THE PATH OF LEAST RESISTANCE

How electricity generated from coal is leaking into the EU

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Data

The data behind the report, including each graphic, is available at sandbag.org.uk/project/interconnectors-and-coal. Contact chris@sandbag.org.uk for more information. The report data is primarily based around publicly-available data at the ENTSO-E Transparency Platform, cross-checked against the ENTSO-E's Grid Map of Europe, and supplemented by desk-based research. The data covers the period from 1st January 2015 to 31st December 2019.

Disclaimer

The data is complete to the best of our knowledge, but if you spot an error, please email chris@sandbag.org.uk so we can update the data file we share.

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Thanks

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Executive summary

Coal power plants just outside European borders are supplying electricity to the EU while avoiding the carbon price. We reveal that countries covered by the EU carbon price are increasingly importing electricity, and many new links are planned. Allowing this carbon leakage to continue will undermine EU emissions cuts, as well as incentivising further use of coal in neighbouring countries, turning them into 'offshore carbon havens'.

The solution is to apply a carbon price on electricity imports - also known as a border carbon adjustment (BCA). Applying a BCA for electricity is easier than for other internationally traded products (i.e. steel or cement), as flows of electricity are transparent, and the relatively simple production chain allows tracing of carbon emissions. Without ETS free-allocation, administration is easier, and trade politics are far simpler. A border carbon adjustment on electricity would not only restore the integrity of EU climate policy, but also incentivise low-carbon electricity generation in neighbouring states, and the spread of carbon pricing.

This report analyses:

- How much CO2 leakage is there from electricity today?
- What growth in imports should we expect?
- Could a carbon border adjustment on electricity work to reduce carbon leakage?

Key findings

- **Countries in the EU ETS are increasingly importing electricity.** Net imports were up from 3TWh in 2017 to 21TWh in 2019. **All the imports are from countries that have zero or near-zero carbon pricing.**
- **Imported electricity emitted an estimated 26 million tonnes of CO2 - more than the annual emissions of Italy's coal fleet.** Generating the same volume of electricity in the importing EU member states would have emitted 11 million tonnes less, as their power grids are lower carbon on average.
- **Gross electricity imports in 2019 were worth €1.6bn. Had they paid the EU ETS carbon price, this would have generated revenue of €630m.**
- **Plans exist to increase interconnection capacity between EU and non-EU countries by 31%**, further exposing EU power markets to imports. 15% of this expansion is with the Western Balkans, home to Europe's most polluting power stations.
- **New coal power (up to 57GW) is being planned or constructed in countries connected, or soon to be connected to EU power grids**. This would mean a 53% increase in coal capacity in connected countries as a whole. Most is planned in Turkey (34GW), Egypt (11GW), Bosnia & Herzegovina (4GW), and Serbia (2GW).
- **By 2025, five additional non-EU countries - Egypt, Tunisia, Libya, Israel, and Moldova - could be connected with EU member states**. None of these have a carbon price.

Which EU member states are most exposed?

Of the 13 EU countries connected to a non-EU neighbour, some are particularly exposed to coal power imports. This is because they have ample interconnection with neighbours operating (or planning) large coal fleets, while themselves pursuing more ambitious decarbonisation. The key countries at risk are:

- **Greece**, which will phase out coal by 2028, but is connected to Europe's largest coal developer Turkey, and plans to connect with the fossil fuel-heavy grid of Egypt.
- **Finland**, the largest importer of electricity in the EU - all from the fossil-heavy Russian grid.
- **Spain**, where domestic coal generation is collapsing, but imports of coal power from Morocco are rising, and more interconnection is planned.
- **Croatia**, which has proposed high renewable electricity targets for 2030, but is heavily integrated with the grid of Bosnia & Herzegovina, which is actively developing coal.
- **Romania**, which has the third highest interconnection capacity with non-EU neighbours, is expanding interconnection with Ukraine, and planning new connections with coal-powered Turkey and Moldova.
- **Hungary**, which intends to move beyond domestic fossil generation almost entirely by 2030, yet is the largest EU importer of carbon intensive electricity from Ukraine.

Policy recommendation

We propose a border carbon adjustment (BCA) on gross electricity imports into the EU ETS region. This would defend the integrity of EU climate policy by preventing offshoring of power sector emissions. It would also create an incentive for neighbouring states to decarbonise and/or align climate policies, accelerating the spread of carbon pricing. We offer some design recommendations, to reduce carbon leakage effectively, mitigate unintended consequences, and minimise the risk of legal challenge.

New European Commission President von der Leyen has put forward border carbon adjustments as part of a green deal for Europe. We believe the power sector is the best place to start implementing such a policy.

Contents

How much carbon is leaking into the EU?

Interconnectors are undoubtedly effective at lowering electricity costs and reducing curtailment of renewables. However, a disparity in carbon pricing at the border of the EU is creating a competitive advantage for high-carbon generators in neighbouring countries. In this section we analyse the effect this is having on electricity imports and associated carbon emissions.

Electricity flows

The trade flows considered in this analysis are between the block of countries participating in the EU Emissions Trading Scheme (EU ETS, i.e., EU member states plus Norway and Switzerland), and any neighbouring country not in this block. In total, 13 EU countries are physically connected with 11 non-EU countries.

The ENTSO-E Transparency Platform[1] pubishes hourly flows of electricity between these countries[2]. We cross-checked this dataset against the ENTSO-E's Grid Map[3] of Europe, and found hourly exchange data exists for all relevant interconnections, except Morocco to Spain, for which we retrieved equivalent data through the Red Eléctrica de España eSIOS platform[4].

The EU ETS region is a net importer of electricity. Figure 1 shows that every year since 2015, the EU ETS region has imported 3-21TWh more than it has exported. The highest gross and net imports have come in the last two years, simultaneous with the increase in the EU ETS carbon price. The net import in 2019 was 21TWh, or 0.6% of EU electricity demand (3256TWh in 2016[5]). Annual figures are provided in Table 1.

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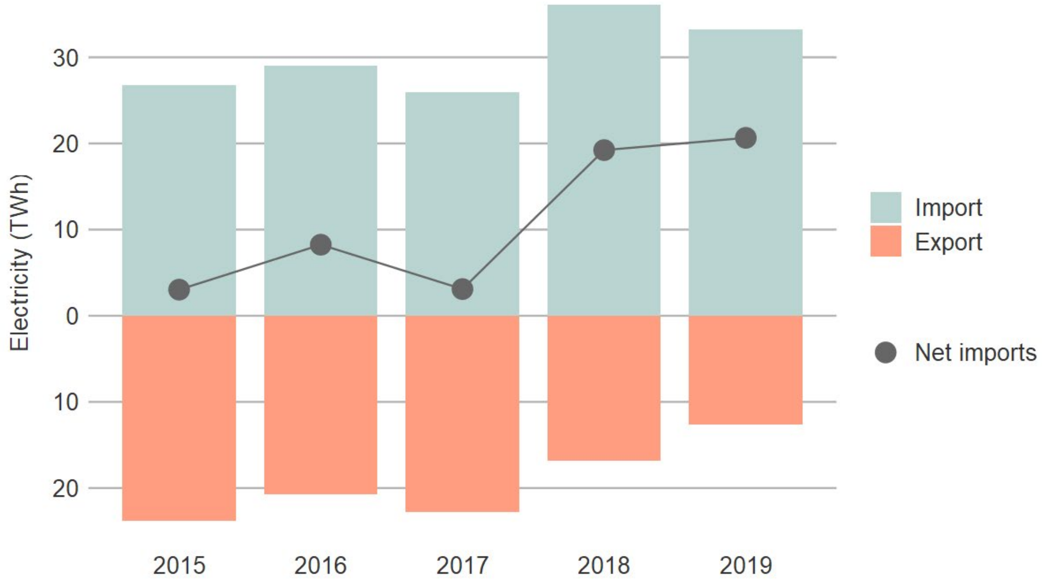
1. ENTSO-E Transparency platform.
2. Due to a high number of missing values in ENTSO-E physical flow data to/from Turkey in 2015-2017, aggregated annual and monthly flows were supplemented with data from the Turkish TSO. Available here: https://www.teias.gov.tr/tr/elektrik-istatistikleri
3. ENTSO-E Transmission system map.
4. Red Eléctrica de España eSIOS platform.
5. Overview of electricity production and use in Europe, EEA, 2018 https://www.eea.europa.eu/data-and-maps/indicators/overview-of-the-electricity-production-2/assessment-4

FIGURE 1:

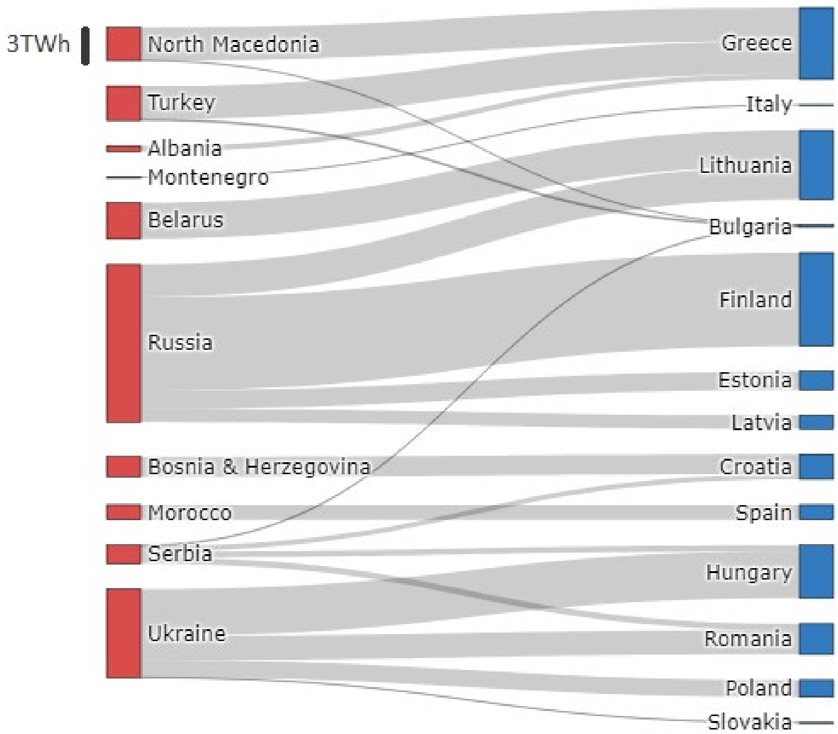
Electricity exchange between the EU and neighbouring countries



Gross (bars) and net (grey points) electricity flows in and out of the EU ETS region through all interconnectors.

