Réseau de transport d'électricité

# Information transmitted by RTE to the French energy regulator, Commission de Régulation de l'Energie in the context of the instruction of ELECLINK's exemption request

## Connection at the MANDARINS substation of Eleclink's new exempted interconnector project

*Version translated by CRE*

October 24, 2013

# CONTENTS

# A. SUMMARY:

Eleclink wishes to build a DC interconnector between France and the United Kingdom in relation to the provisions of article 17 of Regulation 714/2009 of the European Parliament and the Council of July 13, 2009 on conditions for access to the network for cross-border exchanges in electricity.

Following Eleclink's exemption application addressed to the French Energy Regulator, Commission de Régulation de l'énergie (CRE), CRE requested, on September 26th, 2013, that the French transmission system operatior, Réseau de Transport d'Electricité (RTE) provides, within one month, a series of information concerning the impact of this new interconnector on the functioning of the regulated system. The purpose of this study is to satisfy this request. Its main conclusions are:

- Eleclink's connection to the PTN (Public Transmission Network) involves new or increased constraints on the 400 kV network of the North of France, for certain configurations of flows and exchange.
- The constraints partly disappear following the reinforcements already planned and decided by RTE (Electricity Transmission Network) in the North of France[1]. Nevertheless, constraints appear on the Attaques-Warande-Mandarins 400-kV line and are to remain significant in 2021/2022 according to the selected assumptions.
- RTE recommends a reinforcement solution, which seeks the best technico-economic compromise in dealing with the constraints generated by the new interconnector on the PTN and to minimise the costs covered by the community of grid users subjected to network tariff (tariff d'utilisation des réseaux publics d'électricité, TURPE). This solution involves reinforcements in the 400-kV substations of Mandarins, Warande and Attaques, combined with the implementation of system of fast curtailment of ElecLink, which enables curative management, in real-time, of a major part of the constraints only occurring if one of the 400-kV circuits of the Mandarins-Warande-Attaques line is damaged.
- Once the reinforcements planned by RTE in the North of France and the additional reinforcement solution recommended by RTE have been implemented, the operation of the interconnector will generate residual constraints requiring redispatching actions for a maximum cost assessed at around 3 million euros per annum. The operation of the fast curtailment system may also generate costs for the community.

RTE specifies that this study follows the guidelines defined by CRE for enabling Eleclink to access the grid as a user and does not take into account the consequences of the application to the Eleclink interconnector of the provisions of the "Capacity Allocation and Congestion Management" and "Forward Capacity Allocation" codes, such as the integration of Eleclink in a "Flow-Based" capacity allocation process for example.

On the basis of the various deliberations of CRE and the information provided in this study, and assuming that the exemption request issued by Eleclink is accepted by CRE (and Ofgem), the insertion of the new Eleclink interconnector would therefore be subjected to the following regulatory framework:

- The costs related to the reinforcement solution recommended by RTE to reduce the constraints induced by the operation of the interconnector on the PTN are mutualised via the TURPE in accordance with the Deliberation of CRE of May 9, 2012.

- The residual redispatching costs, generated by Eleclink, following the implementation of the reinforcement solution and the reinforcements already decided by RTE in the North of France are mutualised by the TURPE and registered in the "Compte de regulation des charges et des produits" (the CRCP – an annual regularisation account for the network tariffs)[2] as international congestion costs.

[1] These reinforcements were presented in 2010 to CRE in the RTE investment programme. It is to be recalled that these investment decisions (for a cumulated amount of 350 million euros) were made to accommodate production in a favourable region without affecting the exchanges of France with Benelux and Germany.

- The costs induced by the operation of the system of fast curtailment of Eleclink, following the implementation of the reinforcement solution and of the reinforcements decided by RTE in the North of France, would be mutualised by the TURPE and registered in the CRCP as international congestion cost.

CRE is to make a decision concerning the exemption request, especially in relation to the comparison between the socio-economic interest of a new interconnector and the related costs for the community of users subjected to the TURPE. If necessary, such as mentioned in the Deliberation of March 29, 2012, CRE could also implement a regulation system for Eleclink's income, leading to give back to the network users a part of this income.

[2] Strictly speaking, in order to ensure a complete financial neutrality of Eleclink's regulation for RTE, it would be appropriate that the above costs be passed on as network user rates, without being subject to the cap-and-trade clearance mechanism of the CRCP provided for in the framework of TURPE4.

## B. INTRODUCTION:

Eleclink wishes to build a direct current interconnector between France and Great Britain in application of the provisions of article 17 of Regulation 714/2009 of the European Parliament and the Council of July 13, 2009 concerning the network access conditions for transboundary electricity exchanges.

Eleclink has asked RTE to connect its Public Transmission Network (Réseau Public de Transport – PTN) for a maximum injection power of 1000 MW and a maximum export power of 1,050 MX.

In its deliberation of March 29, 2012 concerning the application of article 17 of Regulation (EC) No. 714/2009 of July 13, 2009, the Commission for Energy Regulation (CRE) specifies that it "may [...] have to request additional information from the transmission system operator, especially details on the studies carried out in relation to the technical and financial proposal as well as information concerning the impact of the new interconnector on the French Public Transmission network. If necessary, the non-confidential part of these studies and analyses will be transmitted to the exemption applicant and integrated into the file subject to public consultation".

In its deliberation of May 9, 2012 concerning the Public Transmission Network connection and access conditions mentioned in article 17 of Regulation (EC) No. 714/2009 of July 13, 2009, CRE recalls that: «However, such as provided for in the deliberation of CRE of March 29th, 2012 concerning the application of article 17 of Regulation 714/2009, CRE will be particularly attentive to the reinforcement costs generated by the new interconnector and, pursuant to paragraph 1 of article 17 of Regulation 714/2009, could refuse an exemption if it considers that the costs covered by the community of users subject to the public network tariff are disproportionate compared with the expected profits".

In this context, CRE has submitted an official request on September 26, 2013 to the RTE to provide a study of the consequences for the Public Transmission Network (PTN) of the insertion of the new interconnector being developed by the applicant, Eleclink.

In this context, the purpose of this note is to present the information required by CRE and especially the constraints generated or increased by the new interconnector and the solutions likely to reduce or minimise these constraints with a cost assessment.

# C. PRINCIPLES OF THE STUDIES UNDERTAKEN:

The studies undertaken by RTE follow the process described below:

- Definition of the data: Definition of the study time horizons, determination of the study geographical scope and of the most significant time points for this study, construction of a series of assumptions (network structure, consumption, production and transboundary exchange assumptions), determination of the different scenarios to be studied (alternatives).
- Active and reactive power statistical deterministic analysis for the various time points and alternatives which have been identified: complete power flows and voltage analysis, characterisation of thermal constraints.
- Stability studies and slow dynamic studies, characterisation of dynamic and transient stability constraints.
- Short-circuit current studies
- Definition at this stage of a first series of solutions in order to solve the identified constraints.
- Probabilistic study performed to determine the costs of preventive redispatching and to specify the frequency of occurrence of the power flows constraints identified in the active and reactive power statistical deterministic analysis.

# D. ASSUMPTIONS:

## D. 1. Study timeframes:

CRE requests that the generated constraints are “studied during a period corresponding to the first 5 years of commercial operation of the interconnector and involve networks whose voltage exceeds 150 kV”.

The connection of the interconnector to the PTN is planned to be commissioned by the end of 2016.

The main parameters for the constraints are the reinforcements planned by RTE in the North of France, the new plants which planbe connected in the area and international exchanges. As the issue mainly concerns a very dense 400-kV transmission network, the expected variation of the consumption of the area only has a secondary impact on the constraints.

Thus, two time horizons have been selected aiming at simplifying the number of cases to be dealt with. The first timeframe is before the reinforcement of the 400-kV network and the second is five years following this date: i.e. in 2016/2017 and 2021/2022.

The study of the constraints at both time horizons provides a reasonable assessment of the impacts related to the insertion of the new interconnector on the PTN.

## D. 2. Study area

The study area being considered is limited to the area of influence of the power flows on the interconnector link planned by Eleclink.

RTE is comparing the current situation of the network and the situation of the network following the connection of the interconnector. The lines of the transmission network which incur power flows variations exceeding 5 % are to be integrated in the scope of this study.

All the constraints generated or increases in this area by Eleclink will be analysed in the following sections of the document.

