Presentation to NeuConnect

NeuConnect socio-economic welfare impact

Results of socio-economic welfare analysis

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ENERGY

FINAL

19 May 2022

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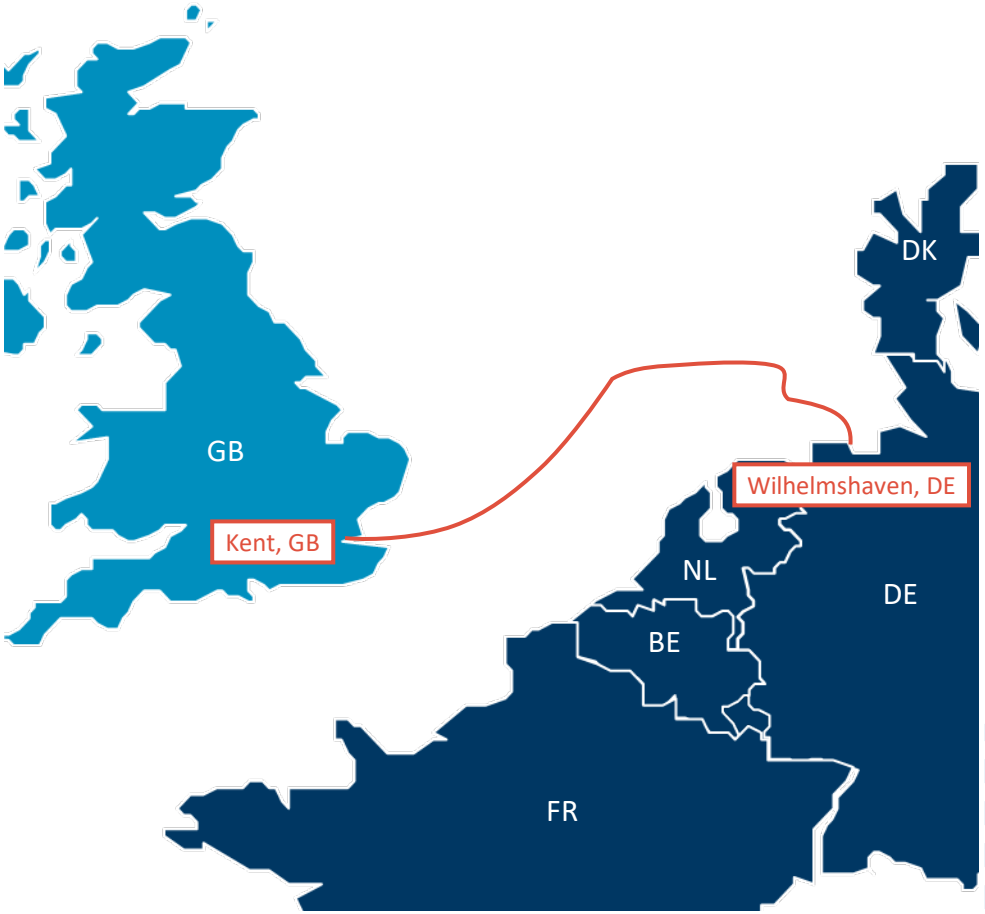
Executive summary

FTI-CL has been engaged to perform an independent analysis of the socio-economic welfare impact of the NeuConnect interconnector

Proposed NeuConnect interconnector



Source: FTI-CL Analysis

Current stage of the project

Asset overview

- NeuConnect is a proposed 1.4GW HVDC electricity interconnector, connecting Kent in the South-East of GB to Wilhelmshaven in the North of Germany.
- During Ofgem's FPA Consultation, the regulator requested an updated socio-economic modelling analysis reflecting current project costs and connection date, and any additional independent analysis relevant to the overall needs case.

Project timeline

Initial IPA Consultation (19 Jun 2017)	Initial Project Assessment evaluates the asset's impact on GB Consumers and GB Welfare
IPA Decision (9 Jan 2018)	Cap and Floor regime awarded by Ofgem
Ofgem's FPA Consultation (11 Apr 2022)	Ofgem requests updated socio-economic modelling analysis

We have analysed the impact of the interconnector on GB socio-economic welfare using NeuConnect's Policy Scenario, developed in 2021

Introduction and methodology

- FTI-CL has **analysed the impact of NeuConnect on GB's socio-economic welfare (SEW)** using the following equation: (i) change in consumer surplus; ***plus*** (ii) change in producer surplus; ***plus*** (iii) change in IC (non-NeuConnect) rents; ***plus*** (iv) NeuConnect Congestion rents; ***less*** (v) NeuConnect's cost.
- Additional benefits of NeuConnect, such as contribution to **ancillary services** and to the **GB Capacity Market** have not been quantified in this assessment, but these factors could enhance the benefits of the link to GB consumers.
- We have estimated the SEW impact using FTI-CL's in-house power market model (that runs on Plexos® Market Simulation Software – a **well known and widely used power market model**), calibrated with a detailed representation of the European power market.
- **Using the formula** and the **projected components of socio-economic welfare** mentioned above, we **calculate the net impact on GB's socio-economic welfare**, if NeuConnect was to be approved and construction completed by 2028.

Policy Scenario

- To perform the assessment of NeuConnect, we have developed a set of assumptions regarding demand, generation mix, commodity prices, and others that we refer to collectively as the **'Policy Scenario'.**
- This scenario reflects a decarbonisation pathway **consistent with the Net Zero ambitions / legal commitments** of European (including UK) governments. We use these assumptions to project the components of socio-economic welfare (mentioned above) to 2050.
- The Policy Scenario has been developed using a range of **third-party projections**, **FTI's expert judgement**, as well as **NeuConnect's input** on specific issues.
- Examples of **third-party projections** include, among others:
  - European Network of Transmission System Operators for Electricity's ("ENTSO-E's") Ten-Year Network Development Plan ("TYNDP")
  - National Grid Electricity System Operator's Future Energy Scenarios ("FES"); and
  - Germany's National Energy and Climate Plan ("NECP").
- The Policy Scenario (version from 2020) has been used in the past in publicly available reports, such as here.

Note: *1) Namely ENTSO-E, National Grid ESO, European Commission, and a range of European TSOs.*

The Policy Scenario used in our analysis reflects a range of external benchmarks to provide a consistent and credible pathway to Net Zero

Development process for the Policy Scenario

1 GB and EU policy ambitions

In assessing the benefits of the interconnector, NeuConnect has elected to use a scenario…

…reflective of the stated ambitions of the **GB** and **German** governments to **achieve Net Zero by 2050**.

2 Input benchmarking

FTI-CL collated data from **third party scenario forecasts** to guide the scenario definition…[1]

…and developed specific inputs for the scenario, based on both an **assessment of the range of data** collected and **expert judgment**.

3 Policy Scenario

Based on the **proposed inputs**, FTI-CL developed the Policy Scenario…

…which achieves **Net Zero** in the **UK and wider Europe by 2050**…

…and can be compared to a number of external benchmarks, but **do not align to a specific external scenario**.

Comparison of the Policy Scenario to NG ESO's Future Energy Scenarios ("FES")

FES 2021

- ✓ Scenarios published by NG ESO (which may make them more 'familiar')
- ✓ Three out of four FES scenarios are consistent with Net Zero by 2050
- × Developed prior to July 2021, so are out of date (relative to developments in late 2021 and 2022). Indeed they:
  - × do not reflect the 2021 energy supply issues and associated policy responses; and
  - × do not reflect the Russia-Ukraine conflict and BESS[2]

FES 2022

- × Have yet to be published…
- × …and are not expected to be available until later in 2022
- × Unclear which recent energy market developments will be included

Policy Scenario

- ✓ Consistent with Net Zero targets
- ✓ Credible and internally consistent assumptions, based on external benchmarks
- ✓ Developed in Autumn 2021, hence reflects the energy supply issues (notably gas) that were already apparent
- ✓ Developed to support FID

The **Policy Scenario** provides a **more relevant representation of the future power markets** in GB and Germany compared to the FES 2021 scenarios.

