EU CBAM impact study focused on electricity imports from Great Britain

Summary Report

06 MARCH 2024

AFRY
ÅF PÖYRY

EU CBAM impact study focused on electricity imports from Great Britain

- This report by AFRY Management Consulting summarises our independent assessment of the impact of the EU Carbon Border Adjustment Mechanism (CBAM) on electricity imports into the EU from Great Britain.
- The study was commissioned by the group of interconnector businesses and transmission companies indicated on this slide.

AFRY study shows application of EU CBAM to electricity imports into the EU from GB could jeopardise North Sea offshore grid infrastructure

Issue identified #1

Risk of significant over-statement of emissions factor assumed to apply to electricity imports from GB, as values linked to historic fossil fuel generation.

Issue identified #2

Practical obstacles to demonstration of a carbon price having been paid in GB lead to excessive carbon pricing exposure for all electricity imports from GB.

Frustrating efficient and effective market operation by unduly blocking flows that would otherwise be economic and increasing administrative burden.

Key implication #1

Adverse effects on business models for EU-GB interconnectors, putting goals for building out of offshore grid infrastructure in the North Sea at risk.

Key implication #2

Harming decarbonisation policies by frustrating GB RES integration, presenting barriers to low carbon projects and increasing EU and EU & GB net carbon emissions.

Key implication #3

EU CBAM impact study focused on electricity imports from Great Britain

STUDY OBJECTIVES

- This study focuses on the EU Carbon Border Adjustment Mechanism (CBAM) regulation[1] and specifically on its effects on **electricity imports from GB only**. Other aspects of CBAM, including products other than electricity and interactions with third countries other than the UK, are not in scope.
- The objectives of the study are to provide an **independent review** of the potential impacts of CBAM on electricity imports from GB. It draws on (a) review of CBAM legislation to form an interpretation of its application, (b) qualitative assessment, and (c) quantitative assessment of the effects of this interpretation of CBAM application.
- The outputs and insights from the study are intended to support future activity to **amend** the treatment of electricity imports from GB under the CBAM arrangements in order to deliver outcomes that are **supportive of decarbonisation and energy policy goals**.
- The issues identified are **relevant now**. Trading activities are already underway for 2026 and beyond, so expectations of the enduring arrangements are **already affecting the markets.**

REPORT STRUCTURE

1. **Executive Summary:** summarising the key messages of this study.
2. **Context**: setting the scene for the study.
3. **Issues linked to the regulation application**: outlining potential implications of CBAM as currently designed for electricity imports from GB.
4. **Implications**: reporting adverse effects of CBAM application to electricity imports from GB, drawing on qualitative and quantitative assessment.
5. **Mitigations**: highlighting mitigation options requiring action.

KEY ASSUMPTIONS & APPROACH

- The study includes different market scenarios and sensitivities[2]. Unless otherwise specified, this study focuses on the **EU CBAM impact** by investigating the differences between the 'CBAM' cases against the 'Reference' cases (i.e. no EU CBAM) of each scenario and sensitivity. The analysis considers the potential impacts of the implementation of a carbon adjustment adder on flows from GB to **all the directly connected markets** (i.e. EU[3] Member States, as well as Northern Ireland and Norway) through both a European Union and GB perspective.
- All monetary values quoted in this report are in Euros in real 2022 prices, unless otherwise specified.
- The source for all tables, figures and charts is AFRY Management Consulting.

1. Unless otherwise stated, references to CBAM in this report are to be read as references to the EU CBAM specifically. | 2. Please refer to slide 5 for additional information. | 3. For purposes of the quantitative analysis, references to the EU in this report are to be read as references to EU Member States plus Northern Ireland.

SCENARIO FRAMEWORK

Two market scenarios and one sensitivity are tested under a 'Reference' and 'CBAM' case; sensitivities on the CBAM cases are also included

MARKET SCENARIOS & SENSITIVITES	01 CENTRAL SCENARIO	02 HIGH GB EXPORTS SCENARIO	03 LOW UK ETS SENSITIVITY
REFERENCE No CBAM applied	▪ Based on ENTSO-E's TYNDP22 **Distributed Energy** scenario for 2030-2040 with some adjustments to reflect a more updated view for some of the EU Member States in the North Sea basin ▪ Based on the **forward curves** and AFRY's latest central view of the future in terms of demand and capacity mix for 2026 ▪ Based on TYNDP22 **Reference Grid** ▪ GB and EU generators face the **same carbon price**	▪ Incorporating demand and low-carbon capacity projections for 2030-2040 based on ENTSO-E's TYNDP22 **National Trends** scenario ▪ Leading to **GB becoming a net exporter to the EU** ▪ Based on TYNDP22 **Reference Grid** ▪ GB and EU generators face the **same carbon price**	▪ Based on the **Central** scenario assumptions, assuming that thermal generators in the GB market **face a lower carbon price** compared to the EU ETS in line with recent historic price differentials ▪ The effective UK ETS price is reduced by €30/tCO_2 based on the average price differential between the UKA and EUA in the second half of 2023
CBAM Default values No rebates	▪ Approach is based on the following application of the CBAM regulation, as presented in Section 3. More specifically: ▪ **Default values**, based on the 'weighted average of the CO_2 intensity of electricity produced from **fossil fuels**' for a **5-year period** ending two years before the relevant year, are used as the reference to determine the embedded emissions in electricity imports from GB, unless otherwise stated. This is the only route for determining CO_2 emission factors in the regulation with a methodology specified ▪ Prospect of CBAM rebates (with 'rebates' and 'CBAM rebates' in this report referring to reduction in CBAM certificates to be surrendered to reflect 3rd country carbon pricing) is restricted and therefore **no CBAM rebates are included** for the calculation of the cost of carbon applied to the EU imports from GB, unless otherwise stated		
CBAM sensitivities	▪ **CARBON EMISSIONS FACTOR** sensitivity, based on the **CENTRAL** ▪ Carbon emissions factor is based on the GB **system average intensity** from the year before		▪ **REBATES** sensitivity based on the **LOW UK ETS** ▪ Cost of carbon applied to the EU imports from GB is based on the **delta** between the EU and UK ETS price

ENTSO-E's TYNDP22 Scenario Report available here: https://2022.entsos-tyndp-scenarios.eu/ | Distributed Energy (DE) pictures a pathway achieving EU27 carbon neutrality by 2050 and at least 55 % emissions reduction in 2030; National Trends (NT), based on a bottom-up approach building on supply and demand data from gas and electricity TSOs, is in line with national policies.

AFRY ÅF PÖYRY

Table of contents

Table of contents

Principles and intentions of EU CBAM, as a tool to mitigate carbon leakage, in pursuit of decarbonisation are positive

OVERVIEW

What

- The EU's Carbon Border Adjustment Mechanism (CBAM) is designed as a tool to put a **fair price on carbon emitted** during the production of certain carbon intensive **goods originating in a third country and imported in the customs territory of the Union**.
- **Electricity imports** are included in the scope of CBAM.

Why

- CBAM is intended to **fight carbon leakage** and is a central pillar for **achieving Fit for 55 goals** and longer-term **climate neutrality**.
- As such, the **principle** behind CBAM is **positive** and to be **supported**.

How

- CBAM aims to create **equivalence** in terms of carbon pricing for imports of certain goods into the customs territory of the Union.
- To achieve this, importers of goods subject to CBAM application need to **purchase CBAM certificates** priced in line with EU ETS prices in respect of the carbon content of such imports.
- Intention for there to be a **CBAM rebate** (i.e. a reduction in CBAM certificates to be surrendered) reflecting carbon prices already paid in the country of origin.

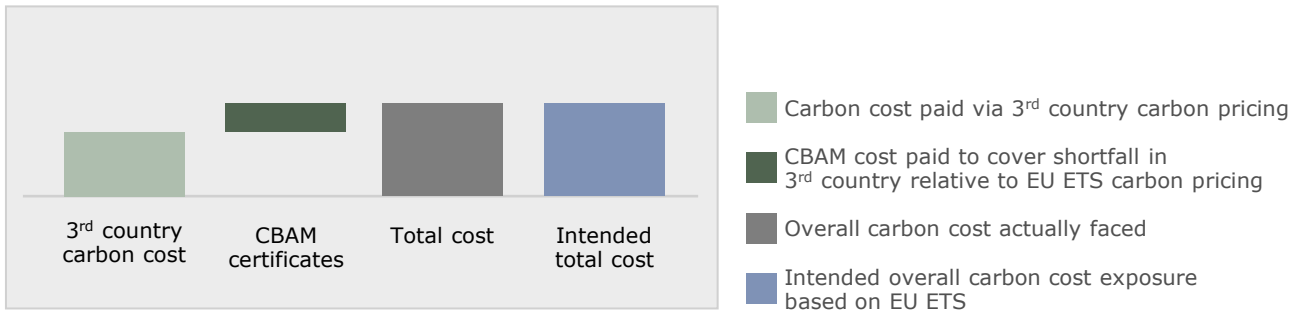
When

- CBAM is in its transitional phase (1-Oct-23 to 31-Dec-25), which entails compliance with reporting obligations but no requirement to purchase and surrender CBAM certificates. The definitive regime will apply from 1-Jan-26.
- However, trading activities are already underway for 2026 and beyond, so expectations of the definitive regime arrangements are **already having effect**.

POLICY INTENTION

CBAM certificates, priced in line with EU ETS prices, need to be acquired to reflect carbon content of electricity originating in a third country and imported in the customs territory of the Union. The quantity of CBAM certificates to be surrendered is reduced to reflect carbon pricing applied in the country of origin. Therefore, CBAM exposure reflects the difference between country of origin and EU ETS carbon pricing for the carbon content of imports.

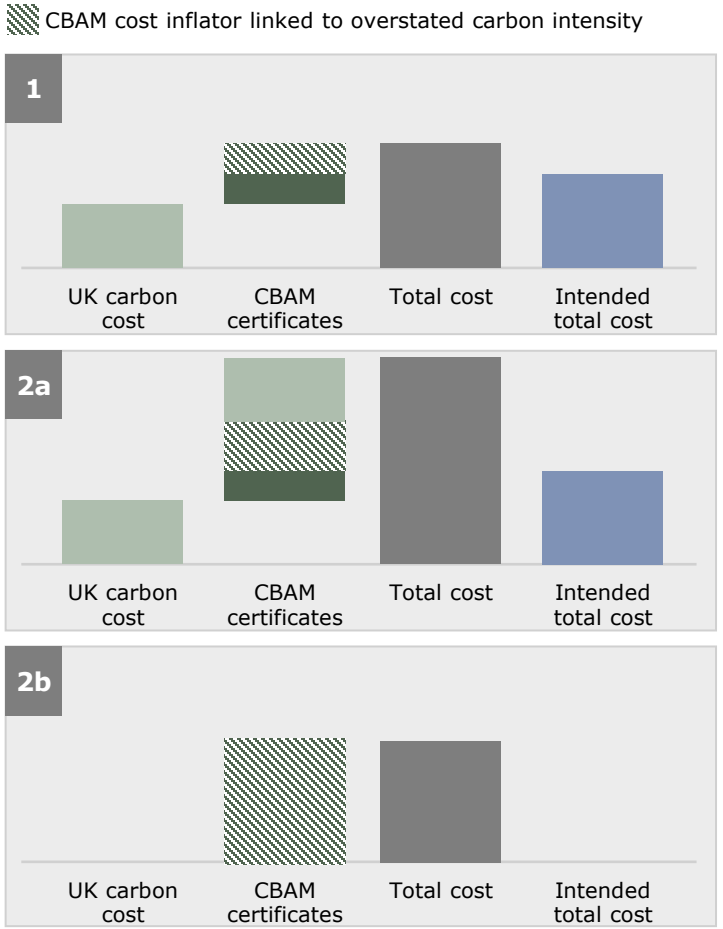
Result: imports are, overall, exposed to EU ETS price levels for carbon content.



Note: A 'third country' means a country or territory outside the customs territory of the Union.

