MOG2 TF
First stakeholder workshop

April 1, 2022 – 9AM-11AM

elia
| Elia Group

Agenda

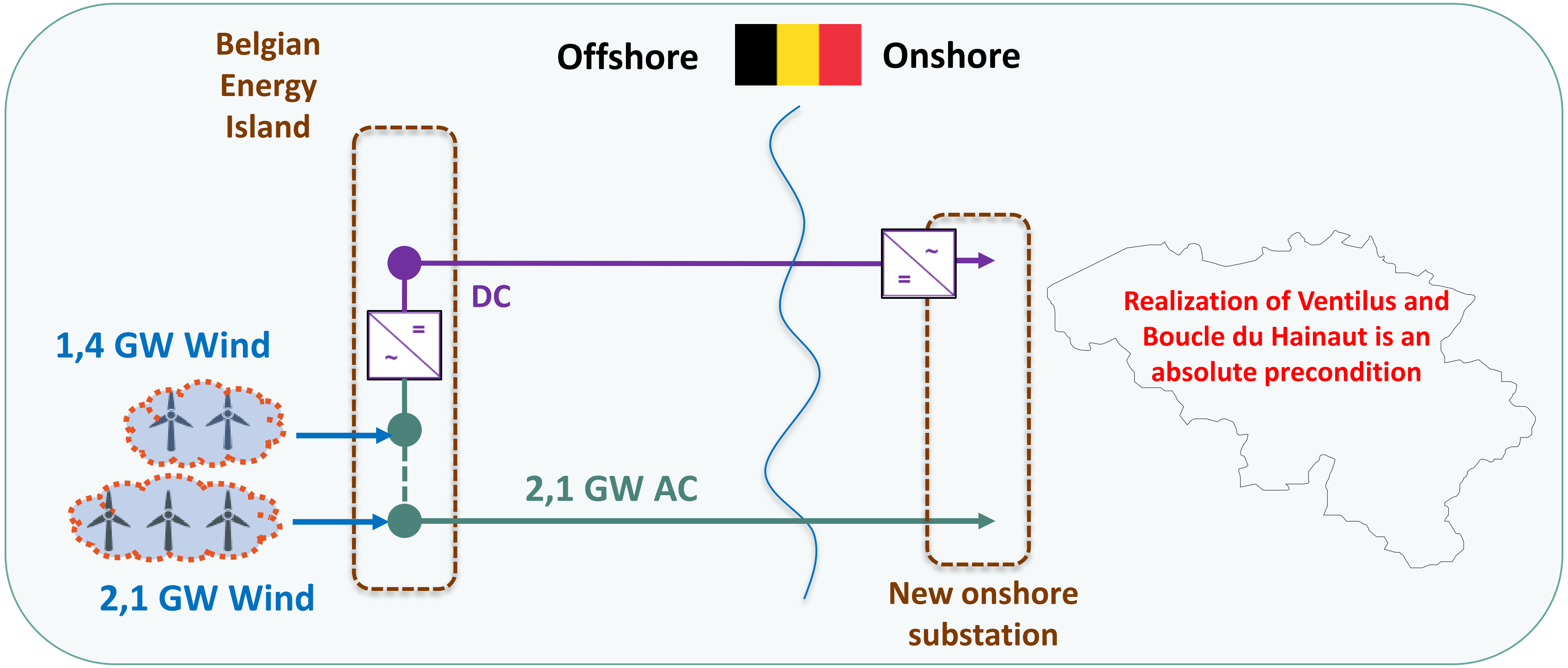
1. Introduction – 15 min
2. Balancing integration – 1h
3. Market integration – 45 min

Introduction

Benjamin Genêt

Slide from Belgian Energy Island – Stakeholder conference on 28 January

Princess Elisabeth zone
Modular offshore Grid 2



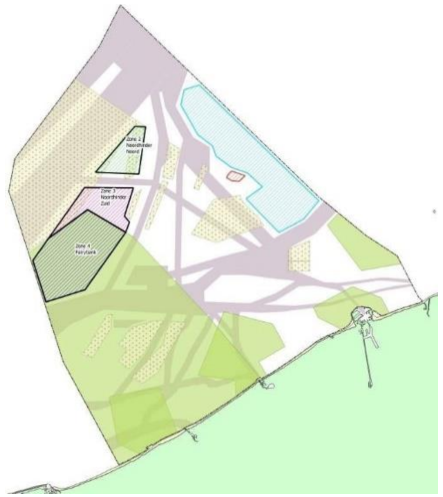
As previously communicated and agreed with stakeholders, Elia will resume its offshore system integration study taking into account the additional capacity of the Princess Elisabeth Zone. The scope of the study will also be enlarged to other market design consideration (e.g. delineation of bidding zones). Further communication will follow in Elia's Balancing Working Group.

Relevant documentation can be found via the following links:

► https://www.elia.be/en/public-consultation/20201001-public-consultation-on-integration-of-additional-offshore-capacity---mitigation-measures
► https://www.elia.be/-/media/project/elia/elia-site/users-group/ug/workshop/documents.zip
► https://www.elia.be/en/users-group/plenary-meetings/20211213-meeting

Task force MOG II

- The task force is resuming its work after having been put on hold
- Higher ambitions: from 4.4 GW offshore wind to 5.8 GW
- Broader scope
  - System and balancing integration
  - Market integration
  - Connection requirements (voltage management, protection philosophy…)
- First workshop today
  - Focus: planning, scope and approach of the balancing and market integration aspects
    - Assumptions regarding the new simulations for the offshore system integration study – feedback possible until April 22nd
    - Introduction to market design considerations (e.g. delineation of bidding zones for hybrid interconnectors)



How to balance the system with such level of offshore capacity?

How to most efficiently integrate the offshore capacity into the market?

What are the grid connection requirements?

