Appendix 3: Methodology and criteria applied to the grid connection study part of an orientation study (to regional or federal transmission grids) or to the grid connection study part of a detailed study to the federal transmission grid.

1.1 Introduction and objective

This appendix describes the methodology and criteria applied to the grid connection study part of an orientation study (to regional or federal transmission grids) or to the grid connection study part of a detailed study to the federal transmission grid.

The objective of the grid connection study is to propose to the applicant (grid user or candidate grid user) a set of variants for connection to the electricity grid of the requested connection capacity for its installation at its requested geographical location while complying with the needed technical criteria for Elia to fulfil its mission as a network operator.

The study also makes it possible to identify the points of attention specific to this request in order to facilitate the connection of the installation of the applicant while respecting the rules in force.

The installation of the applicant is either a Power Generating Module (PGM), a Storage Park Module (SPM), a Demand Facility (DF) or a combination of several elements in the context of a mixed site.

1.2 Principle and context of the study

1.2.1 Clarification of the reference context

The reference context corresponds to the expected situations of the power system in the future years impacted by the study. It is established and updated regularly[1] based on:

- The evolution in the overall level of offtakes (from consumption facilities and storage units) and injections (from production and storage units);
- The geographical distribution of offtakes and injections;
- The evolutions of the electricity grid, constituting the reference network;
- The estimation of the functioning of the electricity market, taking into account typical annual profiles for temperature, solar irradiance and wind;
- Reactive power control and voltage adjustment means.

The overall level of offtakes and their geographical distribution in the Belgian control area for a reference year is compiled by Elia, on the basis of statistical data from the past, announced changes of offtake at existing or new connection points, as well as macroeconomic information for Belgium and its various sectors of activity.

[1] This reference context is typically updated yearly.

The overall level of injections and their geographical distribution in the Belgian control area for a reference year is compiled by Elia and takes into account the latest known agenda for the commissioning and decommissioning of production units and storage systems as well as expected developments in the macroeconomic scenarios for generation and storage.

The evolution in offtake and injections may therefore result from evolution of allocated and reserved capacities, but also from growth potential by technology[2], geographically distributed, not yet reserved or allocated, but taken into account for the establishment of the grid infrastructure project portfolio.

It must be noted that the reference context aims at representing a best estimation of the future situation at Belgian level which could differs from the best estimate and reserved capacities at local level. A local adaptation of the reference context to represent this local best estimate is therefore presented in section 1.2.2[3].

At the level of the foreign grids, the reference context in the other countries covered by the ENTSOe TYNDP is established by Elia on the basis of the information exchanged between transmission system operators as part of the data collection organised by ENTSOe as well as on the basis of other bilateral information exchanged between Elia and neighbouring system operators.

The reference network is the network as it is expected to evolve based on the portfolio of infrastructure projects having at least a status “in study”. The latest published Development Plans, or any publicly communicated update of the timing of the projects at the date of the study are considered.

1.2.2 Adaptation of the reference context as part of the grid connection study

Depending on the type and localization of the installation of the applicant, this reference context is adapted in order to achieve the following key objectives:

- Remain consistent with contractual engagement Elia and DSOs have already made to other grid users or candidate grid users with either firm or flex access where a cap is defined on the volume of modulated energy borne by the grid users or candidate grid users.
- Ensure that grid capacities will be present for evolutions in low-voltage generation and consumption which do not require capacity reservation and can therefore connect without further notice.
- Ensure that grid hosting capacities will be present for the growth potentials considered as one of the objectives for federal and regional network development plans. Connection requests realizing this growth potential will then benefit from these grid hosting capacities

[2] The list of technologies considered in different categories are [LV Solar], [MV&HV Solar], [Wind], [other generation], [Storage], [Electrical Vehicle Heat Pump and other LV demand], [HV&MV data centers], [other HV&MV demand].

A data center is defined as a structure or a group of structures used to house, connect and operate computer systems/servers and associated equipment for data storage, processing and/or distribution, as well as related activities (according to EU regulation 2022/132).

[3] The growth potentials of the local best-estimate scenario are updated asynchronously at the time of the establishment of the local grid infrastructure project portfolio (long term grid development study).

while only the remaining grid hosting capacities prior to grid reinforcement will be available for the connection requests outside of the identified growth potential.

It must therefore be concluded that low-voltage connections and connection requests within identified growth potential come first before other connection requests. Doing otherwise would lead to an unwanted situation where opportunistic connection requests could be made to tap in a hosting capacity that was intended, approved and developed for another purposes. Within these categories of connection requests or for the other connection requests, the principle of first come first served applies.

- Give the possibility to the installation of the applicant to connect to the grid before the realization of grid reinforcements with a flexible access.
- Provide a reasonable approach for the estimation of the expected flexibility volume of connection with flexible access that is balanced between risk of overestimation of flexibility volumes (which could negatively impact the business case of the applicant installation project) and risk of underestimation of flexibility volumes (which could lead to higher socialization of congestion management costs resulting from a market position of the applicant (injection or consumption profiles for the installation of the applicant) that cannot be anticipated).

Concretely, a local zone of influence is defined around the location of the installation of the applicant in order to cover the set of capacities of existing, reserved allocated capacities or of consumption and injection growth potentials that have a significant influence on the conclusions of the grid connection study.

In this local zone of influence, the following adaptations to the reference context are made:

- Reserved or allocated capacities with firm access that are not already included in the reference context are taken into account.
    - Note that this is done in order to be coherent with the contractual engagements of Elia and DSOs towards those other grid users or candidate grid users. It must be noted that the consideration of these capacities[4] could either increase or decrease the grid capacity of hosting the installation the applicant.
- Reserved or allocated capacities with flexible access that correspond to capacities identified in the growth potential and that would not already be included in the reference context are taken into account. Their flexibility will not therefore be used to reduce the modulation of the requested power.
    - Note that this is done in order to be coherent with the contractual engagements of Elia and DSOs towards those other grid users or candidate grid users; the flexibility of these other grid users or candidate grid users will therefore not be used to reduce the flexibility of connection request.
- Evolutions in low-voltage generation and consumption, for which a capacity reservation is not required, are taken into account.
    - Note that these capacities correspond to generation or consumption growth that do not need to follow a connection reservation procedure to the distribution grid[5] and can therefore connect without further notice. It must be noted that the

[4] Either reserved or allocated for a connection to the distribution or transmission grid.

[5] The capacities that need to follow the connection reservation procedure to the distribution grid are also reserved and allocated capacities (CAPAC process – that has the same implication as the EDS process) like any other capacities to the transmission grid.

consideration of these growth potentials could either increase or decrease the grid capacity of hosting the installation the applicant.

