Comments on the Artelys report of 17 July 2019 on the “Determination of a target electrical interconnector capacity between France and the United Kingdom”

Memo of 16 June 2020

CONFIDENTIAL

Contents

1 Introduction

The CRE commissioned a report from its Artelys consultant presenting a cost and benefit analysis ("CBA") of increasing the interconnector capacity between France and Great Britain (the "Artelys report")[1]. Using a number of important scenarios, this report concludes that a *"new interconnection between France and the United Kingdom appeared appropriate in none of the main scenarios"*[2].

This report was taken into account by the CRE as part of the assessment of the Investment and Cross-Border Cost Allocation Request (submitted by AQUIND) in the context of the RTE-E regulation and we understand that the CRE also plans on taking into account this analysis when assessing the AQUIND exemption request (2020). However, from our point of view, the Artelys report is not appropriate in determining the value created by the AQUIND interconnection.

Some of the scenarios applied in the Artelys report are also unusual: to our knowledge, the assessment of other interconnections (such as Biscay Bay or Celtic Interconnector) was not performed using such ambitious scenarios (in particular with regard to the Power to Gas ("P2G") scenarios as discussed below). It therefore appears that the AQUIND interconnection is assessed using particularly unfavourable scenarios. This creates a risk of inconsistency in regulatory decisions on the development of various interconnector projects as they are based on very different scenarios.

In this memo, we comment on the Artelys report: In particular we outline:

- limitations of scenarios applied by Artelys;
- the weakness of some scenarios used by Artelys and their impact on the results of the collective surplus;
- scenarios and results of AQUIND's CBA; and
- conclusions of our review of the Artelys report.

[1] Determination of a target electrical interconnector capacity between France and the United Kingdom. Report. 17 July 2019.
[2] Artelys report, page 3.

2 Scenarios applied by Artelys

Scenarios selected by Artelys for its analysis are hampered by various limitations. After reviewing the four scenarios applied, we would like to outline their limitations.

2.1 Presentation of scenarios

The Artelys report develops three main scenarios and one alternative:

- Energy Transition: Ten-Year Network Development Plan ("TYNDP") 2018, "Sustainable Transition";
- National Plans: TYNDP 2018 & Multi-year Energy Progamming ("MEP");
- Modest: TYNDP 2018 & slower transition; and
- Distributed Generation & MEP

The Artelys report relies on the TYNDP 2018 scenarios: for example, the "Energy Transition" scenario is based on the TYNDP "Sustainable Transition" scenario while the "Modest" and "National Plans" scenarios add scenarios from the MEP in France.

2.2 Scenario limitations

The analysis of any potential interconnector project must be based on well supported and reasonable scenarios relating to the evolution of British and French electricity markets as well as, more broadly, to that of European markets. This viewpoint is shared by European political decision-makers: for example, according to the recommendation no. 5/2015 of ACER, project leaders are to take into account "*robust additional scenarios which they consider plausible*"[3]. In our opinion, scenarios selected by Artelys do not provide an adequate basis for a solid CBA for three main reasons as detailed below.

First, public information on the TYNDP scenarios is insufficient to carry out the CBA of a specific project owing to the limited detail level of data available for external parts.

It is therefore not clear whether Artelys had to complement available public information about TYNDP scenarios with their own assumptions, and how such additional assumptions were determined. From AQUIND experience, it is very difficult to reproduce the analysis of TYNDP scenarios for a stakeholder that is not a GRT. A large part of the data and tools required for modelling are only available to existing GRTs (in particular internal network models).

Secondly, TYNDP scenarios reflect primarily political ambitions that may differ from economic realities. For example, the ENTSO-E issues caution about the fact that TYNDP scenarios "*are not forecasts* [and] *are not intended to inform political decisions*"[4].

[3] ACER (2015) Recommendation no. 5/2015 of the Agency for the Cooperation of Energy Regulators of 18 December 2015 on good practices in the handling of Investment and Cross-Border Cost Allocation Requests, concerning electricity and gas common-interests projects, Annex I.1.
[4] ENTSO-E et ENTSO-G public workshop on TYNDP 2020 draft scenarios, 5 December 2019.

