Task Force MOG 2

24th of March 2023

Agenda

Balancing

[60 min] Mitigation measures

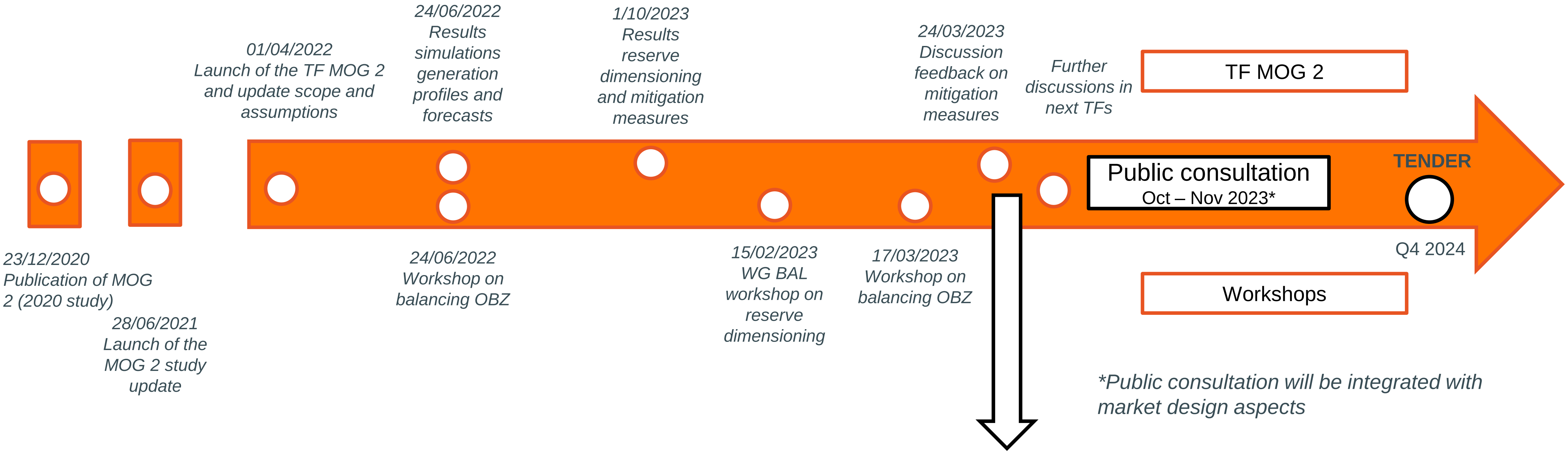
Dynamic and harmonic

[60 min] Data & models provision and introduction on conformity process

Balancing – mitigation measures

Kristof De Vos and Aline Mathy

Timeline balancing aspects



Discussion feedback on mitigation measures

- discussion on the justification and implementation of the recommended mitigation measures (based on questions received from stakeholders) presented in the TF MOG 2 of 10.01.2023

Input received from stakeholders

QUESTIONS WERE RECEIVED ON :

Clarifications will be provided throughout the presentation

A. General design principles of mitigation measures

- level playing field between BRP's, without differentiation in function of technology
- avoid any retroactive application of the mitigating measure
- distinction between balancing (risks) and grid security (risks)

B. Assumptions on system simulations

- in particular to the market reaction related to CCMD scenarios
- re-evaluation of the need to maintain the alpha component.

C. Impact of the recommended mitigation measures

- ability of equipment suppliers will be able to install wind turbines with high wind speed technologies.
- preventive curtailment : remuneration and the implementation of the maximum number of activations on wind parks
- ramping limits level playing field in procedures on cut-in coordination, and possibility to re-enforce requirements under worst case market conditions

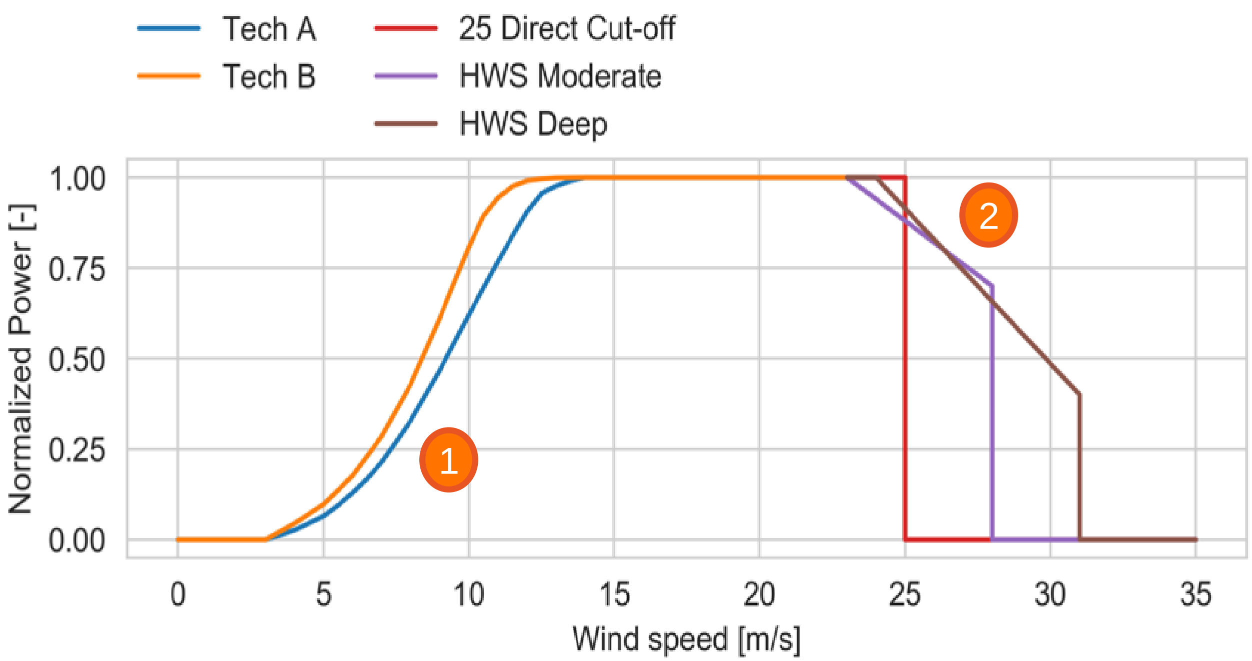
Summary

What ?

When focusing on extreme offshore weather events, **two relevant cases** are identified

1. **Ramps (below wind speeds of 20 m/sec)**
   Sudden variation of wind power generation as a result of wind speed variation related to the exponential profile of the power curve at normal wind speeds.

2. **Storms (above wind speeds of 20 m/sec)**
   Sudden variation of wind power generation due to cut-out / cut-in behavior of wind turbines in case of elevated wind speed related to high wind speed management systems of turbines.



Power curves for assumed technology scenarios and storm shutdown scenarios in MOGII integration study

Mitigation measure design principles

1. **Elia is responsible for system security and needs to avoid <u>system violations</u> at any time.**

2. **Mitigation measures are designed to**

   A. imply the least cost possible for society

   B. take into consideration the complexity and timing to solve the issue

   C. mitigate cost when market shows good performance and activation of measures can be avoided.

Measures are designed under assumptions of future market performance, it does not exclude that additional measures / reserves are needed when observing an evolution towards market performance beneath the scenarios presented.

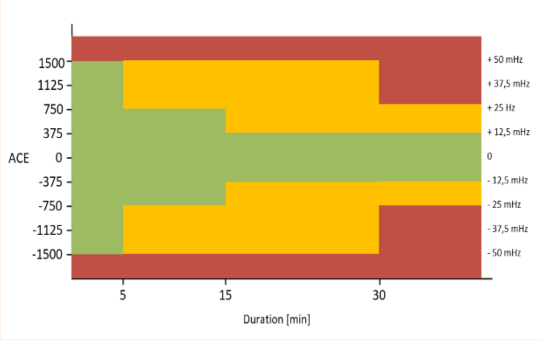
3. **Aim for transparency and visibility on the impact for the wind park / BRP**

The mitigation measures are identified for upcoming tenders corresponding to the announced 3.5 GW offshore capacity. Existing parks are not impacted except that they can choose to voluntary adopt the ramp rate limitation regime (instead of the current cut-in coordination)

The impact of additional offshore wind power above 5.8 GW needs to be assessed separately. Additional, more stringent, mitigation measures might be required with increasing capacity. Existing information does not allow detailed assessment, and certainly not to impact tenders for the foreseen 3.5 GW.

While Elia agrees with stakeholders to avoid retro-active application of new measures, it cannot be fully excluded as this is not solely in the hand of Elia.