- The local best-estimate consumption and generation growth potentials of other types than the one of the installation of the applicant, are taken into account.
- Depending on the situation, whether or not the connection request corresponds to a capacity identified in the growth potential for the zone and technology of the request:
    - If the connection request corresponds to a capacity identified in the growth potential, all reserved or allocated capacities with flexible access that correspond to capacities that are outside their growth potential are set to zero and all reserved or allocated capacities with flexible access that correspond to capacities that are inside their growth potential are taken into account.
        - Note with such an approach the need for flexibility means is not computed twice and the hypothesis made for the grid connection study of the connection request is coherent with the hypotheses made for the connection grid study of the reserved or allocated capacities with flexible access that correspond to capacities that are outside the growth potential.
    - If the connection request corresponds to a capacity that is outside the growth potential, all reserved or allocated capacities with flexible access are taken into account, whether or not they are inside the growth potential.
        - Note that this is done in order to be coherent with the contractual engagements Elia has made with the reserved or allocated capacities with flexible access. The expected volume of flexibility for these other grid users or candidate grid users would then not be increased to facilitate the connection of the installation of the applicant.

The adaptations in the local zone of influence can therefore be illustrated and summarized by the following table:

	Connection request in line with the growth potential considered for the establishment of the local infrastructure project portfolio	Connection request outside the growth potential considered for the establishment of the local infrastructure project portfolio
Existing firm and flexible capacities & firm reserved or allocated capacities & expected low-voltage growth potential	Considered present for the study	Considered present for the study
Reserved or allocated flexible capacities in their growth potential	Considered present for the study	Considered present for the study
Reserved or allocated flexible capacities outside their growth potential	Not considered for the study	Considered present for the study

Injection or consumption growth potential of the same type of technology	Not considered for the study	Not considered for the study
Injection and consumption growth potential of other technologies	Considered present for the study	Considered present for the study

Table 1 : Adaptation of the reference context in the local zone of influence

As the above-mentioned adaptations in the local zone of influence may have an impact on the Belgian level of offtakes and injection identified in the reference context described in Section 1.2.1, adaptations are also made in geographical areas other than the one concerned by the connection study in order to avoid significant deviations in total installed capacity per type as well as in Belgian power balance compared to the reference context.

In terms of production or consumption profile for the installation of the applicant:

- In the context of a renewable energy production units, the connection request is considered with a realistic specific production profile is applied.
- In the context of a conventional generation or of a consumption, the connection request will be considered to be operating permanently at maximum power and under all realistic reactive power setpoints.
    - Note that wind and PV installations (without embedded storage) are not considered capable of producing more than the available power and producing less at these moments is not expected to create issues in the grid, as currently the requested connection capacity of the applicant is not present. For dispatchable generation, storage and demand facilities, an expected profile cannot be ensured and contractually secured.
- In the context of a storage facility, two studies are carried out, one with a constant injection profile and the other with a constant withdrawal profile. These profiles will be taken into account when determining the contractual conditions associated with connection and access to the network.
- In the case of a connection request for a mixed installation, different combinations of the profiles of the individual parts, for the determination of injection capacity or withdrawal capacity, are considered as illustrated by the table below:

	For the assessment of the connection request with respect to	
	Offtake capacity	Injection capacity
Profile for the consumption part	constant consumption profile	zero profile
Profile for the conventional generation part	zero profile	constant production profile

Profile for renewable generation	specific production profile (PV, Wind, etc.)	specific production profile (PV, Wind, etc.)
Profile for the storage system	constant consumption profile	constant production profile

Table 2 : Combinations of the profiles for connection request of mixed installation

In terms of production or consumption profile for the existing, reserved or allocated capacities in the local zone of influence:

- The capacity of existing (in operation for more than one year) consumption facilities or non-renewable non-market driven generation are represented by a realistic profile based on historical measurements and a projection of this profile for future years such that all its capacity is used at least once in the future year.
- The capacity of reserved, allocated or recently connected facilities (in operation for less than one year) consumption facilities or non-renewable non-market driven generation are represented by a profile that is representative of the sector of activity and such that all its capacity is used at least once in the future year.
- The capacity of existing, reserved or allocated renewable generation are represented by a realistic specific profile such that all its capacity is used at least once in the future year.
- The capacity of existing, reserved or allocated conventional generation or storage facilities are represented by a profile generated as part of a simulation of the future functioning of the electricity market.

1.2.3 Specific cases of the substantial modernization of existing sites

In the specific context of the connection of storage or local generation within an existing demand facility and without adaptation of the contractual connection capacity (PPAD) of this demand facility, no active power flow constraints need to be verified in the context of the connection study. Grid studies for the validation the connection would then be limited to short-circuit power, voltage & reactive power other dynamic constraints.

In case the connection study requests an adaptation of the contractual connection capacity (PPAD), the study will focus on the impact of the increased capacity above the existing connection capacity of the full substantially modernized site following the same approach as for a new industrial site with mixed installation.

Finally, in the context of a modification of an existing installation of generation with non-market driven profile (such as renewable generation) for which a specific production profile was considered in the context of the connection contracting, the new constraints could be identified below the existing maximum capacity (but above the existing firm capacity) linked to the new profile of the full substantially modernized site.

1.2.4 Technical characteristics of the installation of the applicant

Unless explicitly stated at the time of the application, typical technical characteristics resulting from a conventional design of the production, consumption or storage unit will be considered.

- For production units, these characteristics cover the limits in active and reactive power, current limits, impedances, regulators (speed, frequency, voltage, etc.), step-up transformer, consumption of auxiliary services, etc.
- For consumer installations, these characteristics cover reactive behaviour, three-phase short-circuit power contributions, etc.
- For storage units, these characteristics include active and reactive power limits (MW, Mvar), storage capacity, ramping rate, impedances, regulators (frequency, voltage, etc.), step-up transformer, consumption of auxiliary services, etc.
- …

1.2.5 Analyzed situations.

In future years, evolutions in the reference context, as well as periods of network infrastructure works may lead to different connection or operating constraints for the subject of the application. Phases, periods during which the constraints will be considered equivalent, are identified.

For each identified phase, different possible operational situations are considered. They are the result of the synchronized combination of production profiles, consumption profiles and of the market.

The situations considered are chosen in such a way as to identify the main constraints of the power system in the presence of the applicant's new installation(s)/unit(s), for each phase and for each of the proposed connection solutions.

Typically, 100 situations per year will be analysed in order to best represent all the different market situations of an average year in terms of temperature, wind or sunshine profile. Each of the 100 situations will therefore have a weight, resulting from a grouping of the 8760 hours of the average year and will be used to determine the conditions of the connection, including the average annual flexibilization volumes required in the case of a connection with flexible access.

