Effects of energy and climate political regulations on electricity prices in paper, steel and aluminium production – a comparison for Germany, the Netherlands, the UK and France

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Abstract

The EU aims to reduce energy consumption and expand the renewable energy supply to ultimately reduce greenhouse gas emissions. Member states have introduced different instruments to trigger the necessary changes in the generation and use of energy. Often these instruments lead to price increases for consumers, but include preferential treatment for industrial electricity consumption. We investigate the electricity price differences resulting from several political instruments for sample companies from three energy-intensive sectors: paper, steel, and aluminium production. We find that net power prices may differ by 1.7 ct/kWh to 2.6 ct/kWh for the same company across countries. In Germany we observe a higher burden for a small than for a big paper mill.

We note that the results show diverging power prices, but do not allow a conclusion on international competitiveness since we disregard other factors such as availability of raw material or proximity to key markets. We also neglect differences in spot market prices that influence power purchase prices available to companies.

Importantly, power prices influence the profitability of energy efficiency investments. Lower power prices decrease the pay-off from energy efficiency investments and increase amortization time. But improved efficiency also decreases annual power costs. An efficiency improvement of 5 % could decrease power cost by 0.1 to 8 million euro/a depending on the annual power consumption, presumed that the investment is viable. In relation to power consumption before the improvement, this corresponds to savings of 0.23 ct/kWh to 0.37 ct/kWh. This effect is nearly by factor 10 smaller than policy driven differences. Hence, energy efficiency could mitigate effects from politically driven power price differences, yet, it is unlikely to fully compensate for them. It is good news that preferential treatment is often coupled with the existence of an energy management system or energy efficiency targets.

Introduction

The EU has set itself the goal to reduce CO_2 emissions by 20 % by 2020, reduce primary energy consumption by 20 % and at the same time increase renewable energy use by 20 %. With the climate and energy package, the EU has published a set of binding legislation to ensure that these goals will be reached.[1] At the time of drafting (early 2014), the EU has proposed a framework on climate and energy for 2030. The proposal includes a binding target for greenhouse gas (GHG) emission reductions and an EU-wide binding target for renewable energy. The role of energy efficiency is left unclear and will be investigated in a review during the year 2014 (EC 2014). The parliament discussed the proposal in February. It voted for a 40 % reduction in CO_2 emissions and a 30 % share for renewable energies. Notably, it also voted for a 40 % improvement in energy efficiency by 2030.[2] The energy ministers will meet and discuss the 2030 targets within the European Council in March. Reaching these goals requires a significant expansion of renewable energies in

1. http://ec.europa.eu/clima/policies/package/documentation_en.htm
2. http://www.euractiv.com/energy/meps-confirm-ambitious-stance-20-news-533298

heating, electricity, and transport as well as an increase in energy efficiency. Member states can use different instruments to foster this transformation such as command-and-control measures, informational and educational measures or economic instruments. Economic instruments are e.g. subsidies, taxes or tradable certificate systems. Some of these instruments have an impact on electricity prices. This effect may be direct such as with the electricity tax or indirect as in the case of the emissions trading system that puts a price on carbon that is priced into the cost of electricity production. Additional indirect effects are rooted in subsidy or support systems that are financed via a levy on the electricity price. An example is the feed-in tariff. It grants renewable generators a fixed remuneration per kWh generated. The costs are socialized to final consumers via a surcharge on the power price. The feed-in tariff is seen as a key driver for the expansion of renewables in Germany. Several other countries meanwhile have also established feed-in tariffs. Notwithstanding the success of feed-in tariffs, the resulting cost for consumers are a point of debate (see e.g. Spiegel 2013). This debate can be extended to other energy and climate political instruments that raise the electricity price e.g. eco taxes.

Typically, exemptions from these regulations exist to limit price increases for energy-intensive industries and thereby protect their international competitiveness. These exemptions are similar in some cases to tax exemptions for electrolysis and metal production. In other cases qualification criteria for exemptions differ across countries. The exemptions may thus benefit different companies or company groups and possibly cause competitive distortions. Currently the EU is running state aid investigations with regard to several of the exemptions and compensation mechanisms in place. With regard to Germany, e.g. the EU opened an inquiry into the exemption of large electricity consumers from paying network tariffs (EC 2013a) and into the reduced rate of the renewable surcharge available to energy-intensive customers (EC 2013b). With regard to network tariffs and the state aid investigation, Germany for example has already changed the legislation abandoning full exemption from network tariffs and ties the reductions more tightly to beneficial effects for the network caused by privileged customers (Schwarz 2013). The Commission has also investigated regulated electricity tariffs in France (EC 2009a), electricity prices and grants for interruptability in Italy (EC 2009b, EC 2012a) and the SDE+ scheme to support renewables in the Netherlands (EC 2012b). In case of the latter two, no objections were raised.

We pick up the point of exemptions for industrial energy-intensive consumers and possibly resulting distortions and investigate the impact of the regulations on the electricity prices of sample companies from different sectors. We analyse Germany, France, the Netherlands, and the UK based on their international relevance within the paper, steel, and aluminium sector. The first three all have a leading position in the world export share in these sectors: Germany 9–10 %, France roughly 4 %, and the Netherlands roughly 3 %. In addition we have picked the UK as non-continental Europe. In export terms, the UK has a share of above 3 % in the paper sector.[3] We find a policy-driven difference in net power prices of 2.01 ct/kWh to 2.55 ct/kWh for the same stylized company across countries. This disregards differences in power purchase prices except for the Exeltium tariff in France. Neglecting reductions from Exeltium, the tariffs still differ by 1.64 ct/kWh to 2.01 ct/kWh. For energy-intensive firms with a demand of several hundred GWh/a, such a difference easily sums up to several millions of euro per year. We find that effects differ in the sectors and for company types (here: size). Hence, a solid statement on the impact for companies and potential competitive distortions and a detailed analysis at the level of company types are necessary.