Note: *1) Namely ENTSO-E, National Grid ESO, European Commission, and a range of European TSOs. 2) British Energy Security Strategy, available here: https://www.gov.uk/government/publications/british-energy-security-strategy*

Of the four NG ESO FES Scenarios, the Policy Scenario is most comparable to (but remains distinct from) the System Transformation Scenario

	Input assumption	Policy Scenario	System Transformation (FES 2021)	Commentary
1	**CO2 prices**	▪ **€66/tCO2** in **2030** ▪ **€250/tCO2** in **2050**	**FES 2021 mid-case:** ▪ **€51/tCO2** in **2030** *(FES high-case is €50.9/tCO2)* ▪ **€122/tCO2** in **2050** *(FES high-case is €255.8/tCO2)*	▪ Policy Scenario is closer to the FES high-case, than the FES mid-case.
2	**Gas prices**	▪ **€22.5/MWh** in **2025** ▪ **€23.4/MWh** in **2030** ▪ **€27.6/MWh** in **2050**	**FES 2021:** ▪ **€16.9/MWh** in **2025** ▪ **€19.3/MWh** in **2030** ▪ **€24.1/MWh** in **2050**	▪ Close to FES 2021
3	**GB nuclear capacity**	▪ 3.7GW in 2025 ▪ 3.7GW in 2030 ▪ 10.2GW in 2050	▪ 5.4GW in 2025 ▪ 5.8GW in 2030 ▪ 14.9GW in 2050	▪ Greater level of caution over the build-out of new GB nuclear capacity under the Policy Scenario
4	**GB RES capacities**	▪ **Onshore wind:** 23GW in 2030, 41GW in 2050 ▪ **Offshore wind:** 38GW in 2030, 93GW in 2050 ▪ **Solar:** 25GW in 2030, 63GW in 2050	▪ **Onshore wind:** 23GW in 2030, 31GW in 2050 ▪ **Offshore wind:** 38GW in 2030, 95GW in 2050 ▪ **Solar:** 25GW in 2030, 57GW in 2050	▪ GB RES capacities are largely in line with the FES 2021 System Transformation Scenario
5	**GB IC capacities**	▪ 11.7GW in 2030 ▪ 15.1GW in 2050	▪ 15.9GW in 2030 ▪ 19.6GW in 2050	▪ Lower expected build-out of new GB interconnectors under the Policy Scenario

We make use of the Plexos Integrated Energy Model[1] platform to estimate the impact of NeuConnect on GB wholesale markets

Inputs

Policy Scenario

Net Zero is achieved in both **Europe and GB by 2050**

Key assumptions

1 **Commodity prices**

Prices of CO_2, gas, etc. are the **main drivers** of **short-run marginal costs** of thermal power plants

2 **Electricity demand**

Higher **demand** increases the need for higher cost generation

3 **Electricity generation capacity**

3a The **deployment of low SRMC generation** (e.g. renewables) decreases power prices

3b Expected **future interconnectors** that may cause prices to converge

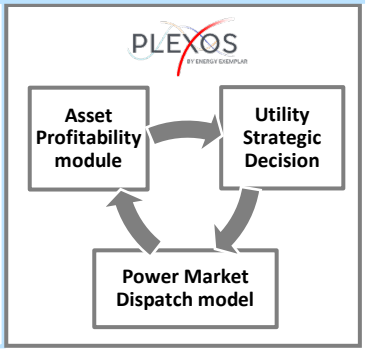
Power Market Model[1]

'Long Term' model PLEXOS

Determines the optimal evolution of generation capacity (GW):
- Finds the lowest-cost combination of generation plants (of all technologies)…
- …that meets the minimum capacity margin…
- …constraints on CO_2 and other emissions…
- …for each price zone in Europe

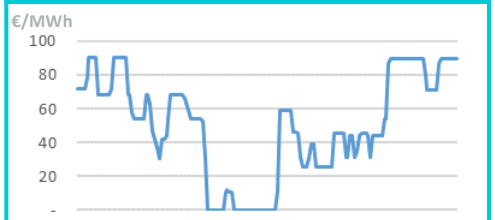
'Short Term' model PLEXOS

Takes capacity from the Long Term model as given and determines the optimal output of generation (GWh):
- Finds the least-cost dispatch profile of generation…
- …that meets demand…
- …on an hourly basis…
- …for each generating plant…
- …for each price zone in Europe

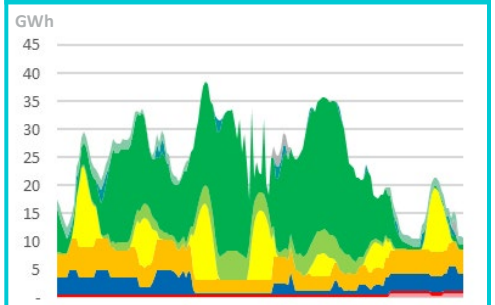


Hourly outputs

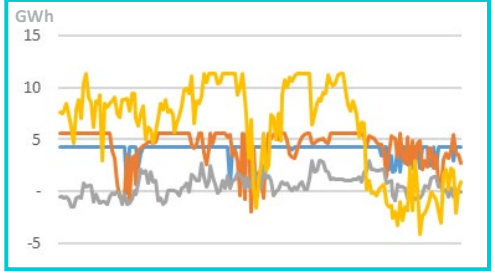
Wholesale power prices



Generation



Interconnector flows

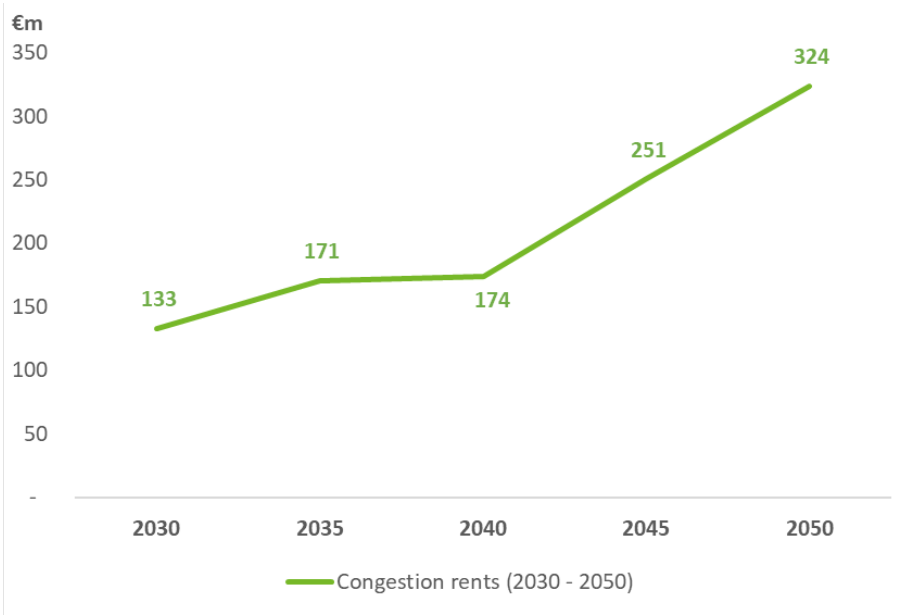


Etc.

Note: *1) The Plexos® Integrated Energy Model platform is a dispatch optimisation tool used to forecast power market outcomes at an hourly granularity for a given set of inputs and constraints. The Plexos® platform is external to both FTI and NeuConnect, and is widely used by practitioners and Transmission System Operators globally.*

Under NeuConnect's Policy Scenario, the cable's socio-economic welfare impact is greater than at IPA stage, and its consumer impact is positive

NeuConnect rents, Policy Scenario (€m)



- The **Policy Scenario** reflects a state of the world in which European countries pursue accelerated decarbonisation policies …
- …such that **Net Zero** is achieved by **2050**.
  - As a result, the penetration of renewables capacity is assumed to be significant and growing across Europe from 2030 to 2050…
  - …while high CO2 prices prompt a decommissioning of existing thermal plants over time.

NeuConnect socio-economic welfare impact, Policy Scenario (Present value over 25 years, €m)[1]

	Ofgem IPA (2017)	Policy Scenario (2021/2022)
NeuConnect costs	*As per IPA submission*	*As per FPA submission*
GB net socio-economic welfare impact	(€314m)	**€127m**
GB consumer welfare impact (incl. C&F impact)	€3,803m	**€2,094m**

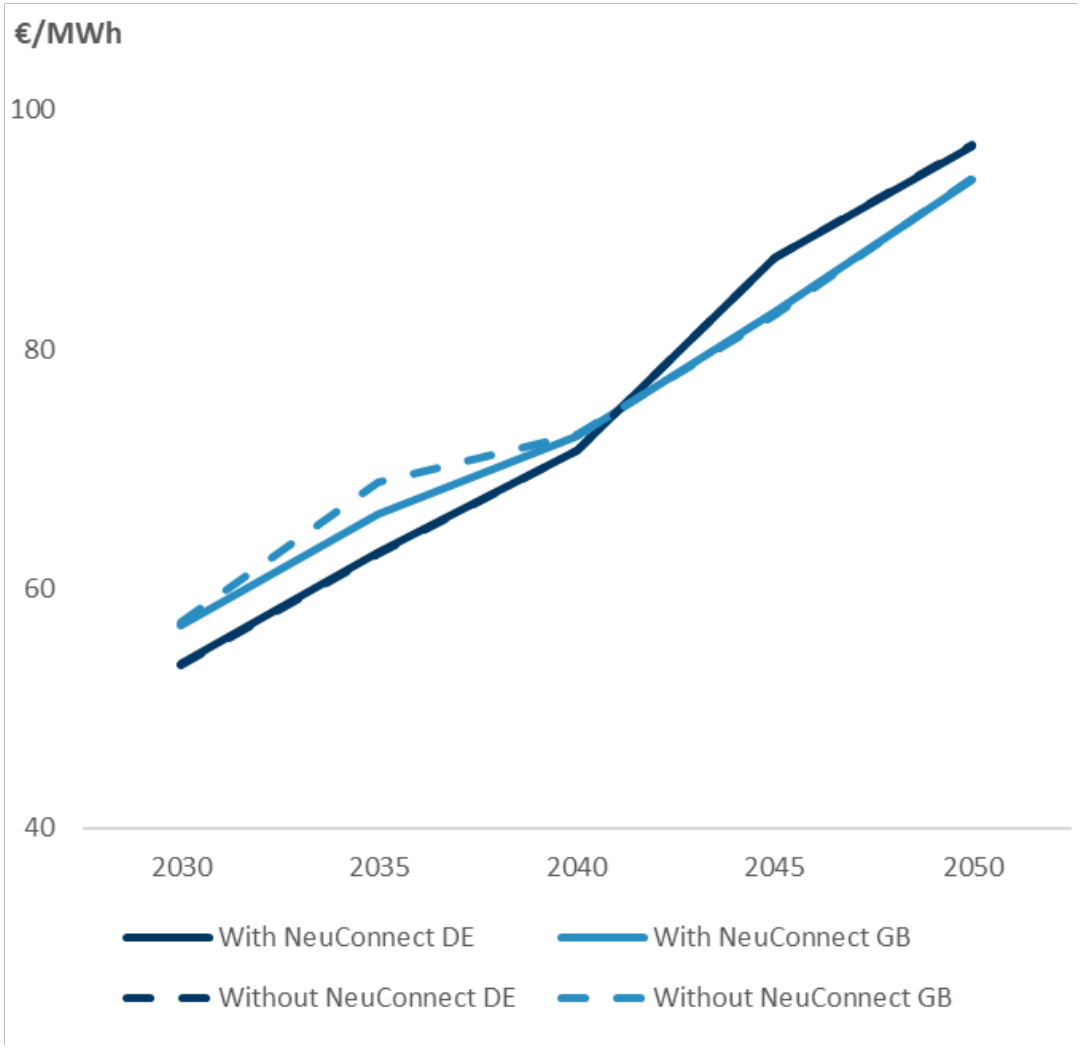
- All figures above in 2020 prices, in €m
- Net socio-economic welfare impact takes into account NeuConnect's impact on: (i) consumer surplus; (ii) producer surplus; (iii) congestion rents earned by other interconnectors; (iv) its own congestion rents; and (v) its annualised costs.
- Under the Policy Scenario, NeuConnect has a greater net socio-economic welfare impact in GB, relative to modelling performed at the IPA stage.