1.2.6 Analyzed system states.

For each of the identified situations, the currents and voltages in the system, the dynamic stability and the compliance with the requirements in terms of voltage quality are checked for different system states. A state is characterized by a planned or unplanned outage of one or more grid elements (line, cable, busbar, grid user installation, etc.).

Typically, the following states are studied:

- N state, where all the grid elements available in the reference context are operational. For each phase of network evolution, a new N state is studied.
- N-1 state, where relative to the N state, a grid element or grid user installation is disconnected (either planned or unplanned) from the system.

    - With the exception of specific situations linked to certain types of grid elements or to the phasing of network development works, the average unavailability of grid elements is 1% of the time. This unavailability rate includes both maintenance work on the grid element (planned N-1 state) and incidental disconnection of the grid element (unexpected N-1 state). It should be noted that since the frequency of maintenance is not annual, the annual volume of flexible energy that could be needed, may therefore vary around the average value determined in the grid connection study.
    - In the context of the realization of network infrastructure works, the unavailability of certain grid elements can be significantly greater. For network development works in the zone of the installation of the applicant, in progress or planned within 3 years after the commissioning date of the connection request, as well as for network development works to upgrade the 400kV network and which would impact the determination of the firm power or the volume of needed flexible energy, phases of work realization will be taken into account in the context of the grid connection study.
- N-1-1 state, where a grid element is preventively taken out of service in order to carry out maintenance, updates or repairs and during which an unplanned incident occurs. It should be noted that this state must respect operational criteria only during a sufficient number of situations (or periods of the year) (and not during the whole year) to carry out the tasks of the network operator. It is also important to identify, during the study, whether specific agreements need to be made between the network operator and the connection applicant in order to enable each party to manage its own system.

1.2.7 Technical criteria

1.2.7.1 Limits for a responsible system operation

The grid development criteria of application in the context of the grid connection study are deemed to be met, for each situation and state, if:

- The requirements set out in the contingency list of the "methodology for coordinating operational security analysis in accordance with EU 2017/1485 (SOGL)"[6] and the requirements of Regulation (EU) 2019/943 of June 2019 on the internal market for electricity are met;
- The voltage at each point of the network remains within the specified limits;
- The currents in the various grid elements do not exceed the maximum specified values provided; the maximum values of grid elements that must not be exceeded are divided into permanent and temporary maximum values. Temporary maximum values can be used in an unplanned N-1 situation when curative actions are available to reduce currents below permanent maximum values within a 15' timeframe;

[6]https://www.acer.europa.eu/sites/default/files/documents/Individual%20Decisions_annex/Annex%20I%20-%20ACER%20Decision%20on%20CSAM.pdf

- The short-circuit currents do not exceed the maximum specified values;
- The dynamic and transient stability of the production units is ensured;
- The requirements in terms of voltage quality are met.

1.2.7.2 Limits for a responsible system development

Additionally, in the context of connection studies, criteria exist for the proposal of the connection point of the installation of the applicant:

- If a voltage level or substation is planned to be dismantled (e.g. 70kV), as mentioned in the network development plan, generally no connection options on this substation or at this voltage level are proposed as the installation of the applicant would then need to be connected to another substation or voltage level later. It could however still be proposed if this variant is techno-economically interesting for the applicant even if he would then need to foresee multi-voltage transformers and connection links.
- If a new voltage level is created in a zone (e.g. 150kV), a connection option is proposed to the applicant if the network evolution is within the relevant time horizon or if an anticipation of the infrastructure project is possible.
- Currently, the following metrics and thresholds are deemed appropriate in order to ensure that investments in public grid infrastructure benefit more than a single grid user. Based on the current typical ratings of existing and planned grid elements and depending on the full capacity of the new or substantially modernized installation of the applicant, the figure below defines a maximum full capacity for the installation of the applicant per voltage level for source substations (i.e. a substation of a given voltage level supplied by transformers from a higher voltage level in N & N-1) and for remote substations. Taken this metric and thresholds into account, a connection option having the adequate voltage level will be proposed.

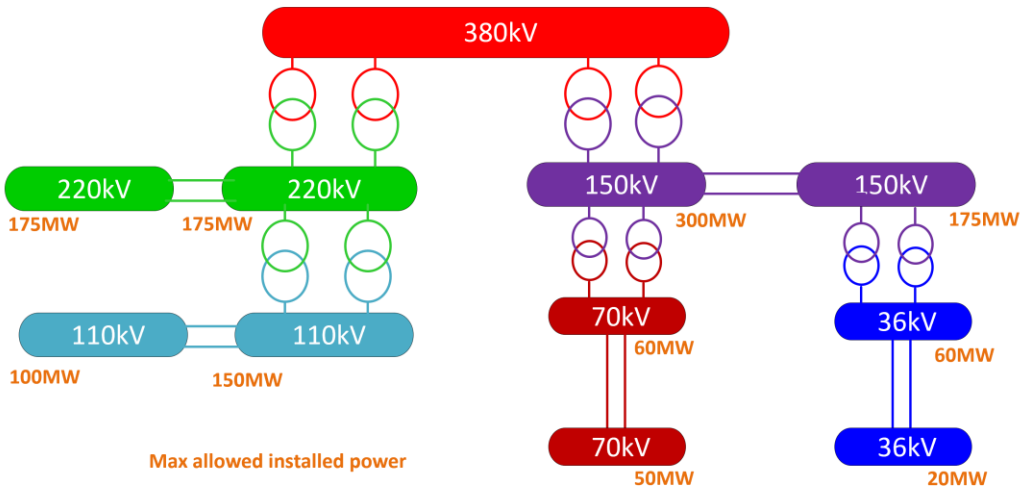

Figure 1 : Maximum full capacity of the installation of the applicant per voltage level for source and remote substations.

1.2.7.3 Connection solutions considered.

For illustration purposes, here is a non-exhaustive list of considered connection solutions:

- A standard connection to a substation of the transmission network. This connection may consist of one or two bays (for a redundant connection). In the case of a redundant connection, Elia will specify in the orientation study the authorised operating mode(s) in the installation of the applicant in order to avoid any transit flow through the installation of the applicant in case of N or N-1 in the transmission network (see diagram on the left in the figure below).
- A double-tapping connection with the unavailability of only one of the installation of the applicant's two connection in the event of maintenance or works on the concerned grid element[7] (see diagram in the middle of the figure below).
- A single tapping connection only at voltages below 400kV and for a production or storage facility with an interruptible connection contract. The connection for the installation of the applicant is unavailable in the event of an incident, maintenance or work on the concerned grid element[8].
- A standard connection to a substation of the transmission system through one or more links temporarily made available to the installation of the applicant for exclusive use (Part B)[9] but which could possibly be partly integrated into the transmission network and part of which will then become Part Z[10]. This will involve the construction of a substation and the relocation of the installation of the applicant's connection point (see diagram on the right in the figure below).

