Task Force Princess Elisabeth Zone

19th of October 2023

Agenda

13:00-13:30 **Public consultation TF PEZ**

- Scope and planning

13:30-14:30 **Connection requirements**

- Cables
- Marine and Works Coordination
- Flexibility connection contract for lot 1 PEZ tender

14:30-15:30 **Balancing**

- Feedback on open points and final recommendations

15:30-16:00 **Break**

16:00-18:00 **Dynamic and Harmonic**

- Update forced oscillation
- Update voltage control study
- Conformity process

Task Force PEZ

Scope and timing public consultation

Elia will organize a public consultation from the 20th of November to 20th of January of topics addressed in the Task Force Princess Elisabeth Zone in preparation of the first tender OWF PEZ

Scope of the public consultation

A public consultation will be organized **from 20th of November until 20th of January** on topics presented in the framework of the Task Force PEZ:

- **Balancing design:** impact on balancing, recommended mitigation measures and Offshore Bidding Zone balancing market implications
- **Market design:** Offshore Bidding Zone market implication and process
- **Dynamic & harmonic:** Clarification of amendments foreseen for the technical specifications for PEZ related to D&H
- **Connection requirements:** summary of technical aspects presented during TF/workshops including questions received from BOP

Planning

Overview main topics foreseen in the public consultation report

Presented in TF PEZ
Not yet presented
Update to communicate

1 Connection requirements

1. Grid design
2. Phasing of works
3. Island concept
4. Cable routing and pull-in — NEW! Today
5. High voltage systems
6. Secondary systems
7. Marine and works coordination — NEW! Today
8. Operations & maintenance

2 Dynamic & Harmonic

1. Additional req. for voltage control — Today
2. Additional req. for stability and robustness
3. Additional req. for data & model exchange
5. Additional req. for forced oscillation — Today
6. Additional req. for conformity process — Today

3 Balancing

1. General assumptions
2. Offshore generation profiles
3. Impact on Elia's reserve requirements
4. Impact on Elia's system operations
5. Impact on Elia's exceptional measures — Today
6. Impact of an offshore bidding zone
7. Implementation roadmap — NEW! Today

4 Market

1. Rational behind PEZ and hybrid grid design
2. Target market design for PEZ
3. Implications of target market design
4. Implementation of the OBZ

Connection requirements

Part 1 – Cables

- Cable routing around island
- Cable Pull – in
- Cable routing on island

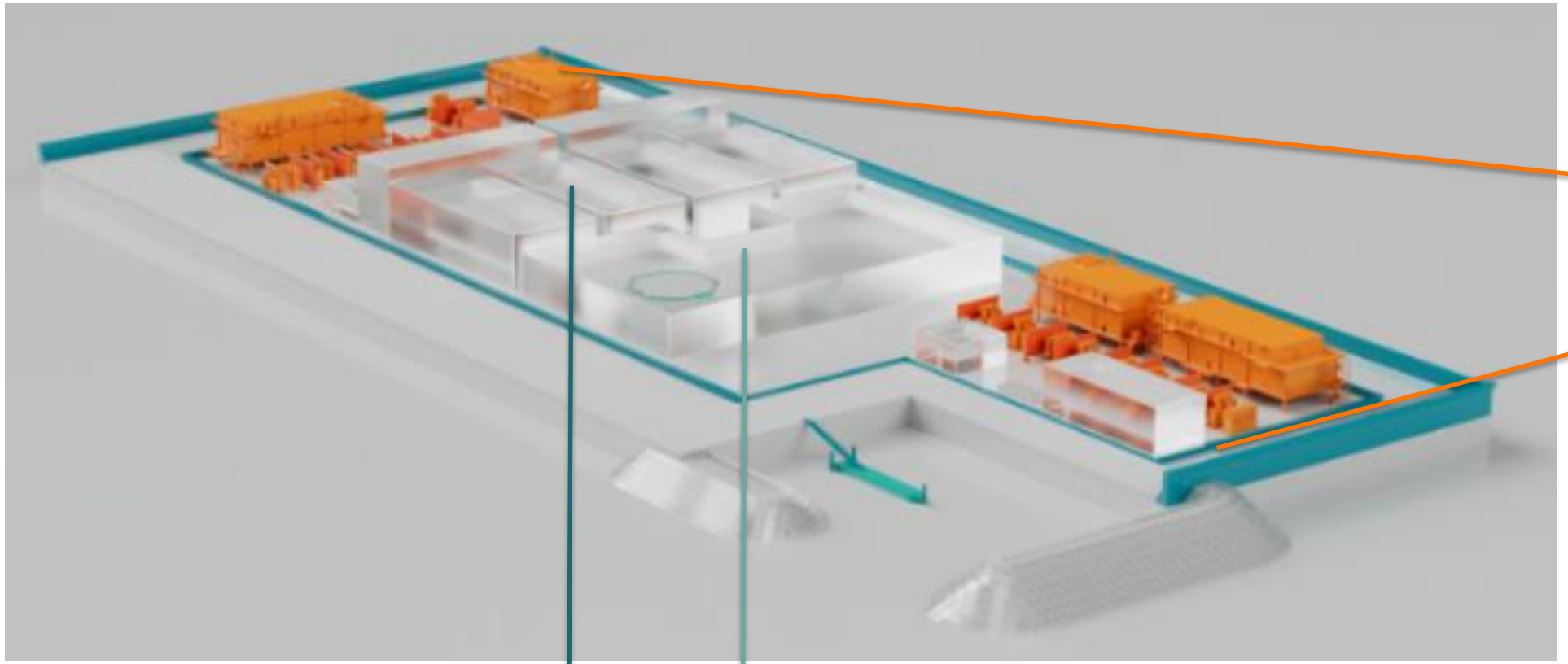
Part 2 – Marine and Works Coordination

- Update Timing Princess Elisabeth Island
- Marine and Works Coordination

Part 3 – Flexibility connection contract for lot 1 PEZ tender

Introduction

Potential layout for Princess Elisabeth Island Design



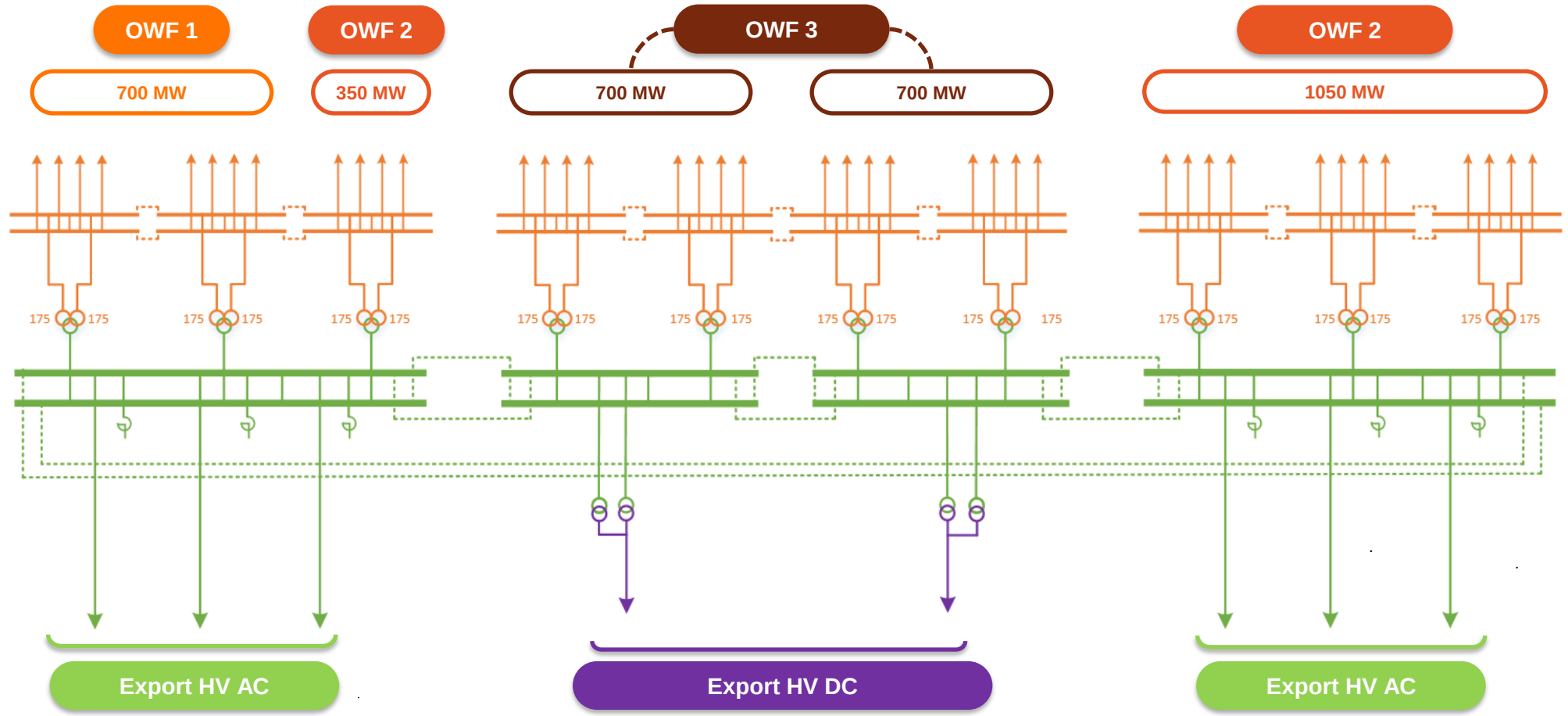
AC substations

DC substations

DC converter

Single Line Diagram - version 12/12/2022

350MW per 66kV building block / spare bays not shown on the SLD



Staged phase for the Princess Elisabeth Island

- The PEZ was divided into **3** parcels (Parcel 1, Parcel 2, Parcel 3).
- To be able to connect all parcels **Elia has divided the project in several phases** :

Phase 1

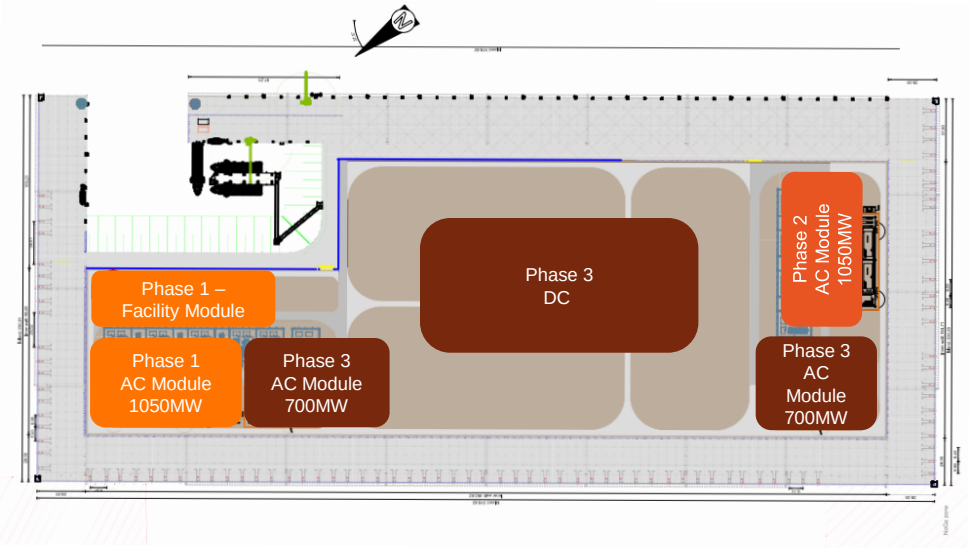
- Installation and commissioning of 1x Facility Module and 1x AC Substation 1050MW
- **Connection of Parcel 1: 700MW**

Phase 2

- Installation and commissioning of 1x AC Substation 1050MW
- **Connection of Parcel 2: 1225 – 1400MW**

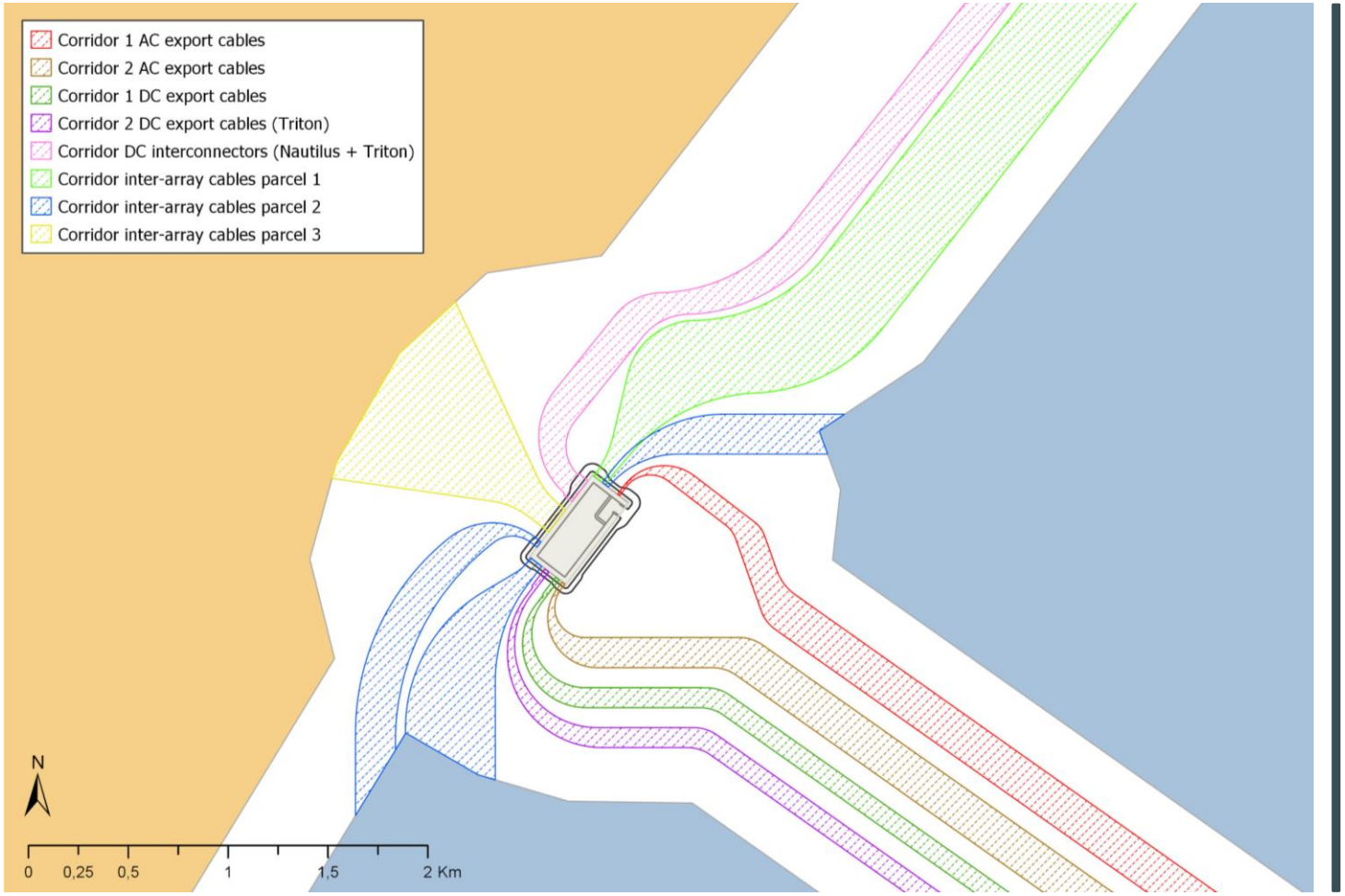
Phase 3

- Installation and commissioning of 2x AC Substation 700MW
- Installation and commissioning of onshore and offshore DC convertor
- **Connection of Parcel 3: 1225 – 1400MW**



Cables

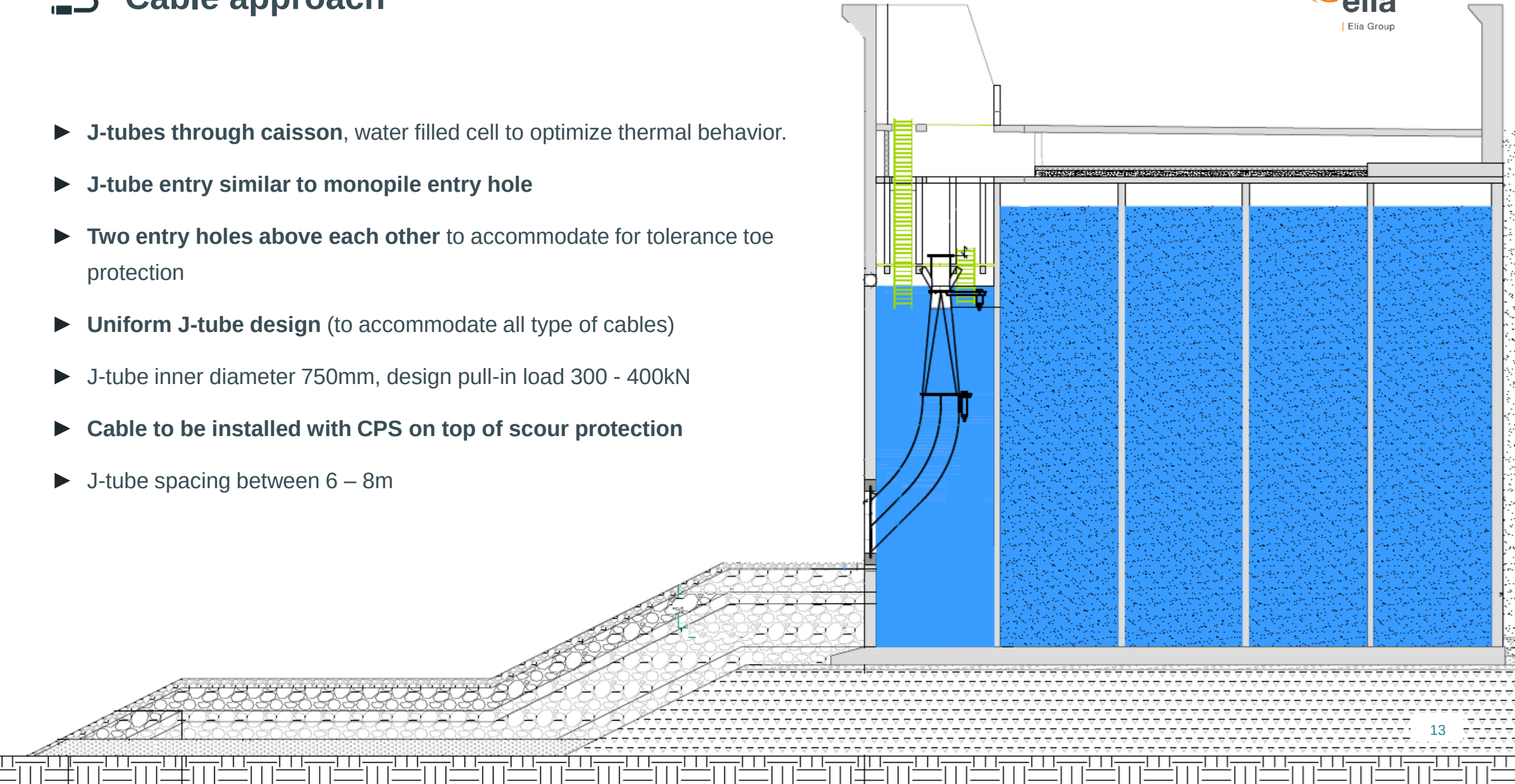
Cable Routing around Princess Elisabeth Island