Note: *1) FTI-CL figures calculate the present value based on an interpolation of NeuConnect's socio-economic welfare impact between modelling years. We extend the analysis backwards to 2028 (setting the years 2028 and 2029 equal to the average of all five modelled years), and forward to 2052 (setting the year 2051 and 2052 equal to 2050). The total is discounted to 2028 at 3.5% discount rate.*

Wholesale price impact

Across most modelled years, NeuConnect has a downward impact on GB wholesale prices

Average annual wholesale prices with and without NeuConnect, Policy Scenario (€/MWh)



Annual wholesale prices (2030 – 2050)

- Annual wholesale prices are expected to rise in both GB and Germany over time, due to expected increases in carbon prices and electricity demand, and a reduction in French nuclear capacity.

Annual wholesale price differential, earlier years (2030s)

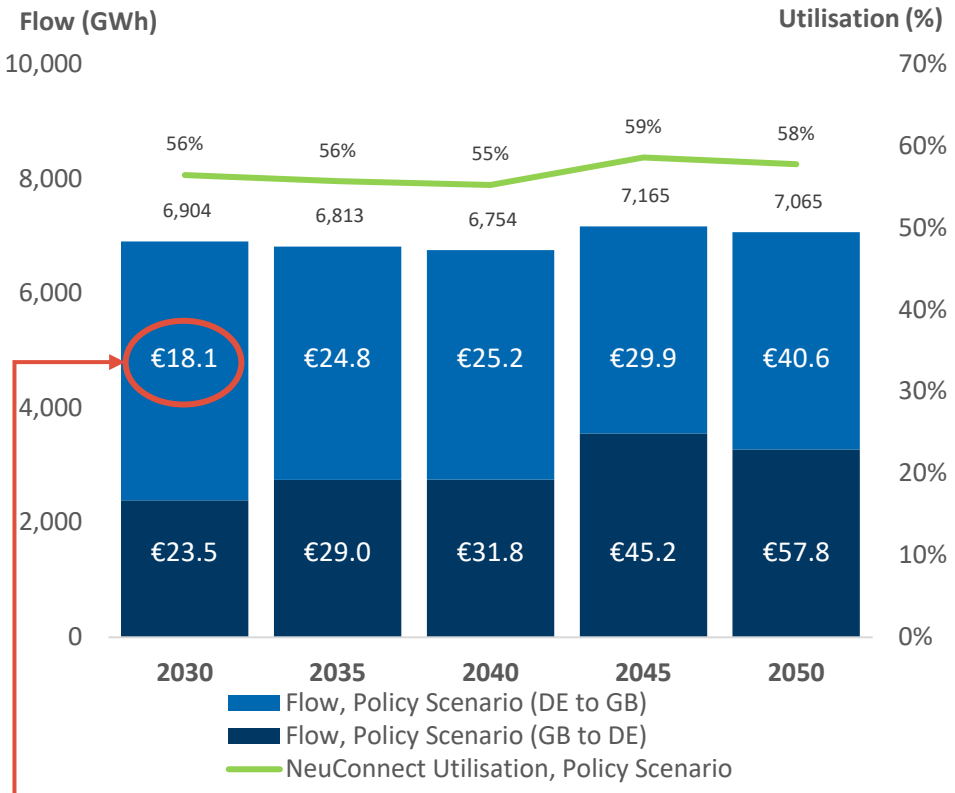
- Across the 2030s the average yearly difference between GB and German prices is around €5/MWh.
- Throughout this period, **average GB prices are higher than average German prices**. Germany has a relatively higher RES mix than GB, with high DE solar output often leading to lower daytime prices in the 2030s.

Annual wholesale price differential, later years (2040s onwards)

- The **fall in French nuclear capacity in later years** (from the early 2040s onwards) has a **strong upward impact on German prices** (to the point that they exceed GB prices).
- Prices continue to rise in both GB and Germany in later years, due to an increase in carbon prices.

Average price differentials in hours when NeuConnect is flowing increase across the modelling period, and are greater for flows from GB to DE

NeuConnect flows and utilisation, Policy Scenario



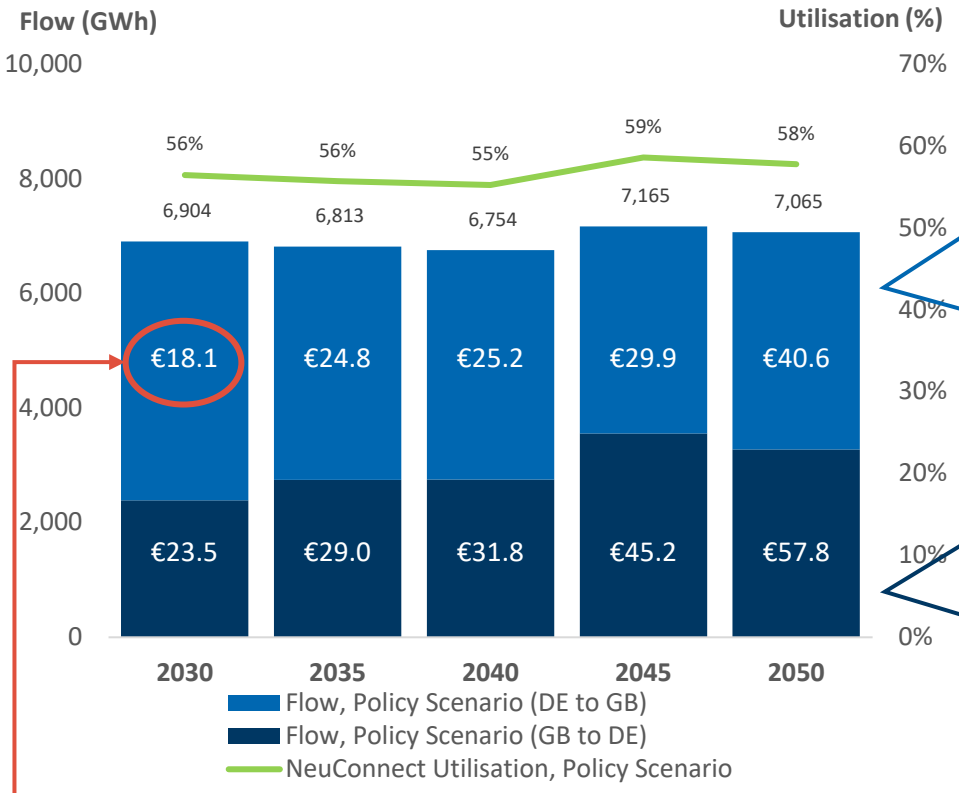
The average price differentials are calculated for the periods when NeuConnect is flowing in the relevant direction (e.g. the highlighted figure of €18.1/MWh is the average price differential between GB and DE in the hours when NeuConnect flows from DE to GB in 2030).

- While **average annual wholesale prices are broadly similar** between GB and DE across the modelling period (see previous slide), the average price differential **in hours when NeuConnect is flowing** more than doubles by 2050...
- ...reflecting **increased volatility** in wholesale prices in the two countries.
- Volatility is driven both by an **increased reliance** on variable output from **intermittent renewable generators**...
- ...and **rising carbon prices** (which increases the marginal cost of the remaining thermal plants, and thereby the clearing price, when those thermal plants act as the marginal plant).
- With NeuConnect's annual flows relatively consistent across the modelling period, the increased price differential in periods when NeuConnect is flowing is a **key driver of the increasing revenues** in later years.
- Across the 2030s, the majority of flows on NeuConnect are imports into GB, with relatively cheaper German power helping to lower prices in GB.
- In 2045 and 2050, exports from GB make up a greater proportion of flows on NeuConnect. However, GB is still a net importer, and across the year cheap imports from DE outweigh the upward impact of GB exports on GB prices.