Balancing integration

Kristof De Vos

Context

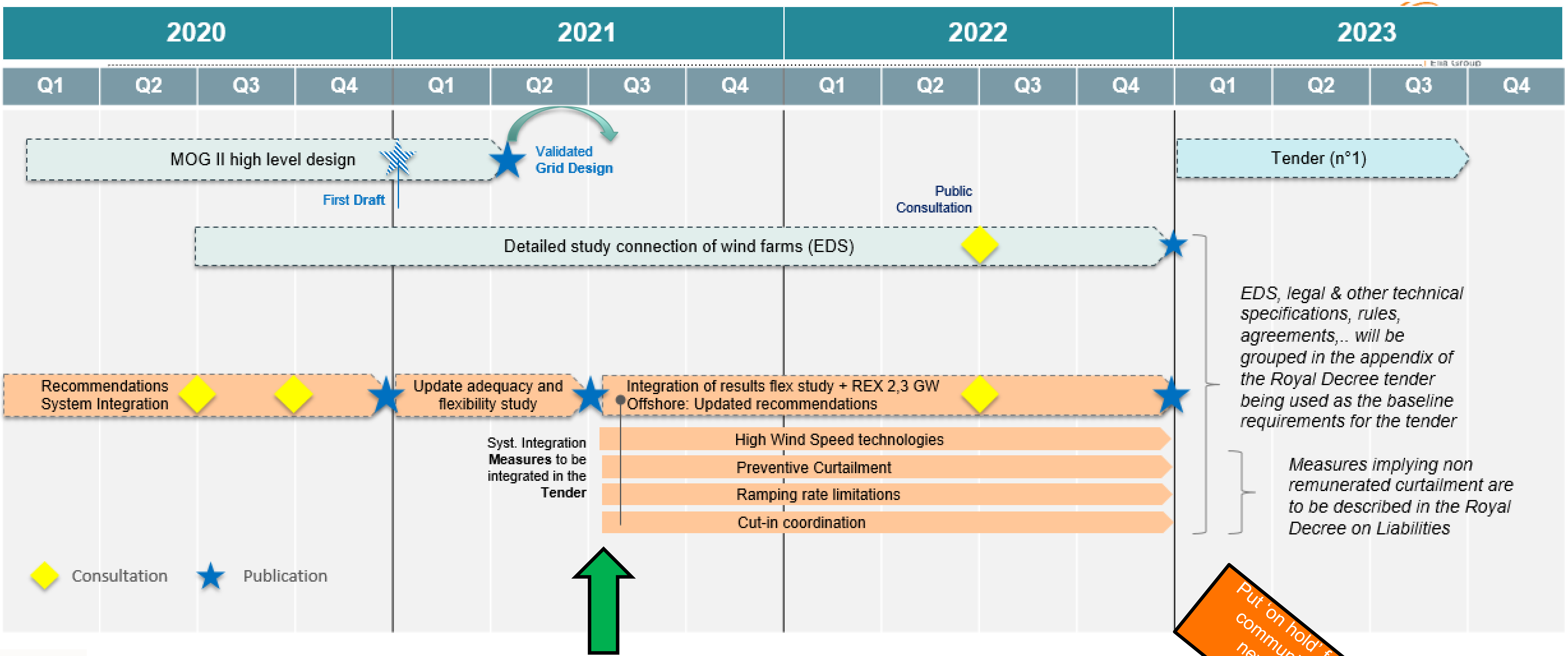
- **In 2019, Elia initiated its MOG 2 system integration study which formulated recommendations for the system integration of offshore capacity up to 4.4 GW.**
  - **These recommendations included operational and technical constraints for the wind parks or concerned BRPs which need to be specified before the offshore tendering process.**
    - June 2020 - Public consultation on assumptions, methodology and preliminary list of measures
    - October 2020 - Public consultation on the mitigation measures
    - December 2020 - Final report

Public consultation page (link)

- **In 2021, Elia initiated an update of the study on request of the stakeholders. The objective was to confirm proposed mitigation measures and parameters towards the Tender. The scope, objectives and planning were validated with stakeholders on 28.06.2021.**
  - **The update was put on hold following new offshore developments communicated by the Minister**

- **In 2022, Elia re-launces the update including, for the balancing integration aspects:**
  - **Impact of increasing capacity from 4.4 GW to 5.8 GW on real-time balancing, reserve needs and proposed mitigations measures**
  - **Investigate impact of the offshore grid topology (e.g. dimensioning incident) and an OBZ (e.g. Elia's LFC structure / imbalance price area)**

General planning presented on 28.06.2021



- The planning of this study is retro-actively made to deliver our recommendations to the tender by 1.1.2023
- If due to new evolutions, the timing of this study is impacted, this will be discussed with the stakeholders

Put 'on hold' following communication of new offshore developments

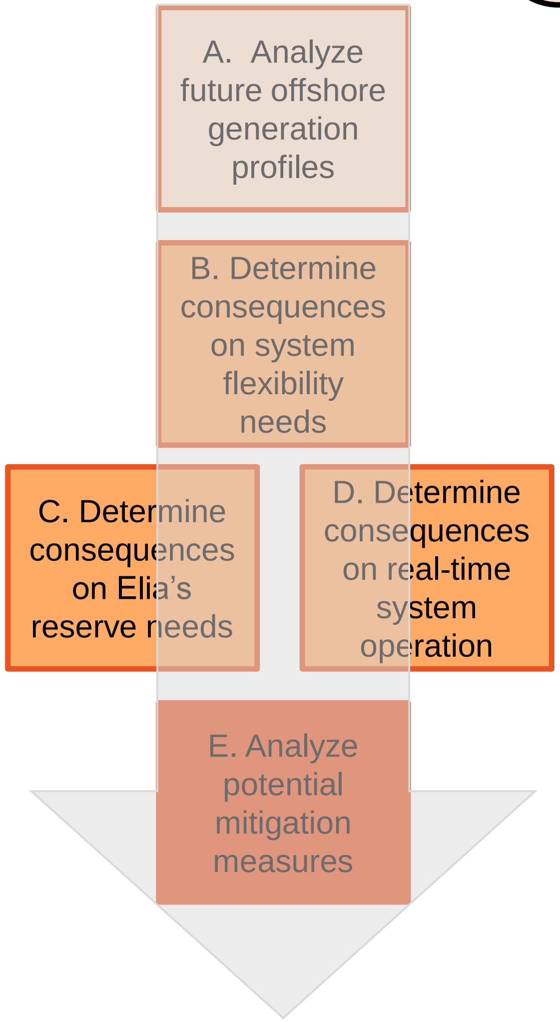
Objective and agenda

- Present an update of the planning, scope and proposed approach
- Gather inputs from the stakeholders to update data and assumptions

1. Briefly recapitulate the method, data and conclusions / recommendations
2. Discuss proposed scope, approach and planning for the update
3. Call for input

1. Summary of the original study

Methodology overview



A

- Task conducted by DTU
- Simulation of future offshore generation profiles and prediction errors
  - During normal conditions
  - During extreme wind power conditions (storms and ramps)
- Statistical analysis of the results
- Additional analysis on BRP portfolio imbalances following offshore

B

- Update of the flexibility needs study 2019 with DTU's wind power profiles
- Taking into account high resolution variations and correlations with other renewable capacity
- Analyze effect of offshore wind on the system's flexibility needs

C

- Develop reserve needs projections based on extrapolation of LFC block imbalances
- Taking into account the effect of market performance scenarios
- Analyze the effect of offshore on the system's reserve needs