- **Cables grouped in corridors**, per OWF concession and TSO
- **Separation between the different corridors**
- **No offshore crossings** within close proximity of the Energy Island
- **Offshore crossings cannot be avoided for future interconnectors**

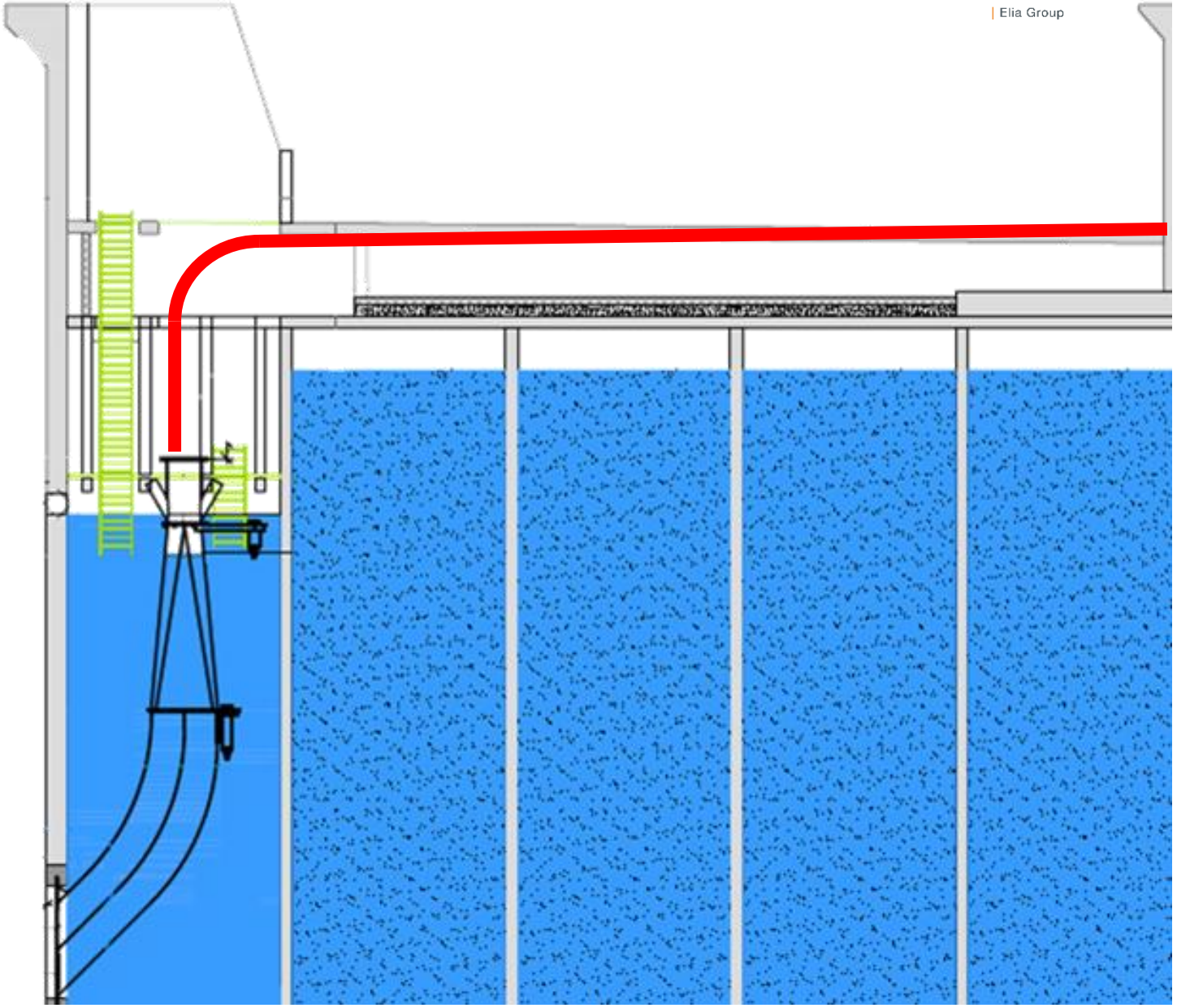
Cable approach

- **J-tubes through caisson**, water filled cell to optimize thermal behavior.
- **J-tube entry similar to monopile entry hole**
- **Two entry holes above each other** to accommodate for tolerance toe protection
- **Uniform J-tube design** (to accommodate all type of cables)
- J-tube inner diameter 750mm, design pull-in load 300 - 400kN
- **Cable to be installed with CPS on top of scour protection**
- J-tube spacing between 6 – 8m



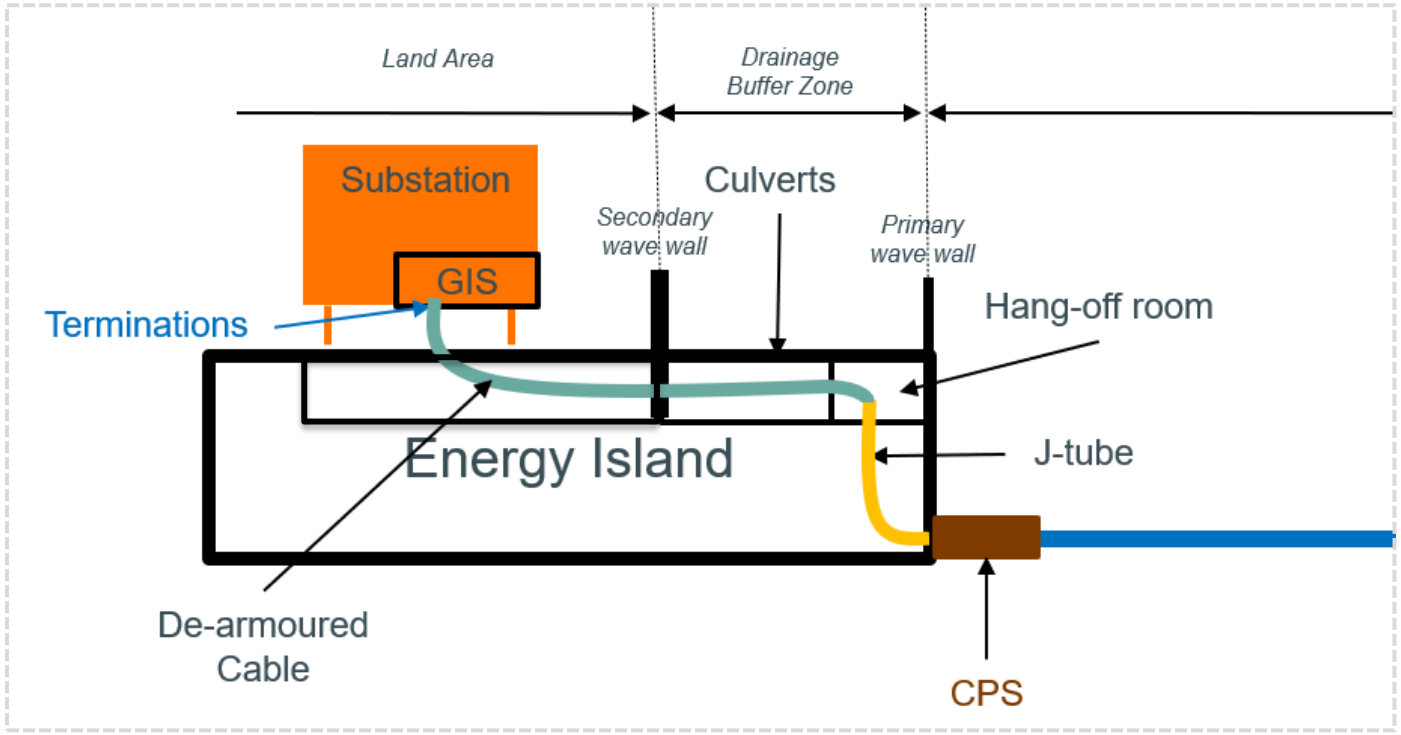
Cable pull-in concept

- **Hang-off room** will be **inside** the caisson
- Lid above hang-off to be opened, **pull-in system / structure to be placed above to accommodate pull-in**
- Cable to be routed in concrete culverts over the **caisson through secondary wave wall**.

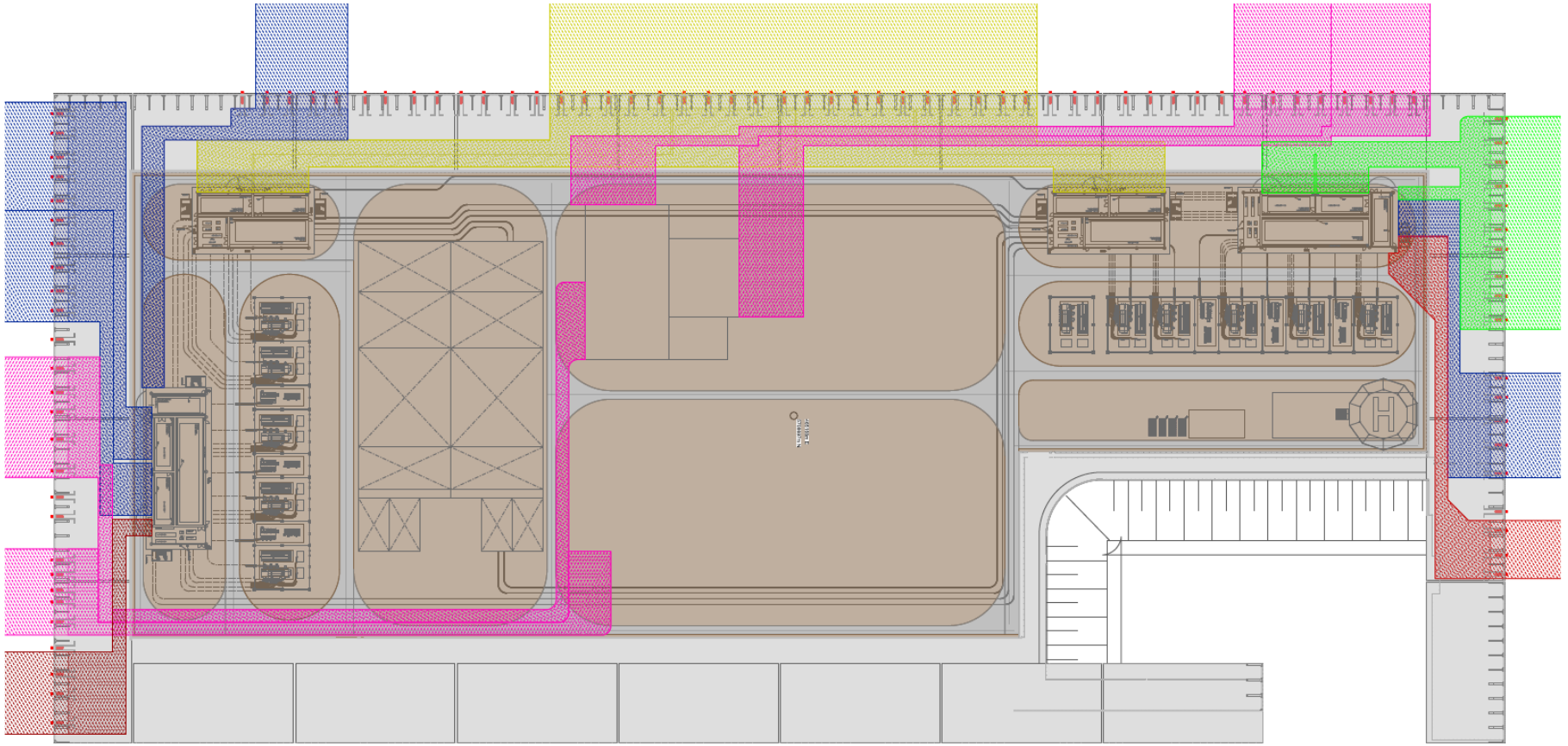


Routing on the Princess Elisabeth Island

- **Each OWF concession** will have their **designated corridor** to route their cables.
- **Cables routed through secondary wave** wall via **watertight cable transits**
- **Cables to be routed on the island, inside culverts**, from the secondary wave wall towards the GIS inside the dedicated AC substation
- **Culverts will have lids** that can be removed for easy access



Routing on the Princess Elisabeth Island



- Corridor 1 AC export cables
- Corridor 2 AC export cables
- Corridor inter-array cables parcel 2
- Corridor inter-array cables parcel 1
- Corridor DC cables
- Corridor inter-array cables parcel 3

Marine & works coordination

Why Marine and Island Coordination

To **coordinate personnel**, vessels, helicopters, equipment, marine operations and **island activities**.
Decrease the risks linked to SIMOPS.*

To **assist**, coordinate and liaise the **relevant assisting parties** in the event of any **incident or emergency situation**

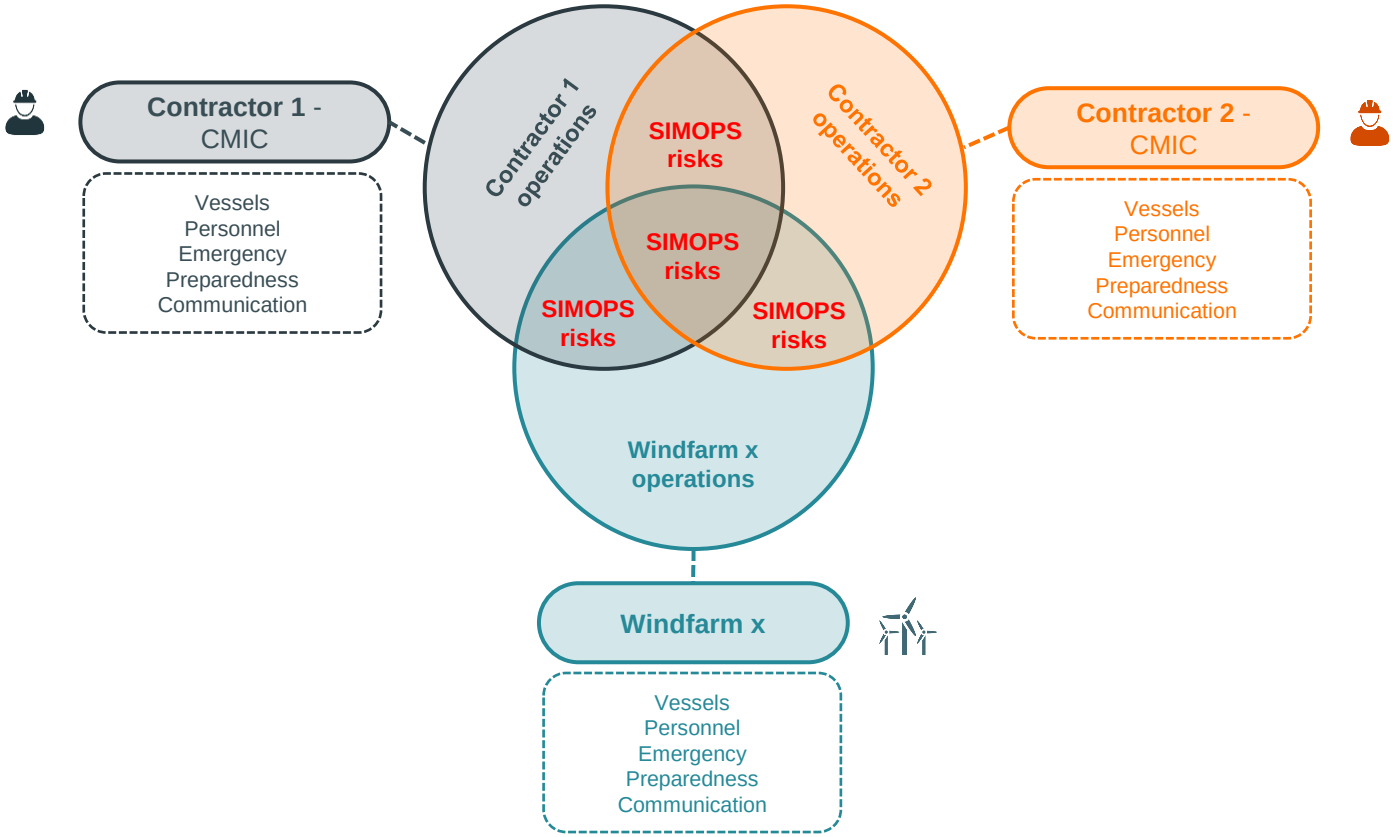
To ensure that **all vessels & crews** working on the project are **appropriately certified and inducted**

