase of the grid hosting capacity by 1,4 GW, which would be required to welcome Nautilus on top of MOG2.
- This reinforcement is to be considered as an optimization of the existing corridor capacity and is not an end in itself as other parts of the backbone, further inland, are also gradually reaching their limits by 2035
- This reinforcement aims at supporting the repowering of the first OWP
- The feasibility of this reinforcement is to be confirmed still by further studies

Accelerate the reinforcement of the backbone is not an option

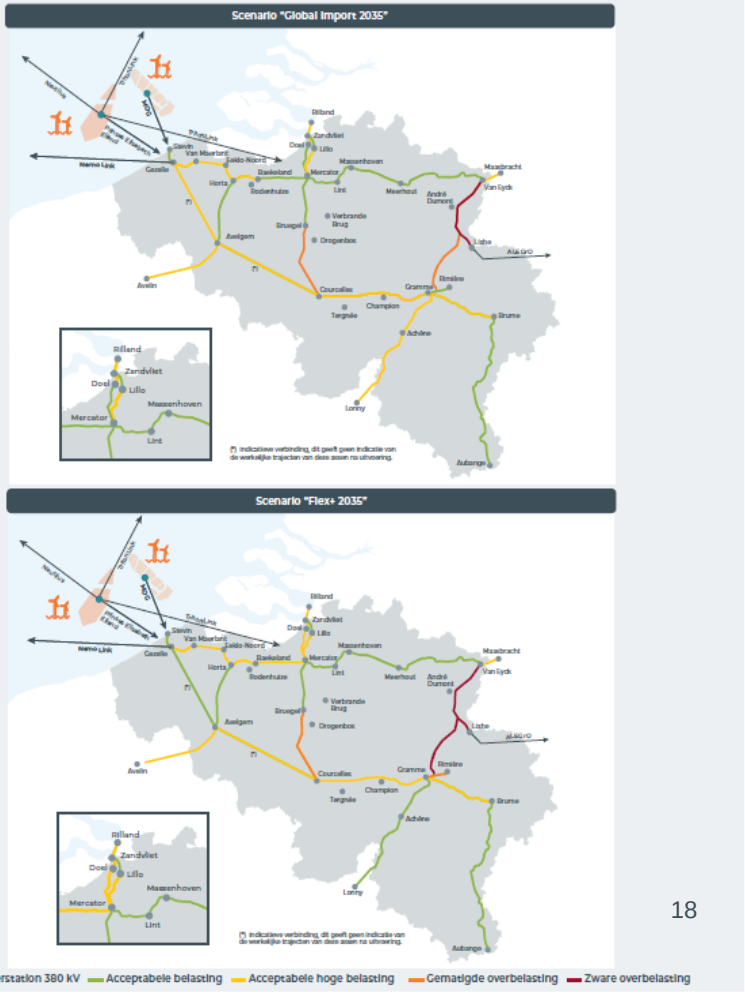
- Incompressible permits delay
- Complex outage planning as the network is operated closer to its limits
- Ressources (human + €) under pressure

It doesn't solve the increased risk of system instability

Conclusion:

The potential reinforcement of GEZEL-MAERL can support the repowering of the first OWP and the maintainability of the backbone network but certainly not the connection of an additional interconnector, on top of the offshore RES located in the Belgian part of the North Sea.

FIGUUR 3.22: BELASTINGEN EN OVERBELASTINGEN, IN N-1 SITUATIE, IN HET INTERNE 380 KV NET VOOR HET REFERENTIEJAAR 2035, ZONDER NUCLEAIRE CENTRALES