Note: *All average prices are time-weighted*

Average price differentials in hours when NeuConnect is flowing increase across the modelling period, and are greater for flows from GB to DE

NeuConnect flows and utilisation, Policy Scenario



The average price differentials are calculated for the periods when NeuConnect is flowing in the relevant direction (e.g. the highlighted figure of €18.1/MWh is the average price differential between GB and DE in the hours when NeuConnect flows from DE to GB in 2030).

Average GB and DE prices, when power flows to GB (imports), Policy Scenario

	2030	2035	2040	2045	2050
GB	€64.8	€74.6	€72.2	€81.6	€98.5
DE	€46.8	€49.8	€47.0	€51.7	€57.9

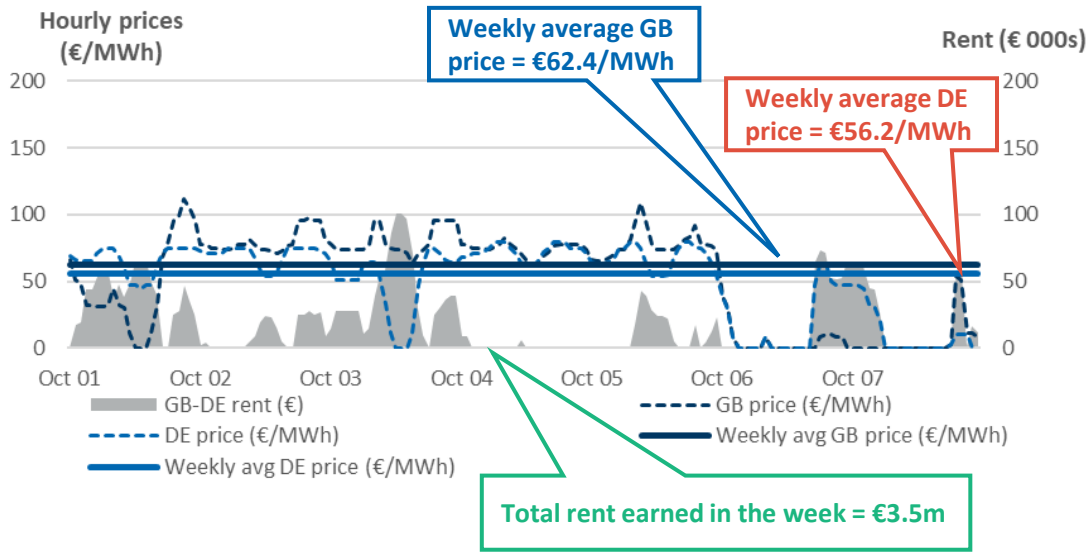
Average GB and DE prices, when power flows out of GB (exports), Policy Scenario

	2030	2035	2040	2045	2050
GB	€38.2	€49.5	€60.4	€65.6	€63.7
DE	€61.7	€78.6	€92.2	€110.9	€121.5

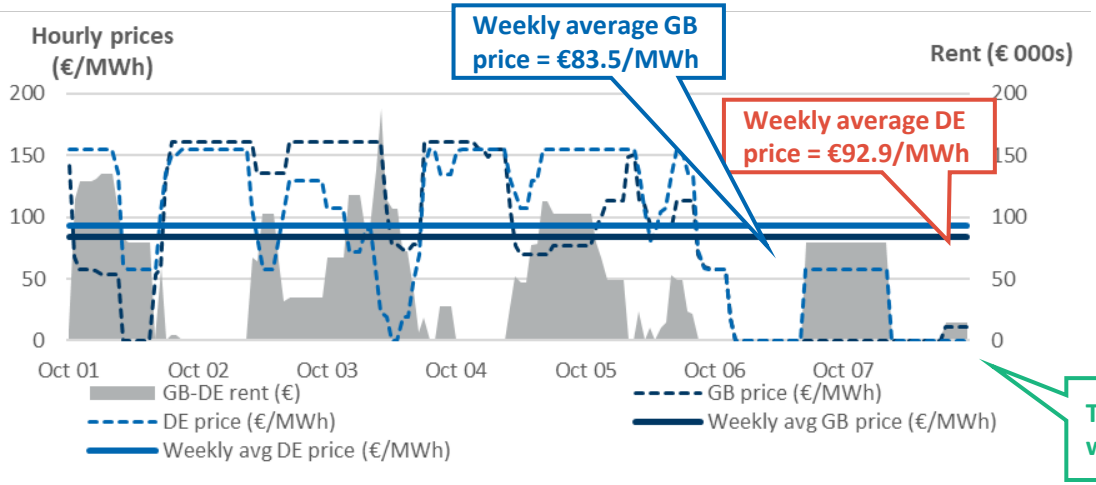
Note: *All average prices are time-weighted*

A significant volume of congestion rents can be earned on NeuConnect even when average wholesale prices converge

Congestion rents and wholesale prices – 1st-7th October 2030



Congestion rents and wholesale prices – 1st-7th October 2050



- Interconnectors, including NeuConnect, can earn **significant congestion rents** even **when the average wholesale prices of the countries they connect appear to converge.**
- These **graphs** show **hourly wholesale prices in GB and DE**, and congestion rents forecasted for NeuConnect from 1st to 7th October in 2030 and 2050, respectively. Average GB and DE prices in those weeks **are similar**.
  - If in **2030** NeuConnect were to earn only the "weekly average" price differential of €6.2/MWh (€62.4 minus €56.2 per MWh), this would lead to a total weekly **congestion revenue of €1.5m** (168 hours x 1,400MW capacity x €6.2/MWh), assuming a 100% utilisation.
  - By contrast, in our modelling, hourly price volatility means that NeuConnect is forecast to earn **€3.5m congestion revenues.**
  - For **2050** the equivalent numbers are **€2.2m and €7.5m.**
- NeuConnect is therefore able to earn significant congestion rents, as it **benefits from the volatility of GB and DE wholesale prices** (rather than just their average levels) – driven both by the **low correlation of RES output in GB and DE** and **rising carbon prices** (increasing absolute prices).

Socio-economic welfare impact

The socio-economic welfare impact of NeuConnect is made up of five separate elements

Socio-economic impact of NeuConnect =

Change in consumer surplus
- Change in wholesale costs paid by consumers
- Typically a fall in wholesale prices results in an increase in consumer surplus

+ **Change in producer surplus**
- Change in wholesale revenues, less generation costs, earned by generators
- Typically (but not always) moves in the opposite direction to the change in consumer surplus

+ **Change in IC (non-NeuConnect) rents**
- Change in congestion rents earned by all other ICs
- Typically additional interconnection capacity causes the rents of other ICs to fall
- We assume all interconnector rents are shared equally between their connecting price zones

+ **NeuConnect congestion rents**
- Congestion rents earned by NeuConnect
- We assume NeuConnect's rents are shared equally between GB and Germany

− **NeuConnect costs**
- Cost (CAPEX & OPEX) of NeuConnect, annualised
- We assume NeuConnect's costs are shared equally between GB and Germany

We are not able to estimate the impact of NeuConnect on ancillary services, but at the IPA stage, Ofgem indicated these are likely to be positive. As a result, the estimated SEW impact estimated for NeuConnect is likely to be a lower bound of the actual welfare impact.

Welfare impacts of NeuConnect we have not estimated[1]:

- **Ancillary services**
- **Network reinforcement and constraint costs** (i.e. the cost of any additional onshore transmission build-out, and any impacts on balancing)
- **Intraday markets**

We are not able to estimate this, but likely to be improved from Ofgem's IPA estimate given accelerated decarbonisation agenda.

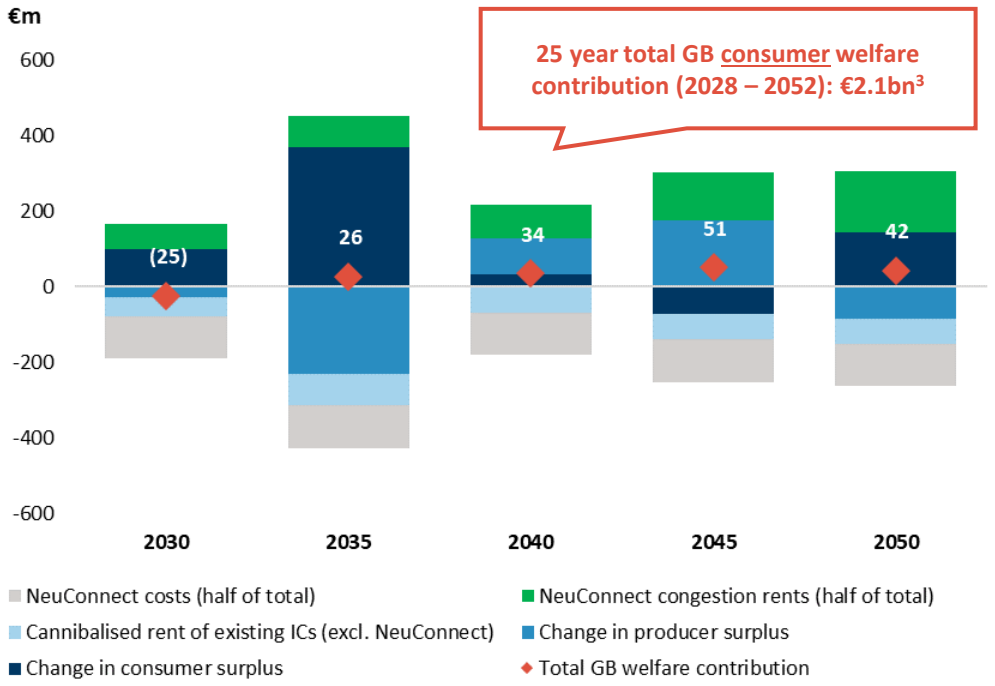
Our modelling assesses the impact of NeuConnect using day-ahead prices. As a result, our assessment does not capture additional benefits of NeuConnect from providing flexibility between the day-ahead stage and real-time.