Identified issues for application of CBAM to electricity imports from GB unduly increase carbon price exposure for GB resource and the cost of imports into the EU

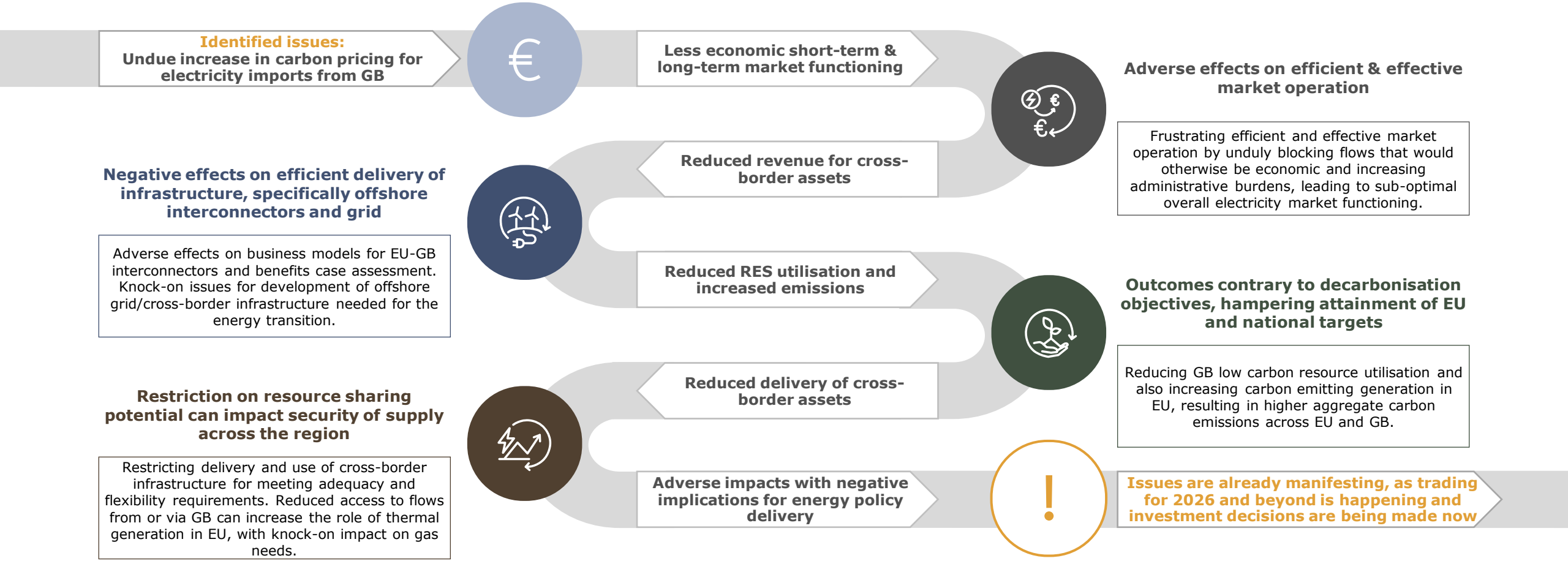
	GB CONTEXT	CHALLENGES	PROBLEM STATEMENT
Carbon intensity	– GB already has a **lower carbon intensity**[1] than many Member States, has net zero commitments and ambitions similar to the EU, and is actively pursuing stated decarbonisation goals.	– Under CBAM rules, carbon content of imports from GB is likely to be based on a CO_2 emission factor that reflects GB **fossil fuel generation carbon intensity**.	**#1** Use of fossil fuel-based CO_2 emission factor **overstates carbon intensity**. This **unduly increases carbon price exposure for electricity exports from GB**.
Carbon pricing	– **Carbon pricing** is already **in place** for GB generation creating eligibility for CBAM rebates (i.e. reduction in the number of CBAM certificates to be surrendered).	– While **carbon emitting generation** in GB will have paid the domestic carbon price, the nature of trading (i.e. frequently traded anonymously and multiple times) means it is **not practicable for a reporting entity to demonstrate this**. – Even if proof of carbon price paid was practicable**, zero carbon** generation does not pay carbon price and so **cannot demonstrate** payment domestically.	**#2a** Barriers to demonstration of carbon price paid in country of origin **block** ability to claim CBAM rebates (i.e. a reduction in CBAM certificates to be surrendered), which **increases carbon price exposure** of GB electricity exports.[2]
Trading	– In line with common practice throughout Europe, electricity is frequently **traded anonymously**, for example via power exchanges, and the same MWh can be traded **multiple times**.		**#2b** Non-carbon emitting generation in GB will not pay a domestic carbon price and so will be **unable to claim a reduction in CBAM certificates**. This means **zero carbon GB generation faces an undue carbon price**.



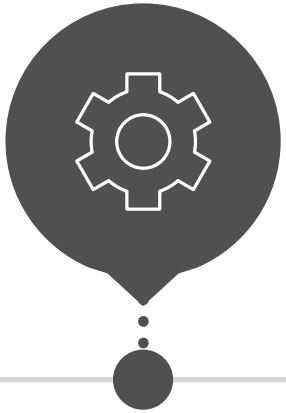
1. In 2023, more than 50% of electricity generation was from zero carbon sources, 32% from gas and 1% from coal. https://www.nationalgrideso.com/news/britains-electricity-explained-2023-review.
2. To illustrate that payment made under UK ETS cannot be demonstrated and so is duplicated, the UK carbon cost is replicated in the CBAM certificates column.

AFRY ÅF PÖYRY

Goals for building out offshore grid infrastructure in the North Sea are being put at risk, with negative implications for EU and GB energy policy delivery



Offshore grid at risk due to negative implications on market operation and IC/MPI business cases – hurting decarbonisation objectives for both EU & GB



EU IMPORT VOLUMES FROM GB

Reduction of more than **50%** in 2026 increasing to **more than 85%** by 2040

53 TWh of green electricity lost by 2040, comparable to the electricity demand foreseen in Denmark or the I-SEM

SEW DISTRIBUTIONAL TRANSFERS IN THE EU

Large distributional transfers from EU consumers to EU producers

Wholesale electricity costs to the EU consumers increase by **€2.3-4.6 billion** annually across the scenarios

Congestion rents in the EU also decrease by as much as **€1.1 billion** annually

BUSINESS CASE FOR IC & MPI

Annual congestion rent reduces by around **50% to 90%** on average across the scenarios

Reduction of between **€75 million** and **€170 million** per GW in a single year **undermining** the business cases for future projects

GB RES UTILISATION

RES curtailment in GB increases by **more than 50%** and in certain scenarios almost **doubles** offset by increased thermal generation in the EU

13-34 TWh annual increase in RES curtailment by 2040

Equivalent to up to **8 GW** offshore wind (1/6 of the 2030 50GW target)

CARBON EMISSIONS

Total carbon emissions in the EU and GB increase by **1.5-2.4 $MtCO_2$** annually in the initial years following CBAM implementation (2026)

In the EU, emissions can increase by as much as **5.3-12.9 $MTCO_2$** in a single year

Equivalent to the annual carbon emissions of **3.4-8.3 million cars**

Note: SEW: Socio-Economic Welfare | IC: Interconnectors | MPI: Multi-Purpose Interconnectors | RES: Renewable Energy Sources

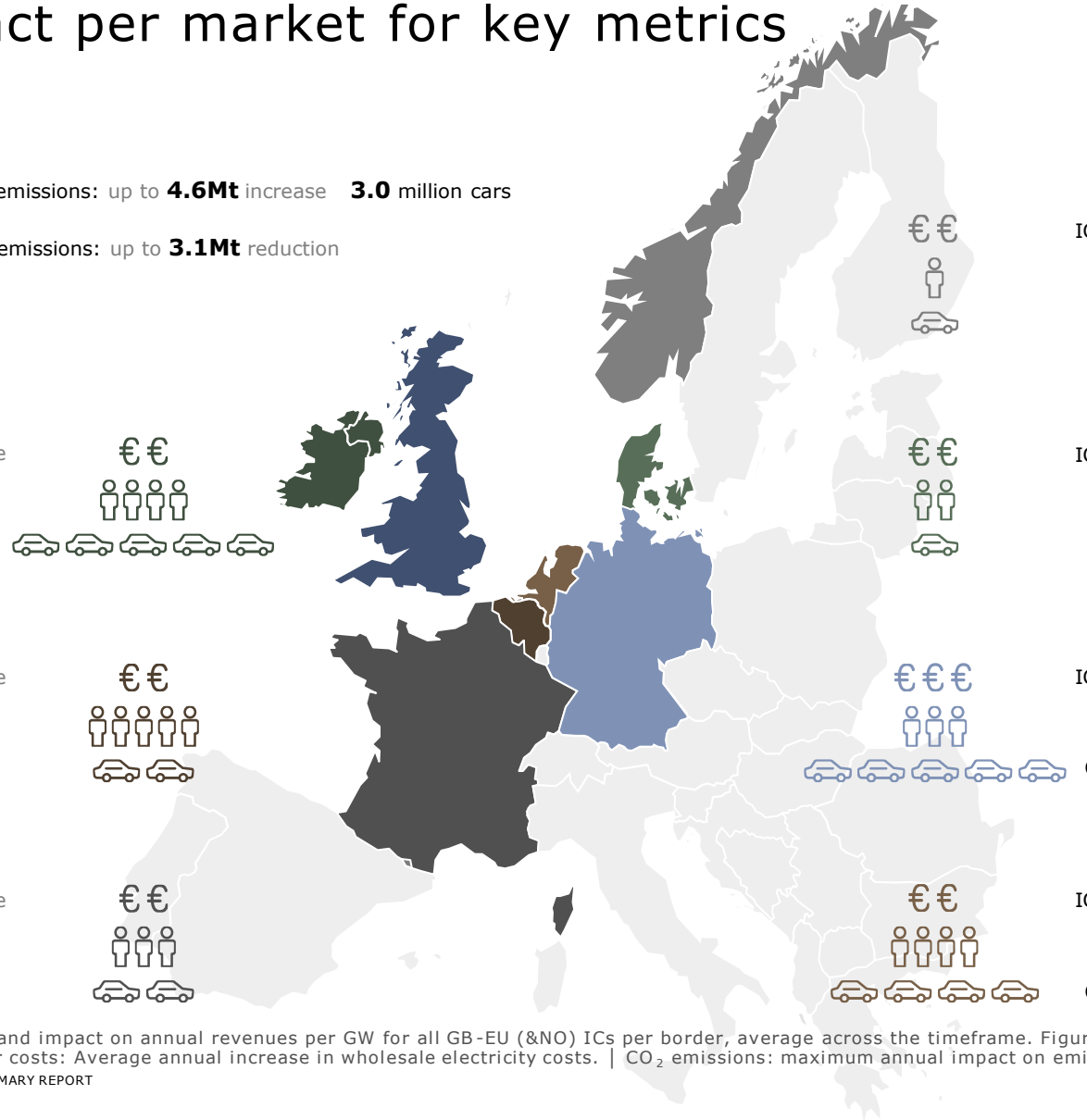
AFRY ÅF PÖYRY

EXECUTIVE SUMMARY

Annual CBAM impact per market for key metrics

EU: Congestion rent: **€0.2bn** reduction | CO_2 emissions: up to **4.6Mt** increase **3.0** million cars

GB: Congestion rent: **€0.3bn** reduction | CO_2 emissions: up to **3.1Mt** reduction



I-SEM

IC utilisation: **51%** down from 66% in Reference
Congestion rent: **€44m per GW** 24% reduction
Consumer costs: **€73m** increase
CO_2 emissions: **1.4Mt** increase **0.9** million cars

BELGIUM

IC utilisation: **41%** down from 74% in Reference
Congestion rent: **€46m per GW** 53% reduction
Consumer costs: **€249m** increase
CO_2 emissions: **0.2Mt** increase **0.1** million cars

FRANCE

IC utilisation: **57%** down from 75% in Reference
Congestion rent: **€38m per GW** 20% reduction
Consumer costs: **€524m** increase
CO_2 emissions: **0.2Mt** increase **0.1** million cars

NORWAY

IC utilisation: **62%** down from 79% in Reference
Congestion rent: **€33m per GW** 11% reduction
Consumer costs: limited impact
CO_2 emissions: limited impact

DENMARK

IC utilisation: **61%** down from 74% in Reference
Congestion rent: **€35m per GW** 15% reduction
Consumer costs: **€4m** increase
CO_2 emissions: limited impact

GERMANY

IC utilisation: **45%** down from 74% in Reference
Congestion rent: **€73m per GW** 45% reduction
Consumer costs: **€740m** increase
CO_2 emissions: **0.9Mt** increase **0.6** million cars

THE NETHERLANDS

IC utilisation: **38%** down from 66% in Reference
Congestion rent: **€46m per GW** 50% reduction
Consumer costs: **€344m** increase
CO_2 emissions: **0.6Mt** increase **0.4** million cars