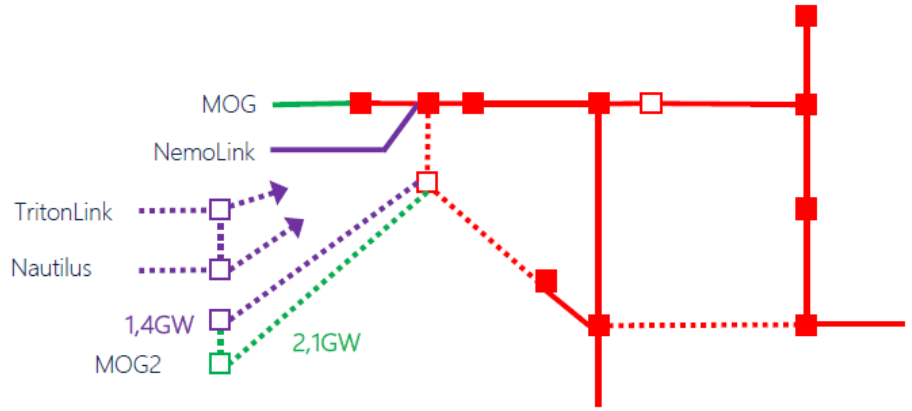


BOP’s Grid Design proposals

Remarks per option

BOP’s option 1 : Nautilus inland

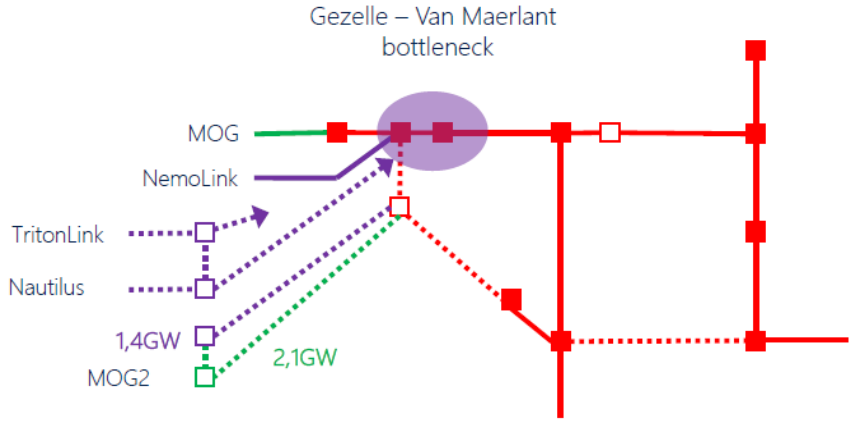
- General comments
  - See idea 1.
- Additional comments
  - The connection of a part of MOG2 via a HVDC system is also a stepping stone to Belgium’s participation to a future offshore network in the North Sea. If this offshore HVDC connection point is not used by Nautilus, it will soon or late be used by another interconnector anyhow.



- Use currently planned MOG2 design for 3,5GW OWP
- Direct Nautilus to Gent-Antwerp-Brussels area:
  - Corridor is feasible for TritonLink, so also feasible for Nautilus (similar technology);
  - Bundling of TritonLink and Nautilus corridors might reduce local impact
- Coupling Nautilus and MOG2 later in time when DC technology is ready

BOP's option 2 : Faster elimination of GEZEL-MAERL bottleneck & Nautilus to Stevin-corridor

- General comments
  - See idea 3.
- Additional comments
  - Nautilus on STEVN or Ventilus doesn't make a significant difference, both from a power flow and dynamic stability perspective.



- Elimination of the bottleneck on Stevin now planned for ~2035
- Accelerate this project and plan commissioning by 2030
  - Creates sufficient access capacity for both Nautilus and 3,5GW offshore wind on Stevin+Ventilus corridors
- Connect Nautilus to the Stevin corridor

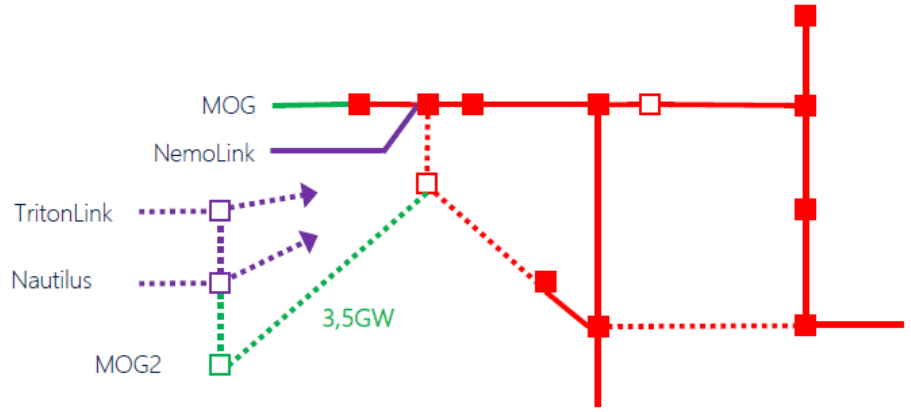
BOP's option 3 – Extra 220kV AC for MOG2 & Nautilus inland

– General comments

- See idea 1, regarding Nautilus inland.
- See idea 2, regarding MOG2 in full AC.

– Additional comments

- No HVDC connection point is offered on the PE island for MOG2 (except a converter station is installed offshore, on top of the 10 AC export cables). The connexion with Nautilus and TritonLink is thus impossible or very costly.