Such scenarios therefore do not necessarily provide an appropriate basis upon which decisions to invest in energy infrastructures should be made. For example, to the extent that the TYNDP scenarios have a political ambition, in contrast with current policies and legislation, they may not be a realistic representation of future potential pathways and may therefore provide an inappropriate basis for assessing potential projects. The use of more "extreme" scenarios may bias such evaluation in favour of projects that are beneficial only under specific circumstances, to the detriment of projects that are beneficial in more conservative assumptions.

Finally, the development of electricity surpluses using P2G, a technology that is still under development, is unrealistic. We will examine this assumption in detail in the following section.

3 Assumptions applied by Artelys

The analysis of any potential interconnector project must also be based on well supported and reasonable assumptions, particularly with regard to the network supply and demand characteristics. The assumptions applied by Artelys are questionable and produce inaccurate results with regard to the value created by the AQUIND interconnection. The most questionable assumptions are:

- The deployment and effectiveness of P2G technology;
- Operational costs (Opex); and
- The development stage of competition interconnections.

3.1 Deployment and efficiency of P2G technology

We consider that the assumptions made by Artelys concerning the deployment of P2G technology are inappropriate. As one of the many potential sources of flexibility for balancing electricity supply and demand, any assumption that overestimates the role of P2G technology on the market naturally risks underestimating the benefits of investing in such interconnections. The Artelys report assumes that power-to-gas technology acts as a direct competitor to interconnectors, resulting in a significant reduction of the estimated benefits of interconnector investment. This assumption about the deployment of P2G technology poses four problems we will develop in succession below.

First, the assumption on the deployment of power-to-gas (P2G) technology appears to be highly ambitious and the primary driver of the report conclusions.

- Artelys acknowledge that in the absence of power-to-gas conversion, the French interconnection built in 2025 is economically justified over the lifetime of the projects. The report assumes approximately 12 GW of electrolyser capacity by 2040, running 3,000 hours annually.[5] The scale of these assumptions is currently unsubstantiated and there is no evidence that the P2G industry can develop at such a pace over the next 20 years. In mid-2020, this assumption seems even less valid given the challenges posed by the current COVID-19 pandemic and the likely economic recession.
- The Artelys report fails to take into account the cost and benefit analysis of this technology, its technological readiness for mass deployment and practical issues of its implementation such as French planning laws and environmental regulations. To achieve such a level of P2G capacity by 2030, as applied in the Artelys report, all those projects would be starting their permit and authorisation applications now.

Secondly, the assumptions concerning the deployment of the P2G seem specifically developed for the Artelys report. In other reports published by Artelys, assumptions and conclusions differ, which suggests that Artelys do not necessarily have a consistent vision of how P2G technology is likely to develop:

- In September 2019, Artelys observed that the development of the P2G is highly complex and that, sometimes, it is possible to identify “synergies” between P2G and electrical

[5] Artelys Report, Table 3:

interconnections – in other words, P2G does not always act as a direct competitor to interconnections.[6]

- In October 2019, an Artelys report on the question of gas storage used the basic assumption that P2G is not developed at all[7]. It therefore appears that a scenario without P2G is the central scenario presented by Artelys.

The differences between assumptions made by Artelys in the different reports are very significant. By consequence, it appears plausible that, had the study assessing the benefits of the interconnection relied on P2G scenarios used in other Artelys studies, conclusions concerning the need for an additional interconnection would have been very different.

Thirdly, assumptions on the efficiency of P2G show that this technology is considerably inferior to that of electricity transmission. The TYNDP 2020 report (Scenario methodology report) indicates that the technical efficiency of P2G is between 67 and 82% (for Alkaline Water Electrolysis) and around 44 to 86% (for Polymer Electrolyte Membrane electrolysis).[8] These two estimates are lower than the efficiency of electricity transmission using HDVC cables: losses linked to transmission in underground and undersea cables of the AQUIND interconnection, which will occur in "full power" scenarios on the cables, represent an approximate overall loss of 3.6%.[9] In other words, the efficiency of electricity transmission is above 96%.

We therefore conclude that electricity transmission projects, such as AQUIND, are likely to play a role in the development of the European energy system. In contrast, technologies such as P2G, which are significantly inferior in performance, are unlikely to provide optimum results for energy consumers.