Optimize construction **time**

*SIMOPS: **Sim**ultaneous **Op**eration**s***

Marine and Island Coordination concept

Elia responsible of the Marine and Island Coordinator watch within a MIC site

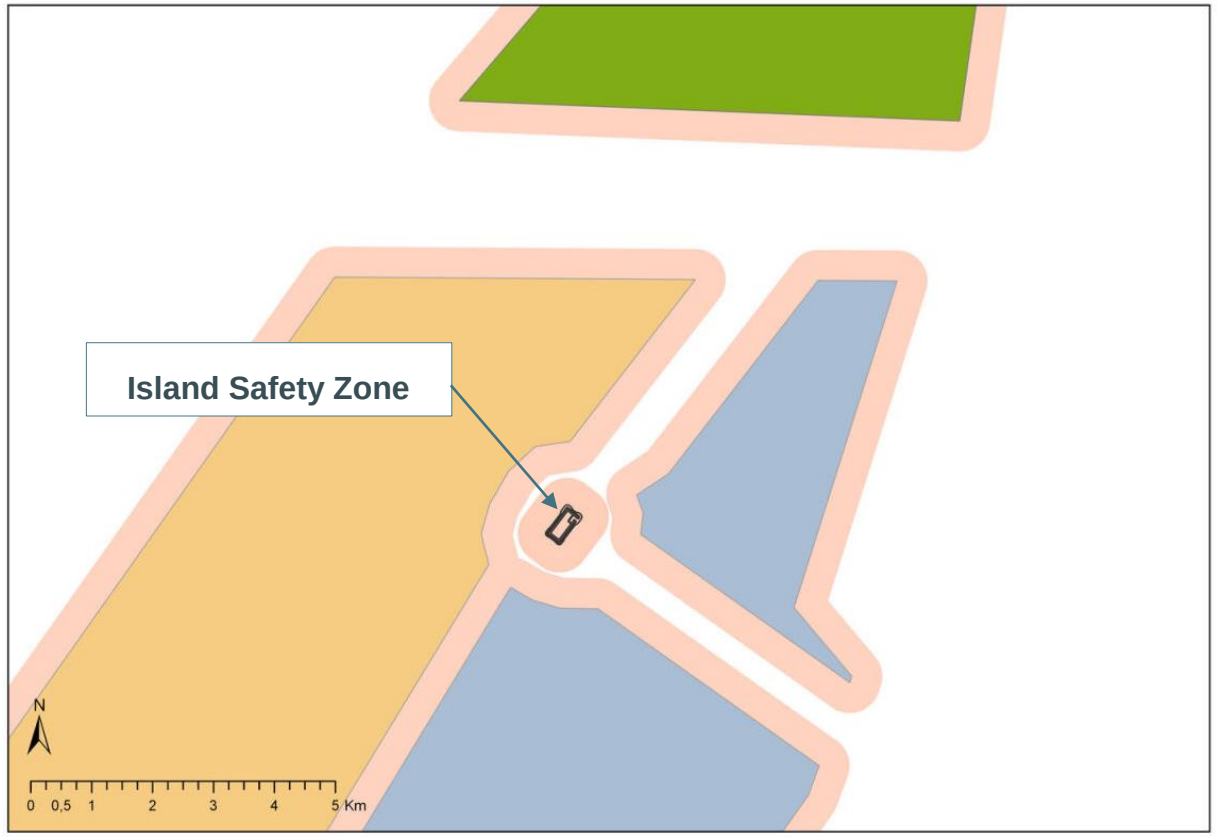


Possible parties present within the Marine and Island Coordination:

- **Construction Contractors** (Island, AC/DC, Cables)
- **Elia O&M** (Operations and Maintenance)
- **Windfarm owners**

SIMOPS: Simultaneous Operations
MIC: Marine and Island Coordination

Marine and Island Coordination Sites



Energy Island site is subdivided in **multiple zones**

1. 500m Safety Zone (salmon color zone)
2. CTV harbour
3. Island main quay
4. Cable landing area
5. Land Area
6. Modules

Documents for Marine and Island Coordination

Month-18 before construction operation

Wind farm owner

- High-level **planning**
- High-level **Method Statement**

Month-12 before construction operation

Wind farm owner

Documents describing the Marine operations and/or Island activities as per DNV-ST-N001 standards

Month-6 before construction operation

Wind farm owner

- **List of equipment** involved (detailed)
- **List of vessels** involved
- Vessel **certification**, information and contact details to be uploaded in the MIC Software
- MIC Windfarm **point of contact to be appointed**

Safe Marine Operations and/or Island Activities

Week-6 before construction operation

Vessel project acceptance

- **Vessel inspected** by Elia
- After approval, Elia will grant a **Permit to Access** an Offshore site to the vessel
- **MRCC permit for exceptional marine activities** to be shared with Elia

Hour-48 before construction operation

Pre-operational administration by Windfarm Owner

- **Final information/documentation** to be uploaded in the MIC Software
- **Permit to Work application** as per Elia procedure
- **Personnel certification** and contact details
- **Transfer plans** (vessels and personnel tracking)

Start **Construction operation starting**

MIC: Marine and Island Coordination

Access to Marine and Island

A **“Permit to Access an offshore site”** will be granted by Elia to a certain **vessel** after having met the following criteria:

1. Windfarm vessel approved under the Vessel **Project Acceptance procedure**
2. **Contact details and documents of the vessels** have been uploaded to Marine and Island Coordination Software.
3. **Information about the activity/operation** must be provided to Elia.
4. **MRCC Permit** for exceptional marine activities has been delivered.

The permit to access will only be approved by Elia

MRCC: Marine Rescue Coordination Center

Access to Marine and Island

Before being allowed on the Island, **personnel** will need to meet the following criteria:

1. **Windfarm Personnel certification** (**Training Requirements**) and contact details to be uploaded to Marine and Island Coordination Software
2. **Windfarm Personnel** to follow the Marine and Island coordination site induction
3. Personnel to be **approved** in the Marine and Island Coordination **Software**

Inductions, Medical fitness and certificates/training required

Inductions and Medical fitness

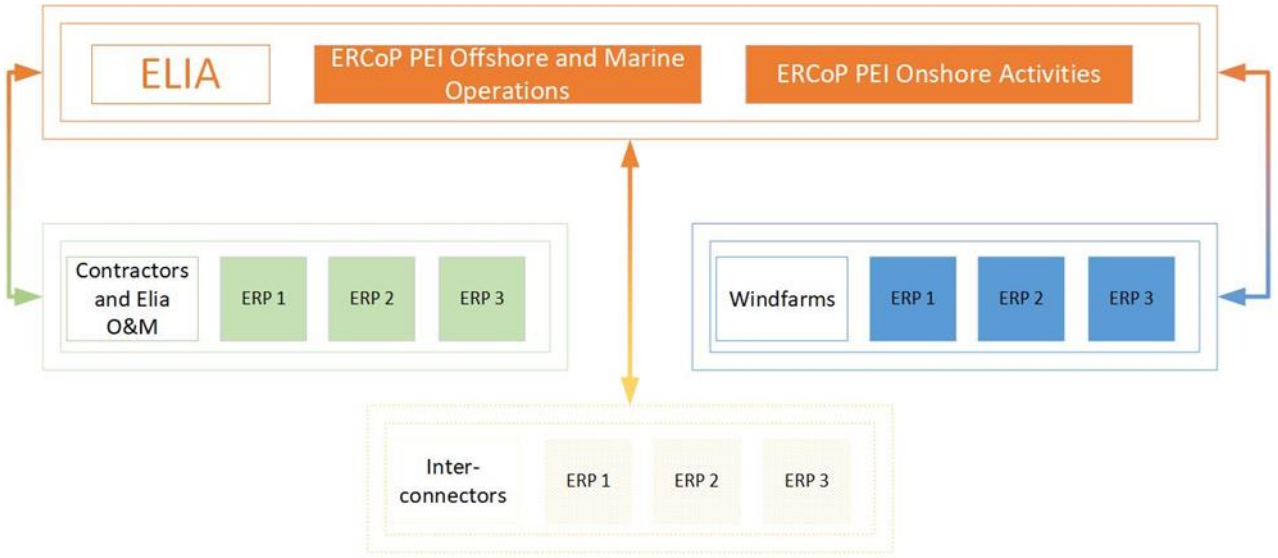
- Induction (site specific and transportation mode specific)
- Offshore Health certificate

Certificates and training

- [BOSIET + Boat-landing] or GWO (Sea-survival including boat-transfer, First-aid and fire-fighting)
- GWO Advanced First Aid for 10% of the workforce
- Transfer per helicopter (HUET + CA-EBS)
- Elia Electrical training and BA5
- Based on tasks specific and risks assessments, extra trainings might be required (e.g.: Working at height, confined spaces,…)

Emergency Response and Coordination Plan (ERCoP) and Emergency Response Plan (ERP)

- **The Emergency Response and Coordination Plan (**ERCoP) **provides the guidelines** for the coordination and management of an emergency or possible emergency within the PEI Project for Offshore and Marine Operations.
- The **ERCoP** is **managed by Elia**.
- **ERP managed** by **Windfarms, contractors and inter-connectors**.

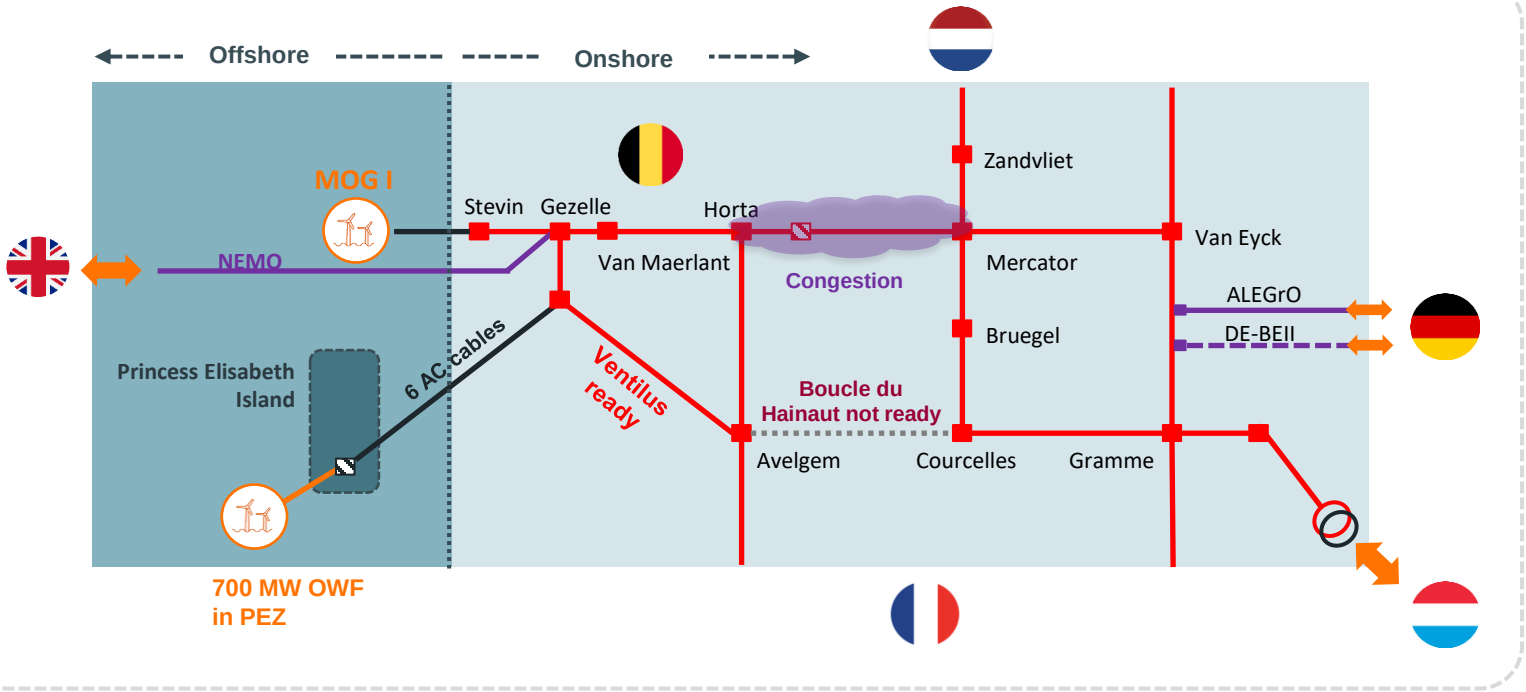


ERCoP: Emergency Response and Coordination Plan
ERP: Emergency Response Plan

Flexibility connection contract for lot 1 PEZ tender

Flexible connection contract to cover for scenario where first wave of 700 MW OWF is connected prior the realization of Boucle du Hainaut

- As highlighted in the FDP 2024-2034, **both Ventilus and Boucle du Hainaut are required to unlock the full hosting capacity for the Belgian coastal area**. As mentioned in the FDP, Ventilus (2028-2030) is to be commissioned before Boucle du Hainaut (2030).
- **Without Boucle du Hainaut, the already existing congestions on the Horta-Mercator axis remain present in the system**. These congestions are aggravated when supplementary generation is connected (e.g. offshore wind is connected).
- A maximum of **700 MW** of offshore wind (=Phase I) can already be connected to the electricity system **after the realization of Ventilus**, however **production** of these offshore windfarms needs to be **limited in case of congestion on Horta-Mercator.**



Given the fact that congestions can already occur in N situation, this entails **preventive curtailment of possibly up to 700 MW.**

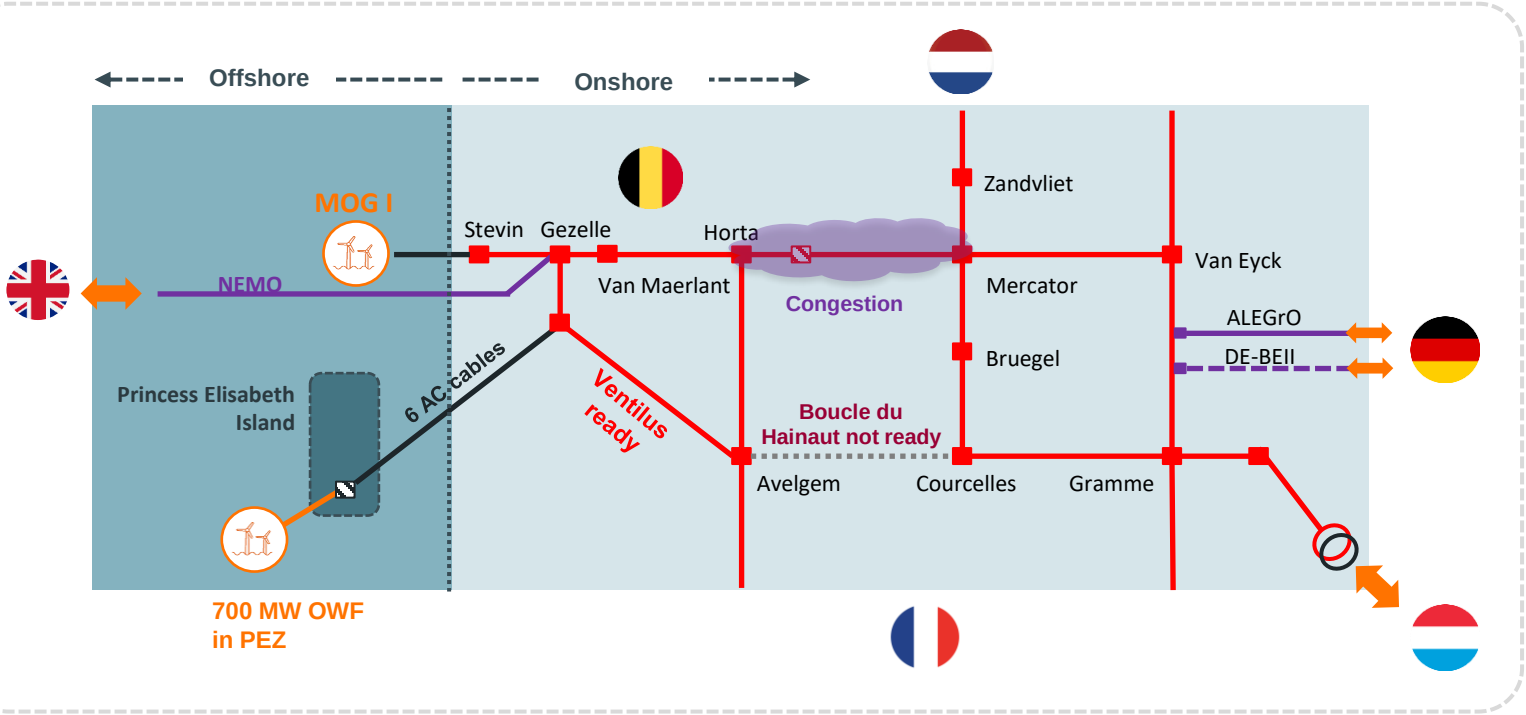
Such limitation of the offshore wind production is required for **as long as Boucle Du Hainaut is not realized yet**

Flexible connection contract to cover for scenario where first wave of 700 MW OWF is connected prior the realization of Boucle du Hainaut

- Our **standard approach** is to work within the existing framework for **flexible connections:**
  - Clear link with a given congestion (Horta – Mercator), and a project to solve this congestion (Boucle du Hainaut);
  - Remuneration for activations is not foreseen;
  - BRP remains responsible for balancing their own portfolio;

- Amount of curtailed energy will be determined by specific studies during **Q1 2024.**
  A specific report will be submitted to the regulator, in coherence with other flex dossiers.

- Elia notes that a capability based CfD covers part of the flex risk.



As **cross-zonal market exchanges heavily determine the utilization of the Horta-Mercator lin**e, a good view on the congestions can only be expected after the day-ahead market coupling.

Balancing

Part 1 – Introduction

- Re-cap of recommendations give in previous Task Forces

Part 2 – Clarifications on open points

- Implementation of the preventive cap in high BE import conditions
- Implications of ATC limitations in the balancing time frame
- Imbalance price design in an Offshore Bidding Zone
- Review market performance assumptions
- Financial impact of the recommended mitigation measures

Introduction

Context of the PEZ balancing study

Reminder

Reminder context

- **In 2019 - Elia initiated its MOG 2 system integration study which formulated recommendations for the system integration of offshore wind power capacity up to 4.4 GW**

- **In 2021 - Elia initiated an update of the study on request of the stakeholders**

Public consultation page (link)

- **In 2022 - Elia re-launched the update of the study :**
  - **Impact of increasing offshore wind capacity from 4.4 GW to 5.8 GW** on real-time balancing, reserve needs and proposed mitigations measures
  - **Impact of the foreseen offshore grid topology (hybrid interconnectors in a meshed HVDC network)** and the **creation of an Offshore Bidding Zone**

Conclusions

It was concluded that additional mitigation measures were needed to manage the integration of additional 2.1 GW of offshore wind power in the system. Elia recommended :

- To enforce **High Wind Speed technologies** as a solution to limit the impact of storms to the extent possible
- To extend the existing storm procedure with a measure for **preventive curtailment** of offshore production in case of expected flexibility shortages and inadequate market response
- To impose **ramp rate limitations** to deal with fast and unexpected upward power ramps affecting the system imbalance (including during the cut-in phase after a storm)

Justification of the recommended mitigation measures

1. Elia is responsible for system security and needs to avoid system violations at any time: **system simulations** based on worst case balancing market conditions **demonstrate the need for mitigation measures to avoid alert and emergency state situations**

   ► Mitigation measures are a safety net for Elia and the required wind power capabilities are therefore to be ensured via the Tender requirements

2. **The recommended mitigation measures are designed to give BRPs all opportunities to self-manage** the expected impact of storm and ramping events in the intra-day, and even up to the balancing time frame

   ► No costs are incurred when market shows good performance

3. **The recommended mitigation measures are proportionate in view of alternative solutions** based on procuring additional reserve capacity, and is therefore fair in view of allocation of the costs to the parties responsible for these costs.