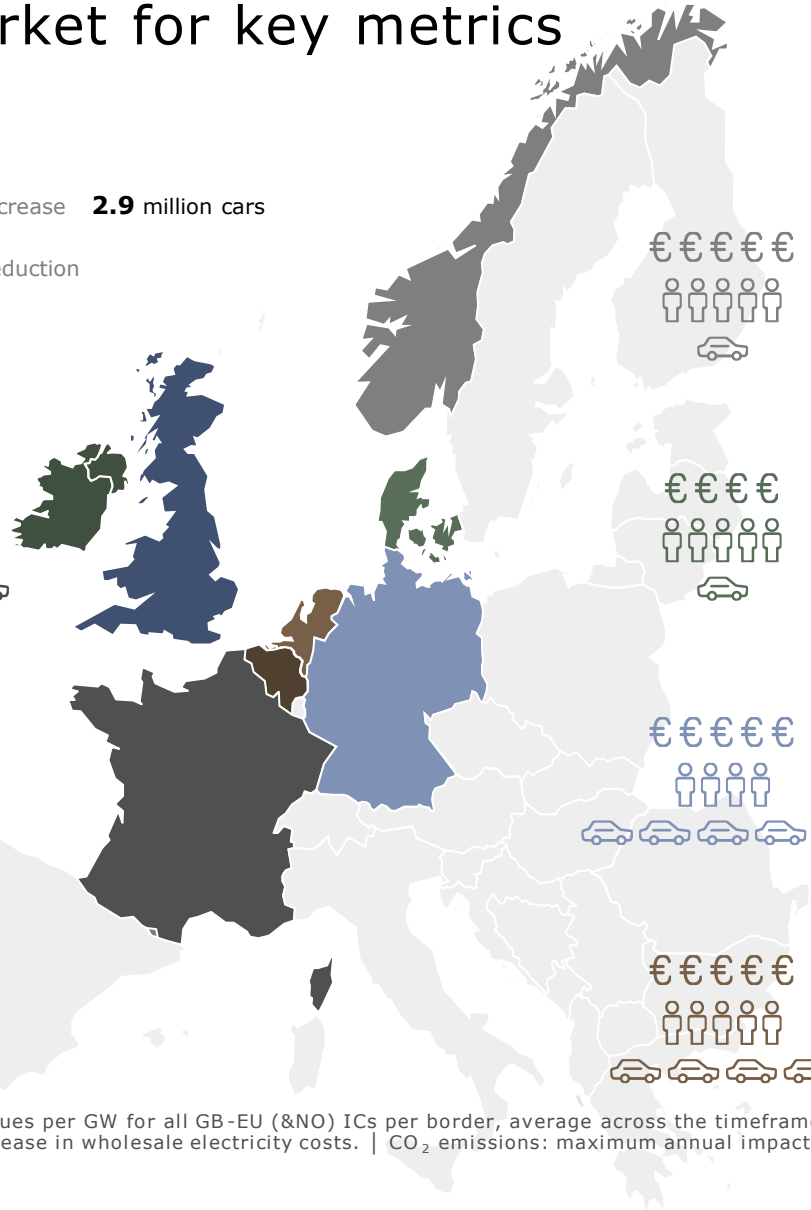
IC utilisation & Congestion rent: Annual utilisation and impact on annual revenues per GW for all GB-EU (&NO) ICs per border, average across the timeframe. Figures exclude MPIs. For the EU and GB, congestion rent includes the total revenue impact. | Consumer costs: Average annual increase in wholesale electricity costs. | CO_2 emissions: maximum annual impact on emissions expressed as number of cars.

EXECUTIVE SUMMARY

Annual CBAM impact per market for key metrics

EU: Congestion rent: **€1.1bn** reduction | CO_2 emissions: up to **4.4Mt** increase **2.9** million cars

GB: Congestion rent: **€0.8bn** reduction | CO_2 emissions: up to **2.9Mt** reduction



NORWAY

IC utilisation: **47%** down from 83% in Reference
Congestion rent: **€109m per GW** 52% reduction
Consumer costs: **€457m** increase
CO_2 emissions: limited impact

I-SEM

IC utilisation: **28%** down from 58% in Reference
Congestion rent: **€57m per GW** 62% reduction
Consumer costs: **€159m** increase
CO_2 emissions: **1.5Mt** increase **1.0** million cars

DENMARK

IC utilisation: **34%** down from 72% in Reference
Congestion rent: **€85m per GW** 70% reduction
Consumer costs: **€150m** increase
CO_2 emissions: limited impact

BELGIUM

IC utilisation: **31%** down from 79% in Reference
Congestion rent: **€138m per GW** 83% reduction
Consumer costs: **€287m** increase
CO_2 emissions: **0.4Mt** increase **0.3** million cars

GERMANY

IC utilisation: **31%** down from 77% in Reference
Congestion rent: **€169m per GW** 83% reduction
Consumer costs: **€943m** increase
CO_2 emissions: **1.0Mt** increase **0.6** million cars

FRANCE

IC utilisation: **37%** down from 76% in Reference
Congestion rent: **€99m per GW** 66% reduction
Consumer costs: **€1,132m** increase
CO_2 emissions: **0.2Mt** increase **0.1** million cars

THE NETHERLANDS

IC utilisation: **30%** down from 74% in Reference
Congestion rent: **€134m per GW** 83% reduction
Consumer costs: **€423m** increase
CO_2 emissions: **0.6Mt** increase **0.4** million cars

IC utilisation & Congestion rent: Annual utilisation and impact on annual revenues per GW for all GB-EU (&NO) ICs per border, average across the timeframe. Figures exclude MPIs. For the EU and GB, congestion rent includes the total revenue impact. | Consumer costs: Average annual increase in wholesale electricity costs. | CO_2 emissions: maximum annual impact on emissions expressed as number of cars.

Action is needed now to progress measures to lessen impacts in the short-term and to secure enduring exemption for the longer-term

	REVISIONS TO APPLICATION TO BETTER REFLECT GB CONTEXT		EXEMPTION ROUTES	
	Demonstrating carbon price paid	**Carbon intensity basis**	**Economy wide via ETS linkage**	**Electricity specific via market integration**
What	– Implicit **recognition within reporting of UK carbon price** having been paid in GB for any electricity imports from GB into the EU.	– Base derived carbon intensity for electricity imports on an alternative to a 5-year average fossil-based measure (e.g. system CO_2 factor from Y-1), to better reflect GB decarbonisation.	– Agreement **fully linking** the UK ETS to the EU ETS.	– Deliver **market coupling** arrangements and steps in support of **market integration** needed to fulfil cumulative conditions for exemption.
Why	– To **overcome** reporting requirement impracticalities and support **realisation of CBAM rebates**, as per the design intent, and lessen risk of undue carbon price exposure.	– To **avoid unduly over-stating** the assumed carbon intensity to be applied to electricity imports from GB and so lessen issue of excess carbon cost exposure and its impacts.	– To **exempt** the UK, as a whole, from the scope of the CBAM.	– To **exempt** GB from the scope of the CBAM with regard to the importation of electricity into the customs territory of the Union.
How	– Create **approach** to recognise in reporting UK carbon price paid. – **Implementing acts**, which are under development, are intended to specify reporting requirements for definitive regime. This change could be progressed via this step.	– Link between emission factor and fossil-fuel intensity is **defined in Regulation**, but where objectively justified, there may be scope for implementing acts to advance a change, but this is not clear.	– Regulation creates provision for an **agreement** for full ETS linkage to be concluded between the EU and a third country and an ETS linkage precedent exists[1].	– Regulation provides for exemption, reliant on cumulative conditions being fulfilled, although process and full details on requirements are not clear. However, steps being followed by Western Balkans provide guidance[2].
Need	– **Methodology** via implementing acts for **implicit recognition** of UK carbon price.	– **Methodology** via implementing acts to allow **use of recent GB system carbon intensity** measure as basis for GB export emissions.	– Advance **political agreement** to create **full ETS linkage**.	– Ensure developing GB-EU **implicit coupling model fulfils** market integration requirements and **political alignment** on condition fulfilment.
When	– Next 6-12 months.	– Next 6-12 months.	– By 2026. Route via Trade and Cooperation Agreement process.	– By 2026. Route via Trade and Cooperation Agreement process.

1. An agreement to link EU and Swiss emissions trading systems has been in operation since 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2017:322:TOC
2. Western Balkans' progress towards CBAM exemption. https://balkangreenenergynews.com/energy-community-tracker-western-balkans-progress-towards-cbam-exemption/

Effectiveness of solution: fuller = more effective **Ease of solution:** fuller = greater ease

Table of contents

Intentions behind CBAM are positive, but there are issues with its application to electricity imports from GB

CONTEXT

1

Principle that CBAM is seeking to achieve is a good one

- Steps to reduce carbon leakage are of great importance for the achievement of global decarbonisation, so the intent of CBAM is positive.
- This includes appropriate application to electricity imports into the EU, as means to incentivise a switch towards decarbonisation of generation in third countries.

2

However, the method of application in the context of electricity imports from GB is problematic

- GB already has a lower carbon intensity than many Member States and is actively pursuing stated decarbonisation goals.
- Carbon pricing is already in place for GB generation creating eligibility for CBAM rebates (i.e. reduction in CBAM certificates to be surrendered).
- Specific parameters / methodologies are not known for definitive regime to apply from 1-Jan-26. But trading for 2026 and beyond is happening and investment decisions are being made now.

INTENT

To put a fair price on carbon emitted during the production of certain carbon intensive goods originating in a third country and imported in the customs territory of the Union.

To create equivalence in terms of carbon pricing for imports of certain goods into the customs territory of the Union.

Electricity imports are included in the scope of CBAM.

APPLICATION

CBAM certificates, priced in line with EU ETS prices, need to be acquired to reflect carbon content of electricity originating in a third country and imported in the customs territory of the Union.

CBAM rebates are provided to reflect carbon pricing in place in country of origin. So, CBAM exposure reflects the difference between country of origin and EU ETS carbon pricing for the carbon content of imports.

CHALLENGES

1. Default values based on the CO_2 intensity of electricity produced from fossil fuels are likely to be used as the reference to determine the embedded emissions in electricity imports from GB.
2. Difficult to establish that a carbon price has been paid given the way electricity is traded (e.g. anonymous power exchanges, multiple trades for the same MWh). Zero carbon generation does not pay carbon price and so cannot demonstrate payment domestically.

RESULTS

Problem Statements

which trigger deviation from policy intent (see next slide)

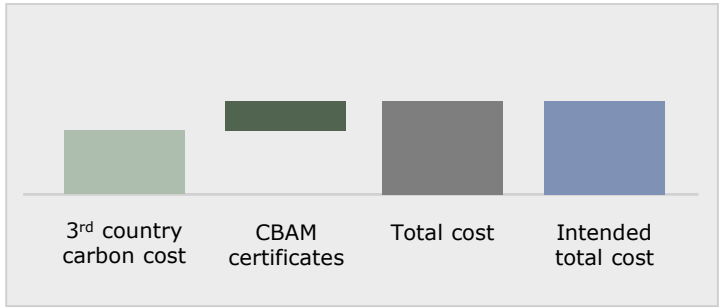
CONTEXT

Specific issues with CBAM application to electricity imports from GB highlight several problem statements triggering undue carbon pricing exposure

POLICY INTENTION

CBAM certificates, priced in line with EU ETS prices, need to be acquired to reflect carbon content of electricity originating in a third country and imported in the customs territory of the EU. CBAM certificates to be surrendered are reduced to reflect carbon pricing in place in country of origin. Therefore, CBAM exposure reflects the difference between country of origin and EU ETS carbon pricing for the carbon content of imports.

Result: imports are, overall, exposed to EU ETS price levels for carbon content.

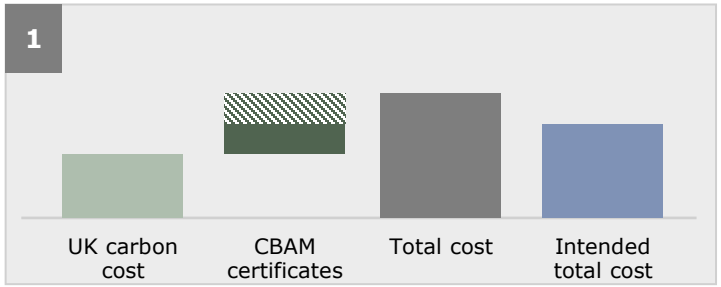


- Carbon cost paid via 3rd country carbon pricing
- CBAM cost paid to cover shortfall in 3rd country relative to EU ETS carbon pricing
- Overall carbon cost actually faced
- Intended overall carbon cost exposure based on EU ETS
- CBAM cost inflator linked to overstated carbon intensity

PROBLEM STATEMENTS

#1

Use of fossil fuel-based CO_2 emission factor **overstates carbon intensity**. This **unduly increases carbon price exposure for electricity exports from GB**.

