A unilateral climate and supply market model

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Abstract

In the midst of its respective energy transitions, the European power sector faces several challenges. Low levels of both European Union Emissions Trading Scheme (EU ETS) allowance prices and wholesale power prices fuelled concerns over drivers for decarbonisation and long-term generation adequacy. While some countries have introduced capacity remuneration mechanisms to ensure generation adequacy, reforming the EU ETS has proven to be difficult. This paper proposes a unilateral approach by a state introducing a CO_2 levy that internalises and prices CO_2 at a national level. The suggested climate and supply market model thereby incentivises and rewards production from CO_2-neutral sources during times when it does not cover the targeted share of production. Prior to describing the model in detail, this paper discusses the theoretical policy steering background and the problems associated with current energy policies. This is followed by a discussion on the legal aspects of the model, its compatibility with international as well as EU law. The model is explored further by using Switzerland as an example, showing that a cross-sector carbon price can be implemented at acceptable costs for consumers. For a broader picture, other CO_2 taxation models are briefly presented. Last but not least, the paper examines varieties of the model and the adaption potential for European countries.

Energy policy and the concept of direct and multiple steering

It is the objective of modern energy policies to decarbonise without jeopardising other policy objectives. Within this context, one usually refers to the energy policy objective triangle of i) security of supply, ii) affordability and iii) sustainability. In order to tackle climate change and fight global warming, governments strive to reduce emissions. Carbon dioxide (CO_2) in particular has become a common standard to measure the sustainability of a given system and quantify emissions growth or reductions. CO_2 is emitted by a variety of sources from different sectors; the power and transport sector being amongst the most prominent. Depending on the sector, there are different energy policies and strategies to initiate emission reductions.

Focusing on the power sector, one can differentiate between two theoretical policy concepts: direct and multiple steering. The former centres around the idea of pricing and internalising CO_2 or, more generally, greenhouse gas emission costs. In practice, this can be put into effect by introducing a CO_2 tax with an emission trading system such as the European Union Emissions Trading Scheme (EU ETS). Given the declared objective of decarbonisation, this approach can be seen as plausible and straightforward. Putting a price on CO_2 emissions should reduce the overall output and thus give rise to further decarbonisation. The concept thereby relies on market effects to work out ways to reduce emissions. This somewhat liberal approach directly targets CO_2 emissions, which is why we refer to it as 'direct steering'.

In contrast, an indirect steering method would indirectly work towards achieving the same objective, for example by setting other incentives to reduce emissions or promote alternatives which entail less or no emissions. Examples would include taxes on emission-intensive fuels or support for renewables.

If multiple policy measures coincide and interact with the common objective of reducing emissions, one speaks of a multiple steering model (Everts et al., 2016, pp. 119-120)[1]. For example, a CO_2 tax and trading system can be a part of a multiple steering model. Indeed, most governments nowadays have a range of policies in place that not only price CO_2 but also incentivise emission reduction in other ways. It is an advantage of this multiple steering model that policy makers have greater control over emission reduction contributions of different sectors, technologies used and general concepts. There are, however, several problems with those designs which currently prevail.

Current issues of the EU ETS

There is an extensive body of literature on the weak performance of the EU ETS and the continuous drop in price of allowances since the financial crisis; from about 30 EUR/tCO_2 to below 5 EUR/tCO_2[2]. The low allowances price level has led to circumstances in which there exist great uncertainty as to whether the EU ETS is still and can be a main driver for decarbonisation, despite being designed to fulfil exactly this role (Marcou et al., 2016, pp. 7–11). In general, scholars regard the price level as too low to fulfil the intended

[1] Multiple steering models usually include direct and indirect measures.
[2] Koch et al. provide a concise overview of current state of research on the EU ETS and the causes of the price drop (Koch et al., 2014)

functions (Abrell et al., 2016, p. 2; Rogge et al., 2011; European Commission, 2014). It has been argued that at the current price level, costs of negative externalities stemming from carbon emissions are no longer properly internalised (Carbon Market Watch, 2015, p. 4). Further, the price of allowances is too low to trigger investments in low carbon technologies and facilitate innovation (Carbon Market Watch, 2015, p. 4; Hepburn et al., 2016, p. 1; Rogge et al., 2011).

This points towards the prevailing problems of the EU ETS and a necessity for reform. However, reforming the EU ETS has proven a difficult political matter, given the diverse interests of the stakeholders and parties involved. Currently, there is an ongoing reform process of the EU ETS for which the European Parliament voted and on which the European Council recently agreed a position (European Council, 2017). However, observers remain sceptical that the proposed changes will be sufficient to end the run of very low allowance prices (Boffey, 2017; Rattay, 2017).

This run of very low allowance prices (on average 6.2 EUR/tCO_2 during the last five years)[3] has also had subsequent effects. It is part of the concept of the multiple steering model to maintain some level of price neutrality with respect to wholesale power prices. But CO_2 pricing systems such as the EU ETS have a price-increasing effect on wholesale power prices, whilst the deployment of low marginal cost renewables have a price-decreasing effect, which is why both policies together have the potential of retaining overall price neutrality. Power prices have fallen drastically since the financial crisis and the price decline of CO_2 allowances and the deployment of low marginal cost renewables have been found to be the most contributing factors to this wholesale power price drop in Germany (Bublitz et al., 2017, p. 330; Everts et al., 2016, p. 122; Hirth, 2016, p. 11).

This development of wholesale power prices has in turn given rise to a phenomenon that has been labelled the 'missing money problem'[4] – a problem which might threaten the long-term security of supply. If there is no investment rationale for investments in flexible generation capacity to balance intermittent renewable production or in conventional backup capacity, security of supply is threatened. As a consequence, many governments have recently introduced mechanisms to provide market

[3] Average ICE EUA futures 2012-2016 (Intercontinental Exchange, 2017)
[4] The 'missing money problem' describes a situation in an energy-only market where low power prices and few price spikes do not provide sufficient (long-term) investment incentives in new (flexible) generation capacity. For a closer examination of the missing money problem see Crampton & Stoft (2006), Joskow (2008) and Newbery (2016).

participants with more incentives for building or maintaining generation capacities in order to guarantee that power demand can be met at all times. In theory, there should be no need for such market interventions, as the energy-only market should provide sufficient incentives for new capacity with scarcity price spikes. Therefore some see capacity remuneration mechanisms[5] as market distortions (European Commission, 2016; Hancher et al., 2015).

It should be noted at this point that the investment cycles in the energy industry are generally characterised by their long-term nature and high capital costs. Power plants have long life times with high upfront costs. The high capital intensity amplifies the impact of investment cycle changes and raises the risk of excessive or insufficient capacities (Lu et al., 2015, p. 3242). A low-price outlook as well as regulatory uncertainties may exacerbate this effect. This, combined with technology innovations and doubts over future market designs, has made traditional investments in power plants with an expected lifetime of half a century or longer rather complex.

The dearth in investment incentives has also been identified by the European Commission as a market failure. It is commonly acknowledged that further policy measures targeting emissions reductions and addressing concerns on (long-term) investment incentives are needed (European Commission, 2016, p. 4). Electricity supply is now more than ever a vital good in modern societies and is also in liberalised markets regarded as a public good[6] (Abbott, 2001, pp. 31–33; de Vries and Hakvoort, 2003, p. 2; Finon and Pignon, 2008, p. 3). Insufficient investments to guarantee long-term security of supply can thus be seen as a market failure, and capacity mechanisms represent a regulatory market intervention to address the issue.