FIGURE 2:

EU ETS gross electricity imports (TWh) in 2019



Gross imports into EU ETS countries in 2019, by origin (left) and destination (right). The thickness of lines is proportional to the volume of electricity in TWh. Note: Imports from Russia to Lithuania all originate from the Kaliningrad enclave.

In Figure 2 we show gross imports in 2019 by origin and destination. A total of 33TWh was imported. The majority (79%) originated from just three regions: Russia (38%), Ukraine (22%), and the Western Balkans (19%). Imports were received mostly by 4 EU countries: Finland (23%), Lithuania (17%), Greece (17%), and Hungary (13%).

Only 12.6TWh was exported in 2019 (Figure 1). The biggest exporting member states by far were Bulgaria (40%) and Slovakia (23%).

Taking into account both imports and exports, the EU ETS countries with the largest net imports were Finland (8TWh), Lithuania (5TWh), Greece (5TWh), and Hungary (4TWh). Trade with the Western Balkans was high in both directions, with 6.3TWh imported and 6.9TWh exported by the EU. Annex 1 contains full data for country-country exchanges in 2019, and the full multi-year dataset can be explored on our website.

In Figure 3, we show how exchanges with individual neighbouring countries have changed over time. Russia, Ukraine, Belarus, and Bosnia & Herzegovina have been consistent exporters to the EU since 2015. Morocco became a net exporter to Spain for the first time in 2019. Gross imports from Morocco to the Iberian peninsula grew from almost nothing in 2018 (0.18TWh) to 1.2TWh in 2019.

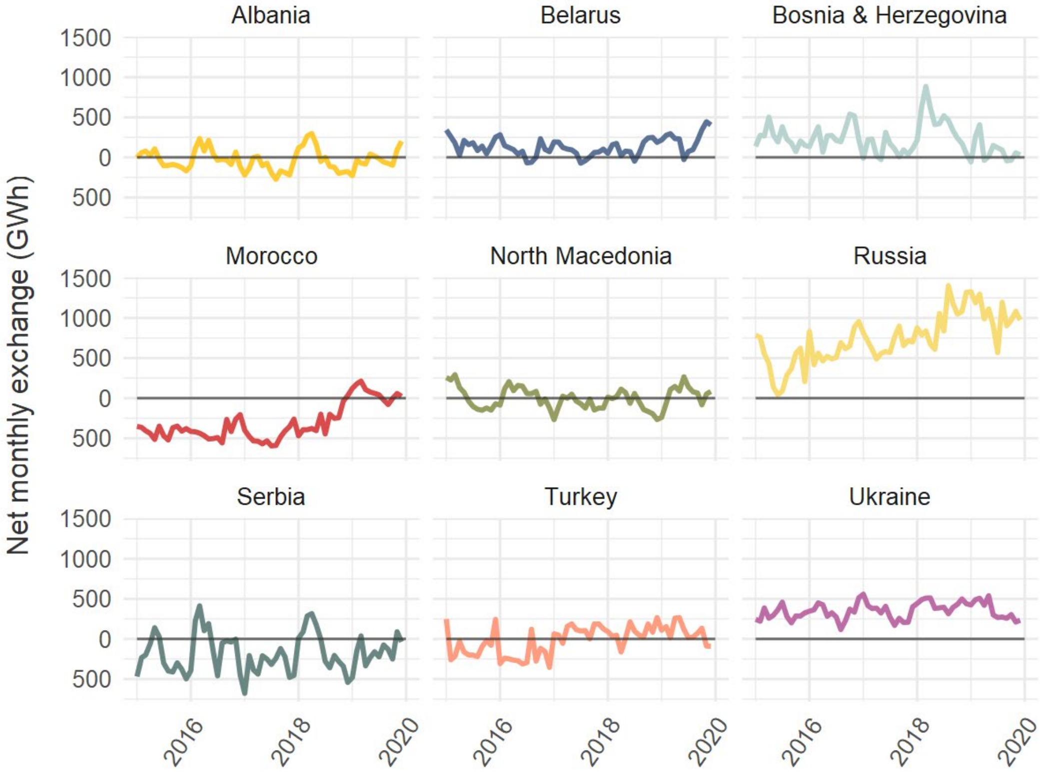
The average ETS carbon price rose from approximately €6 in 2017 to €16 and €25 in 2018 and 2019 respectively. This is a cost that EU generators face, but electricity imports do not. We find that between 2017 and 2018, net imports increased from 8 out of 9 non-EU countries (Turkey being the only to decrease).

As well as volume, ENTSO-E publishes the hourly price of electricity in each EU country. We multiplied the hourly price by the hourly import flows to calculate the value of electricity imports in every country. We found that the total value of gross imports in 2019 was €1.6bn. Despite having the third largest imports by volume, Greece was the largest EU importer by value, importing €366m in 2019, up from €259m and €338m in 2017 and 2018 respectively. In terms of origin, €549m was purchased from Russia, €370m from Ukraine, €363m from the Western Balkans.

This means that in 2019, 33TWh of electricity worth €1.6bn was imported into the EU ETS region, having been generated in an effective carbon price haven.

FIGURE 3:

EU electricity imports from neighbouring countries



Net monthly imports to all EU member states from different non-EU countries, for the period January 2015 to December 2019 inclusive.

TABLE 1:

Annual electricity trade, and associated carbon emissions, between countries in the EU ETS and connected neighbours.

	Year	2015	2016	2017	2018	2019
Electricity (TWh)	Import	26.8	29.0	25.9	36.1	33.3
	Export	23.8	20.8	22.8	16.8	12.6
	Net	3.0	8.2	3.1	19.2	20.7
Carbon (MtCO2)	Import	21.5	23.2	20.3	29.2	25.6
	Export	12.0	10.2	10.9	8.5	6.0
	Net	9.5	13.0	9.4	20.7	19.6

Carbon emissions from traded electricity

Of the 11 connected non-EU countries, only Ukraine has any form of carbon pricing applying to electricity generation (currently set at €0.31/tCO2). In comparison, electricity generators in the EU ETS must surrender allowances to cover their carbon emissions, which in 2019 cost approximately €25/tCO2. In this section, we ask: how much unpriced CO2 is being emitted in connected countries to satisfy the demand of EU imports?

There is sufficient open data to quantify volume and value of electricity trade, but estimating the resulting carbon emissions is more difficult. It requires knowledge of the carbon intensity (gCO2/kWh) of electricity flowing through each interconnector. Such an estimate is not straightforward, because the electricity is rarely traceable to a specific power plant, and even if it were, the carbon intensity of an individual power plant is not easily available. The best approximation would use the carbon intensity of the marginal generating unit at the time of export. However, despite recent efforts [1], this remains a challenging calculation, beyond the scope of this report.

We followed a simplified approach, estimating the average carbon intensity of the exporting country's electricity supply. For this calculation[6,7] we took the annual CO2 emissions from each country's power sector (EDGAR[8] v5, data for 2018), and divided this by total annual electricity generation (IEA[9]). While sufficient for this analysis, this method could be improved upon in several ways. For example, an hourly estimate could be achieved by combining the hourly flow data with the hourly generation mix in each exporting country. Combining this with an assumed carbon intensity for each generating technology would then provide an hourly average carbon intensity of electricity generation. ENTSO-E publishes such hourly generation data for some, but not all countries considered in this analysis.

6. All Imports into Lithuania are from the Kaliningrad enclave, which has a different generation mix to Russia as a whole. The largest power stations in Kaliningrad are the gas-fired Kaliningradskaya (900MW) and Pregolskaya (455MW). We therefore adopted an assumed carbon intensity for gas power stations of 500gCO2/kWh [2].