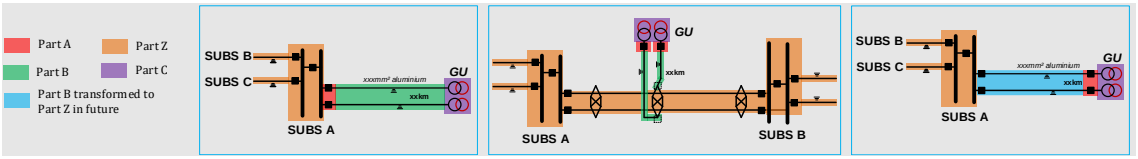

Figure 2 : Considered connection solutions.

1.2.7.4 Actions considered for controlled network operation.

- **Standard operating topologies and preventive actions**

In the context of the grid connection study, network security is ensured by proposing one network infrastructure and operating topologies (that can be different for each sufficiently identifiable, predictable and stable grid situation[11]).

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[7] Max one tapping per grid element allowed.

[8] Max one tapping per grid element allowed.

[9] Part B = all equipment making up the connection link between the connection bay at Elia substation (Part A) and the installation of the applicant (Part C)

[10] Part Z = equipment's and infrastructure part of the electricity grid

[11] The potentially very fast ramping rates of storage units rule out the use of real-time adaptation of the operating topology to manage potential network congestion.

The main objective of preventive actions is to ensure that in a full grid situation (N state), the grid elements would not be overloaded beyond their permanent maximum value and, at the same time, to ensure that after an unplanned incident the grid elements would not be overloaded beyond their temporary maximum value.

If these preventive actions are not sufficient another connection variant, a network adaptation and/or a connection with flexible access (pending network reinforcement) are proposed. In the case of a connection with flexible access, the active power of the connection request will be modulated in the network situations that require it up to a level where all technical criteria are met again.

- **Actions in case of planned outage (planned N-1 state)**

The main objective of these actions is to ensure that in a system state where a grid element is taken out of service in a planned manner, the other grid elements would not be overloaded beyond their permanent maximum value and, at the same time, to ensure that after an unplanned incident the grid elements would not be overloaded beyond their temporary maximum value.

The occurrence of these actions is therefore the product of the occurrence of the planned outage on the grid element (e.g. to perform maintenance) and of a situation where the other grid element's permanent capacity in N-1 state would be exceeded.

- **Curative actions in case of unexpected N-1 state.**

After the loss of a grid element, certain technical criteria will be between their permanent and temporary limits. The return of the system within the permanent limits of these technical criteria will require the use of a limited number of curative actions that can be carried out in less than 15 minutes.

If these curative actions are not sufficient, network reinforcement and/or connection with flexible access (possibly pending network reinforcement) is proposed. In the case of a connection with flexible access, the active power of the connection request will be curatively modulated in N-1 or N-1-1 situations.

The probability of a curative activation is therefore the product of the probabilities of an unplanned N-1 and of a situation where a grid element's permanent capacity in N-1 would be exceeded.

- **Modulation of the connection request (in case of connection with flexible access)**

In cases where preventive or curative internal Elia's actions are not sufficient and in the event that network reinforcement alternatives cannot be implemented before the requested capacity is connected, a modulation of the requested power is proposed. These modulations therefore only concern situations where the installation of the applicant is still connected to the network and exclude situations where the installation of the applicant is disconnected from the network following an N-1 situation. (Note that these specific situations will be covered by non-redundant or interruptible connection contracts).

The flexibilization volumes determined in the grid connection study are based on the assumption that the new connection request will be modulated in the event of congestion caused or exacerbated by the connection of the installation of the applicant, before the installations of other grid users or candidate grid users taken into account in the reference context adapted for the study (see Section 1.2.2) except in cases where the connection request has a low influence on a congested grid element , *in line with Art. 61ter. §4 of the code of conduct,*.Under these conditions, the constraint is not taken into account for the calculation of the flexibility energy volume.

Currently, the following metrics and thresholds are deemed appropriate to determine if the critical network element shall be considered as limiting element and shall be taken into account for the calculation of the flexibility energy volume ::

- The critical network element is only being considered if the product of the PTDF[12] of the applicant on this element and the ratio of the power of the request to the power of the network element is greater than a threshold or if no other means to manage the congestion is available in real time.

$$\left(\left|PTDF_{GU,CNECGU}\right| \times \frac{P_{max_{GU}}}{S_{perm_{CNEC_{GU}}}}\right) > 1\ \%$$

- Additionally, for congestion located at a voltage level lower than the voltage level of the proposed connection point for the installation of the applicant, the critical network element is only being considered if, in addition to the previous criteria, the PTDF of the connection request on this element is above a threshold or if no other means to manage the congestion is available in real time.

$$U_{CNE} < U_{GU}; \qquad PTDF_{GU,CNECGU} > 10\ \%$$

1.3 Methodology and conclusion of the study

The connection request is integrated into the reference situation either at different grid connection locations in the physical vicinity of the installation of the applicant in de context of an orientation study or as defined in the selected variant in the context of a detailed study. The resulting system is simulated in the situations and states mentioned above. The simulations cover the functioning of the market, the functioning of the power system (load-flow, etc.), the manual actions of dispatchers and the automatic systems.

In the context of an orientation study, through an iterative process, in order for all technical criteria to be met,

- Connection variants to the electricity grid are being considered. Variants that are technically not feasible or not economically justified, in discussion with the applicant, are not retained. The list of all variants considered whether or not they have been selected, shall be communicated to the applicant.
- Realistic adaptations to the timing or phasing of planned infrastructure projects and/or changes in the way the network is operated will be proposed.

Once this objective is achieved,

- An estimate of the cost to be borne by the applicant to enable its connection is made. It is accompanied by an estimated time frame for the completion of all required network adaptations. These estimations are non-binding in the context of an orientation study.
- Where applicable, a period, during which the connection of the installation of the applicant is possible subject to flexibilization of the connection request, is determined.

[12] Power Transfer Distribution Factor (PTDF): the PTDF describes how an exchange between two nodes is distributed over all grid elements.

In line with Art. 61ter. §2 of the code of conduct, the maximum active power that is modulated preventively less than 0,1% of the time and less than 0.1% of the time curatively, considering the profile of power for the installation of the applicant, will be referred to as "firm power". If this “firm power” is less than the power requested, then the remained power which can be modulated is called "flexible power".[13]

Additionally, after applying the above-mentioned criteria and, in line with Art. 61ter. §3 of the code of conduct, the “flexible power" of a connection cannot be less than 1 MW. If this is the case, the full capacity of the connection request is proposed firm.