Unilateral climate and supply market model

It has been shown that, regarding energy policy objectives, further policy measures targeting emissions reductions as well as addressing concerns over (long-term) investment incentives are needed. The authors propose a climate and supply market model that tackles not only the aforementioned

[5] Whilst capacity remuneration mechanisms can take different forms, they generally provide monetary payments towards generators for available generation capacity.
[6] A public good is commonly defined by the characteristics of nonrivalry and non-excludability, i.e. additional consumers add no additional costs (zero marginal costs) or reducing the good's availability for others and people cannot be excluded from consuming the good.

climate issue but also the insufficient investment incentives provided by the energy-only market.

Given the difficulties in reforming emission trading systems such as the EU ETS at a multilateral level, the climate and supply market model suggests a unilateral approach in which a state introduces a CO_2 levy that internalises the external costs of CO_2 emissions at a national level. It aims to correct the aforementioned market distortions caused by the low EU ETS price level and its subsequent effects by reintroducing a significant carbon price for the power sector. The model exempts the consumption of CO_2-neutral electricity from the new CO_2 levy, using national guarantees of origin (which already exist in many countries). The levy is introduced for suppliers who pass the costs on to the final electricity consumers. The EU ETS allowance price is taken into account, whereby the proposed CO_2 levy decreases when the EU ETS allowance price rises. The government, relevant ministry or institution in question sets the amount of the national CO_2 levy. This amount could be related to the social costs of carbon[7] or if available, existing CO_2 taxation on fuels.

In the suggested model, producers report their production to a certification body (in many cases already existing and responsible for handling guarantees of origin) and receive corresponding guarantees or certificates. Suppliers report to the certification body their deliveries to the final consumers and they pay the corresponding CO_2 levy or present national guarantees of CO_2-neutral origin instead[8]. Guarantees of origin are traded and as long as national CO_2-neutral production does not surpass the national demand, the guarantee price should roughly equal the CO_2 levy, since suppliers have either to pay the CO_2 levy or present the guarantees of CO_2-neutral origin[9]. It should be noted at this point that the certificate market remains independent and separate from the energy-only market on which electricity is traded.

In order not to discriminate against any form of production (thus adopting a principle of non-discrimination), the CO_2 levy applies generally to every unit

[7] The social costs of carbon is a scientific approach to measure the marginal costs of emitting an additional unit of CO_2 or CO_2 equivalents at a given time. The comprehensive scientific approach tries to incorporate climate change-related costs to estimate the social costs of carbon. See National Academies of Sciences, Engineering, and Medicine (2017) for a recent overview of social costs of carbon estimates.

[8] It is assumed that foreign guarantees of origin cannot offer exemptions as long as there is no such agreement.

[9] If national production exceeds final national consumption, the guarantees of origin have no additional value.

of electricity consumed within the country and does not differentiate between technologies – apart from the fact that only guarantees of origin from CO_2-neutral sources offer an exemption from the levy. Costs associated with CO_2 (such as the social costs of carbon) are usually expressed per tonne of CO_2. For the purpose of the climate and supply market model, a calculation to express the costs per unit of electricity (i.e. MWh) is necessary. The CO_2 intensity of either the national power sector or a European Economic Area (EEA) average can be used for this, resulting in the following formula which also incorporates the EU ETS:

$$\left(CO2\ levy\ \left[\frac{EUR}{tCO2}\right] - EU\ ETS\ price\ \left[\frac{EUR}{tCO2}\right]\right) * \ CO2\ intensity\ \left[\frac{tCO2}{MWh}\right] = CO2\ levy\ \left[\frac{EUR}{MWh}\right].$$

Consequently, the final CO_2 levy decreases if the EU ETS allowance price rises or the CO_2 intensity is reduced. In terms of decarbonisation, this means the model is designed to eventually become redundant if the decarbonisation of the power sector progresses and/or EU ETS reforms lead to a higher level of allowance prices. In order to reach the objective of a CO_2-neutral supply covering national demand, the guarantees of origin remain valid only for a specific period of time. This ensures that the investment incentives are set in a way that incentivises CO_2-neutral production when it is needed (i.e. during the winter months when demand is high). In this way, the climate and supply market model strengthens security of supply and makes a country less dependent on imports. As soon as CO_2-neutral sources satisfy the national demand during the chosen time periods, the model becomes obsolete. In the case of renewable power plants that are currently supported through some form of renewable support mechanism such as feed-in tariffs or quota schemes, the support scheme administrative authority (rather than the plant operator) should receive the certificates. Those guarantees can then be sold on the market and used, for example, to finance the costs of the existing renewable support scheme.

Currently, several governments in Europe have some form of CO_2 levy in place usually concerning fuels used in the transport or heating sector[10]. The emissions originating from electricity generation for electric radiators or vehicles is, in contrast, often only charged through EU ETS and there is no true cross-sector approach. CO_2 levies for fuels could be used and applied to other sectors, in order to implement a cross-sector carbon price. Such a

[10] Examples of carbon taxes can be found in Switzerland, Sweden, Finland and Denmark (see World Bank et al., 2016).

cross-sector approach would help to clear market distortions and effectively reward the most carbon-efficient approach in fields such as heating or mobility. Introducing the climate and supply market model inevitably leads to higher electricity bills for consumers, due to its financing structure. The exact costs would be country specific and depend amongst other things on the set CO_2 levy, the country's electricity generation mix, import/export balance, potential exemptions of some customers and the final consumption of electricity. In this regard, the test case presented in the next section shows an acceptable level of costs for consumers.