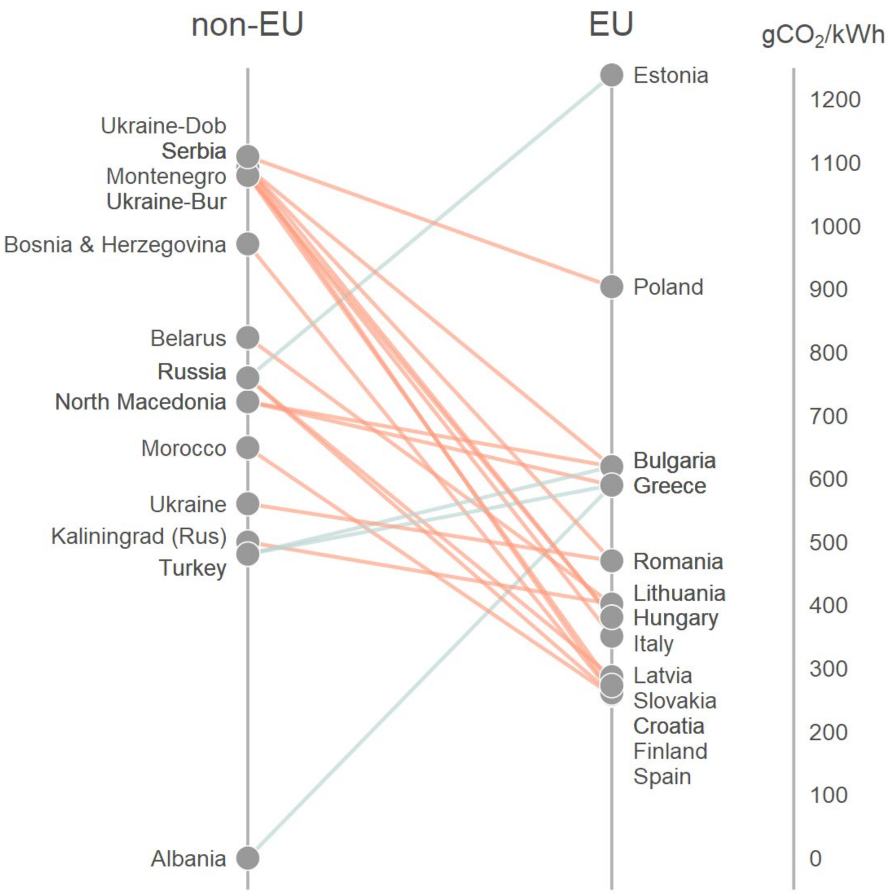
7. We took a slightly different approach to Ukraine, due to its segregated grid structure. Hungary and Slovakia are connected to the 'Burshtyn island', a section of grid disconnected from the rest of Ukraine since 2002, operating synchronously with its ENTSO-E neighbours, and dominated by the Burshtyn (2.3GW) coal plant. Similarly, the connection with Poland is specifically with the Dobrotvirska (510MW) coal plant. For exports through these connections we use carbon intensities of these individual plants taken from the literature [3].

8. Emissions Database for Global Atmospheric Research (EDGAR), version 5.

9. IEA 2019, Electricity Information, www.iea.org/data-and-statistics

FIGURE 4:

Carbon intensities of connected grids



Average carbon intensity of electricity (gCO2/kWh vertical axis) for every country in this analysis. Lines represent physical power connections between non-EU regions (left) and EU member states (right).

In Figure 4 we plot our estimated carbon intensities for all connected countries. **We find that out of the 21 cross-border interconnectors, 17 serve to connect an EU grid to a higher carbon intensity non-EU grid, with just 4 doing the opposite**. Moreover, 8 of the 10 connections carrying the largest gross imports into the EU do so from a higher-carbon grid.

Given the EU ETS region is a net importer of electricity, and connected grids are predominantly higher carbon intensity, it follows that it is also a net importer of carbon. We estimate that in 2019, the EU ETS region imported 26MtCO2 while exporting 6MtCO2, i.e., a net import of 20MtCO2. This net import of CO2 has doubled since 2017. Approximatley 35% of gross CO2 imported in 2019 originated from Russia, followed by 27% from Ukraine and 20% from the Western Balkans.

Countries in the EU ETS collectively imported 26MtCO2 in 2019 (20MtCO2 net), equivalent to the annual emissions of the Italian coal fleet[10].

It's clear that significant and increasing amounts of high-carbon electricity is entering the EU via a number of routes. These dynamics are highly suggestive of carbon leakage in the EU ETS. What's driving this leakage? More detailed modelling of connected grids would be required to answer definitively. However, it can only be encouraged by the sharp disparity in the price of carbon at the border of the EU, combined with ample interconnection providing generators on either side access to the same markets. This view is supported by the observed increase in net imports in 2018 and 2019, simultaneous with the increase in EU ETS carbon price.

If gross electricity imports had been subject to the EU ETS carbon price on a real-time basis in 2019, additional costs would have totalled €630m.

This works out as an average of €19/MWh (€630m/33TWh). This is indicative of the cost advantage enjoyed by generators in the EU's 13 neighbouring countries, which will be higher for high-carbon generators such as coal power plants. The avoided carbon costs of €630m are not insignificant compared to total ETS auction revenues, which were €14bn in 2018[11].

Electricity used in EU countries, but generated outside of the EU ETS, avoided €630m of carbon costs in 2019.

Allowing this to continue risks undermining decarbonisation objectives in the affected EU states, and beyond. As EU member states attempt to decarbonise their power sectors, interconnectors tapping in to cheap, high-carbon electricity risks emissions being exported rather than genuinely reduced. The EU's target to increase interconnection between member states to 15% by 2030 could expose more member states - beyond those considered here - to the same risks of carbon leakage.

In the following section we show that without policy intervention to prevent carbon leakage, divergence in energy policy (i.e., decarbonisation ambition) combined with increases in interconnection, means the problem is only likely to get worse.

10. Emissions in 2018 were 25.3MtCO2 based on EU ETS data from the European Union Transaction Log, via Europe Beyond Coal.

11. European Commission, Report on the functioning of the European carbon market, 2019 https://ec.europa.eu/clima/sites/clima/files/strategies/progress/docs/com_2019_557_en.pdf

BOX 1

How much are current interconnectors utilised?

More capacity is planned, but how much spare capacity already exists? A 2018 EU study [4] provides the total interconnection capacity of every EU country with its non-EU neighbours. These capacities are not always fully available for exchange, because in price-coupled areas such as those encompassed by ENTSO-E, capacity for (day-ahead) trade is allocated based on the optimum market solution. However, given the objective of this process is usually to maximise trade between price zones, to even prices, the physical capacity should be a reasonable approximation of what is made available. We compared these total connection capacities to the total physical energy flows observed in 2018, to estimate interconnector utilisation for each non-EU country. Our estimates ranged from 5-41%, with an overall utilisation of 13%. Albania had the highest (the only one above 20%), and Belarus the lowest. **On this basis we conclude that spare interconnection capacity exists with every presently connected non-EU country.**

What changes in imports can we expect?

Overview

In the previous section we established that high-carbon electricity is leaking into the EU, through interconnections with non-EU states that predominantly generate electricity with a higher carbon intensity. In this section we explore the future of interconnection, and power sector development in connected countries, to assess the future of carbon leakage without policy intervention.

More interconnectors are planned. To assess developments in interconnection, we consulted the ENTSO-E Ten Year Network Development Plan (TYNDP), the EU Commission list of Projects of Common Interest (PCI), and national energy strategies. In Figure 5 we present a map of all existing and planned interconnectors between EU (ETS) and non-EU countries. We found that by 2030, interconnection capacity between EU and non-EU countries is planned to increase by 31%. This expansion will connect 2 additional EU ETS countries (Cyprus, Portugal) and 5 additional non-EU countries (Tunisia, Libya, Egypt, Israel, Moldova[12]). In Figure 6 we summarise the increases that are planned between 14 pairs of countries. It can be seen that 10 out of 14 of these pairs involve a non-EU country with higher carbon intensity electricity than its EU counterpart. Figure 7 and Table 2 provide a full breakdown of current and future interconnection capacity with each neighbouring country.

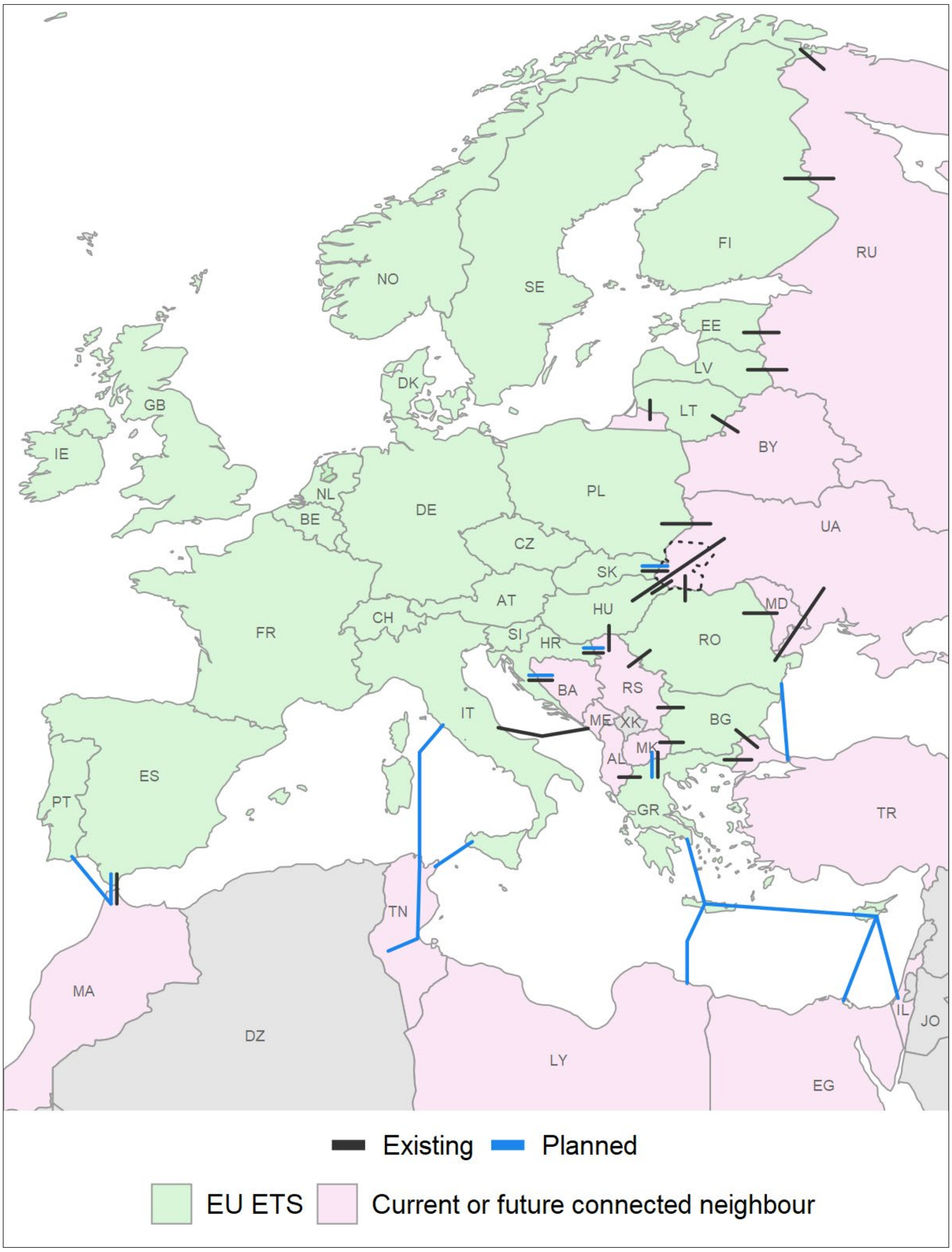
More coal plants are also planned, in countries connected or soon-to-be connected to the EU. Using data from Global Energy Monitor on coal power development (July 2019) [5], we found that connected or soon-to-be connected countries are collectively planning 57GW of new coal capacity[13]. The largest developers are Egypt, Turkey, Serbia, and Bosnia & Herzegovina. A full breakdown by country is given in Figure 7, and values can be found in Table 2.