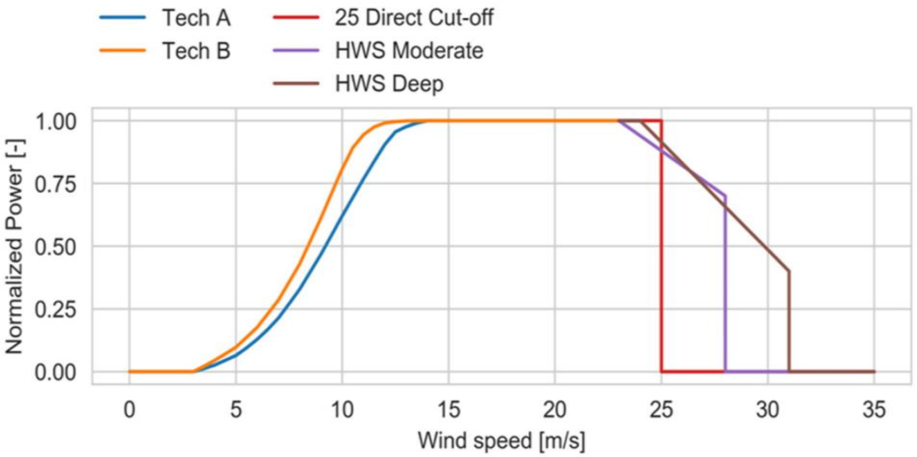
D

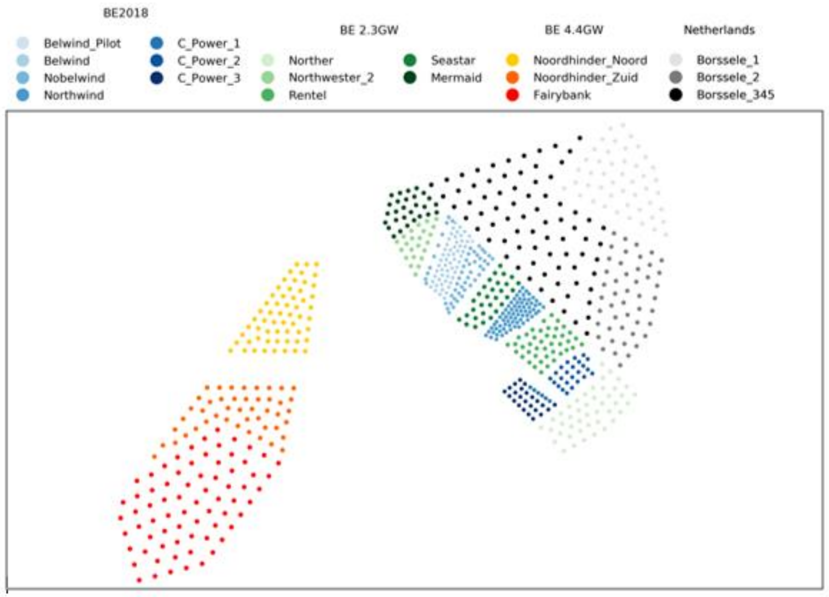
- System simulations of FRCE during extreme wind power conditions
- Taking into account reactive balancing and reserve activations

E

- Propose a list of potential mitigation measures
- Recommendations based on qualitative and quantitative analysis

A. Analyze wind power profiles





Denmark Technical University (DTU) has provided the offshore generation profiles that have been used as input for the required analyses

Scenarios

Technology / Topology assumptions

2.3 GW

3.0 GW

4.0-4.4 GW

Data

Simulated time series representing 2018-19 system conditions :

- 5 ‘real-time wind power [MW];
- 15’ day-ahead / intra-day forecasted wind power [MW];

Dataset with historic and simulated extreme events in the future (storm and ramping events) :

- 1 ‘real-time wind power [MW];
- 15’ day-ahead / intra-day forecasted wind power [MW];

B. / C. Flexibility and reserves

Update of the flexibility needs calculations

- Update of offshore generation and prediction profiles better capturing :
  - Geographical smoothing effects
  - Fast wind power variations (5 min)

The system's flexibility needs remain relatively close to the results of the adequacy and flexibility study 2019 despite the increase in accuracy by using the high resolution data provided by DTU (intra-qh variations and geographical smoothing)

Market performance scenarios

- Model LFC block imbalances towards 2028
- Based on upscaled forced outages & prediction risks
- Assumptions on market parties' ability to balance their portfolio

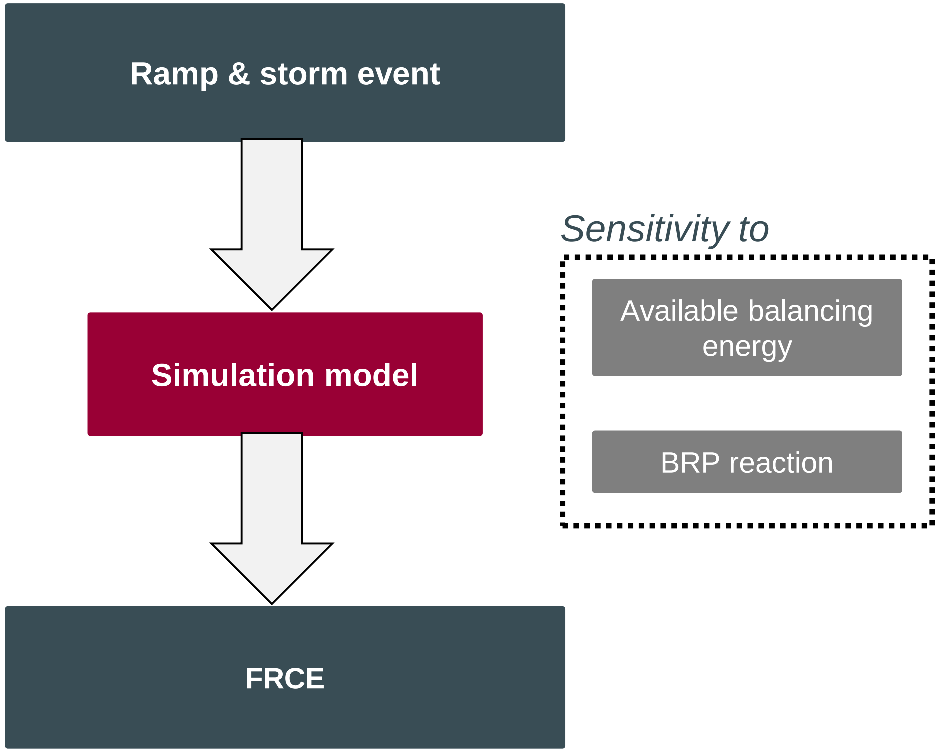
Reserve capacity projections

- Simulation of dynamic FRR needs methodology
- Analysis of probabilistic result & dimensioning incident
- Allocation to aFRR and mFRR needs

Elia's reserve capacity requirements are expected to face increasing FRR reserve needs following the integration of additional offshore wind power capacity, as well as the increasing capacity of other renewables

- It is found that the market performance (i.e. the ability of BRPs to balance their portfolio) can substantially impact the future FRR needs
- A dynamic dimensioning methodology will help managing the impact of these increasing needs, taking into account the observed market performance

D. Real-time system operation



- ✓ Evaluation aimed to identify **possible impact in terms of balancing** considering validation criteria and overall system behavior;
- ✓ Observed violations are **sensitive towards the considered assumptions**, specifically for BRP coverage;
- ✓ Certain violations **persisted** during extreme events even considering **optimistic scenarios**.

Effective mitigation measures can be found by :

- ➢ increasing the availability of **flexibility** (in Belgium or abroad) and/or
- ➢ increasing the **reaction speed** for the activation of said flexibility (by BRPs and/or Elia) and/or
- ➢ **reducing the origin** of the deviations at the source

E. Mitigation measures

RECAP MITIGATION MEASURES DISCUSSED IN THE REPORT		Up ramps	Down ramps	Storm cut-out	Storm cut-in	Reserve needs
Existing mechanisms	Current storm procedure			X		
	Alpha	X	X	X	X	X
	Coordination of cut-in phase				X	
Actions to be investigated by Elia	Incentivize reactions to real-time prices	X	X	X	X	X
	mFRR activation triggers	X	X	X	X	
	Enhanced forecast functionalities	X	X	X	X	X
Measures implying constraints for wind parks and / or concerned BRPs	**High wind speed technologies**			X		
	Preventive curtailment of wind parks			X		
	Ramping rate limitation	X	(X)	(X)	X	
	Coverage of imbalances by BRPs	X	X	X	X	X

(X): apply only in cases of voluntary production decrease before a storm event

Proposed scope, approach and planning for the update

Scope of the update of the system integration study

Projections of offshore generation profiles

DTU

- ***Scope on :***

Update simulation of future offshore generation profiles and corresponding prediction errors

  - *During normal conditions*
  - *During extreme wind power conditions (storms and ramps)*

- ***Focus on :***

I. *Increase installed capacity projections up to 5.8 GW*

II. *Update of the technology assumptions if relevant*

Impact assessment of exceptional conditions and need for mitigation measures

- ***Scope on :***

Update of real-time system simulations

Confirm or amend proposed mitigation measures impacting the Tender.