The rest of the paper is structured as follows: First, we present the main energy political instruments raising the electricity price and the criteria for exemptions by country. Second, we present the stylized companies and assumptions used in the analysis. We then present and discuss the resulting electricity prices for the stylized companies from the aluminium, steel and paper industry.

Selected instruments of energy polity with an effect on the electricity price

The electricity price is typically composed of the cost for the generation of electricity and for its transportation, i.e. the network, as well as costs for retailing, metering, and billing. Politically driven components add to this basic electricity price. Most notably, this includes levies to finance the support of renewable power generation. Additionally, taxes apply.[4] Importantly, exemptions from certain regulations exist for energy-intensive industries to limit (power) price increases and protect national industrial competitiveness.

We classify the power price components to ease comparison across countries. We differentiate four categories: power procurement, distribution and transmission network, renewable energy support, taxes and other levies. Table 1 lists the components by category. In the following, we present the underlying energy political instruments and the qualification criteria that lead to an exemption of energy-intensive firms by country. We concentrate on the four categories: transmissions and distribution, taxes, and renewable energy support. In France certain companies benefit from an exceptionally low power price via the Exeltium consortium.

GERMANY

The electricity price in Germany is the sum of the generation cost, network tariffs including metering and billing, electricity tax (*Stromsteuer*), concession levy (*Konzessionsabgabe*) as well as the apportionments for financing the feed-in tariff for renewable generation (*EEG-Umlage*), the support for combined heat and power generation (*KWK-Umlage*), and for compensating network operators for offshore grid connection liability[5] (*Offshorehaftungsumlage*).

3. The next European country to include would be Italy which also has high world export shares. First priority, however, would be the addition of competitors from outside Europe such as the US, China, or Russia.

4. The analysis in this paper is based on net electricity prices disregarding value added tax (VAT) since this tax should be relevant only for final products, not for electricity as an input good in the production. We note that higher VAT leads to higher product prices for final customers.

5. Network operators pay compensation for delays or failures in network access to offshore wind generators. (Part of) these compensation costs can be socialized to consumers.

Table 1. Categorization of power price components in D, UK, NL, F.

	Exemptions for energy intensive consumers [y/n]	*Energy efficiency related requirement for exemptions [y/n]*
Power procurement (generation cost including mark-up)		
Transmission and distribution		
Network charges (D, UK, NL, F)	y, Only in D: based on atypical network utilization or full load hours ≥7,000 h/a	n
Concession levy (D)	y	n
Levy according to §19 of network tariff regulation (D)	y	n
Taxes (consumption tax)		
Electricity tax (D, NL, F)	y	D: EMS (for surplus settlement) NL: EMS F: no
Climate Change Levy (UK)	y	y: energy efficiency or carbon-saving targets (typically at sector level)
Renewable energy support		
Levy according to the renewable energy law (EEG-Umlage) (D)	y	y (if consumption is at least 10 GWh/a)
offshore grid connection liability levy (D)	y	n
combined heat and power generation levy (D)	y	n
SDE+ (NL)	y	y: EMS, realize cost-effective energy efficiency measures
CSPE (F)	y	n
Renewables Obligation (UK)	Indirect effect	n.a.
Carbon Price Floor (UK)	Indirect effect	
Value added tax		
Gross electricity price		

Energy-intensive companies can benefit from several exemptions that shield them from price increases. The qualification criteria diverge across the instruments. Most relevant are the absolute electricity consumption per year, the ratio of power procurement cost to turnover and/or gross value added, and the production activity (by NACE code and/or processes).

Transmission and distribution

The calculation of **network charges for transmission and distribution** is regulated (*Stromnetzentgeltverordnung StromNEV*). For industrial consumers it consists of a capacity charge (euro/kW) and a variable charge (euro/kWh). The charges depend on the voltage level and capacity of the grid connection. Notably, reduced network tariffs can be granted to companies with atypical utilization patterns or alternatively, with extensive network utilization indicated by a consumption of 10 GWh/a and more than 7,000 utilization hours per year (§19 StromNEV). The individualized tariffs have to reflect the cost decreasing effect of the respective user on the network. They may not be lower than 20 % of the published network tariffs in case of a minimum of 7,000 utilization hours. The minimum decreases to 15 % (10 %) of published tariffs for 7,500 h/a (8,000 h/a). The regulator has to approve these special tariffs.

The foregone income from reduced network tariffs is recovered via the **§19-levy**. The levy applies to all consumers for the first 1 GWh/a consumption per supply point. For the consumption above 1 GWh the levy is reduced to 0.05 ct/kWh. A further reduction to 0.025 ct/kWh is granted to companies that had electricity costs above 4 % of turnover in the previous year AND that belong to manufacturing, rail- bound traffic or rail infrastructure.

The **Concession levy** (D) compensates municipalities for the right to install and operate power lines on public grounds. The height of the levy principally depends on the number of inhabitants, the voltage level, and the demand structure. For special contract customers, the levy is limited to a maximum of 0.11 ct/kWh. No levy is charged from special contract customers that pay a price below a defined marginal price.[6]

6. The marginal price is based on the average (net) revenue of all special contract customers. In 2010 this average revenue was 10.66 ct/kWh (destatis.de). Municipality and supplier may negotiate higher marginal prices.

Taxes (consumption tax)

The **electricity tax** is charged on electricity consumption. The regular rate is 2.05 ct/kWh. A reduced rate of 0.513 ct/kWh is available upon application for companies from the manufacturing sector.[7] Certain forms of power generation are generally exempt from paying electricity tax (such as generation from renewables or from plants with a capacity of up to 2 MW and spatially related consumption). Waivers and refund apply for companies from the manufacturing sector for power used in certain processes such as electrolysis, metal production, or chemical reduction.[8] The remaining tax load may be further reduced in special cases based on the relation of electricity taxes and social security contributions. This so-called surplus settlement is available upon request to companies from the manufacturing sector and enables redemption of up to 90 % taxes paid. Since 2013 companies have been required to have a certified energy management system to benefit from the surplus settlement.

