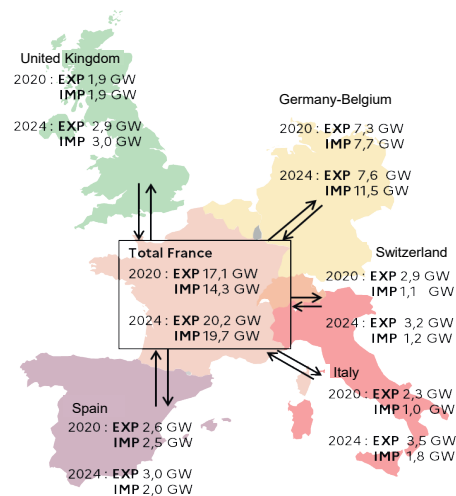


Electricity Interconnections and their Contribution to the Energy Transition

Jacques de Saint Pierre and Jules Grimont

- Electricity interconnections between the French grid and those of neighbouring countries bolster security of supply and provide consumers with priority access to the most competitive and least carbon-intensive electricity.
- During the energy price crises in 2022 and 2023, these interconnections enabled French consumers to avoid outages or even blackouts by offsetting the fall in production of French nuclear and hydropower plants.
- The relevant interconnections also offer regional socio-economic benefits. However, they are uneven between countries, on the one hand, and between electricity producers and consumers, on the other. In order to safeguard incentives for stakeholders to build and use interconnections, it is necessary to have arrangements for redistribution between countries and, within countries, between economic players.
- The expansion of internal domestic grids will play as important a role as interconnections in achieving European electricity integration targets. Investment in national grids helps optimise proper use of interconnections and prevents them from causing congestion in neighbouring power grids.
- Interconnections enable several countries to pool their assets and thus ensure their electricity systems' resilience: peaker power plants, batteries, demand-side flexibility mechanisms, etc. In a European energy system that is undergoing a sweeping transformation, interconnections provide reassurance against the uncertainties created by these changes.
- This means that the expansion of interconnections and other flexibility assets is being considered in a coordinated manner at European level in order to rein in investment requirements and remunerate them at their fair social value.

Interconnection and electricity import capacities via French interconnections in 2020 and 2024



Source: Energy Regulation Commission (CRE).

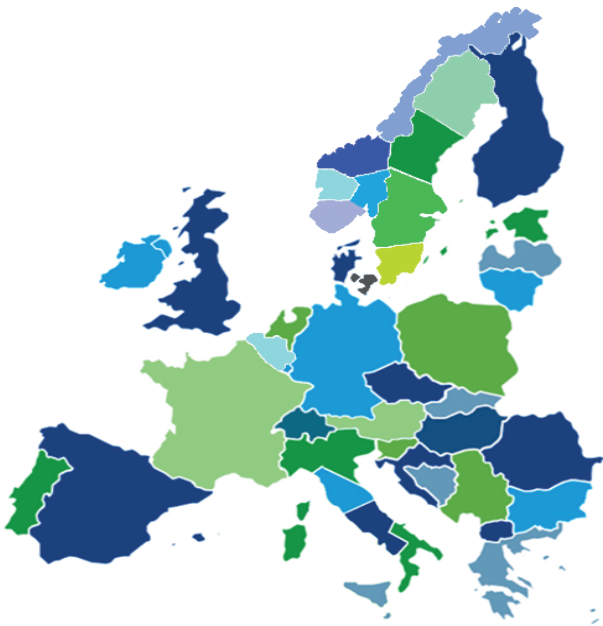
How to read this Chart: EXP is the export capacity to the relevant country and IMP is the import capacity.

1. France is very well interconnected with its neighbours and fully integrated into the EU's electricity capacity mechanisms

1.1 Interconnections were initially built to ensure security of supply

The European electricity market is broken down into a number of bidding zones in which supply and demand, expressed on stock exchanges for a given trading interval, meet to set a single market price. In the majority of cases, each zone follows a country's border (see Figure 1) such as mainland France constituting a single bidding zone, but in the case of Italy the country is divided into five zones from north to south.

Figure 1: Map of Europe's bidding zones



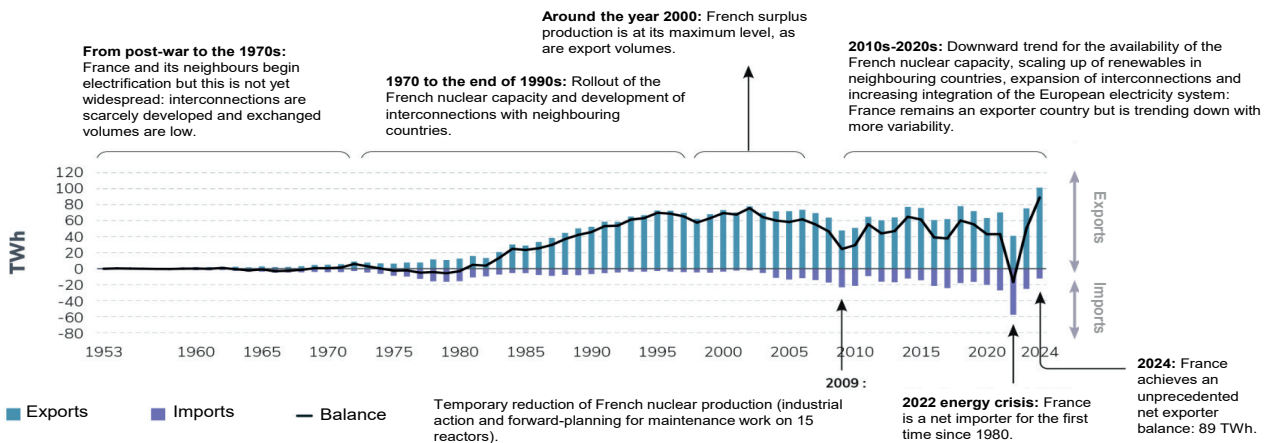
Source: Florence School of Regulation.