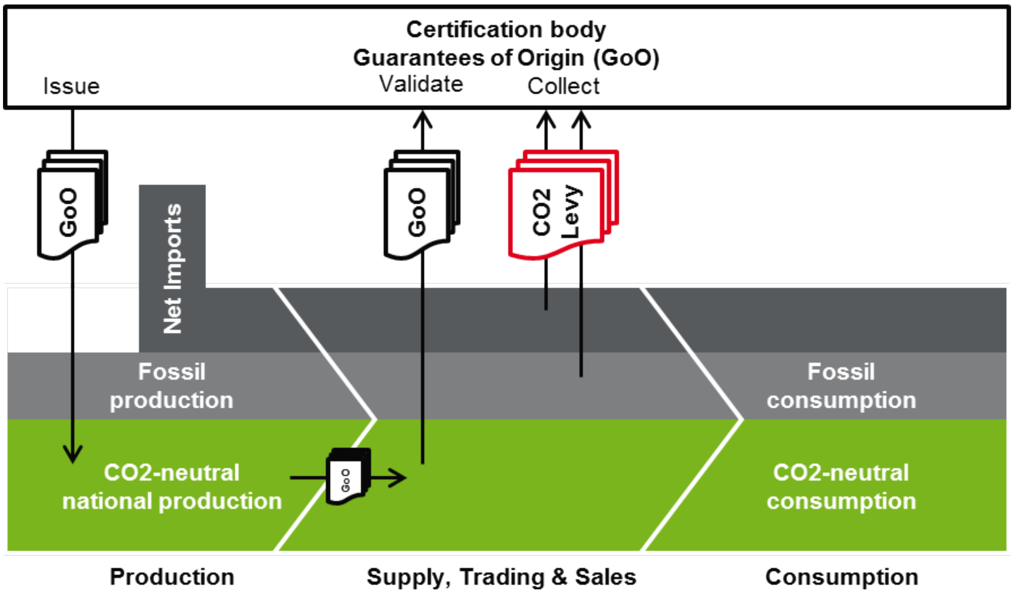

Figure 1: Climate and supply market model

Legal considerations with respect to international and EU law

The concept of pricing CO_2 on a unilateral level is not new and there have been various studies regarding its legal status in the past[11]. In order to initiate a public debate on a concept such as the suggested climate and supply market model, it is necessary to clarify the legal considerations such a market design entails. Any potential market design has to be compatible with existing legislation and in particular with WTO law, EU law and other trade agreements, since CO_2 taxation regimes have to be carefully designed in order not to violate them. A professional legal assessment of the suggested climate and supply market model by a law firm found the model to be in line with all relevant international and EU legislations.

[11] See for instance (Cottier et al., 2011, 2014a; Holzer, 2014; Panezi, 2015)

Fundamental for the legal compatibility of the suggested model is the two-fold approach of putting a levy on the final electricity consumption (rather than production) and the clear separation of the national guarantees of origin market on the one hand, and the energy-only market on the other. Generally, guarantees of origin are not considered goods or products under internal trade law since they are not tangible and have no customs tariff number in the Harmonized Commodity and Coding Systems (short Harmonized System [HS]) of international law (Petsonk, 1999, pp. 199–200)[12]. They are also generally not considered as services under the General Agreement on Trade in Services (GATS) even though the subsequent trading of the certificates may be regarded as such (Delimatsis and Mavromati, 2009, p. 251).

Also as concerns EU law, guarantees of origin are not handled as goods which fall under the free movement of goods within the single market. Court rulings by the European Court of Justice underline that green certificates or guarantees of origin are not treated as goods and that guarantees do not have to be recognised by other Member states. One can refer at this point to the prominent case of Åland Vindkraft and a following similar case relating *inter alia* to Belgian guarantees of origin.

The Åland Vindkraft court ruling (which gained prominence by confirming the national character of renewable support schemes) clarified that Member States only have to recognise foreign guarantees of origin to a limited extent (European Court of Justice, 2014a, p. 11). In a similar case, one of the involved parties explicitly argued that the intangible nature of guarantees of origin prevents their categorisation as goods. The court refrained hereby from ruling definitely, answering that "even if it were accepted that guarantees of origin … constitute 'goods'" it would not change the question at stake (European Court of Justice, 2014b, p. 15). Accordingly, it is fair to say that thus far, guarantees of origin have not been treated as goods in international law and EU law, which is crucial for the legal compatibility of the suggested climate and supply market model.

Finally, as regards this legal perspective, it is worth taking a brief look at the EU state aid law vis-a-vis the suggested model. The support of companies or

[12] It should be noted that there is no clear definition of what exactly constitutes a good in international law and thus far, guarantees of origin or certificates as part of renewable support schemes (often referred to as quota obligation or green certificates) have not been regarded as goods or services (Buchmüller, 2013; Delimatsis and Mavromati, 2009; Howse, 2009; Petsonk, 1999).

industries with state resources is considered state aid by the European Commission. The legal assessment asserts that the climate and supply market model does not constitute state aid. The associated costs arising through the CO_2 levy of the suggested model are borne by consumers and the amounts paid for the CO_2 levy are not received by producers. The fact that the value of guarantees of origin experience a substantial increase through a state intervention does not change this principle. Strictly speaking, the model does therefore not constitute state aid in this context. However, even if the model was considered state aid, it would likely be considered proportionally and approvable (similar to other permitted measures). This should be seen in the broader context of approved measures regarding support for renewables and mechanisms strengthening the security of supply.

Climate and supply market model example: Switzerland

One can use Switzerland as an example to illustrate the proposed climate and market model. Switzerland's domestic power production is virtually CO_2 neutral. Yet during the winter months, Switzerland relies on imports to meet its demand. The validity for guarantees of origin could therefore be set for one month. During summer months, when Switzerland is a net exporter of electricity, the guarantees of origin from CO_2-neutral sources would be without additional value and no CO_2 levy applies. However, in winter months when Switzerland imports electricity, the value of guarantees of origin from CO_2-neutral sources would rise to approximately that of the CO_2 levy to be paid for non-CO_2-neutral production (i.e. imports). Existing Swiss laws include a CO_2 levy on thermal fuels of 84 CHF/tCO_2 ($\approx$78 EUR/tCO_2) (Federal Office for the Environment, 2016; Bundesrat, 2011). The suggestion is to apply the same carbon price level to the power sector. Consequently, in winter months when imports are necessary, suppliers would need to pay the CO_2 levy for the electricity that cannot be exempted with guarantees of origin (imports).

For the calculation of the applicable CO_2 levy, an estimated average EEA[13] power generation carbon intensity of 0.23 tCO_2/MWh[14] can be used. To take

[13] An EEA plus Switzerland average rather than EU average is used here for legal reasons. The economic area of the EEA plus Switzerland encompasses a wider European market and does not discriminate specific countries or on the basis of political Union.

[14] Estimation based on a published EU CO2 emission intensity of 0.276 tCO_2/MWh for 2014 (European Environment Agency, 2016). Assuming a similar CO_2 emission intensity reduction as in previous years and taking the virtually CO_2-free Swiss, Norwegian, Icelandic and Liechtenstein production into account to form an EEA + Switzerland average, one can use 0.23 tCO_2/MWh as a rough estimation for 2016 (Amt für Statistik, 2016, p. 18; European Environment Agency, 2016; Norwegian Water Resources and Energy Directorate (NVE), 2017; Orkustofnun, 2017, p. 1; Swissgrid, 2017).

the EU ETS price into account that has already been paid, one can deduct the EU ETS allowance price off the Swiss carbon price. With a carbon price of 78 EUR/tCO_2 and a 2016 average EU ETS allowance price of about 5.3 EUR/tCO_2 the suggested CO_2 levy would thus equal:

$$\left(78\ \left[\frac{EUR}{tCO2}\right] - \ 5.3\ \left[\frac{EUR}{tCO2}\right]\right) * 0.23 \left[\frac{tCO2}{Mwh}\right] = 16.7\ \left[\frac{EUR}{MWh}\right].$$

Swiss suppliers would therefore have the choice of either buying national guarantees of origin from CO_2-neutral sources or paying the CO_2 levy. Given the certificate scarcity in import months (i.e. when Swiss national CO_2-neutral production does not cover demand) the price for the guarantees of origin would equal that of the CO_2 levy of 16.7 EUR/MWh – since for every MWh delivered suppliers have to provide either a guarantee of origin or pay the CO_2 levy.

An increase of the EU ETS allowance price level or a decrease of the EEA power generation carbon intensity leads to a lower CO_2 levy without further adjustments. In summer months, when Switzerland is traditionally an exporter of electricity and its domestic CO_2-neutral production exceeds consumption, the guarantees of origin have no additional value.
This example shows that the climate and supply market model would reward CO_2-neutral production in times when it is needed and set incentives for expanding capacities that produce CO_2-neutral electricity during those times.