Fourthly, the Artelys report overestimates the role of P2G and relies on assumptions that contradict the MEP, the scenarios of the Ten-Year Network Development Plan ("TYNDP") and the report on 'the transition to low-carbon hydrogen' published by RTE in January 2020 ("RTE Report").

MEP makes no mention of electrolysis or hydrogen in the electricity sector in its draft for comments (2020). Furthermore, the future role of hydrogen and the time-frame within which it may be deployed remain uncertain. Therefore, the main measures of this draft for comments relate to the realisation "*of studies to prepare for a possible longer-term deployment of hydrogen as a flexibility solution to serve electricity and gas systems*"[10]. Furthermore this draft for comments adds: "*The conversion of electricity from renewable sources into gas is generally mentioned in situations where the production of renewable electricity is in excess of consumption [...] These situations are not forecast on a large scale in France before 2035 [...]*"[11]

Assumptions used in the Artelys report concerning electrolyser capacities (9GW and 12GW by 2030 and 2040 respectively) corresponding to "*capacities necessary to produce the volumes of hydrogen announced by the MEP with electrolysers operating on average 3,000 h/year*", are in fact in contradiction with the MEP.[12] The goals set to increase hydrogen consumption announced by the

[6] Artelys: Investigation on the interlinkage between gas and electricity scenarios and infrastructure projects assessment. Section 4.3.2.1.
[7] Artelys: Value of the gas storage infrastructure for the electricity system. Page 31: "*P2X is absent from the scenario*".
[8] TYNDP 2020 Scenario Methodology Report, Section 8.2.1 et Section 8.2.2.
[9] AQUIND analysis, submitted to the CRE in the context of the Exemption Request, 2020.
[10] French Strategy for Energy and Climate, Multi-Annual Energy Plan (MEP), Summary, page 33.
[11] French Strategy for Energy and Climate, Multi-Annual Energy Plan (MEP), Draft for Comments, page 103.
[12] Artelys report, page 29.

MEP are 1-10 MW by 2023 and 10-100 MW by 2028 for P2G demonstrators.[13] An industry that is to reach demonstration-scale level by 2028 (10-100MW) is extremely unlikely to develop over the following two years to attain an electrolyser capacity of 9GW (2030 Artelys assumption).

In addition, the TYNDP, published by RTE in 2019, is based on the National Low-Carbon Strategy ("SNBC"), which focuses on an objective of 7 GW of electrolyser by 2035.[14] Once again, this shows that the assumptions made by Artelys (9 GW in 2030) are not compatible with those made by RTE in the TYNDP.

The TYNDP acknowledges that, among the potential sources of flexibility, P2G does not represent an alternative solution to reinforcements of the French network: *"power-to-gas is currently a technology that is still experimental [which] has no economic or technical relevance today"*.[15]

Moreover, the assumptions made by Artelys are not consistent with those of the RTE Report published after the Artelys report. With regard to the P2G assumptions, the Artelys report assumes a necessary capacity of 9 GW to 12 GW (by 2030 to 2040) assuming that the electrolysers operate on average at 3,000 hours per year.[16] Conversely, the RTE Report presents a range of assumptions: on the one hand the development of 38 GW of electrolyser capacity with electrolysers operating only 800 hours per year (9% load factor), and on the other hand 3.7 GW of electrolyser capacity with electrolysers operating on average more than 8,000 hours per year (93% load factor).[17] The RTE Report specifies the assumptions made for the production of hydrogen by electrolysis (630,000 tonnes H2/year), contrary to the Artelys report, which does not specify this.[18] Similarly, while the RTE Report describes three main operating methods for electrolysis, thus highlighting the inherent complexity of the subject, the Artelys report does not specify the operating method used for its analysis.[19]

The RTE Report acknowledges the complexity of the competitive effect that P2G could have on interconnectors as well as the impact of P2G on the volumes of electricity available for export.[20] Conversely, the Artelys report assumes that the P2G is a direct competitor to interconnectors without justifying this underlying assumption. However, Artelys acknowledges, in other studies conducted in 2019, that the relationship between P2G and interconnectors remains very complex.[21]