System violations



Alert: system is still within Operational Security Limits, but a Contingency has been detected, for which in case of occurrence, available Remedial Actions are not sufficient to keep Normal State

=> To be solved as soon as possible

Emergency: One or more operational security limits are violated

⇒ To be avoided at all time

The need for mitigation measures for exceptional balancing conditions (assuming 4.4 GW offshore wind power installed) as per Elia study of 2020

Elia | Elia Group

2.3 GW *offshore wind capacity* — **2018**

- Elia investigated the potential impact of storms towards the commissioning of the first 2.3 GW offshore
- Mitigation measures put in place focused mainly on power shortages following (unexpected) cut-out events following storms
- A **storm mitigations measure** was implemented to follow-up on market response after detection of a storm, and complemented with the potential pro-active activation of flexibility by the TSO if needed
- An **additional measure** has been put in place **to react to imbalance price signals** (alpha-parameter)

4.4 GW *offshore wind capacity* — **2020**

- **Elia investigated** the potential impact of storms and ramp events when extending the offshore generation fleet to **4.4 GW (as foreseen at that time)**
- **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
- A recommendation of **High Wind Speed technologies** was presented as a good solution to limit the impact of storms to the extent possible
- The storm mitigations measure was extended to a measure for **preventive curtailment** of offshore production in case of expected flexibility shortages and inadequate market response
- **Ramp rate limitations** were put forward to deal with fast and unexpected upward power ramps (including during cut-in phase after storm)

5.8 GW *offshore wind capacity* — **2023**

- An **update of the 2020 study** was requested by stakeholders before specifying requirements in the Tender with the following objectives:
  - update the simulations with latest observations and expected system evolutions
  - confirm the proposed mitigation measures
    - *High wind speed technologies*
    - *Preventive curtailment*
    - *Ramp rate limitations*
- **Update increased in relevance** with the decision to increase offshore wind to **5.8 GW**.
  - Investigate how the expected impact on the system evolves by increasing the capacity to 5.8 GW
  - Investigate if the proposed mitigation measures are still adequate in a 5.8 GW offshore context and potentially complement / strengthen them.

Market performance assumptions

- Based on historical observations for 2.3 GW offshore park (2020-22)
  - 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
- Best case events generally result from predicted events while worst case events rather result from unpredicted events
- Additional wind power is assumed to be managed with same performance as today when having access to additional flexibility (through CCMD market reform)

Aligned with REA+ scenario presented in WG BAL workshop on reserve dimensioning 15.02.2023

MOG 2 2022 Observations for 2.3 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%	10 min	3,5%	85%	15 min	3,5%
Worst case	30%	130 min		50%	100 min		60%	120 min	

**Average of minimum and maximum over events analyzed in 2020, 21 and 2022*
***Average of average over events analyzed in 2020, 21 and 2022*

Performance compared to MOG 2 (2020) assumptions: = (orange), < (green), > (red)

Increasing wind installed to 5.8 GW ⇔ Additional available flexibility

MOG 2 2022 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%	80%	15 min*	3,0%	85%	15 min	3,0%
Worst case	30%	120 min*		50%	120 min*		45%	120 min	

**Values rounded*
In red: reduced performance compared to current observations

MOG 2 balancing responsibility

- **Per article 5 of Electricity Regulation 2019/943 (internal market for electricity – recast), all market participants shall be responsible for the imbalances they cause in the system. It clarifies that this entails full financial responsibility**
  - Via the imbalance tariff, the wind farm is incentivized to follow through on their sold volumes in the market. It can control this by improving forecasting accuracy or adjusting their position closer to real-time (intra-day, self-correction…).
  - Without balancing responsibility, higher forecast errors will result in increased risks for real-time flexibility shortages and network congestions, in worst case leading to demand shedding or renewable energy curtailment.
  - The lack of balancing responsibility renders the market ineffective to ensure its function of distributing the responsibility to dispatch the entire system and the TSO will need to take over this function via additional reserve capacity and exceptional balancing measures (of which costs will be attributed to the grid user)

- **This presentation and design principles need to be seen in the light to create adequate (representing value of balancing energy) and consistent (in line with intra-day and day-ahead) price incentives in the balancing time frame allowing to** :
  - Mitigate the impact of renewable generation on reserve dimensioning (= balancing procurement costs) and exceptional balancing measures (= activations costs) accounted to the grid user

General conclusions of system simulations

	Storm	Ramp

Cut-out / Ramp down	- **No violations are observed anymore** compared to 4.4 GW under **best case assumptions** (thanks to better market performance assumed)
	
	- **Frequency of violations increases under worst case assumptions** compared to 4.4 GW even during periods with high flexibility available in the system
	
	The results under worst case assumptions confirm the need for the proposed mitigation measures in the MOG 2 2020 study
		- **Amount of violations increases under worst and best case** assumptions compared to 4.4 GW despite better market performance assumed :
		  - Violations become also present in the best case
		  - Substantial increase of the violations in the worst case
		
		This creates the need for mitigation measures dealing with downward ramping

Cut-in / Ramp up		- **Still no violations** are observed **under best case assumptions** - **Amount of violations under worst case assumptions remains similar** to 4.4 GW (due to increasing market performance) **The results under worst case assumptions confirm the need for the proposed mitigation measures in the MOG 2 2020 study**

Summary of Mitigation Measures

Existing mechanisms

Recommended measures with explicit impact on wind power producers and BRPs

	Storm	Ramp
Cut-out / Ramp down	**Preventive curtailment** (Storm and Ramp)	
	High wind speed technologies Current storm procedure for existing parks	
Cut-in / Ramp up	**Ramp rate limitations** (Storm and Ramp)	
	Automatic cut-in coordination for existing parks	

General actions for investigation by Elia

- Price incentives Real Time Pricing (incl. alpha)
- **Access to flexibility : Exchange of Energy Blocks**
- Enhanced forecasting capabilities
- Advanced mFRR activations strategies

CCMD
(taken into account in market performance indicators)

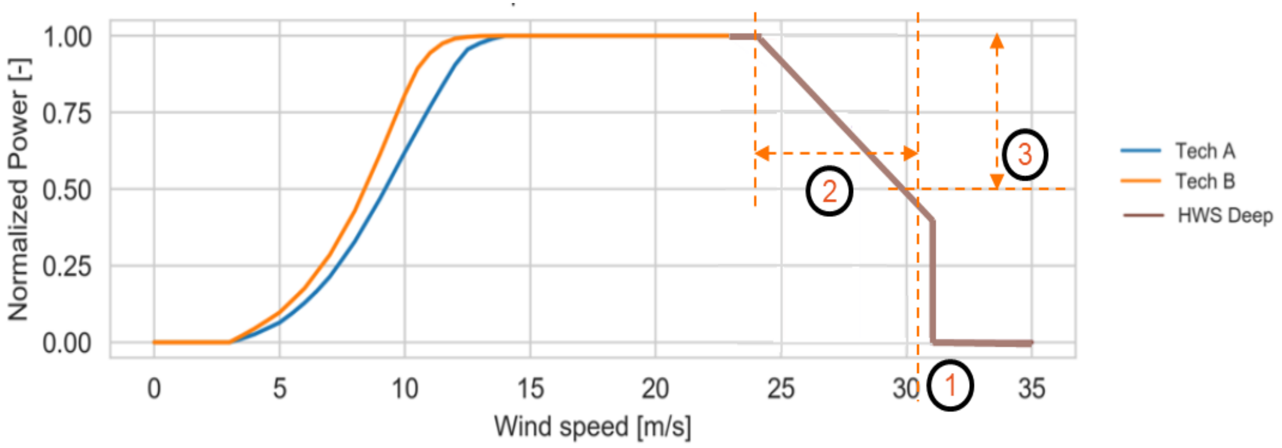
Recommended mitigation measures

High Wind Speed (HWS) technology requirements

Storm Cut-out

High wind speed technology

- Elia proposes a technical minimum requirement on new wind turbines to be able to maintain generation until 31 m/sec.
- The recommendation was proposed by Elia in 2020 as a desirable mitigation measure to manage storm cut-outs



Implementation as foreseen :

- Respect the following requirements at turbine level, for each single turbine:
  1) sudden cut-off cannot occur before 31m/s (for an averaging time of 10 minutes)
  2) gradual power decrease starts at average wind speeds at least 5m/s below the sudden cut-out average wind speed
  3) gradual decrease of power must be guaranteed until a Nominal Power of at least 0.5 before sudden cut-out occurs.

Alternative implementation option (on request of BOP) :

- Elia seeks confirmation first of market players that this option will be effectively used
- The alternative will be based on the ability of wind parks to demonstrate that the solution chosen is at least equivalent at the connection point based on:
  - Extreme events (wind speed profiles) that need to be simulated to provide equivalent Power Output
  - Resulting ramp rates difference (power output) shall not be worse than an equivalent behavior of the requested profile by Elia

Elia will specify the HWS technology requirement on turbine level in the Tender requirements

It will also specify it will allow equivalent characteristics as connection point level.

Elia will provide the expected behavior at connection point level towards the commissioning of the wind parks.