A subsequent step is to calculate the economic impact and overall costs arising from a CO_2 levy of 16.7 EUR/MWh. Over the last five years (2012-2016), there were on average four months per year during which the final electricity consumption was greater than the total energy production in Switzerland (Swissgrid, 2017).

The average final electricity consumption over those four months equalled 21,119,886 MWh (21.12 TWh). A CO_2 levy of 16.7 EUR/MWh would hence result in costs of around EUR 353 million per year. It should be noted at this point that this sum may vary depending mostly on the number of months during which the final electricity consumption exceeds the production of CO_2-neutral electricity. The total annual Swiss final electricity consumption has been just below 60 TWh in the last couple of years (Bundesamt für Energie, 2017, p. 4). The costs of EUR 350 million per year would thus equal additional costs of around 0.6 cents/kWh, which can arguably be seen as an acceptable level of additional costs.

Other carbon taxation models currently in practice

The following section briefly presents and examines other CO_2 taxation models; namely, a differential taxation model, the use of border tax adjustments and the current CO_2 taxation models of the United Kingdom, France and Denmark.

Differential Taxation

Cottier et al propose a CO_2 taxation model described as differentiated electricity tax (Cottier et al., 2014b). It aims to replace renewable support schemes and act as a steering system. They suggest different tax rates based on the technology used to generate electricity, aiming not only to reduce consumption but also to promote renewables. Renewable energy sources would profit from exemptions and tax rates for electricity produced from non-renewable sources would depend on their carbon intensity (Cottier et al., 2014b, p. 3). Guarantees of origin (or alternatively specifically designed renewable energy certificates) occupy a central role by determining the corresponding tax rate. The scholars discuss four main, different varieties of the model in detail with respect to the legal considerations they entail.[15]

They find that offering exemptions in their model only for domestic renewable electricity – effectively treating domestic and foreign production differently – would most likely constitute discrimination under the GATT (Holzer et al., 2017, pp. 380-381). One approach which could circumvent this is introducing additional requirements and constraints for imported electricity eligible for tax exemptions. Yet, even in that case, compliance with WTO law remains uncertain, depending on the exact criteria (Holzer et al., 2017, p. 382). A central issue associated with also offering unrestricted exemptions for foreign renewable production is the significant availability of guarantees of origin at very low prices in the EU, especially from Nordic hydropower. Producers could simply purchase those guarantees of origin instead of paying the – it is assumed – costlier carbon tax.

In contrast to the proposed climate and supply market model with one uniform CO_2 levy, the differentiated electricity tax aims to tax electricity at different rates depending on the electricity source. Even though both models use guarantees of origin, their functions differ. In the proposed climate and supply market model, the guarantees act as a source of additional income

[15] See Holzer et al., 2017 and Cottier et al., 2014b, 2014a

for renewable producers due to their – at times – significant increase in value. Cottier et al's legal analysis of their model regards a limitation of tax exemptions only for domestic renewable electricity as problematic, whereas the structure of the proposed climate and supply market model enables a lawful increase in value of exclusively domestic guarantees of origin from CO_2-neutral production.

Carbon tax with border tax adjustments

Border tax adjustments (BTA) have in recent years been increasingly discussed in relation to enforcing an environmental tax on imported goods within WTO law. A particular focus of research has been the interplay of emission trading schemes and BTA, and how BTA can be used to avoid carbon leakage[16]. Regarding the power sector, one could introduce an environmental CO_2 tax on power generation. BTA could then be used to tax imports in order to prevent competitive disadvantages for domestic production. If the tax shall depend on the CO_2 intensity of the technology used to generate the electricity, one effectively applies a differential taxation model such as the aforementioned model.

In practical terms, one aspect which comes hand in hand with the problem is that the origin of electricity is not always known and guarantees of origin are often only issued for renewables. Guarantees of origin would need to be introduced for all technologies and, possibly, also certify the CO_2 footprint of the electricity. It remains an open question how imports without guarantees of origin would be handled. A subsequent question in this cross-border context is if one can legally differentiate between electricity produced from CO_2-neutral sources (green electricity) and electricity produced from unknown or fossil energy sources (grey electricity). As a matter of fact, there exists significant legal debate among scholars as to whether green and grey electricity are considered 'like' or 'unlike' products under WTO law – thus far this question has not been subject to WTO jurisprudence (Holzer et al., 2017, p. 373; Kreiser et al., 2015, p. 167).

If all electricity was considered a 'like' product independent of its method of production and origin, equal treatment is required from a legal perspective. In this case, imported grey electricity could not be treated less favourably than domestically produced green electricity[17]. A flat tax on all electricity

[16] See Ismer and Neuhoff, 2007; Kuik and Hofkes, 2010; Panezi, 2015.

[17] It should be noted that Art. XX GATT on exceptions may leave some room for policy measures, potentially enabling a justification of violation of the non-discrimination rules. See Cottier et al., 2014c, pp. 34–37 for a detailed discussion.

generation would fail to set incentives for low or carbon free production. In case grey and green electricity are deemed ‘unlike’ products, a taxation model taxing them at different rates and using BTA seems theoretically feasible. However, a unilateral implementation of such a market design would face the aforementioned practical issue of a significant availability of renewable guarantees of origin at comparably low prices in the EU. Treating domestic electricity from CO_2-neutral sources differently than that from foreign CO_2-neutral sources would - as discussed - most likely contravene GATT rules.

United Kingdom: Carbon Price Floor

In 2013, the British government’s Department of Energy and Climate Change (DECC) established a carbon price floor for electricity generation taxing fossil fuels used to generate electricity. It can be described as a ‘top-up’ of the EU ETS. The carbon price floor was initially introduced at 16 GBP/tCO_2 and was supposed to reach 30 GBP/tCO_2 in 2020 and 70 GBP/tCO_2 in 2030 (in real 2009 prices). To this end, the government charges power generators a top-up of the EU ETS called Carbon Price Support (CPS) making up the difference between the floor price and the EU ETS allowances price. The amount of this CPS is announced with budget statement by the British Treasury two years in advance.

Due to the lower than expected EU ETS allowance prices, the CPS was frozen at 18 GBP/tCO_2 until 2021 in order to limit the competitive disadvantage faced by businesses and prevent electricity bills from rising (HM Revenues & Customs, 2014, p. 1; HM Treasury, 2016).

The carbon price floor was introduced with the intention of correcting the market distortions created by the low EU ETS prices. It was supposed to underpin the price of carbon at a level that drives low carbon investment (Ares and Delebarre, 2016, p. 3). The mechanisms contributed to a significant drop in electricity generation from coal-fired power plants due to higher costs associated with such generation, which in turn helped to reduce emissions (Clark, 2017).

Analysing the design of the carbon price floor, it is essential to highlight that the carbon price floor affects only producers in Great Britain. Electricity imports to Great Britain are not subject to the carbon price floor; charging producers abroad would most likely violate the General Agreement on Tariffs and Trade (GATT) (in particular Article III)[18]. The subsequent competitive disadvantages for electricity producers in Great Britain compared with those abroad are rather limited due to the relatively low interconnector capacity of Great Britain with other countries (4GW) as a result of its natural geographically isolated island location (Ofgem, 2017). In a more interconnected market, the design of the carbon price floor that only charges national producers would not be sensible as it would disadvantage national production disproportionately. This is also the reason why Northern Ireland is exempted from the carbon price floor (Foster in Sync Ni, 2013).