Note: *1) In line with previous Ofgem methodology, our analysis does not estimate the impact of NeuConnect on the CfD payments and/or CM clearing prices in GB.*

NeuConnect has a positive impact on GB social welfare in most modelled years, largely to the benefit of GB consumers

- In most years, NeuConnect facilitates **GB consumer savings** in wholesale electricity prices, providing an additional source of flexible supply that helps address periods of 'tightness' in the GB power system:
  - Across the 2030s, average **wholesale prices are higher in GB than in Germany**. With NeuConnect, the **GB network makes use of relatively cheaper German generation**, to the detriment of GB generators, with consumer surplus outweighing the lower producer surplus.
  - In 2035, NeuConnect helps to significantly lower prices during periods of low wind output, with the GB system particularly reliant on RES in the Policy Scenario.
- In **2040**, consumers benefit from a slight fall in average wholesale prices across the year driven by imports on NeuConnect. GB producers also benefit, with NeuConnect allowing the export of GB wind power (in periods of relatively high German prices) that would otherwise be curtailed.
- In **2045**, with NeuConnect, German prices rise above GB prices, causing increased exports of GB power to Germany. This drives a corresponding increase in GB prices (relative to a scenario without NeuConnect), to the benefit of GB producers and the detriment of GB consumers.
- In **2050**, the average price differential between DE and GB narrows from €4.0/MWh to €1.6/MWh, reducing this impact on consumers. Furthermore, GB consumers benefit across the year, as the effect of imports lowering prices during system tightness in the spring months outweighs increased summer prices (when consumption is lower).

Impact of NeuConnect on GB social welfare (€ million)[1,2]



Impact of NeuConnect on GB wholesale prices (€/MWh)

	2030	2035	2040	2045	2050
Without NeuConnect	€57.2	€68.9	€72.8	€82.9	€94.3
With NeuConnect	€56.9	€66.3	€72.8	€83.1	€94.1
Impact of NeuConnect	↓ (€0.2)	↓ (€2.6)	↓ (€0.0)	↑ €0.2	↓ (€0.2)

Notes: *1) Consumer surplus does not include the impact of the GB Cap & Floor regime's Floor contributions and Cap benefits; 2) Figures presented here exclude the impact of 7 outlier hours in 2035, which were manually removed from the GB and DE results; 3) The total is based on an interpolation of the in-year 'Change in consumer surplus' between modelling years. We extend the analysis backwards to 2028 (setting the years 2028 and 2029 equal to the average of all five modelled years), and forward to 2052 (setting the year 2051 and 2052 equal to 2050). The total is discounted to 2028 at 3.5% discount rate.*

Impact of the GB Cap & Floor on GB consumer welfare

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GB consumer welfare is also affected by payments made to, and received from, NeuConnect under the GB Cap & Floor regime

Assessing the additional impact on GB consumer welfare

- FTI-CL has **analysed the impact of NeuConnect on GB's socio-economic welfare** using **two different sets of costs** received from NeuConnect:
  - Cost estimates consistent with those submitted as part of the **FPA** (as of **December 2021**).
  - Cost estimates consistent with **NeuConnect's latest cost estimates** (as of **April 2022**).
- These cost estimates are used to **estimate the Cap & Floor level applicable to NeuConnect**, and in turn, affect the payments to GB consumers if revenues are above the Cap, and payments from GB consumers to NeuConnect if revenues are below the Floor.

We understand from NeuConnect that, in the course of March 2022, some contracts were signed and actions undertaken by NeuConnect's contractors (such as booking metals) that, in the context of disruptions to the supply chain caused by the war in Ukraine, led to price increases and hence changes in costs.

Estimated NeuConnect costs, Cap and Floor, £m (FPA and revised estimates)[1]

	Units	FPA cost estimates – and corresponding Cap & Floor level	Latest cost estimates – and corresponding Cap & Floor levels
Total Costs	£m	3,284	3,409
Floor	£m	72.2	75.1
Cap	£m	146.5	153.9

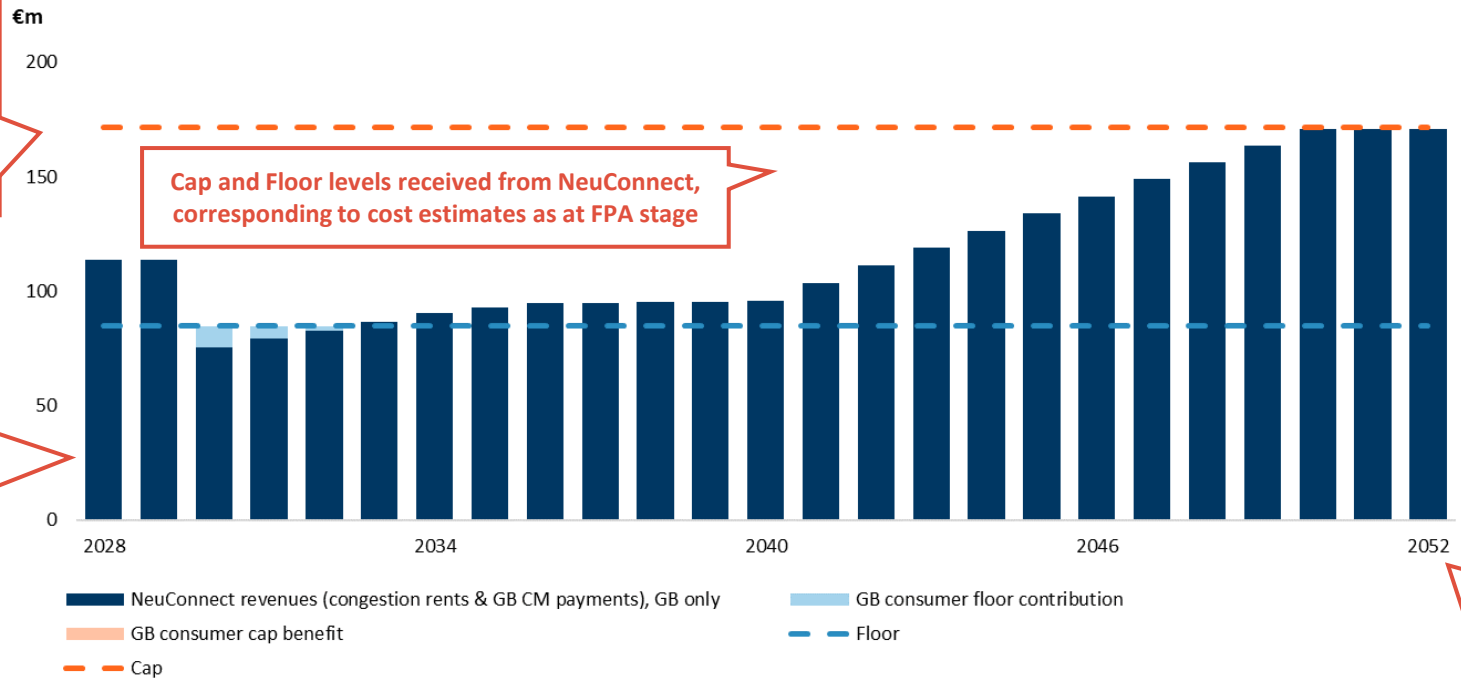
Notes: *1) Calculations in subsequent slides are performed in €m. Figures in £m in this table have been converted to €m at a rate of £1 : €1.172, as provided by NeuConnect.*

With Cap and Floor levels consistent with FPA cost estimates, a small volume of Floor payments may be required from consumers in early years

Forecast NeuConnect GB revenues (€ million, 2020 prices)

Based on Ofgem's guidance, we have provided estimates based on two different cost estimates from NeuConnect (here and in the following slide).

For pre-2030 results, we have assumed revenues to be in line with the average over the modelled years.