How to read this Figure: Each bidding zone is represented by a colour and borders. Two zones with the same colour are not related.

An electricity interconnection is an electric line that crosses the border between two zones. It enables electricity to be exchanged between these zones commensurate with its capacity (in GW).

European interconnections emerged in the wake of the Second World War, with the initial rationale being mutual assistance. So, in the event of an outage of domestic infrastructure or an unforeseen peak in demand, a country can rely on a proportion of the surplus electricity capacity of its interconnected neighbour (see Box 1). Since the first European interconnection at the meeting point of the French, German and Swiss borders in 1958, over 400 interconnections have been created in Europe, 37 of which are on French borders representing an exchange capacity of around 20 GW in 2024. France is a longstanding exporter of electricity (see Chart 1). For the second consecutive year, France exceeded its record for electricity exports in 2025 with a net exporter surplus of 92.3 TWh.

Chart 1: Exchanges of electricity between France and its neighbours since 1953



Source: Réseau de Transport d'Électricité (RTE) (2025), Annual Electricity Review 2024.

How to read this Chart: The positive values represent French exports and the negative values correspond to imports.

Box 1: The role of interconnections during the 2022-2023 energy price crisis

Due to low electricity generation levels in France, in particular by nuclear power (owing to stress corrosion cracking, SCC) and hydropower (the summer 2022 drought) plants, France was a net importer of electricity in 2022 for the first time since the 1980s.

That year, France was an importer 70% of the time: interconnections ensured the country's security of supply for 5% of the time (avoiding the need for demand reduction measures: load shedding and outages) and provided competitive sources of electricity during 65% of the year's hours.

This pressure on the electricity supply led to especially high wholesale prices in France compared to its European neighbours.

Table 1: Differences in daily wholesale electricity prices between 2016 and 2023 as an annual average (difference between the price in neighbouring countries and the price in France)

€/MWh	Great Britain	Germany	Belgium	Switzerland	Italy	Spain
2015-2020	11	-6	2	1.5	10	6.5
2021	28.5	12	-5	6	16	3
2022	-34	-40	-31	6	32	-108
2023	11	-2	0.4	11	31	-10

Source: Energy Regulation Commission (CRE), 2024, Report on electricity and gas interconnections 2020-2023.

How to read this Table: In 2022, the Spanish average daily wholesale price was, on average, less than the French price of €108/MWh.

N.B. This very significant difference is related to the rollout of an Iberian mechanism with a cap on gas prices for electricity generation. French consumers benefitted from this mechanism which allowed for imports of electricity generated in Spain at capped prices.

According to the operator of the French *Réseau de transport d'électricité* (RTE),^a if interconnections had not been expanded since the 2010s and in the absence of a reduction in consumption, winter 2022-2023 would have witnessed five instances of an orange alert from the Ecowatt system and 12 instances of a red alert,^b meaning that there is an imminent risk of supply being disrupted for some consumers.

a. RTE (2025), "Bilan Prévisionnel 2023-2035" (in French only).

b. Compared with no activation of these alerts during the 2022-2023 crisis.

1.2 Interconnections allow for the introduction of economic optimisation mechanisms and lead to price convergence

Interconnections allow for the extension and pooling of the available market place to meet electricity supply and demand. Domestic electricity consumption can be met by a surplus existing in a neighbouring country if there is still exchange capacity available on the interconnections. As a result, they make a larger number of production facilities – activated according to their increasing marginal cost – accessible to market optimisation mechanisms (see Chart 2).