Currently there are ongoing discussions about the future of the carbon price floor[19]. There are both calls to phase out the mechanism as well as calls to maintain it. Of particular interest, there are studies that project the carbon price floor to lead to an overall *increase* in emissions. An increased interconnection capacity with planned interconnectors to mainland Europe and Iceland might, together with the carbon price differential, cause European wide-emissions to rise as gas-fired generation in Britain might be undercut by coal-fired generation in mainland Europe. (Aurora Energy Research, 2016, p. 2). In light of Brexit, there remains policy uncertainty regarding the future of interconnectors and the UK's participation in the EU ETS (Howard, 2016, p. 11). The UK Government has, however, signalled its intention to maintain the carbon price floor mechanism at its current rate until 2021 (HM Treasury, 2016).

France: Carbon prices

In May 2016, France announced that it would introduce a carbon price targeting the power sector with a price floor of 30 EUR/tCO_2. The plans were eventually dropped in autumn 2016 after opposition from energy companies and concerns over state aid investigations from the EU Commission (Enerdata, 2016).

In July 2016, a commission set up by COP21 president and Minister of Ecology, Sustainable Development and Energy Ségolène Royal suggested ten different carbon pricing proposals (Canfin et al., 2016, p. 20). These proposals included the introduction of a carbon price corridor within the EU

[18] The role and classification of electric power as a good under WTO law and the subsequent legal implications are subject to substantial legal debate. (Cottier et al., 2014c, pp. 34–37) provide an overview of handling electricity under WTO law and Horn and Mavroidis (2011) discuss the legality of Border Tax Adjustments for climate purposes. It is generally agreed that CO_2 taxation regimes not limited to domestic production may easily violate WTO (GATT) rules.
[19] For an overview see the recent research note by Policy Exchange (Howard, 2016)

ETS, a unilateral French price floor (as mentioned above) and measures to incentivise a switch from coal-fired plants to gas-fired plants[20]. Independently of this, France already introduced a CO_2 levy on the final consumption of fuels for sectors not covered by the EU ETS. As of 2017, the current rate is 30.5 EUR/tCO_2 –supposed to reach 56 EUR/tCO_2 in 2020 and 100 EUR/tCO_2 in 2030 (World Bank et al., 2016, p. 48).

Newly elected President Emanuel Macron, who served as Minister of the Economy when the initial carbon price floor plans were announced, revealed during his campaign new plans for a carbon price floor. His manifesto calls for a pan-European carbon price floor without however specifying more details (Macron, 2017, p. 21). He has nonetheless been quoted on a proposal for a price of 100 EUR/tCO_2 in 2030 which would equal the aforementioned levy and hence represent a cross-sector approach (Tolbaru et al., 2017, p. 7).

Denmark: energy tax, CO2 tax and SO2 tax

Denmark introduced its first specific CO_2 tax in 1992 (Kitzing et al., 2016, p. 24). Today it has a comprehensive system in place with three main taxes (energy tax, CO_2 tax and SO_2 tax) targeting fossil fuel consumption similar to the French and Swiss models with a rate of roughly 170 DKK/tCO_2 ($\approx$ 23 EUR/tCO_2) (Partnership for Market Readiness, 2017, p. 28; Withana et al., 2013, p. 22; World Bank, 2017). Fuels that are used for electricity generation are exempted from this tax to prevent a competitive disadvantage for Danish electricity producers (Duer, 1995, p. 44).

Instead, the Danish system taxes final electricity consumption, independent of the origin of the electricity. This consequently means that the tax itself does not provide incentives to switch to less polluting fuels in electricity generation (Withana et al., 2013, pp. 23–24).

The examples of CO_2 taxation in Great Britain, France and Denmark as well as the model proposed by Cottier et al illustrate the economic and legal constraints of CO_2 steering models. Reforms on a European level haven proven difficult, levying only domestic power producers results in competitive disadvantages, and taxes on imports are likely to violate international law. For countries with a low share of interconnector capacity, a carbon price floor such as the British model - levying only domestic production - effectively counters low EU ETS allowance prices and can (re-

[20] For more details on the proposals see the full report by the Canfin Grandjean-Mestrallet Commission (in French) (Canfin et al., 2016).

)establish carbon prices as a driver for decarbonisation. The networks of most European countries are, however, much more deeply integrated and connected, which is why the British model does not represent an appropriate solution.

In the absence of effective European reforms, the suggested climate and supply market model can therefore offer an alternative way of pricing CO_2 on a national basis, internalising the costs of CO_2 emissions and clearing market distortions originating from EU ETS allowance prices which are too low without violating international trade agreements or EU law.

Varieties of the climate and supply market model

The model can be altered in many ways to incorporate specific requirements or change its effects. The most straightforward steering instrument is the government-set CO_2 levy in EUR/tCO_2, which together with the EU ETS allowance price and the carbon intensity translates into the final levy expressed in EUR/MWh. Policy makers can choose whichever price is perceived as appropriate to work towards given policy objectives. This might result in a cross-sector carbon price as in the described example or one that relates to the social costs of carbon.

One recurring aspect of CO_2 taxation regimes are exemptions or special conditions for energy-intensive industries. Such measures can be included in the suggested climate and supply market model in case policy makers choose not to place additional burdens on the energy-intensive industry.

It may also be in the interest of a government to choose which particular CO_2-neutral generation technologies should profit from the guarantees of origin value increase. It could for example be restricted to CO_2-free rather than CO_2-neutral technologies thereby excluding technologies such as biomass or landfill power plants.

Another central element of the suggested model is the time period for which guarantees remain valid. In the presented example, the time period is set to one month, but different time frames are possible. Depending on the country's requirements and circumstances, the administrative body could set a longer time frame (i.e. quarters or seasons) or shorter one (i.e. weeks, days or even hours). A shorter time frame represents a more precise steering instrument but increases potential market power abuses[21]. Additionally, it comes at higher administrative costs and efforts for market participants and the administrative body.

In the suggested version of the model, suppliers have to provide one guarantee of origin from CO_2-neutral production for every MWh delivered or pay the CO_2 levy. But the administrative body could also require suppliers to provide more or less than one guarantee per unit of energy delivered. This way, one could steer the demand for guarantees and it enables setting targets of a desirable share of production from CO_2-neutral sources for the chosen time period.

Adaption potential for the climate and supply market model

The concept of the climate and supply market model was developed in a European context and the focus of this research rested on European countries. The general principle of a CO_2 price component with exemptions for CO_2-neutral production using guarantees of origin can theoretically also be applied elsewhere. Naturally this would entail some necessary adaptions such as the removal of the EU ETS pricing in the formula of the CO_2 levy and further legal assessments.