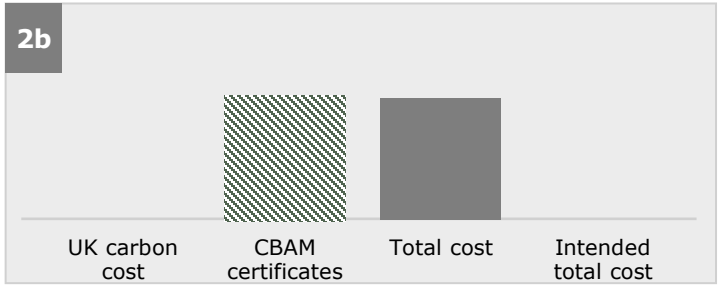


#2a

Barriers to demonstration of carbon price paid in country of origin block ability to claim CBAM rebates (i.e. a reduction in CBAM certificates to be surrendered), which **increases carbon price exposure** of GB electricity exports.[1]

#2b

Non-carbon emitting generation in GB will not pay a domestic carbon price and so will be **unable to claim a reduction in CBAM certificates**. This means **zero carbon GB generation faces an undue carbon price**.



Note: Schematics are indicative for problem statement illustration. | 1. To illustrate that payment made under UK ETS cannot be demonstrated and so is duplicated, the UK carbon cost is replicated in the CBAM certificates column.

Table of contents

ISSUE 1: CO_2 EMISSION FACTOR

Risk of significant over-statement of embedded emissions applied to imports of electricity from GB if based on historic fossil fuel generation intensity

REGULATORY INTERPRETATION & ISSUES IDENTIFIED

1

There is a high **likelihood that default values, based on the CO_2 intensity of electricity produced from fossil fuels and potentially over a 5-year historic period, will be used as the reference to determine the embedded emissions in electricity imports from GB[1], with the criteria for use of actual embedded emissions not likely to be met**, given practical obstacles to demonstrating the original source of generation.

The CBAM Regulation defines the CO_2 emission factor as 'the weighted average of the CO_2 intensity of electricity produced from **fossil fuels** within a geographic area'. This approach will lead to **significant over-statement of carbon intensity** assumed to apply to electricity imports from GB.

Considering the definition of CO_2 emission factor, default values, based on the **CO_2 intensity of electricity produced from fossil fuels only potentially over a 5-year historic period**, will be used as the reference to determine the embedded emissions in electricity imports from GB.

Default values will apply unless it can be demonstrated that the cumulative conditions for use of actual embedded emissions are met. These **conditions are unlikely to be met, meaning default values will apply**.

The CO_2 emission factor applied to flows from GB to the EU&NO, calculated in line with the historic fossil generation intensity basis, starts at **463gCO_2/kWh** in 2026. In 2040, it is expected to be between **374-380gCO_2/kWh** depending on the scenario.

In 2026, when GB exports to the EU the carbon emissions intensity is for **50% of the time less** than **80gCO_2/kWh** and it is **always** less than **300gCO_2/kWh** when GB exports to the EU.

(Central scenario)

By 2040, more than **95% of the exports** from GB to the EU have an emissions intensity of **0gCO_2/kWh**. The **maximum** carbon intensity when GB exports to the EU is **70gCO_2/kWh**.

(Central scenario)

In a scenario that results in higher low-carbon penetration levels in GB, by 2040, **all exports** from GB to the EU have a carbon emissions intensity of **0gCO_2/kWh**.

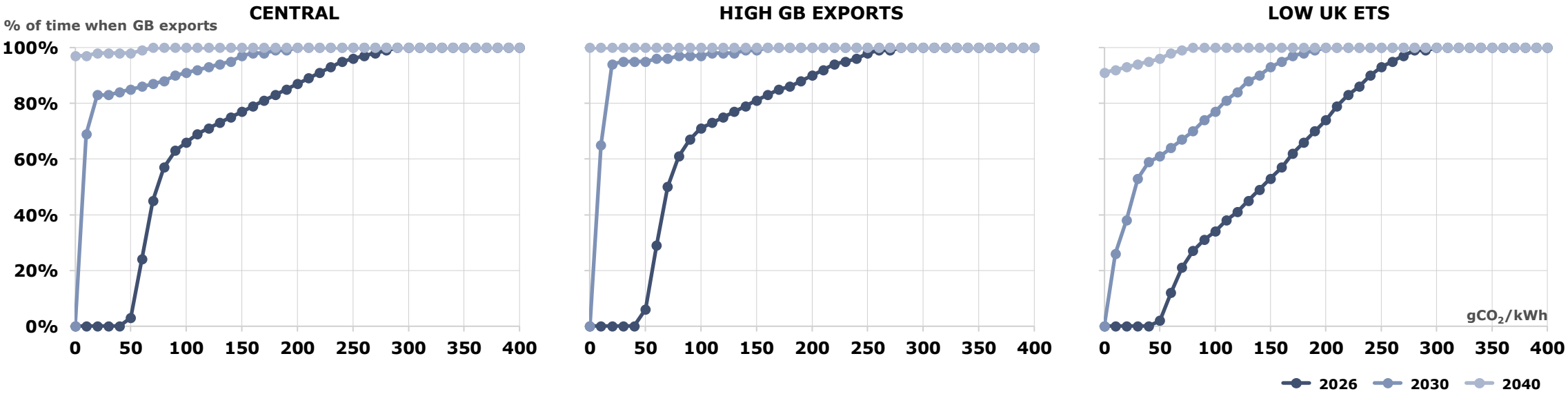
(High GB Exports scenario)

1. Of the possible default value routes, the only one with a calculation methodology specified at this stage involves calculation based on a weighted average of the CO_2 intensity of electricity produced from fossil fuels for a 5-year period ending two years before the relevant year. This default value calculation methodology is applied in this study, unless stated otherwise.

ISSUE 1: CO_2 EMISSION FACTOR

Carbon content of GB flows into the EU remains significantly lower than the estimated CO_2 emission factor used to set default values

EVIDENCE FROM THE MODELLING: GB ELECTRICITY EMISSIONS INTENSITY DURING EXPORT FLOWS TO BELGIUM



- The charts represent a cumulative duration curve of the flows from GB to Belgium with GB's emissions intensity (in gCO_2/kWh) on the x-axis and the percentage of time GB is exporting in the y-axis[1]. The charts are provided for the Reference case of the different scenarios. Belgium is provided as an example; however, effects are similar for the other EU markets connected to GB.
- The carbon intensity applied to flows from GB to the EU&NO, calculated as a 5-year historic weighted average of fossil fuel generation CO_2 emission factors, **starts at 463gCO_2/kWh in 2026** (all scenarios). In 2040, it is between **374-380gCO_2/kWh** depending on the scenario.
- In 2026, GB emissions intensity at times when it exports to Belgium is **always less than 300gCO_2/kWh,** in all scenarios. This is **significantly lower** than the 463gCO_2/kWh value expected to be applied to the flows from GB to the EU. By 2040, **more than 90% of exports from GB have an emissions intensity of 0gCO_2/kWh** (all scenarios). In a scenario that assumes that GB is decarbonising relatively faster than the EU (i.e. High GB Exports), the carbon content of GB flows to the EU is **zero at all times** in 2040.

1. For example, a point on 200 gCO_2/kWh on the X-axis and 50% on the Y-axis, suggests that GB's emissions intensity is less than or equal to 200gCO_2/kWh for 50% of the time when GB is exporting to Belgium.

ISSUE 2: CARBON PRICE PAID IN A THIRD COUNTRY

In the absence of CBAM rebates, the carbon price exposure for GB exports increases significantly

REGULATORY INTERPRETATION & ISSUES IDENTIFIED

2

Difficulty in demonstrating carbon price paid in GB means that there are **practical challenges** for securing a CBAM rebate (i.e. a reduction in the number of CBAM certificates to be surrendered to account for the carbon price already paid in GB)**.**

Issues relating to demonstration of a carbon price having been paid in GB lead to **excessive carbon pricing exposure** for all electricity imports from GB.

With electricity often traded on anonymous exchanges and with the same MWh traded multiple times, an electricity import cannot be **readily traced** back to the originating installation.

Thus, providing any proof of actual carbon price paid, at an installation level, to claim a reduction in CBAM certificates to be surrendered **does not appear practicable,** increasing carbon pricing exposure of GB electricity exports.

Even if proof of carbon price paid was practicable, **GB zero-carbon electricity** will not be able to claim a reduction in CBAM certificates to be surrendered, as it would not have faced a carbon price, meaning it faces an undue carbon price.

Without CBAM rebates, the carbon price exposure for GB exports to the EU & Norway **increases significantly**. In certain years, there is an annual increase of **€0.4 billion** – despite GB and EU generators facing the same carbon price under the scenario.

(Central scenario)

In a scenario that assumes that GB is decarbonising relatively faster than the EU, this annual cost can increase to **€1.4 billion** in certain years.

(High GB Exports scenario)

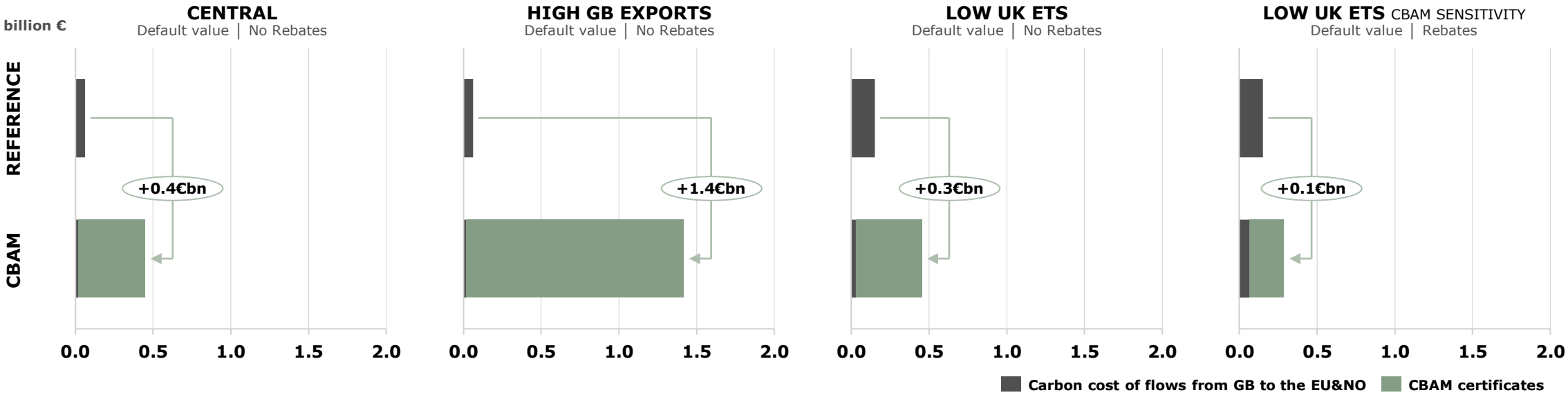
This impact can be **mitigated** if effective arrangements for CBAM rebates are introduced, with carbon costs **dropping by 2/3**. There is still a cost increase of €0.1 billion; however, this is the result of the inefficiencies and implications introduced by default values.

(Low UK ETS vs. Low UK ETS CBAM sensitivity)

ISSUE 2: CARBON PRICE PAID IN A THIRD COUNTRY

Carbon price exposure for GB exports increases significantly, however, the impact can be mitigated if CBAM rebates are possible

EVIDENCE FROM THE MODELLING: ANNUAL CARBON PRICE EXPOSURE FOR GB EXPORTS AND CBAM CERTIFICATE COST



- The charts show the carbon cost paid by GB generators corresponding to the export volumes from GB to the EU&NO[1] and the cost of CBAM certificates in 2030 (in billion Euros). The charts are comparing the 'Reference' and the 'CBAM' cases of the Central, High GB Exports and Low UK ETS, and the Low UK ETS CBAM sensitivity.
- The Central and High GB Exports scenarios assume that **EU and GB generators face the same carbon price**. Without CBAM rebates, the carbon price exposure for GB exports to the EU&NO **increases significantly**. In the Central scenario, there is an increase of €0.4 billion per year. In a scenario that assumes that GB is decarbonising relatively faster than the EU (i.e. High GB Exports), this cost can **increase to €1.4 billion** per year. Under the Low UK ETS sensitivity – 'Rebates' case, this **impact is mitigated**. There is still a cost increase of €0.1 billion; however, this is the result of the inefficiencies and implications introduced by default values.
- The carbon cost corresponding to the export volumes (dark grey bars) is lower under the CBAM cases compared to the Reference cases of each scenario, due to the overall reduction in the flows from GB to the EU&NO (see Section 4).