4. **Elia aims to provide as much visibility and transparency today** by presenting the design principles to market parties. Nevertheless, the recommended mechanisms are subject to regulatory approval and might also be subject to system evolutions towards 2029.

Overview of the recommended mitigation measures

		Definition	Justification	Implementation*	Activation
Storm and Ramps	**High wind speed technologies**	*Technical minimum requirements on new wind turbines of wind parks to maintain generation during high wind speeds*	*Reduce frequency and impact of shortage power following storm cut-off wind speeds* *Technology capabilities exist already today and are assessed to become a standard technology*	*Technical specifications on turbines or at park level are specified via connection requirements to continue generation until 31 m/sec after a gradual power decrease*	*Technical capability is assumed to used by market players to limit impact of storm events on wind power injections*
	Ramp rate limitations	*Real-time limitation of the upward ramp rate of new parks (and existing parks on voluntary basis) during elevated positive imbalances in the LFC block*	*Mitigate frequency and impact of excess power following increasing wind speed conditions or re-activations after a storm* *Simple, automatic and transparent procedure compared to the manual cut-in coordination of existing parks*	*Control requirements are specified via connection requirements* *Operational procedure will be implemented via LFC block operational agreement and T&C for Scheduling Agents*	*Automatic trigger communicated by Elia after market reaction and limited to periods of large positive LFC block imbalances* *No trigger is expected in high balancing market performance scenarios*
	Preventive curtailment	*Intra-day communication of wind power curtailment of new parks following predicted storm event or downward ramping event to reduce expected LFC block imbalances*	*Mitigate frequency and impact of shortage power following storm cut-off wind speeds.*	*No specific technical requirements needed* *Operational procedure will be implemented via LFC block operational agreement and T&C for BRPs*	*Trigger by Elia only as last resort after a storm or ramp forecast, insufficient market reaction and insufficient flexibility in reserves* *No trigger is expected in high balancing market performance scenarios*
Hybrid IC	**Preventive cap**	*Real-time limitation of the excess wind power injection of new wind parks following remaining network capacity in the balancing time frame*	*Maintain system stability in hybrid HVDC system during high import conditions to Belgium as complement and back up for balancing agreements with connected region*	*Control requirements are specified via connection requirements* *Operational procedure will be implemented via Capacity Calculation processes and local congestion management framework (ICAROS)*	*Continuous cap limiting positive imbalances in function of available network capacity.* *Impact is limited to high import conditions to Belgium and further limited when disposing of balancing agreements with connected regions.*

**Technical specifications in connection requirements will be defined during tendering phase in 2024, proposals of the modifications to the regulatory framework are foreseen around 2027*

During and after the Task Force presentations and workshops, a few open points were identified for further clarification and these are clarified in this presentation

1 Implementation of the preventive cap during high import conditions to Belgium

- Clarifications are given on the mechanism presented in the TF workshop of 17.03.2023 to preventively cap excess wind power injections in the balancing time frame when facing export ATC limitations from the PEZ to the connected regions

2 Implications of ATC limitations in the balancing time frame

- An analysis is presented on request of CREG which investigates implications and solutions in an OBZ to balance situations where the ATC to the PEZ are below the physical capacity of the cable

3 Imbalance price design in an Offshore Bidding Zone

- Elia answers on the questions of stakeholders raised concerning the plans of Elia to implement an alpha and real-time price in the OBZ, following the activation of balancing energy in the OBZ through the EU balancing platforms

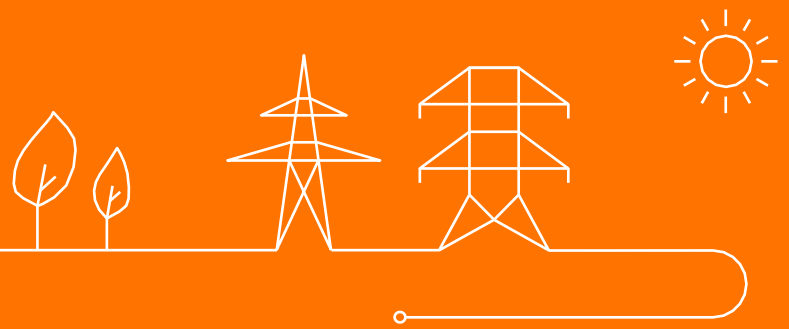
4 Review of market performance assumptions

- On request of stakeholders (TF 24.03.2023), Elia presents the results of its update on the market performance indicators of market players (to balance their portfolio) during storm and ramp events used as input for the system simulations to justify the recommended mitigation measures

5 Financial impact of the recommended mitigation measures

- Following discussions with stakeholders during the presentation in the TF of 24.03.2023, Elia presents the expected impact of the activation of the mitigation measures on the revenues of the wind parks

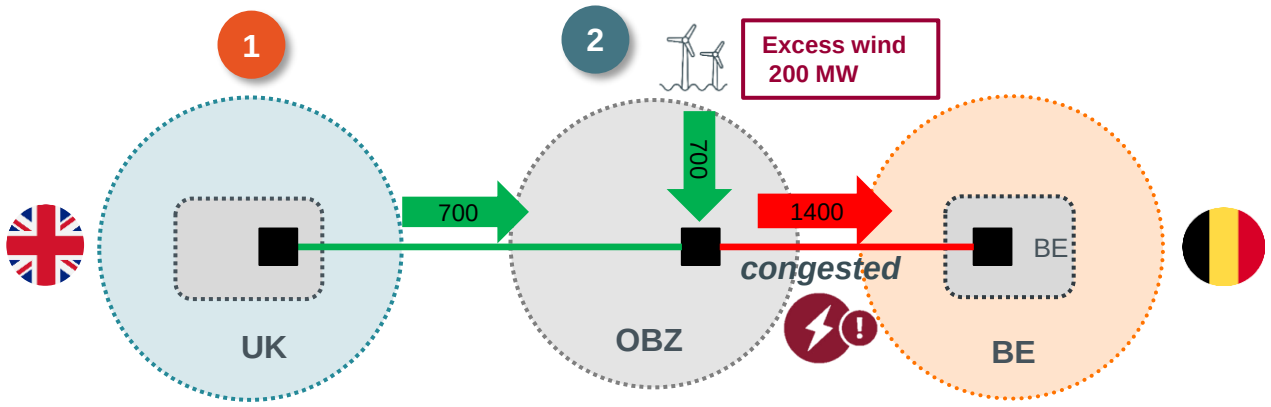
1 Implementation of the preventive cap during high import conditions to Belgium



Preventive cap

Reminder of the mitigation measure presented in TF workshop of 17/03/2023

Excess wind power (+ 200 MW) in balancing time frame **during high export conditions from PEZ to Belgium**



1 **In the target scenario, the excess wind power can be managed via balancing cooperation via UK (Nautilus) or DK (Triton)**

- Reduction of the injection from the foreign LFC Areas to the offshore LFC Area (until ATC limitation) through downward activation of flexibility via the foreign LFC Area

2 Alternatively, it can be **managed via reducing the offshore wind power injections** through downward activation of wind power flexibility

- In case activation of downward balancing energy on wind in the offshore LFC Area is economically cheaper
- In case of absence of balancing cooperations with regions connected to the Belgian offshore area.

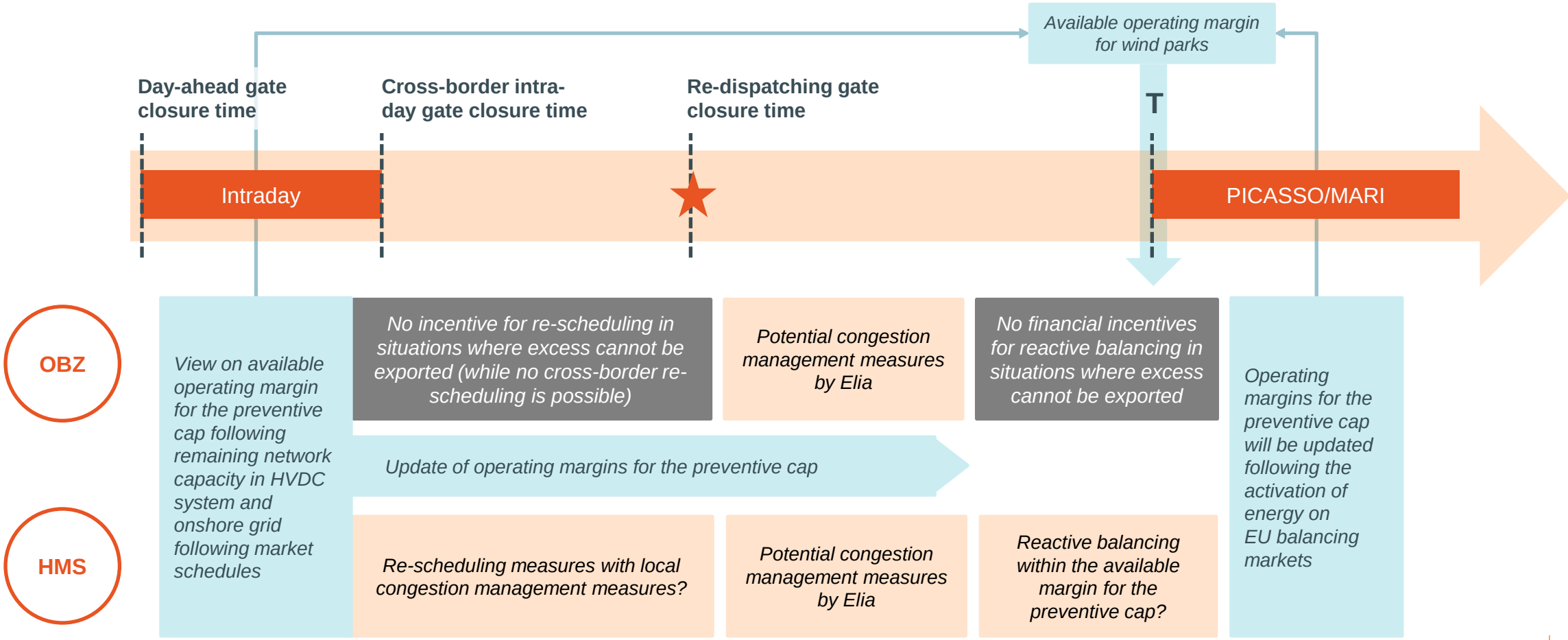
Preventive cap

(Part of) the **wind power might need to be capped in real-time** by TSO following real-time HVDC operational management in order **to maintain safe operation of the assets** in case of wind power variations exceeding the physical capacity of the cables **until the imbalance can be managed via** :

- **Export to the connected LFC Area**
- **Activation of downward balancing energy on wind**

Further specifications on the mechanism

*The **preventive cap shall result in a margin in which wind power can operate** (and thus inject its positive imbalances). This operating margin is **continuously updated** over **the different time frames** (day-ahead, intra-day and balancing)*



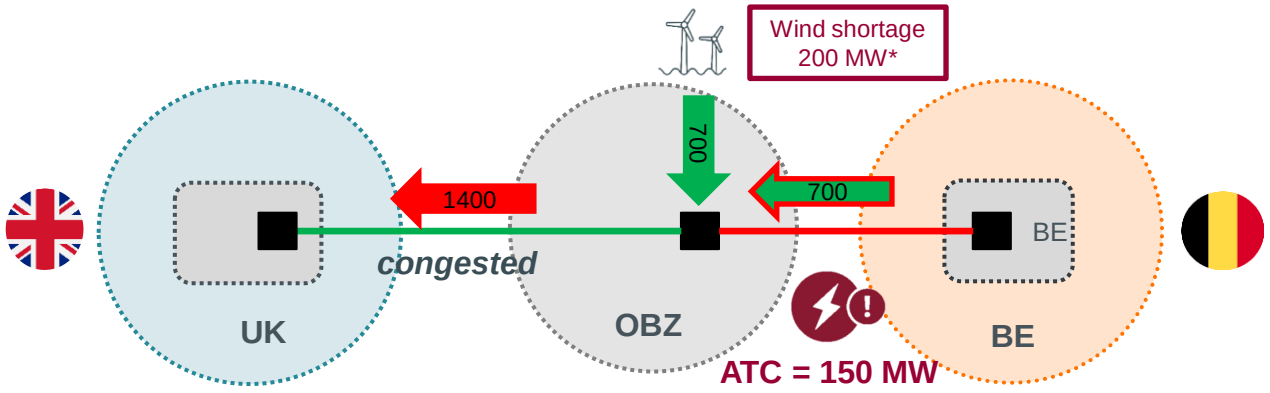
2 Implications of ATC limitations in the balancing time frame

Impact of onshore network limitations during periods with shortage wind power and high export conditions to the connected LFC Area

Context : *Elia presented during the Task Force Workshop of 17/03/2023 a particular situation where injections to the connected region might need to be curtailed when the ATCs are lower than the physical capacity on the HVDC system*

► ***CREG asked to further investigate this case in terms of potential impact and solutions.***

Shortage wind power (- 200 MW) in balancing time frame during high export conditions from PEZ to the connected LFC Area



700 MW cross-zonal capacity was allocated in DA/ID. The cross-zonal capacity available for balancing equals 150 MW.

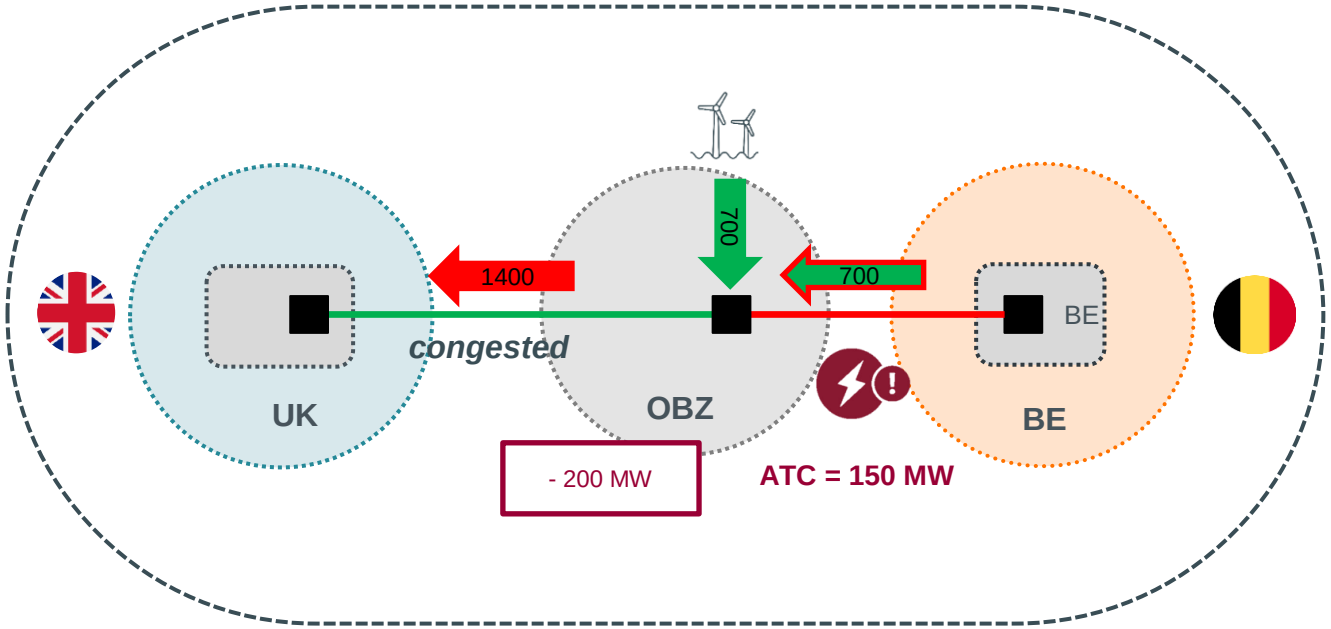
Note that **despite physical capacity on the HVDC interconnector**, the **available cross-zonal capacity for balancing can be limited** as it is subject to a coordinated capacity calculation in the Core CCR. The limitation may be due to :

- **Capacity calculation methods**
- **Operational limits in the onshore network**

- When **now assuming a shortage of 200 MW of wind power in the OBZ, the HVDC system cannot be balanced via the normal approaches presented**
- **The insufficient cross-zonal capacity from Belgium to the OBZ inhibits the activation of upward flexibility in Belgium to balance the HVDC system and sustain the export to the Foreign LFC Area**

** Excess case can always be managed via downward reduction of the wind*

Practical implication of such case



In the operational time frame, the export to UK needs to be reduced with 50 MW through an **operational or balancing agreement with UK:**