Impact assessment of HWS technology requirements

- Elia's system simulations show that the measure is helpful in reducing emergency situations, particularly during :
  - Worst case market behavior (e.g. unforecasted storms)
  - Low availability of non-contracted mFRR balancing energy
  - During the beginning of the storm-cut out

  But **still needs to be complemented with additional mitigation measures** as risk of emergency situations persist

- The market is implementing HWS technologies as this is becoming a **customary feature** for most turbine manufacturers.

- No objections received by wind power sector (including technology providers participating in the TF MOG 2) on the future technical capability (but no information is currently available on new storm control capabilities)

- The use of HWS technologies is already incentivized through Grid Connection compliance requirements

Elia considers that this technical requirement (already being or becoming a standard technology) has limited impact for the business case of wind power in comparison to the advantages for the system

Ramp rate limitations for wind power generation

Storm Cut-in | Ramp up

Ramp rate limitation

- Elia proposes to limit the maximum upward ramp rate to 15 MW per minute for new offshore wind parks when system imbalance exceeds 500 MW
- The recommendation was put forward by Elia in 2020 as a desirable mitigation measure to manage storm cut-in and expected / unexpected ramps, as well as simplify the existing cut-in coordination procedures

SA → TSO → SA

Ramping rate limitation dependent of the system conditions

When a storm event has ended, the SA Offshore Power Park Module informs Elia to cut-in by sending an IDPCR

The IDPCR will be automatically approved by Elia.

Parks are subject to general ramp rate limitations depending on system conditions (system imbalance level)

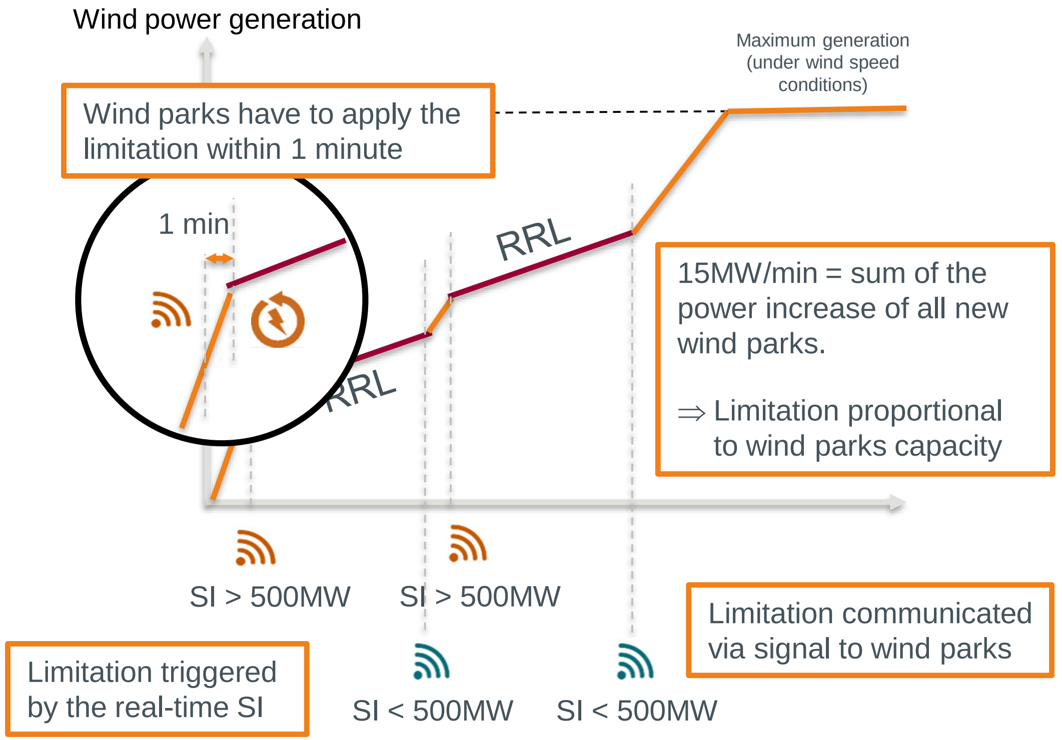


Illustration of a wind power (fleet, park or turbine) cut-in after full cut-out

Relation of the ramp rate limitation to the existing cut-in coordination

As most existing parks cannot react based on real-time system conditions / signals

- Analysis from DTU clearly demonstrates the need to coordinate the cut-in phase after a storm event
- Requirement is already implemented in the T&C SA and T&C OPA and is in line with Article 131 of the Code of Conduct
- Implementation of the automatic cut-in coordination or ramping rate limitation at the latest when connecting the new parks

Request from the market

Currently applied on a case by case basis. Market parties requested clear parameters and guarantees, particularly:

- Clear and transparent **framework** around cut-in coordination
- No undue **delay** + **maximum duration** of the cut-in
- **Non-discriminatory** process between wind parks
- Existing parks shouldn't be impacted by **new wind parks rules**
- Take into account the **available technical functionalities**

BUT, manually, this cannot be guaranteed anymore in the future configuration due to increased system complexity

⇒ **The coordination must be automatized** (via A or B)

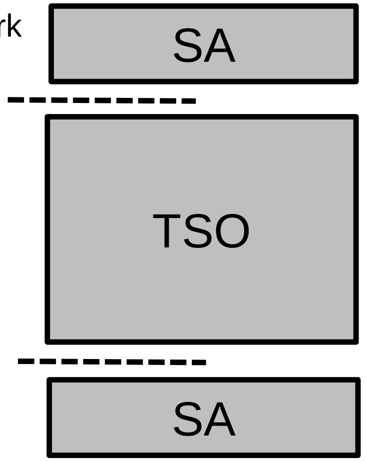
A — **Cut-in coordination for existing** offshore **wind parks**: Automatic 'static' cut-in coordination independent of system conditions

When a storm event has ended, the SA Offshore Power Park Module request approval to cut-in by sending an IDPCR

As is : Elia manually approves the IDPCR and coordinates the cut-in phase for each wind park individually.

NEW — To be : Elia automatically approves IDPCR but imposes a linear ramping profile (or equivalent) in a pre-defined period of around 1 hour after request to come back via the SA

→ To be discussed with existing parks



B — For existing offshore wind parks **able to react on real-time signals**, the **Ramping Rate limitation** proposed to new parks **can be applied** instead of the automatic cut-in coordination

Impact assessment of the ramp rate limitation

Storm Cut-in

Ramp up

- **Elia's system simulations show that proposed ramp rate limitations can eliminate almost all emergency situations :**
  - A sensitivity analysis confirms the trigger at 500 MW and ramp rate at 15 MW/min
  - But some emergency conditions are expected to remain :
    - Worst case market behavior (e.g. non-forecasted ramps)
    - Low availability of non-contracted mFRR balancing energy, even under best case market behaviour
- **By applying the wind production measurement from an existing wind park on top of the historical system imbalance data over 1 year, we showed that the measure results in very limited / negligible generation reductions with a full load impact of 0,2 hours per year**
  - Note that the activation frequency of mechanism may be impacted with an offshore bidding zone (cf. next slide)
  - Note that the financial impact will depend on the selected subsidy scheme (further iteration will be needed after selection of the subsidy mechanism)
- **The applied generation limits depend directly on the performance of the market. Activation is avoided when market parties react pro-actively on the system imbalance**

Simulations demonstrate that fast upward ramps are a threat to the system, particularly in cases with worst case market performance. While already managed today via cut-in coordination after storm, this measure needs to be generalized towards upwards ramps in general (also outside storm conditions). The impact of the measure is mitigated if market reaction keeps the system imbalance under control.

Impact of an offshore bidding zone on the activation frequency of the ramp rate limitations

<u>First analysis following feedback received during the workshop 17/03</u>

- In line with the proposed measure, the ramp rate limitation would be triggered under the netted imbalance over the two LFC Areas in the LFC block
    - It allows to take into account the onshore imbalance situation and thus to take into account imbalance netting between the two LFC Areas before activating the ramp rate limitations.
    - But it can be expected that the market reaction of onshore BRPs is lower in an OBZ as they will react on onshore LFC area system imbalances and system imbalances prices rather than on the offshore LFC area imbalances and prices.

    - The expected frequency of activation of the ramp rate limitation is thus expected to increase in an OBZ.

Preventive curtailment

Storm Cut-out	Ramp down

Preventive curtailment

- Mitigation measure allowing to preventively curtail wind power **after forecasted storm or downward ramping event** and **assessment of mitigation measures undertaken by BRPs**
- Proposed in the MOG 2 study in 2020: to be integrated with the existing exceptional balancing measure for storm risk management

AS-IS storm procedure

Forecast: RMI → Storm forecasts → Send storm alerts and communicate with BRP

BRP communications: Communicates intra-day measures taken to mitigate impact on portfolio → Remaining risk > balancing reserves

Fallback: Activation of additional flexibility via activation slow-start units

Extension for Storm cut-out

Extension for Ramp Down

A forecast tool for downward ramping is to be developed*

**Feasibility of such forecast is still to be evaluated. Limited predictability may still require complementary solutions (e.g. reserve capacity increase, or exceptional balancing measures)*

Considering the volumes needed, the slow-start units that could be activated on the day of the storm in the current storm process might not be sufficient.