1. Performed at hourly-level, approach is based on the carbon cost paid by GB generators and allocating an amount to the GB export flows based on the ratio between total export flow and total GB generation.

Table of contents

IMPLICATION 1: ADVERSE EFFECTS ON EFFICIENT & EFFECTIVE MARKET OPERATION

Risk of frustrating efficient and effective market operation, leading to sub-optimal overall electricity market functioning

IMPLICATIONS

1

CBAM issues identified carry the risk of **frustrating efficient and effective market operation** by unduly **blocking flows that would otherwise be economic** and increasing administrative burdens, leading to **sub-optimal overall electricity market functioning**.

Imports into the EU from GB **reduce by 50%** in the short-term and **by 85%** in the long-term. This is a reduction of **53TWh of green electricity** flowing into the EU in 2040.

This volume is comparable to the **electricity demand** foreseen in Denmark or the I-SEM by 2040.

(High GB Exports scenario)

Assuming that **CBAM rebates** are in place, there is still a reduction in the volume of imports into the EU from GB. However, this impact is **mitigated** and reduced by **1/3 in the short-term** and is **halved in the long-term**.

(Low UK ETS vs. Low UK ETS CBAM sensitivity)

Assuming a **system-average** CO_2 emission factor for GB exports into the EU, the short-term CBAM impact on GB flows into the EU **is halved**.

In the long-term, and as the systems become **fully decarbonised**, using a GB system-average factor means that CBAM has **no effect** on the import volumes into the EU.

(Central vs. Central CBAM sensitivity)

Blocking flows that would otherwise be economic, creates **large distributional transfers** from EU consumers to EU producers.

Wholesale electricity costs to the EU consumers increase by **€2.3-4.6 billion** annually.

(Central & High GB Exports scenario & Low UK ETS sensitivity)

Preventing economic transit flows via GB that would otherwise help to **alleviate EU network** congestion and potentially triggering **unnecessary grid reinforcement** domestically.

For example, flows from the I-SEM to GB **reduce by 1TWh** in 2035/40 with knock-on impacts on Irish wind curtailment.

(Central scenario)

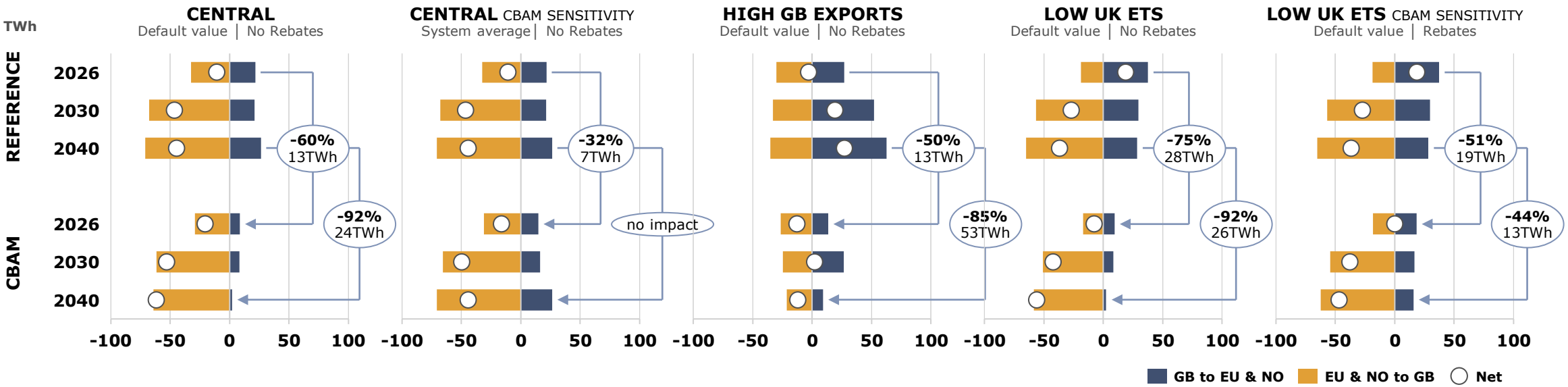
Increased uncertainty regarding trade opportunities across market timeframes, potentially increasing **risk premiums** and reducing **liquidity**.

AFRY ÅF PÖYRY

IMPLICATION 1: ADVERSE EFFECTS ON EFFICIENT & EFFECTIVE MARKET OPERATION

Volume of imports into EU from GB is significantly reduced under the CBAM cases applying a multi-year average historic fossil fuel intensity to GB export

EVIDENCE FROM THE MODELLING: TOTAL ANNUAL FLOWS BY DIRECTION BETWEEN GB AND EU&NO



- The charts show the total annual flows (in TWh) between GB and all the connected markets in both directions. The charts are comparing the 'Reference' and the 'CBAM' cases of the different scenarios and sensitivities[1].
- CBAM implementation **blocks flows that would otherwise be economic**. Under these circumstances, flows in the direction from GB to the EU&NO are **significantly reduced** compared to the Reference, as flows require higher price signals to additionally cover for the cost of the CBAM certificates. Flows in the GB to EU&NO direction are around 50% to 60% reduced in the short-term, and as much as 85% to 92% in the long-term. In a scenario that assumes that GB is decarbonising relatively faster than the EU (i.e. High GB Exports), in 2040 there is a **53TWh loss of green electricity**.
- Assuming that CBAM rebates are in place, this impact is **reduced by 1/3 in the short-term and is halved in the long-term** (i.e. comparing the Low UK ETS vs. Low UK ETS CBAM sensitivity). Assuming the CO_2 emission factor is based on the system average of the year before, the impact in **halved in the short-term and completely disappears in the long-term** (i.e. comparing the Central vs. Central CBAM sensitivity).

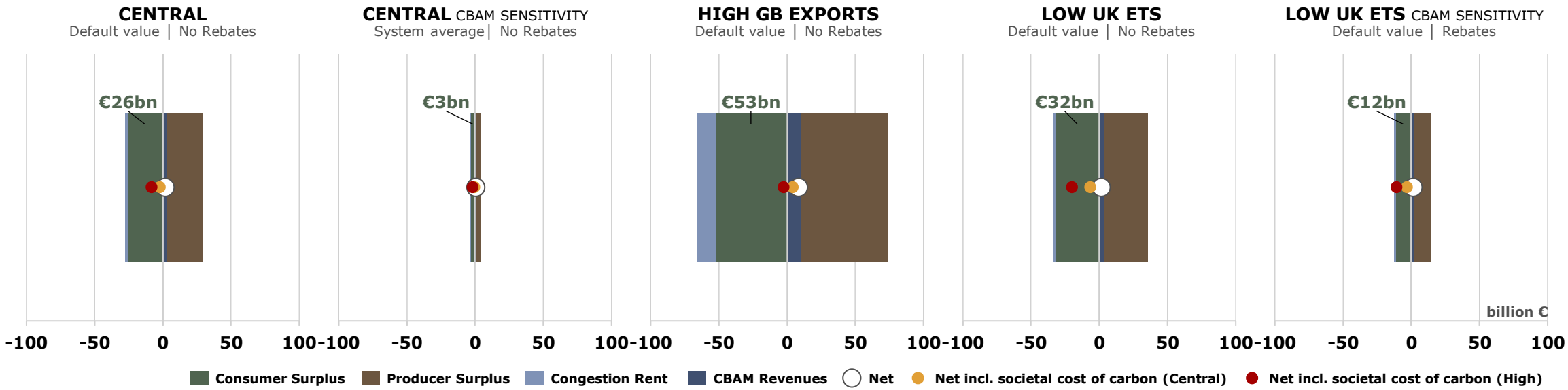
1. In the with CBAM cases, default values based on 5-year historic fossil fuel generation CO_2 intensity are applied, except in the Central CBAM sensitivity.

AFRY ÅF PÖYRY

IMPLICATION 1: ADVERSE EFFECTS ON EFFICIENT & EFFECTIVE MARKET OPERATION

Large distributional transfers leading to income transfer from EU consumers to EU producers

EVIDENCE FROM THE MODELLING: CBAM IMPACT ON SEW ASSESSMENT FOR THE EU



- The charts show the SEW impact of the CBAM on the EU (in line with B1 metric of ENTSO-E's CBA guideline, in billion Euros) over the 15-year period[1], under all scenarios and sensitivities. The values reflect the negative impact on the EU consumers. The SEW assessment does not include secondary effects and other considerations such as impact on support costs. In addition to the net SEW position, the charts also show the net impact accounting for the societal cots of the additional carbon emitted in the EU under two different sets of assumptions for climate change (avoidance) costs[2].
- CBAM implementation creates **large distributional transfers** leading to **income transfer from EU consumers to EU producers**. Wholesale electricity costs to the EU consumers increase by **€2.3-4.6 billion annually**. Congestion rents in the EU also decrease by **as much as €1.1 billion annually** (High GB Exports). Under the CBAM sensitivities, distributional effects are lessened considerably.
- The SEW assessment does not capture the impact on generation and grid costs, resulting from the **increased domestic resource requirements within EU**.

1. NPV based on the 2026-2040 period assuming 3.5% rate. | 2. Based on the EU carbon emissions impact provided on slide 33, accounting for the difference between the societal cost and the EU ETS price. Values based on TYNDP22 Implementation Guidelines. Before 2030 the cost is estimated at €100/tCO2 (Central) or at €189/tCO2 (High); post-2030, it is €269/tCO2 (Central) or €498/tCO2 (High) (real 2016).

IMPLICATION 2: NEGATIVE EFFECTS ON EFFICIENT DELIVERY OF INFRASTRUCTURE, SPECIFICALLY OFFSHORE INTERCONNECTORS AND GRID

Adverse effects on business models for EU-GB interconnectors, putting goals for building out of offshore grid infrastructure in the North Sea at risk

IMPLICATIONS

2

CBAM issues identified create **adverse effects on business models** for EU-GB interconnectors and **benefits case assessment**, with knock-on issues for **development of offshore grid and cross-border infrastructure** needed for the energy transition. This compromises offshore interconnector projects, including MPIs, and their delivery will increasingly depend on uncertain financial support.

In a scenario where the direction of flows is relatively balanced, total **congestion rent can be halved**. This is a reduction of **€75million** for a 1GW project in a single year.

(Central scenario)

Assuming **GB decarbonises faster** than the EU and flows are primarily in the direction from GB to the EU, the impact is **even bigger.**

Congestion rent can decrease by roughly **90%.** This is a reduction of **€170million** in a single year for a 1GW project.

(High GB Exports scenario)

Adverse impacts on the **benefits case** for existing and anticipated IC & MPI projects and domestic grid reinforcements, resulting in **sub-optimal** investments and/or increased need for consumer-funded **support.**

Significant **reduction in the net socio-economic welfare (SEW) position**.

Net SEW position for the connected markets can decrease by roughly **€30million to €60million** annually.

(Central & High GB Exports scenarios)

Reduced competition and increased uncertainty in long-term and short-term **transmission rights** markets.

Reduced efficiency in terms of auction outcomes, by affecting **competitiveness** and **liquidity**.

Reduced **hedging opportunities**, which goes against latest market design proposals[1].

Uncertainty for application to **hybrid links.**

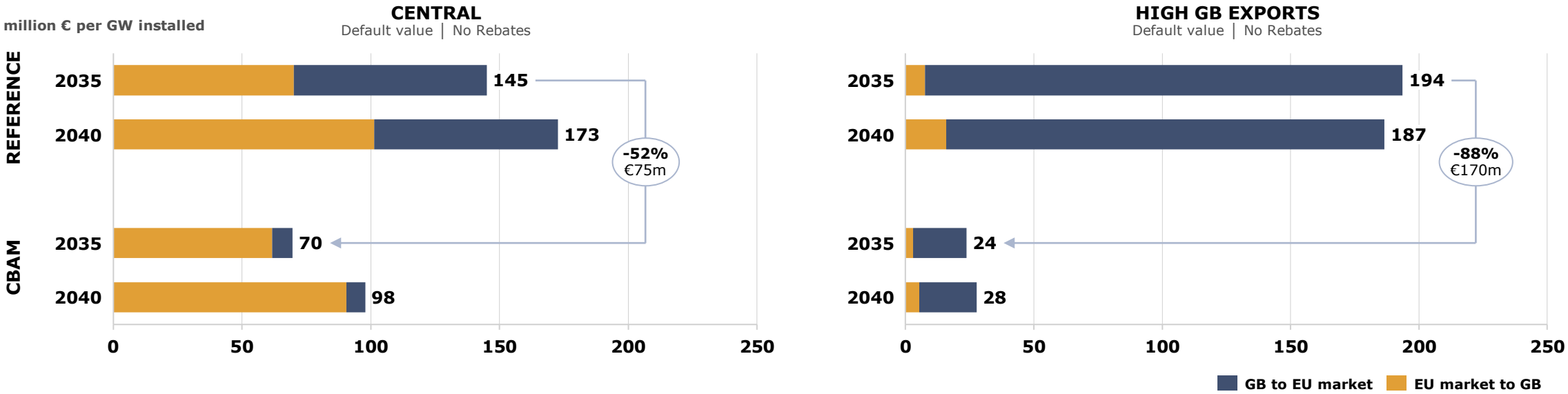
Large uncertainties for prospecting studies for hybrid interconnections across the North Sea and cost-benefit analysis of hybrid interconnection in meshed configurations.

1. Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Regulations (EU) 2019/943 and (EU) 2019/942 as well as Directives (EU) 2018/2001 and (EU) 2019/944 to improve the Union's electricity market design.

IMPLICATION 2: NEGATIVE EFFECTS ON EFFICIENT DELIVERY OF INFRASTRUCTURE, SPECIFICALLY OFFSHORE INTERCONNECTORS AND GRID

Investment cases for new projects are negatively affected with congestion rent decreasing by as much as 50% to 90% depending on the scenario

EVIDENCE FROM THE MODELLING: TOTAL CONGESTION RENT BY DIRECTION OF A NEW IC DEVELOPMENT



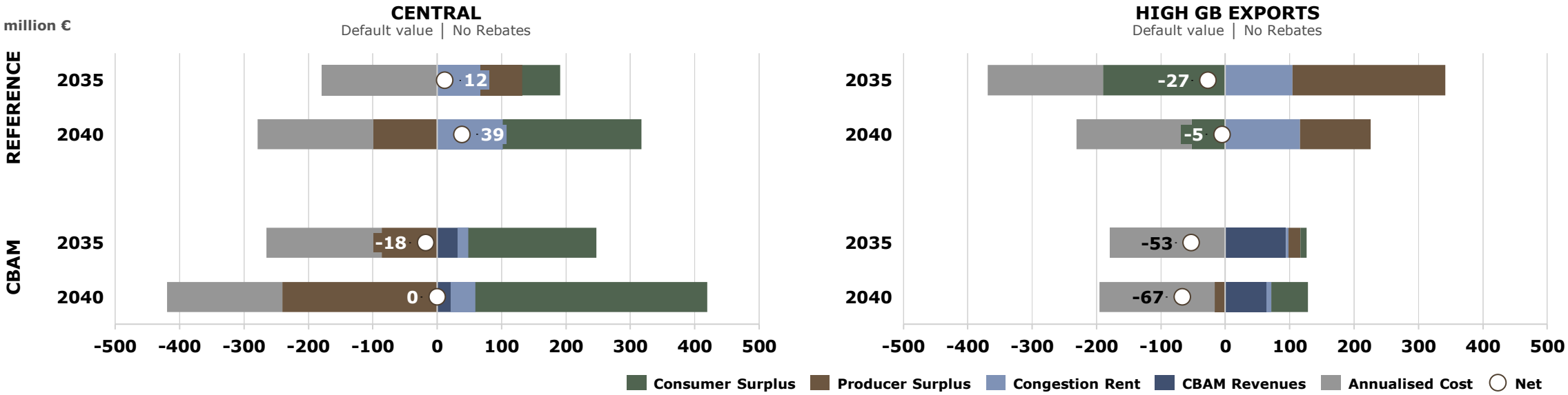
- The charts show the annual congestion rent (in m€/GW) of a new 'generic' IC development[1] between GB and a European market, assumed to be commissioned after 2030. The charts are comparing the 'Reference' and the 'CBAM' cases of the Central and High GB Exports scenarios.
- In a scenario where the direction of flows is relatively balanced under the Reference (i.e. Central), total congestion rent can **decrease by as much as 52%** (i.e. a **reduction of €75million** in a single year) once CBAM is implemented. When flows are primarily in the direction from GB to the EU market (i.e. High GB Exports), the CBAM impact on congestion rent is **even greater**, with **congestion rent decreasing by as much as 88%** (i.e. a **reduction of €170million** in a single year)**.**
- The scenario interconnection assumptions (baseline) are based on the TYNDP 2022 Reference Grid for 2030 and 2040 which is assumed to materialise despite the increased risks on IC and MPI investment cases.

1. For the purposes of this analysis, we have assumed a 1GW interconnector between GB and Germany commissioning after 2030.

IMPLICATION 2: NEGATIVE EFFECTS ON EFFICIENT DELIVERY OF INFRASTRUCTURE, SPECIFICALLY OFFSHORE INTERCONNECTORS AND GRID

Reductions in the net SEW position of a new IC cable in the range of €30 million to €60 million per year

EVIDENCE FROM THE MODELLING: SEW ASSESSMENT OF A NEW IC DEVELOPMENT FOR THE TWO MARKETS



- The charts show the impact of a new 'generic' IC development[1] between GB and a European market on the annual SEW assessment of the two markets (net effect, in million Euros). The SEW assessment is **comparing the 'with cable' against the 'without cable' cases** – under the Reference and separately under the CBAM cases of the Central and High GB Exports scenario. The SEW assessment is in line with the B1 metric of ENTSO-E's CBA guideline.
- In the Central scenario, the net position of the SEW assessment can **decrease by as much as €30 million to €39 million per year**. This can result in a **negative position** under the CBAM case.
- Similar results for the High GB Exports scenario, in which the net SEW position is **€26 million to €62 million lower** per year under the CBAM case (compared to the Reference).

1. We have assumed a 1GW interconnector between GB and Germany commissioning after 2030. Annualised cost is based on a €2,075m CAPEX and €32m OPEX paid over 25 years with a rate of 5%.

IMPLICATION 3: OUTCOMES CONTRARY TO DECARBONISATION OBJECTIVES, HAMPERING ATTAINMENT OF EU AND NATIONAL TARGETS

Harming decarbonisation policies by frustrating GB RES integration, presenting barriers to low carbon projects and increasing EU and EU&GB net carbon emissions

IMPLICATIONS

3

CBAM issues identified reduce **GB low carbon resource utilisation**, by unduly restricting its export, and also **increase carbon emitting generation in the EU**, resulting in **higher aggregate carbon emissions across EU and GB**.

Adverse effects on the business case for investment in low carbon generation in GB, **increasing the price and volume risks** for many RES projects.

Threat to business case of GB offshore wind projects with project financing more difficult or coming at a premium.

Utilisation of GB RES is reduced with curtailment[1] increasing by **more than 50%** in the long-term, which is a **13TWh** annual increase.

A system average emissions factor for GB exports results in **no increase**, while CBAM rebates reduce this negative effect by **half**.

(Central scenario & Low UK ETS sensitivity)

In a scenario that results in higher RES penetration levels in GB, curtailment increases by **34TWh** per annum, a 2-fold increase, in 2040.

This volume equates to **8GW of offshore wind being lost.** This is almost **1/6 of GB's 2030 target** of 50GW offshore wind capacity.

(High GB Exports scenario)

Increased generation needed in the EU, with greater use of **emitting technologies**

Gas-fired generation in the short-term increases by **9-26TWh.** To put this in context, the 2026 electricity demand in the I-SEM or Denmark is expected to be around 45TWh.

(Central & High GB Exports scenario & Low UK ETS sensitivity)

Carbon emissions in the EU increase.

In the EU, they can increase by as much as **5.3MtCO_2 to 12.9MTCO_2** annually.

This is equivalent to the annual carbon emissions of **3.4 million to 8.3 million** passenger petrol/diesel cars in the EU.

(Central & High GB Exports scenario & Low UK ETS sensitivity)

Total carbon emissions in the region (EU&GB) also increase.

CBAM leads to an increase in carbon emissions up to around **1.5-2.5MtCO_2** annually in the EU&GB.

However, from 2030 onwards, the **impact can be zero** if CBAM rebates or an alternative CO_2 emission factor are in place.

(Central & High GB Exports scenario & Low UK ETS & CBAM sensitivities)

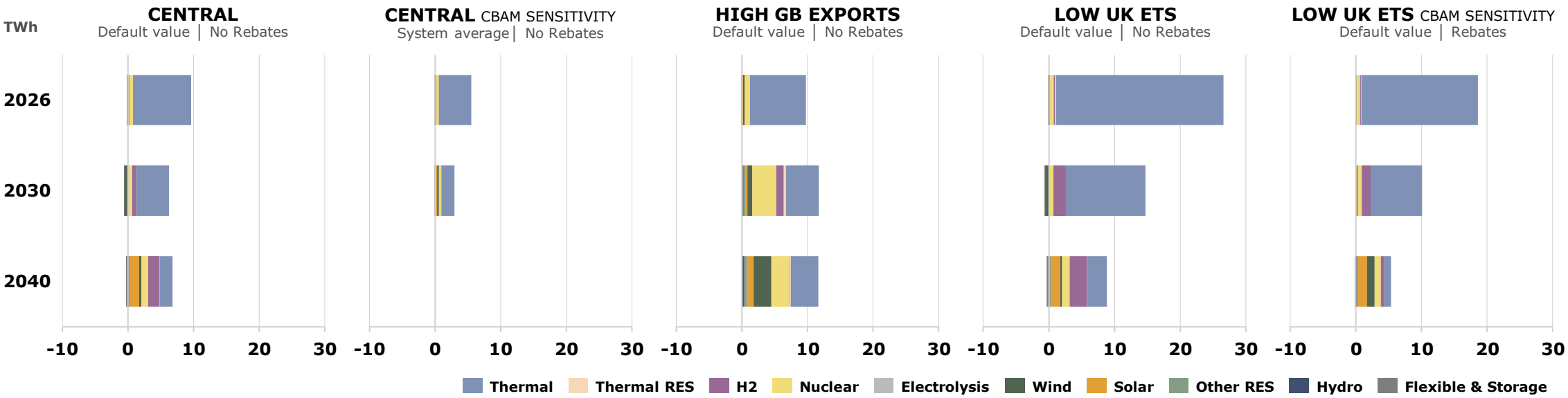
1. Curtailment refers to the economic market curtailment, resulting from rational economic dispatch of renewable generation.

AFRY ÅF PÖYRY

IMPLICATION 3: OUTCOMES CONTRARY TO DECARBONISATION OBJECTIVES, HAMPERING ATTAINMENT OF EU AND NATIONAL TARGETS

Increased generation needed in EU, with greater use of carbon emitting technologies

EVIDENCE FROM THE MODELLING: CBAM IMPACT ON EU GENERATION MIX



- The charts show the CBAM impact on the generation mix of the EU (in TWh) across all scenarios and sensitivities.
- In the short-term thermal generation in the EU, primarily gas generation, **increases by around 9TWh** per annum (Central and High GB Exports); under the Low UK ETS sensitivity, gas use **increases even further** – by **26TWh** in 2026. This triggers **additional gas demand within the EU**. In the short-term, the increase in gas use corresponds to 4% of the total 2022 LNG imports in the EU[1] (Low UK ETS).
- Assuming CBAM rebates are in place, this short-term **impact is reduced by 30%**. Assuming a system-average carbon emissions factor for the GB exports into the EU, the **impact is lessened by 45%**.

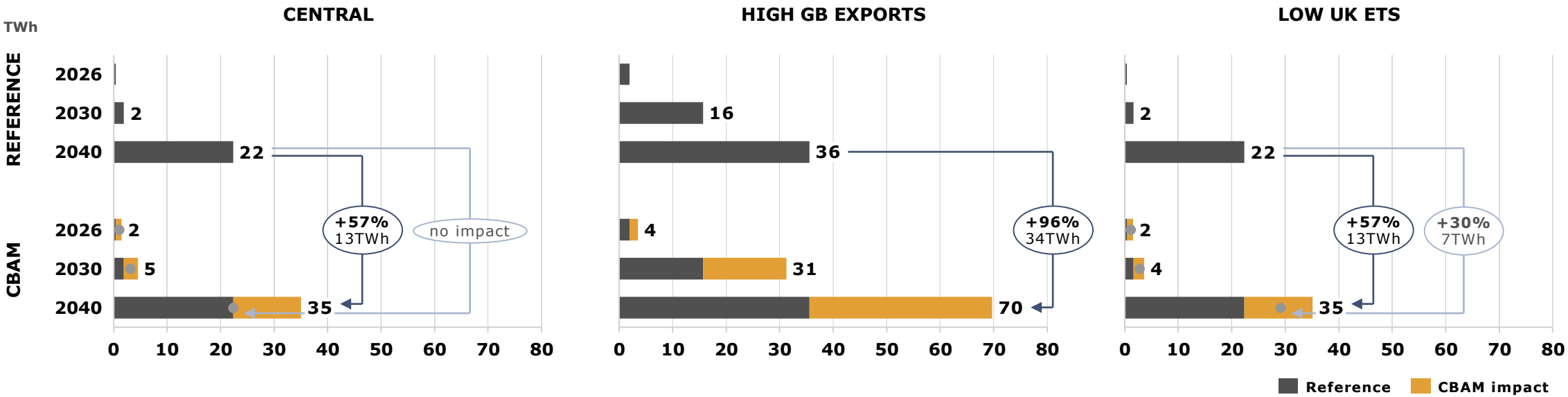
1. Gas use is calculated based on our HHV efficiency assumptions of the gas fleet. LNG imports in the EU (2022) based on the IEA Statistical Review of World Energy 2023.