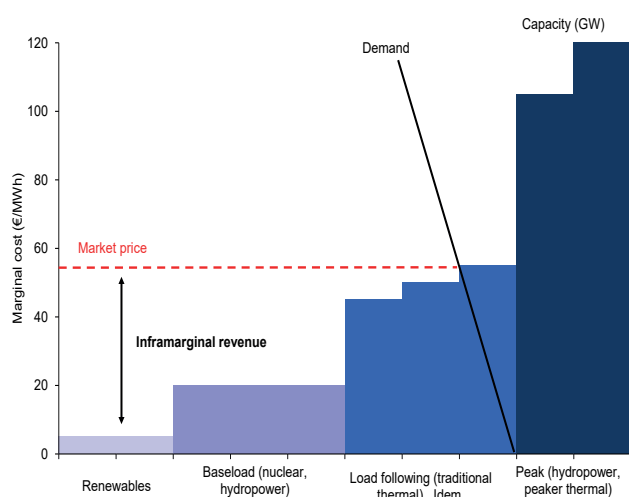
The sources called upon first – the least expensive – are usually those with a zero or low fuel cost (including the associated emission factor). Electricity generating power plants are subject to emission allowances that are traded on the European Emissions Trading Scheme (ETS) market which adds carbon pricing according to emissions from the fuel used. This means that the European market favours power plants with the lowest greenhouse gas emission factors such as those powered by renewables and nuclear power.¹ By extending the market place, interconnections therefore enable the number of available low marginal cost and low-emission sources to be increased to meet domestic demand for electricity.²

(1) G. Zachmann et al. (2024), "Unity in power, power in unity: why the EU needs more integrated electricity markets", *Bruegel Policy Brief*.

(2) M. Didier, A. Loublier and A. Souletie (2017), "The Benefits of a European Approach to Green Electricity", *Trésor-Economics* No. 197.

When interconnections are not saturated, prices between two zones converge. Expanding interconnections therefore increases the convergence of French prices with those of neighbouring countries. Daily prices within the France-Germany-Belgium zone converged for approximately 45% of the time in 2023 compared to around 20% in 2015, thus testifying to the scale of France's integration into the European market.³

Chart 2: Theoretical diagram of calls on production facilities on the electricity market



Source: DG Trésor, the marginal costs are presented for illustration purposes.

How to read this Chart: Wholesale electricity prices on the day-ahead market (for the next day, the benchmark electricity market that is also known as the spot market) are established on the basis of marginal production costs. Production facilities, including those made available by an interconnection, are called on by increasing marginal cost, until supply matches demand. The marginal cost of the last power plant called on to balance supply and demand in the zone sets the wholesale electricity price for the entire zone. In this Chart, the supply and demand curves meet at the activation point of a load-following power plant whose marginal production costs are €55/MWh. The price of electricity will therefore be set at this level for all the power plants called on; those with a marginal production cost that is lower than the market price record a margin known as inframarginal revenue.

1.3 France still has bold targets for further developing interconnections

The energy transition by electrification and a greater proportion of variable electricity production facilities, such as wind and solar power, is increasing requirements for flexibility resources for the electricity grid, which include interconnections. The

interconnection capacity could double by 2050:⁴ up to 45 GW of interconnections (in import capacity) could be justified from a socio-economic standpoint⁵ at French borders, representing annual gains of between €2bn to €6bn for the French system (corresponding to the avoided cost of new power plants in France and the avoided cost of operating dispatchable power plants) compared to a scenario without new interconnections.⁶

This scale of interconnections is justified by factoring in the socio-economic benefit at European level. However, by only measuring this benefit for France, up to 39 GW of interconnections are justified in all case scenarios. Over and above this figure, the economic benefits are only still positive for France in scenarios for very substantial development of renewables and a gas price that either remains stable or increases (see Chart 3).⁷ For its part, the most-recent European Ten-Year Network Development Plan following the Identification of System Needs pinpoints an economic area for 24 GW of additional French interconnection capacity by 2040.⁸

It should however be noted that the analyses presented in the two paragraphs above refer to best-case scenarios and do not factor in the cost of internal reinforcement that is required for interconnections, nor the increase in their cost since 2021 (see for example the Bay of Biscay interconnection below), which mitigate these economic benefits.

1.4 A robust assessment process provides guidance for decisions to invest in building new electricity interconnections

To encourage the building of new interconnections, the EU takes a normative approach setting a common single target for minimum interconnections (non-binding) equalling 15% of the electricity capacity of each Member State and a minimum of 70% of electricity interconnection capacity to be made available to market participants (the remaining 30% can be used for reliability margins, loop flows and internal flows on each critical network element – see Section 3.1). For France, the installed interconnection capacity accounted for 13% of the installed electricity

(3) Prices observed on the ENTSO-E Transparency Platform, convergence is deemed achieved when the price difference is less than €1.

(4) RTE (2021), "Energy Pathways to 2050".

(5) For example, on the basis of regional socio-economic benefits: total of gains and losses of surplus for consumers and producers in the relevant countries, net of construction and interconnection management costs.

(6) RTE (2021), op. cit.

(7) RTE (2021), op. cit.

(8) ENTSO-E, Ten-Year Network Development Plan 2024.

capacity in 2024.⁹ In practice, decisions to invest in interconnections remain the purview of each Member State.