⇒ **Preventive curtailment of offshore wind power (from new parks)** for the remaining risk (after BRP mitigation measures), not covered by balancing reserves or <u>via slow-start units</u>

Also applicable for ramping down events

<u>Timing:</u>

DA: allows BRPs to find the energy necessary on the day-ahead market to stay in balance

ID: based on last (more accurate) forecasts. Requires liquidity on the intra-day market

Exact timing of the trigger to be determined

Impact assessment of the preventive curtailment measure

Storm Cut-out	Ramp down

- Elia's system simulations show that the measure is needed to deal with storm cut-outs and downward ramp events
  - Worst case market behavior (e.g. unforecasted storms) and even best case market behaviour (e.g. unforecasted ramps)
  - Low to even moderate availability of non-contracted mFRR balancing energy
  - Even after assuming implementation of HWS technologies

- This measure is expected to result in a limited generation reduction for wind power, i.e. in a conservative estimation
    - The cap is low in comparison with the average annual production hours
  - 187,5 hours per 5 years for storms (under assumption of full curtailment for 7.5 hours, for 5 storms a year)
    - The cap includes hours where the wind park would likely not have been able to produce anyway due to the storm
  - 265 hours per 5 years for ramps (under assumption of full curtailment for 1 hours, for 53 ramps a year)
    - Curtailment will limit the risk for the BRPs to be unbalanced at a moment where the imbalance price is expected to be high

- Note that the potential effect of lost energy revenues will depend on the selected subsidy scheme (further iteration needed)
  - A certain price risk cannot be avoided as it intends to make the BRP cover shortages in the intra-day market
  - The initial proposal was to specify a cap ahead of the tender under which activations are not remunerated

- Implementation will be integrated in the exceptional balancing measures, encouraging / obliging BRPs to manage their portfolio (cf. storm procedure). Correct behavior of BRPs will result in avoiding activation of the measure.

> Elia considers storm cut-outs and downward ramps as a serious threat to the system. While already managed today via HWS (in case of storm), analyses show that HWS is not sufficient and that preventive curtailment is needed in case of storms and also needs to be extended towards downward ramps. The financial impact can only be assessed after the subsidy scheme has been selected

General messages on mitigation measures

In depth simulations / analysis by DTU / Elia reveal the need for mitigation measures

Even with high wind speed technologies, simulations conducted by DTU show that downward variations up to 3.5 GW in 60 minutes may happen every 10 years (and up to 2,5 GW every year) and upward variations up to 5.5 GW every 10 years (and up to 3,5 GW every year).

- Observations and simulations demonstrate that BRP reactions for storms and ramps events is not always sufficient to mitigate their impact.
  - Exceeding operational security limits arises for all up- and downward ramps (including related to storms) under worst case market conditions
  - Exceeding operational security limits arises with downward ramps even under best case market conditions

Proposed mitigation measures are designed to :

- fully cover the operational risk following storm and ramps
- find a trade-off between :
  - limit impact on cost for grid users by limiting impact on reserve needs
  - limit impact on wind parks, at least when showing good market reaction

The high wind speed requirement for new parks is confirmed as 'no regret solution' as it reduces escalation events while expected to become standard technology. On request of market parties, Elia will develop the possibility to translate the requirement to the connection point level

Ramp rate limitations for new wind parks during high system imbalance conditions in the Elia LFC block for new parks are crucial to manage extreme upward ramping events (including storm cut-ins). Elia will allow existing parks to voluntary switch from cut-in coordination procedures to ramp rate limitations.

Preventive curtailment during low market reactions will be further elaborated to deal, besides forecasted storm cut-outs, with forecasts downward ramping events, after follow-up on mitigation measures taken by the market (in line with current storm procedures).

- Both measures allow to (almost) mitigate all escalation events the impact for wind parks on lost revenues is limited
- Both measures avoid activation and costs incurred when market achieves to balance the variations
- **Elia will investigate the predictability of ramping events. It is not excluded that forecast issues and limited market reaction requires complementary solutions (e.g. reserve capacity increase, or exceptional balancing measures)**

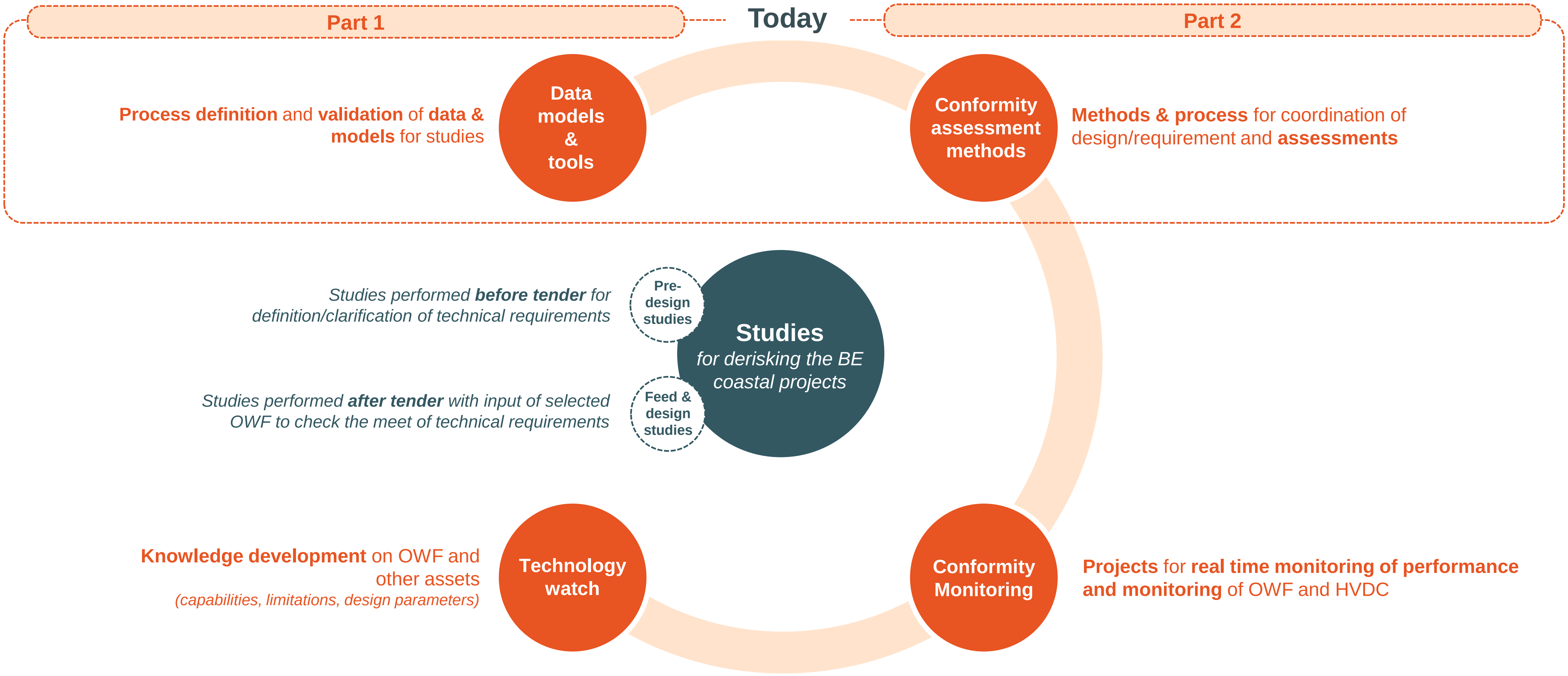
Poor market performance or bad predictability of storms and ramps may trigger need for additional measures

- The capability to deliver the mitigation measures will be specified in the Tender requirements, while the implementation of the measures itself will be developed in the regulatory framework towards commissioning of the parks (after consultation and regulatory approval).

Dynamic & Harmonic

Reminder

Several activities and studies are required for derisking the Belgium coastal projects from pre-design till real time operation.