AFRY
ÅF PÖYRY

IMPLICATION 3: OUTCOMES CONTRARY TO DECARBONISATION OBJECTIVES, HAMPERING ATTAINMENT OF EU AND NATIONAL TARGETS

Utilisation of GB RES is reduced with curtailment levels increasing by more than 50%; by 2040 this translates to lost output from 3-8GW offshore wind

EVIDENCE FROM THE MODELLING: RES (WIND & SOLAR PV) CURTAILMENT VOLUMES IN GB

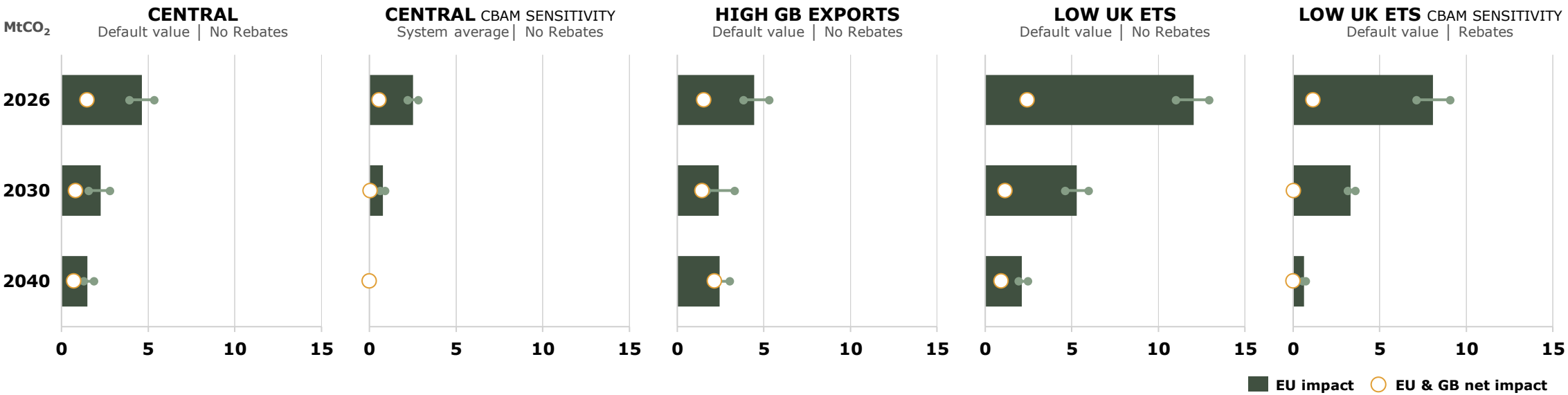


- The charts show the RES curtailment volumes in GB (in TWh) under the 'Reference' and 'CBAM' cases. Where applicable, the grey points on the charts represent the total curtailment volumes under the two CBAM sensitivities (i.e. the Carbon Emissions Factor based on the system average of the Central and the Rebates of the Low UK ETS).
- In the long-term, RES curtailment in GB increases by **more than 50%, a 13TWh increase**, in the Central and Low UK ETS once CBAM is implemented. In a scenario that results in higher RES penetration levels in GB (High GB Exports), the introduction of CBAM can **double RES curtailment levels**, resulting in a **34TWh increase**. By 2040, this is the equivalent of **lost output from 3-8GW of offshore wind** operating at 50% load factor.
- Assuming CBAM rebates are in place, this negative **impact is halved**. Assuming a system-average carbon emissions factor for the GB exports into the EU, the **impact is zero**.
- The introduction of the CBAM leads to an increase in curtailment volumes and a reduction in GB wholesale electricity prices. This will increase risks and financial support for RES generators in the GB market. This study assumes that the total RES capacity is the same across both cases despite these negative impacts.

IMPLICATION 3: OUTCOMES CONTRARY TO DECARBONISATION OBJECTIVES, HAMPERING ATTAINMENT OF EU AND NATIONAL TARGETS

Overall carbon emissions increase; in the EU, they increase by as much as 12.9MTCO$_2$ annually, equivalent to the annual emissions of 8 million cars

EVIDENCE FROM THE MODELLING: CBAM IMPACT ON EU&GB CARBON EMISSIONS



- The charts show the CBAM impact on the total annual carbon emissions in the EU (green bars) and the impact on the total annual carbon emissions in the EU and GB (circles) under all scenarios and sensitivities (in MtCO$_2$). Positive figures indicate an increase in emissions and therefore a negative impact. The lines represent the maximum and minimum values of the EU impact resulting from the different weather years modelled.
- Total carbon emissions in the EU can **increase** in the early years by as much as **5.3MtCO$_2$ to 12.9MTCO$_2$** annually following the implementation of CBAM, with default values calculated in line with 5-year historic weighted average of fossil fuel generation CO$_2$ intensity and no CBAM rebates. This is equivalent to the annual carbon emissions of **3.4 million to 8.3 million passenger petrol/diesel cars**[1].
- The negative impact on the EU is mitigated by a positive impact (i.e. carbon emissions reduction) in GB. However, the **net impact remains negative under all cases tested**. CBAM leads to an increase in total carbon emissions, in the short-term, of around **1.5-2.5MtCO$_2$ annually** in the EU&GB. This effect is significantly reduced under the CBAM sensitivities. From 2030 onwards, the **net impact is zero** if CBAM rebates or a system average emissions factor is in place.

1. Assuming 136.8 gCO$_2$/km, based on data from the European Environment Agency on CO$_2$ emissions of new registered petrol/diesel passenger cars in 2022 in the EU. Assuming 11,298km average distance travelled per car in the EU in 2019, from Odyssee – Mure.

IMPLICATION 4: RESTRICTION ON RESOURCE SHARING POTENTIAL CAN IMPACT SECURITY OF SUPPLY ACROSS THE REGION

CBAM issues identified restrict delivery and use of cross-border infrastructure for meeting adequacy and flexibility requirements

IMPLICATIONS

4

CBAM issues identified **restrict delivery and use** of cross-border infrastructure for meeting adequacy and flexibility requirements, increasing the need for within-EU resource. Reduced access to flows from GB can increase the role of thermal generation in EU, with knock-on effects for gas supplies.

Under-delivery and under-utilisation of cross-border infrastructure **increases resource requirements** within the EU for national **adequacy and flexibility needs.**

Increased **gas usage** for generation in the EU, raising issues with regards to domestic storage levels at peak and **increased dependence** on foreign supplies in a current complex geopolitical environment.

In the short-term annual gas generation in the EU increases by up to 26TWh once CBAM is introduced.

This triggers **additional gas demand** within the EU. In the short-term, the increase in gas use corresponds to **4% of the total 2022 LNG imports in the EU.**

(Low UK ETS sensitivity)

Reduced GB contribution to EU price signals.

Reduced responsiveness of flows from GB to EU price signals in periods of tightness, increasing **scarcity issues** and **costs of alleviation.**

Uncertainty regarding **last resort resource sharing** and potentially higher costs in managing the grid.

Preventing flows from GB that would otherwise **support EU market resource adequacy**, potentially increasing resource needs and costs in the EU.

AFRY ÅF PÖYRY

Table of contents

MITIGATIONS

Action is needed now to progress measures to lessen impacts in the short-term and to secure enduring exemption for the longer-term

	REVISIONS TO APPLICATION TO BETTER REFLECT GB CONTEXT		EXEMPTION ROUTES	
	Demonstrating carbon price paid	**Carbon intensity basis**	**Economy wide via ETS linkage**	**Electricity specific via market integration**
What	– Implicit **recognition within reporting of UK carbon price** having been paid in GB for any electricity imports from GB into the EU.	– Base derived carbon intensity for electricity imports on an alternative to a 5-year average fossil-based measure (e.g. system CO_2 factor from Y-1), to better reflect GB decarbonisation.	– Agreement **fully linking** the UK ETS to the EU ETS.	– Deliver **market coupling** arrangements and steps in support of **market integration** needed to fulfil cumulative conditions for exemption.
Why	– To **overcome** reporting requirement impracticalities and support **realisation of CBAM rebates**, as per the design intent, and lessen risk of undue carbon price exposure.	– To **avoid unduly over-stating** the assumed carbon intensity to be applied to electricity imports from GB and so lessen issue of excess carbon cost exposure and its impacts.	– To **exempt** the UK, as a whole, from the scope of the CBAM.	– To **exempt** GB from the scope of the CBAM with regard to the importation of electricity into the customs territory of the Union.
How	– Create **approach** to recognise in reporting UK carbon price paid. – **Implementing acts**, which are under development, are intended to specify reporting requirements for definitive regime. This change could be progressed via this step.	– Link between emission factor and fossil-fuel intensity is **defined in Regulation**, but where objectively justified, there may be scope for implementing acts to advance a change, but this is not clear.	– Regulation creates provision for an **agreement** for full ETS linkage to be concluded between the EU and a third country and an ETS linkage precedent exists[1].	– Regulation provides for exemption, reliant on cumulative conditions being fulfilled, although process and full details on requirements are not clear. However, steps being followed by Western Balkans provide guidance[2].
Need	– **Methodology** via implementing acts for **implicit recognition** of UK carbon price.	– **Methodology** via implementing acts to allow **use of recent GB system carbon intensity** measure as basis for GB export emissions.	– Advance **political agreement** to create **full ETS linkage**.	– Ensure developing GB-EU **implicit coupling model fulfils** market integration requirements and **political alignment** on condition fulfilment.
When	– Next 6-12 months.	– Next 6-12 months.	– By 2026. Route via Trade and Cooperation Agreement process.	– By 2026. Route via Trade and Cooperation Agreement process.

1. An agreement to link EU and Swiss emissions trading systems has been in operation since 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2017:322:TOC
2. Western Balkans' progress towards CBAM exemption. https://balkangreenenergynews.com/energy-community-tracker-western-balkans-progress-towards-cbam-exemption/

Effectiveness of solution: fuller = more effective **Ease of solution:** fuller = greater ease

ANNEX

Supporting information

BACKGROUND INFORMATION

Notes to readers

- Unless otherwise stated, references to CBAM in this report are to be read as references to the EU CBAM specifically
- In most cases (and unless otherwise specified), this report **focuses on the EU CBAM impact by investigating the difference** between the 'CBAM' cases against the 'Reference' cases within each scenario and sensitivity
- The assessment includes the following years: **2026, 2030, 2035 and 2040**, assuming CBAM is in place in 2026 (years 2024 and 2025 are also modelled in order to calibrate our short-term views against the forward curves). Due to increased uncertainties in this timeframe, the study does not assess CBAM impacts post 2040
- Annual data relates to the calendar year running from 1 January to 31 December 2035
- Unless otherwise specified, results are presented as an average of **five historical weather-years**, i.e. 2012, 2014, 2015, 2017, and 2018 (assuming equal probability)
- NPVs are calculated for the 15-year period (2026-2040) based on a 3.5% rate (the years that have not been modelled are linearly interpolated)
- All prices and monetary values are provided in **Euros real 2022 money**
- For the purposes of the quantitative assessment, EU figures exclude Cyprus but include Northern Ireland, which is reported upon as part of the I-SEM
- Modelling approach assumes implicit market coupling arrangements are in place for all markets; hence additional suboptimal market clearing outcomes from explicit coupling are not included in this study
- Interconnector volumes are reported after losses
- Curtailment refers to the economic market curtailment, resulting from rational economic dispatch of renewable generation
- The source for all tables, figures and charts is **AFRY Management Consulting**