  - *High wind speed tech.*
  - *Preventive curtailment*
  - *Ramp rate limitations*
  - *Cut-in coordination*

- ***Focus on :***

I. *Investigate how the expected impact on the system impacted by increasing the capacity to 5.8 GW*

II. *Investigate if the proposed mitigation measures still adequate in a 5.8 GW offshore context*

III. *Investigate impact of evolutions such as offshore bidding zones or consumer centricity*

Impact on flexibility and reserve needs

- ***Scope on :***

Update on Elia's expectations on future reserve needs and procurements

Less relevant for the tender but large impact on real-time system operation and costs

Flexibility study is proposed to be kept outside the scope as the 5.8 GW was covered by high RES scenario.

- ***Focus on :***

I. *Analyze the effect of 5.8 GW offshore on the system's reserve needs*

II. *Analyze pre-conditions of the market to manage reserve needs and costs (consumer centricity)*

LFC block configuration

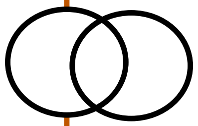
- ***Scope on :***

Assess the impact of an offshore bidding zone configuration on reserves, system operation and proposed mitigation measures

- ***Focus on :***

I. *Analyze the impact on LFC block structure and balancing market ?*

II. *Analyze the impact on reserve dimensioning, real-time system operations and recommended mitigations measures*



Market integration

Corrwind - Methodology for making projections of offshore generation profiles

A. Analyze future offshore generation profiles

B. Determine impact on system flexibility needs

C. Determine impact on Elia's reserve needs

D. Determine impact on real-time system operation

E. Analyze potential mitigation measures

Simulated time series and profiles of offshore wind power generation and predictions are a key requirement for all system integration analyses

Denmark Technical University (DTU) will update its validation of the offshore wind power model on the full existing Belgian offshore fleet

Scenarios

Technology / Topology assumptions

- 3.0 GW
- 4.4 GW
- 5.8 GW

Data

Simulated time series representing 2018-19 system conditions :

- 5 'real-time wind power [MW];
- 15' day-ahead / intra-day forecasted wind power [MW];

Dataset with historic and simulated extreme events in the future (storm and ramping events) :

- 1 'real-time wind power [MW];
- 15' day-ahead / intra-day forecasted wind power [MW];

Assumptions for making projections of offshore generation profiles

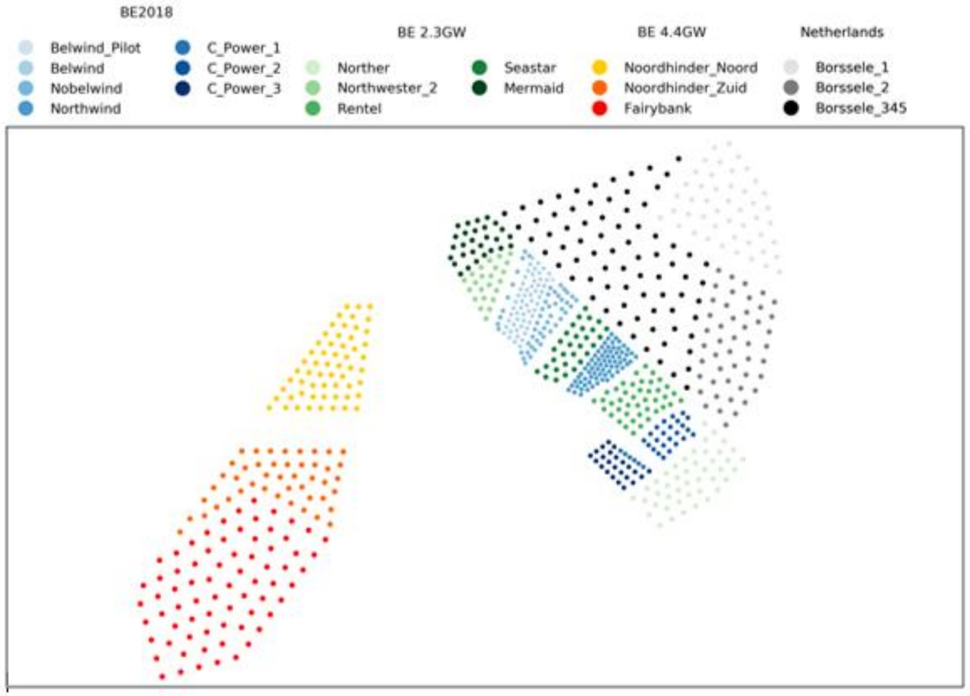
1. Installed capacity

Installed capacity

3.0 GW	By 2028
4.4 GW	By 2029
5.8 GW	By 2030

- *Based on latest communications of the Federal Government (link)*
- *Targets an installed capacity of minimum 3,15 GW en maximum 3,5 GW in de Prinses Elisabeth-zone […]*
- *In order to specify robust technical criteria, the study focuses on the maximum targeted capacity*

2. Topology



- *In the first study, Elia assumed a fixed volume per zone as in the previous study*
- *Elia will in this study assume a fixed density on the foreseen geographical are (Princess Elisabeth zone)**
- *An open question remains how to model the construction phases (no information yet available)*

** Elia will use latest information available before the launch of the simulations*

Assumptions for making projections of offshore generation profiles

3.A Technology - ratedpower

Study 2020

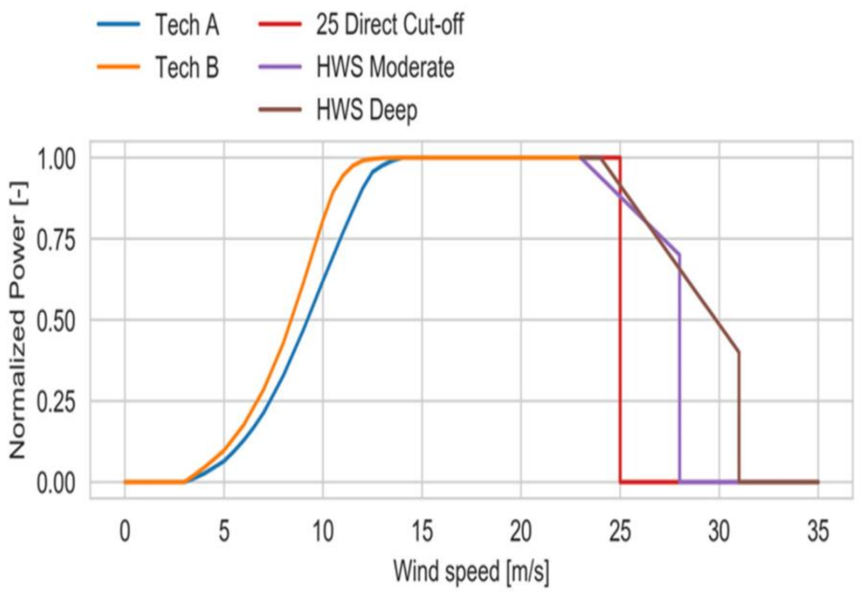
Technology scenario	A	B
Rated power	12 MW	12 MW
Rotor diameter	184 m	220 m
Hub height	118 m	150 m
Specific power	450 W/m^2	316 W/m^2