## D. 3. Time points selected for the deterministic studies[3]:

Four representative time points are to be studied:

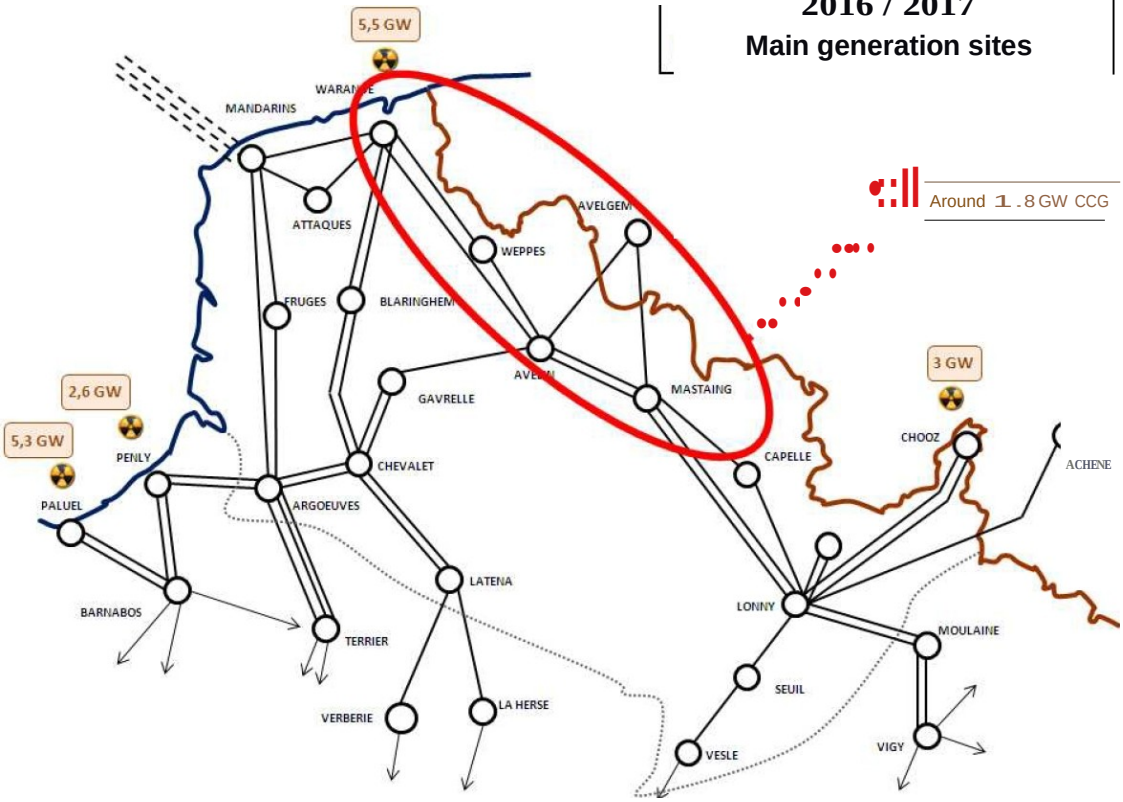
January 9h: Peak load in winter (PH)
January 4h Off-peak in winter (CH)
June 10h: Peak load in summer (PE)
June 4h: Off-peak in summer (CE).

## D. 4. Generation assumptions

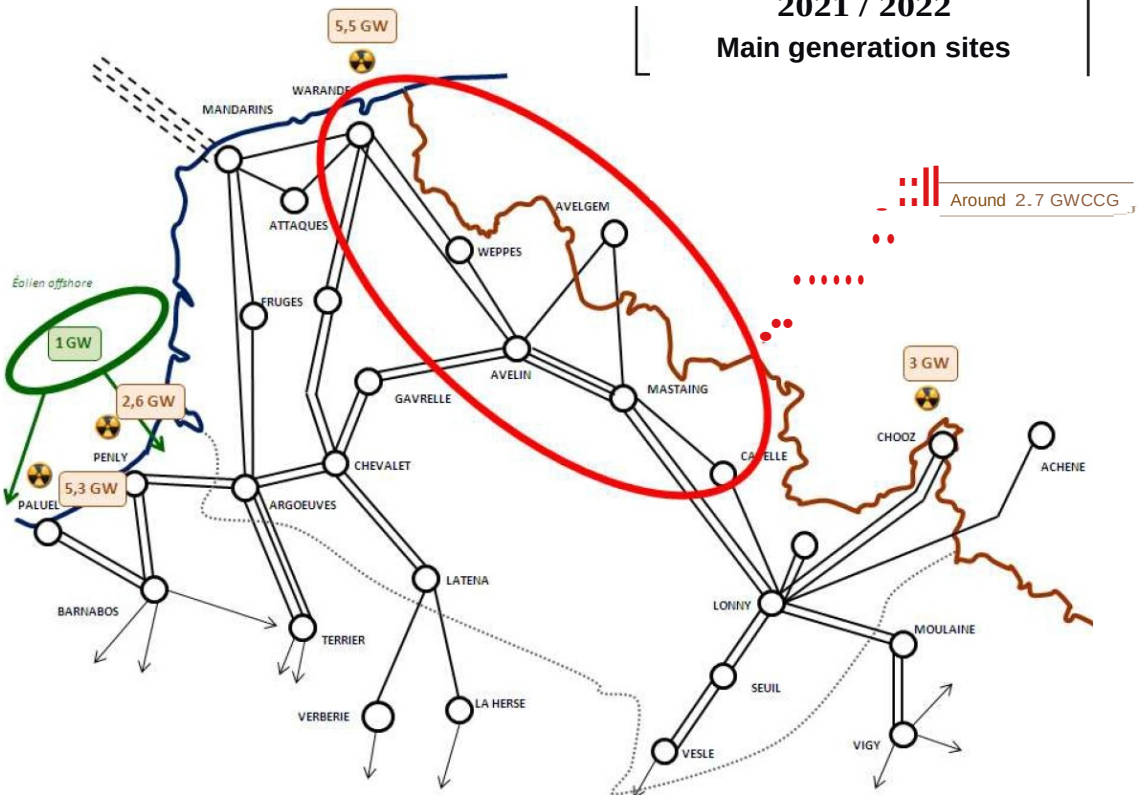
The following maps provide an overview of the main generation facilities selected in the area for the two study timeframes.

[3] Note: For probabilistic studies, all of the points of the year are taken into account.

## 2016 / 2017
## Main generation sites




## 2021 / 2022
## Main generation sites



The following table summarises the generation assumptions by fuel:

| | Type | Studies 2016/2017 | Studies 2021/2022 |
|---|---|---|---|
| Production | Nuclear (study area) | 16 GW | 16 GW |
| | Combined cycle gas (study area) | 1.8 GW | 2.7 GW |
| | Offshore wind (study area) | 0 GW | 1 GW |
| | Onshore wind (study area) | Around 4.5 GW | Around 7 GW |
| | PV (study area) | Around 0.5 GW | Around 1 GW |

Generation assumptions for renewable energy sources are based on the regional network development plans for renewable energy sources (S3REnR). The variation in onshore wind and photovoltaic generation, in the study area, is assessed to be 3 GW between 2016/2017 and 2021/2022.

The network studies carried on for 2016-2017 take into account all pending projects, assuming realistic provisional commissioning dates for these projects. The assumptions made for 2021-2022 are, for the major part, based on pending projects as well as on projections made by RTE.

These projections naturally involved uncertainties. The assumptions related to the volume of gas combined cycles, for instance, may be over-estimated, insofar as RTE was recently informed that a production project, which could impact the network constraints in the study area, has been abandoned (the project was to be implemented beyond 2016/2017). On the other hand, off-shore wind generation could be under-estimated considering the ambitions of the Nord-Pas de Calais region of accommodating an offshore wind farm in relation to the third call for tender.

As a general rule, it can be said that this study is robust regarding the development of the production in the North of France.

## D. 5. Cross-border exchanges assumptions:

The exchange volumes are built from the statistical distributions of balances of European countries determined in market studies performed by RTE for the time horizons from which, in the case of deterministic studies, are studied contrasted alternatives in terms of exchanges with England and the Northern block (Germany and Benelux).

The flows on the 400-kV network of the North of France are indeed highly impacted by exchanges with bordering countries. These statistical distributions of the balances of European countries are also taken into account in the probabilistic studies which have been carried out.

It should be noted that the network study which has been undertaken considers as input data the preservation of the exchange capacity between France and Belgium, with respect to the current situation. Such an approach tends to increase the volume of identified constraints insofar as, in a real context, adjusting exchange capacitiesallows dealing with congestions on lines identified as “critical” in the interconnected European network. The option of adapting the exchange capacities was not retained in the studied conducted by RTE.

## D. 6. Consumption assumptions

| | Time points | Studies 2016/2017 | Studies 2021/2022 |
|---|---|---|---|
| Consumption France (GW) | PH | 84 | 87 |
| | CH | 66 | 68 |
| | PE | 56 | 58 |
| | CE | 41 | 42 |

Powers at normal temperature

The assumptions are those which are taken into account in the Provisional Balance published in 2012 by RTE. The difference between these assumptions and their 2013 update is not significant.