Context

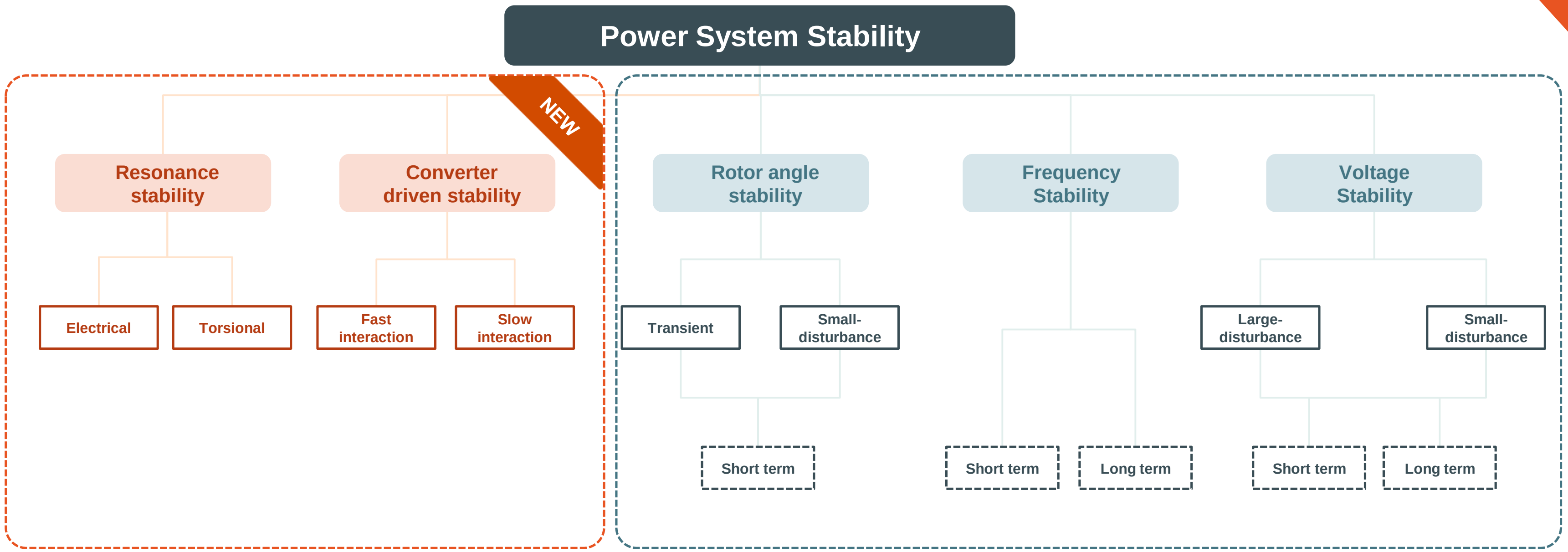
Olivier Bronckart

The Belgian and European system will face massive changes in the coming years leading to new power system stability phenomena and a reduced system strength

Reminder

Recent and new trends

- Increasing & accelerating RES ambition
- Development of offshore grid
- Increase of power electronic converter & interface devices
- Partial nuclear phase-out
- Increasing exchanges over long distances



Strength indicators

Weigthed Short Circuit Ratio =

$$\frac{\text{Short circuit power coming from AC grid} * \underline{\text{Installed}}\text{ power of power electronics}}{(\underline{\text{Installed}}\text{ power of power electronics})^2}$$

Max Transmissible Power Issue =

$$\frac{\text{Short circuit power coming from AC grid*}}{\underline{\text{Injected}}\text{ power}}$$

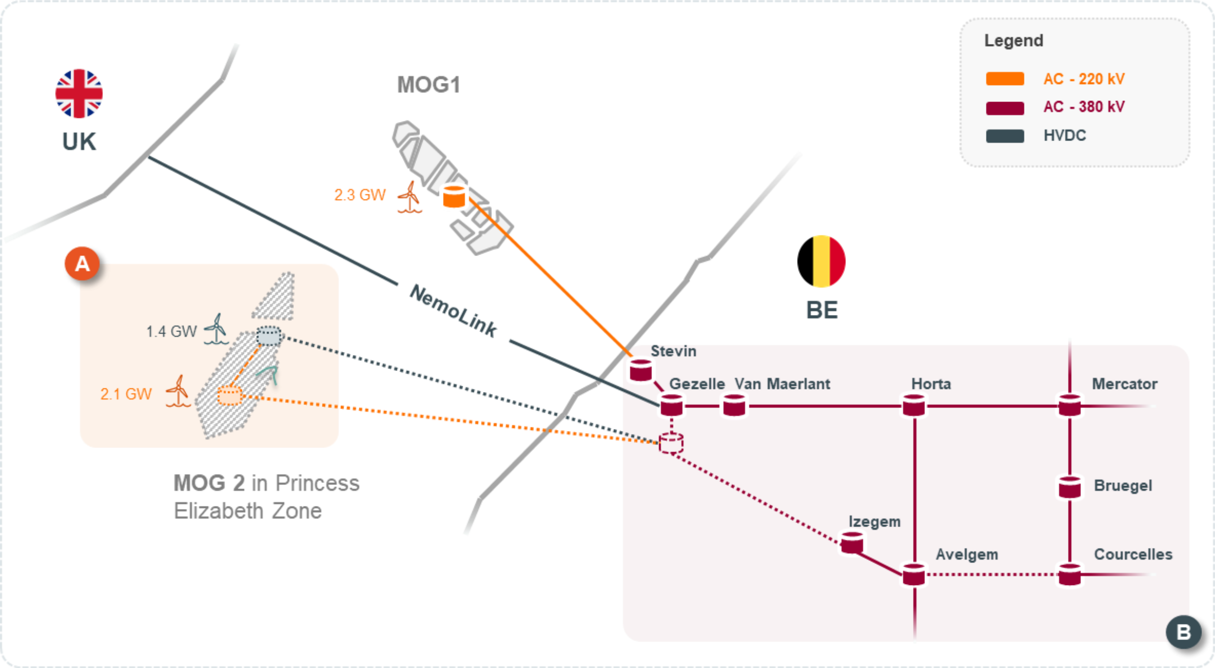
Studies required

EMT simulation
Very fast phenomena

RMS simulation
“Slow” phenomena

The MOG 2 project is in a range of system strength (WSCR) that will require data & model and strong coordination for the conformity of the design of each installation

MOG 2 grid design



Grid strenght calculation with WSCR

WSCR from Energy Island and Onshore

	1 node	2 nodes
A Offshore	1.32	3.07
B Onshore	0.95	2.14

+3 syncons onshore

	1 node	2 nodes
A Offshore	1.51	3.53
B Onshore	1.05	2.33

** Values are indicative and are considering grid fully available (no contingency)*

Weigthed Short Circuit Ratio =

Acceptable

- **Standalone tuning** of IBR control system is **often sufficient** to achieve satisfactory outcomes
- **Standard control system parameters** are **likely to work**

2.5

Not guarantee

- **Standalone tuning** of IBR control system is **not sufficient** due to increased risk of interactions with other nearby IBR
- **Site-specific control system tuning** is **likely to be required**

1.5

Unacceptable
(not working)

- **Site-specific control system** tuning by itself **is not sufficient**.
- **Additional equipment** like **synchronous condensers** and **grid-forming inverters** will be required to achieve acceptable behavior

** IBR represents all resources asynchronously connected to the electric grid and are either completely or partially through power electronics (wind, solar, HVDC, etc)*

Part 1 - data & models

Aymen Chaouachi

Key needs and justifications

What?	Why?	How?
Model simulation needs	Key to **reflect new phenomena** and conduct stability studies	**The targeted models are** • **RMS models*** (Aggregated and detailed) • **EMT models*** (Aggregated and detailed)
Model validation framework	**Inaccurate models** impact the accuracy of studies and thus the **overall system security**	Validation based on **International norms** • **Stepwise validation** through the whole life cycle of the installation • **Continuous monitoring** process to allow the model quality
Process & Procedures	**Needs clear roles & responsibilities** and transparency toward clients	**Transparent requirement** communicated upfront • Management and **traceability of models** • Clear and transparent **Roles and Responsibilities**

Models needs

Methodology to define the model needs

1 **Analyze the current state**

- **Lack** of dedicated prescription on **model requirements**
- The **information is crucial** due to the new facilities to be connected

2 **Benchmark & GAP analysis**

- **Gaps specifically** on simulation model for EMT, harmonics and black-box models provisions

3 **Develop new prescription**

- **New Elia documents** aimed to clarify with clients the needs, **well ahead,** to their connection to Elia's grid

4 **Implementation**

- **Generic and/or detailed simulation models** reflected in the documents
- Requirement depend **on the size and the technology**