Renewable energy support

The German feed-in tariff to support renewable power generation is financed via an apportionment on final consumers (**renewable energy surcharge, EEG-Umlage**). Companies from the manufacturing sector (and track railways) can apply for exemptions. The reduced rates depend on the annual power consumption and the share of power cost in gross value added. The standard rate is 5.277 ct/kWh (2013).[9] There are four classes of exemptions available under the special exemption rule (*Besondere Ausgleichsregelung* – BesAR). To qualify for the first three, companies need a share of power cost in gross value added of a minimum of 14 % and a consumption of 1 GWh/a or more. In that case the following reductions are granted:

1. for the consumption share between 1–10 GWh/a the levy is reduced to 10 % of the original value, i.e. 0.528 ct/kWh.
2. for the consumption share between 10–100 GWh/a, the levy is reduced to 1 % of the original value, i.e. 0.053 ct/kWh.
3. for the consumption share above 100 GWh/a, the levy is reduced to 0.05 ct/kWh.

For the fourth category, companies classify if they have a consumption of 100 GWh/a or more and a share of more than 20 % electricity cost in gross value added. They are then granted a reduced renewable surcharge of 0.05 ct/kWh for the entire electricity consumption.

The **combined heat and power (CHP) generation levy** recovers the cost for the support of CHP plants. In 2013, the normal rate was 0.126 ct/kWh. It applied to consumption of up to 100,000 kWh per supply point. For consumption above 100 MWh the levy was reduced to 0.05 ct/kWh. A further reduction to 0.025 ct/kWh is granted to companies that had electricity costs above 4 % of turnover in the previous year AND that belong to the manufacturing sector, rail- bound traffic or rail infrastructure.

Network operators pay compensation for delays or failures in network access to offshore wind generators. (Part of) these compensation costs can be socialized to consumers via the **Offshore grid connection liability levy**. The levy applies to all consumers for the first 1 GWh/a consumption per supply point. The standard rate is 0.25 ct/kWh. For consumption above 1 GWh the levy is reduced to 0.05 ct/kWh. A further reduction to 0.025 ct/kWh can be granted to companies that had electricity cost above 4 % of turnover in the previous year AND that belong to the manufacturing sector.

NETHERLANDS

Transmission and distribution

The **network charges for transmission and distribution** in the Netherlands consist of a capacity-based transportation charge (Transporttarief) in euro/kW and a variable system services component (Systemdienstentarief) in euro/kWh. The tariffs depend on the voltage level, the yearly and monthly peak load.

Taxes (consumption tax)

The Dutch energy tax on electricity applies a degressive block structure. For the first 10 MWh a rate of 11.4 ct/kWh applies (year 2012), 4.15 ct/kWh for the next 40 MWh, 1.11 ct/kWh for the further consumption up to 10 GWh. Above 10 GWh a rate of 0.5 ct/kWh applies to industrial consumers.[10] A tax waiver may be applied to industrial consumers with a consumption above 10 GWh. Companies have to sign a covenant in which they commit to taking measures to improve their energy efficiency. Furthermore, a process-based tax exemption applies e.g. to electrolysis, metal production, or chemical reduction (Article 64 of the Environmental Taxes Act).[11]

Renewable energy support

Since 2013 the costs for the support of renewable power generation have been socialized to consumers in the Netherlands via the **incentive scheme for sustainable energy production** (*Stimulering Duurzame Energieproductie* – SDE+). The rate for the first 10 MWh is 1.1 ct/kWh, for the next 40 MWh the rate is 1.4 ct/kWh and then degressive: for the consumption share from 50 MWh to 10 GWh a rate of 0,04 ct/kWh applies, for the consumption share above 10 GWh the rate is 0.0017 ct/kWh. Similar to the tax exemption, industrial firms are exempt from paying SDE+ if they have signed the covenant on energy efficiency improvements and if their consumption is above 10 GWh.

UNITED KINGDOM

Transmission and distribution

Transmission network use of system charges (TNUoS-Charges) in the UK feature a capacity-based charge and a variable charge. Tariffs vary by location and the peak load in a defined period. TNUoS-charges recover the cost of using the national transmission network. Additionally, *distribution network use of*

7. The reduction has to exceed 250 euro/a.

8. Further exemptions exist. See Electricity tax law (Stromsteuergesetz) for details.

9. The rate is being adapted from year to year so that costs for granted feed-in tariffs for renewable electricity can be covered. In 2014 the standard rate is 6.24 ct/kWh.

10. For private consumption above 10 GWh a rate of 1 ct/kWh applies.

11. For a full overview of regulations and exemptions see WET van 23 december 1994, houdende vaststelling van de Wet belastingen op milieugrondslag, Hoofdstuk VI. Energiebelasting.

system charges (DNUoS-Charges) apply. DNUoS-charges typically consist of a capacity charge based on the peak load measured in kVA, a unit charge depending on the volume (kWh) and timing of demand, and a fixed charge.

Taxes (consumption tax)

The **Climate Change Levy** (CCL) taxes energy use in industry, commerce and the public sector. The standard rate on electricity for 2013 is 5.24 pounds/MWh (ca. 0.61 ct/kWh). Energy-intensive users can receive a reduction if they are part of a climate change agreement and meet energy efficiency or carbon saving targets. The reduction is estimated to be 65 % in 2012 and 90 % in 2013 (DECC 2013, p. 76)

Renewable energy support

Renewables Obligations (RO) are a central instrument to support power generation from renewable sources in the UK. Suppliers are required to source a defined part of the electricity they supply to consumers from renewable sources. It can be assumed that they pass on these costs to consumers, but there is no regulated methodology for the pass-through. ROs were estimated to make up for 0.8 pounds/kWh on average for household consumers and 0–0.8 pounds/kWh (0–0.94 ct/kWh) for commercial and industrial consumers (DECC 2013, p. 80–83). We calculate with a medium value of 0.47 ct/kWh.