## D. 7. Network structure assumptions:

### Reinforcements decided for the 400-kV network

Four projects concerning the reinforcement of the 400-kV network in the study area may affect the flows in the study area.

RTE comitted to carry on these projects, independently from the connection project of the new Eleclink interconnector:

- The doubling of the Avelin-Gavrelle 400-kV axis.
- The upgrading from 225 kV to 400 kV of the Avelin Mastaing line.
- The doubling of the Lonny-Vesle-Seuil 400-kV line.
- The creation of a new 400-kV link between the substations of Cergy and Persan.

These reinforcements are referred to in the Ten-Year Network Development Plan (Schéma Décennal de Développement de Réseau - SDDR) in the 10-year section.

The provisional cost of these reinforcements (according to the economic conditions of 2014), their progress status and their provisional implementation date are specified in the following section.

| Structure | Estimated cost | Around Status of progress of the project on October 1st, 2013 | Provisional implementation date |
|---|---|---|---|
| Doubling of the 400-kV Lonny-Vesle-Seuil line | 134 million euros | - "Public Utility Declaration" application submitted<br>- Public enquiry from 23/9/13 to 30/10/2013. | End of 2016 |
| Doubling of the 400 kV Avelin-Gavrelle line | 141 million euros | - Following public debate, consultation in progress under the guidance of a guarantor. | End of 2017 |
| Upgrading from 225 kV to 400 kV of the Avelin-Mastaing line | | - Detailed design studies in progress | End of 2017 |
| Creation of a new 400-kV link between the substations of Cergy and Persan | 53 million euros | - Detailed design studies in progress | 2018 |

The studies carried on show that the insertion of Eleclink tends to increase the constraints which have justified the above-mentioned reinforcements. Therefore, the usefullness of the projects which have already been decided is not questioned by the Eleclink project.

Furthermore, the realisation of this type of project is complex and the implementation of such significant projects could be delayed beyond the provisional deadlines specified above, due to events independent of RTE's will.

Reinforcements planned in relation to the regional plans for renewable energy sources network connection (S3REnR)

The S3REnR concerned by the study area and thus chosen for assessing the impact of Eleclink's flows are the regions of Nord Pas de Calais, Picardie and Champagne Ardennes.

The S3REnR project approval process for the Nord Pas de Calais region, proposed by RTE in May 2013, is in progress.
The S3REnR project was made available to the public, with its environmental report in compliance with article R122-22 and following articles of the Environmental Code, from August 22 to September 22, 2013.

The S3REnR of the Picardie and Champagne Ardennes regions were approved by the regional Prefects. For both S3REnR, the HV works created or reinforced are listed below:

For the Champagne Ardennes region:

HV structures created and accounted for in the generators connection charges:

- Addition of a 400/90 kV transformer at Mery/Seine (RTE's quota 6,250 k€)
- 90/20 kV substation equipped with 3 transformers, connected via a 90-kV underground line to the Mery/seine substation (RTE's quota 13,250 k€).

Reinforced HV works not taken into account in the generators connection charges (covered by RTE)

| Reinforced structures | Cost covered by RTE (k€) |
|---|---|
| Busbar works at the 63-kV substation of Froncles | 1,000 |
| Increasing the transmission capacity of the Bassigny-Chaumont 63-kV link | 1,300 |
| Increasing the transmission capacity of the 63 kV Bassigny-Montigny link | 1,000 |
| Increasing the transmission capacity of the 63 kV Montigny le Roi – Rolampont link | 1,200 |
| Total | 4,500 |

For the Picardie region:

HV structures created and accounted for in the generators connection charges:

| Created structures | Cost (k€) |
|---|---|
| Creation of the 225-kV substation at Thiérache | 6,950 |
| Creation of the 90-kV substation at Thiérache | 700 |
| Creation of the 90-kV substation at Buire | 2,900 |
| Creation of an underground 90 kV Marle – Thiérache link | 6,300 |
| Cut-off of the 225-kV substation of Thiérache | 400 |
| Creation of a 225-kV bus-tie circuit breaker at Sétier | 700 |
| Creation of the Nord-Amiens substation connected to the 225-kV Amiens – Avesne link | 300 |

Reinforced HV works not taken into account in the generators connection charges (covered by RTE):

| Reinforced structures | Costs covered by RTE (k€) |
|---|---|
| Works performed on the 225-kV substation at Thiérache | 800 |
| Works performed on the 63- and 90-kV substations at Marle | 1,600 |
| Upgrade of the Lislet substation from 63 kV to 90 kV | 900 |
| Works performed on the 63- and 90-kV substations at Buire | 1,500 |
| Upgrade of the Lislet-Mare substation from 63 kV to 90 kV | 700 |
| Removal of the overhead 63-kV Buire – Marle link | 1,300 |
| Total | 6,800 |

These different transmission network new or reinforcement projects allow accommodating the generation capacity taken into account in the assumptions are mentioned in the “Generation assumptions” paragraph. However, they do not constitute network structure developments which may modify the results of the studies related to the insertion of Eleclink.

# E. RESULTS OF THE STUDIES:

## E. 1 Deterministic analysis: Summary of the constraints generated or increased by Eleclink:

The first step of these studies involves performing a deterministic analysis for the two study time horizons, for the four time points which have been selected, each time with and without Eleclink, all other things remaining equal. During these analyses, numerous alternatives have been developed with various scenarios involving exchanges between France and England.

A summary of the main 400-kV lines where constraints are created or increased by the insertion of the Eleclink interconnector (the most restrictive for Eleclink are in bold characters), is presented below.

In 2016/2017:

| xchange scenario th GB | Main constraints on 400 kV lines | Comments |
|---|---|---|
| IMPORT | Lonny-Vesle-Seuil (LVS)<br>And to a lesser extent:<br>Cergy-Terrier, Argoeuve-Terrier, Plessis Gassot-Terrier | Eleclink overloads this line in the following direction<br>Import and mainly in winter. |
| EXPORT | Avelin-Mastaing<br>Attaques-Mandarins-Warande (AWM) | Eleclink overloads these axes during exports. The constraints generated on the AWM line occur mainly in summer. |

In 2021/2022 :

| Exchange scenario with GB | Main constraints on 400 kV lines | Comments |
|---|---|---|
| IMPORT | Argoeuve-Terrier, Plessis Gassot-Terrier | Although relatively distant, these 400-kV lines, are impacted by Eleclink. |
| EXPORT | Attaques-Mandarins-Warande (AWM) | Eleclink overloads these axes specifically during exports. |

## Deterministic analysis: illustrations:

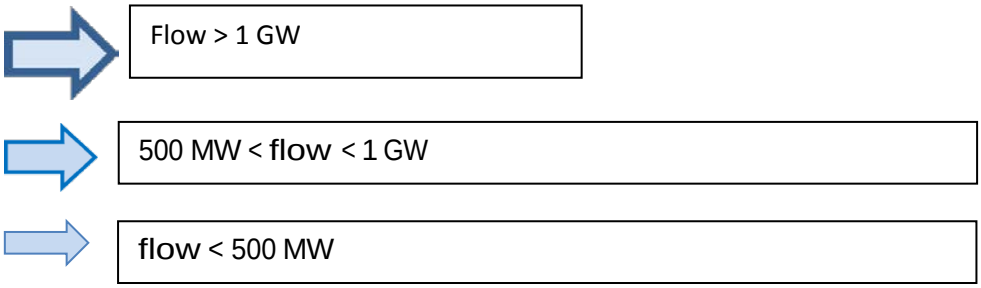
In order to illustrate these results, among all the alternatives being studied, three deterministic situations particularly representative of the generated constraints have been chosen:

2016-2017: Winter Peak load (Export to England and import from Belgium)