In line with Art. 61quater. § 1 of the code of conduct, for connection studies proposing a connection with flexible access to the federal transmission network, a technical report mentions the conditions for flexible access to the network. A confidential version of this report is sent to the competent regulator and to the Directorate General for Energy. The non-confidential version of this report is sent to the applicant. More details on the content of the confidential and non-confidential version is provided in the document “Technical report for connection studies proposing flexible access: content description and justification”, attached to the present document.

- The additional non-exhaustive technical requirements from the technical regulation of application to the connection solution (federal technical regulation, local transmission network technical regulation, regional transmission network technical regulation, etc.) are communicated.
- In the event of a potential impact of the installation of the applicant on the stability of the network, the study mentions the need to carry out a detailed dynamic stability study during the connection study, which follows the grid connection study. The dynamic stability study may possibly lead to additional or different investments at the expense of the applicant, such as a different choice of design of the production unit or the step-up transformer. The dynamic stability study may also result in additional network investments, which may lead to a delayed commissioning of the installation of the applicant.
- In the event of a potential impact of the installation of the applicant on the voltage quality, the study mentions the need to carry out a detailed Power Quality study during the connection study, which follows the grid connection study. The Power Quality study may possibly lead to additional investments at the cost of the applicant, such as filters. The Power Quality study may also result in additional network investments, which may lead to a postponement of the commissioning of the installation of the applicant.

[13] Among these rare situations, we will find the need for flexibility in the case of N-1-1 in order to carry out maintenance or repairs of grid elements (N-1-1 for infrastructure project not included here).

In addition, the following technical information is provided to the applicant:

- Connection variants considered:

Connection variant	Access type	Connection point	Explanation
Variant 1	FLEX	*PPPPPUUU*	*Considered / Discarded*
Variant 2	FLEX	*PPPPPUUU*	*Considered / Discarded*
Variant 3	FLEX	*PPPPPUUU*	*Considered / Discarded*
FIRM variant	FIRM	*PPPPPUUU*	*e.g. Discarded given length of the connection link that is not technically-economically justified.*

- Relevant network evolution phases

Phases	Period	Description
Phase 1	20xx - Qx 20xx	*e.g. before commissioning of infrastructure project X*
Phase 2	20xx - 20xx	…
Phase 3	20xx - 20xx	…
Phase 4	20xx - 20xx	…
Finale Phase	20xx - 20xx	…

- In the cases of connection solutions with flexible access, and in order to provide the applicant with factual information on the risks of modulation of the connection request, the information in the following table is provided.

Profile consumption/injection		**Variant 1**			**Variant 2**
		Phase 1	**Phase X**	**Finale Phase**	**... (idem)**
Injection Capacity	Flexible Power (MW)	xx			
	Firm Power (MW)	yy			
	% preventive flexibility (time)	aa (= $aa_{[0-25]}$ + $aa_{[25-75]}$ + $aa_{[75-100]}$)			
	% curative flexibility (time)	bb			
	% flexibility (active energy)	cc			
	MWh flex./y (active energy)	zz			

	Description of market conditions with power modulation of the connection request (eg. high offtake and low production in the zone, or high imports from France combined with high offshore wind production)				
Consumption Capacity	... (idem)				

To understand this table, it is important to remember that the need for power modulation of connection request in the event of congestion is typically linked to one, the other or both phenomena described below:

- A high flow (higher than its permanent maximum power in N or higher than its temporary maximum power in N-1) on a critical grid element linked to a combination of the position of several players on the Belgian and EU markets. This phenomenon is the main cause of preventive flexibility volume (see table above). A description of the market conditions, among the 100 situations per year analyzed of the average year in terms of temperature profile, wind or sunshine, and correlated to these modulation needs is provided in the table.
- Unplanned or planned disconnection of grid elements (lines, cables, transformers, etc.), resulting in a high flow on another critical network element. This phenomenon is the main cause of curative flexible volume (see table above).
- Additionally, in order to provide additional information to the applicant, the % of time with preventive flexibility (aa) is separated in 3 sub-categories ($aa_{[0-25]}$, $aa_{[25-75]}$ and $aa_{[75-100]}$) where
  - $aa = aa_{[0-25]} + aa_{[25-75]} + aa_{[75-100]}$
  - $aa_{[0-25]}$ is the % preventive flexibility when the expected modulated power is between 0% and 25% of the flexible power range
  - $aa_{[10-90]}$ is the % preventive flexibility when the expected modulated power is between 25% and 75% of the flexible power range
  - $aa_{[90-100]}$ is the % preventive flexibility when the expected modulated power is between 75 % and 100% of the flexible power range
- The split of the % of time with preventive flex in 3 sub-categories as well as the description of market conditions with power modulation are non-binding piece of information and will not be written in the connection contract.

ELIA TRANSMISSION BELGIUM

Technical report for connection studies proposing flexible access: content description and justification.

29 November 2024

Table of content

1 Introduction

As the result of a connection study, a (candidate) Grid Users' connection request could lead to a proposal of connection with flexible access. In this context, technical reports are shared with the CREG and to the (candidate) Grid User.

The present document aims at describing the content and the purpose of the two versions of these technical reports and at explaining why some information are only shared with the CREG.

The document is structured as follows:

- Section 2 & 3 describe the information provided in the context of the connection study report as well as the content of the technical report for the (candidate) Grid User and explains that this information allows the (candidate) Grid User to take decision concerning the future of his project;
- Section 4 describes the confidential version of the technical report, explains that this information allows the CREG to judge on the correct application by Elia of the criteria for connection studies indicated in article 22 of the Code of Conduct and contains a justification on why some information can only be shared with CREG, and not with the Grid Users;
- Section 5 provides a conclusion.

Elia is open for comments on this document until 05/12/2024. Elia will consider the received inputs and will share its conclusion with CREG about the need to adapt the technical reports.

2 Connection study report for the (candidate) Grid User

This section details the information provided by Elia to the (candidate) Grid User concerning the different possible connections for his request.

- Connection points in the vicinity of the (candidate) Grid User: this section explains which substation and voltage levels are currently available, will be available in the future and/or will be dismantled in the future. This section concludes with the different considered connection options.
- For each of the considered connection options:
    - a description of this option is provided, explaining where part A is located and what would be the technical solution for the part B (type of connection cable, length, voltage level, capacity)
    - the need for flexibility (or not) in different phases of the evolution of the grid. This section is partly redundant with the content of the technical report for the connection with flexible access (see next section for details) but contains additionally a description of each phase which affects the connection option.
    - The specific technical capability to be implemented to be granted a “Final Operational Notification”, this includes for example the needs for real-time measurement, communication, remote control such as Gflex requirement, …
    - An indication of the costs for connection to the grid which are to be borne by the (candidate) Grid User. These costs, in line with the regulatory framework, are split between part A, part B and in case needed part Z costs, splits between one shot cost and annual costs and between CAPEX and OPEX costs.
    - The expected commissioning lead time needed for the connection infrastructure after the ordering of the connection.