12. Power lines already connect Romania and Moldova, but these are not in operation. A project to restore the connection to 600MW was identified as a Project of Mutual Interest in 2016 in the framework of Energy Community.

13. This figure includes new coal units classified as “Announced”, “Pre-permit”, “Permitted”, or “Under Construction”.

FIGURE 5:

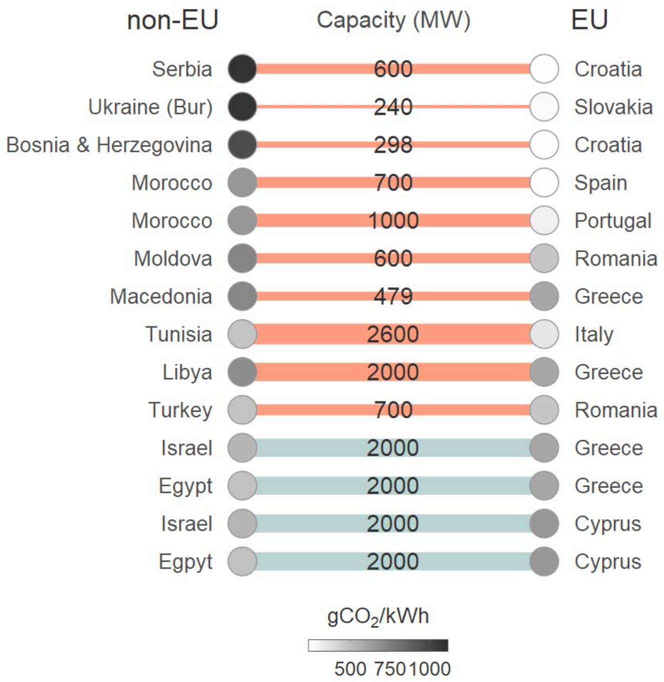
Schematic map of existing and future interconnection between EU (ETS) member states and non-EU neighbours



The dashed area represents the Burtshyn island, an isolated section of the Ukrainian grid synchronised with EU neighbours.

FIGURE 6:

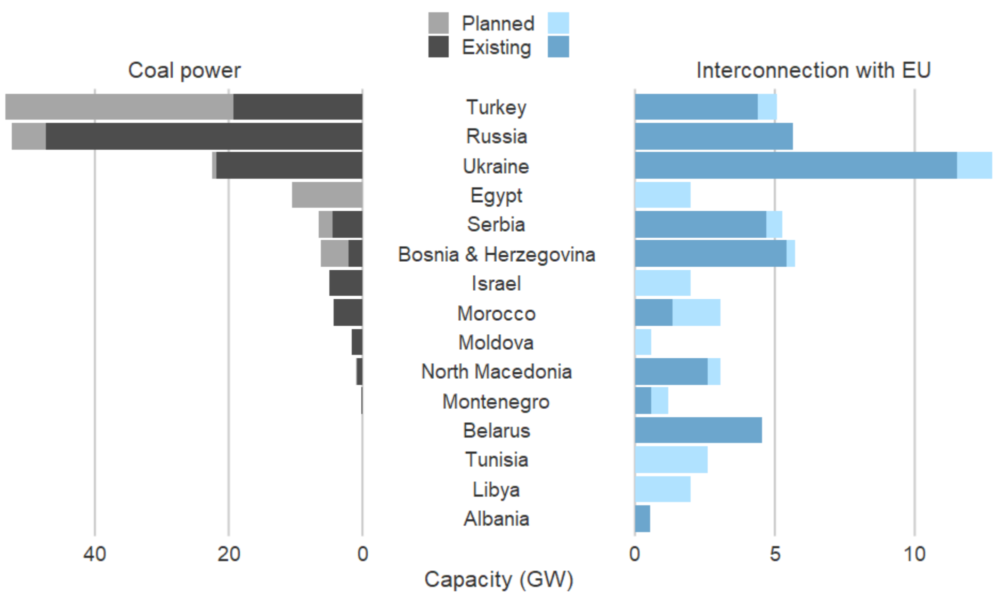
New and increasing interconnection



Increases in interconnection between EU and non-EU countries. Circles are shaded according to estimated average carbon intensity of electricity in each country. The thickness of lines is proportional to the capacity increase (also labelled, MW). Red lines signify higher carbon intensity on the non-EU side, and vice versa for blue.

FIGURE 7:

Current and future coal and interconnector capacity



Current (dark) and future (light) capacities of coal power and interconnection for each non-EU country connected or soon-to-be connected to EU electricity grids.

TABLE 2:

Current and future capacities of interconnection and coal eneration in connected or soon-to-be connected countries outside of the EU ETS

Country	Interconnection capacity (MW)	Planned increase (MW)	Total future capacity (MW)	Coal capacity (MW)	Planned increase (MW)	Total future capacity (MW)
Turkey	4,385	0	4,385	19,337	14,684	34,021
Russia	5,650*	0	5,650	47,367	4,991	52,358
Ukraine	11,513	1,240	12,753	21,840	660	22,500
Egypt	0	2,000	2,000	0	10,600	10,600
Serbia	4,682	600	5,282	4,405	2,100	6,505
Bosnia & Herzegovina	5,429	298	5,727	2,073	4,080	6,153
Israel	0	2,000	2,000	4,900	0	4,900
Morocco	1,359	1,700	3,059	4,317	0	4,317
Moldova	None operational	600	600	1,610	0	1,610
North Macedonia	2,582	479	3,061	800	130	930
Montenegro	600	600	1,200	225	0	225
Belarus	4553	0	4,553	0	0	0
Tunisia	0	2,600	2,600	0	0	0
Libya	0	2,000	2,000	0	0	0
Albania	533	0	533	0	0	0
Total	**41,286**	**14,817**	**56,103**	**106,874**	**56,582**	**163,456**

Sources:
Coal capacity: Global Energy Monitor, Coal Plant Tracker (July 2019) [5].
Current interconnection: EU commission, Second report of the Commission Expert Group on electricity interconnection targets [4].
Future interconnection: ENTSO-E TYNDP, Projects of Common Interest.
*Does not include connection to Finland. Data not available.

Some of the highest ambition EU countries, in terms of power sector decarbonisation, are the most exposed to coal power imports. We assessed power sector developments in connected countries, using draft National Energy and Climate Plans (NECPs, EU) or Intended Nationally Determined Contributions (INDCs, non-EU), as well as national strategy documents. We found that some of the largest importers of electricity, such as Finland, Greece, and Croatia, also have the most ambitious power decarbonisation plans. Six EU countries: Portugal, Greece, Hungary, Italy, Slovakia, and Finland, have committed to phasing-out coal power domestically before 2030, but will remain exposed to non-EU coal power imports after this date without policy intervention. In general, decarbonisation progress in EU countries risks being undermined if imports of coal electricity continue to have a competitive advantage. Climate goals will be thwarted if emissions are exported rather than genuinely saved.

From here, we focus our analysis on five regions that strongly exhibit the problems outlined above:

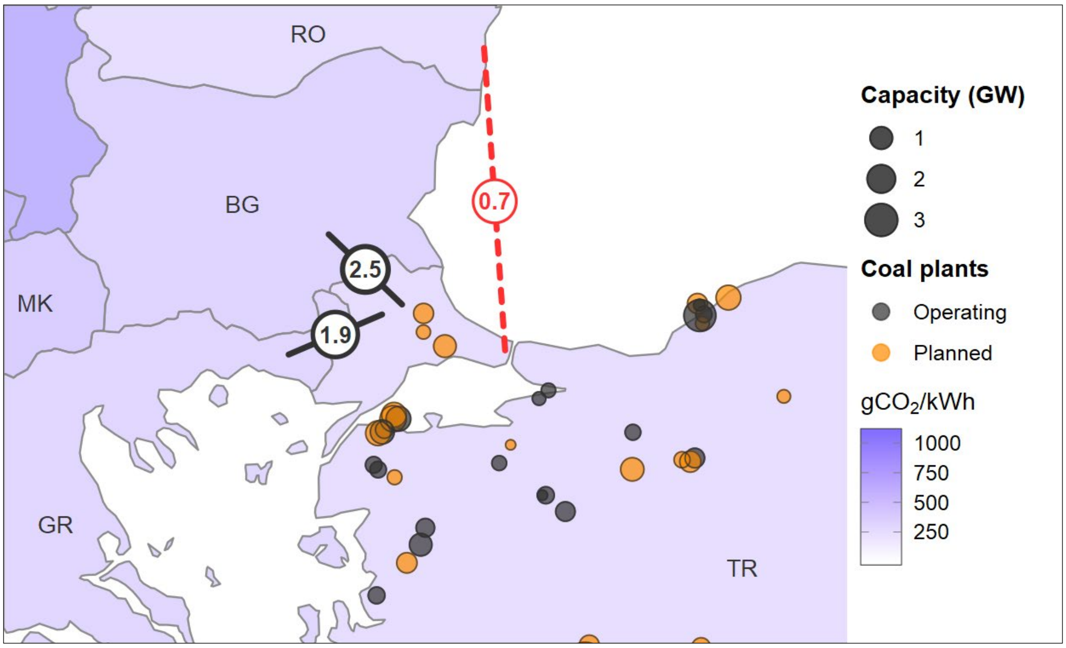
- Turkey ↔ Greece / Bulgaria
- Morocco ↔ Spain
- Ukraine ↔ Poland / Slovakia / Hungary / Romania
- Western Balkans ↔ Croatia / Hungary / Romania / Bulgaria / Greece
- Egypt ↔ Greece

We do not provide further analysis on Russia or Belarus, despite both being major sources of electricity imports to the EU. In brief, the Baltic states - importers of Russian and Belarusian electricity - are seeking to reduce their reliance on these imports, instead pursuing projects to synchronise their networks with the EU grid by 2025. The other major recipient of Russian electricity is Finland, which has no plans to increase interconnection capacity with Russia. The increase in imports is partly caused by the delays in commissioning the Olkiluoto-3 nuclear reactor, which is currently due to connect to the Finnish grid in summer 2020.