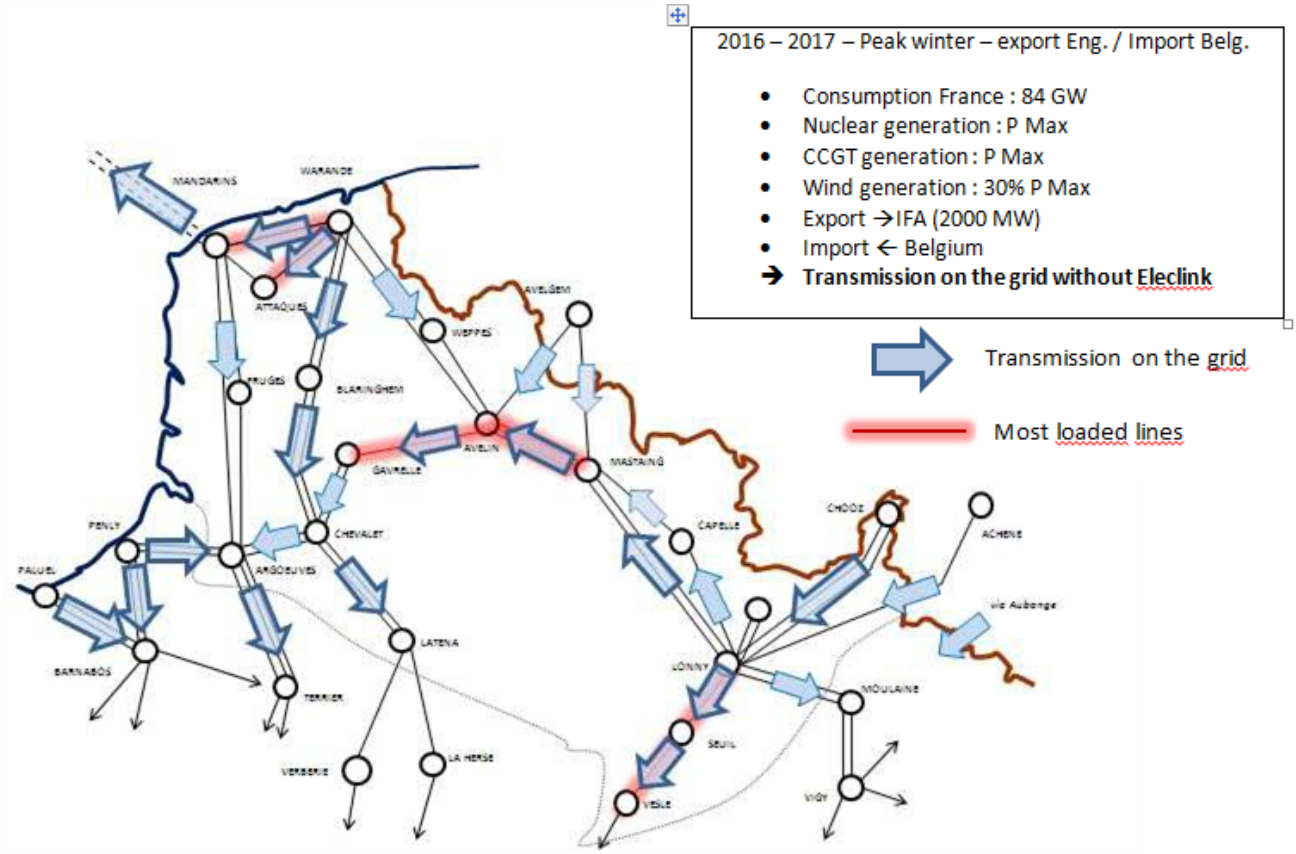
2016-2017: Winter Peak load (Import from England and Import from Belgium)

2021-2022: Summer Peak load (Export England and Import Belgium).

Legend:



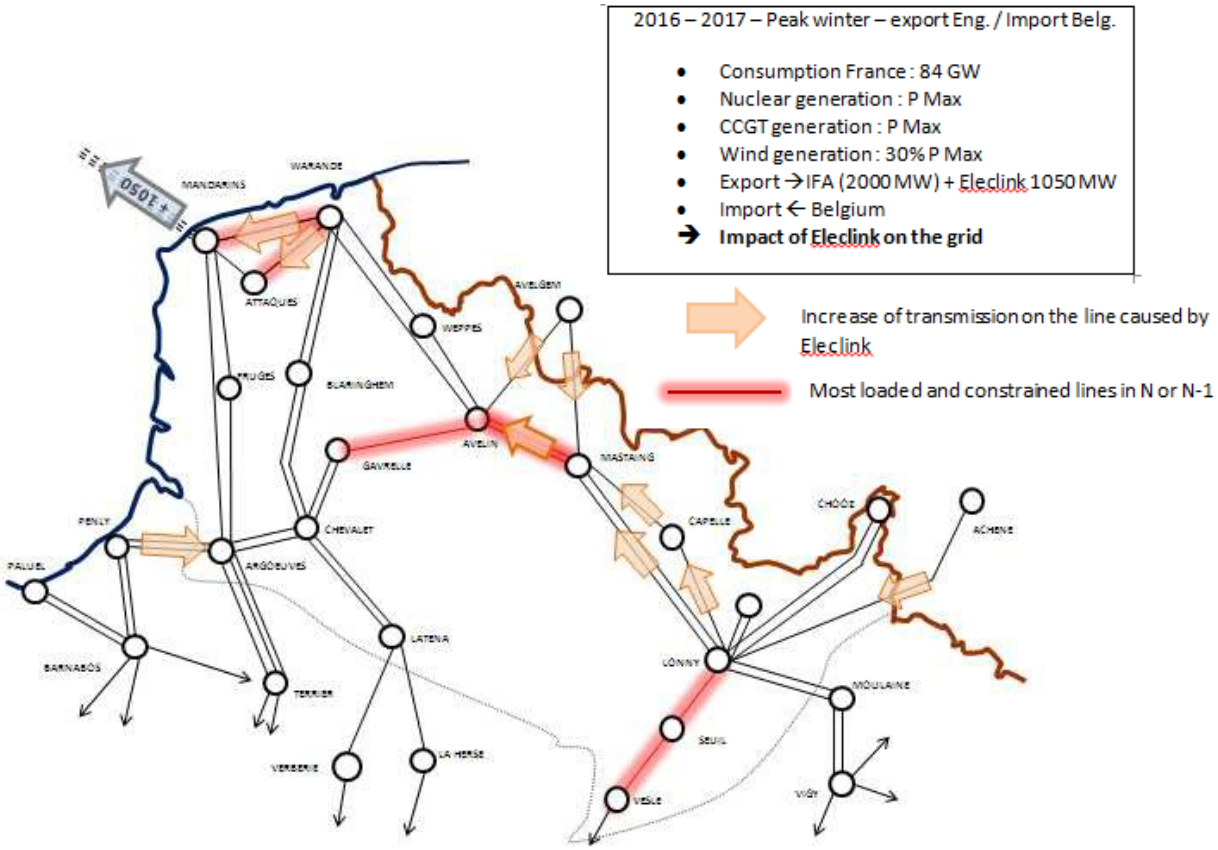
2016-2017: Peak Winter Period – Export to England and Import from Belgium




In this situation, the consumption in France amounts, at a normal temperature, to around 84 GW. The thermal powerstations (nuclear and CCGT) are started up at maximum power and the wind energy production at 30% of the installed capacity in the area.

The physical imports from Belgium are significant (physical flows of around 2 GW on the interconnection links) and exports to England amount to 2 GW.

The most loaded lines with a complete network are the 400 kV-lines Lonny-Vesle-Seuil, Avelin-Gavrelle, Avelin- Mastaing and the 400-kV Attaques-Mandarins-Warande line.