Other instruments with an effect on electricity bills exist in the UK such as Certified Emission Reduction Target (CERT). CERT, however, targets household consumers only. Our analysis concentrates on main instruments with an impact on industrial bills. For a detailed analysis of energy and climate policy on electricity bills in the UK see DECC (2013).

FRANCE

Transmission and distribution

Network charges in France (tarif d'utilisation des réseaux publics d'électricité, TURPE) are uniform within a supply area. They include the cost for the transmission and distribution network. Charges include a capacity component and a variable fee. The tariffs vary depending on the voltage level of connection and the connection capacity in kVA.

Taxes (consumption tax)

In France, consumption taxes on electricity apply on the level of municipalities (*TCCFE – taxe communale sur la consommation finale d'électricité*) and departments (*TDCFE – taxe départemental sur la consommation finale d'électricité*) for consumption with a connection capacity below 250 kVA. Above 250 kVA, a **general consumption tax** (*TICFE – taxe intérieure sur la consommation finale d'électricité*) applies instead with a standard rate of 0.05 ct/kWh. For energy-intensive consumers exemptions from TICFE are available based on processes such as electrolysis, metal production, or reduction processes. Another criterion for exemptions is a share of more than 50 % power costs related to product costs.

Renewable energy support

The support of renewable power generation in France is financed via a **public service charge** (*contribution aux charges de service public de l'électricité CSPE*) that also contributes to subsidized power prices for disadvantaged people.[12] The standard rate of CSPE was 1.05 Cent/kWh in 2012. The annual CSPE payments per supply point are limited to the maximum amount of 559,350 euro (2012). The limit is adjusted yearly. Energy-intensive companies with an annual consumption of more than 7 GWh benefit from a limitation of the CSPE payment to a maximum 0.5 % of the company's gross value added. Consumption of self-generated electricity is exempt from paying CSPE up to a volume of 250 GWh/a per generator location. This exemption also applies if only one further consumer is connected to the generator.

In France, a **social apportionment for financing social security** of employees from the energy sector is levied from consumers via the network tariffs. The *CTA (contribution tarifaire d'acheminement*) is applied with a fixed percentage to the fixed part of the network tariff (TURPE). The percentage varies by grid level (e.g. 8.2 % at transmission level and 21 % at distribution level). The absolute height therefore depends on the voltage level on demand characteristics.

Modelling the effects for the electricity costs of stylized companies

The components presented above such as electricity taxes and renewable energy support but also the network tariff methodology have a direct impact on the final electricity price paid by consumers. In contrast to household consumers, energy-intensive industrial consumers typically benefit from a varying degree of exemptions to protect industrial competitiveness. The policy-driven components in the power purchase price differ across countries. The same applies to the regulations that exempt energy-intensive industries based on different qualification criteria. Thus, different companies or company groups may benefit from the exemptions, possibly resulting in competitive distortions.

We shed light on the differences by modelling the power price components that are added to the purchase price. We analyse the UK, the Netherlands, France, and Germany. We present the components for sample companies from the aluminium, steel and paper industry. We include differently sized paper mills to illustrate how widely the burden varies even within one sector. We define the company types below. The description includes the criteria that are relevant for the determination of a possible exemption. The most important criteria are the classification of economic activity and processes as well as the absolute power consumption and the share of power cost in value-added and/or turnover. In addition, to determine network tariffs, the voltage level and capacity of connection are relevant. Within the calculation, we omit differences in electricity intensity across countries. This focuses the analysis on the diverging burdens from policy-driven power price components for a comparable production plant. We note that of course lower electricity intensity leads to a reduced (absolute) burden. Improvements in energy efficiency thereby mitigate the effect from higher power prices. We investigate the potential impact in a sensitivity analysis. Across the countries investigated, in the paper industry,

12. CSPE also contributed to financing power supply in non-grid connected oversee areas.

Table 2. Electricity intensity of the paper sector in Germany, France, UK and the Netherlands.

	Germany	France	United Kingdom	Netherlands
Electricity Intensity* (kWh/t)	1,148	1,087	2,219	1,060

*Electricity intensities are based on power consumption of the pulp and paper sectors as published in Enerdata and production volumes as given by the German paper association for the year 2009 (VDP 2012).

this effect is likely to work to the disadvantage of British paper companies that seem to have comparably higher electricity intensity (see Table 2).

In the following paragraphs, we detail the assumptions made for the sample companies. Table 3 presents a summary of the stylized facts.

PAPER INDUSTRY

For the paper industry we investigate a small and a big paper mill. For simplicity we assume both plants to produce at an electricity efficiency of 1,300 kWh/t of paper. We abstract from differences that result from different inputs, processes and paper quality produced. To put this into context: The intensity of 1,300 kWh/t is slightly above the world best practice in 2008 for an integrated plant producing bleached, uncoated fine paper or sanitary paper (Worrell et al. 2008). The annual electricity demand of the two plants is hence 26 GWh/a for the small plant and 650 GWh/a for the big plant.

Paper production is typically designed to high full load hours. We assume 7,500 h/a for the big plant corresponding to roughly 85 % utilization. We assume the small plant to have a lower rate e.g. because of alternating production of different qualities. We assume 6,000 h/a. This results in a calculated peak demand of 4.3 MW for the small plant and 87 MW for the big plant.

We assume both the small and the big paper plant to have a share of just above 20 % power cost in gross value added and roughly 6 % power cost related to turnover. Of course this is a simplification since these numbers vary with the product quality, input prices and the prices that may be achieved (see e.g. Vogt et al. 2008 for a different share of electricity cost to turnover based on company interviews).