In France, this process results from an ex-ante socio-economic analysis for each project that takes account of its own material, economic and financial parameters, in conjunction with the other relevant zones. The ex-post analysis of existing interconnections on French borders highlights the fact that the ex-ante cost/benefit analyses are fairly robust:

- The flows carried by the interconnections – projected by forecasting exercises on changes to electricity mixes carried out by grid operators and audited by the regulators – are at satisfactory levels. In 2019, Franco-Italian interconnections were used at 94% of their capacity while those with Spain were used at 87%, those with Switzerland at 70% and those with the United Kingdom at 76%.¹⁰

- The construction costs of land-based alternating current projects do not significantly exceed the budgets approved by the regulators. However, a number of recent direct current¹¹ and underwater¹² interconnection projects, such as the Bay of Biscay and Celtic Interconnector projects, have generated additional costs deemed substantial by the Energy Regulation Commission (CRE).¹³ With these scenarios, the regulators may provide for review clauses. For instance, for the Bay of Biscay project, the benchmark for cross-border cost sharing was revised in 2023 to take account of inflation: Spain was initially to have borne 62.5% of the costs, including additional costs of up to €250m. As this threshold was exceeded due to the sharp rise in site and material costs, the regulators decided on a 55%/45% split of total investment costs between Spain and France respectively in exchange for the rebalancing of the financial profits from the interconnection once it had been built (through a rider to the joint decision to share costs and profits that had been taken by the regulators in 2017).¹⁴

2. Interconnections lead to the pooling of electricity grids with uneven benefits that are shared

2.1 Relevant electricity interconnections create socio-economic benefits for society

The presence of lasting differences in electricity prices between two zones underpins the economic relevance of investments in interconnections. In this respect, a zone that produces cheaper electricity can export its production to a zone where the price is higher, thus avoiding this zone having to activate costly production facilities. If total benefits exceed the cost of building and operating the interconnection then it creates socio-economic benefits for society.

The benefit for society generated by an interconnection is therefore contingent on the prices of electricity in the region, their volatility, and the cost of the required

commodities and labour. For instance, electricity interconnections will have more economic value in an electricity grid with a large proportion of non-dispatchable renewable electricity resources. They allow access to a broader consumption and production base, providing flexibility that contributes to balancing supply and demand in real time (see Chart 3).

Gas prices still often determine the medium-term price of electricity in Europe to a varying degree¹⁵ and, hence, price differences and the economic value of trade. Interconnections delay the activation of gas-fired power plants that would have otherwise pushed up the price of electricity. As a result, higher gas prices have a positive effect on the economic benefit provided by interconnections.

(9) Interconnection capacity: around 19.5 GW for imports. Electricity generation capacity: around 155.5 GW. Sources: RTE (2025), Annual Electricity Review 2024, and RTE (2024), Bilan prévisionnel 2023-2035 (in French only).

(10) DG Trésor calculations based on the CRE's 2020 Report on Electricity and Gas Interconnections.

(11) More costly than "traditional" alternating current interconnections.

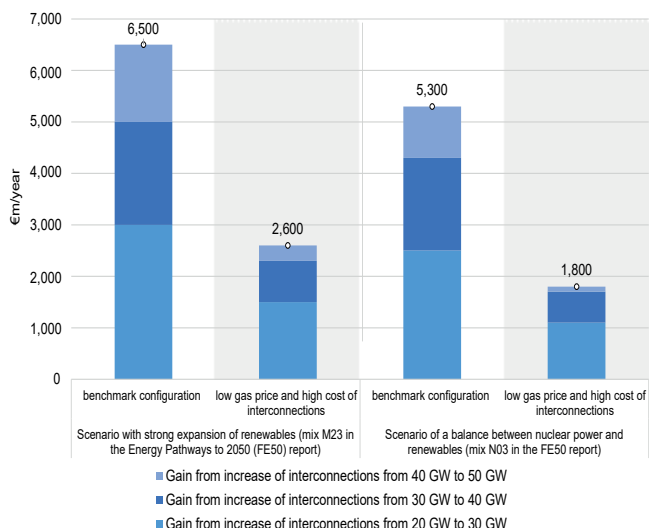
(12) More risky and costly than land-based interconnections (in addition to being in direct current).

(13) CRE (2023), "Délibération portant modification de la décision conjointe de répartition transfrontalière du projet Golfe de Gascogne" (in French only).

(14) CRE (2023), op. cit.

(15) For a given gas price, European gas-fired power plants produce electricity at different costs depending on their performance levels.

Chart 3: Gains for society from the development of interconnections up to 2050 in various mix and price scenarios



Sources: RTE, DG Trésor calculations.

2.2 The breakdown of regional socio-economic benefits is uneven between countries and stakeholders

An interconnection that is relevant from an economic standpoint ensures economic gains for society but leads to an uneven breakdown of benefits (i) between countries¹⁶ and (ii) between consumers and producers in the same country. For a country exporting electricity, in which prices were initially lower, the interconnection favours the producers (by increasing turnover) whereas in the importer country, where the prices were initially higher, it benefits electricity consumers be they households or businesses (that experience lower electricity prices due to the convergence caused by the interconnection).

Excluding offsetting arrangements, these asymmetrical surpluses generate opposing incentives for producers and consumers in the relevant countries as producers in countries with low prices have significant interest in developing new interconnections whilst consumers in these countries would be better off if such development is slowed. The opposite is true in countries where electricity prices are higher.

2.3 Case study: the redistributive effects of a new interconnection

This case study describes the effects of the rollout of a 5 GW interconnection between country E (exporter) and country I (importer) compared to an initial situation without an interconnection. The figures are only given as an illustration and do not correspond to an actual situation.