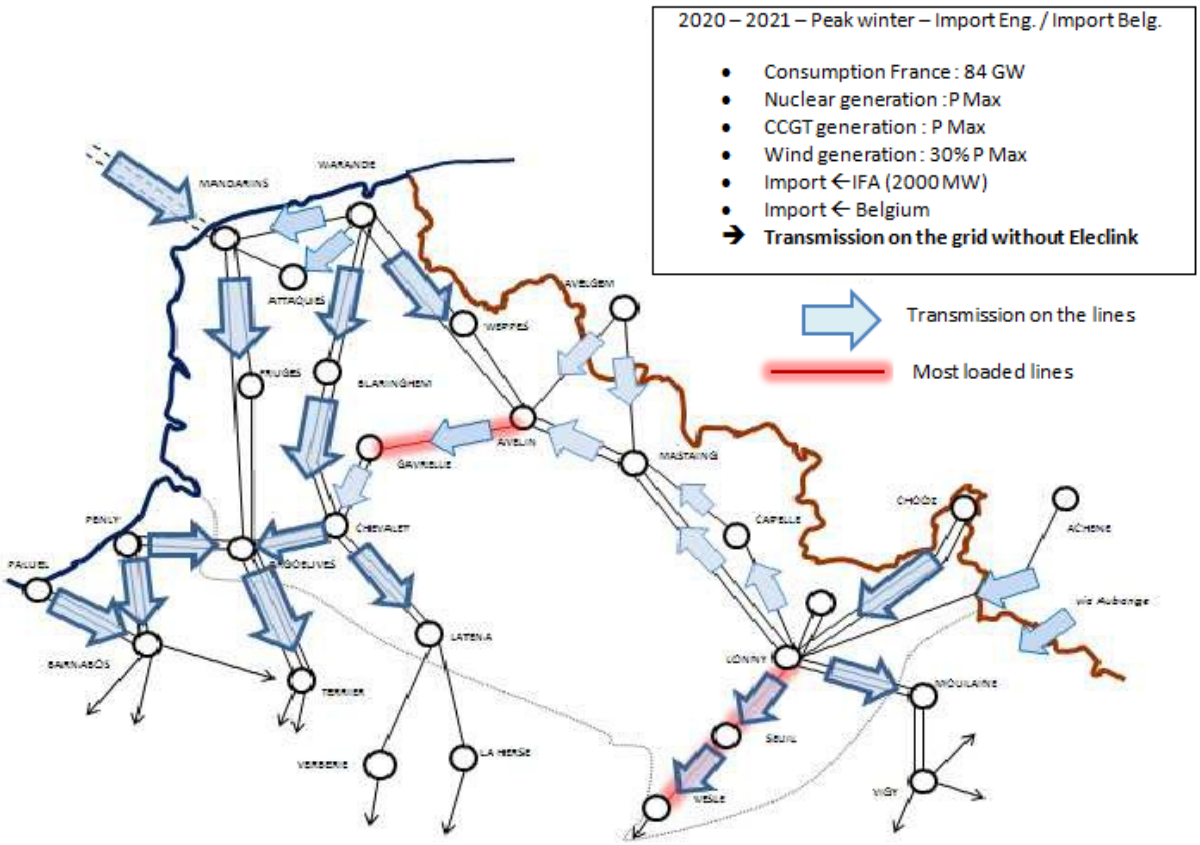



The exports following the insertion of Eleclink f(1,050 MW) increases flows on the Avelin-Mastaing 400-kV lines. If one the two transmission lines is lost, the second could therefore be constrained..

Eleclink also increases constraints on the Attaques-Mandarins-Warande 400-kV line. The Attaques-Warande and Mandarins-Warande lines are subjected to constraints if either line is lost.

Lastly, the increase of imports from Belgium increases the flows on the Avelin-Mastaing 400-kV line and this line is the first to be subjected to constraints if one of the two transmission line is lost. The fact that Eleclink has the same effects on this line shows that Eleclink, , could be a limiting factor for imports from Belgium if no measures are taken.

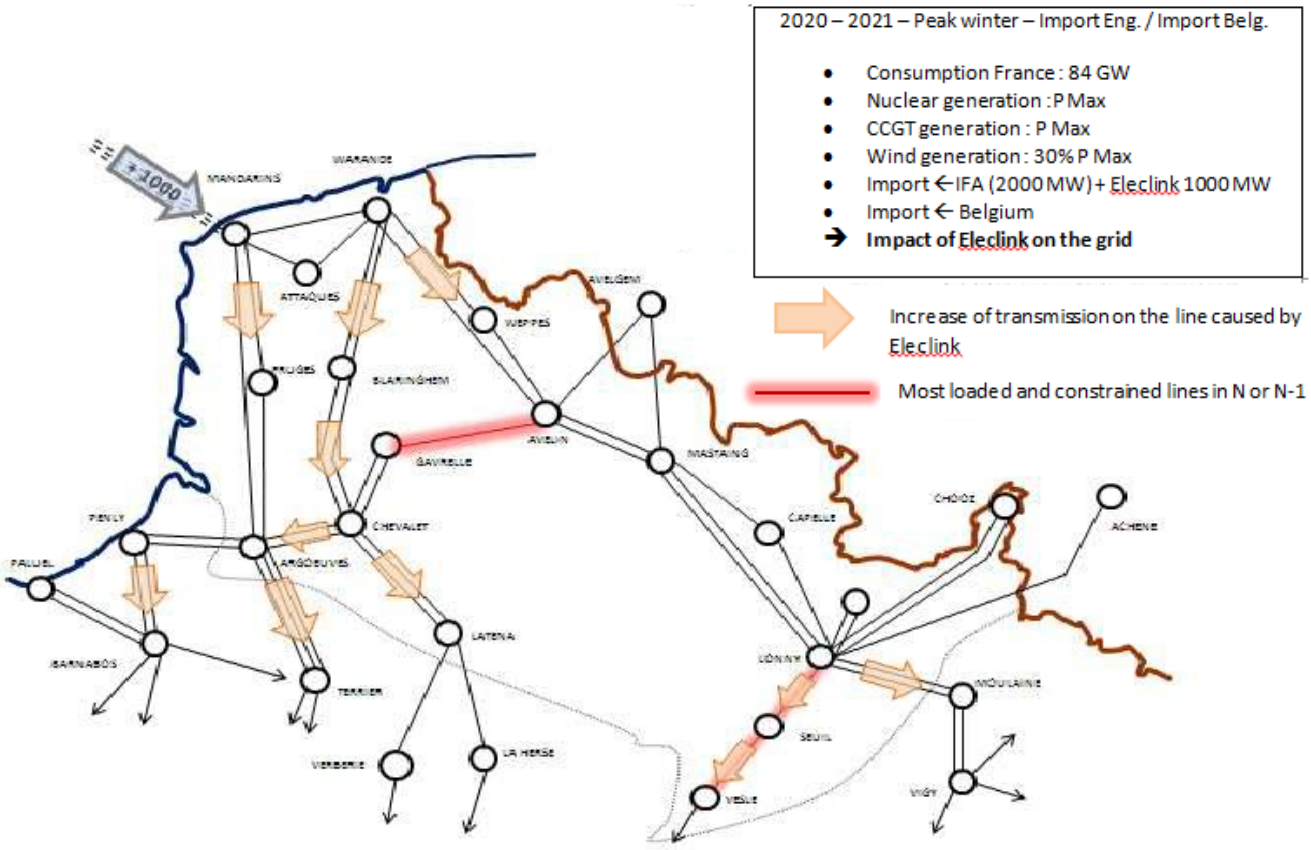
2016-2017 : Peak Winter Period – Import from England and Import from Belgium:




In this situation, which is identical to the previous situation as regards consumption and generation conditions, imports from Belgium amount to around 1 GW (physical flows on the interconnection links) and imports from England amount to 2 GW.

We can clearly see that, in these conditions, the flows are directed “North → South” to supply the consumption of the region of Paris.

In such conditions, the Avelin-Gavrelle and Lonny-Vesle-Seuil lines are already extremely loaded.



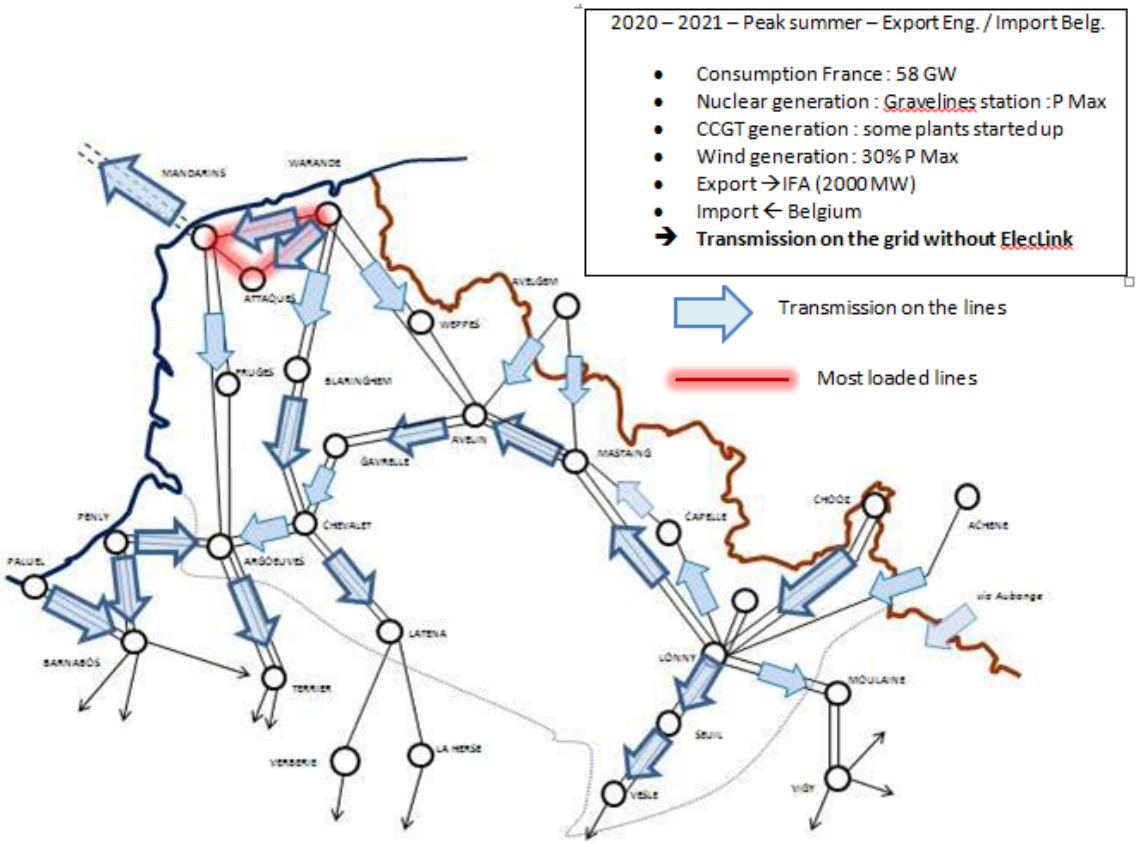

It is noted that Eleclink has a real impact on the 400-kV lines, which are already significantly loaded. Therefore, the additional import of 1000 MW also increases flows on the Lonny-Vesle-Seuil 400-kV line.