We make some additional assumptions that are relevant with respect to determining the price paper companies have to pay for electricity:

- For France, we assume that the big paper company is part of the Exeltium consortium and benefits from reduced power prices while the small plant does not benefit from Exeltium. In the determination of network tariffs, we assume both plants consume with an optimal power factor, i.e. cosinus phi of 1. We assume electricity cost to be less than 50% in product cost and gross value added to be roughly 139 euro/t (based on EUROSTAT and VDP 2012).
- UK: we assume the two paper mills have concluded climate change agreements with the UK government and hence benefit from a reduced climate change levy.
- Germany: We assume that companies benefit from the surplus settlement and are repaid 90 % of their (electricity) tax load. For network tariffs, we assume the small plant pays the average industrial tariff (reference price) of 1.68 ct/kWh, while we assume a reduction to 0.6 ct/kWh for the big plant. This equals a reduction down to 35 % of the reference tariff which does not fully exploit the potential given in the regulation (down to 25 % of regular tariff) yet, corresponds to reported values for lower network tariffs from the industry.
- Netherlands: we assume the paper mills fall under a covenant. Since both have an electricity consumption above 10 GWh/a this qualifies them for an exemption from paying electricity tax and the renewable energy levy SDE+.

ALUMINIUM INDUSTRY

Within the aluminium industry, primary smelting is the most electricity-intensive process. The specific electricity consumption per ton of primary aluminium is roughly 15 MWh. We assume a plant with a production volume of 150,000 t/a which results in an annual power consumption of 2,250 GWh. Aluminum is typically produced over the entire year with a relatively constant power consumption. We assume the capacity demand to be 280 MW and full load hours to be 8,500 h/a. The share of electricity costs in gross value added is relatively high; we assume >20 %. For the electricity costs in relation to turnover, we assume a ratio of >5 %.

- For France, we assume that the aluminum smelter is part of the Exeltium consortium. We assume the smelter withdraws electricity with a cosinus phi of 1. We assume electricity costs to be less than 50 % in product cost and gross value added to be roughly 1,417 euro/t (based on EUROSTAT and Metal Statistics 2011). We assume the aluminium smelter to benefit from reduced power prices within the Exeltium consortium in France.
- UK: we assume the smelter has concluded a climate change agreement.
- Germany: We assume that the smelter's electricity consumption is to 90 % tax exempt because the electricity is used in the electrolyses. Additionally, we assume the company benefits from the surplus settlement and is repaid 90 % of the remaining (electricity) tax load. For network tariffs, we assume a reduction down to 10 % of the reference tariff i.e. 0.168 ct/kWh based on the maximum reduction allowed for companies with 8,500 utilization hours.
- Netherlands: we assume the smelter does fall under a long-term energy efficiency agreement and hence (demand >10 GWh/a) does not pay electricity tax or renewable energy levy SDE+.

STEEL INDUSTRY

For the steel industry, we analyse the power price components for a stylized electro steel company. We assume a production volume of 1 mio t/a. With an electricity intensity of 792 kWh/t

(VDE 2012), this amounts to an annual electricity demand of 990 GWh. We assume the plant to be connected to the high-voltage electricity grid. We assume the electricity costs to be approximately 15 % in relation to gross value added and roughly 10 % in relation to turnover. The steel production as a process of metal production benefits from electricity tax exemptions in all countries investigated. We further assume the company to benefit from reduced power prices in France under Exeltium.

- For France, we assume the plant is part of the Exeltium consortium and reaches an optimal power factor, i.e. cosinus phi is 1. We assume electricity cost to be less than 50 % in product costs and gross value added to be roughly 137 euro/t (based on EUROSTAT and wordsteel.com). We assume the steel plant to benefit from reduced power prices within the Exeltium consortium.
- UK: we assume the steel plant has concluded a climate change agreement.
- Germany: We assume that the steel plant's electricity consumption is to 80 % tax exempt because the electricity is used for metal production. Additionally, we assume the company benefits from the surplus settlement and is repaid 90 % of the remaining (electricity) tax load. For network tariffs, we assume the plant pays the reference price of 1.68 ct/kWh.
- Netherlands: we assume the plant to have concluded a covenant and hence (demand >10 GWh/a) to be exempt from paying electricity tax and renewable energy levy SDE+.

Based on these input data, we calculate the resulting electricity price split into the different components. In the calculation we do account for base rates/ minimum values that might apply for example with regard to electricity taxes as well as for absolute cost limits such as for annual payments for renewable energy support (CSPE- contribution aux charges de service public de l'électricité) in France.

For power procurement and network costs we disregard privileges and assume prices are equal in the privileged and unprivileged case. The exceptions are Germany and France. In Germany, we assume network tariffs do be the average tariff paid by industrial and commercial customers in the unprivileged case and assume lower tariffs for the big paper production plant and the aluminum smelter. For the Netherlands, France, and UK, we calculate network tariffs based on demand characteristics. In UK, we disregard locational tariff differentiation by applying the average. In France, we assume the aluminum smelter, the big paper mill and the steel plant to be part of the Exeltium consortium that negotiated a long-term contract for low electricity prices with EDF. The small paper mill is assumed to pay the reference purchase price of 5 ct/kWh that we also assume for all other countries.

Results and discussion

RESULTS FOR THE BASE CASE

Not surprisingly, we find that the electricity prices for electricity-intensive companies differ across countries. We first present the results for the components: taxes, network tariffs, and renewable energy support. The mark up on the power procurement price that has to be paid by companies ranges from 0.3 ct/kWh to 2.3 ct/kWh (see Figure 1). The lion's share of the difference is caused by differences in the network tariffs. These differences often result from differences in the network charging methodology reflecting network cost caused by demand according to different characteristics. Hence, they are no exemptions to protect energy-intensive industry per se. Germany may be considered an exception. Currently, the network charging methodology allows for individualized network tariffs for "extensive network utilization" characterized by utilization hours of 7,000 h/a and more. The reduction may be down to 10 % of the applicable standard tariff which causes the notably very low network tariffs for aluminum smelting. Yet, also these reductions are motivated by the contribution of energy-intensive users to reductions in network costs (or prevention of cost increases) (Schwarz 2013).

