AQUIND Interconnector: French network costs

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1 AQUIND's impact in France

AQUIND Interconnector will be a new 2 GW High Voltage Direct Current (HVDC) electricity interconnector between France and GB. The project, commissioning in 2024, will benefit France and GB by facilitating cross-border flows of electricity between wholesale electricity markets. These electricity flows will have an impact of the French and GB electricity networks in the form of possible network constraints and network losses. These system costs are not unique to AQUIND and are present for any new network connection, including new renewable, thermal or nuclear generators, new demand connections (for example, data centres) or other cross-border connections.

This note provides a summary of the impact AQUIND Interconnector could have on system costs in France. The French electricity network is owned and operated by RTE, the French Transmission System Operator (TSO). This note does not provide any new analysis but provides a summary of four studies completed to date:

- The analysis completed by RTE, and submitted to CRE as part of the 2017 AQUIND Interconnector exemption application in July 2017[1]
- RTE's response to AQUIND as part of AQUIND's consultation [redacted] in May 2019[2]
- The AQUIND Interconnector Cost-Benefit Analysis (CBA) completed by AQUIND, and its advisors, in 2018 and 2019
- An independent technical study by AQUIND's technical advisors, Consentec, on the impact of AQUIND on the French transmission system completed in 2020

1.1 Constraints

As part of the 2017 advice to CRE, RTE completed a modelling study to identify when and where AQUIND could cause constraints on the French electricity network. The RTE study focussed on the high voltage 400kV transmission network in France and considered spot years 2022 and 2027.[3] The study considered the impact of AQUIND on transmission constraints, along with stability constraints, voltage, consignments, short-circuit constraints and network losses.

1.1.1 Transmission constraints

RTE did not identify any network constraints in 2022. For 2027, RTE found that the expected flows across AQUIND could results in constraints in the following elements of the French 400 kV transmission network:

- Dambron-Verger
- Plessis-Gassot - Sausset
- Plessis-Gassot - Villevaudé

[1] "*Information transmitted by RTE to the Energy Regulation Commission within the framework of the examination of AQUIND's exemption application*" – July 2017

[2] [redacted].

[3] At the time of the 2017 exemption application AQUIND planned to commission in 2022.

- Mézerolles-Villejust

In its analysis for CRE, RTE noted that these constraints exist without AQUIND, however could become more frequent, and more costly to manage, when AQUIND connects to the network.

To alleviate these constraints, and keep the electricity system within safe operating limits, RTE identified three possible types of action:

1. **Re-dispatch**: Paying to turn up or turn down generation or demand on the network in certain period(s) which would alleviate network constraints for that period(s)
2. **Import/export reduction on AQUIND**: Paying to turn up or down the imports or exports across AQUIND in certain period(s) to alleviate the constraint in that period(s)
3. **Network reinforcement**: Investing in new network capacity, i.e. increasing the capacity on the parts of the network subject to constraints, to alleviate the constraint altogether.

All of RTE's costs would be recovered, subject to regulatory approval from CRE, from French network users through network tariffs. This is the same network cost recovery route that is used for any network reinforcement on the French transmission system.

1.1.2 Other constraints

In addition to the transmission constraints identified above, RTE also identified a number of possible other constraints that AQUIND could cause on the French network.

- **Stability constraints**: RTE conducted a study as part of AQUIND's connection application (Proposition Technique et Financière, or PTF) to consider AQUIND's potential impact on stability of other generators in Northern France in the event of a network outage. RTE concluded that whilst AQUIND may have a small negative impact on stability for some generators, stability margins will remain acceptable and therefore no further action was required. RTE note that some technical requirements (relating to reactive management) will be included in the AQUIND connection agreement, however no further costs can be attributed to AQUIND.
- **Voltage constraints**: RTE's studies show that there are specific situations where AQUIND could result in a voltage event in Northern France. As an example, this could occur with the combined impact of maximum import or export from France to GB combined with nuclear output limits or peak demand in Paris. At the time of writing in 2017, RTE could not confirm the impact of AQUIND on low voltage risk (RTE do confirm that AQUIND will not have an impact of high voltage risk).[4]
- **Consignments (maintenance)**: In order to complete necessary engineering maintenance on the French transmission network, RTE may need to isolate certain parts of the network. To cut off the network in this way, RTE must shut-down generation and/or demand, or in AQUIND's case, the interconnector. This comes at a cost to RTE who has to pay the asset owners for the outage. For AQUIND, RTE calculates this cost based on the

[4] RTE note that high voltage risks are caused by local high output from onshore renewables and low power flows with neighbouring countries.

expected lost revenue for AQUIND (approximated by the difference in French and GB electricity prices).[5]

- **Short-circuit constraints**: These constraints relate to the earthing system and circuit breakers that form part of the AQUIND network connection. RTE note that the cost of equipment to alleviate any short-circuit constraints is already included in AQUIND's connection costs (and therefore already included in AQUIND's CBA).
- **Network losses**: As AQUIND will facilitate flows between France and GB it will change the pattern of electricity flows across the French network. Any electricity flow will result in lost energy, through resistance, which can be attributed to AQUIND. RTE value losses based on the marginal price of electricity in that period (i.e. the approximate cost of replacing the lost electricity).