Study 2022

	Before 2030		As from 2030	
Technology scenario	A	B	A	B
Rated power	15 MW	15 MW	20 MW	20 MW
Rotor diameter	206 m	246 m	238 m	284 m
Hub height	132 m	168 m	150 m	175 m
Specific power	450 W/m2	316 W/m2	450 W/m2	316 W/m2

Turbines of 14 – 16 MW are commercially available for installation in 2023-25 (e.g. Vestas 236)
Turbines of 20 MW are expected to be available in 2030 (Danish Technology Data Catalogus)

3.B Technology – power curve

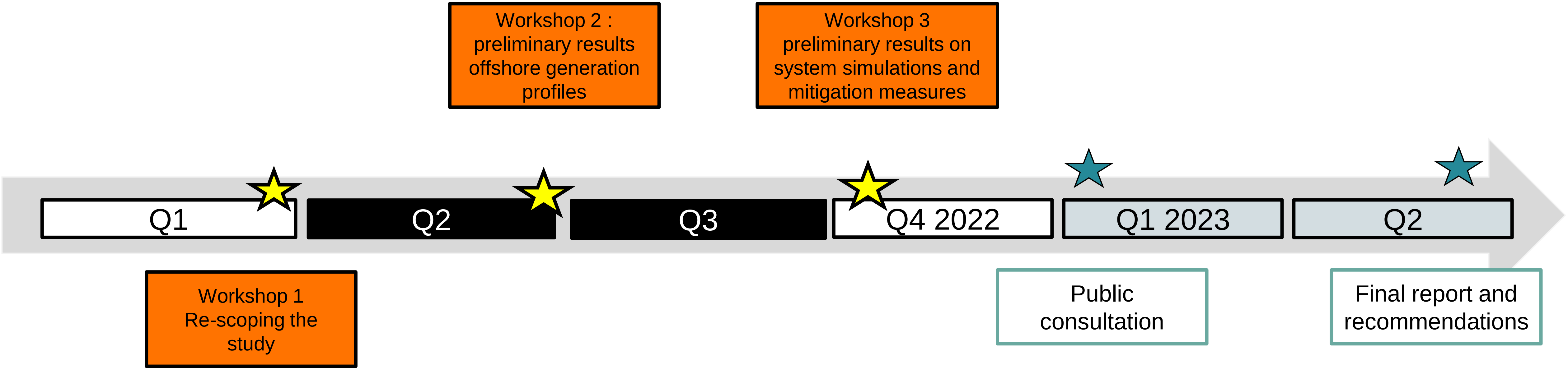


- *Similar to the first study, new generation turbines are expected to fit with Tech A or Tech B (next generation) assumptions*
  - *Newest turbines in the existing fleet confirm a good fit with the Tech A scenario*
- *Similar to the first study, assumptions on storm cut-off is covered with three scenarios (25 direct cut-out, HWS Mod, HWS Deep)*
  - *Note that Elia recommended the HWS Deep as technical requirement*
  - *The newest turbines in the existing fleet confirm a fit with the HWS Deep*
  - *No information is currently available on new storm control capabilities*

Although the turbine size is adapted (impacting the absolute generation and prediction profiles), the per unit power curves are maintained in comparison with the first study.

FGOV – "De publicatie van de eerste oproep tot mededinging is voorzien in het vierde kwartaal van 2023"

The original planning of the update is shifted with six months in order to deliver the final report and recommendations before the launch of the tender



- The planning of this study is retro-actively made to deliver our recommendations to the tender by 1.7.2023
- If due to new evolutions, the timing of this study is impacted, this will be discussed with the stakeholders
- Alignment with other streams will be sought to the extent possible, both for the workshops and for the consultation

Call for feedback

- DTU Denmark will conduct simulations between April and June
- Consequently, any relevant input from stakeholders which might improve the accuracy of calculations needs to be received before the end of April 22, the latest (cf. mail invitation)
- Note that Elia has signed a non-disclosure agreement with DTU and Elia / DTU guarantee the confidentiality of technical data subject to confidentiality.

Thank you for your attention. Please contact Kristof.DeVos@Elia.be for further questions and discussion