Turkey ↔ Greece & Bulgaria

FIGURE 8:

Schematic map of interconnection between Turkey and neighbouring EU member states



Shading indicates average carbon intensity of electricity generation. All cross-border power lines are represented as a single line, with total transfer capacity indicated (GW). Planned connections (dashed) are shown in red. Points indicate operating and planned coal power stations in Turkey (GEM).

Current trade

Turkey exported 2.8TWh of electricity to its EU neighbours in 2019 (2.7TWh to Greece, 0.1TWh to Bulgaria), worth €177m. Turkey was the 4th largest source of electricity imports to the EU ETS, and Greece the 3rd largest importer. We estimate gross imports from Turkey accounted for 5% of all CO2 from electricity imports. Over the same period, Turkey imported 1.1TWh almost entirely from Bulgaria, making it a net exporter to the EU, and almost a pure exporter to Greece. This is suggestive of a potential flow loop, with Bulgaria exporting to Greece, via Turkey. However, even if this is the case, the majority of Turkish exports to Greece must originate in Turkey.

Energy development plans

Using data from 2018, we estimate that Turkey has a slightly lower average grid intensity than both Greece and Bulgaria. In its 2012 energy efficiency strategy,

Turkey announced a target to reduce the intensity of its electricity by 20% by 2023, however, an 2016 IEA[14] review found “no concrete steps taken”. Instead, renewable energy installations have stalled, and a radical increase in coal capacity is planned. According to GEM, an enormous 34GW of coal power is at some stage of planning, adding to 19GW already operational, and placing Turkey third behind only China and India in its intent to add new coal capacity. This has already started, with 7GW permitted or under construction.

In contrast, power sector emissions in **Greece** are declining (approx 40% between 2007-2016), and further decarbonisation plans have been outlined. These include phasing-out all 4GW of coal power by 2028[15], and a commitment to increase the share of renewable electricity consumption to 61% by 2030. The latter will require significant investment. The carbon intensity of **Bulgaria**’s electricity will likely fall steadily, with the latest NECP draft[16] recommending a 27% share of renewable generation by 2030 (up from 15% in 2017), and no new coal capacity planned.

Future of interconnection

Turkey is connected to neighbouring EU member states with a substantial 4.4GW capacity (1.9GW Greece, 2.5GW Bulgaria). This means that after retiring its own coal fleet, Greece could feasibly import half the same capacity from Turkey. While our research revealed no plans to increase capacity with Greece or Bulgaria, we estimate both existing lines have spare capacity, with both operating at less than 20% of the physical maximum in 2018 (see Box 1). A new 700MW sub-sea connection with Romania has been proposed (Figure 8), and was included in Romania’s energy strategy for 2011-2020.

Carbon pricing in Turkey?

An Emissions Trading Scheme is being considered. So far the Government has only adopted legislation for monitoring, reporting and verification (in 2012), with monitoring commencing in 2016 [6].

Summary

Turkey is a net electricity exporter to the EU, almost entirely to Greece. We estimate these exports emitted over 1.3 million tonnes CO_2 last year. Unlike generators in Greece, Turkish power stations do not face a carbon price, and are unlikely to for several years. The power sectors of Greece and Turkey are quickly

14. Energy Policies of IEA Countries: Turkey 2016 Review

15. https://cordis.europa.eu/article/id/413274-greece-is-first-balkan-country-to-announce-a-coal-phase-out-date-the-revolution-has-already-s

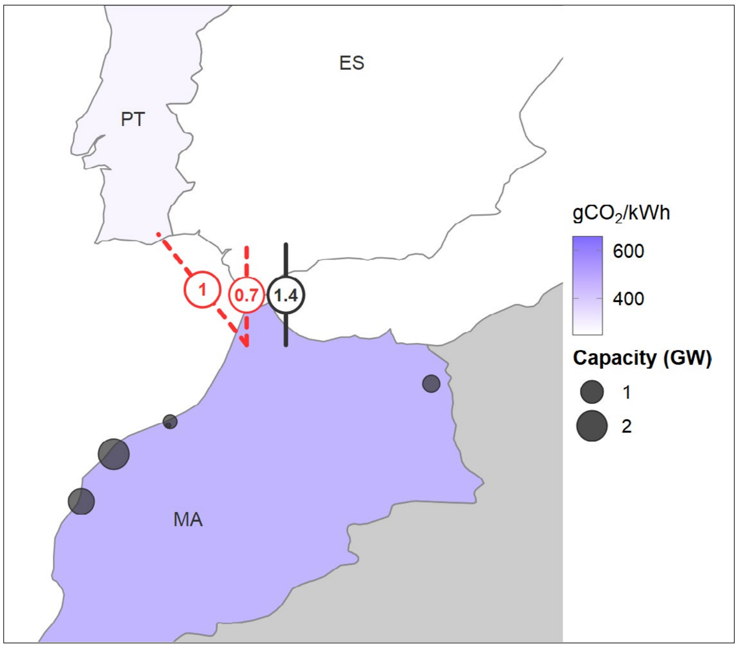
16. Pre-final version of Bulgarian NECP as presented during a hearing in the National Assembly, 19th December 2019

diverging, with Turkey on a path to increasing use of coal, and Greece quickly decarbonising. Sufficient interconnection capacity exists to replace a substantial amount of Greece's retiring coal fleet with coal imports from Turkey, repeating the pattern seen with Spain and Morocco. A border carbon adjustment on electricity would remove the cost advantage for coal generators in Turkey, hence reducing carbon leakage, while protecting investments in renewables in Greece.

Morocco ↔ Spain & Portugal

FIGURE 9:

Schematic map of interconnection between Morocco and neighbouring EU member states



Shading indicates average carbon intensity of electricity generation. The capacity of cross-border power lines is indicated (GW). Planned connections (dashed) are shown in red. Points indicate operating coal power stations in Morocco (GEM).

Current trade

Europe's only existing connection with North Africa is via subsea cables to Morocco. Until late 2018, these predominantly carried power from Spain to Morocco, however the direction has now reversed. From 2018 to 2019, net imports to Spain increased by 4.2TWh from -3.4TWh to 0.8TWh. Over the same period, Spain reduced domestic coal generation by a much larger 24.6TWh[17], meaning the interconnector is far from fully compensating for this. However, coal power in Morocco will out-live that in Spain, risking many more years of carbon leakage.

Future of interconnection

Two subsea cables with a combined 1.4GW connect Spain and Morocco. A memorandum of understanding was signed in February 2019 to build a third, 700MW cable, commissioned 'before 2026'. A new 1GW connection between Morocco and Portugal has also been proposed[18], with feasibility studies supposedly concluding in 2019, and completion possible before 2030. If delivered, these projects would increase the interconnection capacity between Morocco and the EU by 120%, to 3.1GW by 2030. However, recognising the threat of coal power imports, the energy ministers of both Spain and Portugal have raised concerns about the lack of carbon pricing at the border.

Energy development plans

We estimate the carbon intensity of Morocco's electricity is ***twice*** that of Spain's (using 2017 data). The opening of the 1.4GW Safi coal plant in Morocco in December 2018 has likely increased that gap. How is this likely to develop? **Morocco** pledges in its INDC to limit total GHG growth to 24-57% between 2010 and 2030, and in the power sector is aiming for 52% renewable electricity by 2030[19]. **Spain** has a head-start, and is set to proceed much faster. Their draft NECP outlines an ambitious target of 74% renewable electricity by 2030, rising to 100% by 2050. Electricity generated in **Portugal** has a slightly higher carbon intensity than Spain, but still far below Morocco. Portugal also plans to decarbonise swiftly, phasing-out its 2GW remaining coal power by 2023, and growing renewable electricity to 80% by 2030. These renewables in Portugal and Spain will mostly satisfy domestic demand, and are unlikely to export to Morocco due to the correlation with wind and solar there. This means the main function of the interconnector will likely become importing Moroccan coal power in periods of high demand when solar or wind are not producing.