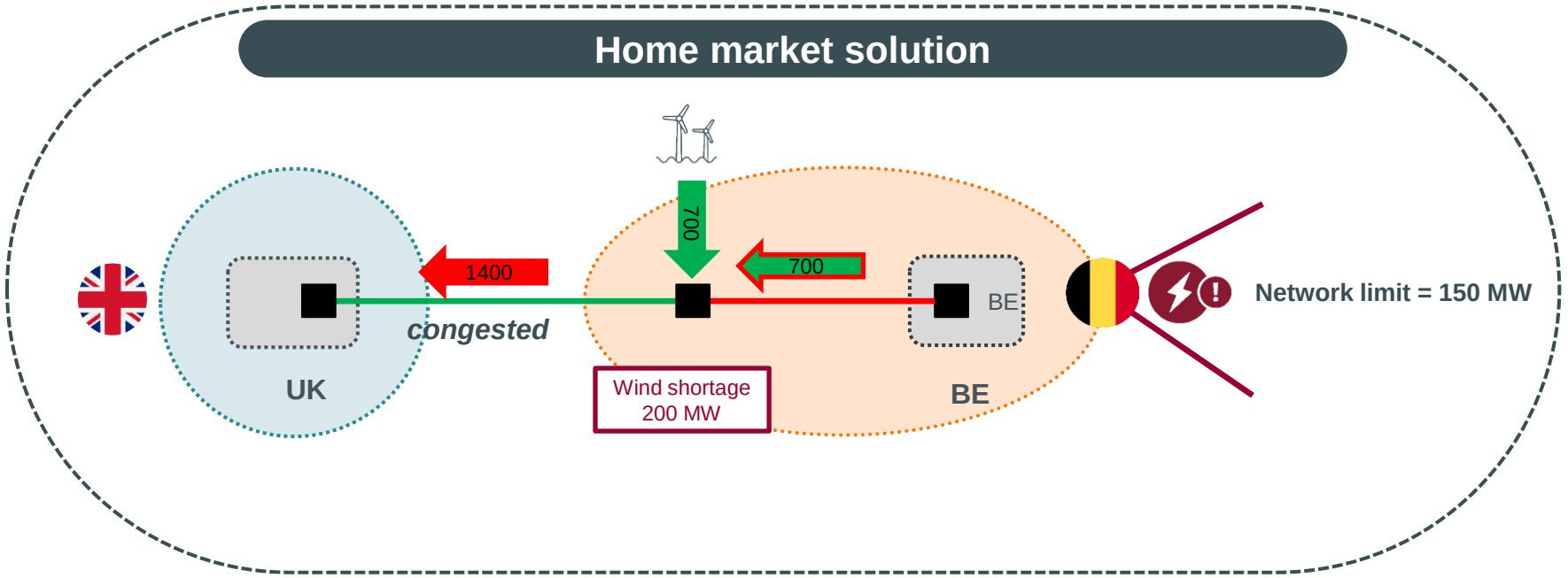
- *It is standard to have operational agreements on all interconnectors needed for covering what is happening in the "operational timeframe" (e.g. cable incidents)*
- *Note that such agreements are yet to be negotiated with UK and subject to uncertainty*

In the balancing time frame, **the imbalance price in the OBZ might need to be adapted to reasonable values** (to avoid the price cap as shortage cannot be solved, price levels would reach price cap in balancing platforms)

Additional considerations

- **Ambition is to have a balancing cooperation with UK** (via EU balancing platforms or at least cooperate bilaterally) in which the **dependency on the above- mentioned measures is reduced.**
- **Ambition is to connect Princess Elizabeth Island (and therefore the OBZ) to multiple regions,** including Denmark (part of EU Balancing platforms). **With more connections, the dependency on the above- mentioned measures is reduced**.
- **Improvements in capacity calculation are also expected to reduce the frequency of transmission capacity limitations**. Improvements in the pipeline are subject to regulatory uncertainty. Further improvements on capacity calculation can be discussed in due time within CORE / EU context but will not be a silver bullet.

Implications in a Home Market Solution



- ***If the network limits follow congestions in the onshore network**, the exact **same situation occurs** in a home market solution*
- ***This results in exactly the same assessment*** presented in an offshore bidding zone presented in the previous slide*

**But note that the cross-border marginal price in the offshore area would remain equal to the onshore area. A low or negative price in the Belgian LFC block might thus give wrong incentives to wind power to further reduce injections and worsen the problem.*

3 Imbalance price design in an Offshore Bidding Zone

Imbalance management in an OBZ

- **Wind power plants in an offshore bidding zone are foreseen to remain responsible for their imbalance (via BRPs), and will be subject to an imbalance price based on the value of balancing energy following the activation of balancing energy through the EU balancing platforms**

- **Wind power plants in an offshore bidding zone can use intra-day markets (60' before real-time) and downward control of wind power to balance their positions**
  - *In comparison to wind parks outside the OBZ, no portfolio advantages currently exist (no possibility to aggregate imbalances)*
  - *This is due to the lack of portfolio diversification options offshore (no or limited room for controllable generation sources, demand and storage)*

- **Note that :**
  - In the framework of the electricity market design reform discussion at EU level, it is expected that the intraday cross-zonal gate closure time will be reduced to 30 minutes before real-time (ant this before the OBZ would be created)
  - Other solutions (pooling portfolio imbalances over bidding zones, facilitate cross-zonal reactive balancing) are not straightforward in view of congestion management

- Reduced reactive balancing possibilities are taken into account in market performance assumptions for reserve dimensioning and extreme balancing conditions (storms and ramps)
- It is expected that increased needs for reserve capacity will be managed via available non-contracted balancing energy bids of available flexibility in the onshore LFC Area (partial procurement)
- Note that in general, flexibility to manage extreme balancing conditions remains accessible via the EU balancing platforms

No <u>fundamental</u> impact is expected on mitigation measures or balancing capacity needs

Imbalance Price design for the Imbalance price area

- **The imbalance price design is in constant evolution** to accommodate changing market circumstances and **can therefore not be set today** for a market situation that is still many years away.

- **The balancing philosophy and the consequent imbalance price design** applied in the offshore LFC area will need to **take into account the specificities of the OBZ** (e.g. the type of flexibility available within the zone) and will be discussed and developed with all the stakeholders in due time once the context becomes clearer.

4 Review market performance assumptions

Questions raised by stakeholders (MoM Task Force)

Question were raised on the market performance assumptions *taken in the system simulations used to justify the need for mitigation measures :*

Febeliec and Otary did not agree that market performance under best and worst case circumstances could be lower compared to situation observed today

a. *Febeliec asks if Elia sees a positive evolution over time in market performance, particularly for the upward ramping events as this requires new mitigation measures.*
b. *Otary feels that the downward best case for upward ramps should not be reduced compared to the observed best case values (from 90% to 80%), as a high performance can be explained by self-curtailment incentives.*

Elia committed to cross-check on the market performance assumptions based on the latest market observations

An update of the analysis does not reveal the need to re-run the system simulations

- **On request of some stakeholders, Elia conducted an update of its original analysis (until Summer 2022) with observations until Summer 2023**
- **No new storm events are registered since Summer 2022**
  - Values are maintained on best and worst market performance observed (average performance over the duration of the storm)
  - No obvious positive trends in market performance are observed during the latest 3 years (large variations in behavior or storm, predictability and system impact)
- **The analysis is extended with largest up- and downward ramping events in the second part of 2022 and first part of 2023**
  - The update confirms that base case market performance during upward ramping events should be improved to 90% (in line with remarks made by Otary and BOP)
  - The worst case assumptions is maintained at 50%, based on the yearly average of the minimum performance between 2020 and mid-2023.

  ➔ As mitigation measures are based on the worst case conditions, no impact of increasing the performance to 90% is expected on the conclusions of the study.
  - Market performance assumptions on the downward ramping events are confirmed (yearly average of the minimum and maximum performance)
- **Average gradient over different type of events varies between 2,8% and 3,7% and is therefore maintained at 3,0% for simplification**

Presented market performance assumptions and values discussed with stakeholders (in red)

Assumptions for 5,8 GW	Down Ramping event (shortage)			Up Ramping event (excess)			Storm cut-out		
	Coverage	Full recovery time	Gradient	Coverage	Full recovery time	Gradient	Coverage	Full recovery time	Gradient
Best case	60%	45 min	3,0%	90% (80%)	15 min	3,0%	85%	15 min	3,0%
Worst case	30%	120 min		50%	120 min		45%	120 min	

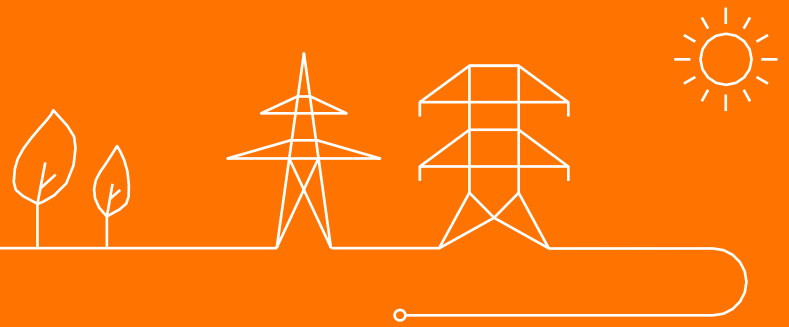
Coverage : represents the part of the increase or reduction in wind power production covered by the BRPs

Full recovery time : represents the time needed for BRPs to fully cover the system imbalance in a stable way.

Gradient : represents the rate with which the BRPs react to cover power variations

Performance compared to MOG 2 (2020) assumptions = <

5 Financial impact of the recommended mitigation measures



Context

- The activation of the recommended mitigation measures for new parks will impact the injection of wind power and stakeholders requested to provide as much visibility as possible on the impact on the business case of offshore wind power
    - *Elia already clarified (including during the TF of 24.03.2023) that the impact should remain limited for the wind parks following the limited occurrence of storm and ramping events, further reduced under good market performance and sufficient flexibility in the system.*
    - *Elia also clarified during previous discussions that it will provide a full picture on the financial implications of activating the mitigation measures after having more information on the foreseen support schemes.*

With the choice for a capability-based CfD support scheme (as communicated by the Government), Elia presents the assessment of the financial impact of each of the recommended measures

- *The **capability-based nature of the support scheme** inhibits an impact of the activation of the recommended measures on the revenues generated by the subsidy.*
- *This is a different from the assumptions taken in the MOG 2 system integration study where the activation of the measures was still assumed to result in a lost subsidy revenue (e.g. under green certificates mechanisms or feed-in tariffs)*

- Elia also assumes that Per article 5 of Electricity Regulation 2019/943, all market participants shall be responsible for the imbalances they cause in the system. Elia reminds that the recommended measures are designed to let the market take action first, as incentivized by the **balancing responsibility**, to which the parks are exposed .

Financial implications of the HWS and RRL measures

High wind speeds technologies allow to increase the generation of wind turbines during storm conditions by means of a later cut-out wind speed and an earlier cut-in wind speed and thus have a positive impact on the revenues of the parks during operations

OBZ impact

In a home market, the mechanism is triggered by means of the observed system imbalance while market players have clear incentives for reactive balancing

In an OBZ, the mechanism :

- will be triggered by means of the observed system imbalance in the LFC block (after netting) to limit the activation frequency of the measure
- less reactive balancing possibilities offshore may indeed increase activation frequency

- **Ramp rate limitations** mitigate excess energy of wind power parks during high excess system imbalances (in the LFC block)
- **This will reduce imbalance revenues** (note that these are likely to be very low or even negative under the envisioned conditions)
- **Day-ahead, intra-day and PPA/CfD* revenues are not impacted**

**In a capability-based CfD*

Amount of days with large upward ramps in 5.8 GW scenario

Ramp [GW]	Tech A Deep	Tech B Deep
2.0	16	19
2.5	5.5	5.7
3.0	2.2	2.2
3.5	0.9	1.1
4.0	0.45	0.65
4.5	0.28	0.35
5.0	0.18	0.2
5.5	0.05	0.13

- Large upward ramping events which are more susceptible to lead to high positive imbalances, do not happen at a high frequency (e.g. upward ramps of 2.0 GW are expected to happen around 20 days a year)
- Market reaction is expected to further reduce the frequency of triggering the ramp rate limitation

Financial implications of the preventive curtailment

- **Preventive curtailment reduces the wind power** in the intra-day time frame to anticipate unmanaged cut-outs, only when BRPs are not adequately covering the identified balancing risks.
- **The mechanism creates a portfolio shortage requiring to buy energy in the intra-day market**. Meanwhile, the mechanism avoids a (high) imbalance shortage cost in the BRPs' portfolio
- **Day-ahead and PPA/CfD* revenues are not impacted**

**In a capability-based CfD*

OBZ impact

In a home market, the mechanism is triggered by means of the observed available flexibility in the system while market players have clear incentives for reactive balancing

In an OBZ, the mechanism :

- will be triggered by means of the available flexibility in the LFC block to limit the activation frequency of the measure
- less reactive balancing possibilities offshore may increase the activation frequency

Amount of days with large down ramps in 5.8 GW scenario (including storms)

Ramp [GW]	Tech A Deep	Tech B Deep
1.0	157	171
1.5	48	58
2.0	11	15
2.5	2.9	4.2
3.0	0.48	1
3.5	0.15	0.28
4.0	0.05	0.05
4.5	0	0

- Based on 2020-22 observations limited to 4 storms a year of, in average, 13 hours, the maximum impact is only 52 hours per year
  - Market reaction is expected to further reduce the frequency of triggering preventive curtailment
- Large downward ramping events may happen more frequently (downward ramping of 2.0 GW may happen around 10 days per year) but with lower duration (a few hours)
  - Market reaction is expected to further reduce the frequency of triggering preventive curtailment*

**Adequacy of this measure to cover system violations depends on future predictability of ramping events. Failure to develop accurate forecast might result in a need for additional measures (e.g. reserve capacity)*

Financial implications of the preventive cap

The preventive cap mitigates excess wind power in view of available network capacity in the balancing time frame.

- This occurs during full import conditions to Belgium when excess energy cannot be absorbed via very fast flexibility agreements with UK or other connected regions.
- The use of the cap can be relieved in the balancing market time frame (when having FRR balancing cooperation with UK or other connected regions)

The application of the cap might impact the balancing revenues of positive imbalances

Day-ahead, intra-day and PPA/CfD* revenues are not impacted

**In a capability-based CfD*

- **The impact of the lost balancing revenues depend on the frequency of excess wind power during high import conditions**
  - *Excess wind power follows positive forecast errors which are an inherent part of forecasting variable generation. While it can be assumed that these are reduced with better forecasting tools, these will likely remain present*
  - ***In an OBZ**, the balancing market price is assumed to reflect that there is no value when excess energy cannot be exported following network constraints. The OBZ gives adequate price signals to not inject wind power. The activation of the preventive cap does therefore not result in balancing costs for wind power.*
  - ***In a HMS**, the balancing market price of the LFC lock can remain positive providing incentives to re-schedule injections and/or inject excess energy which cannot be accommodated by the system. Congestion management principles are likely to be revised in view of efficient system operation and fair allocation of costs.*

Conclusions

- **The activation of the recommended measures does not impact the revenues generated by the capability-based subsidy** and remains therefore limited to the costs and revenues in the balancing (or intra-day) time frame.
- **This impact of the measures is thus expected to have a limited effect on the business case of the wind parks :**
  - As the activation of the recommended mitigation measures related to storm and ramping events are expected to be limited in frequency due to the nature of these events.
  - The measures are designed to let the market take action first, as incentivized by the balancing responsibility, and is expected to minimize the activation of the measures.
  - Adequate price signals are expected to mitigate the negative impact on the balancing revenues, and might even help BRPs to avoid balancing costs,

- In view of this analysis, and in view of a fair allocation of costs (where the party responsible for the system security risks and the activation of the mitigation measures is expected to bear the costs rather than socialize the costs to the grid users), **Elia concludes that a financial compensation for the measures cannot be justified.**
- **Elia also concludes that a cap on the number of activations of the measures is not to be considered anymore following the change of nature of the support mechanism**. While this was initially proposed for the preventive curtailment measure to limit the impact of lost revenues following subsidies, this principle loses its benefit in the above-mentioned context.

Dynamic & Harmonic

Part 1 – Forced oscillations

- Update requirements for forced oscillation tender PEZ

Part 2 – Voltage control & MVAr management

- Update requirements for wind park capability

Part 3 – Conformity process

- General process for all future new installations in Elia grid
- PEZ application case - deepdive

4 main clarifications are foreseen in the technical requirements (standard RfG) related to Dynamic & Harmonic for the tender offshore PEZ

1. **Forced oscillations:** this phenomena must not lead to critical consequences for BE/EU system

   Update

   Introduced in June 2022
   Final proposal today

2. **Data & model provision:** requirements for data and model sharing from asset owner to perform conformity study

   Presented

   Presented and already in application

3. **Conformity process:** need for coordinated simulations/studies to perform conformity study

   Update

   Introduced in January 2023
   Final proposal today

4. **Voltage control:** adjustment of voltage and MVar capabilities*

   Update

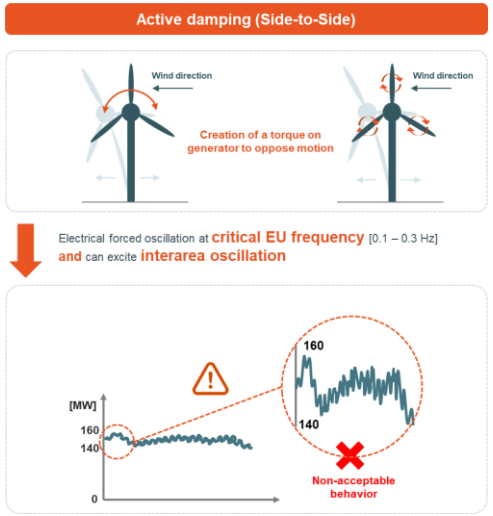
   Introduced in January 2023
   Final proposal today

Forced oscillation

Update on forced oscillations in the framework of the PEZ offshore tender

Context - reminder

- The **forced oscillations and interearea phenomena** and their critical consequences for EU system **were introduced by Elia**
- **During the TF MOG 2 (24/06), Elia presented the main potential clarifications foreseen in the technical requirement** for 1st tendering of MOG 2 OWF
- **No explicit reference in EU and BE law for forced oscillations** leading to diverging interpretation and position between TSOs and wind industry



Proposal

End-September ENTSO-E/WindEurope sent a joint-proposal for forced oscillation for offshore wind to ACER as input in the framework of the ongoing process for the EU network code amendment and was recently published on ACER webpage

ACER www

Use this joint-proposal developed by ENTSO-E and Wind Europe for the tender PEZ

Website link: https://www.acer.europa.eu/documents/public-consultations/pc2023e07-public-consultation-amendments-electricity-grid-connection-network-codes

Common proposal for Forced oscillation OWF performance developed by ENTSO-E and Wind Europe and sent to ACER as input for the RfG Amendment that will be used for the PEZ offshore tenders

Final proposal ENTSO-E/WindEurope towards ACER

(a) The forced oscillations shall not exceed continuously the maximum of:

(i) a limit in the range of +/- 0,5% to +/- 2% of the actual value, as defined by the relevant TSO. The default limit shall be +/- 1%.