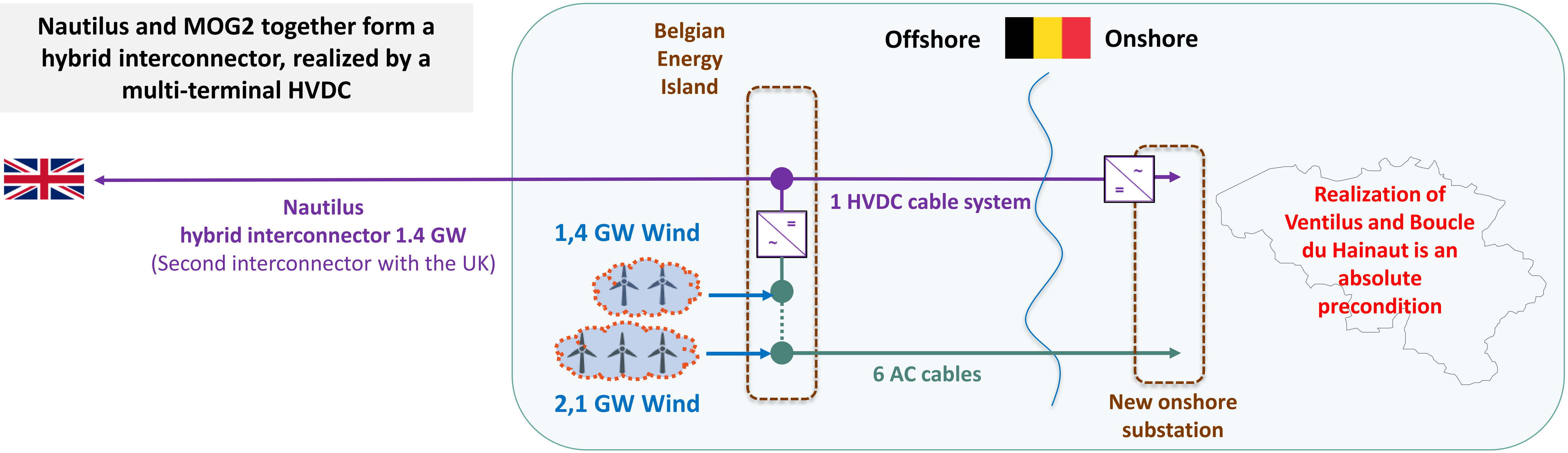
Market integration

Steve Van Campenhout

Today’s objective: setting the scene

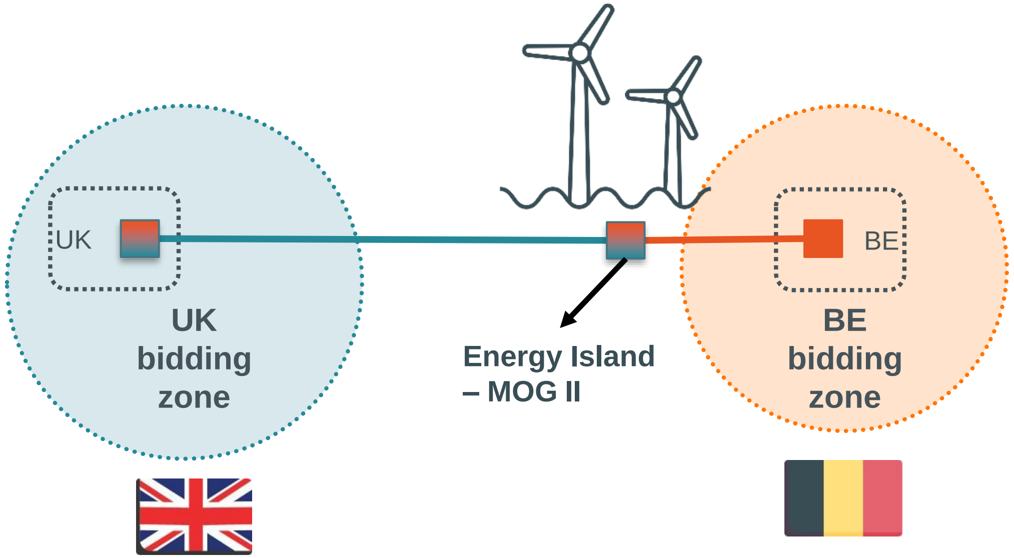
Enabling a hybrid interconnector is part of MOG II scope

Nautilus and MOG2 together form a hybrid interconnector, realized by a multi-terminal HVDC



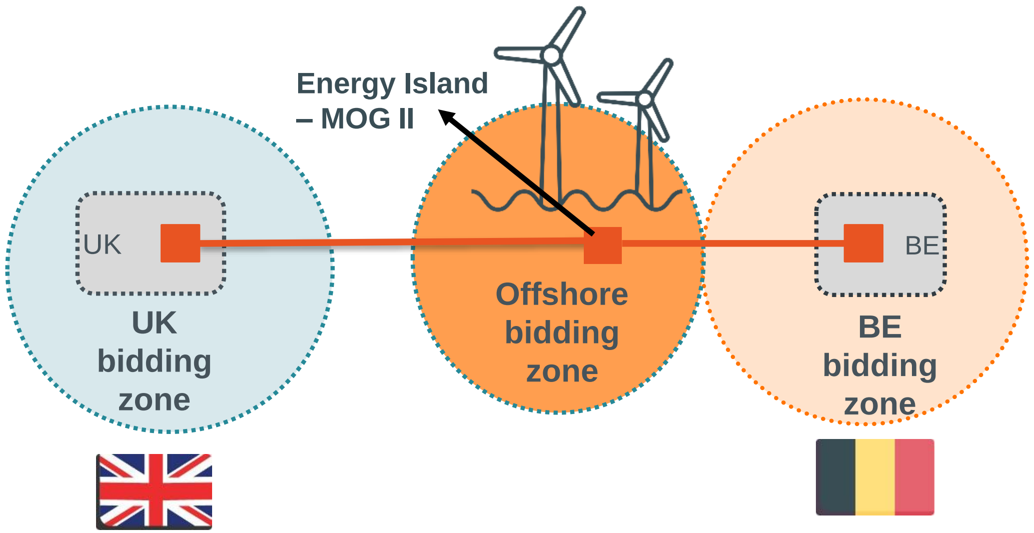
Two options to integrate Hybrids into the electricity market

Home Market



- The **Home Market** model replicates the conventional arrangement as much as possible.
- In this conventional arrangement the offshore RES generation commercially and physically feeds into its home market, i.e. into the grid of the same country in whose territorial waters or Exclusive Economic Zone (EEZ) the park is located.

Offshore Bidding Zone

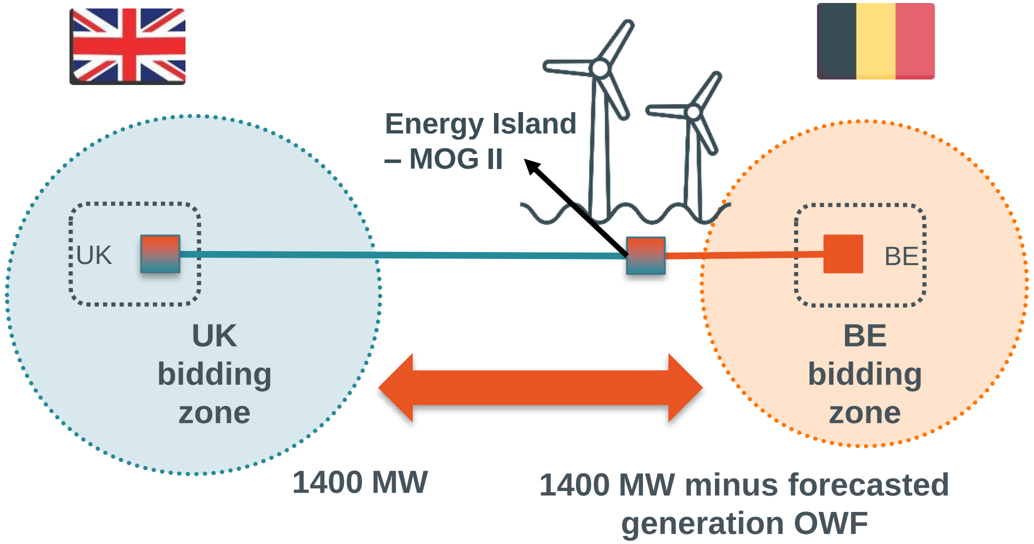


- In the **Offshore Bidding Zone** model the offshore RES generation is situated in a separate bidding zone, being physically connected to several markets.
- This ensures that RES generation can flow to where it is needed, and can be fully integrated into the market by simultaneously integrating renewable energy and using cross-border interconnections for trade.

‘Pure’ Interconnector
Multi-Purpose asset
HVDC converter
Bidding zones

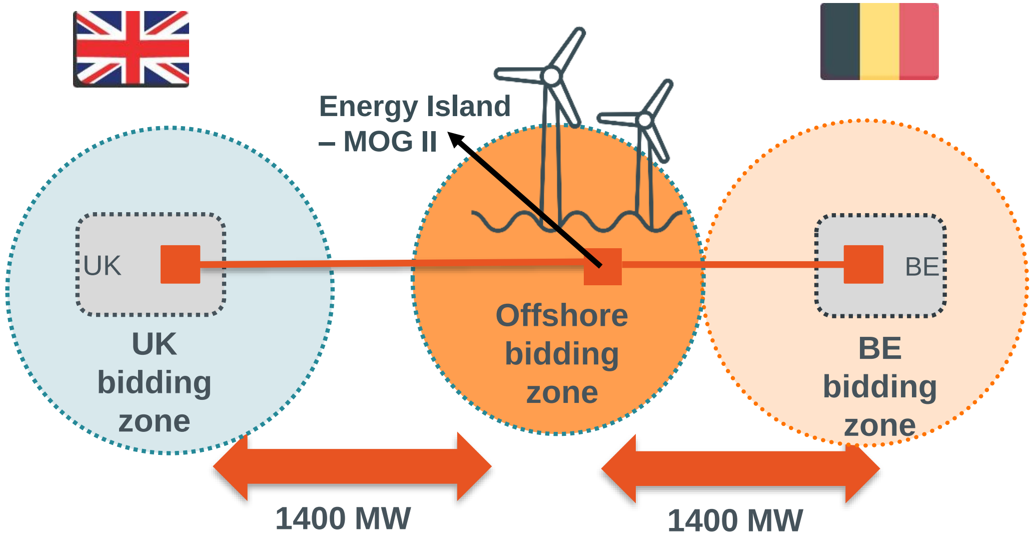
The available capacity for cross-zonal market exchanges differs between the 2 approaches