In the scenario without an interconnection, the level of demand in country I (50 GW for an hour of consumption) requires triggering 5 GW of oil-fired production capacity with a very high variable production cost (€100/MWh). In country E, the level of consumption (80 GW for an hour of consumption) is covered by wind farm and nuclear power generation, with the latter being the marginal unit with a variable cost of €10/MWh. The market prices therefore stand at €100/MWh and €10/MWh in countries I and E respectively, in self-sufficient markets.

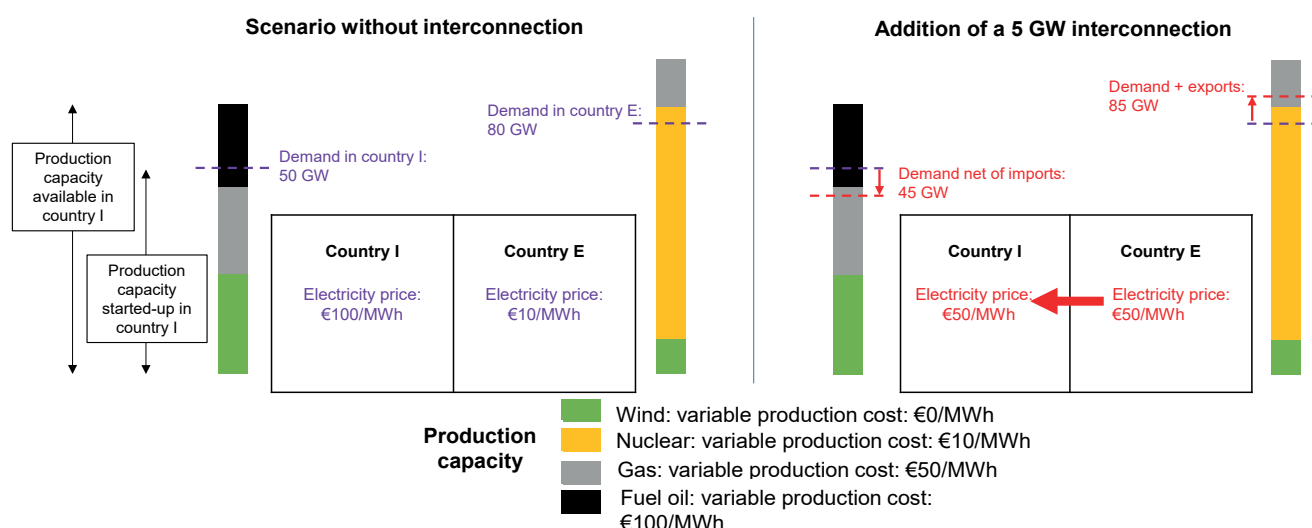
Rollout of a 5 GW interconnection provides country I with country E's production capacity, the production costs of which are lower than those of the oil-fired peaker power plants in country I. Here, interconnection capacities reduce production requirements in country I which allows it to shut down its oil-fired plants. Concurrently, the existence of demand for 5 GW for an hour of consumption in country I that is made to country E's production requires start-up of its gas-fired power plants. The price of the energy becomes stable at the same level for both the countries in this scenario at a variable cost in marginal production units, such as gas-fired power plants, at €50/MWh.

Without factoring in investment costs, the existence of an interconnection does create a benefit for society. The production costs of a regional electricity grid [E; I] fall: in this case study, the variable production costs of oil-fired power plants in country I are higher than those of gas-fired and nuclear power plants in country E.¹⁷ A comprehensive cost/benefit analysis of the interconnection would nevertheless require a comparison of the benefits over the interconnection's lifespan with its investment costs.

(16) In this paragraph and the following ones, the term "zone" is replaced by that of "country".

(17) When the production costs in "self-sufficiency" are the same, the interconnection has no impact.

Figure 2: Rollout of an interconnection between two countries and operation of the markets



Sources: RTE, DG Trésor calculations.

Table 2: Economic result of the interconnection for one hour's operation of the electricity grid

In €m	Country I	Country E
Consumer surplus related to variations in bills (a)	+2.50	-3.20
Net income from variable production costs for producers (b)	-2.25	+3.24
Result for the domestic society (a)+(b)	+0.25	+0.04
Result for society [E; I]	+0.29	

Source and calculations: DG Trésor. Electricity capacity assumptions (Country I: 20 GW of wind power, 25 GW of gas and 15 GW of fuel; Country E: 10 GW of wind power, 71 GW of nuclear power and 10 GW of gas), variable and consumption costs are given as an illustration. The calculations are also presented as an illustration and show the gains/costs compared with a scenario without interconnection, for one hour's operation of the electricity grid:

(a) Consumers in country E pay an additional €40/MWh for all their consumption (80 GWh); consumers in country I pay €50/MWh less for all their consumption (50 GWh).