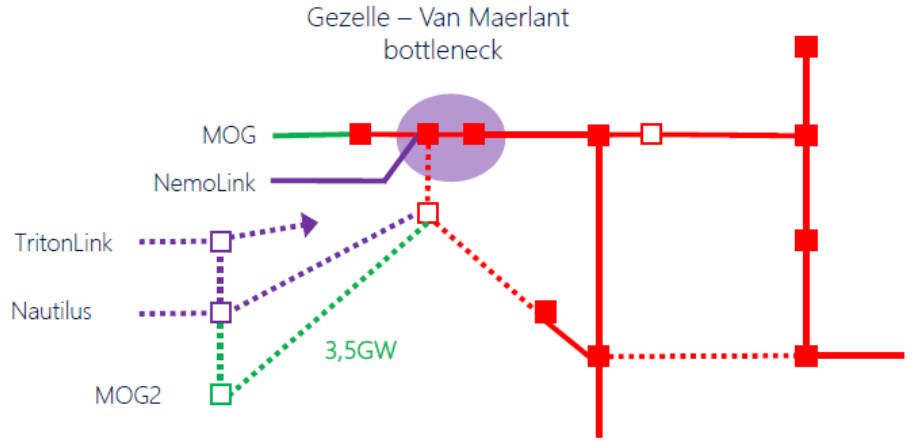


- 4 extra 220kV AC cables for MOG2: 3,5GW instead of 2,1GW
- Direct Nautilus to Gent-Antwerp-Brussels area
- No AC/DC convertor required on Ventilus might reduce local impact

BOP's option 4 : Extra 220kV AC for MOG2 & Faster elimination of GEZEL- MAERL bottleneck

– General comments
  - See idea 2, regarding MOG2 in full AC.
  - See idea 3, regarding GEZEL-MAERL

– Additional comments
  - No HVDC connection point is offered on the PE island for MOG2 (except a converter station is installed offshore, on top of the 10 AC export cables). The connexion with Nautilus and TritonLink is thus impossible or very costly.



- Elimination of the bottleneck on Stevin now planned for ~2035
- Accelerate this project and plan commissioning by 2030
  - Creates sufficient access capacity for both Nautilus and 3,5GW offshore wind on Stevin+Ventilus corridors
- 4 extra 220kV AC cables for MOG2: 3,5GW instead of 2,1GW

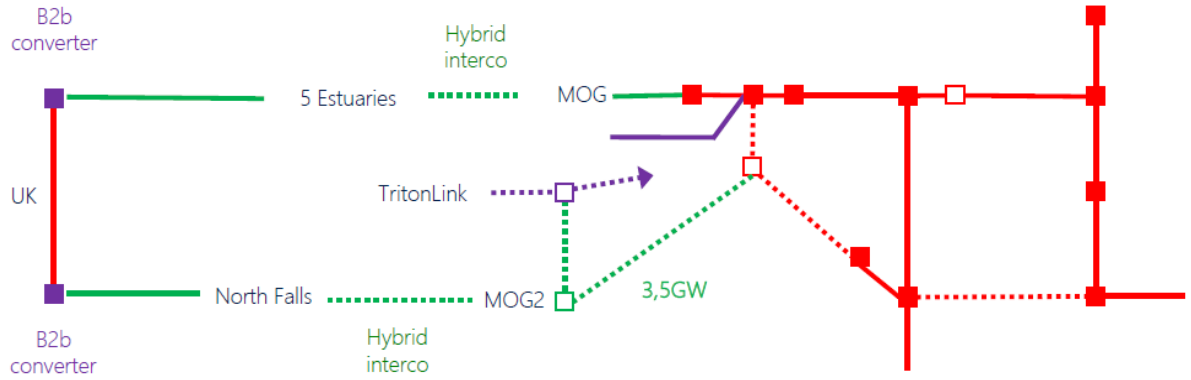
BOP's option 5: Replace Nautilus with different hybrid interconnector(s)

– General comments

- See idea 2, regarding MOG2 in full AC.

– Additional comments

- AC export cables of MOG1 and MOG2 are not dimensioned for a hybrid use (wind-infeed + interconnector).
- Reserve connection points on OSY are much more efficiently used to support the repowering of the first OWP. .
- To make it work efficiently from a market perspective, this would require the creation of 1 OBZ on MOG1 and 1 OBZ on MOG2.
- Significant CAPEX and OPEX increase on GB side (2*B2B converters).
- Big mismatch between 5 Estuaries and North Falls planned OWF capacity (=~750 MW) and Nautilus planned capacity (=1400 MW).
- No HVDC connection point is offered on the PEI (except a converter station is installed offshore, on top of the 10 AC export cables). The connexion with TritonLink is thus impossible or very costly.
- Significant increase in project complexity (various stakeholders involved and related coordination & interaction issues, power flow control, compatibility with the OFTO model,…)



- Connect the most Northern OWF in BE with the most Southern OWF in UK
- These distances of new connections are much smaller, and they will create a hybrid interconnector between UK & BE, allowing for import/export in case of low winds
- With a more limited investment (short cable + back-to-back converter), an interconnection could be made that will truly increase cable utilisation

Thank you.