Interestingly, and somewhat unexpected, is the relatively high importance of renewable energy contributions in the UK. For the steel plant, the aluminum smelter and the big paper mill, the contributions are higher than those levied in Germany. Importantly, for the small paper mill, the contribution for renewable energy in Germany is significantly higher. The biggest difference can be seen for the steel plant and aluminium smelter with 2.5 ct/kWh (UK to France). The difference is

Table 3. Assumptions for Stylized Companies from the Paper, Steel and Aluminum Sector.

		Pulp and Paper		Steel	Aluminum
		small paper company	big paper company	electro steel	primary smelter
production volume	t/a	20,000	500,000	1,000,000	150,000
electricity intensity	kWh/t	1,300	1,300	792	15,000
electricity demand	GWh/a	26	650	792	2,250
peak demand/ connection capacity	MW	4,3	87	120	265
full load hours	h/a	6,000	7,500	6,600	8,500
share of electricity cost in gross value added		>20 %	>20 %	15 %<x<20 %	>20 %
share electricity cost in turnover		>5 %	>5 %	>5 %	>5 %
turnover per ton*	euro/t	691		846	8,086
value added per ton*	euro/t	139		137	1,417

* Based on EUROSTAT for turnover and value added and VDP for paper production, wordsteel.com for raw steel production and metal statistics 2010 for aluminum production (primary and secondary).

slightly smaller for the big paper company, with 2.47 ct/kWh difference. These differences mainly result from different network tariffs. Abstracting from network tariffs, the difference would be 0.43 ct/kWh (0.5 ct/kWh for steel/aluminum). For energy-intensive firms such differences sum up to several millions of euro per year. For the aluminium smelter e.g. an increase of just 0.5 ct/kWh would imply an additional payment of 11 million euro/a for its power consumption, 2.5 ct/kWh would imply additional expenses for electricity in the order of 56 million euro/a; even for the small paper mill the annual difference would be 0.13 million euro (+0.5 ct/kWh) to 0.65 million (2.5 ct/kWh).

In Figure 2, we present the prices by components for the aluminum smelter (left side of Figure 2) and the electro steel plant (right side of Figure 2). For the aluminum smelter, the price is lowest in France with roughly 4.5 ct/kWh and highest in the United Kingdom with 7.1 ct/kWh. Notably, this is driven by presumably low Exeltium power prices in France and relatively high network tariffs calculated for the UK. We note that this may result from assuming average network tariffs in the UK. In Northern Scotland e.g. the network tariffs are significantly lower. Applying tariffs for the network region Northern Scotland (see below in the sensitivity analysis) would decrease the price by 0.47 ct/kWh to 6.61 ct/kWh. This lower priced network region is the area, where the last existing primary aluminium smelter in the UK is located: namely in Lochaber. Importantly also, for the case of aluminium smelter, the highest contribution to renewable energy support has to be paid in the UK. In the Netherlands and Germany, the contributions are reduced to a minimum (D), respectively waived entirely for companies participating in long-term agreements for energy efficiency (NL).

For steel the picture looks slightly different for Germany now being the country in which the second highest (net) prices have to be paid. This is driven by network tariffs. The contribution to renewable energy support (0.11 ct/kWh) is still lower than in the UK (0.47 ct/kWh). Across all countries, except Germany, the price resulting for the electro steel company is similar to that for the aluminium smelter. In Germany, the difference is significant with 1.5 ct/kWh (5.3 ct/kWh compared to 6.8 ct/kWh). The driver for the difference is the different reduction category with respect to the renewable surcharge.

In Figure 3 we present the price components for the small and the big paper mills. Interestingly, the prices are similar for both mills in the Netherlands (5.5 ct/kWh to 5.6 ct/kWh) and the UK (7.1 ct/kWh to 7.2 ct/kWh), i.e. the prices in these countries do not differ much by the size of the paper mills. Yet, the price in the Netherlands is the lowest across the four countries for the small paper mill and the UK price is the highest for the big mill and the second highest, just short of the price for the small paper mill in Germany. For Germany, the price difference for the small mill compared to the big mill is 1.4 ct/kWh (7.3 ct/kWh compared to 5.9 ct/kWh). This large deviation results to a large degree from the reduced network tariffs assumed for the big mill, and also from the different reductions regarding the renewable energy surcharge. The lowest price for the big paper mill can be observed for France. This result is driven exclusively by the assumption of a special power price of 3.7 ct/kWh within the Exeltium consortium.

SENSITIVITY ANALYSIS

We made a number of assumptions to calculate electricity price components. In the following we test the sensitivity of results to some core assumptions. We provide three scenarios:

- **A1:** discontinuation of a core privilege: no climate change agreement, i.e. no waiver from climate change levy in the UK, discontinuation of BesAR in Germany, hence payment of full renewable energy surcharge, no covenant and hence no exemption from electricity tax and SDE+ in the Netherlands. And for France, we assume a discontinuation of the reduced power prices under Exeltium. We do not change network tariff reductions in Germany to focus on the effect of the renewable energy surcharge reductions.
- **A2:** differences in energy efficiency. We assume an increase in energy efficiency, i.e. the power consumption per ton of product, to test to which degree this can mitigate the effect of price differences. We calculate the annual savings and divide them by the original power consumption to get a specific value.
- **A3**: network tariffs: location and power factor. For France, the power factor determines the level of the network tariffs. In the UK, network tariffs depend on location. For the sensitivity analysis, we assume companies do not achieve an optimal power factor, i.e. we assume they achieve a cosinus phi of 0.95 in France. In the UK, we assume companies are located in Northern Scotland as the area with the lowest network tariffs.