(b) Producers' net income is calculated as the total for all production facilities of the difference between the price on the energy market and variable production costs. Producers in country I see their profits fall by €50/MWh for the 45 GWh produced to a cost that is much lower than the self-sufficient price (wind and gas); producers in country E make an additional profit of €40/MWh for all their self-sufficient production (80 GWh) and for production earmarked for export that is generated at a lower cost with the interconnection (1 GWh for nuclear power production that remains available).

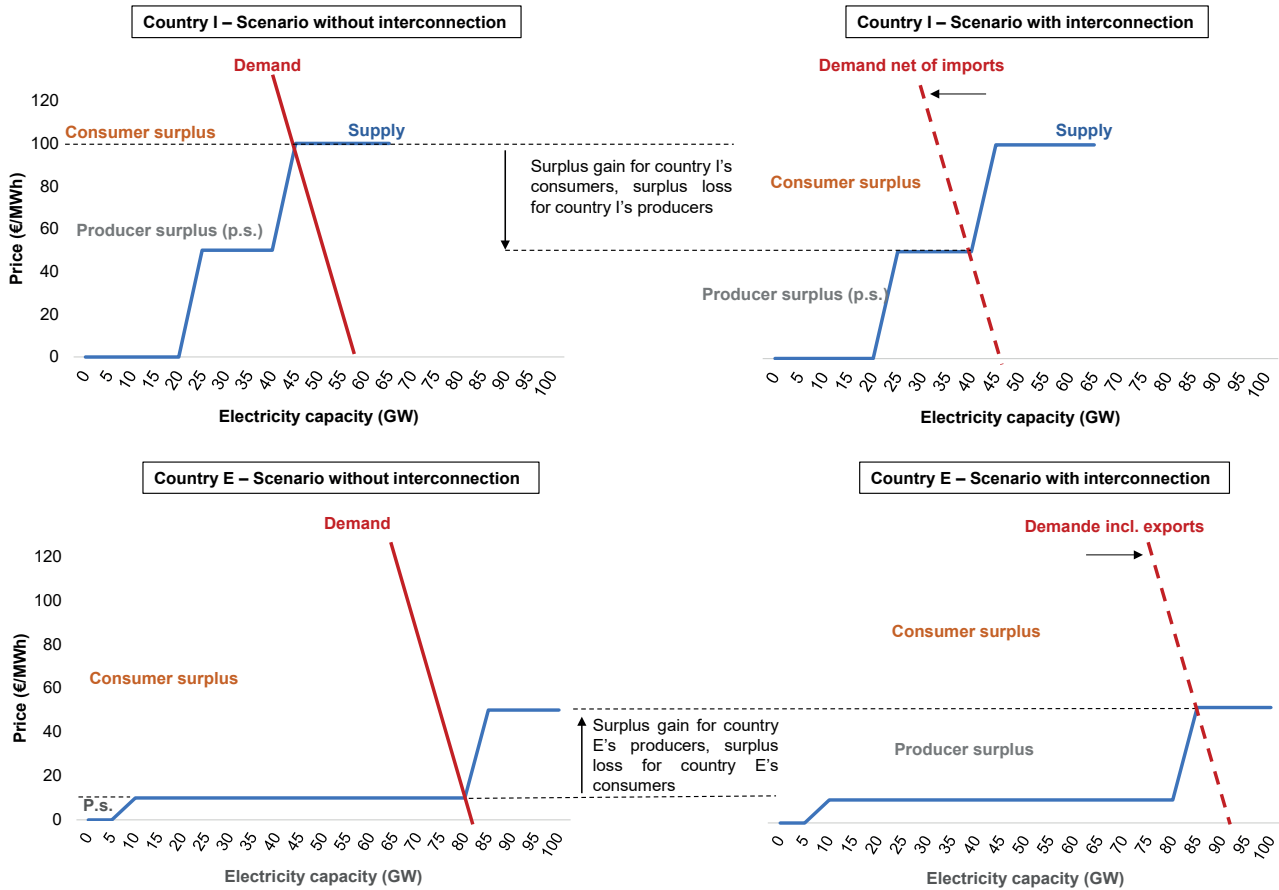
This case study highlights significant transfers between producers and consumers brought about by rollout of the interconnection (see Chart 4). For consumers in country I, the interconnection cuts the costs of electricity supply due to a fall in the market price. On the other hand, this reduction of prices in country I drags down the income of this country's electricity producers.¹⁸ The situation is the opposite in country E as the increase in demand owing to the interconnection leads to higher market prices to the detriment of

consumers. However, country E's producers profit from implementation of the interconnection in two ways (i) the price increase enables them to sell energy to country E's consumers at higher prices than in the model without the interconnection and (ii) the increased demand with exports leads to a rise in nuclear power generation (which had not fully started-up without the interconnection), and generates additional profit due to the gap between the variable production costs of nuclear power plants and the market price.¹⁹

(18) In this scenario, this shutdown of fuel-based peaker production plants does not reduce profits for the producers in country I that own them as these plants were not turning a profit in a situation without the interconnection (the price of electricity without the interconnection is the same as these plants' variable production costs). However, profits are cut for producers in country I that own gas-fired power plants or wind farms.