1.2 Constraint costs

RTE provide estimates of the cost of managing transmission constraints, and other constraints, caused by AQUIND on the French transmission system. It notes there are no constraints expected in 2022, but some constraints may occur in the time horizon of 2027.

Table 1 shows RTE's cost estimates broken down into the possible constraint management option (re-dispatch, import/export reduction or network reinforcement). These costs are not cumulative. Rather, RTE is expected to select the least costly option within each row (insofar as the constraint in that row is in fact relevant). For example, the estimated cost of managing the Plessis-Gassot – Sausset – Villevaudé constraint is €30m/year under option 1, or €11m/year under option 2 or a €15m one off cost under option 3.

It's inevitable that AQUIND, or any other connection, will cause some system costs in France. Conversely, the presence of AQUIND will alleviate the implicit constraint on flows between France and GB (and indeed, this is a major driver of the need for the interconnector). The overall changes to the system constraints are therefore two different facets of the interconnection impact. Table 1 shows that the actual cost caused by AQUIND depends heavily on the way RTE chooses to manage or alleviate the constraint. Re-dispatch options, whether this involves re-dispatch of French generation or demand or re-dispatch of AQUIND, result in annual cost for RTE (columns 1 and 2 in Table 1). These costs are linked to the actual costs that RTE would face constraining units on or off the system through the French Balancing Mechanism, for example. These costs would continue until a decision was made to invest in the network to alleviate the constraint. RTE's responsibility is to manage the French transmission network in an efficient manner. Therefore, we expect RTE to select the most cost-efficient option among those listed below: for example, in relation to the first row, it is highly unlikely that RTE would select to address a constraint through redispatch costs of €30m/year, if the alternative is a network reinforcement costing €15m (as a one-off cost).

It's important to note that the cost estimates provided by RTE are a result of a number of assumptions in RTE's modelling. For example, RTE's assumptions about other generation or demand, and the flows across AQUIND will have a significant impact on the constraints on the network. Different assumptions could drive significantly different costs in the modelling. In particular, the configuration of the network is likely to evolve between now and 2027, in response to other changes to the system, such as new

[5] RTE note that the AQUIND connection agreement will include a number of days during which RTE can request and HVDC interconnector to shut-down without compensation. The costs referred to in this paragraph relate to those in addition to this mandatory shut-down time.

renewables connections and changing demand patterns. To the extent that the French transmission network is likely to require reinforcements to accommodate these changes, it is plausible that the stronger network will be better able to accommodate additional interconnection.

Where RTE faces significant costs in operating the system, it may be efficient to invest in network reinforcement to alleviate the constraint altogether. The decision to invest in the network in this way is typically subject to regulatory approval from CRE (for example, as part of the regulatory tariff control set by RTE).

Column 3 in Table 1 shows the potential cost of network reinforcement that RTE could take to alleviate the costs attributed to AQUIND (all costs provided by RTE). The investment in column 3 shows a one-off capital cost to RTE – for example the construction of a new overhead 400kW line. These costs estimates have been provided by RTE.

Table 1 Potential constraint costs in 2027[6]

Constraint	Cost option – attributed to AQUIND Interconnector		
	System re-dispatch (1)	Re-dispatch AQUIND (2)	Network reinforcement (3)
Transmission constraints (400kV)			
Plessis-Gassot – Sausset – Villevaudé	€30m/year	€11m/year	€15m one-off cost (resulting in no further costs from AQUIND)
Mézerolles-Villejust	€3m/year (Negligible without AQUIND)	€1m/year	€22m one-off cost (resulting in no further costs from AQUIND)
Dambron-Verger	€6m/year	Not possible	€50m one-off cost (resulting in no further costs from AQUIND) *Note that RTE indicate that 13% (<€7m) of this cost could be attributed to AQUIND*
Other constraints			
Stability constraints	No cost	No cost	No cost
Impact on Voltage		Can be manage by temporarily reducing exports to GB (likely to be infrequently) – no cost provided.	Can be alleviated with 2 capacitor banks in the Paris Region at a cost of approximately €3m
Impact on consignments	Not possible	€3.5m/year Valuation based on GB-FR price differentials value at €7/MWh	Not possible
Current short circuit constraints	No cost	No cost	No cost

The constraint costs in Table 1 are based on RTE's 2017 analysis. In RTE's more recent response to the AQUIND [redacted] (May 2019) RTE provided little detail on its assessment approach. The range of costs that RTE attributed to AQUIND was consistent with the totals presented in Table 1 – "*It thus appears that the costs required to reduce these congestions specifically induced by the Aquind*

[6] In their own analysis, RTE typically show the total constraint costs with and without AQUIND. For the purposes of this table, we have only considered the cost attributed to AQUIND.

project could reach, on average for the three TYNDP scenarios, up to approximately €50 million/year by 2030".