In this new configuration, this line is subjected to constraints if the Avelin-Gavrelle line is faulty.

If exports are increased from Belgium, the Lonny-Vesle-Seuil 400-kV line is the first to be subjected to constraints upon loss of the Avelin-Gavrelle line, which therefore limits exchanges from Belgium.

By Increasing the flows on the line limiting exchanges with Belgium, Eleclink would therefore reduce the maximum possible exchanges from the Northern zone if no measures are taken.

2021-2022 : Peak Period in Summer – Export to England and Import from Belgium




In 2021/2022, the study considers that the network reinforcements, which have been decided, will have been implemented:

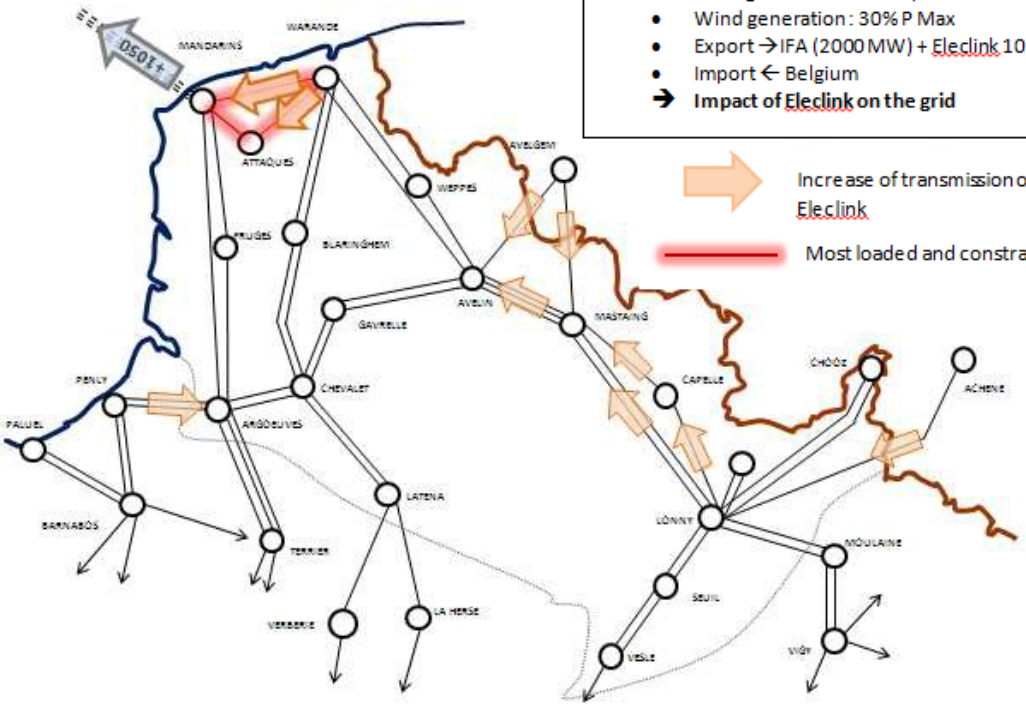
- Doubling of the Avelin-Gavrelle 400-kV axis.
- Upgrading from 225kV to400 kV of theline (Avelin Mastaing).
- Doubling of the Lonny-Vesle-Seuil 400-kV axis.
- Creation of a new 400-kV link between the substations of Cergy and Persan.

In the same conditions as those described in the first case (see above), with a slightly higher consumption in 2021/2022, the lines, which are then loaded in the same configuration as in 2016/2017, are less loaded and this is due to the reinforcements, which have been implemented.

However, the Attaques-Mandarins-Warrande line is extremely loaded and **these constraints are increased by the integration of Eleclink, such as shown in the figure below.**

2020 – 2021 – Peak summer – Export Eng. / Import Belg.

- Consumption France : 58 GW
- Nuclear generation : Gravelines station : P Max
- CCGT generation : some plants started up
- Wind generation : 30% P Max
- Export → IFA (2000 MW) + Eleclink 1050 MW
- Import ← Belgium
- → **Impact of Eleclink on the grid**




Increase of transmission on the line caused by Eleclink

Most loaded and constrained lines in N or N-1

## E. 2 Probabilistic analysis:

The purpose of this probabilistic study is to assess, on a quantitative basis, the constraints generated or increased by Eleclink's imports and exports.

RTE will charge Eleclink the costs of dealing with these constraints, via limitations, until the implementation of the network reinforcements deemed necessary, including the reinforcements proposed in relation to this study and which would result from a favourable CRE's decision as regards Eleclink's exemption request. CRE's deliberations specify that RTE must no longer impose limitations to Eleclink in relation to the aforementioned constraints after the implementation of the corresponding network reinforcement works. If congestion costs arise, they will be accounted for as "international congestions" and integrated as such in the CRCP.

Eleclink capacities may be reduced by preventive or curative limitations:

Preventive-type limitations: These limitations apply in normal operating conditions when RTE provides for a constraint risk (constraint at N, or constraint not tolerated in relation to N-K rules) on the transmission system if the facility is importing or exporting. RTE has made a commitment to Eleclink as regards the annual maximum duration of these reductions and the maximum reduction volume via its "technical and financial connection proposal".

Curative-type limitations: These limitations only apply if an effective failure of ae part of the transmission system generates constraints, which may be dealed with by reducing imports or exports of the facility with a given delay. RTE has guaranteed Eleclink that only a limited number of failures justifying curative-type reductions will occur and has assessed, on average, the annual duration of the risk related to the occurrence of these situations and the reduction volume.

The probabilistic study models the behaviour of the network over the entire year and summarises the assumptions of the deterministic study. For the purpose of clarity, the presentation of the results is segmented over four periods in the year.

The tool employed can be used for causing the variation of the parameters affecting the constraints detected during the deterministic study and therefore confirm its results.

Thus, these thousands of calculations vary through random simulation (according to parameterised probabilistic laws) as regards:

- Consumption
- Availability of and costs related to generation plants
- Balances of foreign countries
- Volume of renewable energy.

The simulation tool is employed for assessing situations in which Eleclink's imports and exports generate or increase a constraint, which cannot be solved by a panel of acceptable curative actions involving a complete network and upon loss of the 400-kV structure of the area.

As a general rule, the probabilistic analysis confirms the constraints generated or increased by Eleclink, detected during the deterministic analysis (see above).

- Constraints have been identified, for 2016/2017, on the Avelin-Mastaing and Lonny-Vesle-Seuil 400-kV lines but also on the Attaques-Mandarins-Warande 400-kV line. To a lesser extent, the analysis is used for detecting, in specific configurations of certain selections, constraints on the Cergy-Terrier, Plessis Gassot-Terrier and Argoeuvres-Terrier 400-kV lines but with small occurrences.

- For 2021/2022, constraints which remained on the Attaques-Mandarins-Warande 400-kV line.

The tool is also employed for assessing, for these constraint-related situations, the generation redispatching required to alleviate the constraints:this redispatching involves reducing the production on certain power plants in order to reduce the flows on the structures detected as constraints and increasing generation on other power plants by the same amount in order to guarantee the balance of the supply-demand. Thus, for each of these alternatives, the model optimises the control of the power plants in order to minimise the constraints detected with a complete network or upon loss of a structure. This optimisation consists either in increasing or decreasing generation for lifting the network congestions while ensuring the balance of the French supply-demand. By difference for each alternative of the volumes redispatched with and without Eleclink, the additional redispatched volumes due to the insertion of Eleclink are obtained.

Another possible approach for characterising, in a quantitative manner, the constraints highlighted by probabilistic studies involve assessing the volume of limitations which should be applied to Eleclink so that the level and occurrence frequency of the constraints are not increased by the operation of the interconnector.