(ii) a limit in the range of +/- 0,25% to +/- 1% of the maximum capacity, as defined by the relevant TSO. The default limit shall be +/- 0,5%.

(b) In case that the limits defined in (a) are temporarily exceeded, forced oscillations shall:

(i) not exceed a limit in the range of +/- 2,5% to +/- 5% of the maximum capacity, as defined by the relevant TSO. The default limit shall be +/- 4%

(ii) be within the limits defined in (a) within a range of 100-180 seconds, as defined by the relevant TSO. The default limit shall be 180 sec. *

(iii) be damped to be lower than 50% of the limit specified in (i) within 50% of the time limit specified in (ii)

(c) While always respecting the criteria defined in (b), temporarily exceedance of the limits defined in (a), not considering oscillations that are damped to be within the limits within 10 seconds, is allowed for:

(i) a maximum percentage of time per day, as defined by the relevant TSO in a range between 1% and 2%. The default limit shall be 1%.

(ii) a maximum in a range of 2-4 times per hour, based on the range of the 85th to 95th percentile of hourly exceedances measured over one week, as defined by the relevant TSO. The default maximum shall be 3 times and default percentile shall be 95.

(d) Forced oscillations originated from system support requests by the relevant system operator, such as power oscillation damping, are excluded from this requirement.

Clauses	Ranges	Default values
(a) (i) Continuously - FO max actual	0.5% - 2%	1%
(a) (ii) Continuously - FO max capacity	0.25% - 1%	0.5%
(b) (i) Temporary - FO max capacity	2.5% - 5%	4%
(b) (ii) Temporary - duration	100-180 sec	180sec
(b) (iii) damped	50% of b(i) and b(ii)	2% for 90sec
(c) (i)	1% - 2%	1% of day
(c) (ii)	2-4 times/h for 85th-95th percentile	3 times/h for 95%

Check with MOG 1 measurements

Ongoing assessment with existing MOG I wind farm measurements to check level of compliance with EU default value

Park A	Park B
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Pass	Pass
Fail/in the limit*	Pass

*Fail for 3 times/h for 95% and at the limit 3 times/h for 90th percent

First analysis (on 3 weeks data) show positive results. Additional monitoring is ongoing with larger set of data.

As Elia's first assessments show **that existing Belgian offshore wind parks are broadly compliant**, and hence the **new parks should be able to reproduce at least similar performance.** It is therefore proposed to anticipate **the legal process for the amendment of the RfG at EU level** and to clarify these criteria for forced oscillation as additional requirements for the PEZ tenders. This provides further **certainty for all bidders compare to an absence of explicit requirements**.

* By using default value for all criteria except for criteria (c) (ii) where value 3 times/h for 90th percent will be used

Voltage management

Update on voltage management requirements

Context – reminder TF PEZ 14/10

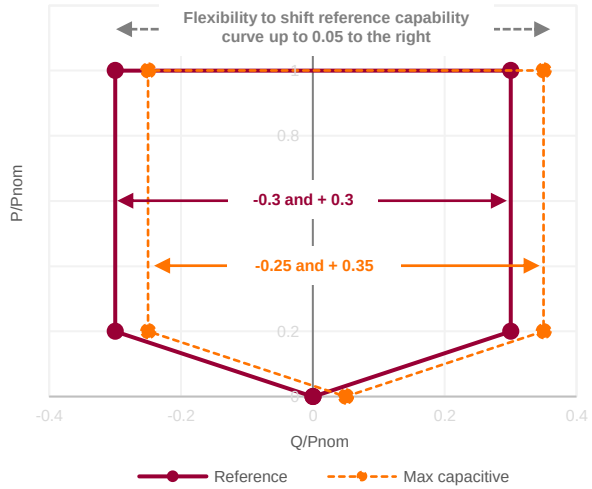
- During **the Task Force PEZ organized the 14th of October, the voltage management and MVAr study was presented** to clarify the capability foreseen for the offshore wind farm in the Princess Elisbaeth Zone
- The main reason of this adjusted capability is linked to the fact that **the step-up transformer is no more managed by wind farm (as for MOG 1) but by Elia**
- P/Q capability curve from Federal Grid Code was considered as sufficient
- Q-V capability was reduced from +/-10% of the nominal value to +/-5% of the nominal value having no impact at 220kV Elia grid

Remarks received & updates

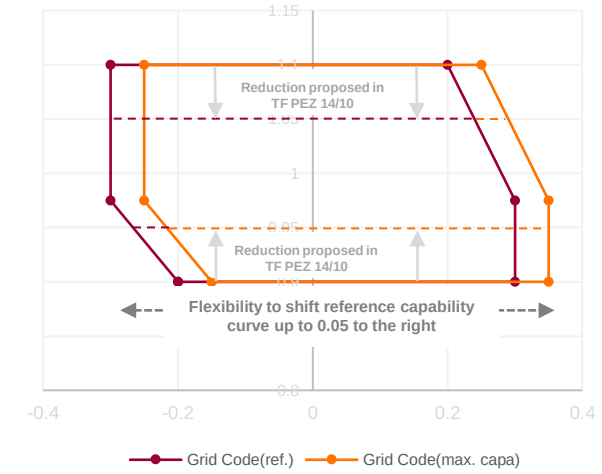
- Question were received from stakeholders on the **impact of the assumptions used for cable length and operation voltage level**
  - **3 scenarios were simulated** : 1km, 12.5km and 25km of 66kV cables
  - **3 operating voltage level were considered:** 0.95 pu, 1.0 pu, 1.05 pu

- **A parametric study (for a string) was performed to assess the maximum capability** that can be given by a PEZ wind park at different voltage levels without extra compensation devices.

P-Q capability curve for PEZ PPM – TF PEZ 14/10



Q-V capability curve for PEZ PPM – TF PEZ 14/10



Update on voltage control requirements

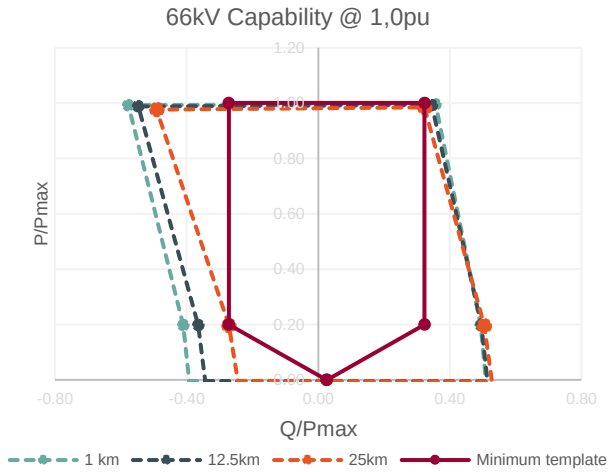
Updates and conclusions

1 P/Q capability curve for wind farm

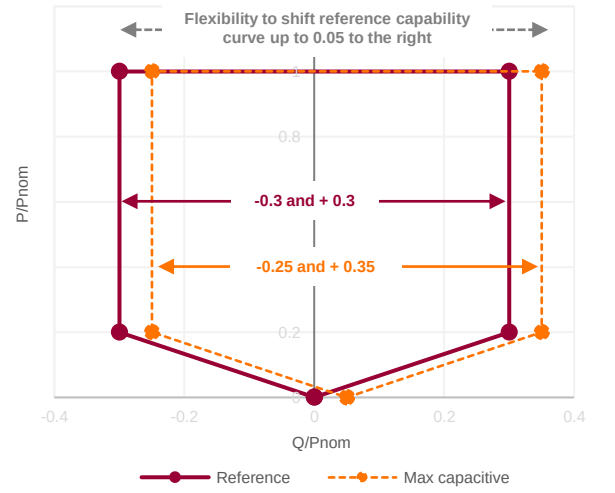
- Different simulations were performed to verify the P/Q capability of wind farm following different 66kV cable lengths
- The simulation confirmed that in the **worst case simulation** (**longest string**, e.g. 25 km), the P-Q capability curve as defined in **the Federal Grid Code** for type C-D PPM is **covered** (see appendix for more info)
- ✓ The P-Q capability curve as foreseen in the Belgian Grid Code for type C PPM **can be covered with the intrinsic capability of the wind turbines without extra assets**
- ✓ As foresee in the Belgian Grid Code for type C-D PPM, the reference capability curve can be move up to 0.05 to the right

P-Q capability curves remains the same than the Federal Grid Code for the PEZ tender

Results of simulations



P-Q capability curve for PEZ PPM



Update on voltage control requirements

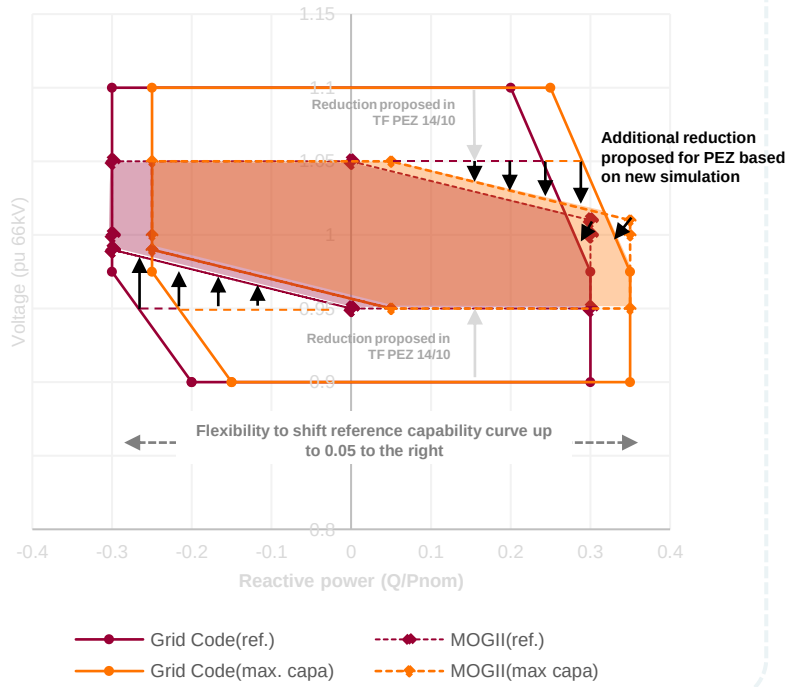
Updates and conclusions

2 **Q/V capability curve for wind farm**

- In the Task Force PEZ 14/10, Q-V capability was reduced from +/-10% of the nominal value to +/-5% of the nominal value having no impact at 220kV Elia grid
- **The simulations performed demonstrated that additional flexibility can be provided to offshore wind on Q-V capability curve**
- The Q-V capability curve that will be considered for the tender PEZ OWF is represented in the graph with area in red and orange

Additional flexibility is provided to OWF for requirement related to Q/V capability curve

Q-V capability curve for PEZ PPM

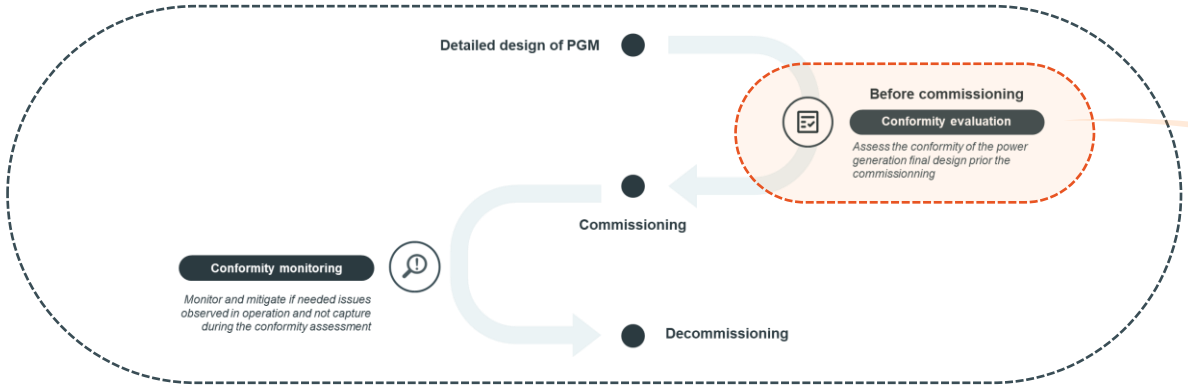


These adaptations will be included in the technical specifications for the OWF PEZ tender and included also in the public consultation

Conformity process

General process

A conformity process already exists in Elia to assess dynamic performance of individual power generation module with simplied approach (Single Machine Infine Bus – SMIB)



EDS

Conformity process start after reception of EDS

Energization Operational Notification (EON)

Permits to energise the internal network by using the grid connection

Interim Operational Notification (ION)

Permits using the grid connection for a limited period of time and to initiate compliance tests to ensure compliance with the relevant specifications and requirements

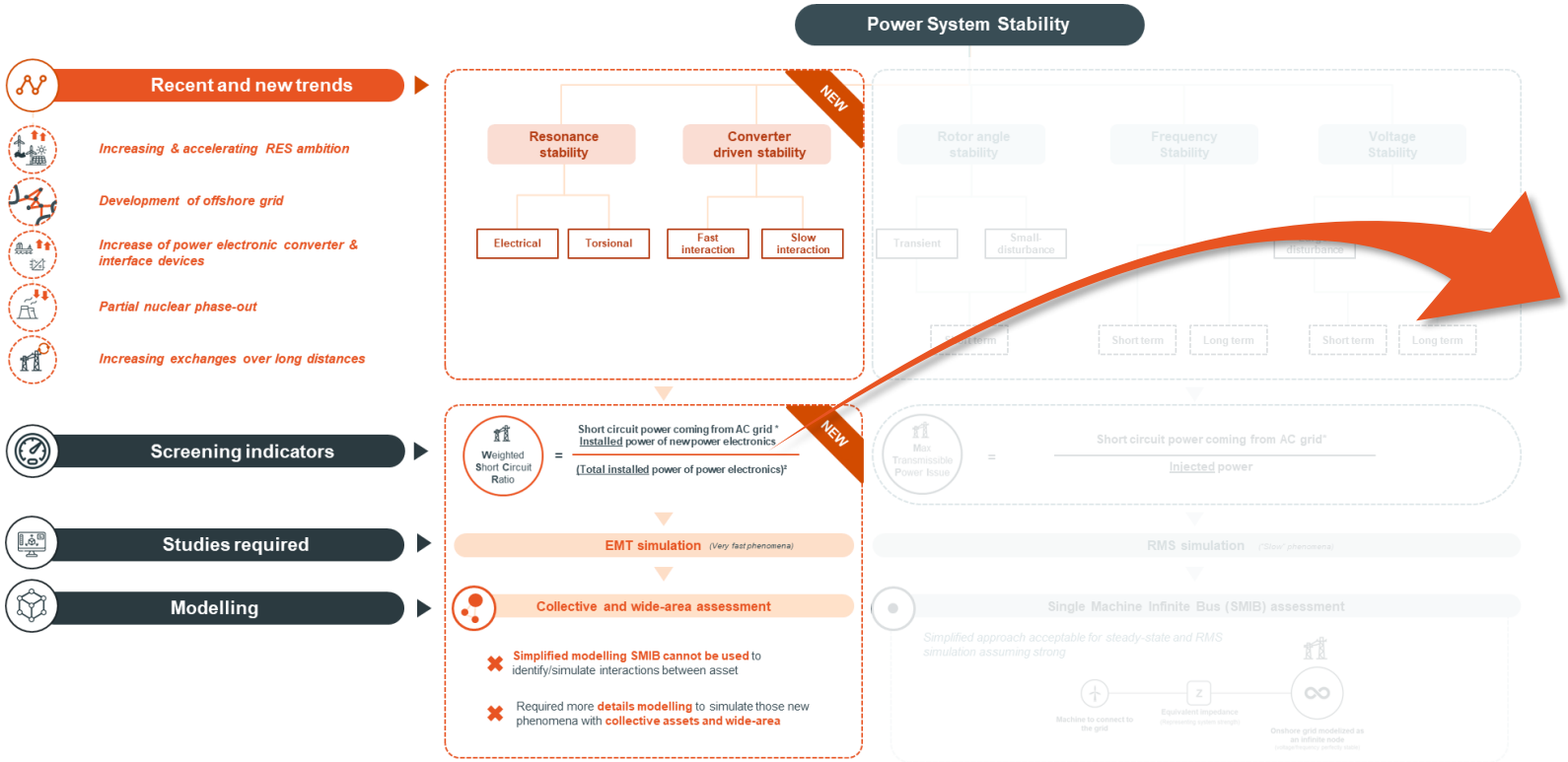
Final Operational Notification (FON)

Permits to operate the module which compliant with the technical requirement by using the grid. At this stage only, the owner can receive the reimbursement from the bank for the loan

Current conformity process

EDS	Stage 0	Pre-requesites : provision of general documentation & preliminary relevant system information
EON	Stage 1	Kick-off & System operating envelope requirements
	Stage 2	Proof of compliance, Data & model provision and validation
ION	Stage 3	Individual conformity assessment (SMIB)
		a Individual SPGM/PPM/SPM within the control area
	Stage 4	Non-conformance individual mitigation
FON	Stage 5	Commissioning and compliance testing
		a PPM/SPM test
		b Model validation
		c Staged tests

BE and EU system will face massive changes in the coming years leading to **new power system stability phenomena requiring upgraded of the generic conformity process applicable for any power generating module** to properly assess the dynamic performance of new installations and to secure the grid



Screening indicator for BE costal area

*These new phenomena will take place in Belgium with the Princess **Elisabeth Island** and especially in the single node operation*

Weighted Short Circuit Ratio

		Single node	Split node
A	Offshore	1.51	3.53
B	Onshore	1.05	2.33

Update of the generic conformity process for all future power generating module

These new phenomena, foreseen to take place with PEZ, **require to update the current conformity process** to assess the dynamic performance of the new assets **with new type of simulation** (RMS vs EMT) and **more detailed modelling** (SMIB vs multiple assets and wide-area) not currently covered in the existing process

An improved conformity process is needed to operate the system in reliable and stable way

Target

Improve conformity assessment and monitoring for power generation module (PGM) **to ensure reliable and stable operation of the system** and **secure timely delivery of FON**