Summary

Between 2018 and 2019, Spain reduced domestic coal generation by 25TWh, yet increased net imports from Morocco by 4TWh. This is a clear sign of carbon leakage. On average, the imported electricity was twice as carbon intensive as the domestic supply, but no price was paid on these emissions, and carbon pricing is

17. Red Eléctrica de España, REData.

18. This project is also mentioned in a joint declaration signed between Portugal, Spain, France, Germany, and Morocco.

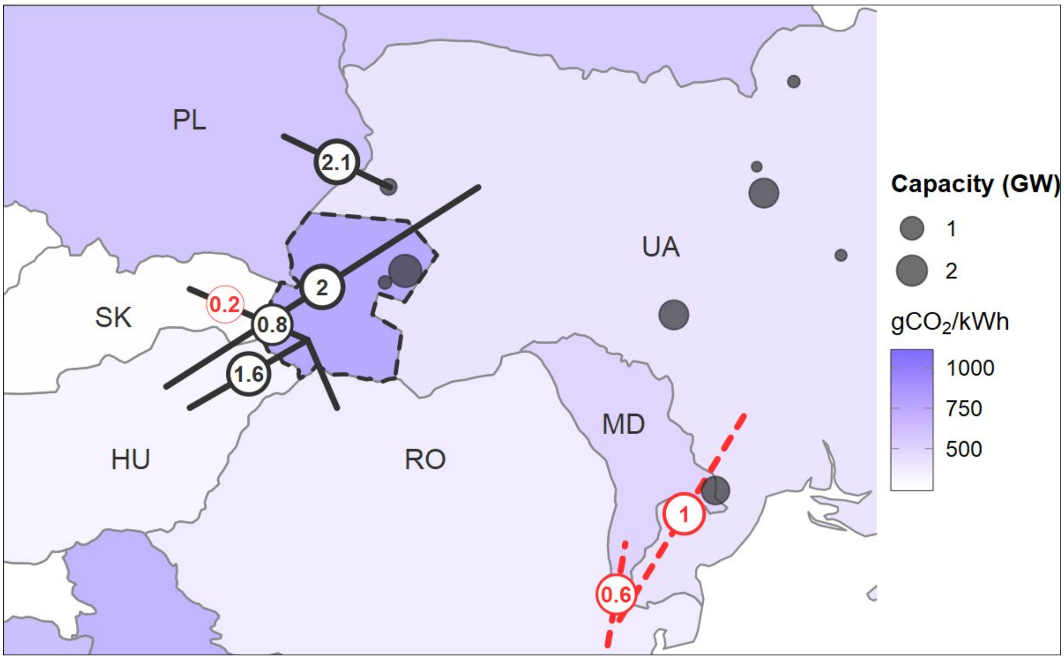
19. Energy Policies Beyond IEA Countries: Morocco 2019 Review

not forthcoming in Morocco. The differing speed of decarbonisation in Morocco compared to Spain and Portugal means the carbon intensity gap is likely to grow in the 2020s, and the interconnectors will continue to import coal power. Simultaneously, the proposed expansion of interconnection risks the Iberian becoming more exposed to coal, offsetting GHG emissions saved by domestic power decarbonisation and coal phase-out. A border carbon adjustment would protect against this, and support the deployment of clean alternatives in all three countries.

Ukraine ↔ Hungary / Romania / Poland / Slovakia

FIGURE 10:

Schematic map of interconnection between Ukraine and neighbouring EU member states



Shading indicates average carbon intensity of electricity generation. The Burtshyn island (separated from the rest of Ukraine) is shown as a separate region, with a dashed border. All cross-border power lines are represented as a single line, with total transfer capacity indicated (GW). New connections (dashed) and planned increases are shown in red. Points indicate operating coal power stations in Ukraine and Moldova (GEM).

Current trade

Ukraine has physical connections with 4 neighbouring EU member states. In 2019, Ukraine exported 7.2TWh to these countries, and imported 3.0TWh, making it a net exporter to the EU. Electricity imports from Ukraine accounted for 22% by volume, but 27% in terms of CO2 emissions. As shown in Figure 2, the largest net flow from Ukraine is into Hungary, followed by Romania and Poland, whereas Slovakia provides nearly all flows in the other direction. It's possible this electricity flowing into Ukraine from Slovakia is in transit to a third country, e.g., Romania, rather than a genuine import by Ukraine, which would make Ukraine an even more significant exporter to the EU.

Future of interconnection

Ukraine has the largest interconnection capacity with EU neighbours of any non-EU country (Table 2). A small increase in the interconnection with Slovakia is planned, in the form of a new 400kV line. Slovakia, Romania, and Hungary are connected to the so-called 'Burshtyn island', a section of grid disconnected from the rest of Ukraine since 2002, operating synchronously with its ENTSO-E neighbours, and dominated by the Burshtyn (2.3GW) and Kalush (200MW) coal power plants. Romania and Hungary have second connections to the main (eastern) grid of Ukraine. The connection with Poland allows access specifically to Ukraine's 510MW Dobrotvirska coal power plant, and has only flowed in the direction of Poland (since 2015). This means ***Ukrainian electricity exports to Hungary, Poland and Slovakia are almost entirely coal powered.***

Energy development plans

Ukraine as a whole has a substantial 21.8GW of operational coal capacity, with a further 660MW at the pre-permit stage in the eastern section of its network, connected with Romania and Hungary. In 2017, coal had a 32% share of generation, with the remainder largely from nuclear (55%), hydro (7%), and natural gas (5%) (IEA). However, as explained above, most connections with the EU are with coal-dominated sections of grid. The Burshtyn and Dobrotvirska power stations have emissions factors of 1080 and 1110g/kWh respectively [3], meaning they generate some of the highest carbon electricity in Europe. Given the Burshtyn island represents the first step toward integrating the wider Ukrainian grid with ENTSO-E, the Burshtyn power station is expected to remain operational for the foreseeable future.

The dominant importer of this extremely high-carbon electricity from Ukraine is **Hungary**. They have announced the phase-out of all 1GW of coal by 2030, and plan to increase the share of renewable electricity to 20% by the same year (from 7% in 2016), eventually moving beyond fossil generation completely. Next is **Romania**, which also generates lower carbon electricity than Ukraine. **Slovakia** has also announced a coal phase-out, with its remaining 800MW retiring by 2023.

Carbon pricing in Ukraine?

In 2014, the Ukrainian government signed an EU Association Agreement[20], obliging them to develop an emissions trading scheme within 2 years of it coming into force, which happened on 1st September 2017. This scheme is yet to materialise. Ukraine does however have a functioning carbon tax, which applies to power generation. As of 1st January 2019, the government agreed to increase the rate from UAH0.41/tCO2 to a still very low UAH10/tCO2 (€0.31/tCO2), and communicated an intention to increase it by UAH5 per year to reach UAH30 (~€1/tCO2) in 2023[21].

Summary

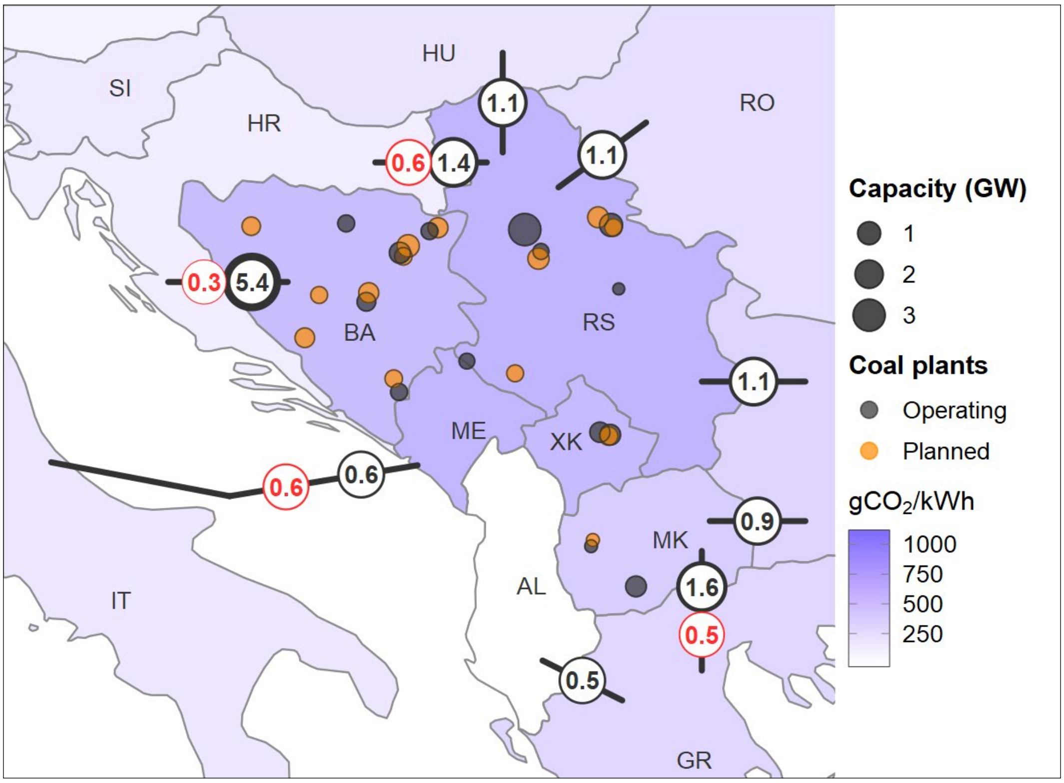
Connections of Hungary and Poland with Ukraine are being used to import some of Europe's highest carbon electricity into the EU. The carbon price paid on this electricity at the point of generation is a tiny fraction of what would be paid in neighbouring EU member states. The strong disparity in carbon price at the border with Ukraine is expected to persist, and gap in carbon intensities across these connections is expected to widen. Ukraine continues to operate heavily polluting thermal power plants, while the main importer of this - Hungary - aims to phase-out coal and increase its share of renewable electricity by 2030. The coal phase-out in Slovakia might also cause this trade flow to flip, risking further Carbon leakage.

20. https://trade.ec.europa.eu/doclib/docs/2016/november/tradoc_155103.pdf
21. Carbon Pricing Dashboard, World Bank, Dec 2019.