Results for Scenario A1:

A discontinuation of privileges from certain energy political instruments with an impact on the power price would have very different effects across the four countries. The effect would be biggest in Germany (in the range of 5 ct/kWh) and smallest in the Netherlands (around 0.05 ct/kWh). The significant effect in Germany is driven by the high differential costs of renewable energy support that are socialized via the renewable energy surcharge. Currently, energy-intensive industries benefit from a significant reduction of the charge. While the charge was 5.27 ct/kWh for household consumers in 2013, industrial consumers with the highest exemption only paid 0.05 ct/kWh. The state aid investigation of the European Commission creates uncertainty about future developments of the surcharge and the exemptions for industrial consumers. This is a severe problem for the industry since a burden of the standard surcharge could potentially cause a significant increase of electricity costs of around +5 ct/kWh.

In the Netherlands and the UK, a discontinuation of selected privileges would only have a minor effect, but still in the range of 0.5 ct/kWh for the UK. For France, the discontinuation would imply an increase of around 1.3 ct/kWh under the assumption of a reference power price of 5 ct/kWh. Of course the increase is sensitive to the assumption of a diverging alternative power price.

Results for Scenario A2

An efficiency increase of 5 % decreases the annual power consumption needed for production and hence, annual power costs by 5 %. Obviously, the savings increase with the absolute power

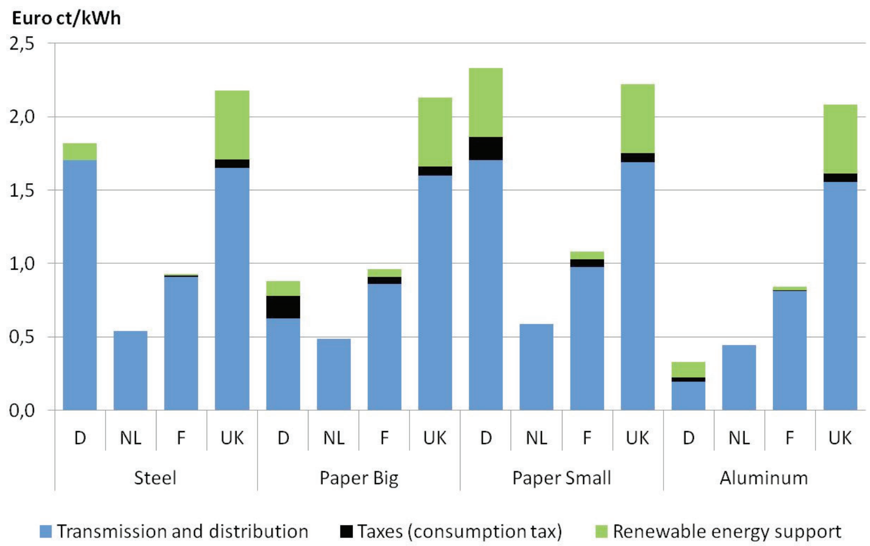

Figure 1. network tariffs, electricity tax, and renewable energy apportionments in the electricity price for the stylized companies across countries.

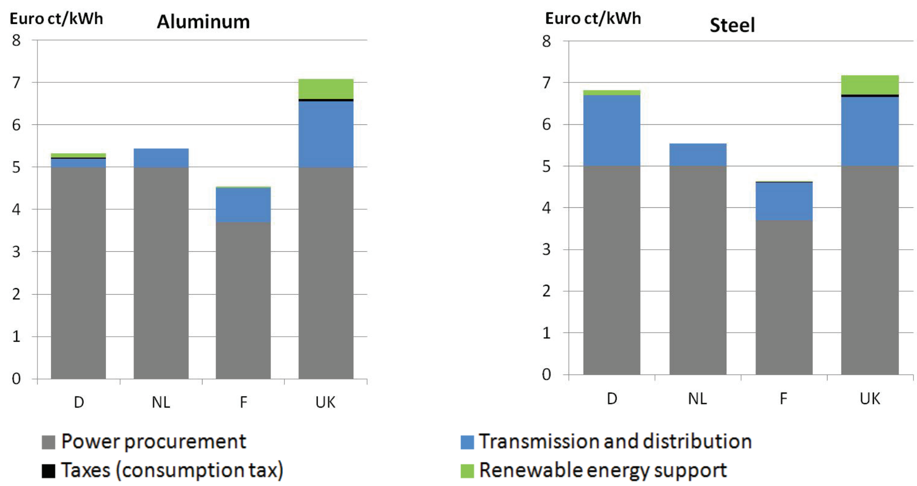

Figure 2. Electricity price by components for the stylized aluminum smelter and electro steel company.

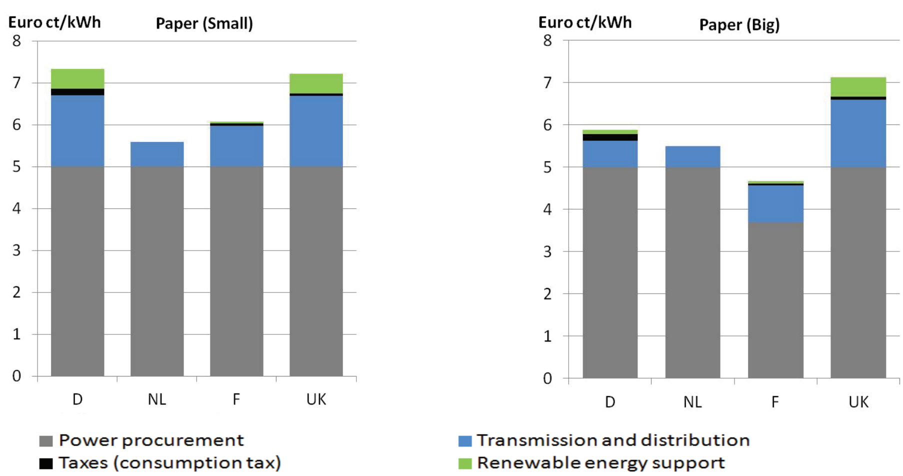

Figure 3. Electricity price by components for the stylized paper factories.

consumption. The annual savings in the expenses for power procurement would amount to approximately 0.1 million euro for the small paper mill and up 5–8 million euro for the aluminium smelter. To investigate whether improved energy efficiency could compensate for higher prices, we build the ratio of the monetary savings and the power consumption before the improvement. We find that a 5 % energy efficiency improvement is comparable to a reduction in electricity costs of approximately 0.23–0.37 ct/kWh. In comparison to policy driven price differences in the range of 1.7 to 2.5 ct/kWh, this indicates that improvements in energy efficiency can only mitigate disadvantages from these effects. They cannot fully compensate for them. This perspective does not investigate whether the investment in energy efficiency improvement by industrial companies would be viable and whether there are other barriers to energy efficiency improving investment (see e.g. Fleiter 2012).