Home Market



- Nautilus will be considered as 1 interconnector between the UK & BE bidding zones
- The capacity in the direction of UK is equal to physical capacity of the DC link, which is 1400 MW in this example
- **The capacity in the direction of Belgium changes every hour and is equal to physical capacity of the DC link minus the forecasted wind generation**

Offshore Bidding Zone



- There are 2 new interconnections
  - One between the Energy island and UK
  - One between the Energy island and BE
- **Capacity of both interconnectors is always 1400 MW in all directions**

‘Pure’ Interconnector Multi-Purpose asset HVDC converter Bidding zones

When looking for an efficient solution, we have to be mindful about the crucial role of costly remedial actions

Regulatory framework

Clean Enery Package Art 16(8): minimum 70% of grid capacity is to be made availbale for cross-zonal exchanges

Core day-ahead and intraday capacity calculation methodology: internal grid is not allowed to limit the market

TSOs are required to apply redispatch/countertrading

System operation

There will be moments where offshore wind uses > 30% of the capacity

Forecasting errors do occur

Offshore Bidding Zones lead to the most effective market integration of a hybrid interconnector

	Home Market	Offshore Bidding Zones
Optimal market outcome	Not guaranteed, for example due to forecast errors or in situations with negative prices	Guaranteed optimal dispatch
CEP 70% compliance	Significant volumes of RDCT needed	CEP 70% compliant ➔ less need for TSO intervention through RDCT
Capacity allocation	Additional commercial agreements needed to define how capacity is shared and possibly remunerated	No additional agreements needed. Integration in the market via the existing mechanisms

Preferred option

European Commission mentions an offshore bidding zone model to be more efficient overall, as it reduces the need for costly after-market corrective action by TSOs such as redispatching and countertrading and it keeps costs down for consumers.

Different other analysis have put forward the advantages of offshore bidding zones


European Commission

Offshore Renewable Energy Strategy

19 November 2020
#EUGreenDeal

The EU is raising its climate targets for 2030 and is committed to becoming climate-neutral by 2050.

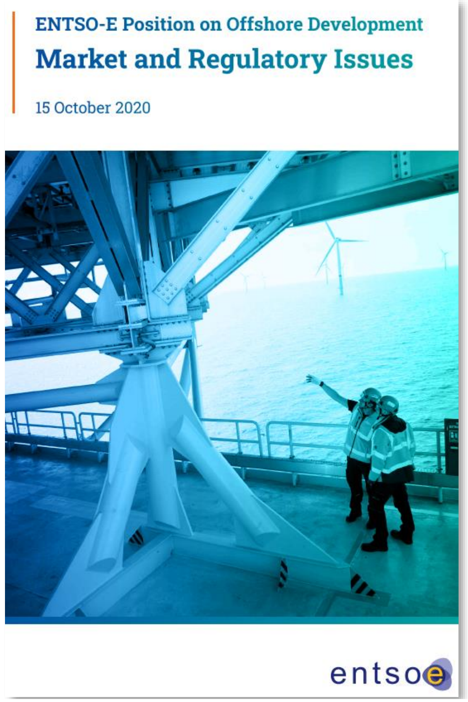
Renewable energy will play an important role in reaching this higher ambition – including the **generation of more energy at sea and from the sea**.

The EU is already **a world leader** in offshore renewable energy production and technologies. And there is potential for further development in a cost-effective way.

The European Commission's Offshore Renewable Energy Strategy will help to make this happen and **maintain the EU's leadership in this sector**.

This EU Strategy will:

- set **ambitious targets** for the growth of the offshore renewable energy sector
- encourage **public and private investment** in new infrastructure and research
- make it easier for different regions to **work together more efficiently**
- provide a **clear and stable legal framework**


ENTSO-E Position on Offshore Development

Market and Regulatory Issues

15 October 2020

entsoe


ENERGINET FINGRID Statnett

The ideal market design for offshore grids

- A Nordic TSO perspective

The Nordic TSOs are of the opinion that new offshore grids need to be built on the principles of offshore bidding zones which can be both connected to each other and to more than one onshore bidding zone. There is, in terms of market functioning, no difference between onshore and offshore bidding zones, in both cases congestions are efficiently handled by the bidding zones. Applying offshore bidding zones means that current electricity market regulations can be applied.

"Offshore bidding zone for a hybrid project can be done in a way that is compatible with the electricity market rules and can be a well suited option for a large scale-up of offshore renewables"

"the OBZ concept seems to be a promising concept for future offshore hybrid projects and meshed HVDC projects, when considering the efficiency of markets and system operations. However, the OBZ solution is expected to reduce revenues for offshore wind farms

"There is, in terms of market functioning, no difference between onshore and offshore bidding zones, in both cases congestions are efficiently handled by the bidding zones. Applying offshore bidding zones means that current electricity market regulations can be applied"

Challenge 1: remuneration for OWF

	Home Market	Offshore Bidding Zones
OWF revenue	Revenues are unchanged compared to a radial connection	Possibly reduced OWF revenues

- Offshore Bidding Zones (OBZ) offer more efficient signals for dispatch & investment than the alternative Home-Market (HM) model: markets reflect physics better, the solution is compatible with 70% and scalable for future offshore developments.

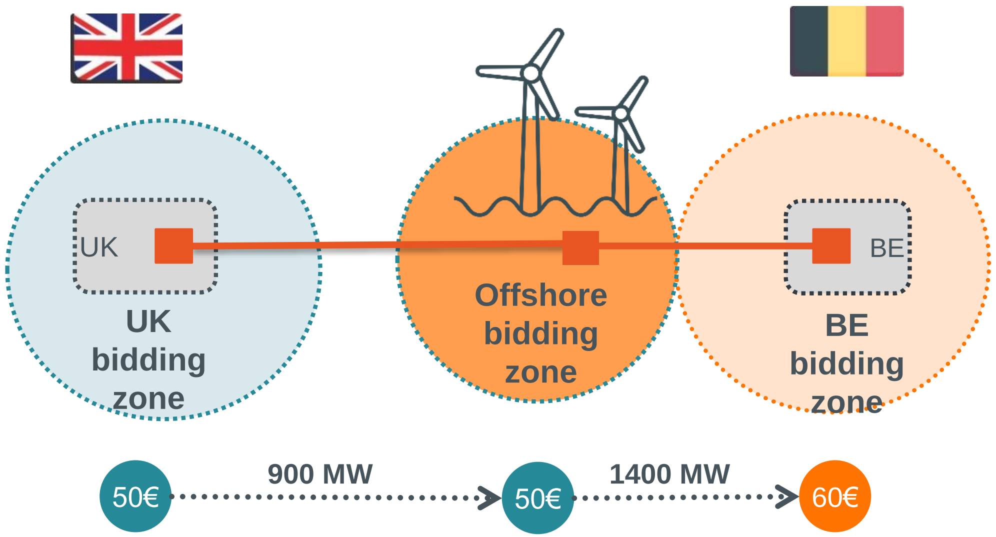
- However, lower and more volatile market revenues under OBZ may affect the willingness to invest in hybrid-connected offshore wind farms (OWFs).