It should be noted that these calculations aim to clarify possible PTN reinforcement investment decisions on the basis of assumptions involving uncertainties, especially since the schedduled commissioning date of these reinforcements is far away. The simulation tool can, in a certain manner, be used for making a conservative assessment of the actions to be conducted (redispatching or limitations) for minimising the constraints. It does not account for all the means which could be implemented by operators in real-time for processing the constraints insofar as the availability of these means is not certain when we are extremely farfrom real-time.

Furthermore, the study tool only redispatches generating stations in France and does not modify the network's topological structure.

Therefore, the following assessments are theoretical, insofar as they aim to measure the depth of the constraints by considering that they are exclusively processed through redispatching or limitations. Moreover, the current exchange capacities with transboundary countries are systematically preserved in the calculations performed by the simulation tool.

## Approach for contraints based on the exclusive use of a redispatching process

The simulations carried out in relation to the probabilistic study described above can be used for calculating an assessment of the volumes of "redispatched" energy, which would be necessary for minimising the constraints generated or increased by the operation of Eleclink. These simulations have been performed for two timeframes: 2016-2017 and 2021-2022.

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The volumes determined with the tool must be considered as high assessments and lead to assessing the redispatching related to Eleclink at around [redacted] for 2016-2017.

Beyond this timeframe, following the commissioning of the reinforcements provided for by RTE in the North of France, the simulations show that the volume of constraints on the PTN, imputable to Eleclink, would significantly increase if the assumptions of an increased production defined in section D4 are retained. The impact of these reinforcements would not be sufficient for minimising the constraints generated by the increased production in the area. This situation is not very probable if we select the reinforcement solution recommended by RTE in § F due to the fact that the implementation of this solution should take place at the same time as that of the reinforcements planned by RTE

## Approach for contraints based on the exclusive use of Eleclink limitations

In this approach, only Eleclink's capacity is reduced and there is no redispatching action imputable to Eleclink.

RTE has assessed the limitation volumes over the two following periods:

- A first period between the date on which Eleclink is to be commisioned (scheduled for end of 2016) until the date on which the main reinforcement projects provided for by RTE in the North of France are to be commissioned. This date is scheduled for end of 2017 but could be postponed according to events independent of RTE's will, which could delay the implementation of these reinforcements.
- A second period, beyond the implementation date for the reinforcements provided for by RTE in the North of France and without the additional reinforcements considered in the solutions described below for minimising the constraints generated by Eleclink on the PTN.

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The limitation volumes resulting from this assessment are the following:

**Reductions in First Period**

**Import capacity**

| Period | Maximum reduction period (in number of hours) | Maximum reduction volume (in MW) |
|---|---|---|
| Winter | [redacted] | |
| Summer | | |

**Export capacity**

[redacted]

| Period | Maximum reduction period (in number of hours) | Maximum reduction volume (in MW) |
|---|---|---|
| Winter | [redacted] | |
| Summer | | |

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**Reductions in Second Period**

**Import capacity**

| Period | Maximum reduction period (in number of hours) | Maximum reduction volume (in MW) |
|---|---|---|
| Winter | [redacted] | |
| Summer | | |

**Export capacity**

[redacted]

| Period | Maximum reduction period (in number of hours) | Maximum reduction volume (in MW) |
|---|---|---|
| Winter | [redacted] | |
| Period | | |

[redacted]

## E. 3 Other network studies:

### Short-circuit current constraints

For the timeframes being studied, short-circuit current constraints have been studied.

No specific constraint generated or increased by the insertion of Eleclink into the PTN has been detected. Thus, short-circuit current limits are respected at the Mandarins substation, after the connection of Eleclink.

It should be noted that, due to a lack of data from Eleclink on the level of short-circuit current supply by the interconnector, a supply of once the nominal current has been considered for this type of link.

## Voltage level and dynamic stability constraints:

The impact of the insertion of Eleclink has been studied from the viewpoint of voltage-related constraints and dynamic stability. These studies de not show any specific constraints if the Eleclink facility complies with the specifications defined by RTE in Article 1.4[4] of its Reference Technical Documentation (Documentation Technique de Référence – DTR).

4 Article 1.4 of the “Transitory technical rules for the design and operation of the connection to the PTN of a New Derogatory Direct Current

24 octobre 2013

Interconnection (article 17 of Regulation CE-714-2009).”

# F. PROPOSAL OF SOLUTIONS FOR MINIMISING CONSTRAINTS FOR 2021-2022:

It should be recalled that, for 2021/2022, the insertion of the new Eleclink interconnector will generate constraints on the PTN, and mainly on the Attaques-Warande-Mandarins 400-kV line. In order to minimise these constraints, RTE must perform redispatching actions or limit the operation of the interconnector.

RTE has analysed the transmission system reinforcement solutions, which could limit the impact of the new interconnector on the overall operation of the transmission system and reduce the amplitude of the constraints management actions to be implemented.

This analysis has been carried out while searching for the best technico-economic compromise: RTE has searched for the optimal reinforcement solution for increasing the transmission capacities of the PTN in order to prevent the development of most of the constraints generated by Eleclink while minimising the overall cost covered by the user community of the network subject to the TURPE.

The solution recommended by RTE is defined below.

## F. 1 Solution recommended by RTE: Installation of an Eleclink fast curtailment system and of the reinforcements limited to substation works

The solution recommended by RTE combines the installation of a fast curtailment system for Eleclink, which can be used for the curative management of the constraints and reinforcement structures in the substations of Attaques, Warande and Mandarins.

### Installation of Eleclink's fast curtailment system

The duration of the preventive limitations related to the export capacity can be significantly reduced if RTE can solve, in real time, the transmission constraints generated on the by the operation of the facility.

The studies show that, in the event of an incident generating constraints on one of the lines of the Attaques-Warande-Mandarins line, a reduction of the flows on the interconnector, in less than 10 min, is particularly effective for solving these constraints.

It is proposed to install a fast curtailment system, which will make it possible to reduce flows on the interconnector in the event of constraints detected on the Attaques-Warande-Mandarins line. In these conditions, in the event of constraints upon reciprocal losses of a 400-kV line on the second line (e.g. Attaques-Warande and Mandarins- Warande), the interruption in less than ten minutes of the flows (especially in the case of exports) on the interconnector makes it possible to convert a very significant part of the redispatching and/or preventive limitations into curative limitations.

The fact of acting within a curative approach - i.e. only in the event of a proven incident – considerably reduces the volume of energy to be mobilised to alleviate the constraints.

The operating principles of the Eleclink fast curtailment system will be specified by RTE in relation to the Performance Commitment Convention. The conditions of use of this system shall also be specified in coordination with National Grid.

It has been considered in the, signed with Eleclink, to set up this fast curtailment system as soon as the interconnector is implemented, which also makes it possible to significantly decrease the level of limitations applicable to Eleclink.

## New assessment of limitations with the Eleclink fast curtailment system

The residual “preventive” limitations are assessed below for the period prior to the implementation of the reinforcements. The “curative” limitations induced by the operation of the fast curtailment system are assessed further in the study. Such as mentioned above, these limitations, for the period being considered, are to be handled by Eleclink and have been contracted in the PTF.

Limitations assessed in 2016-2017 with the installation of Eleclink’s fast curtailment system as soon as Eleclink is implemented

Import capacity

| Period | Maximum reduction duration (in number of hours) |
|---|---|
| Winter | [redacted] |
| Summer | |

Export capacity

Redacted for commercial secrecy

| Period | Maximum reduction duration (in number of hours) |
|---|---|
| Winter | [redacted] |
| Summer | |

### Reinforcement in the susbstations of Attaques, Warande and Mandarins:

The capacity of the 400-kV lines of the Attaques-Warande-Mandarins is currently limited due to the connection equipment in the 400-kV substations of Attaques, Warande and Mandarins.

The works being considered consist, in this solution, inin replacing and redesigning certain connection components so that they no longer limit the transmission capacities of the lines.

These works are assessed at approximately 3 million euros (order cost).

The indicative time for commissioning these reinforcements is of 4 years as from the granting of the exemption to Eleclink. With the Eleclink connection, the substation of Mandarins will comprise 3 interconnectors (2 X 1,000 MW for IFA and 1,050 MW for Eleclink) and 4 outgoing 400-kV lines. The structure of the substation must make it possible for RTE to comply with the operating rules (especially, not losing more than 1,500 MW due to bar faults) including during scheduled maintenance periods and without having to limit the capacities of IFA or Eleclink. It therefore involves, except in rare situations, being able to distribute both IFA links and the Eleclink interconnector on different electrical buses. In these conditions and in compliance with the 400-kV substation structure practise, the structure of the substation of Mandarins must be adapted: RTE therefore plans to replace the busbar disconnecting switches with sectioning circuit breakers so that the substation comprises 4 electrical buses.