Finally, the RTE Report shows that electrolysers remain a relatively immature technology, with a much higher cost price than that of other hydrogen-producing technologies (such as steam reforming), regardless of the selected operating method. Thus, the RTE Report states that the

[13] French Strategy for Energy and Climate, Multi-Annual Energy Plan (MEP), Draft for Comments, page 104.
[14] TYNDP, page 67.
[15] TYNDP, page 289.
[16] Artelys Report, Table 3, page 29.
[17] RTE Report, page 39.
[18] RTE Report, page 37.
[19] RTE Report, page 37.
[20] RTE Report, page 41.
[21] Artelys, 2019, 'Investigation on the interlinkage between gas and electricity scenarios and infrastructure projects assessment'. The report states that interconnectors and the production of P2G are not necessarily in direct competition: *"the precise impact [of P2G] depends on the location of the power-to-hydrogen technology relative to the infrastructure project. For example, a new electricity interconnector could result in fewer episodes of low electricity prices in poorly connected areas and hence limit the hydrogen production by electrolysis. On the contrary, if an area has high variable e-RES surpluses, and there is high power-to-hydrogen capacities in a neighbour area, a new electric interconnector can increase the use of power-to-hydrogen*." (page 22).

development of this technology cannot be done without public support.[22] Paradoxically, the RTE Report shows that the increase in the price of CO2 could even lead to a greater increase in the cost price of low-carbon hydrogen (such as that produced by electrolyser) than that of fossil-based hydrogen.[23] Conversely, the Artelys report did not review in detail the costs necessary to develop and operate the electrolysers to ensure that their capacity forecasts are plausible.

3.2 Operational costs

The Artelys reports applies assumed operational costs of 35 M € / GW / year (that is, total average costs of 1,200 M € in present value). These operational costs include:[24]

- OPEX of 12 M € / GW / year; and
- Losses (network) of 23 M € / GW / year.

These assumptions appear excessively conservative and are not in line with our expectations, or with recently approved costs for IFA2.[25]

However, AQUIND's own analysis, underpinned by an external study completed by Tractebel, estimates that costs are likely to be lower:

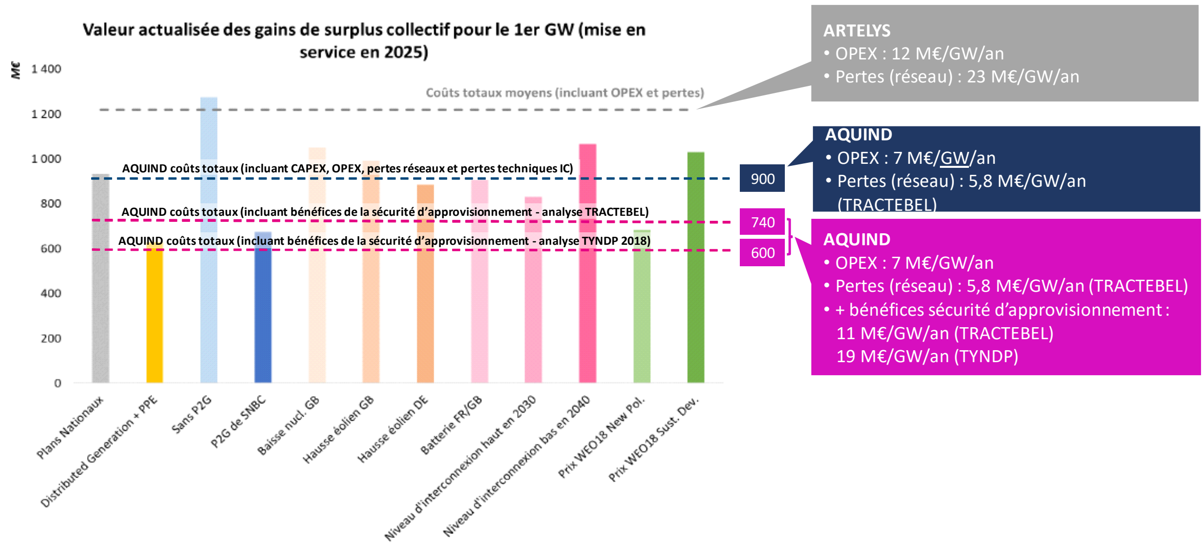
- Actual OPEX of 7 M € / GW / year; and
- Losses (network) of 5.8 M € / GW / year.