Simulation models : model requirements provisions

Model requirements

Model requirement per simulation type

Steady-state
- SPGM
- SPM/PPM
- Demand

RMS
- SPGM
- **SPM/PPM**
- Demand

EMT
- SPGM
- **SPM/PPM**
- Demand

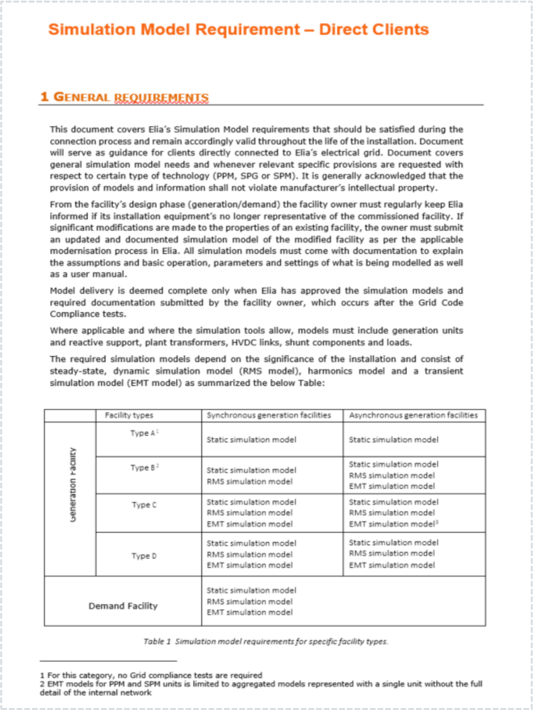
Harmonics
- SPM/PPM
- Demand

Black-box provisions

New Elia document

Model Requirements - Direct Clients

New Elia document aimed for external coordination with ***clients directly*** *connected to Elia's grid.*



Simulation Model Requirement – Direct Clients

1 GENERAL REQUIREMENTS

This document covers Elia's Simulation Model requirements that should be satisfied during the connection process and remain accordingly valid throughout the life of the installation. Document will serve as guidance for clients directly connected to Elia's electrical grid. Document covers general simulation model needs and whenever relevant specific provisions are requested with respect to certain type of technology (PPM, SPG or SPM). It is generally acknowledged that the provision of models and information shall not violate manufacturer's intellectual property.

From the facility's design phase (generation/demand) the facility owner must regularly keep Elia informed if its installation equipment's no longer representative of the commissioned facility. If significant modifications are made to the properties of an existing facility, the owner must submit an updated and documented simulation model of the modified facility as per the applicable modernisation process in Elia. All simulation models must come with documentation to explain the assumptions and basic operation, parameters and settings of what is being modelled as well as a user manual.

Model delivery is deemed complete only when Elia has approved the simulation models and required documentation submitted by the facility owner, which occurs after the Grid Code Compliance tests.

Where applicable and where the simulation tools allow, models must include generation units and reactive support, plant transformers, HVDC links, shunt components and loads.

The required simulation models depend on the significance of the installation and consist of steady-state, dynamic simulation model (RMS model), harmonics model and a transient simulation model (EMT model) as summarized the below Table:

	Facility types	Synchronous generation facilities	Asynchronous generation facilities
Generation Facility	Type A[1]	Static simulation model	Static simulation model
	Type B[2]	Static simulation model RMS simulation model	Static simulation model RMS simulation model EMT simulation model
	Type C	Static simulation model RMS simulation model EMT simulation model	Static simulation model RMS simulation model EMT simulation model[3]
	Type D	Static simulation model RMS simulation model EMT simulation model	Static simulation model RMS simulation model EMT simulation model
Demand Facility		Static simulation model RMS simulation model EMT simulation model	

Table 1 Simulation model requirements for specific facility types.

1 For this category, no Grid compliance tests are required
2 EMT models for PPM and SPM units is limited to aggregated models represented with a single unit without the full detail of the internal network

Content

- **Generic and/or detailed simulation models** reflected at point of connection
- **SPGM models** include electrical components (AVR, PSS, governor), and other physical limits (fuel valve, pitch and internal turbine limits) **when influencing units response**
- **SPM/PPM type B** equivalent while **type C and D both individual / equivalent** models requested
- **Model aggregation** per technology **type**
- **Grey-boxed models** including descriptions and **input/output minimum requirements.**
- **Load models as site-specific** considering on the nature of the load. It includes Scc current / limits and X/R ratio.

Simulation models : data questionnaire to capture data needs

AS IS

AS-IS data collection

3 Generator information

Manufacturer : Siemens AG
Type : SGen5-100A-4P
Year manufactured : 2009

Snom	Rated apparent power (+ related ambient temperature) MVA	50,00	
Pnom	Rated active power (+ related ambient temperature) MW	42,5	
Unom	Rated terminal voltage kV	10,50	
U+	Tolerance on the terminal voltage above the rated voltage %	10%	
U-	Tolerance on the terminal voltage under the rated voltage %	10%	
Inom	Rated stator current at standard cooling condition kA	2,749	
Cos	Rated power factor	0,85	
nom	Rated speed	1500	rpm
PD²alt x m2	Moment of inertia (generator + excitator)	Rotor compl. 172 395	ton Nm²

Bijlage 11 - 2/14

✖ Difficult to integrate

✖ Prone to errors/incorrect data

TO-BE

PROPOSAL – Data questionnaire

8,1 Transformer (generating unit and generating system)

Symbol	Data Description	Units	Value
	Transformer identification number	Text	
	If this is a *generating unit* transformer, the list of *generating units* to which this information applies.	Text	
	Manufacturer and manufacturer's type designation or product name.	Text	
	Possible ground connection impedance (at primary and/or secondary winding)?	Text	
	Connection of an auxiliary tertiary winding in delta?	Text	
	Shell or Core type transformer?	Text	
	Free or forced fluxes magnetic path?	Text	
		Text	

8.1.1 Design Data Sheet

Symbol	Data Description	Units	Value
Snom	Apparent nominal power	MVA	
Unom1	Machine-side nominal voltage	kV	
Unom2	Network-side nominal voltage	kV	
Xcc	Short circuit reactance	Ucc%	
Pcu	Copper losses	kW	
Pfe	Iron losses	kW	
Im	Magnesiting current	A	
GTW	Number of windings		

✔ Effective data integration

✔ Minimized risk of incorrect data

✔ Potential for automatic collection

▶ **EPIC Integration**

▶ **RPN Integration**

Model requirement

Model Requirements - Direct Clients

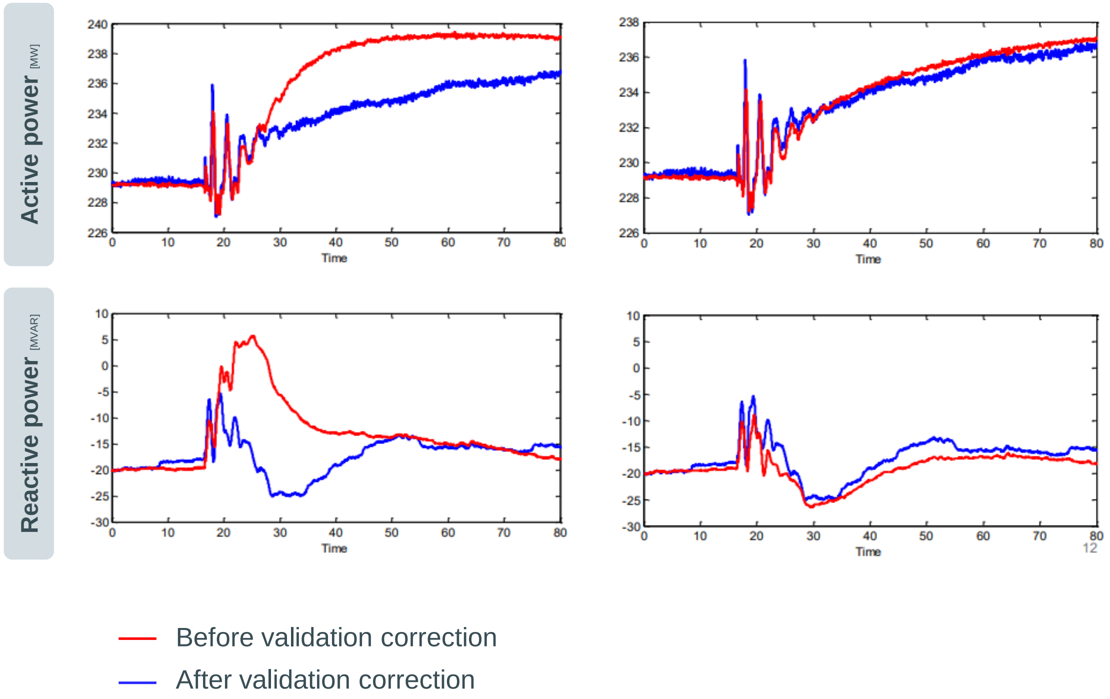
Model Requirements - indirect Clients

Clarification + details on expected models

Model validation

Models validation is key for the accuracy and quality assurance

Model validation



Model validation is a win/win for both Elia, generation owner and manufacturer

- Elia have the right models to **plan and operate a stable** network
- Owner is more confident **in compliance and stable behavior** of his assets
- Manufacturer/contracter have **clear requirements** to develop their models and design their installation

Different steps were followed to define the model validation process

1 **Analyze the current state**

- There is a lack dedicated provisions on model validation, as the current state is **solely based on expert judgement**
- The **European context stipulates the need** of such a **requirement**

2 **International benchmark & GAP analysis**

- Improvements on both : **methodology and process** level were identified
- Requirements are based on existing norms applicable for other TSOs