These works, estimated at 5 million euros, complete the reinforcements mentioned above. They could be implemented within a 3-year deadline as from the moment the exemption is granted to Eleclink.

## F. 2 Disregarded reinforcement solution: Renforcement of the Attaques-Warande-Mandarins 400-kV line

In order to prevent the development of constraints on the Attaques-Warande-Mandarins line in the event fault is detected on one of the 400-kV lines, it would be possible to significantly increase the transmission capacities of these lines, which would make the network robust with respect to all the situations made more constraining due Eleclink's connection. It would be necessary to replace the conductors currently fitted on the 400-kV lines of the Attaques-Warande-Mandarins 400-kV line (lines with two circuits of an overall length of 29 km) with ACSS-type low dilation cables (Aluminium Conductor Steel Supported cables) with a larger section than the current section. This solution would make it possible to increase the transmission capacity by around 30 % and avoid having to use a fast curtailment system.

In order to allow such a power flow between the substations of Warande and Mandarins, a great amount of work would be required in order to reinforce the facilities in the following 400-kV power substations:

- Attaques 400 Kv: Replacing the gas insulated circuit breakers
- Warande 400 Kv: heavy rehabilitation of the gas insulated substations with 2 busbars
- Mandarins 400 kV: Replacement of the substation circuit breakers.

**The cost of the reinforcements of the Attaques-Warande-Mandarins 400-kV axis and of the**

**reinforcements carried out in the 400-Kv substations can be estimated at around 120 million euros.**

This estimate is based on the order costs for the purchase of the equipment, work and engineering services. For a more accurate assessment, it would be necessary to carry out an accurate feasibility study.

This estimate does not take into account the temporary shutdown costs related to the 400-kV line required for carrying out the above-mentioned works. **The strategic character of this line (proximity of the nuclear site of Gravelines and IFA 2000 interconnector) forecasts an expensive temporary shutdown (which can reach several tens of millions euros), which will be difficult to plan (long shutdown periods which may be spread out over several years).**

The new transmission capacities of the Attaques-Warande-Mandarins 400-kV line thus obtained would make it possible to no longer encounter N-1 constraints on this line, regardless of the flows being transmitted via the Eleclink link.

**The indicative time necessary for carrying out these reinforcements would be 8 years as from the moment the exemption is granted to Eleclink.**

Such as in the solution recommended above and for the same reasons, it would also be necessary to re-examine the structure of the substation of Mandarins: These works, estimated at 5 million euros, complete the reinforcements mentioned above.

**RTE proposes to disregard this solution because it appears to be disproportionate, from a technico-economic viewpoint, for processing constraint-related situations whose occurrence rate remains low and which RTE can solve at a reduced cost in real time by means of the fast curtailment system combined with redispatching actions**.

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## F. 3 Assessment of the residual constraints in terms of redispatching in the event of the installation of either of the solutions

A new probabilistic study has been conducted to take into account the solutions proposed above.

The two solutions studied do not allow completely neutralising the impacts related to Eleclink on the overall operation of the PTN in 2022: In both solutions, the assessment of the redispatching volume required for processing the residual constraints generated by Eleclink in 2021-2022 amounts to around [redacted]

A maximum sum of 3 million euros/year can be considered as a majoring value for the residual redispatching costs, which are still to be covered, following the implementation of the chosen solution. This sum is estimated for the following assumptions:

- Increase of the regional production with respect to the assumptions mentioned at the start of this study.
- Maintaining the exchange capacities with Belgium at its current level.
- Taking into account the network reinforcements, beyond those which have already been decided.
- Taking into account of the Eleclink's fast curtailment system.

## F. 4 Assessment of the operating costs of Eleclink's fast curtailment system

For the solution recommended by RTE, for 2021 - 2022, Eleclink's fast curtailment system will mainly operate when the following conditions are met:

- Unplanned unavailability of the one of the Attaques-Warande-Mandarins 400-Kv lines.

- Existing flows on the network such as this unplanned unavailability generates constraints.

The probabilistic studies are used to assess an annual duration for the risk that constraints may appear if a fault occurs on one of the 400-kV lines of the Attaques-Warande-Mandarins axis: this duration is estimated at [redacted]

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In addition, the estimated probabilities of unplanned unavailability of the Attaques-Warande-Mandarins 400 kV lines, and their average unavailability duration, are provided in the table below:

| 400 kV structures | Failure rate | Average unavailability durations in the event of a failure of the structure |
|---|---|---|
| Mandarins - Attaques | 0.173 /year | 31 hours |
| Attaques - Warande | 0.182 /year | 32.4 hours |
| Mandarins - Warande | 0.194/year | 33.9 hours |

Taking into account the above information, it is possible to assess that Eleclink's fast curtailment system could be used once every 5 years. This system will be employed for dealing with immediate emergency situations related to the unplanned unavailability of one of the three above 400-kV structures. If the unavailability of the structure lasts, RTE will take limitation measures for the exchange capacity between France and England until the network's situation allows the restoration of the maximum exchange capacity without any risks for safety. In such a situation, RTE and NGET shall compensate for the non-exchanged energy. It is hazardous to approximately define the volume of non-exchanged energy and whose compensation should be required. However, we can retain 20 to 30 GWh as an order of magnitude.

One way of assessing the cost of this non-exchanged energy is to consider that, instead of being exported from one country to another, electricity is sold in one country and purchased in another. It is thus advisable to refer to the difference in market price between France and England. By analysing the hourly rate differences (spread) between power markets in France and the United Kingdom, since January 2011, it is noted that the spread is lower than 31.3 €/MWh in 90% of the cases and than 60 €/MWh in 99% of the cases.

This historical analysis can obviously not reflect the future market. However, it can be underlined that there is no reason to believe that the incidents affecting the 400-kV links are specifically correlated with situations involving a major price difference between France and England.

## G. CONCLUSIONS:

RTE has conducted the Eleclink insertion studies by taking into account all pending generation projects prior to Eleclink while aiming at keeping the exchange capacities with Belgium and Germany at the same level.

These studies showed that the insertion of Eleclink involves the arrival or increase of constraints on the 400-kV network in the North of France.

The constraints then partly disappear following the reinforcements, which have been planned and already decided by RTE in the study area.

Nevertheless, constraints appear on the Attaques-Warande-Mandarins 400-kV lines and will remain significant in 2021/2022.

RTE has assessed, in the Technical and Financial Proposal (PTF) for the connection of the interconnector, the limitations of the operation of the interconnector, which will allow minimising the constraints before the reinforcements are implemented. RTE has searched for the optimal reinforcement solution for increasing the transmission capacities of the PTN in order to prevent the development of most of the constraints generated by Eleclink while minimising the overall cost covered by the user community of the network subject to the TURPE.

The recommended solution involves the installation of Eleclink's fast curtailment system and performing works in certain 400-kV substations, thus making it possible to minimise the constraints on the Attaques-Warande-Mandarins lines.

Once the reinforcements provided for by RTE in the North of France and the additional reinforcement solution recommended by RTE have been implemented, the operation of the interconnector will generate residual constraints requiring redispatching actions for a maximum cost assessed at around 3 million euros per annum. The operation of the fast curtailment mechanism may also generate costs for the community.

These costs are significantly dependent on the local assumptions, which could vary much over the duration of the exemption granted to Eleclink.

RTE also specifies that this study does not take into account the consequences resulting from the application to the Eleclink interconnector of the provisions of the "Capacity Allocation and Congestion Management" and "Forward Capacity Allocation» codes".

In synthesis, the costs related to the insertion of Eleclink in the electric system and their methods of assumption of responsibility are summarized below:

| **Type of costs** | **Basic assessment** | **Management procedure** |
|---|---|---|
| Financial consequences related to the limitations of the operation of the interconnector prior to the implementation of the reinforcements | See tables above | Managed by Eleclink, within the limit of the volumes specified in the PTF. Beyond these specifications, the volumes are recorded in the Regulated Account for Expenses and Products (CRCP) as internal congestion costs. |
| Reinforcement investments | 8 million euros<br><br>(Reminder: an alternative solution without a curtailment system is assessed at 125 million euros) | Shared via the TURPE in accordance with the deliberation of CRE on May 9, 2012 |
| Residual congestion costs following the implementation of reinforcements in the North of France and the implementation of the additional reinforcements. | ~3 million euros/year | Shared via the TURPE and recorded in the Regulated Account for Expenses and Products (CRCP) as international congestion costs. |
| Financial consequences related to the operation of Eleclink's fast curtailment system following the implementation of reinforcements in the North of France and the implementation of the additional reinforcements. | See assessment information above | Shared via the TURPE and recorded in the Regulated Account for Expenses and Products (CRCP) as international congestion costs. |