This represents savings of over 22 M € / GW / year compared to the Artelys assumptions, or almost 350 M € / GW in terms of present value[26] of collective surplus earnings. Artelys' estimate of total costs of approximately 1,200 million euros / GW would be reduced by approximately 350 million (that is, 30% of the total cost), making the benefits of an additional interconnection far more apparent.

Furthermore, these advantages are all the more significant if we include the benefits of security of supply. The Artelys report considers that an increased connection would offer no additional benefits in terms of security of supply owing to the close correlation between voltage situations on the network in France and Great Britain. This scenario is unlikely but is nevertheless fundamental and requires further examination.[27]

However, these benefits are estimated at between 11 M € / GW / year (TRACTEBEL) and 19 M € / GW / year (TYNDP).[28] Taking into account these benefits in addition to security of supply and to more realistic operational costs (12.8 M € / GW / year) in the scenarios applied by Artelys leads to average total costs of approximately 600-740 M € / GW, lower than the 1,200 M € / GW in the Artelys report, as illustrated in the diagram below.

[22] RTE Report, page 62.
[23] RTE Report, page 64.
[24] Artelys report, page 54 and clarifications provided by the CRE by exchange of electronic correspondence.
[25] Deliberation of the French Energy Regulatory Commission of 2 February 2017 deciding on the interconnector "IFA2" project, section 2.2.2.
[26] The VAN is calculated over 25 years with an adjustment rate of 4%.
[27] Artelys report, page 70.
[28] AQUIND analysis based on the benefits of security of supply of the TYNDP and on the Tractebel analysis.



3.3 The developmental stage of current interconnections

Artelys consider a major deployment of interconnections between Great Britain and continental Europe. Artelys thus include interconnector projects the majority of which are at an earlier development stage compared to AQUIND, which appears inconsistent with the Artelys analysis. In the Artelys report and excluding GB - FR, 3.8 GW are considered certain, although such interconnector projects are less advanced than the AQUIND project:[29]

- BritNed 2: 1.4 GW (Great Britain – Netherlands)
- OPIC: 1 GW (Great Britain – Ireland)
- Nautilus: 1.4 GW (Great Britain – Belgium)

The development of interconnections with Great Britain by 2040 is thus speculative.

[29] The portfolio of 2020 TYNDP projects is available here: https://www.entsoe.eu/Documents/TYNDP documents/TYNDP2020/200226_TYNDP2020_project_portfolio.xlsx.

4 The results of the AQUIND CBA

As discussed in section 2 above, the analysis of any potential interconnector project must be based on well supported and reasonable scenarios and on a set of clear and credible assumptions. In this section, we will explain that AQUIND's CBA relies on scenarios and assumptions that are robust and well supported, and therefore more suitable for the assessment of the project benefits.

In collaboration with its consultants, AQUIND has developed an in-depth analysis of the social and economic value of the project over the past four years. This analysis relies on a set of assumptions developed by AQUIND that represent a central view of how European power markets are expected to evolve in the future, referred to as the Market Scenario. AQUIND has also developed a sensitivity analysis around this central scenario and therefore applies the following three scenarios:

- A market scenario ("AQUIND Market Scenario");
- A low commodity-price scenario; and
- A high commodity-price scenario.

These three scenarios are more plausible than those used in the Artelys report.

In relation to the TYNDP scenarios, these scenarios include a number of amendments and additions, making them more comprehensive and robust for this assessment. For example, we have enriched these scenarios by modelling additional assumptions on capacity mix, estimation of costs specific to technologies or even modelling the strategic behaviour of producers.

Overall, we believe that the AQUIND Market Scenario and both the sensitivities represent a more plausible scenario of the likely evolution of the electricity markets in GB, France and Europe over the next 25 years.

The assumptions applied for drawing up the AQUIND scenarios are not limited to public information on the TYNDP scenarios, even though they remain consistent with the 2018 TYNDP. These assumptions also take into account capacity mixes based on current data and investment decisions in real assets. They are also based on a profitability calculation for each production unit in Europe to validate investment and plant closure decisions.