The model is particularly attractive for countries with a high share of traditional CO_2-neutral production (e.g. hydro, biomass) and looking for ways to maintain or increase it. Newer forms of CO_2-neutral/free production such as photovoltaics (PV) and wind are commonly supported through some form of feed-in scheme. As mentioned, operators of plants receiving subsidies through such a scheme would not be eligible for support through the climate and supply market model, since it would only result in windfall profits.
With compensation levels of support schemes continuously decreasing due to the cost reductions of renewables technologies, learning curves and further innovation, one may question for how long governments will continue their feed-in support schemes. Recent competitive tenders have again led to a decrease in compensation levels and the first German offshore wind auction gained prominence as companies bid to build offshore wind

[21] If in a chosen time period, domestic CO_2-neutral production is projected to be only marginally greater than the final consumption, producers might abuse their market power to transform it into an import period by withholding generation capacity. This might increase their income as the value of the guarantees of origin from CO_2-neutral sources would rise to that of the CO_2 levy. The shorter the time period, the smaller the generation capacity necessary to do so, as long as market data are available to project if domestic production will exceed or fall short of final consumption.

parks without a guaranteed minimum strike price[22]. In this light, it seems plausible that policy makers discuss the future of support schemes with the climate and supply market model comprising a potential option.

Since the climate and supply market model aims to incentivise CO_2-neutral power production during times when the targeted share of this production type is not met, it seems most apt for countries that already have a relatively high share of CO_2-neutral production in their electricity mix. Aside from the aforementioned example of Switzerland, the following European countries have a large CO_2-neutral share (over 65%) in their gross electricity production (according to data published by the European Commission, 2017): Austria, Croatia, Denmark, Finland, France, Slovakia, Slovenia and Sweden.

Given the functioning of the climate and supply market model described herein, the composition of the power sectors of these countries make them ideal candidates for a potential adaption of the model or discussion thereof. This is not to say that the climate and supply market model is not a useful fit for other countries. If policy makers set a lower amount of required guarantees of origin for suppliers per MWh delivered (e.g. 0.5 rather than 1), the model can also be attractive for countries with a lower share of CO_2-neutral production.

Conclusion

It has been argued that the power sector is facing a series of difficulties in light of energy transitions and decarbonisation. Low EU ETS allowance prices have led to a state of uncertainty regarding its role as a driver for decarbonisation. Previous reform processes have had limited success and some countries have looked towards unilateral action to tackle the issue.

A run of very low wholesale power prices in Europe, partly caused by low EU ETS allowance prices, has led to concerns over long-term generation adequacy (the ‘missing money problem') and the introduction of capacity remuneration mechanisms to counter the issue. The authors propose a unilateral climate and supply market model to address these aforementioned concerns. The model’s core component is an introduction

[22] In 2017, EnBW and Dong Energy were awarded the right to build wind farms in the North Sea with submitted bids of 0 EUR/MWh. It should be noted that they will still receive some form of subsidy as they gained the right to operate those parks for 25 years and network charges for electricity consumers finance the costly grid connection(s) (Bundesnetzagentur, 2017, p. 2).

of a CO_2 levy on final electricity consumption. Exemptions from the levy are offered for electricity produced from CO_2-neutral sources. Suppliers have to provide guarantees of origin from CO_2-neutral production for every MWh delivered or pay the CO_2 levy. The government sets the amount of the levy and the time period guarantees of origin remain valid for. This way the climate and supply market model incentivises the power production from CO_2-neutral sources during times when it does not cover demand or the target share of production.

The model can be used to implement a cross-sector carbon price as the analysis of the example of Switzerland illustrates. The example also shows that the model can be realised at an acceptable level of costs for consumers even though the exact costs depend on a number of the factors discussed, first and foremost the set CO_2 levy.

CO_2 pricing schemes targeting the power sector have to be carefully designed in order to comply with international and EU law. Some models, such as the British model, therefore exclude electricity imports from their CO_2 price floor. In other countries with greater transfer capacity to grids abroad, excluding imports would disproportionally disadvantage domestic power producers, which is why the British model only has limited adaption potential abroad. A legal assessment of the proposed climate and supply market model came to the conclusion that the suggested design complies with relevant legal frameworks.

The model offers various steering instruments for policy makers and it can be altered to suit a given country. Aside from setting the level of the CO_2 levy, the government can specify the time period for which guarantees of origin remain valid and impose the number of guarantees of origin required for suppliers per MWh delivered. Together, these mechanisms enable the government to work towards a targeted share of CO_2-neutral production during any time period and incentivise the deployment of additional CO_2-neutral generation capacity.

Finally, even though the model has been developed in a European context, the general principle could also be used elsewhere. Within Europe, there are several countries for which the proposed climate and supply market model might represent a potential policy option.

Bibliography

Abbott, M. (2001). Is the Security of Electricity Supply a Public Good? *The Electricity Journal*, *14*(7), 31–33.

Abrell, J., Rausch, S., & Yonezawa, H. (2016). *Higher Price, Lower Costs? Minimum Prices in the EU Emissions Trading Scheme* (SSRN Scholarly Paper No. ID 2764155). Rochester, NY: Social Science Research Network. Retrieved from https://papers.ssrn.com/abstract=2764155

Amt für Statistik. (2016). *Energiestatistik 2015*. Vaduz: Fürstentum Liechtenstein. Retrieved from http://www.llv.li/files/as/energiestatistik-2015.pdf

Ares, E., & Delebarre, J. (2016). *The Carbon Price Floor*. House of Commons Library.

Aurora Energy Research. (2016). *Dash for Interconnection: The impact of interconnectors on the GB market*. Oxford: Aurora Energy Research. Retrieved from https://www.auroraer.com/wp-content/uploads/2016/10/Dash-for-Interconnectors-Aurora-Energy-Research-February-2016.pdf

Boffey, D. (2017). Reform of EU carbon trading scheme agreed. *The Guardian*. Retrieved from https://www.theguardian.com/environment/2017/feb/28/reform-of-eu-carbon-trading-scheme-agreed

Bublitz, A., Keles, D., & Fichtner, W. (2017). An analysis of the decline of electricity spot prices in Europe: Who is to blame? *Energy Policy*, *107*, 323–336.

Buchmüller, C. (2013). *Strom aus erneuerbaren Energien im WTO-Recht*. Nomos Verlagsgesellschaft mbH & Co. KG.

Bundesamt für Energie (BFE). (2017). *Schweizerische Elektrizitätsstatistik 2016*. Bern: *Schweizerische Eidgenossenschaft*. Retrieved from http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_306571764.pdf&endung=Schweizerische%20Elektrizit%E4tsstatistik%202016

Bundesnetzagentur. (2017). Press Release: Bundesnetzagentur announces successful bids in first auction for offshore wind farms. Bundesnetzagentur. Retrieved from https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/BNetzA/PressSection/PressReleases/2017/13042017_windsee.pdf?__blob=publicationFile&v=2

Bundesrat (2011). Bundesgesetz über die Reduktion der CO2-Emissionen (CO2-Gesetz). Retrieved from https://www.admin.ch/opc/de/official-compilation/2012/6989.pdf

Canfin, P., Grandjean, A., & Mestrallet, G. (2016). *Rapport de la Mission: Propositions pour des prix du carbone alignés avec l'accord de Paris*. Paris: Canfin Grandjean-Mestrallet Commission. Retrieved from https://www.engie.com/wp-content/uploads/2016/07/rapport-mission.pdf