Abbreviations

CBA	Cost-Benefit Analysis
CBAM	Carbon Border Adjustment Mechanism
ETS	Emissions Trading System
EU	European Union
GB	Great Britain
IC	Interconnectors
I-SEM	Integrated Single Electricity Market
LT	Long-term
MPI	Multi-Purpose Interconnectors
NO	Norway
RES	Renewable Energy Sources
SEW	Socio-Economic Welfare
ST	Short-term
TYNDP	Ten-Year Network Development Plan

Modeling and assessment are based on CBAM application set out below

- The 'CBAM' cases are modelled by applying a 'carbon adjustment factor' (based on a 'variable cost') on the relevant Interconnectors (ICs) and Multi-Purpose Interconnectors (MPIs) in the **direction from GB to the EU** (as well as to Northern Ireland as part of I-SEM and Norway).
- The projected **EU ETS carbon price** serves as the basis for the cost of carbon which results in an additional cost to **all flows from GB towards the EU & Norway** (i.e. **no theoretic CBAM rebates** possible despite the presence of a UK ETS).
- This 'variable cost' is in line with the annual **EU ETS price** and the annual GB carbon emission factor **calculated from the respective 'Reference' case** (or historical values where needed – e.g. first years of CBAM application).
- Unless stated otherwise, the GB CO_2 emission factor is calculated based on the weighted average of the CO_2 intensity of electricity produced from fossil fuels for a 5-year period ending two years before the relevant year[1]. For this, annual CO_2 emission factors are calculated by dividing the carbon emission data per fossil fuel technology by the respective gross electricity generation in the relevant geographic area capable of exporting electricity to the EU. It is based on the following equation:

$$Em_{el,y} = \frac{\sum_i^n EF_i \times E_{el,i,y}}{E_{el,y}}$$

- The final CO_2 emission factor is calculated as a moving average of the reported 5 years based on the following equation:

$$Em_{el} = \frac{\sum_{y-6}^{y-2} Em_{el,i}}{5}$$

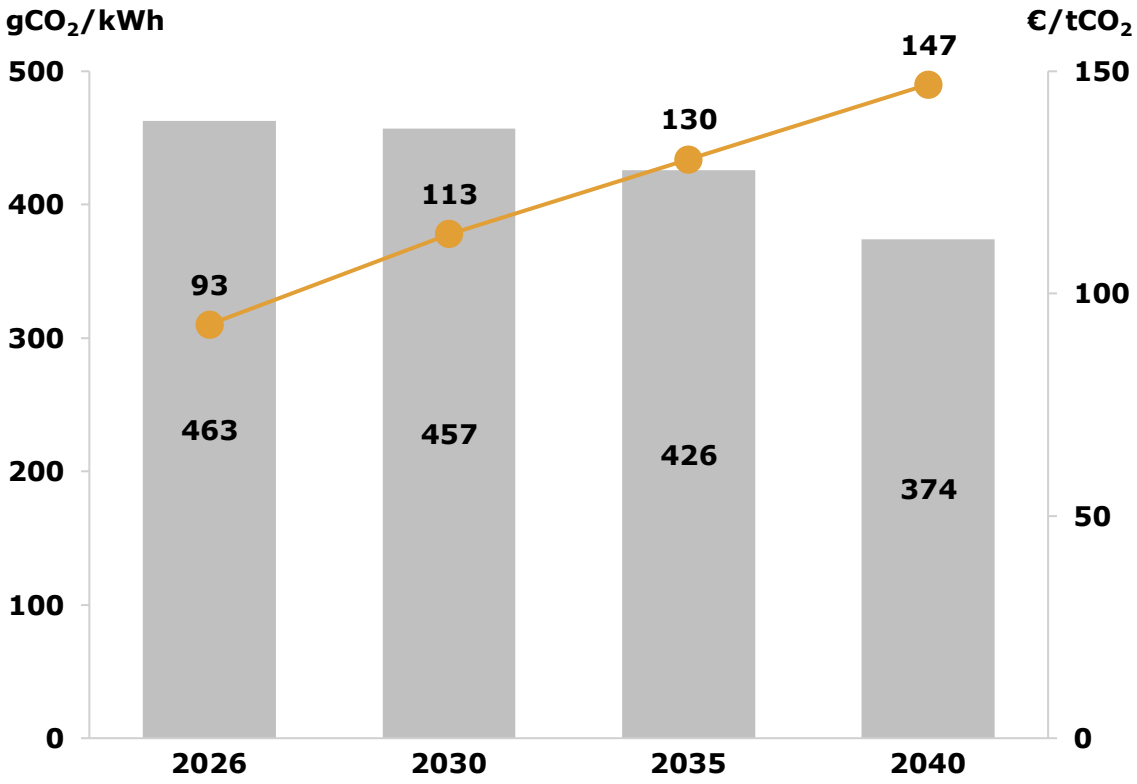
- The CO_2 emission factor (in gCO_2/kWh) is multiplied by the **annual carbon price** of the respective year (in €/tCO_2). Please note that the modelled EU ETS carbon prices assume **a flat annual profile**. The final value (in €/MWh) is applied as a 'variable cost' on **all the ICs and MPIs** in the direction from GB to the EU and Norway.
- This approach essentially approximates the additional CBAM charge, with GB to EU power trades **requiring a higher price spread** in order to make economic sense. Additional administrative and financial barriers for market parties are not captured.
- CBAM applies to Interconnectors and Multi-Purpose Interconnectors between GB an EU or Norway **only** for the purposes of this study. Interconnectors between EU Member States and third countries other than the UK are not in the scope for this study.

1. While other routes for determining default values are referred to, this is the only methodology for determining CO_2 emission factors specified in the regulation.

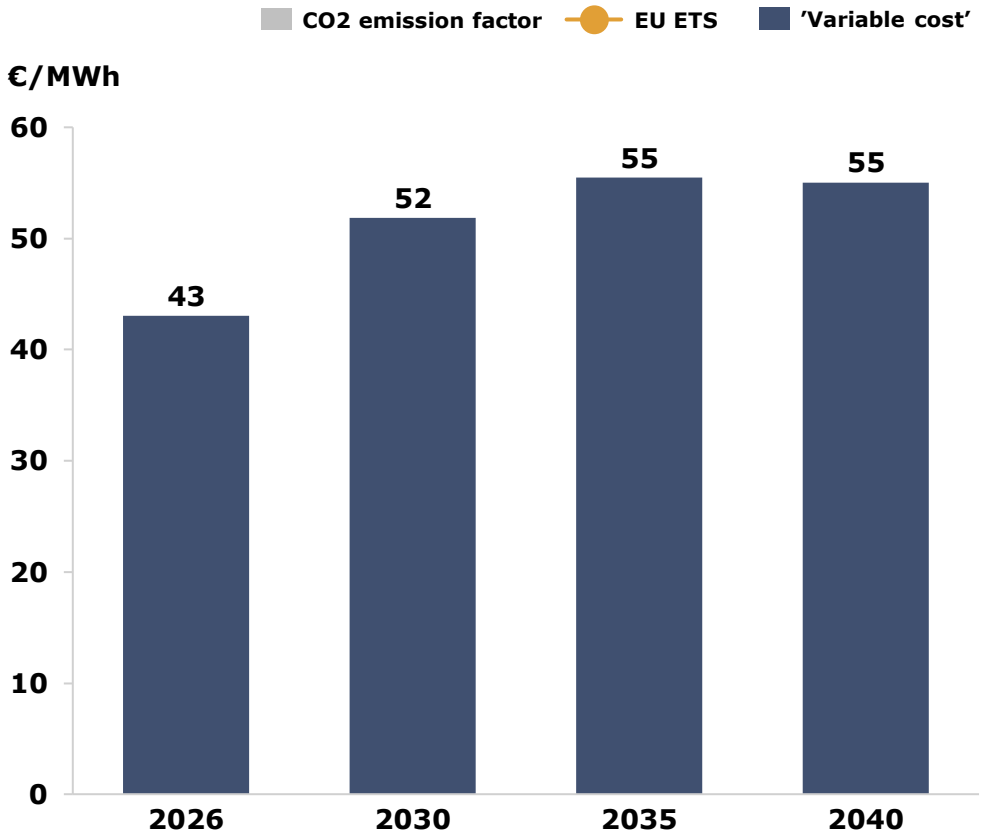
INTERCONNECTOR VARIABLE COST CALCULATION (CENTRAL SCENARIO EXAMPLE)

Modeling approach is based on the implementation of a 'carbon adjustment adder' on flows from GB to all its directly connected markets

GB CO_2 EMISSION FACTOR (DEFAULT VALUES) & EU ETS PRICE



RESULTING 'VARIABLE COST'

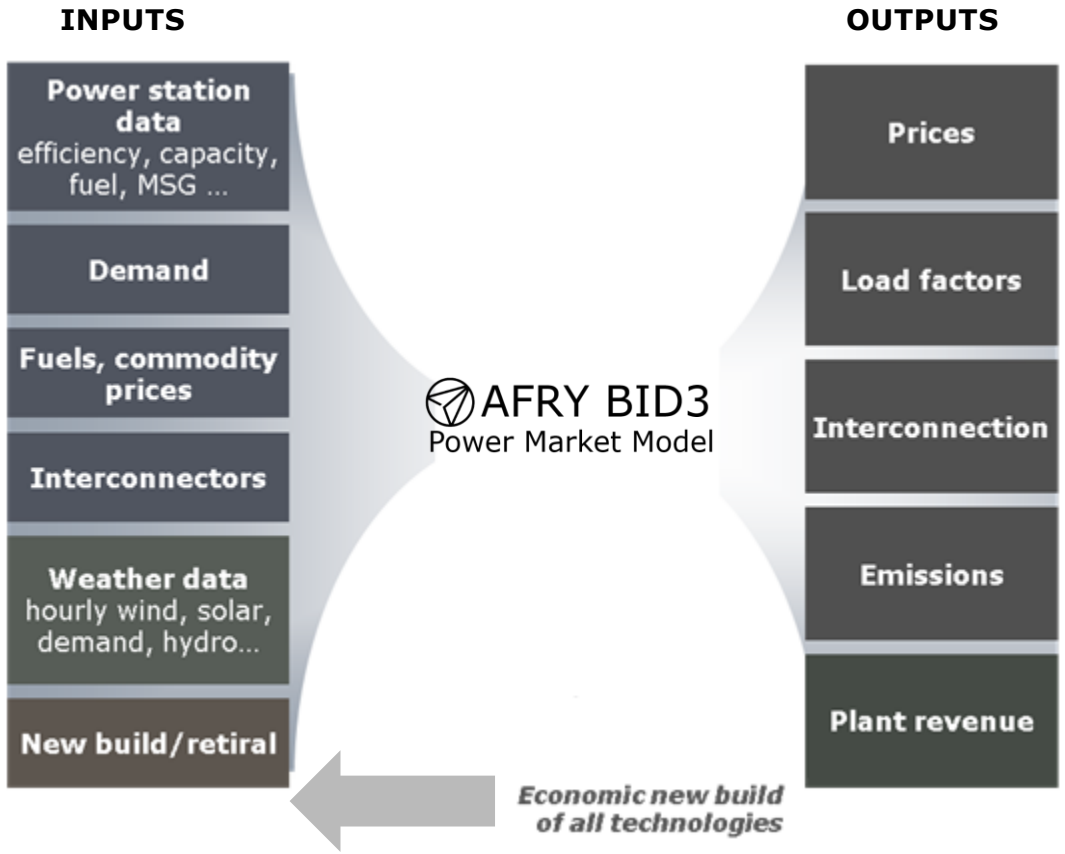


The BID3 model assesses both physical operation and economic behaviour across integrated electricity markets

BASICS OF BID3

- Hourly modelling of the year -sub-hourly possible- while accounting for varying renewables, demand-side management, hydro and pumped/battery storage
- BID3 simulates all plant dynamics:
  - Emissions and plant efficiency
  - Start-up, Part/No-loading, Minimum Stable Generation
  - Minimum on- and off-times
  - CHP, co-firing and secondary fuels
- Specifically designed to model the evolution of the power system, with the:
  - Intermittency of wind, solar, hydro
  - Integration of storage technologies
  - Reserve requirements
  - Balancing Mechanism
  - Capacity expansion (new build and retiral)
  - Hydrogen economy

HIGH-LEVEL ILLUSTRATION OF INPUTS AND OUTPUTS IN BID3



CONTACT DETAILS:

Simon Bradbury | simon.bradbury@afry.com

Asimina Karakyriakou | asimina.karakyriakou@afry.com

KEY AFRY CONTRIBUTORS:

Simon Bradbury | Asimina Karakyriakou | Erica Christofi | Florent Deledalle | Mohamed Eldarawani | Bene Colenbrander


AFRY
ÅF PÖYRY