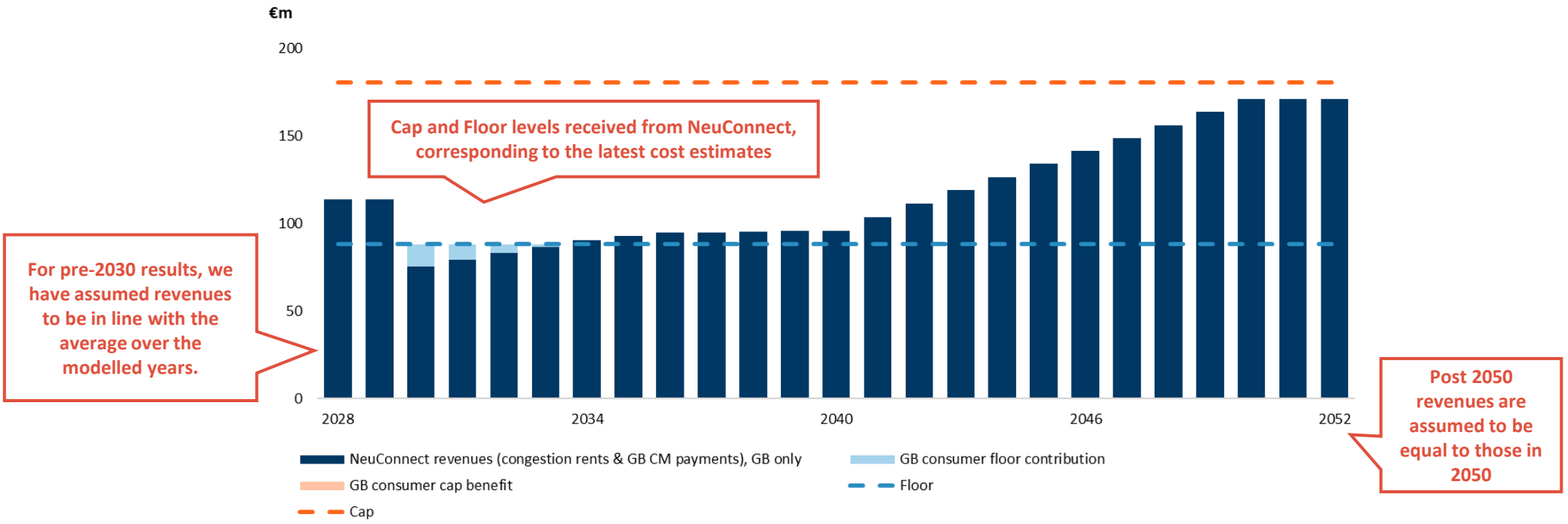


Post 2050 revenues are assumed to be equal to those in 2050

- We have assumed specific Cap and Floor levels as directed by NeuConnect, which we understand reflect NeuConnect's own **cost estimates as at the FPA stage.**
- NeuConnect's revenues are expected to **stay within the Cap and Floor for most of its asset life.**
- We assume a **Cap of £146.5m** based on the 2022 FPA (converted to €171.7m). NeuConnect revenues are forecasted to be below the Cap across the asset's life, although close to exceeding the Cap in the final years of the modelling period.
- We estimate a **Floor of £72.2m**, again based on the 2022 FPA (converted to €84.6m). NeuConnect's revenues are expected to fall slightly below the Floor in the early 2030s, but stay above the Floor from 2035 onwards.
- The cost base used to calculate the Cap and Floor levels include a developer premium. Excluding these costs would reduce both the floor and the cap levels. To the extent that NeuConnect may be able to earn revenues close to the cap levels, this approach would tend to reduce the returns to the project (as a greater share of revenues would be passed on to GB consumers).

With Cap and Floor levels corresponding to NeuConnect's latest cost estimates, the volume of Floor payments remains small

Forecast NeuConnect GB revenues (€ million, 2020 prices)

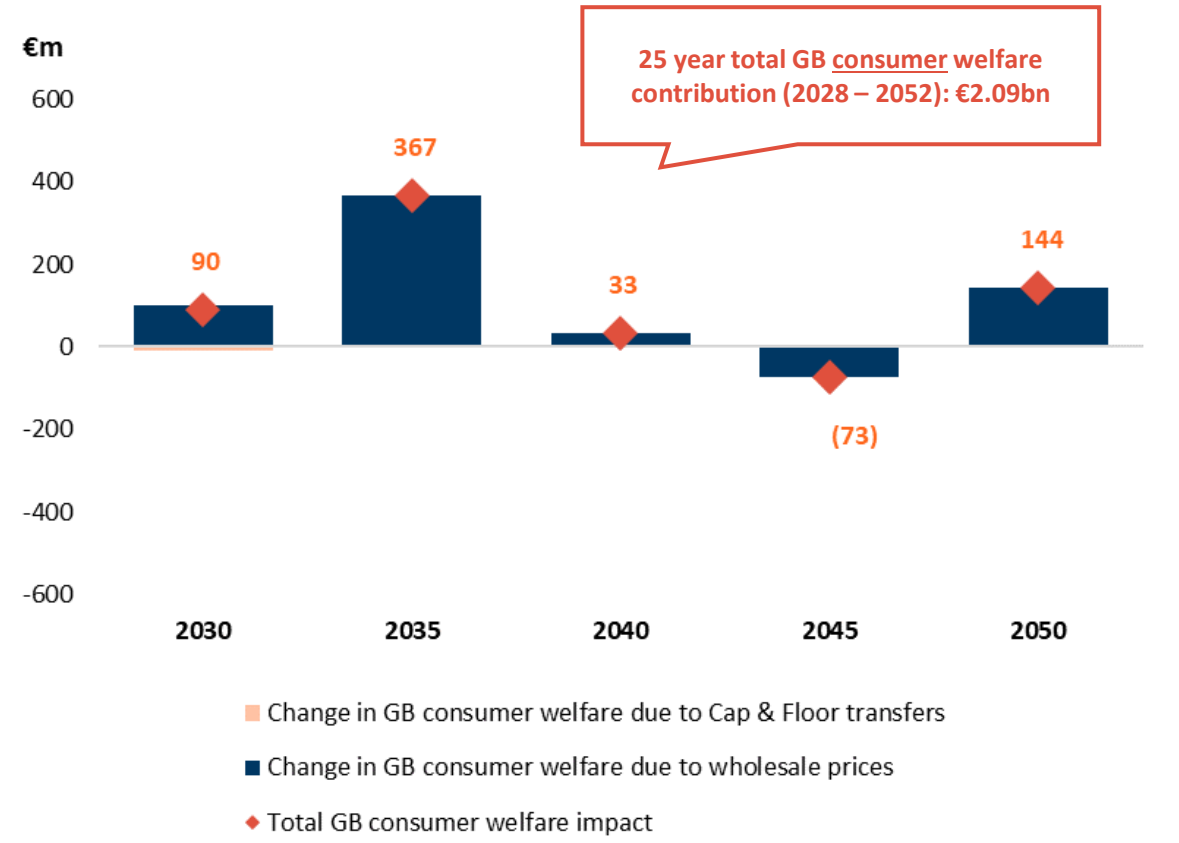


- NeuConnect's **revised cost estimates** result in a small increase in the estimated level of the Cap and Floor.
- We have assumed specific Cap and Floor levels as directed by NeuConnect, which we understand reflect NeuConnect's own latest **cost estimates.**
- NeuConnect's revenues are expected to **stay within the Cap and Floor for most of its asset life.**
- We assume a **Cap of £153.9m** (converted to €180.3m). NeuConnect revenues are forecasted to be below the Cap across the asset's life, although close to exceeding the Cap in the final years of the modelling period.
- We estimate a **Floor of £75.1m** (converted to €88.0m). NeuConnect's revenues are expected to fall slightly below the Floor in the early 2030s, but stay above the Floor from 2035 onwards.
- We understand that Ofgem is currently reviewing NeuConnect's costs as part of the FPA process. The Cap & Floor levels shown in the figure above are dependent on the costs allowed by Ofgem. If Ofgem were to disallow certain costs, the impact on consumers would be positive (as both the cap and floor levels would be reduced). Our analysis therefore shows the most conservative estimate of likely benefits of NeuConnect for GB consumers from the C&F regime.

Under NeuConnect's Policy Scenario, with FPA costs, GB consumers are expected to benefit by a total of €2.09bn[1]

- Due to NeuConnect, the **total wholesale cost of electricity** faced by **GB consumers** (also known as the cost to load) **falls by €2.11bn** on a present value basis.
  - This is equivalent to a €2.11bn **increase in consumer surplus**.
- However, in the early 2030s, NeuConnect's **intrinsic congestion revenues** fall below the estimated Floor level (based on FPA cost estimates), requiring small payments from consumers. These transfers total **€15m** on a present value basis.
- After deducting these transfers, we estimate that NeuConnect leads to a net increase in GB consumer surplus of **€2.09bn.**
- Note that, for GB overall, the net impact of the C&F regime is nil, since these payments represent a transfer between NeuConnect and GB consumers.