1.3 AQUIND's costs to the system

Any TSO must decide whether it is more efficient to manage a constraint through operating action, such as re-dispatch, or through network reinforcements. TSOs face incentives as part of their regulatory price control to consider the trade-off between these constraint management options, and an overarching incentive to ensure efficient costs for consumers.

1.3.1 Transmission constraint costs and other constraint costs

Comparing the costs in Table 1 shows that the choices that RTE makes, and the incentives it faces, will be a key determinant in the costs that can be attributed to AQUIND and AQUIND's benefits case in France.

Evaluating column 1 and 2 in Table 1 indicates that the cost of managing constraints caused by AQUIND could be in the region of €20-40m/year. If we were to assume that RTE did not address the cause of the constraint, and therefore the constraint was never resolved, these annual costs could be attributed to AQUIND annually, for the life of the project. This is an extreme scenario and is very unlikely to occur as it would not represent an efficient outcome for French consumers. We are confident that RTE would take necessary steps to resolve such possible constraints in an appropriate timeframe.

The network investment costs, presented in column 3 of Table 1 indicates that the alternative option, where RTE invests in network infrastructure to alleviate constraints, could be much more cost effective. Column 3 shows that the cost of alleviating all constraints could cost RTE around €47m[7]. This is a one off cost for RTE and would not result in further costs to manage the impact of AQUIND on the system.

1.3.2 Network losses

RTE calculate the impact of AQUIND on network losses in France by comparing a network model with and without AQUIND. As AQUIND will change the flow of electricity across the French transmission network, it will inevitably have an impact on network losses.

In its analysis, RTE conclude that AQUIND will reduce total losses on the French transmission network. Specifically, RTE calculate a reduction in the volume of losses in 2022 and 2027 of 128 GWh and 2 GWh respectively.

To value these network losses, RTE calculates the cost of losses with and without AQUIND using a methodology which appears to be consistent with the methodology proposed by ENTSO-E in their Cost-Benefit Analysis methodology 2.0.[8] RTE's estimate shows that the cost of losses will increase with AQUIND (by approximately €4m per year in 2022 and zero cost in 2027), whilst the volume of losses actually decreases. We note that since RTE's assessment, ENTSO-E has corrected its methodology to

[7] €15m + €22m + €6.5m + 3m

[8] The Second ENTSO-E's Guideline for Cost-Benefit Analysis is available here: https://eepublicdownloads.blob.core.windows.net/public-cdn-container/clean-documents/tyndp-documents/Cost%20Benefit%20Analysis/2018-10-11-tyndp-cba-20.pdf

avoid any double counting in the assessment of losses, and as such, the monetary value of losses is likely to be lower using the new (corrected) methodology.

Whilst we do not have the data to update RTE's calculation with the new methodology, we anticipate that correcting the calculating would show that the cost of losses in France would be negligible as a result of AQUIND.

1.3.3 Independent assessment

As part of AQUIND's ongoing engagement with CRE and Ofgem, the project team sought independent advice on the potential impact of AQUIND on stability constraints, thermal constraints and voltage constraints in France. AQUIND commissioned Consentec GmbH to complete this study in 2020.

Whilst Consented did not have access to the modelling available to the TSO, RTE, Consentec's detailed study concluded that "*the realisation of the planned new DC interconnection between France and Great Britain has no severe negative impact on the continental European transmission system concerning the aspects considered in this study. Any problems that might arise could be managed by the design of Aquind and the respective converter stations itself. In particular, the realisation of Aquind would not cause additional investments in the transmission grid (for instance in order to restore the fulfilment of network security requirements)*."[9]

This study validates the view that AQUIND's impact on constraints in France is not expected to be large.

1.4 Impact on the AQUIND CBA

Whist the cost to the French network appear significant, these costs are very small when considered alongside AQUIND's social welfare benefits.

AQUIND's CBA, presented to CRE as part of AQUIND's Request for Exemption (submitted in May 2020) shows that AQUIND could deliver a total welfare benefit to France in excess of almost €1bn in the central scenario. Taking into account RTE's potential one-off costs of around €47m (in column 3 of Table 1) would still provide a benefit to France in excess of €950m.

[9] Extract from Consentec's study for AQUIND from April 2020: *Impact of a new Interconnector between France and Great Britain on the continental European transmission grid*