Challenges

Modelling& Simulations

Wide-area EMT model development and simulations including relevant parts of other countries

Legal and regulatory

Consideration of IP restrictions for parties in **access to more data/model**

Develop solution which respects responsibilities **of each party (Elia/TSO, PGM and OEM)**

Future power system

Develop models and methodologies to predict a range of future power system performances

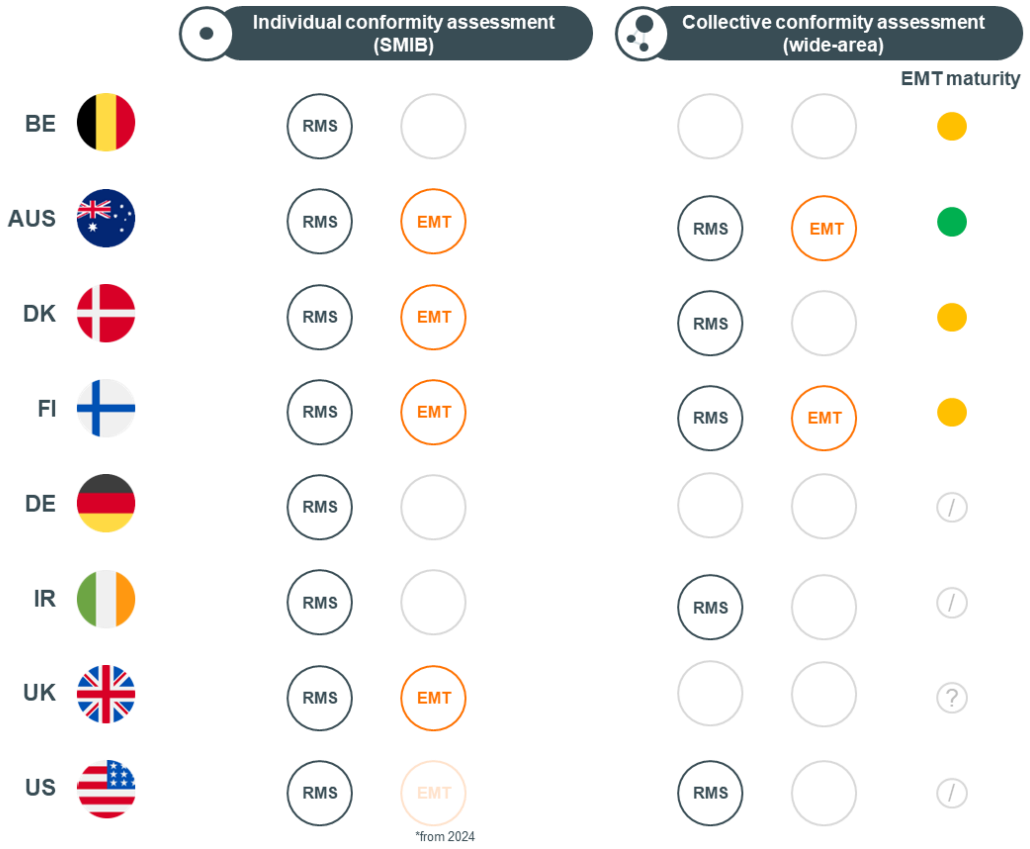
Capability to adapt PGM performance and settings if needed after commissioning

The objective is to **develop a solution** that will meet the target while answering the challenge in the **most proportionate and balanced way for the different parties**

Conformity process

Workshop with TSOs – Benchmark made and used as a basis to define the conformity process

Benchmark conformity process with other TSOs



Main outcomes of the worskhop organized by Elia with TSOs (31/03)

Elia organized a workshop with some EU TSOs facing such challenges and moderated by Australian consultant around conformity process

- **Importance and urgency of developing an improved conformity assessment** to assess the impact of large concentration of IBR was shared by participants.
- Benchmark confirms that **no other TSOs already has a mature collective** conformity assessment process

A conformity process with **a 5-steps approach** was defined/**agreed with the TSOs. This was used as a basis** for the elaboration of the updated conformity process

Overview of the evolution of the conformity process

EON: Energization Operational Notification
ION: Interim Operational Notification
FON: Final Operational Notification

Conformity process

EDS

Stage 0 — Pre-requesites : provision of general documentation & preliminary relevant system information

EON

Stage 1 — Kick-off & System operating envelope requirements

Process for data&model

Stage 2 — Proof of compliance, data & model provision and validation

ION

Stage 3 — Conformity assessment

- a — **Individual** SPGM/PPM/SPM within the control area
- b — **Collective** + multi-PPM/SPM (NEW!)

Collective perfor. assess. of **mult.** PPM/SPM within the control area

NEW! **Stage 4** — Non-conformity mitigation

FON

Stage 5 — Commissioning and compliance testing

Process for data&model

- a — PPM/SPM test
- b — Model validation
- c — Staged tests

Main evolutions of the conformity process

Main **novelty is mainly in the ION phase** linked to the type of simulation to be performed and lead to some change in other stages :

Input

1. **Additional information to be shared**

Assessment

2. **New type of simulation (EMT) and extended perimeter (wide-area)**
3. **How such simulation will be performed**
4. **Scenario to be assessed for the conformity assessment**

Output

5. **How non-conformity will be mitigated and how cost will be shared**

Criteria were defined to determine which type of simulation needs to be performed depending on the characteristics of the installation

SPGM: Synchronous Power Generation Module (nuclear, gas-fired unit, …)
PPM: Power Park Module (offshore wind park, onshore park, PV..)
SPM: Storage Park Module (batteries, pumped-storage…)
SCR: short-circuit ratio

Characteristics of the installation

	SPGM			
	SPM			
	PPM			
Type of the installation	Type A	Type B	Type C & D	Type D
Size of installation	=<1 MW	>1 MW	>=25 MW	>=75 MW
Aggregate SCR				< 3

Calculated without XB contribution

Aggregate SCR

$$= \frac{S_{cc_i}}{S_{nom_i} + \sum_j (MIIF_{ij} * S_{nom_j})} =$$

Min. short circuit power at connection node of assessed asset

Apparent power of the assessed asset and contribution of other relevant assets* impacted (=MIIF) by the assessed asset

Simulation to be performed by the client

Type of modelling	No studies	SMIB	Wide-area BE + SMIB
Type of simulation		RMS	
			EMT

Where

- **Sccl** = Minimum short circuit power at connection node of Assessed PPM/SPM
- **Snomi** = Nominal Apparent Power of Assessed SPM/PPM
- **Snomj** = Nominal Apparent Power of Relevant Assets
- **MIIFij** = Voltage dip on connection node of relevant PPM/SPM j in case of 3-phases metallic short-circuit on connection node of Assessed SPM/PPM

Relevant Asset are determined by relative electrical distance (MIIF) > 0.1pu and relative size weighted by the electrical distance > 10%

Split define to keep equilibrium between additional effort vs risk of such unit in the system

Additional data needs to be shared by Elia to perform more detailed studies

Conformity process

EDS

Stage 0 — Pre-requesites : provision of general documentation & preliminary relevant system information

EON

Stage 1 — Kick-off & System operating envelope requirements

Stage 2 — Proof of compliance, data & model provision and validation

Stage 3 — Conformity assessment

- a Individual SPGM/PPM/SPM within the control area
- b Collective + multi-PPM/SPM (NEW!)

Stage 4 — Non-conformity mitigation (NEW!)

Stage 5 — Commissioning and compliance testing

- a PPM/SPM test

Additional **anonymized** data to be shared **by Elia to the client** (assessed PPM/SPM):

1. *Min and max Scc and X/R at the assessed SPM/PPM connection node*
2. ***When applicable**, list of relevant HVDC/SPM/PPM with Snomj and MIIFij with indication grid following/grid forming control mode*
3. ***When applicable,** list of relevant SPGM/synchronous condenser with Scc contribution to assessed SPM/PPM*
4. *Aggregate SCR*

Additional model/data to be shared **by the client to Elia**

Already covered with "data & model provision" presented in TF PEZ

SPGM: Synchronous Power Generation Module (nuclear, gas-fired unit, …)
PPM: Power Park Module (offshore wind park, onshore park, PV..)
SPM: Storage Park Module (batteries, pumped-storage…)
SCR: short-circuit ratio

Different alternatives were considered to perform the conformity assessment by the client. The “cloud”-based platform with indirect access to wide-area RMS and EMT models put at disposal by Elia was retained as the most adapted solution

1. PPM/SPM owner will **have direct access** to wide-area RMS and EMT models

2. **An independent organisation** with legal access to the wide-area RMS and EMT models will perform the simulation

Discarded as not possible to guarantee implementation in due time for PEZ.

For option 1, *main issues are related to intellectual property & regulatory changes*

For option 2, *required important regulatory change and create this indep. organisation*

3. PPM/SPM owner will have **indirect access** to wide-area RMS and EMT models **via a cloud-based platform**

BASE solution *-The platform solution will allow the plant owner (via consultant and vendor) to directly perform the study and fine tune performance, avoiding unnecessary iteration with ELIA (saving of time and money)*

4. **Elia will conduct the studies by itself** and advise the PPM/SPM owner of the outcome

FALL-BACK *- ELIA remains as fall-back options where the ressources and cost of study will be imputed to the client*

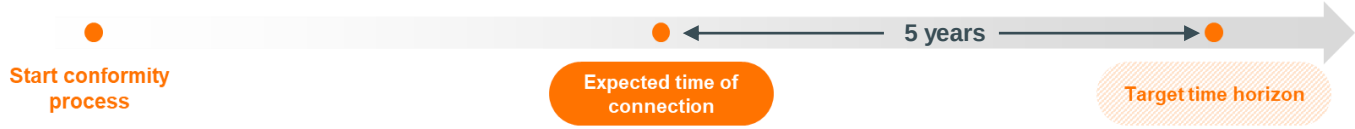
Several simulations is required to perform the conformity process and ensure proper tuning of the installation to secure the grid

Several simulations/references shall be performed by the owner

- ***Generation profiles**: max PGM infeed + min PGM infeed*
- ***Connection topologies***
- ***System strength**: full (strong) grid and weakest grid cases*
- ***Contingency events***

The number and type of simulation per requirement shall be limited to the minimum required to correctly assessed performance and conformity

and this for 2 reference years (expected time of connection and target time horizon)



The client shall perform the simulation for the "expected time of connection" and "target time horizon" (year+5)

In case of non-conformance of the installation, solution shall be found and where different candidates can play a role

List of candidates

1. **Assessed** — **generation/network assets which have kicked-off (stage 1) their conformity assessment**
2. **Future** — **generation/network assets with** known connection point and size, conformity expected in the next **5** years but has not been started
3. **Committed** — **generation/network assets** performance approved and connected < **5** years (FON received)
4. **Existing** — **generation/network assets** already connected for more than **5** years (FON received)

Different principles are considered to manage the non-conformance mitigation

Rules for non-conformance mitigation

1

a In all cases solution will be **first look at the level of Assessed asset**

b **Retuning of ELIA asset shall be considered** at same level as solution on generation

2

Solution to perform on Assessed & Committed generation under **full responsibility and cost of the asset Owner** under the following conditions

- ***Within period of max 5 years following the reception of their FON status***
- *With **maximum 5 occurrences***
- *Considering retuning of control command performance while **respecting hard limits of the installation***
- ***Without impact on the FON status** if delivered and applying the modernization principles*
- *In case the Asset owner is requested to analyze a possible retuning, time for the analysis shall be agreed with the TSO*
- *In case the Asset owner is requested to implement a solution, implementation time shall be agreed with the TSO*

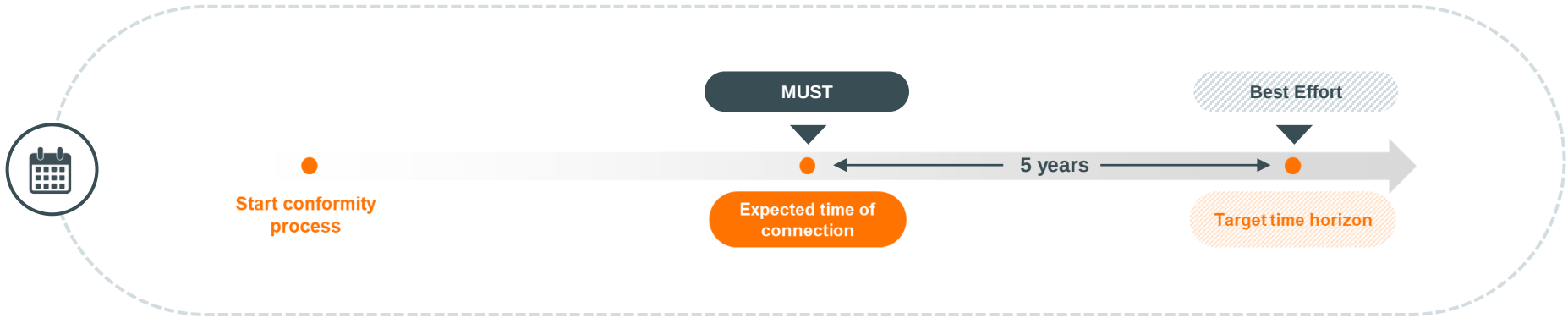
3

If instabilities foreseen for Future asset and cannot be solved by the Assessed asset, **solutions will be further investigated during the conformity assessment of the Future asset**

4

If a solution would concern **an Existing asset**, its implementation shall be assessed **on a case by case basis**

Different principles are considered to manage the non-conformance mitigation



MUST

Expected time of connection

The assessed generation **MUST be compliant for** the “expected time of connection”

Best Effort

Target time horizon

Time horizon that will include **all relevant asset(s) that will perform their conformity assessment in the next** 5 years after the Expected time of connection of the Assessed Asset

- ***The best effort is a trade-off to allow ELIA delivering FON without waiting for the conformity assessment*** *of the last relevant asset in this target time horizon to ensure secure and stable operation of the grid with large concentration of IBRs*
- *This best effort for the target time horizon is necessary* ***to create awareness of the need to improve dynamic performance*** *due to new relevant asset connection that will take place in the* ***near future and anticipate potential request for retuning***

Conformity process

Application of PEZ case

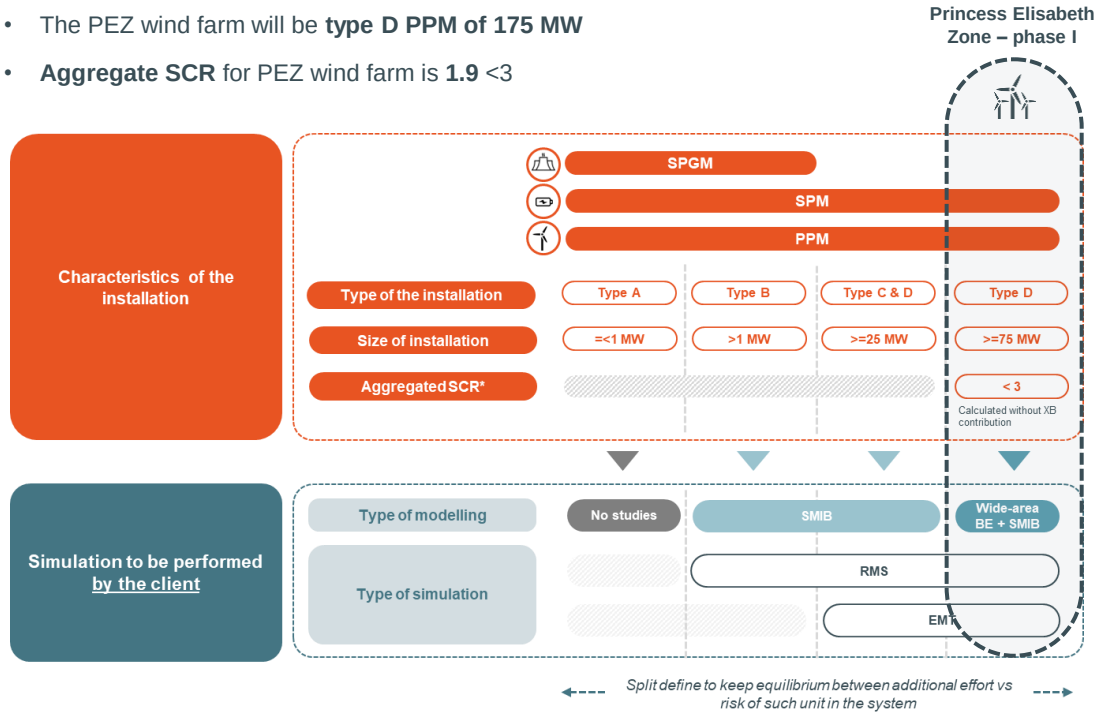
Elia provide the following elements at the end of the EDS stage

1. List of applicable requirements that will be subject to the conformity assessment
2. Conformity process description
3. Data and Modelling provision and validation process and criteria
4. General template for compliance follow-up
5. The Relevant information applicable to the PGM connection case

PEZ tender case

Characteristics of PEZ offshore wind farm

- The PEZ wind farm will be **type D PPM of 175 MW**
- **Aggregate SCR** for PEZ wind farm is **1.9** <3



Type of study to be performed by the client for PEZ

PEZ wind farm phase 1 shall perform **SMIB and BE wide-area RMS and EMT simulation** given the characteristics of the installation

EDS	EON	ION	FON
Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Pre-requesites	Kick-off	Data & model compliance	Conformity assessment	Non-conformance mitigation	Commission & compliance test

Elia provide the following elements at the end of the EDS stage

1. List of applicable requirements that will be subject to the conformity assessment
2. Conformity process description
3. Data and Modelling provision and validation process and criteria
4. General template for compliance follow-up
5. The Relevant information applicable to the PGM connection case

PEZ tender case

Requirement for General Application for type D PPM as defined as defined in the Belgian Grid Code and completed with 5 following requirements:

Voltage control and MVAr management

As described in the TF PEZ – full description foreseen in the public consultation report

Forced oscillation

As described in the TF PEZ – aligned with EE/WIndEurope proposal for EU NC amendments

Data & model provision

As described in the TF PEZ – documentation related to data & model provision for direct client