3 Technical report for the (candidate) Grid User

The content of the technical report shared with the (candidate) Grid User was presented to the Market Parties during the 10/10/2024 workshop.

3.1 Content

The technical report contains the following information:

1) A summary of the connection request
    - Type of installation
    - New connection or significant modernization of an existing installation
    - Existing connection capacities for injection and offtake
    - Requested connection capacities for injection and offtake
    - Maximum active power that the grid user will inject into the Elia grid via his (future) connection. The ratio between the “Maximum active power” and the “Requested connection capacity for injection” is the minimum cos(phi) for this maximum active power.
    - Requested connection date
    - Connection date expected by Elia: This date primarily takes into account the time required to complete the connection. If the request is for an orientation study, the time required to complete the detailed study and other formalities is also taken into account. If the (candidate) Grid User can only be connected after Elia has made an investment in the grid, e.g. the construction of a new substation to which the (candidate) Grid User will be connected, the date of Elia's infrastructure project is mentioned if it is decisive for the time required to complete the connection.
2) A geographic localization of the grid user installation on a geographic map of the existing transmission grid.
3) In case of an **orientation study**, the **considered connection options** with, for each option, the **relevant substation** and connection voltage and the **type of access;**
4) In case of an **orientation study**, the **retained connection options** and the **justification** for **not retaining** the other considered connection options;
5) For each retained connection option, the indication of the **relevant phases until commissioning** of the **necessary grid reinforcements** foreseen in the portfolio of Elia’s infrastructure projects having at least a status “in study”. The latest published development plans, or any publicly communicated update of the timing of the projects at the date of the study are considered.
6) The **firm** and the **flexible power** for the **different phases and for the injection and withdrawn capacities;**
7) An **estimation** of **the yearly average activated flexibility** in term of **energy** (volume) and in terms of **time** for the **different phases;**

8) An **indicative description** of the **market conditions** which can be expected at the time flexibility is expected to be activated. These market conditions are described based on indicators (or a combination of these indicators) that are publicly accessible to the (candidate) Grid User to recognize and maybe anticipate these situations. A non-exhaustive list of these indicators is: season, temperature, Belgian or European wind production, solar production, import/export, Belgian consumption, …

   Finally, a description of the reference context is also provided[1].

The information regarding item for 4) and 5) are presented in the form of a table for each phase as shown in the next example.

[1] The provision of a description of the reference context is provided for reports sent to Grid Users and CREG from now on.

3.2 Practical example

The table below shows a fictive example for the connection of a 200 MW storage.

Type d'étude	
N° d'étude	xxxx
Type d'installation	
Nom du client	
Installation existante ?	NON
Capacité de raccordement pour l' Injection existante (MVA)	
Capacité de raccordement pour le Prélèvement existante (MVA)	
Capacité de raccordement pour l' Injection demandée (MVA)	
Capacité de raccordement pour le Prélèvement demandée (MVA)	
Puissance d'injection maximale demandée (MW)	
Puissance de prélèvement maximal demandée (MW)	
Date de la demande	
Date souhaitée de mise en service pour l'utilisateur réseau	
Date de mise en service estimée par Elia	
EOS réalisée avant l'EDS	NON
[redacted]	

-Explication supplémentaire si la demande finale de l'utilisateur du réseau diffère du formulaire de demande (par exemple, puissance ajustée ou ...)

-explication rapport MW <> MVA (exigences FTR ou cos phi minimale demandé par client est 'ok'?

-délai de mis en service --> determiné par raccordement ou investissement d'Elia dans une partie Z?