Carbon Market Watch. (2015). *Four magic potions to turn the EU ETS into an effective climate mitigation tool* (Policy Brief) (pp. 1–8). Brussels. Retrieved from http://carbonmarketwatch.org/four-magic-potions-to-turn-the-eu-ets-into-an-effective-climate-mitigation-tool/

Clark, P. (2017). UK carbon emissions fall to late-19th century levels. Retrieved from https://www.ft.com/content/2bc62cb8-004f-11e7-8d8e-a5e3738f9ae4

Committee on Assessing Approaches to Updating the Social Cost of Carbon, Board on Environmental Change and Society, Division of Behavioral and Social Sciences and Education, & National Academies of Sciences, Engineering, and Medicine. (2017). *Valuing Climate Changes: Updating Estimation of the Social Cost of Carbon Dioxide*. Washington, D.C.: National Academies Press. https://doi.org/10.17226/24651

Cottier, T., Delimatsis, P., Malumfashi, G., Matteotti-Berkutova, S., Nartova, O., De Sépibus, J., & Bigdeli, S. Z. (2011). Energy in WTO law and Policy. In *The Prospects of International Trade Regulation: From Fragmentation to Coherence* (pp. 211–244). Cambridge University Press.

Cottier, T., Espa, I., Hirsbrunner, S., Holzer, K., & Payosova, T. (2014). *Differentiating Energy Tax on Electricity: An assessment of the compatibility with WTO law and EU law* (Legal Opinion submitted to the Swiss Federal Financial Administration (FFA), the Swiss State Secretariat for Economic Affairs (SECO) and the Swiss Federal Office of Energy (SFOE)). Bern: University of Bern.

Cottier, T., Espa, I., Hirsbrunner, S., Holzer, K., & Payosova, T. (2014). CO2 Levies and Tariffs on Imported Electricity. Bundesamt für Energie BFE.

Cottier, T., Espa, I., Hirsbrunner, S., Holzer, K., & Payosova, T. (2014). *Differential Taxation of Electricity: Assessing the Compatibility with WTO Law, EU Law and the Swiss-EEC Free Trade Agreement* (Legal Opinion submitted to the Swiss Federal Financial Administration (FFA), the Swiss State Secretariat for Economic Affairs (SECO) and the Swiss Federal Office of Energy (SFOE)). Bern: Swoss Federal Office of Energy (SFOE). Retrieved from https://www.seco.admin.ch/dam/seco/de/dokumente/Publikationen_Dienstleistungen/Publi

kationen_Formulare/Umwelt_Energie/Vereinbarte%20differenzierte%20Stromsteuer.pdf.download.pdf/ES2050%20zweite%20Etappe.%20differenzierte%20Stromsteuern.pdf
Crampton, P., & Stoft, S. (2006). The Convergence of Market Designs for Adequate Generating Capacity. White paper for the California Electricity Oversight Board. Retrieved from http://www.cramton.umd.edu/papers2005-2009/cramton-stoft-market-design-for-resource-adequacy.pdf
De Vries, L. J., & Hakvoort, R. A. (2003). The Question of Generation Adequacy in Liberalized Electricity Markets. Presented at the 26th Annual Conference International Association Energy Economics, Prague: IAEE. Retrieved from https://www.ecn.nl/fileadmin/ecn/units/bs/INDES/indes-ldv_paper.pdf
Delimatsis, P., & Mavromati, D. (2009). GATS, financial services and trade in renewable energy certificates (RECs) - just another market based solution to cope with the tragedy of the commons? In *International Trade Regulation and the Mitigation of Climate Change*. Cambridge University Press.
Duer, H. (1995). *EU and Economic Instrument in Environmental Regulation*. Copenhagen: Nordic Council of Ministers.
Enerdata. (2016). France suspends carbon floor price planned on 1 January 2017. Retrieved from https://www.enerdata.net/publications/daily-energy-news/france-suspends-carbon-floor-price-planned-1-january-2017.html
European Commission. (2014). Proposal for a Decision of the European Parliament and of the Council concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC /* COM/2014/020 final - 2014/0011 (COD) */. European Commission, Brussels. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52014PC0020&from=en
European Commission. (2016). *Final Report of the Sector Inquiry on Capacity Mechanisms*. Brussels: European Commission. Retrieved from http://ec.europa.eu/energy/sites/ener/files/documents/com2016752.en_.pdf
European Commission. (2017). Energy Statistics. European Commission, Brussels. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/countrydatasheets_march2017.xlsx
European Council. (2017). Revision of the emissions trading system: Council agrees its position - Consilium. Retrieved from http://www.consilium.europa.eu/en/press/press-releases/2017/02/28-ets-revision/
European Court of Justice. Case C-204/12 Essent Belgium (2014). Retrieved from http://curia.europa.eu/juris/document/document.jsf;jsessionid=9ea7d2dc30d642600f97ae054509900d9ede49291c2f.e34KaxiLc3qMb40Rch0SaxyLbN50?text=&docid=157525&pageIndex=0&doclang=EN&mode=lst&dir=&occ=first&part=1&cid=242997
European Court of Justice. Case C-573/12 Åland Vindkraft, C-573/12 § (2014). Retrieved from http://curia.europa.eu/juris/document/document.jsf?text=&docid=154403&pageIndex=0&doclang=EN&mode=lst&dir=&occ=first&part=1&cid=125045
European Environment Agency. (2016,). Overview of electricity production and use in Europe. Retrieved from https://www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity-3
Everts, M., Huber, C., & Blume-Werry, E. (2016). Politics vs markets: how German power prices hit the floor. *The Journal of World Energy Law & Business*, *9*(2), 116–123
Federal Office for the Environment. (2016). Imposition of the CO2 levy on thermal fuels. Retrieved from https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/climate-policy/co2-levy/imposition-of-the-co2-levy-on-thermal-fuels.html
Finon, D., & Pignon, V. (2008). Electricity and long-term capacity adequacy: The quest for regulatory mechanism compatible with electricity market. *Utilities Policy*, *16*(3), 143–158.
Hancher, L., Hauteclocque, A. de, & Sadowska, M. (2015). *Capacity Mechanisms in the EU Energy Market: Law, Policy, and Economics*. OUP Oxford.
Hepburn, C., Neuhoff, K., Acworth, W., Burtraw, D., & Jotzo, F. (2016). The economics of the EU ETS market stability reserve. *Journal of Environmental Economics and Management*, *80*, 1–5
Hirth, L. (2016). *What Caused the Drop in European Electricity Prices?* (SSRN Scholarly Paper No. ID 2874841). Rochester, NY: Social Science Research Network. Retrieved from https://papers.ssrn.com/abstract=2874841
HM Revenues & Customs. (2013). Carbon price floor- rates from 2015-16, exemption for Northern Ireland and technical changes. HM Revenues & Customs.
HM Revenues & Customs. (2014). Carbon price floor: reform and other technical amendments. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/293849/TIIN_6002_7047_carbon_price_floor_and_other_technical_amendments.pdf

HM Revenues & Customs. (2017). Excise Notice CCL1/6: a guide to carbon price floor. Retrieved from https://www.gov.uk/government/publications/excise-notice-ccl16-a-guide-to-carbon-price-floor/excise-notice-ccl16-a-guide-to-carbon-price-floor

HM Treasury. (2016). Autumn Statement 2016. Retrieved from https://www.gov.uk/government/publications/autumn-statement-2016-documents/autumn-statement-2016

Holzer, K. (2014). *Carbon-related Border Adjustment and WTO Law*. Edward Elgar Publishing.