Impact of NeuConnect on GB consumer surplus (€ million)

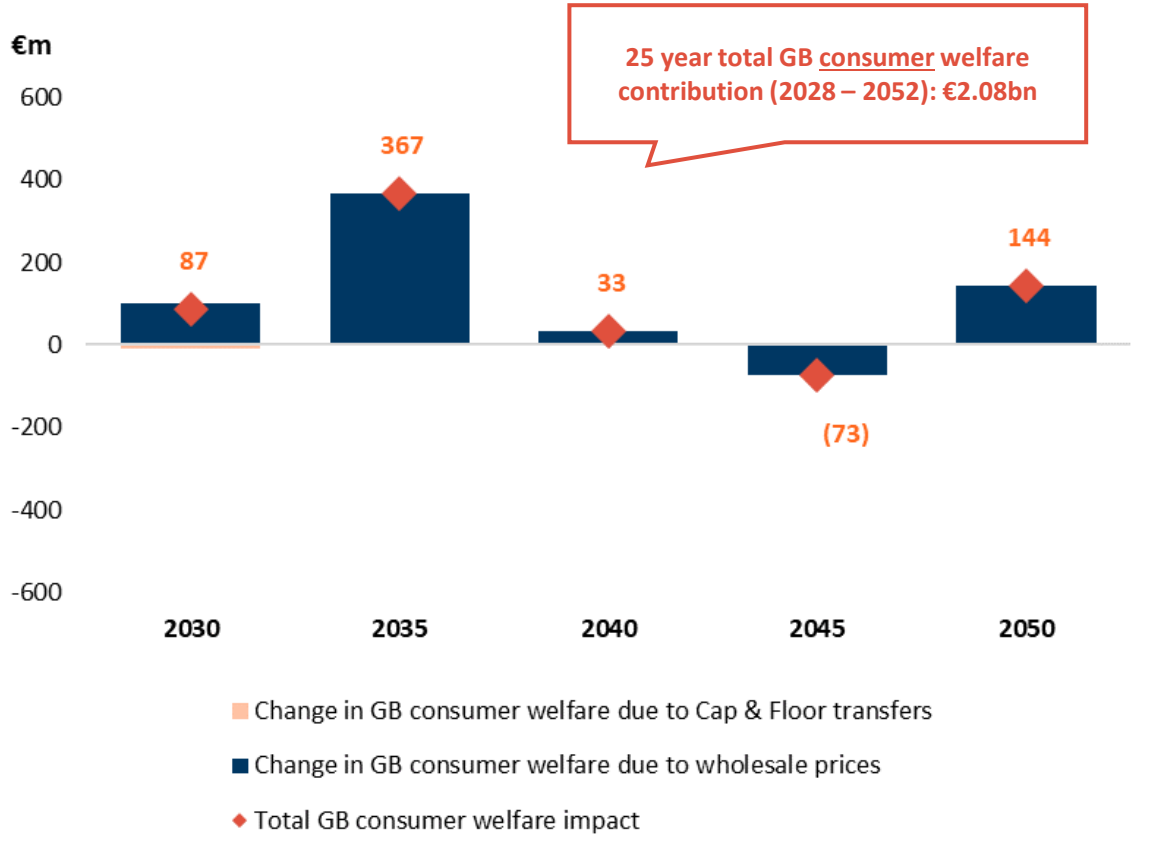


Note: *1) This value is provided in present value terms which is calculated based on an interpolation of NeuConnect's socio-economic welfare impact between modelling years. We extend the analysis backwards to 2028 (setting the years 2028 and 2029 equal to the average of all five modelled years), and forward to 2052 (setting the year 2051 and 2052 equal to 2050). The total is discounted to 2028 at 3.5% discount rate.*

With NeuConnect's latest cost estimates, the benefit to GB consumers falls slightly, to a total benefit of €2.08bn[1]

- Due to NeuConnect, the **total wholesale cost of electricity** faced by **GB consumers** (also known as the cost to load) **falls by €2.11bn** on a present value basis.
  - This is equivalent to a €2.11bn **increase in consumer surplus**.
- However, in the early 2030s, NeuConnect's revenues fall below the estimated Floor level. This impact is slightly increased under NeuConnect's revised cost estimates, requiring transfers from consumers totalling **€25m** on a present value basis.
- After deducting these transfers, we estimate that NeuConnect leads to a net increase in GB consumer surplus of **€2.08bn.**
- Note that, for GB overall, the net impact of the C&F regime is nil, since these payments represent a transfer between NeuConnect and GB consumers.

Impact of NeuConnect on GB consumer surplus (€ million)



Note: *1) FTI-CL figures calculate the present value based on an interpolation of NeuConnect's socio-economic welfare impact between modelling years. We extend the analysis backwards to 2028 (setting the years 2028 and 2029 equal to the average of all five modelled years), and forward to 2052 (setting the year 2051 and 2052 equal to 2050). The total is discounted to 2028 at 3.5% discount rate.*

Other benefits of NeuConnect

Interconnectors (including NeuConnect) are able to provide additional benefits beyond their impact on wholesale markets

Additional benefits of NeuConnect

1 Security of Supply

- ✓ **Reliable contributor** to GB system security, as evidenced by interconnector participation in the GB Capacity Market
- ✓ **Reducing clearing price** for capacity market auctions and enables GB to achieve security of supply more affordably
- ✓ **Diversification of energy sources** insures against isolated system stress events/failures
- ✓ **Relatively low correlation** between GB and German renewables generation (i.e. when climate conditions in GB are such that windfarms/solar plants are not generating, it is more likely that their German equivalents are generating) allows security of supply to be maintained with fewer GB thermal plants.

2 Ancillary services

- ✓ **Provides balancing services** such as frequency response or reactive power
- ✓ **Provides Black Start services** to supply electricity for system restoration in the event of a grid outage
- ✓ Increases competition in provision of ancillary services which **reduces cost** necessary to maintain system stability

3 Environmental

- ✓ **Increases access to renewable generation capacity** by allowing the UK to gain access to German renewables
- ✓ Each country benefits from the other's surplus, helping to **maximise the proportion of low-carbon electricity** each system uses
- ✓ **Reduces carbon emissions** as renewable generation in DE can displace thermal generation in GB, and vice versa

The revenue estimates for NeuConnect are subject to several upside and downside risks

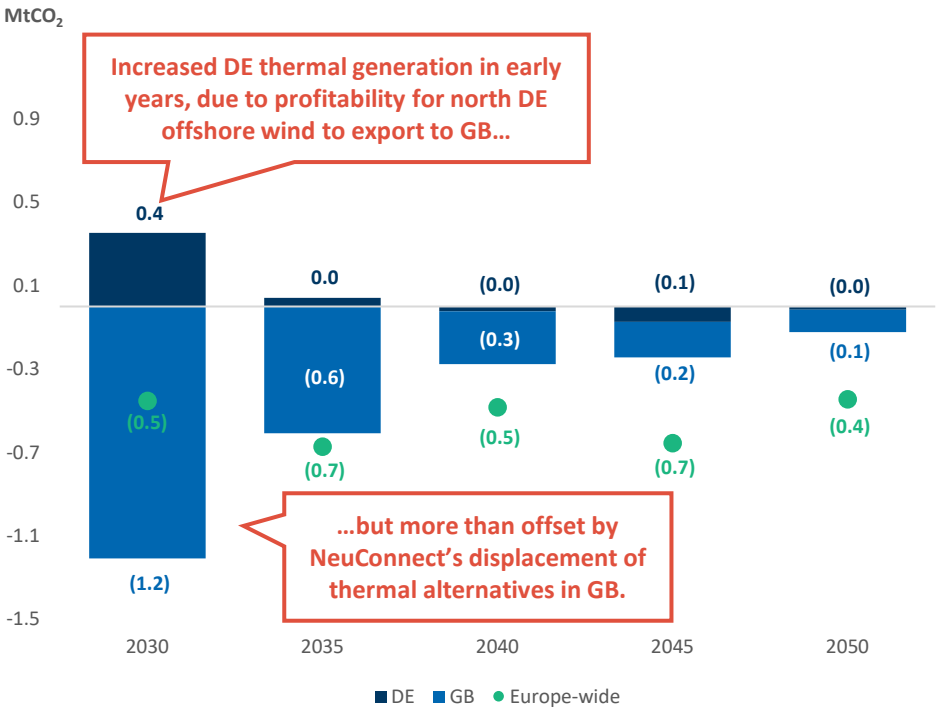
	Risks identified by FTI	Likelihood of mechanism changing	Severity of impact on NeuConnect
1	Differences between actual and assumed evolution of market variables	Risk of structural changes to key variables relative to base case (e.g. Carbon Price Floor, gas prices, GB nuclear, hydrogen)	↑↑ / ↓↓
2	Geopolitical risk and policy response	Uncertainty around GB and European policy response to the energy crisis (e.g. strategy to reduce reliance on gas via greater RES deployment, nuclear, H_2 etc)	↑↑ / ↓↓
3	GB and Germany divided into multiple price zones	Congestion costs likely to continue on upward trajectory – this may lead to market design reforms in both GB and Germany (indeed, NG ESO has indicated a preference for locational wholesale price signals)	↑ / ↓
4	Change in compensation for providing ancillary services	Growing markets, and emerging new markets, for ancillary services as SO demand grows	↑
5	Curtailment of interconnector capacity	SO operability challenges remain despite attempts to maximise cross-border availability (e.g. the 70% Rule)	↓↓
6	Change to compensation mechanism for providing security of supply	Structural changes to GB CM relatively unlikely (at least in short term) given the Dec 2020 UK-EU TCA. Long term risk that Capacity Market may be dropped.	↓

Legend: Less likely … More likely; ↑↑ Higher positive impact; ↑ Lower positive impact; ↓↓ Higher negative impact; ↓ Lower negative impact