Western Balkans ↔ Greece / Croatia / Hungary / Romania / Bulgaria

FIGURE 11:

Schematic map of interconnection between Western Balkan states and neighbouring EU member states



Shading indicates average carbon intensity of electricity generation. All cross-border power lines are represented as a single line, with total capacity indicated (GW). New connections (dashed) and planned increases are shown in red. Points indicate coal power stations in the Western Balkans (existing and planned, GEM).

Current trade

The Western Balkans (WB) exported 6.3 TWh to the EU in 2019, ranking it third - as a group - behind Russia and Ukraine. Over the same period, 6.9TWh was imported from EU neighbours, making WB a net importer overall. The largest flows into the EU occurred across the borders of North Macedonia/Greece (2.7TWh) and Bosnia & Herzegovina/Croatia (1.6TWh). The largest flows into the WB occurred across the borders of Bulgaria/North Macedonia (1.8TWh), Bulgaria/Serbia (1.3TWh), and Romania/Serbia (1.0TWh).

Despite being a net ***importer of electricity by volume***, the Western Balkans are a net ***exporter in terms of CO2*** emissions to the EU. We estimate the 6.3TWh supplied to the EU by the WB emitted 5.2MtCO2, or 20% of CO2 from all electricity imports. On the other hand, EU exports to WB emitted 3.6MtCO2. This reflects the large differences in carbon intensity across EU/non-EU borders in this region, with Serbia and Bosnia & Herzegovina among the most carbon intensive considered in this analysis.

Future of interconnection

The WB already has a large 13.8GW interconnection capacity with EU neighbours (Table 2). Our research revealed plans for 2GW of new interconnection capacity. This includes additional lines connecting Serbia and Croatia, North Macedonia and Greece, and an eventual upgrade (to 1.2GW) of the recently commissioned 600MW connection between Montenegro and Italy.

Energy development plans

Coal power projects totalling 6.3GW are at some stage of planning in the WB, representing an 86% increase on the 7.3GW already operational. **Bosia & Herzegovina** accounts for 4.1GW of this planned coal capacity, while their INDC outlines only a modest annual 3% increase in the share of renewable electricity, from around 25% (in 2017, IEA). The remaining planned coal capacity is mostly in **Serbia**, which has a similar share of renewable electricity to Bosnia & Herzegovina, and has pledged to reduce GHG emissions by 10% by 2030. **Macedonia**'s GHG emissions increase under all scenarios in their INDC, with no target set for renewable electricity, currently providing ~23% (2017, IEA). It is therefore likely that fossil sources will continue to dominate power generation in these countries until at least 2025. Looking towards countries likely to be importing high-carbon electricity from WB, **Greece** and **Croatia** have stated their intentions to increase renewable electricity to 61% and 64%, respectively, by 2030. Greece has also pledged to phase-out coal power entirely by 2028.

Recently connected **Italy** has announced a coal phase-out by 2025, and aims to increase its share of renewable electricity to 55% by 2030 (from 40% in 2018, IEA). **Montenegro** generates a similar share of electricity from renewables, but the rest is entirely coal, meaning the grid intensity is higher. This gap is likely to increase as decarbonisation proceeds faster in Italy.

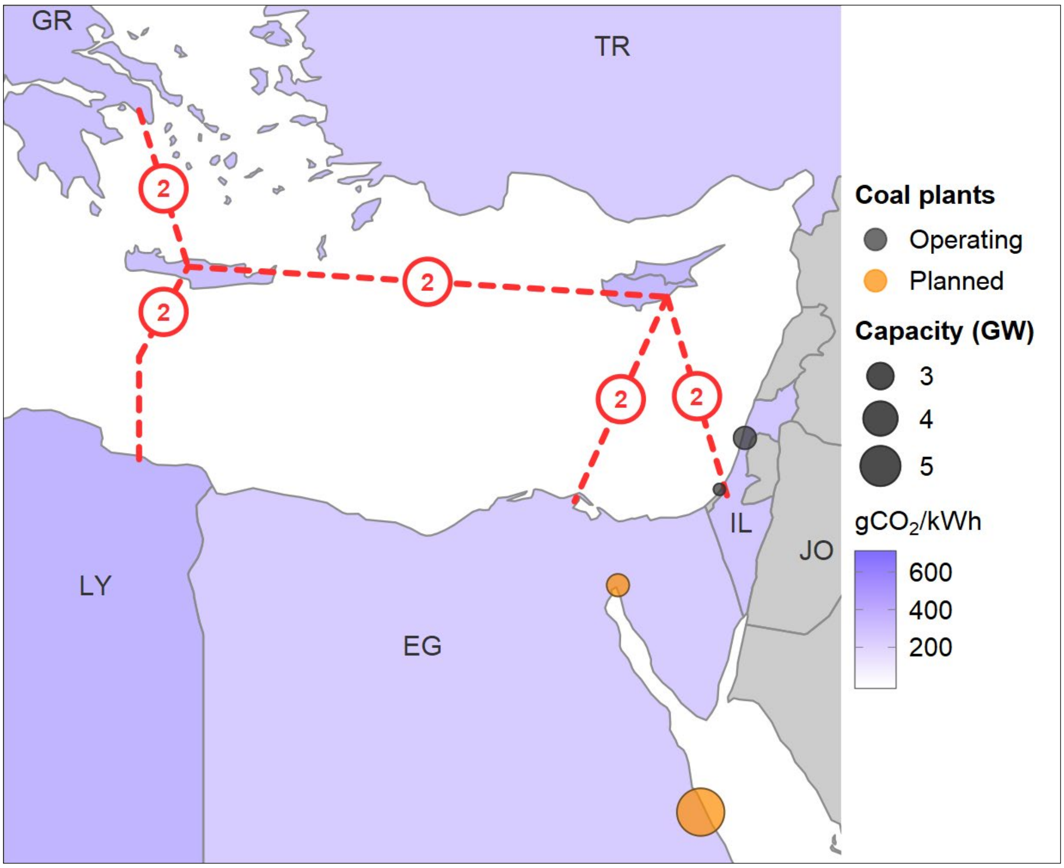
Summary

The Western Balkans are well connected to EU neighbours, and electricity trades are relatively large in both directions. Despite being a net importer of electricity from EU neighbours, WB are a net exporter of carbon emissions, due to high grid intensities. The energy and climate targets of WB countries indicate that fossil sources will continue to dominate power generation until at least 2025. Meanwhile, the largest EU importers of WB electricity (Greece, Croatia, and potentially Italy) have declared ambitions for much faster power sector decarbonisation. Increases in the already high volumes of interconnection increases the risk that emissions saved through EU power sector decarbonisation will be 'offshored' to the WB.

Egypt ↔ Cyprus & Greece

FIGURE 12:

Schematic map of proposed interconnection between Libya/Egypt/Israel and EU member states Greece and Cyprus



Shading indicates average carbon intensity of electricity generation. Points indicate coal power stations in the non-EU countries concerned (existing and planned, GEM).

Future of interconnection

The EuroAfrica and EuroAsia projects propose to build 2GW connections between Greece and Egypt, Israel, and Libya, via Cyprus and the Greek island of Crete. The section linking Greece to Egypt is due to be commissioned in 2021[22].

Energy development plans

Using 2017 data, we estimate that **Egypt** had a slightly lower grid intensity than Greece (485 vs 560gCO2/kWh). However, power generation in Egypt is firmly on a fossil trajectory, whereas Greece has already begun decarbonising. In Egypt, Government bans on coal imports and coal power generation were lifted in 2014 and 2015 respectively, and two large coal power plants are currently proposed totalling 10.6GW, with a tender already awarded for the enormous 6.6GW Hamrawein plant. Egypt is also experiencing a natural gas boom. The discovery of the Zohr gas field in the Mediterranean has doubled Egypt's natural gas reserves, and prompted investment in new gas generation. Siemens has been contracted to construct and operate the three biggest CCGT plants in the world (3 x 4.8GW), increasing Egypt's installed capacity by over 40%. These developments vastly outweigh progress on renewable installations, which only made up 7% of installed capacity and 8% of generation in 2018[23]. The Government has set renewable generation targets of 22% and 42% by 2022 and 2035 respectively. Israel has 4.9GW of operational coal, but has announced this will close before 2025, and is likely to be replaced by gas. Libya has no coal capacity, but still produces carbon intensive electricity owing to its exclusive use of oil and gas.

In contrast, power sector emissions in Greece are declining (~40% decline 2007 - 2016, draft NECP), and faster decarbonisation plans have been outlined. These include phasing-out all 4GW of existing coal power by 2028, and a commitment to increase renewable electricity consumption to 61% by 2030. **Cyprus** currently generates 9% of its electricity from renewables (2017, IEA), but has expressed an ambition to increase this. The 2015 Renewable Energy Roadmap [7] co-produced by the Cypriot Government and IRENA, concluded that between 25-40% is possible by 2030.

Summary

The EuroAfrica and EuroAsia interconnectors will connect the decarbonising grid of Greece, and Cyprus, to new fossil generation in Egypt, coal power in Israel, and gas and oil power plants in Libya. The electricity imported will not pay a carbon price. As Greece phases-out 4GW of coal power by 2028, and Egypt constructs

22. https://www.euroafrica-interconnector.com/historicagreement/

23. Egyptian Electricity Holdings Company, Annual Report 2017/18 (p11) http://www.eehc.gov.eg/eehcportal/eng/YearlyReport/finalEnglish.pdf

10.6GW, the 2GW interconnector could facilitate a significant fraction of emissions being offshored rather than saved. While the interconnector will deliver benefits for renewables and system security on both sides, without a border adjustment it will incentivise fossil generation Egypt, Israel, and Libya. It will also slow the transition in Greece and Cyprus by providing a source of cheap, carbon intensive energy. A border carbon adjustment would accelerate the deployment of clean alternatives on both sides of the Mediterranean.