3 **Develop new prescription**

- The proposal is intended to give **more confidence** to the Grid User with regard to his model and allows **more reliability** on the models delivered to Elia

4 **Implementation**

- A **document covering the process and the detailed requirements**

Overview of model validation process

The first stage is the intial model acceptance, the aim is to:

a) Gain Confidence on the early stage on the delivered model
b) Make sure that the delivered models are compliant to the site specific conditions

Elia internal step to perform the initial checks automatically, the aim is to

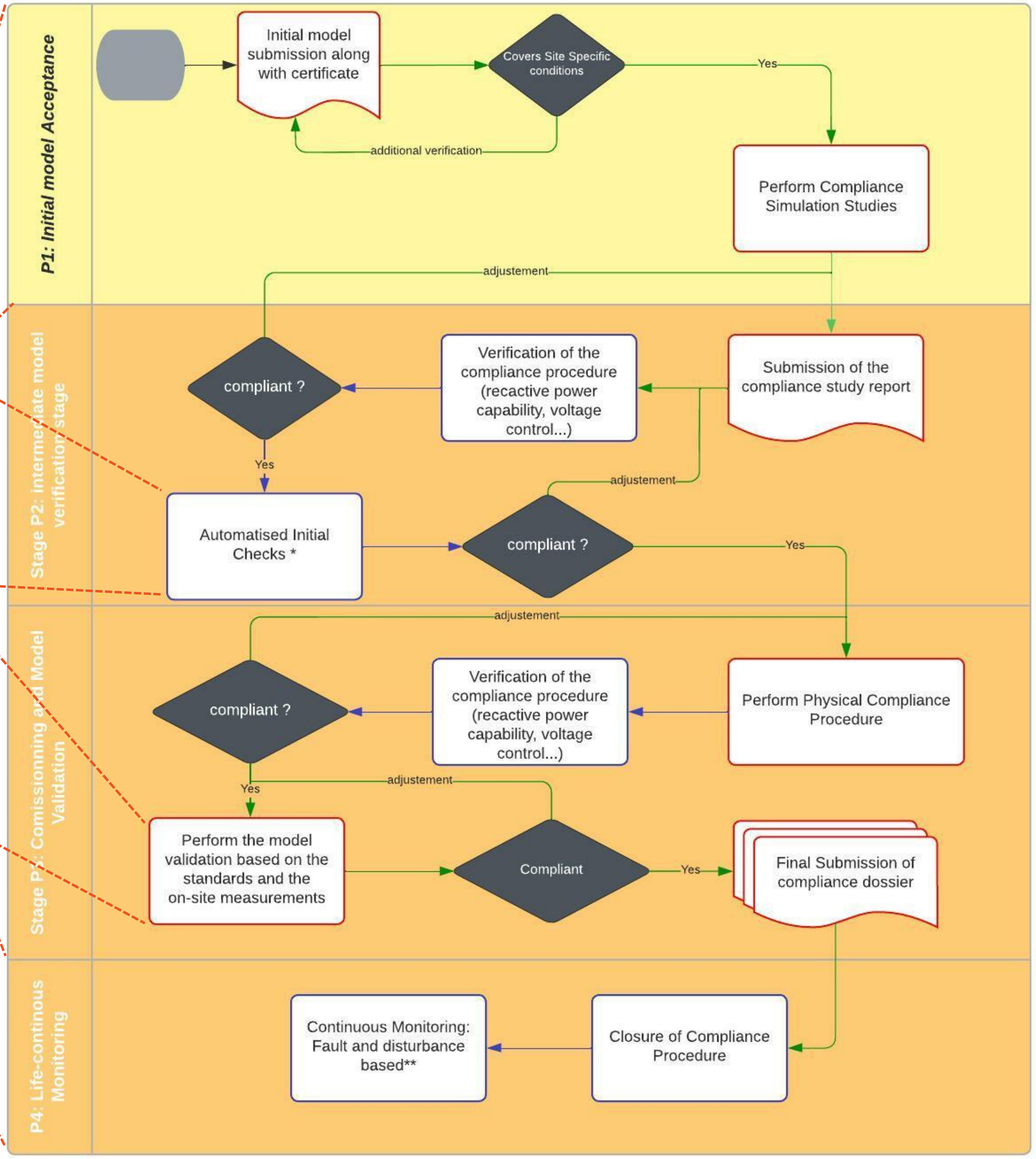
a) Ensure the compliance before the comissionning
b) This is a prequisite for ION (intermediate Operational Notification)

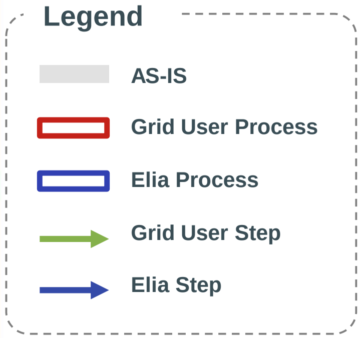
The focal point of the procedure with the aim of:

a) Making sure that the model are reflecting the reality (comparison measurement to simulations)
b) This is a prequisite for FON (Final Operational Notification)

Life-continuous monitoring

- A continious monitoring for the events that could not have been tested (Fault and/or Disturbance based)
- The aim is to ensure a continuous stable performance of the plants in case of inadvertent changes





Main take-aways

Clarification

Dynamic simulation model requirements

New provisions

Model validation requirements

New provisions

Model validation process

Legal Obligation

- Model Validation and accuracy are legally binding provisions
- The TSO is also responsible
- of implementing regulation

Security of supply

- Models reflect exact physical behavior
- Elia can evaluate instability risks and initiate timely actions

Benefits

- The Benefits largely overcome the efforts for both Elia and the Grid User
- GU achieve compliance and Elia preserve security of Grid

Implementation efforts

- The work have to be done in any case to fulfil Grid Code needs
- Clarification of requirement at early stage will improve efficiency

Part 2 - conformity process

Olivier Bronckart

| Elia Group

Conformity assessments and lifecycle of Power Generation Module (PGM)

Detailed design of PGM

Before commissioning

Conformity evaluation

Assess the conformity of the power generation final design prior the commissionning

- *Data&model provision and validation (see new process)*
- ***Simulation***
- *Test (unchanged)*

Commissioning

After commissioning

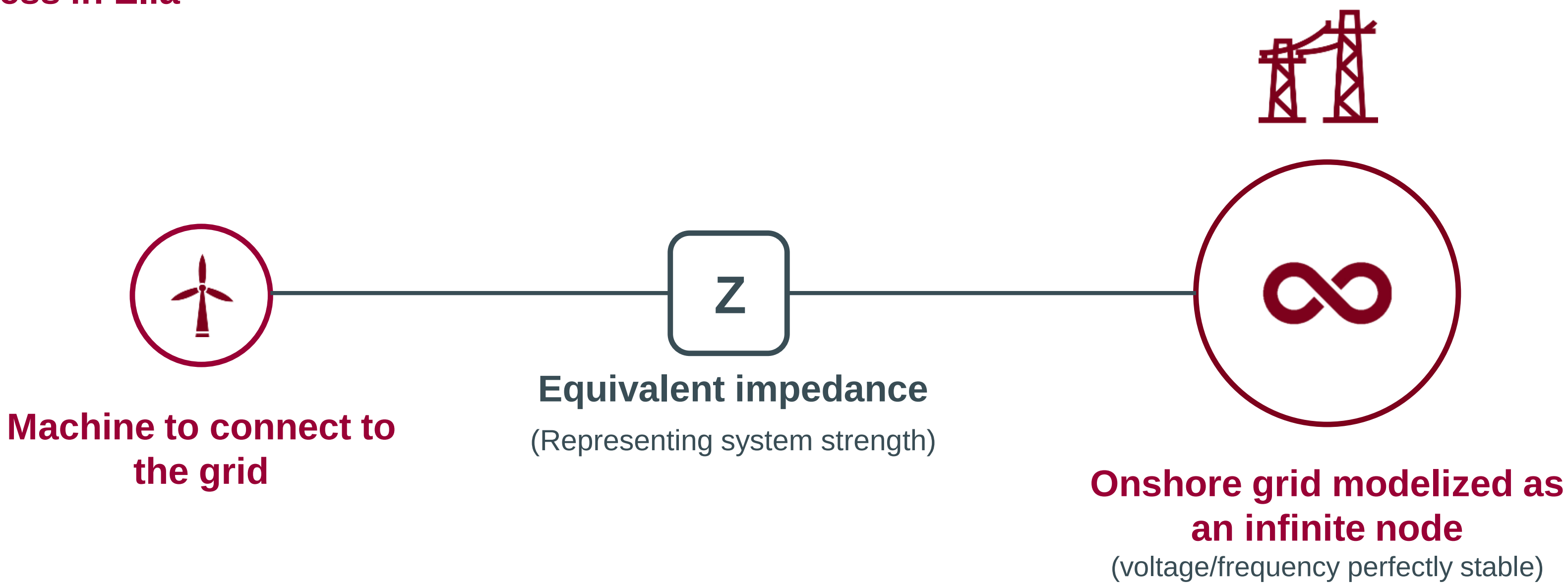
Conformity monitoring

Monitor and mitigate if needed issues observed in operation and not capture during the conformity assessment