(19) Producers of electricity from gas in country E are indifferent in the case study. Without the interconnection, gas-fired power plants are not started-up; with the interconnection, they are started-up but as the market price is the same as their variable production costs, they do not make a profit.

Chart 4: Exchange gains and corresponding surpluses for consumers and producers



Source: DG Trésor calculations.

2.4 Mechanisms can partially offset the unevenness of economic benefits

First and foremost, disincentives to building an interconnection are mitigated by the interconnection capacity at the border (13% for France, see Section 1.4). When the interconnections are saturated, all else being equal, the price of electricity in the exporter country stabilises.

The unevenness of economic benefits between countries can then be mitigated by an asymmetric breakdown of the cost of building the interconnection using the same proportions. The country that receives the majority of the economic benefits assumes a larger proportion of the total cost of the interconnection. These sharing arrangements have already been integrated into the French rationale for investing in an interconnection (see the example of the Bay of Biscay interconnection in Section 1.4). Occasionally, asymmetric sharing of the income from the interconnection between both countries' grid operators may also be decided on.

Within a zone, the diverging effect of the rollout of interconnections on consumers and producers may be subsequently rectified using post-market mechanisms that allow the surplus captured by the producers in the exporter zone to be redirected to consumers (and vice-versa for the importer zone). In exporter zones, these mechanisms may involve:

- a tax on producers' rents that is redistributed to consumers (a similar arrangement to the Universal Nuclear Levy (VNU) in France).²⁰
- providing consumers with supply contracts that are based directly on the costs of the domestic electricity mix.²¹
- implementation of a contract for difference (CfD) enabling consumers to pay a regulated price based on the grid's production costs, irrespective of electricity prices on the wholesale market.

(20) An arrangement that has been in place since 1 January 2026 under which EDF redistributes to consumers, by reducing their electricity bill, a proportion of the income generated by its incumbent nuclear facilities, when certain price thresholds are exceeded.

(21) Similar to Nuclear Production Allocation Contracts in France, that were introduced starting on 1 January 2026.

3. Interconnections are becoming an essential vehicle for transforming the European electricity system and should be assessed against the broad and competitive backdrop of flexibility measures

3.1 Bolstering domestic grids is just as important for integration of the European electricity system as the development of new interconnections

France is becoming an electricity transit country²² – as is already the case for gas – between countries that generate low-carbon and low-cost electricity, such as Spain, and consumer countries. Interconnections can provide this service for society provided their construction and impact on domestic grids are properly passed on to the recipients of their economic benefits.

However, a number of European grids sometimes suffer internal congestion (e.g. the Netherlands or the north-south link in Germany),²³ meaning that there are bottlenecks in their national networks that are saturated during instances of peak production or demand. As this congestion takes place within a zone, it is poorly factored into the European zonal market model, which only takes account, by its nature, of congestion at the borders between zones.

As they allow national electricity grids to be pooled, interconnections can carry forward a country's internal congestion to its neighbours. For instance, northern Germany is home to a high concentration of renewable generation projects (in particular wind farms) whereas the main energy consumption centres are located in the south of the country. During times of high winds and high demand, the German electricity grid is unable to transmit all the north's production to meet demand in the south. As a result, this production is partly absorbed by neighbouring countries thanks to interconnections and "transits" to southern Germany via the domestic grids of Belgium, Poland, France and Switzerland.²⁴ These loop flows – that are not

provided for by the market model and do not represent commercial transactions – disrupt optimum operation of the interconnections and cause internal congestion in these neighbouring countries, generating substantial costs that are not compensated.²⁵ These countries will then need to make occasionally costly investments to address this issue. These include investing in phase shifting transformers²⁶ that filter these flows.

This means that investments in cross-border lines must be consistent with the expansion of domestic grids so as to (i) maximise the use of interconnections and (ii) avoid internal congestion being carried forward to neighbouring grids.

In France, the Ten-Year Network Development Plan, published by RTE in March 2025,²⁷ notes in this respect that it will not be feasible to continue to interconnect the French electricity system after 2030 without bolstering the structure of its national grid. Otherwise, exchange capacity at the borders would be limited. As a result, RTE is planning a benchmark €16bn investment in the national ultra-high-voltage grid up to 2040, €2bn of which will go towards reinforcing the interconnections currently being built on the French borders (Celtic – between France and Ireland, Bay of Biscay – between France and Spain, and increased capacity with Germany and Belgium). This figure could rise to almost €5bn in the event that there are further projects with Great Britain and Spain.²⁸

Symmetrically speaking, the decision to build an interconnection on French borders factors in the condition of the domestic grid of the other zone so that investments harnessing the full potential of the interconnection to be exploited are made as a condition precedent for the building of cross-border lines.

(22) RTE (2025), "Annual Electricity Review 2024", Chapters 4 and 6.

(23) ENTSO-E (2025), "Bidding Zone Review of the 2025 Target Year".

(24) RTE (2025), "Annual Electricity Review 2024", Chapters 4 and 6.

(25) J. Percebois and S. Pommeret (2025), "Flux commerciaux, flux de transit et loop flows dans l'électricité", *La Revue de l'Énergie*, no. 676 (in French only).