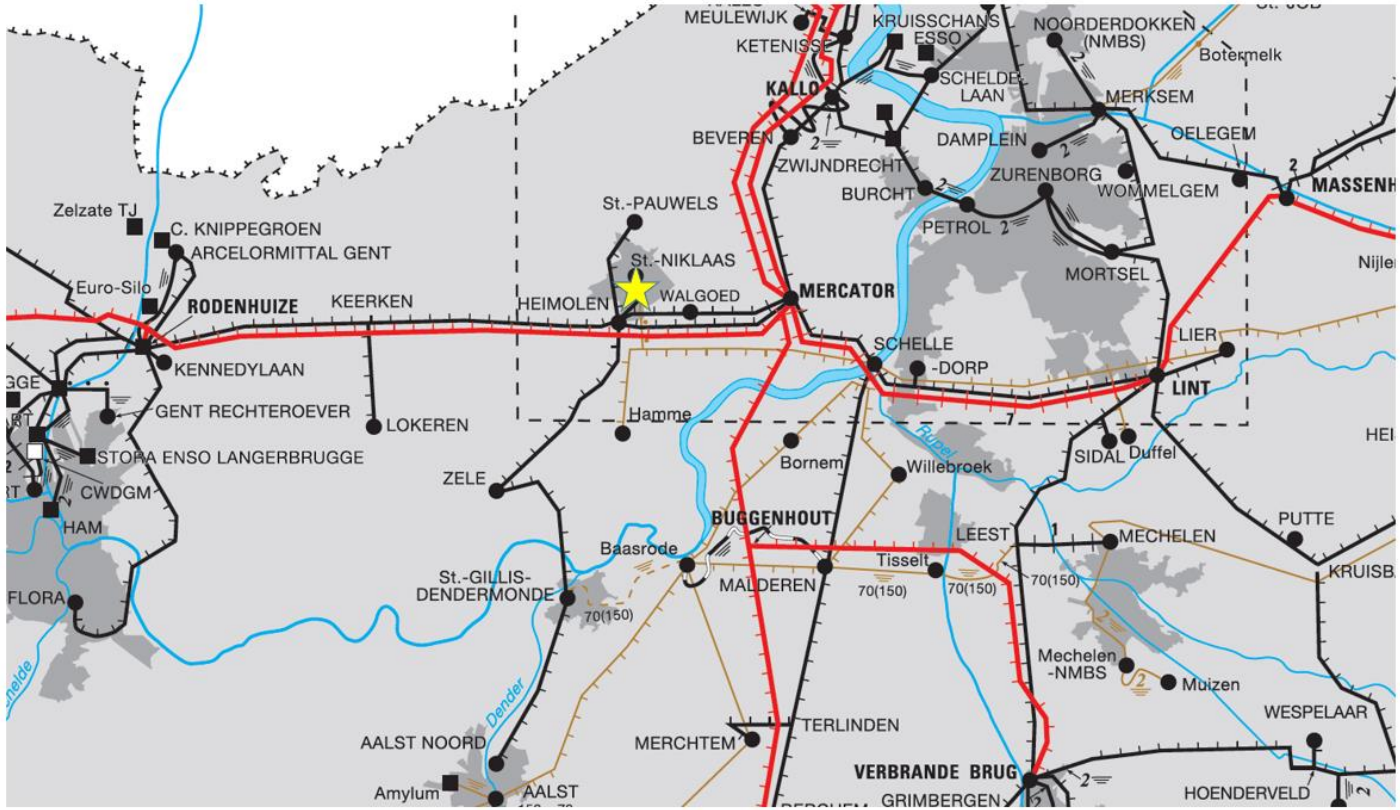

Table 1 : description of the investigated options and of the phases for option 1

Connection option	Type of access	**Aansluitingspunt**	**Toelichting**
Option 1	FLEX	*XXXXX150*	*Connection on XXXXX150 kV substation*
Option 2	FLEX	*XXXXX150*	*...*
FIRM option	FIRM	*XXXXX380*	*Option not retained due to the length of the connection cable which is not viable from a techno-economic point of view*

Phase	**Period**	**Description**
Phase 1	20XX-20XX	Before commissioning of Project XXXX
Phase 2	20XX-20XX	After commissioning of Project XXXX but before commissioning of Project YYYYY
Phase 3		
Phase 4		
Final phase	>= 20XX	After commissioning of Project YYYY

…

Table 2 : Firm and flexible power and needed flexibility for the different phases (option 1 only)

Injection profile / **Injection profile**		**Option 1**		
		Phase 1	**Phase 2**	**Final phase**
Injection	Flexible power (MW)	200	200	0
	Firm power (MW)	0	0	200
	% preventive flexibility (time)	40	30	0
	% curative flexibility (time)	5	2	0
	% flex (active power)	20	5	0
	MWh flex/year (active power)	15.000	5.000	0
	Description of Market conditions	Congestion occurs and needed modulation in case of offshore wind production, and import from UK	Congestion and needed modulation occurs in case of offshore wind production, and import from UK	-

OFFTAKE	Flexible power (MW)	150	0	0
	Firm power (MW)	50	200	200
	% preventive flexibility (time)	20	0	0
	% curative flexibility. (time)	2	0	0
	% flex. (active power)	10	0	0
	MWh flex./year (active power)	5.000	0	0
	Description of Market conditions	Congestion and needed modulation occurs in case of important consumption and limited production in XXX 150 kV zone		

3.3 Added value of this information for the (candidate) Grid User

The connection study report and the technical report for flexible access provide important information about the connection cost, the connection timing, the associated risk in terms of permitting, the expected flexibility volume and the related context (e.g. following an outage on the grid and/or in specific market situations).

Additionally, the information provided is enabling the application of the guarantees as proposed by Elia in the Code of Conduct, and is in line with the article 8§2 of the Electricity law[2].

- The table with the different phases indicates the **duration of the temporary period** and the duration of **each phase**
    - The (candidate) Grid User therefore knows how long activations will occur in priority compared to costly remedial actions and at its charge;
- For each phase, the **estimated yearly average activated energy** is mentioned.
    - The (candidate) Grid User is then able to evaluate the yearly not off-taken and/or not injected energy as well as the related charged costs for the BRP perimeter correction costs (capped imbalance price) and take it into account in its business case.

With this set of information, the (candidate) Grid User can evaluate the expected cost (including the consequences of the flexibility) and revenue of its project and decide if this connection variant fits its need.

[2] Which states that Elia has to provide to the grid users the needed information for an efficient access to the grid.

4 Technical report sent to the CREG (confidential version)

The confidential version of the technical report sent to the CREG contains additional information in order for the CREG to judge on the correct application by Elia of the criteria for connection studies indicated in article 22 of the Code of Conduct. The following subsections describe this additional set of information and contains a justification why this information cannot be shared with (candidate) Grid Users.

4.1 List of considered EDS in the zone of influence

As explained in the methodology for connection studies, the reference context is updated to reflect the most recent information related to the installed and reserved capacities in the zone of influence of the connection study.

The list of the additional considered capacities is communicated to the CREG in the form of a table and contains:

- The EDS reference number
- The name of the (candidate) Grid User
- The concerned substation and voltage level
- The concerned electrical zone
- The type of installation (Wind, PV, Other production, storage, consumption, mixed site)
- The connection capacity for injection and/or offtake (MVA)
- The date of the connection study request, connection study order, capacity reservation and capacity allocation
- The date of the (planned) commissioning
- Additional comments.

This information allows the CREG to ensure that the grid study is consistent with contractual engagement Elia and DSOs have already made to other Grid Users or candidate Grid Users with either firm or flex access in line with Art. 22 § 1er 4° of the code of conduct.

This set of information may not be, according to Art. 8 §3 of the Electricity Law, communicated to the (candidate) Grid User and is therefore only included in the confidential part of the report.

4.2 Detailed description and load flow results per phase and connection variant

4.2.1 Detailed description of the phase & results

For each phase, a detailed description of the grid structure is provided with the related single-line-diagram (SLD).

An example of description is provided below.

Table 3 : example of detailed description

Phase description	Before commissioning of project XXX
Period	20XX-20YYY
Grid structure description	*Description of grid structure*

This information allows the CREG to ensure that the proposed Grid structure is aligned with the latest timing of the projects at the date of the study and to compare infrastructure considered in different comparable connection requests to ensure non-discrimination of the connection request.

For each connection option, the identified Critical Network Elements (CNEs) with their permanent and temporary season rating, as well as the presence of dynamic line rating on the CNE are listed. An example is provided below.

Table 4 : example of list of CNEs

Option 1								
INJECTION								
Flexible power (MW)	200	MW	Congestion on the 380 kV XXX-YYY axis occurs in case of offshore wind production and import from the UK					
Firm power (MW)	0	MW						
% preventive flexibility (time)	30	%						
% curative flexibility (time)	5	%						
% flex. (active energy)	20	%						
MWh flex. (active energy)	15.000	MWh						
			Nominal rating (MVA)	Max perm seasonal rating (MVA)	Min perm seasonal rating (MVA)	Max temp seasonal rating (MVA)	Min temp seasonal rating (MVA)	DLR
CNE 1	DI 380.XX		-	-	-	-	-	Y/N
CNE 2	DI 380.YY		-	-	-	-	-	Y/N
CNE 3	...		-	-	-	-	-	Y/N

This information allows the CREG to ensure that all means such as temporary rating, season dependent ratings or dynamic line ratings have been considered to evaluate the impact of the connection request. It also allows the CREG to compare constraints observed (CNEs) in different comparable connection requests to ensure non-discrimination of the connection request.