Results for Scenario A3:
For the UK, we assumed plants to be located in a virtual region with average network tariffs. For the aluminium smelter we have already noted that this assumption causes relatively high network tariffs since the only existing smelter in the UK is located in Northern Scotland – a region with low network tariffs. Hence, we calculate the reduction in network tariffs available from a location in Northern Scotland for the four stylized companies.

For France, we investigate to what degree the network tariffs would increase in case companies do not achieve the optimal ratio of active to reactive power.

We find that for the UK, the reduction in this case would be around 0.5 ct/kWh. Compared to original network tariffs around 1.6 ct/kWh, this appears to be a quite significant potential decrease.

For France, the network tariffs would increase by approximately 0.5 ct/kWh because of payments for reactive power. Compared to a network tariff of around 0.9 ct/kWh, this is also a significant increase.

Discussion and Concluding Remarks

Based on an analysis of sample companies from three energy intensive sectors: paper, steel, and aluminum production, we find that net power prices may differ by 1.7 ct/kWh to 2.6 ct/kWh for the same companies across countries. We observe that within countries, prices are relatively homogenous. Only in Germany, power prices differ widely between a large and a small paper mill. The burden on the small paper mill is highest in Germany, while the burden on the large paper mill is second lowest in Germany. This illustrates that qualification criteria for reductions are more dependent on size in Germany than in other countries. With respect to network tariffs we generally observe that network tariffs tend to decrease for companies with high consumption and high full load hours (i.e. big paper and aluminum) which are likely rooted in network pricing methodologies and may not be considered a subsidy. Nevertheless, this has been debated with respect to the significant reductions of network tariffs for energy intensive network users (e.g. aluminum smelters) in Germany. The reductions have been criticized (EC 2013a). Even though the full exemption from paying network tariffs was abandoned in 2013 reduction rules might change further in future. The reduction may be considered policy driven.

Focusing on taxes and renewable energy support mechanisms, we find that the UK has the highest burden on the companies, except for the small paper mill, for which the add-ons are highest in Germany. This implies that Germany has significant exemptions that limit electricity price increases for aluminum and steel companies. In France and the Netherlands, the burden from electricity tax and renewable energy support is generally low for the sample cases.

Drawing on the above observations, we note that no general statement can be made on whether policy driven components in the power price and associated exemption rules for energy-intensive companies lead to competitive distortions. Rather, it is necessary to look at the details, since effects differ across the price components: network tariffs, renewable energy support, and taxes as well as across company types. At least for Germany, we observe a strong dependence on electricity demand which might have a distorting effect across company sizes.

We note however, that the exemption of energy-intensive producers from paying certain power price components has several problematic effects. First, in case of an apportionment, the exemption increases the burden on other consumer groups. Take as an example the renewable surcharge in Germany: reductions for industry lead to higher apportionments for household consumers. Second, in case of taxes, the exemptions decrease the tax income of the state. Third, in both cases, an exemption decreases the power price paid by the privileged company. This is intended to secure international competitiveness. At the same time, it may create a barrier for energy efficiency investment since amortization time increases with lower power prices (Fleiter 2012).[13] Exemptions based on a threshold value of absolute power consumption may even set incentives to consume more energy for companies just below the threshold. These disincentives are contained by the addition of energy efficiency requirements in the qualification criteria. In Germany, e.g. the surplus settlement is coupled to the existence of a certified energy management system (EMS) and sector energy efficiency improvements since 2013. Similarly, companies with consumption above 10 GWh/a which want to receive a reduction of the renewable surcharge have to prove a certified EMS. This forces companies that receive large reductions to care for energy efficiency. In the Netherlands, exemptions of electricity tax and renewable surcharge are coupled to the participation in a covenant to increase energy efficiency at sector level. Also in the UK, privileges are granted only if climate change agreements are concluded at sector level. In France, it seems that prescriptions to foster energy efficiency are not included in the exemption regulations. In this paper, we have related monetary savings from energy efficiency improvements to the power consumption to make cost savings comparable to price reductions. We found that effects of energy efficiency on power costs are far lower than those of reduced prices. Hence, it is good news that with the exception of France, the countries coupled the exemptions in some form to energy efficiency targets.

13. We investigate the effect from policy driven reductions in power prices on energy efficiency investment in detail for a sample paper mill in a separate submission: Aydemir & Friedrichsen 2014.

The link of exemption rules that limit electricity prices for energy-intensive industries to energy efficiency requirements seems a promising way to contain disincentives for energy efficiency or even foster energy efficiency. The requirements seem to have led to an increase of certified EMS at least in Germany where the number of certified companies increased from 827 in January 2013 to 3,099 in February 2014. However, this does not allow conclusions regarding the effects on energy efficiency. In a next step, it will be worthwhile to investigate the implications for energy efficiency. This will allow deriving recommendations with respect to designing policy instruments that do not overly burden energy-intensive industries with costs from e.g. renewable energy support, but at the same time do not compromise energy efficiency. It will also be interesting to investigate potential added benefits of these instruments for energy efficiency since energy efficiency investments are not only hindered by financial barriers. Informational barriers are highly relevant (Trianni et al. 2013). Whether the requirement to install EMS helps to overcome this barrier remains a question for the next few years.

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