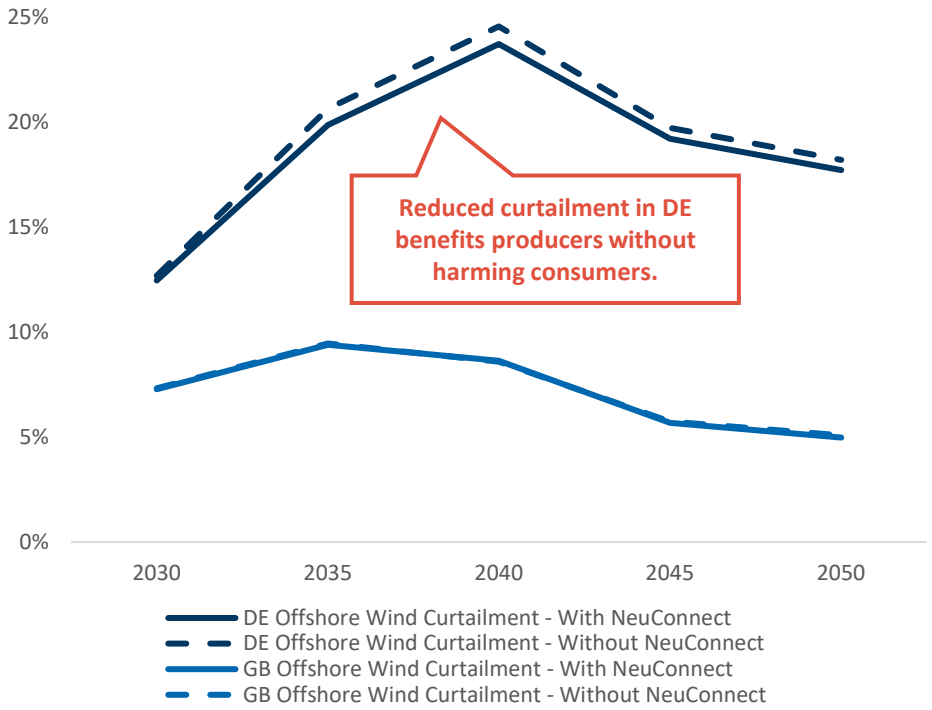
Note: For #1, #4 and #6, corresponding parameters are also likely to continuously change (in addition to changes to the mechanism). For example, GB CM de-rating factors and clearing prices are likely to change annually, and the volume of ancillary services procured by SOs is likely to change frequently.

NeuConnect flows consistently reduce GB emissions by displacing thermal alternatives, and reduces offshore wind curtailment in DE

Change in GB and DE emissions with NeuConnect ($MtCO_2$)



Offshore wind curtailment with and without NeuConnect (%, GB and DE)



- Across the modelling period, **flexibility** provided by NeuConnect **consistently lowers annual emissions in GB** by displacing **fossil-fuel powered alternatives**.
- In **Germany**, this leads to an **increase in emissions across the 2030s**, with the power exported from DE to GB occasionally replaced by increased thermal generation. However, **Europe-wide emissions fall in every year**.
- Across Europe, the total impact of NeuConnect on carbon emissions is expected to be a **reduction of 13.3 MtCO2**[1]

Note: *1) Total impact on carbon emissions calculated by interpolating between modelling years. We extend the analysis backwards to 2028 (setting the years 2028 and 2029 equal to the average of all five modelled years), and forward to 2052 (setting the year 2051 and 2052 equal to 2050).*

NeuConnect increases competition in the provision of ancillary services, which is likely to reduce costs

Interconnectors may be able to provide several types of ancillary services

Frequency management

Rapid delivery or off-take of power from the transmission system

Restoration services (a.k.a. Black Start)

The ability to supply power without relying on power from the transmission network

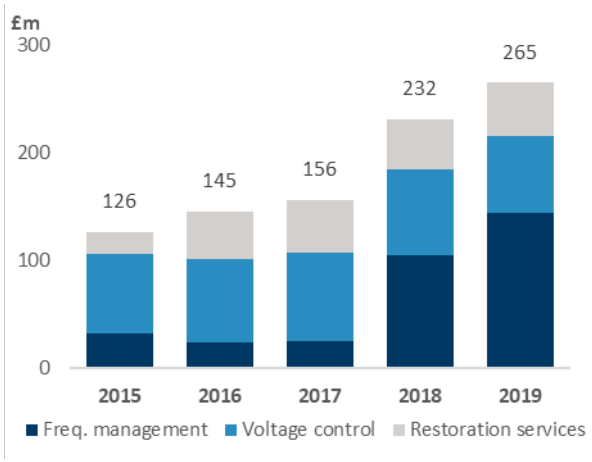
Voltage control

Maintaining system voltage within predetermined limits through the absorption and injection of reactive power

In recent years, System Operators in GB and Germany have spent significant amounts on ancillary services

Between 2013 and 2019, German TSOs spent between **€270 million** and **€870 million per year**, with no clear trend

NG ESO expenditure on ancillary services, 2015 – 2019 (£m)



Increased competition in provision of ancillary services is likely to reduce cost of maintaining system stability

nationalgrid

From NGET's analysis:

"The potential consumer benefit is quantified by assessing the potential cost savings of procuring this service from the interconnector instead of more costly commercial frequency response products" [1]

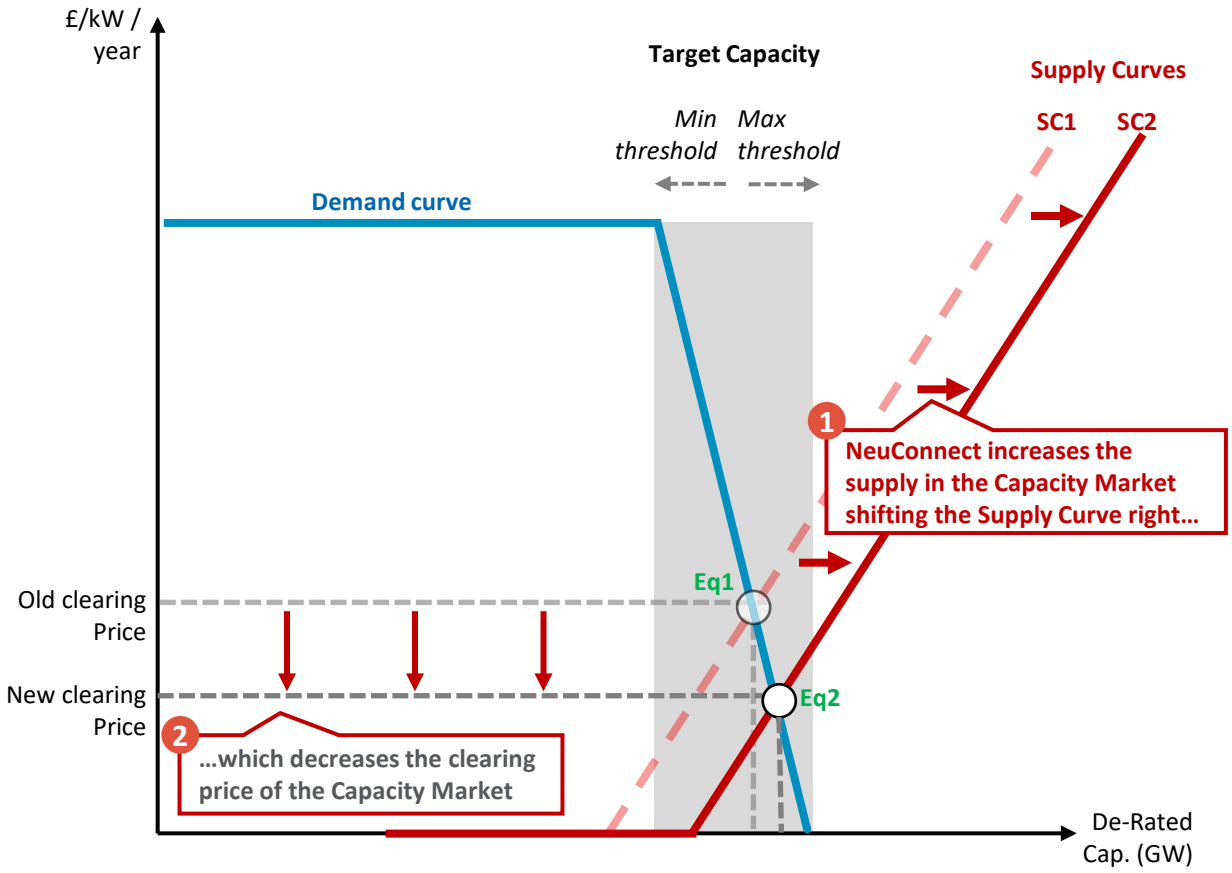
"All three Window 2 projects [including NeuConnect] ***potentially generate considerable consumer benefit*** *from the provision of Frequency Response services"*[1]

We have not included a quantitative estimate of ancillary services in our analysis, but it is reasonable to expect NeuConnect to be able to provide ancillary services (e.g. frequency response), to the benefit of GB consumers

Note: *1) Source: Ofgem (2017), Cap and floor regime: Initial Project Assessment of the GridLink, NeuConnect and NorthConnect Interconnectors (link).*

By participating in the GB Capacity Market, NeuConnect would increase supply which may lead to a decrease in the GB CM clearing price

GB Capacity Market auction, supply and demand



Contribution of interconnectors to GB Capacity Market

- **Interconnector participation:**
  - ICs have been allowed to participate in the GB CM since 2015 (for delivery in 2019/20).
  - **ICs are among the lowest-cost participants in the Capacity Market**, which exerts downwards pressure on the clearing price
- **Contribution of interconnectors to security of supply:**
  - By participating in the GB Capacity Market, NeuConnect causes a rightward shift in the GB CM's supply curve
  - This causes, all else held equal, the clearing price to fall
  - Since the GB CM is a 'pay as clear' auction – this reduction in the clearing price has an impact on all capacity procured through the GB CM…
  - …leading to greater volume of capacity secured at a lower price, to the benefit of GB consumers.

Note: *Source: FTI Consulting (2019), The Contribution of Electricity Interconnectors to GB Security of Supply (link).*

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