4.2.2 Load flow results : worst CNEC per considered situation

For each phase and for each connection option, more detailed Load Flow results are provided in order for the CREG to verify the correct computation of the flex power, flex time and flex energy based on the results of the N and N-1 load flow results.

Relevant load flow results are provided for each of the situations per year (each of the clusters) with the worst CNEC (Critical Network Element and Contingency) per situation and which impact the preventive and curative activation of flexibility. The permanent and temporary rating of the CNE in this situation is provided, as well as the remaining available capacity on this CNE in absence of the installation of the candidate grid user.

Additionally, the PTDF of the installation of the candidate grid user on this CNE for the considered contingency is provided. This information, together with the market data (see section 4.3 for details) allows the CREG to verify:

- the correct and non-discriminatory consideration of the situations per year in the study
- the correct and non-discriminatory computation of the flex power for the connection request
- and the correct and non-discriminatory consideration of the impact of grid user on the considered contingency.

Table 5 : example of worst CNEC per Point in Time

Cluster	Representation [%]	Option 1						
		INJECTIE						
		Type afregeling	CNE	C	Ssea_CNE	Ssea_temp_CNE	PTDF,CNEC	Remaining capacity (MW)
1	X%	Preventief						
1	X%	Curatief						
2	Y%	Preventief						
2	Y%	Curatief						
3	Z%	Preventief	DI 380.XX	DI 380.YY	--	--	--	X
3	Z%	Curatief						
12		Preventief	DI 380.YY	DI 380.XX	--	--	--	Y
12		Curatief						

It is important to recall that the selection of the considered situations is based on a clustering algorithm. For a given year of 8.760 hours, these hours are grouped into clusters. The description of these clusters as well as the time representativity of each of these cluster is provided (see Section 4.3 for details).

The grid calculations are then performed based on the hour representing the centroid of each of these clusters, and not on the 8.760 hours. The provision of results for a sequential time series of the 8.760 hours is therefore not possible. Therefore, information such as the expected duration of the applied modulation cannot be provided.

Furthermore, sharing the information provided to the CREG with the (candidate) Grid User would be problematic given that he would receive privileged information. This while the network operator should prevent disseminating commercially sensitive information about its activities in a discriminatory manner as per Art. 9quater of the Electricity law.

As an example, with such information at its disposal for 2 sequential connection study results of a similar connection request (e.g. an EOS and later an EDS, two sequential EOS, an EDS and a re-computation of flexibility volume, …) the (candidate) Grid User could deduce at

- which location (relatively to the CNEC)
- of which type (demand, production or storage),
- and for how many MW,

another connection capacity has been reserved or released in the meantime, which could give him a strategic advantage, possibly with respect to a competitor, and which would not be in line with the Belgian legislative context as mentioned above.

Finally, the knowledge of the CNEC could lead to strategic bidding behavior after the connection of the unit to the grid due to an increasing possibility for the (candidate) Grid User to anticipate the occurrence of a congestion. This strategic bidding behavior is also referred to as INC-DEC gaming, and has been demonstrated in the technical literature and has been/is observed in practice.

While it is not the goal of the document to provide a detailed description of such strategic approach, the following example allows grasping the issue. In case of outage on one of those indicated grid elements (due to planned outage in the context of an infrastructure project, repair or maintenance) the (candidate) Grid User could anticipate the occurrence of a congestion and the related activation of its unit to solve the issue. By being able to anticipate the activation, the (candidate) Grid User could adapt its bidding behavior in the (day-ahead/intraday) market i.e. selling more energy at a lower price (even lower than its marginal price) to make sure it is selected in the market as it anticipates this energy will anyway not be produced due to the expected downward activation to solve the expected congestion. This behavior leads to market distortion with multiple consequences such as a distortion of the (day-ahead/intraday) market price, an aggravation of the congestion and a perverse investment incentive as investments in congested areas might be stimulated due to a higher margin for the unit in case of strategic bidding behavior.

4.3 Market conditions per phase

The last provided information are the simulated market conditions per phase provided in order for the CREG to verify correct implementation by Elia of the reference context in the market and grid model as well as the adequate and accurate enough description of the market conditions which can be expected at the time flexibility is expected to be active as mentioned in section 3.1.

This information is provided in a table format with the Belgian net position, total Belgian load consumption, wind onshore, wind offshore, total photovoltaic production, aggregated storage position, export/import on BE-FR border, export/import on BE-NL border, export/import on BE-DE border and export/import on BE-UK border for each of the situations (each representing a cluster).

As mentioned above, for each of the situations, obtained by clustering technique, the time representativity is provided. An example of the table is provided next page.

Once again, sharing this information with the (candidate) Grid Users would be in breach with article 9quater of the Electricity law.

Providing the market conditions in addition to the load flow results (worst CNEC per Point in Time) would accentuate the risk of strategic bidding behavior and market distortion mentioned above. Additionally, the fact that such information would be only available to a given grid user would be a discrimination concern.

Table 6 : Market conditions (100 considered situations representing clusters)

Cluster	Representation (%)	BE_Balance	BE_Load	BE_Onshore	BE_Offshore	BE_Solar	BE_Storage	BE==>FR	BE==>NL	BE==>DE	BE==>UK
1	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-
...											
...											
100	-	-	-	-	-	-	-	-	-	-	-

5 Conclusion

With this present note, Elia highlighted that the content of the connection study report, of the technical report enables the candidate to properly evaluate the impact of the connection solution, including the flexible access component of this on their Business Case.

The additional content provided to the CREG in the confidential version of the report is also described and Elia highlighted that such information allows the CREG to take an informed decision on the proposal by Elia for a flexible connection, taking into account the correct application of the criteria for connection studies indicated in article 22 of the Code of Conduct.

Elia also justified that it cannot provide this additional content to the (candidate) Grid Users for following different reasons:

- Some information is confidential and cannot be shared with other Grid Users.
- Some privileged information would only be available for the (candidate) Grid User, which would give him an advantage compared to its competitor and give the opportunity of strategic behavior.

Finally, Elia reminds that it committed to:

1. Increase the transparency regarding the considered scenario and growth potential thanks to publishing the grid study methodology by end of year;
2. Discuss openly the scenarios considered in the future, starting in the context of the Taskforce Scenario that will take place in 2025;
3. Setup a transparent process to be followed when revising the grid study methodology on regular basis.

Elia believes that these different elements, taken together, provide a valid answer to the different challenges that have been raised on its approach. Elia sees such multi-dimensional approach as more appropriate than providing in isolation additional information in the technical report to the grid user. Such approach would indeed lead to the confidentiality and gaming issue highlighted above, without providing an adequate answer to the 3 points mentioned above.