(26) J. Percebois and S. Pommeret (2025), op. cit.

(27) RTE (2025), "France's Network Development Plan (SDDR)", Factsheet 11.

(28) RTE (2025), "France's Network Development Plan (SDDR)", Factsheets 10 and 11.

Box 2: ENTSO-E Bidding Zone Review of the 2025 Target Year

In April 2025, the European Network of Transmission System Operators for Electricity (ENTSO-E) published its electricity bidding zone review.^a It states that splitting Germany into five bidding zones to ease the structural north-south congestion would result in an annual change in socio-economic welfare of €339m. Germany has dismissed the option of reconfiguring its bidding zones^b and is working on an action plan to solve congestion issues and overhaul local renewable production planning.^c This review also looks at the possibility of splitting France into several bidding zones but concludes that congestion in the French grid is too low to warrant this change.

a. ENTSO-E (2025), op. cit.

b. German Federal Ministry for Economic Affairs and Energy (2025), "Bidding Zone Action Plan" (in German only).

c. France/Germany Office for the Energy Transition (2025), *Concentration régionale de l'éolien terrestre en France et en Allemagne* (in French only).

3.2 Interconnections provide domestic and European energy policies with vital flexibility

Interconnections offer prudential value for energy policy. The electricity system is a complex and buoyant asset that is subject to much uncertainty (technological advances and changes to industry, falling costs, geopolitical and social pressure), and interconnections provide a certain amount of long-term flexibility in managing energy-related decisions. They allow for surplus electricity to be exported in the event of overcapacity and for imports in the event of a deficit or use of emergency capacity.

This prudential value was demonstrated, inter alia, during the 2022-2023 energy crisis when the failure of an electricity generation method to which France is structurally exposed (nuclear power plants were partially shut down) was offset by the import capacity via cross-border lines.

Interconnections therefore contribute to the flexibility of the European system along with other measures such as hydropower storage, stationary batteries and demand-side flexibility.

3.3 Interconnections externalise resilience and the shortcomings of domestic electricity systems, and may carry forward certain constraints to neighbouring countries

By pooling resources, interconnections reduce investment requirements in dispatchable power plants and storage assets²⁹ (e.g. thermal power stations, inertia flywheels, batteries, consumption-based flexibility). As a result, they may dampen national incentives to build these flexibility and cutting-edge assets. Co-dependency of electricity grids may lead to under-investment in these assets at European level and create a systemic risk³⁰ at a time when European electricity mixes are increasingly dependent on weather patterns.³¹

This means that the contribution of interconnections to the national electricity grid's stability needs to be properly assessed and certified, and the capacities requested from the foreign country should be subject to a contract.³² For instance, every year, France certifies an interconnection capacity level that could contribute to the French capacity mechanism, meaning an available import capacity (during periods of pressure on the French grid) with a certain commitment based on a risk-analysis method drawn up by the regulator and grid operator. This figure was 7.5 GW in France in 2023, well below the total import capacity at French borders.

(29) G. Zachmann et al. (2024), op. cit.

(30) S. Ambec and C. Crampes (2025), "La péninsule ibérique dans le noir. À qui la faute ?", Toulouse School of Economics (in French only).

(31) RTE (2024), "Bilan prévisionnel 2023-2035" (in French only).

(32) P. Holmberg et al. (2025), "Europe's electricity capacity mechanisms need to be better coordinated", *Bruegel Policy Brief* 11/25.

France's flexibility requirements are far from being met by interconnections but are also covered by the dispatchable nuclear capacity, pumped storage hydropower stations, the dispatchable thermal capacity and batteries. By 2030 when 65% of European electricity capacity will be vulnerable to climate events³³ (a third of French capacity),³⁴ France would have

to invest in around 7 GW of demand-side flexibility mechanisms (e.g. load shedding, dynamic pricing), 6 GW of batteries and 3 GW of low-carbon thermal power stations, as well as in the renewal of its nuclear capacity (life extension of existing reactors and building new ones), in order to maintain its grid's resilience.³⁵

Box 3: The role of interconnections in restoring the Spanish electricity grid following the Iberian blackout

On 28 April 2025, Spain and Portugal experienced a blackout or *gran apagón*, which resulted in the disconnection of almost all their connected production facilities, the instantaneous loss of electricity supply via the grid for the entire peninsula and disconnection from the French and Moroccan grids.^a A final report from ENTSO-E drawing conclusions from the events and conduct of stakeholders should be published in early 2026.^b The resupply of electricity to Spain and Portugal was initiated by France and Morocco. France carried out a staggered recommissioning of interconnection infrastructure. This allowed for a methodical and safe approach to re-energising the peninsula's grid in phases.

a. ENTSO-E (2025), "Grid Incident in Spain and Portugal on 28 April 2025", Investigation expert panel factual report.

b. RTE (2025), "Foire aux questions : *black-out* du 28 avril 2025 sur la péninsule ibérique" (in French only).

(33) RTE (2024), op. cit.

(34) French Government (2026), Multiyear Energy Plan 2026-2035.

(35) RTE (2024), op. cit.

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