Revenue = volume * energy price
There is both a price risk and a volume risk to consider

Challenge 1: illustration of price risk

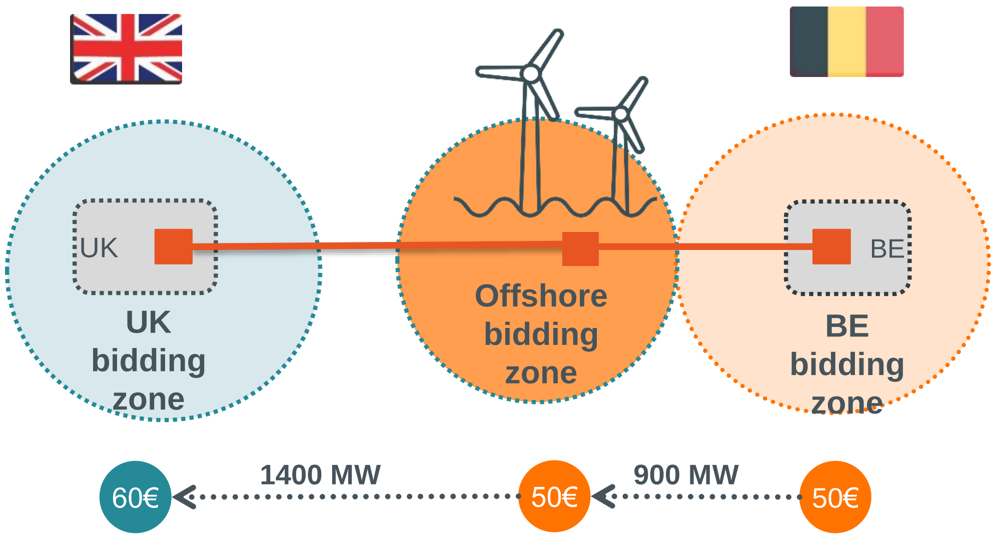
- In HM set-up the OWF always gets the DA reference price of the home market bidding zone
- In an OBZ setup, the OWF will obtain the DA reference price from the OBZ. As price coupling occurs between BZs that are not constrained, the OBZ will convert to the lowest DA price of the 2 onshore bidding zones.

Import UK > BE



OWF receives 50€/MWh under OBZ vs. 60 €/MWh under HM

Export BE > UK



OWF receives same 50€/MWh price under OBZ as under HM

Challenge 1: CfD as appropriate instrument to manage the price risk

Compensation through CfD: a state-funded support scheme awarded via competitive processes

- Makes up an efficient and transparent solution to offer compensation
- Is compatible with the rules of the IEM and EU State Aid guidelines

Revenue under 2-sided CfD = volume * (energy price + (strike price - energy price))

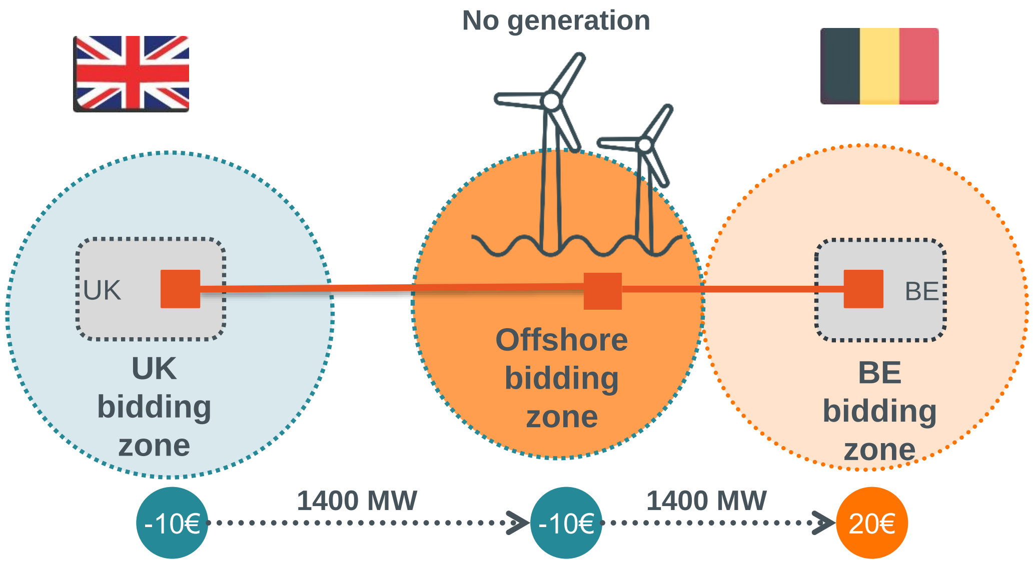
Example 2
- 700 MW during 1 hour
- DA reference price BE BZ: 100 €/MWh
- DA reference price BE OBZ: 80 €/MWh
- Strike price: 70 €/MWh
- Revenue w/o CfD: 700 MWh * 100 €/MWh = 70.000 €
- **Revenue with CfD under HM:** 700 MWh * (100 €/MWh – 30 €/MWh) **= 49.000 €**
- **Revenue with CfD under OBZ:** 700 MWh * (80 €/MWh – 10€/MWh) **= 49.000 €**

Example 1
- 700 MW during 1 hour
- DA reference price BE BZ: 60 €/MWh
- DA reference price BE OBZ: 50 €/MWh
- Strike price: 70 €/MWh
- Revenue w/o CfD: 700 MWh * 50 €/MWh = 35.000 €
- **Revenue with CfD under HM:** 700 MWh * (60 €/MWh + 10€/MWh) **= 49.000 €**
- **Revenue with CfD under OBZ:** 700 MWh * (50 €/MWh + 20€/MWh) **= 49.000 €**

Challenge 1: volume risk stems from negative prices

Competition for scarce interconnection capacity:

- Assume offshore wind bid at 0 €/MWh
- If negative prices occur in UK, then the interconnection capacity between the Belgian offshore bidding zone and the Belgian onshore bidding zone will first be allocated to bids with negative prices.



Our goal is to create visibility on the market integration and grid design scenarios, whilst acknowledging these are inherently subject to legal/political context.

This visibility should help the assessment of volume risk by parties bidding into the tender.

BE OWF will not generate in the offshore bidding zone

Challenge 2: how to solve imbalances and at which price?

Topic for a deeper dive in a future workshop

- How to solve imbalances in a bidding zone with only production?
    - Efficient balancing may require the system operator to be able to trigger balancing actions in all of the connected onshore zones
    - Coupled balancing markets should support this process

- Regulation determines that an imbalance price area cannot be larger than a BZ. So an OBZ will have its own imbalance price. Given the potential interactions with balancing actions in different zones, this raises the question of how to establish an efficient and robust imbalance price for the offshore bidding zone itself.