Finally, the long-term assumptions use robust, mature and reliable technologies, unlike Artelys which uses a technology in the process of development (P2G).

As part of the AQUIND Market Scenario, we estimate that the AQUIND interconnection creates significant economic value for France and more generally for European consumers and producers. Thus, over the first 25 years of operation, the economic value of the AQUIND interconnection for France is estimated at 1.1 B€, making France the country which derives the greatest economic benefit from the interconnection. Over this same period, the economic value for European Union countries (excluding United Kingdom) is 1.5 B€.

The two other scenarios also display a positive economic value over the first 25 years of operation, both for France (0.4 – 0.9 B€) and European Union countries (1.3 – 1.6 B€, excluding United Kingdom).

5 Conclusions

In this memo, we have explained that the Artelys report does not rely on sufficiently robust scenarios. We have also identified serious deficiencies in the Artelys report, pertaining to modelling assumptions. These deficiencies lead to unduly negative results for the CBA of the AQUIND interconnection.

For these reasons, we consider that the conclusions outlined in the Artelys report must be treated with caution and reviewed in the light of new underlying assumptions.

The scenarios developed by AQUIND are more plausible and rely on more detailed assumptions. The positive results of the collective surplus of the AQUIND interconnection resulting therefrom thus appear to us more reliable than the results of the Artelys report.

Valeur actualisée des gains de surplus collectif pour le 1er GW (mise en service en 2025)	**Present value of collective surplus earnings for the 1st GW (commissioning in 2025)**
Coûts totaux moyens (incluant OPEX et pertes)	Total average costs (including OPEX and losses)
AQUIND coûts totaux (incluant CAPEX, OPEX, pertes réseaux et pertes techniques IC)	**Total AQUIND costs (including IC technical losses, network losses, OPEX and CAPEX)**
AQUIND coûts totaux (incluant bénéfices de la sécurité d'approvisionnement – analyse TRACTEBEL)	**Total AQUIND costs (including security of supply benefits – TRACTEBEL analysis)**
AQUIND coûts totaux (incluant bénéfices de la sécurité d'approvisionnement – analyse TYNDP 2018)	**Total AQUIND costs (including security of supply benefits – 2018 TYNDP analysis)**
Plans Nationaux	National Plans
Distributed Generation + PPE	Distributed Generation + MEP
Sans P2G	Without P2G
P2G de SNBC	SNBC P2G
Baisse nucl. GB	GB nuclear decrease
Hausse éolien GB	GB wind increase
Hausse éolien DE	DE wind increase
Batterie FR/GB	FR/GB battery
Niveau d'interconnexion haut en 2030	High level of interconnection in 2030
Niveau d'interconnexion bas en 2040	Low level of interconnection in 2040
Prix WEO18 New Pol.	WEO18 New Pol. price
Prix WEO18 Sust. Dev.	WEO18 Sust. Dev. price
0	0
200	200
400	400
600	600
800	800
1 000	1000
1 200	1200
1 400	1400
M€	**€M**
ARTELYS	ARTELYS
OPEX: 12 M€/GW/an	OPEX: €12 M/GW/year
Pertes (réseau): 23 M€/GW/an	Losses (network): €23 M/GW/year
AQUIND	AQUIND
OPEX: 7 M€/GW/an	OPEX: €7 M/GW/year
Pertes (réseau): 5.8 M€/GW/an	Losses (network): €5.8 M/GW/year
(TRACTEBEL)	(TRACTEBEL)
AQUIND	AQUIND
OPEX: 7 M€/GW/an	OPEX: €7 M/GW/year
Pertes (réseau): 5.8 M€/GW/an (TRACTEBEL)	Losses (network): €5.8 M/GW/year (TRACTEBEL)
+ bénéfices sécurité d'approvisionnement:	+ security of supply benefits:
11 M€/GW/an (TRACTEBEL)	€11 M/GW/year (TRACTEBEL)
19 M€/GW/an (TYNDP)	€19 M/GW/year (TYNDP)
900	900
740	740
600	600