A Border Carbon Adjustment on electricity

We propose that a border carbon adjustment is introduced for electricity entering the EU ETS region, until the trading partner in question implements an equivalent emissions trading scheme or carbon price of their own.

Here we explain why this would further the goals of the EU ETS, and discuss some key design features that it is important to get right for the full benefits to be delivered.

Benefits

A BCA on electricity would:

- **Defend the integrity of EU climate policy** by preventing the offshoring of power sector emissions.
- **Level the playing field** for all generators operating in the same markets.
- **Protect progressive investments of governments and companies**. We have shown that some of the highest-ambition EU member states will remain exposed to imports of carbon intensive electricity, just when investment in low carbon alternatives is needed in order to achieve climate goals.
- **Generate revenue for the EU**. Revenue that could be used to support environmental projects or monitoring in neighbouring countries (generating political capital), or protect vulnerable customers from any electricity price increases.
- **Incentivise carbon pricing in neighbouring countries**. Rather than see revenue streams going to the EU, they may wish to redirect to themselves. This could instigate a domino effect of carbon pricing in EU neighbours.

Unintended consequences

While the benefits are significant, introducing a BCA could result in some unintended consequences, specifically:

- **Resource shuffling**. This is a specific type of carbon leakage, where an exporter lowers their obligation by substituting electricity with lower-carbon intensity, while exporting high-carbon electricity with other trade partners. The risk of resource shuffling is highest in markets with large variations in carbon intensity, and a large global scope. While the former is true for electricity production, the latter is not, due to physical constraints on transporting power. There is some evidence for resource shuffling in the Californian ETS (which includes electricity) [8], where some load-serving entities have divested from coal contracts. Another channel for resource shuffling is the direct purchase of low-carbon electricity for import, by mechanisms like power purchase agreements or renewable energy certificates.
- **Energy price increases**. Detailed modelling would be needed to assess the effect on electricity bills. Depending on the extent to which importers absorb the additional carbon costs, some may be passed down to end users. The revenues generated by the BCA could be used to mitigate this consequence, as the costs should be met by polluters, not citizens.

Design

A BCA on electricity could take one of two forms: a tariff on imports at the border, or the requirement that importers purchase allowances to cover embodied emissions. The only operational BCA on electricity - under the Californian ETS - takes the latter approach. Under that scheme, "first deliverers" of electricity imports[24] are liable to purchase credits to cover the estimated emissions. A separate Sandbag publication compares the two proposed methods, and explores in more detail the issues around BCAs in the EU in general.

Much attention has been paid to whether a BCA would comply with international trade law. More specifically, by causing imports to be treated differently, it's possible a BCA would not comply with the non-discrimination principle of GATT (General Agreement on Tariffs and Trade) Article III. A recent review [9] offers insights into the likely issues, and highlights how the legal validity would depend on specific design features. It is our view that a BCA on electricity could be designed in a compliant way. In short, this is because the carbon content of imports is measurable, and the EU ETS provides an explicit carbon price at which to charge them.

24. Cal. Code Regs. tit. 17: In the Californian ETS, according to section §95811(b), "first deliverers" of electricity include generating facilities, operators of electricity generating facilities located in California, and electricity importers. According to section §95812(c), importers are liable for "All emissions reported for imported electricity from specified sources of electricity that emit 25,000 metric tons or more of CO2e per year are considered to be above the threshold. All emissions reported for imported electricity from unspecified sources are considered to be above the threshold".

Here we offer some design recommendations, which apply regardless of the specific mechanism adopted (ETS or tariff). These would help deliver the benefits highlighted above, mitigate the unintended consequences, and minimise the risk of legal challenge.

Three key features:

1. **Accurate calculation of the carbon intensity of imports**

   This is fundamental to setting the level of adjustment, and the choice of method has important legal implications. The carbon intensity of electricity generation varies enormously, from country to country and hour to hour. Consequently, a fair mechanism would measure the carbon intensity of imports in near real-time. This would require intraday (~hourly) data on generation by fuel type, which is available from some but not all neighbouring countries via ENTSO-E and national TSOs.

   Strictly speaking, the most accurate estimate of carbon intensity would be that of the real-time marginal unit in each exporting country. That is because the direction of flow is determined by the differences in wholesale price - flowing from low to high - and the marginal unit generates in the lower price region to satisfy the additional demand created by the interconnector. However, the highly connected nature of the European grid makes the marginal intensity very challenging to calculate in practice, despite recent progress [1].

   In lieu of hourly generation data, or an estimate or marginal intensity, in this analysis we simply applied an average carbon intensity for each exporting country. In Box 2 we provide a worked example of how a similar approach could be put into practice. Using an average carbon intensity over some period has several benefits. It is simple, reducing the administrative burden; and it is transparent, which could ease political opposition. An average will *underestimate* the real carbon intensity on systems where the marginal technology is carbon intensive. However, this may be beneficial. GATT Art III.2 states that no taxes “in-excess” of internal taxes should be applied to imports of like products. A conservative estimate of carbon would therefore mitigate against this being breached.

   Perhaps the most difficult aspect of trade law to satisfy in this design is the need to avoid country-specific treatment. The calculation of carbon intensity as we have described it is inherently country specific. However, instead of national averages, estimates could use generation data for a country, combined with international benchmarks for the carbon intensity different technologies. Also, it has been suggested that foreign producers should be afforded the ability to document actual emissions, demonstrating where they are lower than an international average. This would also add leverage to the BCA.

In ENTSO-E, there is a good basis for providing the detailed generation data needed to estimate the carbon intensity of imports. The provision of such data would need to be part of any legislative proposal. Finally, it is worth noting that these carbon calculations could be applied ex-post, if there was a lag in data availability. Forecasting of the approximate generation mix at the hourly level, and therefore the likely border adjustment rate, is within the capability of most market participants.

2. No rebates for EU generators

We do not believe that rebates should be given to EU generators for their carbon costs, as the objective should be that all power generated or consumed in the EU pays a carbon price. A border carbon adjustment would introduce this for imports. Removing the cost for EU exports in the form of a rebate would be a protectionist measure, and could incentivise emissions increases.

3. Time-limited and participatory

The proposed BCA is meant to adjust for the difference in climate policy cost between EU and non-EU electricity generators, which we have shown is causing carbon leakage by incentivising coal generation over the EU border. It should therefore only remain in place as long as this difference exists. To avoid becoming entrenched, the expiration of the BCA should be prescribed, and only extended if warranted to prevent carbon leakage. Also, the methodology should be transparent and accessible for affected countries, and the border rate should account for equivalent policy costs in those countries. For example, owing to its domestic carbon price, Ukraine would currently receive a small reduction in its border adjustment, increasing in-step with the level of the domestic price.

BOX 2

Example: Turkey in 2018

Border tariff

We estimate the carbon intensity of the Turkish grid in 2017 was 492tCO2/GWh. Taking an indicative ETS price for 2018 of €24/tCO2 would give a flat-rate BCA tariff for Turkey in 2018 of €12/MWh (24 [€/tCO2] x 0.492 [tCO2/MWh]). The same method could be applied to any time period for which an estimate of carbon intensity is available, the shorter the better, to capture real variations in carbon intensity.

ETS allowances

Using the above emissions factor, gross imports from Turkey to Greece in 2018 (2.9TWh) emitted 1.4MtCO2. The importer (interconnector) of this electricity would therefore be liable to surrender 1.4m ETS allowances.

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9) Mehling. A., et al., Designing Border Carbon Adjustments for Enhanced Climate Action, American Journal of International Law, Vol 113, 3
10) "The A-B-C of BCAs", Sandbag 2019, https://sandbag.org.uk/project/the-abc-of-bcas/

Annex I: Annual electricity trade data

TABLE A1:

Flows of electricity and associated CO2 emissions in 2019, between EU (ETS) member states and non-EU countries

Border	Gross import (TWh)	Gross export (TWh)	Net import	CO2 of gross imports (Mt)	CO2 of gross exports (Mt)	Net CO2
Albania - Greece	0.5	0.8	-0.3	0.0	0.5	-0.5
Belarus - Lithuania	3.0	0.2	2.8	2.4	0.1	2.4
Bosnia & Herzegovina - Croatia	1.6	0.7	1.0	1.6	0.2	1.4
Kaliningrad (Rus) - Lithuania	2.7	0.0	2.7	1.3	0.0	1.3
Montenegro - Italy	0.0	0.0	0.0	0.0	0.0	0.0
Morocco - Spain	1.2	0.4	0.8	0.8	0.1	0.7
North Macedonia - Bulgaria	0.0	1.8	-1.8	0.0	1.1	-1.1
North Macedonia - Greece	2.7	0.2	2.5	1.9	0.1	1.8
Russia - Estonia	1.5	0.3	1.2	1.1	0.3	0.8
Russia - Finland	7.6	0.0	7.6	5.8	0.0	5.8
Russia - Latvia	1.1	0.0	1.1	0.8	0.0	0.8
Serbia - Bulgaria	0.1	1.3	-1.3	0.1	0.8	-0.7
Serbia - Croatia	0.4	0.4	0.0	0.4	0.1	0.4
Serbia - Hungary	0.5	0.8	-0.3	0.5	0.3	0.3
Serbia - Romania	0.5	1.0	-0.5	0.6	0.5	0.1
Turkey - Bulgaria	0.1	1.8	-1.7	0.1	1.1	-1.1
Turkey - Greece	2.7	0.0	2.7	1.3	0.0	1.3
Ukraine - Romania	2.0	0.0	1.9	1.1	0.0	1.1
Ukraine - Hungary	3.8	0.0	3.8	4.1	0.0	4.1
Ukraine - Slovakia	0.0	2.9	-2.9	0.0	0.8	-0.8
Ukraine - Poland	1.4	0.0	1.4	1.5	0.0	1.5

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