Holzer, K., Espa, I., & Payosova, T. (2017). Promoting Green Electricity through Differentiated Electricity Tax Schemes. In Cottier and Espa (eds) *International Trade in Sustainable Electricity*. Cambridge: Cambridge University Press.

Horn, H., & Mavroidis, P. C. (2011). To B(TA) or Not to B(TA)? On the Legality and Desirability of Border Tax Adjustments from a Trade Perspective. *The World Economy*, *34*(11), 1911–1937

Howard, R. (2016). *Next steps for the carbon price floor*. London: Policy Exchange. Retrieved from https://policyexchange.org.uk/wp-content/uploads/2016/11/Carbon-Price-Floor-Research-Note-FINAL3.pdf

Howse, R. (2009). *World Trade Law and Renewable Energy: the Case of Non-tariff Measures*. New York and Geneva: United Nations Conference on Trade and Development. Retrieved from http://unctad.org/en/Docs/ditcted20085_en.pdf

Intercontinental Exchange, (ICE). (2017). *EUA Futures*. Atlanta. Retrieved from https://www.theice.com/products/197/EUA-Futures/data

Ismer, R., & Neuhoff, K. (2007). Border tax adjustment: a feasible way to support stringent emission trading. *European Journal of Law and Economics*, *24*(2), 137–164. https://doi.org/10.1007/s10657-007-9032-8

Joskow, P. L. (2008). Capacity payments in imperfect electricity markets: Need and design. *Utilities Policy*, *16*(3), 159–170

Kitzing, L., Katz, J., Schröder, S. T., Morthorst, P. E., & Andersen, F. M. (2016). *The residential electricity sector in Denmark: A description of current conditions*. Working paper, Department of Management Engineering, Technical University of Denmark, Kgs. Lyngby. Retrieved from http://orbit.dtu.dk/ws/files/121099206/The_residential_electricity_sector_in_Denmark.pdf

Koch, N., Fuss, S., Grosjean, G., & Edenhofer, O. (2014). Causes of the EU ETS price drop: Recession, CDM, renewable policies or a bit of everything?—New evidence. *Energy Policy*, *73*, 676–685

Kreiser, L., Andersen, M. S., Olsen, B. E., Speck, S., Milne, J. E., & Ashiabor, H. (2015). *Environmental Pricing: Studies in Policy Choices and Interactions*. Edward Elgar Publishing.

Kuik, O., & Hofkes, M. (2010). Border adjustment for European emissions trading: Competitiveness and carbon leakage. *Energy Security - Concepts and Indicators with Regular Papers*, *38*(4), 1741–1748. https://doi.org/10.1016/j.enpol.2009.11.048

Lu, B., Ma, X., & Feng, C. (2015). Theory and Model of Energy investment and Financing. In J. Yan, *Handbook of Clean Energy Systems, 6 Volume Set*. John Wiley & Sons.

Macron. (2017). Programme En Marche! En Marche. Retrieved from https://storage.googleapis.com/en-marche-fr/COMMUNICATION/Programme-Emmanuel-Macron.pdf

Marcu, A., Elkerbout, M., Wijnand, S. (2016). *2016 State of EU ETS Report*. Brussels: Centre for European Policy Studies (CEPS). Retrieved from http://www.ceps-ech.eu/sites/default/files/State%20of%20EU%20ETS%20v16_0.pdf

Newbery, D. (2016). Missing money and missing markets: Reliability, capacity auctions and interconnectors. *Energy Policy*, *94*, 401–410.

Norwegian Water Resources and Energy Directorate (NVE). (2017). Norway and the European power market. Retrieved from https://www.nve.no/energy-market-and-regulation/wholesale-market/norway-and-the-european-power-market/

Ofgem. (2017). Electricity interconnectors. Retrieved from https://www.ofgem.gov.uk/electricity/transmission-networks/electricity-interconnectors

Orkustofnun. (2017). *Development of electricity production in Iceland 2015* (Orkustofnun Data Repository). Reykjavik: Orkustofnun. Retrieved from http://os.is/gogn/Talnaefni/OS-2017-T005-01.pdf

Panezi, M. (2015). When CO2 goes to Geneva - Taxing Carbon Across Borders - Without Violating WTO Obligations. *CIGI Papers*, *83*. Retrieved from https://www.cigionline.org/sites/default/files/cigi_paper_no.83.pdf

Partnership for Market Readiness. (2017). *Carbon Tax Guide: A Handbook for Policy Makers. Appendix: carbon Tax Case Studies*. Washington DC: World Bank. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/26300/Carbon%20Tax%20Guide%20-%20Appendix%20web%20FINAL.pdf?sequence=7&isAllowed=y

Petsonk, A. (1999). The Kyoto Protocol and the WTO: Integrating greenhouse gas emissions allowance trading into the global marketplace. *Duke Environmental Law & policy Forum*, *10*, 185

Rattay, W. (2017). Emissionshandel: EU-Parlament stimmt für strengere Regeln. *Die Zeit*. Retrieved from http://www.zeit.de/wirtschaft/2017-02/emissionshandel-eu-parlament-zertifikate-umweltschutz

Rogge, K. S., Schneider, M., & Hoffmann, V. H. (2011). The innovation impact of the EU Emission Trading System — Findings of company case studies in the German power sector. *Ecological Economics*, *70*(3), 513–523

Swissgrid. (2017). Energieübersicht Schweiz 2016. Swissgrid. Retrieved from https://www.swissgrid.ch/dam/dataimport/energy_data/de/EnergieUebersichtCH_2016.xls

Sync Ni. (2013). Foster welcomes Chancellor’s decision to exempt Northern Ireland generators from Carbon Tax. Retrieved from https://syncni.com/news/2/1459/foster-welcomes-chancellor-s-decision-to-exempt-northern-ireland-generators-from-carbon-tax/tab/1356

Tolbaru, A.-M., Roux, L., Franke, A., & Reale, F. (2017). *French Presidential Elections: Crunch time for the country’s energy mix* (Electric power special report). London: Platts. Retrieved from https://www.platts.com/IM.Platts.Content/InsightAnalysis/IndustrySolutionPapers/SR-french-presidential-elections-energy-mix-042017.pdf

Withana, S., ten Brink, P., Kretschmer, B., Mazza, L., Hjerp, P., Sauter, R., … Illes, A. (2013). *Annexes to Final Report - Evaluation of environmental tax reforms: International experiences*. Brussels: Institute for European Environmental Policy (IEEP). Retrieved from http://www.ieep.eu/assets/1283/ETR_study_by_IEEP_for_the_Swiss_Government_-_Final_report_-_21_June_2013.pdf

World Bank. (2017). Carbon Pricing Dashboard | Up-to-date overview of carbon pricing initiatives. Retrieved from http://carbonpricingdashboard.worldbank.org/map_data

World Bank, Ecofys, & Vivid Economics. (2016). *State and Trends of Carbon Pricing 2016*. Washington, DC: World Bank. Retrieved from https://openknowledge.worldbank.org/handle/10986/25160