Decommissioning

Current practice for simulation based conformity assessment in Elia

Representation of approach used today for conformity process in Elia



Conformity based on steady-state and RMS simulation

Such approach is acceptable for connection of synchronous machine or power park modules connected to strong grid, but **not acceptable** with the challenges/trends leanding to new stability phenomena we are facing

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**

Challenges

Modelling

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

Legal and regulatory

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

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

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

Additional info/details available in appendix

Possible future path for conformity process to operate the system in reliable and stable way

Short-term

- **Short-term solutions are required for MOG 2** with some trade-offs due to limited time
- **No directly useful solution** is available from **other countries**
- Most acceptable compromise option for **division of responsibilities and exchange** of data and models between all parties shall be developed
- **Not all connections** within Belgium will require the new more detailed conformity assessment
- Longer-term solutions in collaboration with **other TSOs via European network codes**

Long-term

The effort/time constraint to develop the conformity process should be reasonably proportionate to the size of the project

Current approach for the definition of the conformity process solution

STEP 1 – collection of inputs for conformity process

S1 2023

- **Ongoing mission with an external** (Aurecon – Babak) for support
- **End March: Workshop with TSOs** to collect input and define a joint position
- **Prior summer: Workshop/survey with constructors** to collect their view

→ **July/Aug: draft proposal of conformity process based on input collect**

STEP 2 – Validation of conformity process based on input collect

S2 2023

- **TF MOG 2 Q4 2023 :** presentation of the solution to stakeholders for comments

→ **Q4 2023: Approved final conformity process**

STEP 3 – Final solution for conformity process to include into technical requirements

S1 2024

- **Translation solution into technical requirements** for MOG 2 OWF tendering

The topics presented today are in the scope of the 4 main clarifications that will be potentially defined in the technical requirement for the 1st OWF MOG 2 tender

Reminder

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

Task Force MOG 2 – 24/03

2. **Process for data sharing & model validation:** need for process definition on data and model sharing from asset owner to perform conformity study

3. **Coordination of design study:** need for coordinated simulations/studies to perform conformity study

4. **Voltage control:** adjustment of voltage and MVar capabilities (owner of step-up transformer shift from OWFs (MOG 1) to Elia for MOG 2) **– presented**

The output of pre-design studies* might require additional adaptations

**Pre-design study are performed to prepare the clarification for technical requirements required for the OWF MOG 2 tendering*

Thank you

Appendix

Dynamic & Harmonic

Details on challenges

Challenges for modelling aspect to perform conformity assessment

	AS IS	Likely future practice	Challenges
Extension of the system modelled	PGMs under consideration	PGMs under consideration + **Wider power system** including cross-border plants with a likely impact	(1) Determining the boundaries of wide-area EMT model (2) Wide-area EMT model development skills gaps
Modelling tools for connection studies	RMS	RMS + EMT	(2) ELIA can identify a problem but often not the cause (3) Skills gap in EMT studies
Interaction with other nearby PGMs	✖ **Not considered** from a dynamic response perspective	✔ **Considered** by including dymanic models of all such PGMs	(3) The criteria for queuing or batching concurrent PGMs for dynamic modelling shall be determined

Legend
- Most challenging (red)
- Least challenging (yellow)

Challenges for legal and regulatory aspects to perform conformity assessment

	AS IS	Likely future practice	Challenges
Resp. for grid connection studies	**Developer**	**Developer** + **Increased involvment of TSO (Elia)**	1 Access of all parties involved to wide-area EMT and RMS models
Access to RMS and EMT models of other plants	**TSO (Elia) only**	**TSO (Elia) only** + **Developer (directly or via authorised 3rd party)**	1 No current requirements for the OEMs to provide EMT models to parties other than Elia
Solution to adress instabilities	• **Control system tuning** of the given PGM • **TSO (Elia) to install the devices** • **Restrict** PGM operation	• **Cont. syst. Tuning of one or more PGMs** • **TSO (Elia) to install the devices** • **PGM to install the devices**	1 Need for OEMs to use wide-area EMT models if control system tuning is needed. 2 Responsibility for installing the solution and cost sharing

Legend
- Most challenging (red)
- Least challenging (yellow)

Challenges for future power system aspect to perform conformity assessment

	AS IS	Likely future practice	Challenges
Ongoing performance assessment and validation of the PGM	When there is evidence of non-compliance or after major system events	When there is evidence of non-compliance or after major system events + **plus likely regular intervals checks** (e.g., every three years)	1 TSO (Elia)'s ability to request connected generators to adjust their settings 1 TSO (Elia) to ensure that the models provided will remain valid during the lifetime of the installation
Reference year for connection studies	Anticipated PGM commissioning year	Anticipated PGM commissioning year + For several future years	2 The need for wide-area EMT model development for all those reference years
Access of each new PGM to system strength available in the future	✖ No defined methodology	? A methodology is currently considered	2 Any methodologies will rely on wide-area EMT models which do not currently exist
Future network and generation changes	✖ **Not considered** from a dynamic response perspective	✔ **Considered** by including dymanic models of all such PGMs	2 Problems identified cannot be often attributed to a single PGM 2 The need for wide-area EMT model development for future years

Balancing

Elia’s feedback on questions received

Market Party question	Elia answer
Elia should aim at a level playing field between BRP's, without differentiation in function of technology	Elia agrees with the principle to maintain a level playing field where possible and tries to this principle as much as possible via its balancing market design. Analysis on offshore wind power developments reveal very particular problems with offshore wind which are difficult to cover via reserves or current balancing mechanisms available (limited frequency of events with high impact, challenging predictability of events,…). Note that impact assessment shows that impact of the proposed measures presents a trade-off between impact on the BRPs and the cost for the grid user. Legal framework gives us the means to do this. Ramping rate limitation: ramping rate restrictions are applied in compliance with RfG regulation Article 15(6)(e): *"the relevant system operator shall specify, in coordination with the relevant TSO, minimum and maximum limits on rates of change of active power output (ramping limits) in both an up and down direction of change of active power output for a power-generating module, taking into consideration the specific characteristics of prime mover technology*"
Elia should avoid any retroactive application of the mitigating measure	Discussed on slide 8
There should be a clear distinction between balancing (risks) and grid security (risks)	The foreseen mitigation measures in this presentation aim to cover operational security (grid) risks related to balancing events related to storms and ramps which are not adequately managed by the market and available balancing energy (contracted and non-contracted).
Elia claims that mitigating measures are designed to imply the least costs possible for society. Is there any CBA demonstrating that the savings for Elia outweigh the impacts, increased risks and/or increased investment costs for BRPs?	Slide 16, 19, 22 present an impact assessment of the proposed mitigation measures. A detailed, quantitative CBA is not considered needed as the impact assessment shows that the impact remains rather limited (particularly under high market performance) in comparison of the alternatives to increase reserve needs.

Market Party question	Elia answer
Could Elia please explain how CCMD – which is just a theoretical concept at this stage – is taken into account? .	Best case market performance assumptions in slide 10 are in line with REA+ scenario (assuming the launch CCMD market reform on short-term) while worst case market performance can be considered in line with REA- scenario (assuming delays on CCMD market reform). Scenarios are presented in WG BAL workshop on reserve dimensioning of the 15/02/2023. REA+ is assumed to result in better performance as observed today (even with additional renewable capacity), while REA- is assumed to result in similar criteria as today (despite additional renewable capacity).
FEBEG regrets there's no re-evaluation of the need to maintain the alpha component	An analysis on the need for an alpha parameter has been conducted in the framework of the re-calibration of the alpha. No new evaluation of the alpha-parameter are currently foreseen at this stage (being difficult at this point in view of the energy crisis and periods in which the alpha was suspended).
Risk of pancaking costs: it should be checked if not only a very limited number of equipment suppliers will be able to install wind turbines with high wind speed technologies.	Discussed in slide 16
Preventive curtailment is an intervention of Elia in balancing by BRPs and should be remunerated. Full remuneration shall avoid risk premiums being integrated in business plans. Elia is shifting risks to the market: is there a CBA confirming that is the cheapest solution for society? The maximum amount of activations is equal to all market actors? What about existing and new?	Discussed on slide 22
Is a level playing field ensured in the procedures for the cut-in coordination?	Discussed on slide 18
Elia mentions more stringent requirements will be needed when facing worst case market performance. What is the trigger to switch to more severe requirements? Is there a transparent decision process? Will market parties be informed about the shift to more severe requirements?	Discussed in slide 8