Conformity process

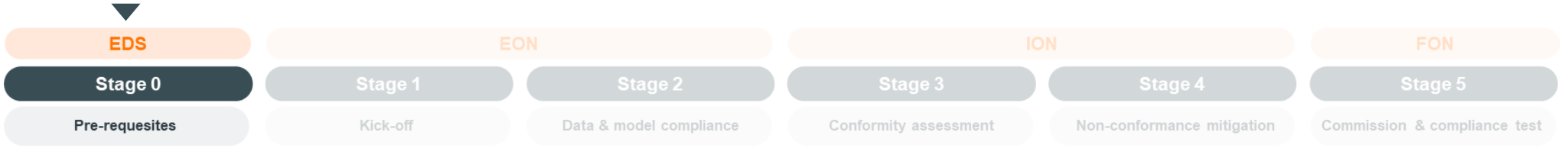
As described in the TF PEZ – full description foreseen in the public consultation report

Active power capability

A reduction from maximum production until a setpoint 0 MW must be done in maximum 1 minute

Full report description of the conformity process as presented today will be shared

As presented in Task Force 24/03 on requirement for direct and indirect client **– PEZ is subject to "DIRECT client" model requirements**



Elia provide the following elements at the end of the EDS stage

1. List of applicable requirements that will be subject to the conformity assessment
2. Conformity process description
3. Data and Modelling provision and validation process and criteria
4. General template for compliance follow-up
5. The Relevant information applicable to the PGM connection case

PEZ tender case

Elia will share the template with the requirements that needs to be foreseen to be compliant with

1. Data Questionnaire
2. PGM internal statement of compliance (RGIE, Icc max, fault clearing time, agreement on protection scheme)
3. Statement of Compliance via simulations or by proof/documentation
4. Compliance statement of the connection (VISA for MSI) and requested additionnal equipment by Elia

> EON

5. Statement of Compliance by simulation and modelling and studies
6. Presence of a decoupling protection
7. Panned tests

> ION

8. Statement of Compliance by field Test
9. Committed Data submission (updated data questionnaire, model tuning and validation)

>FON

More info per section in the next slides

Elia provide the following elements at the end of the EDS stage

1. List of applicable requirements that will be subject to the conformity assessment
2. Conformity process description
3. Data and Modelling provision and validation process and criteria
4. General template for compliance follow-up
5. The Relevant information applicable to the PGM connection case

PEZ tender case

Elia communicate to the client **the relevant information including the list of relevant assets** having an impact on the performance of the installation and to be considered in the wide-area simulation to be performed by the client

- Scc at the connection point of PEZ: 7.69 GVA*
- Snom of PEZ block: 195 MVA
- Aggregate SCR for all AC connected OWF= 1.9

** This value include the contribution of the 3 proposed Elia SynCon also considered as relevant assets*

List of relevant assets or PEZ

Name	Sk" at converter connection node [MVA]	MIIF [%]	App.Pow. [MVA]	Sensitivity [MVA]= MIFF*app.pow.
HVDC_1	17.02307	-41	700	287
HVDC_2	17.02307	-41	700	287
HVDC_3	17.38859	-30.5	1062.8	324.154
PPM_1	7.69585	-100	194.4	194.4
PPM_2	7.69585	-100	194.4	194.4
PPM_3	7.69585	-100	194.4	194.4
PPM_4	7.69585	-100	194.4	194.4
PPM_5	7.69585	-100	194.4	194.4
PPM_6	7.69585	-100	194.4	194.4
PPM_7	7.69585	-99.9	194.4	194.2056
PPM_8	7.69585	-99.9	194.4	194.2056
PPM_9	7.69585	-99.9	194.4	194.2056
PPM_10	7.69585	-99.9	194.4	194.2056
PPM_11	7.69585	-99.9	194.4	194.2056
PPM_12	7.69585	-99.9	194.4	194.2056
PPM_13	3.39028	-27.4	236	64.664
PPM_14	2.97857	-25.8	199.3	51.4194
PPM_15	2.97857	-25.8	240.4	62.0232
PPM_16	8.17579	-32.5	214.6	69.745
PPM_17	8.17579	-32.5	383.8	124.735
PPM_18	8.17579	-32.5	331	107.575
PPM_19	8.17579	-32.5	291.7	94.8025
PPM_20	8.17579	-32.5	263.1	85.5075
PPM_21	8.17579	-32.5	283.5	92.1375
PPM_22	8.17579	-32.5	245.6	79.82

+ 3 Elia Synchronous Condensers

Stage 1

Kick-off

During the kick-off, Elia will :

- Update the information shared at **the Stage 0**
- Shared **the list of simulations** to be performed to validate the data & model
- Share the **SMIB model** to be simulated by the client
- Provide **access to platform**

Stage 2

Data & model comp.

Client shared data/model and compliance proof to Elia before starting simulation for stage 3 in order to receive the EON (right to energized the installation)

1. Data Questionnaire			
1.1	Data questionnaire	FGC: Art 354 and Annex 3	Compliance proof
2. PGM internal statement of compliance (RGIE, Icc max, fault clearing time, agreement on protection scheme)			
2.1	Equipment and protection requirements - RGIE	RfG : Article 32	Compliance proof
2.2	Equipment and protection requirements - Annexe 1B - Icc max	Grid codes annexes applicable to new installations (FTR : art. 43)	Compliance proof
2.3	Equipment and protection requirements - Annexe 2B - Protections	Grid codes annexes applicable to new installations (FTR : art. 44)	Compliance proof
2.4	Specific protections scheme agreement	GR RfG: 4.2.1 FGC: Art.84 §1	Compliance proof
3. Statement of Compliance via simulations or by proof/documentation			
3.1	Frequency withstand capability	GR RfG: 3.1.1 FGC: Art 83 §1	Compliance proof
3.2	Rate of Change of Frequency (ROCOF)	GR RfG: 3.1.2 FGC: Art 83 §2	Compliance proof
3.3	Maximum allowable Power Reduction	GR RfG: 3.1.5 FGC: Art 83 §4	Compliance proof
3.4	Voltage withstand capability	GR RfG: 6.1.1 FGC: Art. 85 §2	Compliance proof
3.5	Information exchanges (communication channels)	GR RfG: 4.2.2	
3.6	Information exchanges (content)	GR RfG: 4.2.2	
3.7	Real-time monitoring of FSM	GR RfG: 5.1.5 FGC: Art 83 §11	Compliance proof
3.8	Frequency Restoration control	GR RfG: 5.1.4 FGC: Art 83 §10	Compliance proof
3.9	Rates of change of active power	GR RfG: 5.1.7 FGC: Art 83 §12	Compliance proof
3.10	Power quality requirements (if required)	Connection contract	Compliance proof
~~3.11~~	~~Automatic connection~~	not required for PEZ tender	~~Compliance proof~~
3.12	Automatic Reconnections	GR RfG: 4.1.2 FGC: Art 83 §6	Compliance proof
3.13	Automatic disconnection by voltage out of range	GR RfG: 6.1.2 FGC: Art.85 §1	Compliance proof
3.14	Loss of Main Protection by ROCOF	GR RfG: 3.1.3 FGC: Art 83 §2	Compliance proof
3.15	Instrumentation	GR RfG: 5.3.2 FGC: Art.87	Compliance proof
3.16	Earthing of the neutral point at the network side of the step-up transformer	GR RfG: 5.3.5	Compliance proof
3.17	Devices for system operation and security	GR RfG: 5.3.4 FGC: Art 87	Compliance proof
4. Compliance statement of the connection (VISA for MSI) and requested additionnal equipment by Elia			
4.1	Compliance of the connection	FGC : 159	Visa for MSI and/or compliance proof

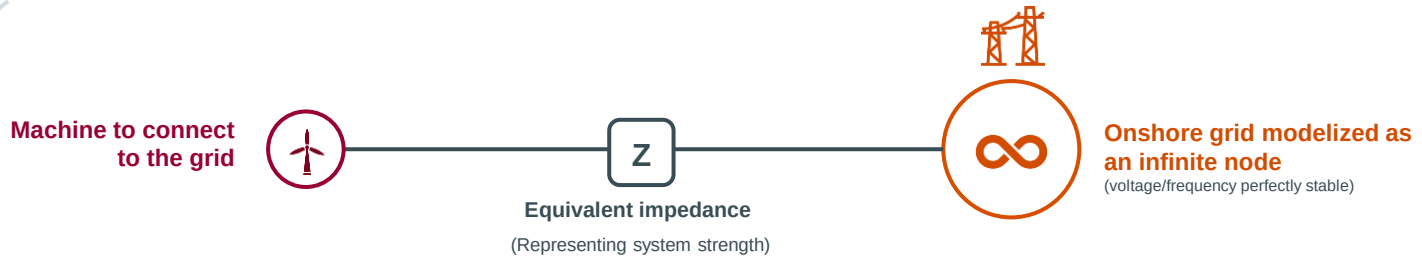
EON

The client will perform different simulations to demonstrate the performance of their installation following different scenarios described in the **table below**

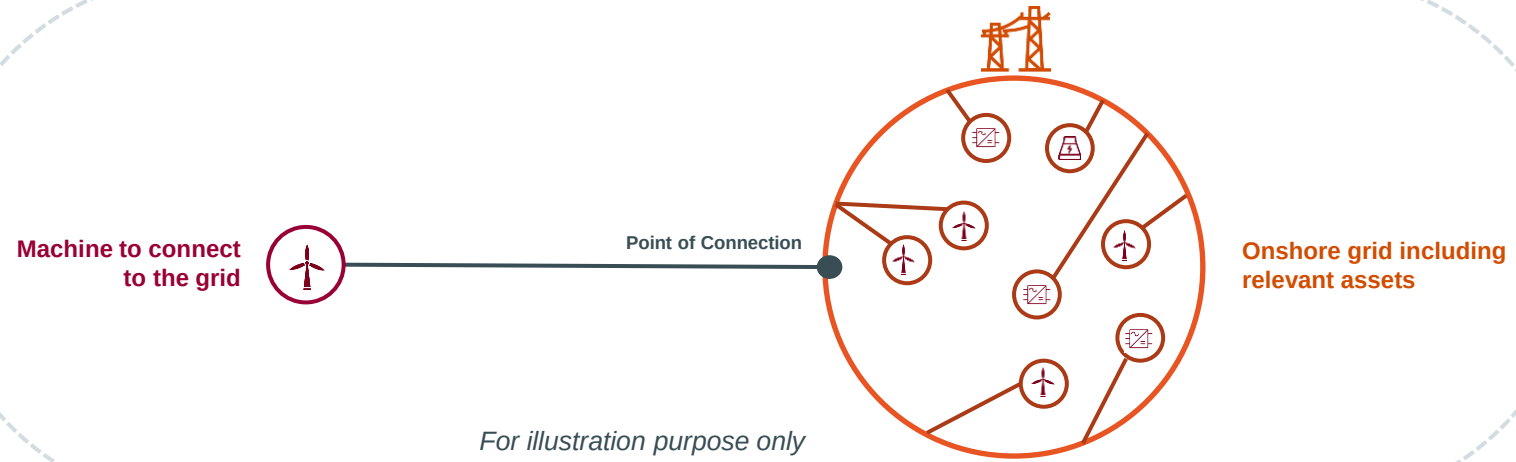
5. Statement of Compliance by simulation and modelling and studies				SMIB RMS	SMIB EMT	Wide-area RMS	Wide-area EMT
5.1	Simulation models	GR RfG: 5.3.3 FGC: Art. 87	Model				
5.2	Model documentation/Userguide	GR RfG: 5.3.3 FGC: Art. 87	Model				
5.3	LFSM-O	GR RfG: 3.1.4 FGC: Art 92 §1	Simulation Needed	2	2		
5.4	Active power controllability & control range	GR RfG: 5.1.1 FGC: Art 83 §8	Simulation Needed	2	2		
5.5	LFSM-U	GR RfG: 5.1.2 FGC: Art 92 §2	Simulation Needed	2	2		
5.6	FSM	GR RfG: 5.1.3 FGC: Art 83 §9	Simulation Needed	2	2		
5.7	Reactive Power Capabilitiy	GR RfG: 5.6.2 FGC: Art. 93 §2	Simulation Needed	2			
5.8	Fault Ride Through	GR RfG: 6.4.1 FGC: Art. 94 §3	Simulation Needed	4	4	12	12
5.9	Fault current & dynamic voltage support	GR RfG : 4.4.3	Simulation Needed				
5.10	Post-fault power active recovery	GR RfG: 4.4.4 FGC: Art. 95	Simulation Needed				
5.11	Voltage Control	GR RfG: 5.6.3 FGC: Art.93 §2	Simulation Needed	2	2	10	10
5.12	Capability to switch reactive control mode	new offshore OWF requirement	Simulation needed	2	2		
5.13	Dynamical performances of automatic voltage control	new offshore OWF requirement	Simulation needed				
5.14	Oscillations and Damping Control	Simulation document	Simulation Needed	4	4		
5.15	Loss of angular stability or loss of control	GR RfG: 5.3.1	Simulation Needed	2	2		
5.16	Frequency Restoration control	GR RfG: 5.1.4 FGC: Art 83 §10	Simulation Needed				
~~5.17~~	~~Island operation~~	not required for PEZ tender	~~Simulation Needed~~				
~~5.18~~	~~Resynchronization capabilities~~	not required for PEZ tender	~~Simulation Needed~~				
6. Presence of a decoupling protection							
6.1	Verification of presence of decoupling protection (Elia standards)		Compliance proof				
~~6.2~~	~~Automatic disconnection for voltage outside ranges~~ *(not required for PEZ tender)*	not required for PEZ tender	~~Simulation needed~~				
7. planned tests							
7.1	List and agreement of planned tests	FGC: Art. 177	List of tests				

In the framework of the PEZ tender phase 1, the client will need to perform around 90 simulations to demonstrate the performance of their installation

SMIB



Collective wide-area



For illustration purpose only

PEZ tender case

46 SMIB simulations

- RMS: ≈ 24 simulations
- EMT: ≈ 22 simulations

44 wide-area simulations

- RMS: ≈ 22 simulations
- EMT: ≈ 22 simulations

Total ≈ 90 simulations

EDS | EON | ION | FON

Stage 0 | Stage 1 | Stage 2 | Stage 3 | Stage 4 | Stage 5

Pre-requesites | Kick-off | Data & model compliance | Conformity assessment | Non-conformance mitigation | Commission & compliance test

Planning

2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034

Offshore tenders

- *Phase 1 - 700 MW AC*
- *Phase 2 - 1400 MW AC*
- *Phase 3 - 1400 MW DC*

5 years

- Phase 1- 700 MW AC OWF commissioning
- Phase 2 - 1400 MW AC OWF commissioning
- Phase 3 - 1400 MW DC OWF commissioning
- Nautilus commissioning*
- TritonLink commissioning*

** Based on the perspective developed in the Federal Development Plan 2024-34*

List of candidates		Application case to PEZ phase 1	Application case to PEZ phase 2/3
1 Assessed	**Network/generation assets which have kicked-off (stage 1) their conformity assessment**	*Phase 1 - 700 MW AC*	*Phase 2 - 1400 MW AC*, *Phase 3 - 1400 MW DC*, *Nautilus*, *TritonLink*
2 Future	**generation/network assets with** known connection point and size, conformity expected in the next **5** years but has not been started	*Phase 2 - 1400 MW AC*, *Nautilus*, *Phase 3 - 1400 MW DC*, *TritonLink*	
3 Committed	**generation/network assets** performance approved and connected < **5** years (FON received)	*Not applicable, phase 1 will be "committed" when conformity process for phase 2 and 3*	*Phase 1 - 700 MW AC*
5 Existing	**generation/network assets** already connected for more than **5** years (FON received)	*MOG1*, *NEMO link*	*MOG1*, *NEMO link*

Flexibility is given to not wait the phase 2 and 3 for the PEZ OWF tender to provide FON to installations from phase 1 PEZ tender

8 As defined in the law, **the client has 24 months after reception of the ION to test the compliance of their installation** to receive their FON

9 **Data and model are revalidated** (following process presented in Task Force 24/03) closing the conformity assessment and providing the FON to the installation

8. Statement of Compliance by field Test			
8.1	Active Power Control	GR RfG: 5.1.1 FGC: Art 83 §8	Test needed
8.2	LFSM-O	GR RfG: 3.1.4 FGC: Art 92 §1	Test needed
8.3	LFSM-U	GR RfG: 5.1.2 FGC: Art 92 §2	Test needed
8.4	FSM	GR RfG: 5.1.3 FGC: Art 83 §9	Test needed
8.5	Reactive Power and Voltage Control	GR RfG: 5.6.3 FGC: Art.93 §2	Test needed
8.6	Reactive Power Capability	GR RfG: 5.6.2 FGC: Art. 93 §2	Test needed
8.7	Telecom tests (communication channels)	GR RfG: 4.2.2	Test needed
8.8	Telecom tests (content)	GR RfG: 4.2.2	Test needed
8.9	Frequency Restoration control	GR RfG: 5.1.4 FGC: Art 83 §10	Test needed
8.10	Power modulation	-	Test needed
8.11	Power quality tests (if required)	Connection contract	Test needed
8.12	Automatic connection/reconnection	GR RfG: 4.1.2 FGC: Art 83 §6	Test needed
8.13	Island operation	GR RfG: 5.2.1 FGC: Art.86	Test needed
8.14	Resynchronization capabilities	GR RfG: 5.2.2 FGC: Art 86	Test needed
8.15	Wire Break Test	-	Test needed
8.16	Test Report	-	Report
8.17	Model Validation	-	Model
8.18	Behavior on receival of MVAR setpoint	**new offshore OWF requirement**	Test needed
8.19	Active power forced oscillations	**new offshore OWF requirement**	Test needed
8.20	Capability to disable the fast current injection by PPM operator	**new offshore OWF requirement**	Test needed
9. Committed Data submission (updated data questionnaire, model tuning and validation)			
9.1	Availability of updated data questionnaire		Compliance proof

FON

Thank you

Appendix

Connection requirements

Cable + terminal system

- ✓ Dry-type termination
- ✓ Interface GIS conform acc. IEC 62271-209 cl 7 in customer's scope of supply, with following amendments:
  - ✓ Elia will provide the Female part of the cable termination (GIS 66kV)
    - ❑ Elia has standardized the type of the epoxy : Pfisterer HV-CONNEX, Size 4 (industry common practice)
    - ❑ Installation in GIS factory
  - ✓ OWF will provide the male part of the cable termination (Cable 66kV)
  - ✓ OWF must qualify the male part with Pfisterer (EN-60840)
  - ✓ Plug – in installation of the Cable