Electricity costs of energy-intensive industries in Norway – a comparison with energy-intensive industries in selected countries

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Karlsruhe, Berlin, 1 February 2016

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1 Introduction

In recent years, climate protection has evolved into one of the core political issues in Europe and worldwide. Against the background of increasing scientific knowledge about climate change and a growing political consensus, policies have been implemented that aim at reducing greenhouse gas emissions in the European Union by 20% by 2020 and by 40% by 2030 (relative to 1990). In March 2015, Norway submitted an INDC stating its goal of reducing emissions by at least 40% below 1990 by 2030.[1] Other countries, such as the USA, China, and Korea, have also started implementing policies to reduce greenhouse gas (GHG) emissions. The development of renewable energy sources (RES) is regarded as an important lever to reduce energy-related greenhouse gas emissions. Currently, in most countries, the expansion of RES and other measures to reduce greenhouse gas emissions are primarily policy driven. The resulting costs and benefits of energy and climate policies have significant impacts on different actors and economic groups. Regulations affect consumption and production costs, but also the competitiveness of companies and overall economic growth. To reduce the cost burden on industry, various exemptions from contributing to the costs of energy and climate change policies have been introduced over time in several countries. These exemptions may ease the burden on privileged companies, but at the same time, they cause higher burdens for non-privileged companies and other energy consumers, including households.

Fraunhofer ISI and Ecofys GmbH published a study on "Electricity Costs of Energy-intensive Industries – an International Comparison" for the German Federal Ministry of Economic Affairs and Energy in August 2015. In this study, they analysed the wholesale and retail prices for different electricity consumers in selected European and non-European countries.[2] The analysis comprised a description of the electricity market and a breakdown of the retail electricity price into its components. In addition, they assessed the electricity costs for energy-intensive industries –steel, aluminium, copper, paper and chemical – and showed how electricity prices affect competitiveness at the level of products and of firms.

This study did not encompass Norway or the Norwegian industry. This add-on report remedies this and focuses on the electricity market and energy-intensive industry in Norway. This allows a comparison of Norway's electricity market, prices and energy-intensive industry with the countries analysed in the previous study for the German Ministry.

The add-on report comprises four chapters: this introduction, an overview of the electricity market and prices in Norway, a depiction and comparison of price components in Norway, and conclusions.

[1] http://www4.unfccc.int/submissions/INDC/Published%20Documents/Norway/1/Norway%20INDC%2026MAR2015.pdf
[2] The number and choice of countries were limited by the contracting entity. Selection factors included the geographic location, existence of energy-intensive industries, competitive power prices and trade volumes of the respective industries in the countries.

2 Description of the electricity market and prices in Norway

2.1 Electricity supply and demand

After a peak in consumption at 121 TWh in 2010, Norway's net electricity consumption[3] amounted to about 119.5 TWh in 2013. This decreased further in 2014, to 117 TWh.[4] In 2013, industry accounted for around 43% of net consumption (29% due to power-intensive manufacturing[5], 7% due to non-energy-intensive manufacturing, 6% mining and extraction), households for 30% and the construction and other services sector for 21%.[6] In the last decade since 2005, the share of industry in total electricity consumption has decreased slightly (despite an increasing production index), while that of households and construction and other services has risen slightly.[7] However, power consumption for extraction of crude petroleum and natural gas together with support activities for this sector has more than tripled since 2008 and accounts for more than 5% of total energy consumption, while electricity-intensive manufacturing displays a slight decrease, mainly due to decreases in the manufacturing of pulp, paper and paperboard over time. In the electricity-intensive manufacturing sector, the non-ferrous metal sector accounted for about 16% of total electricity consumption, the chemical sector for almost 6%.[8]

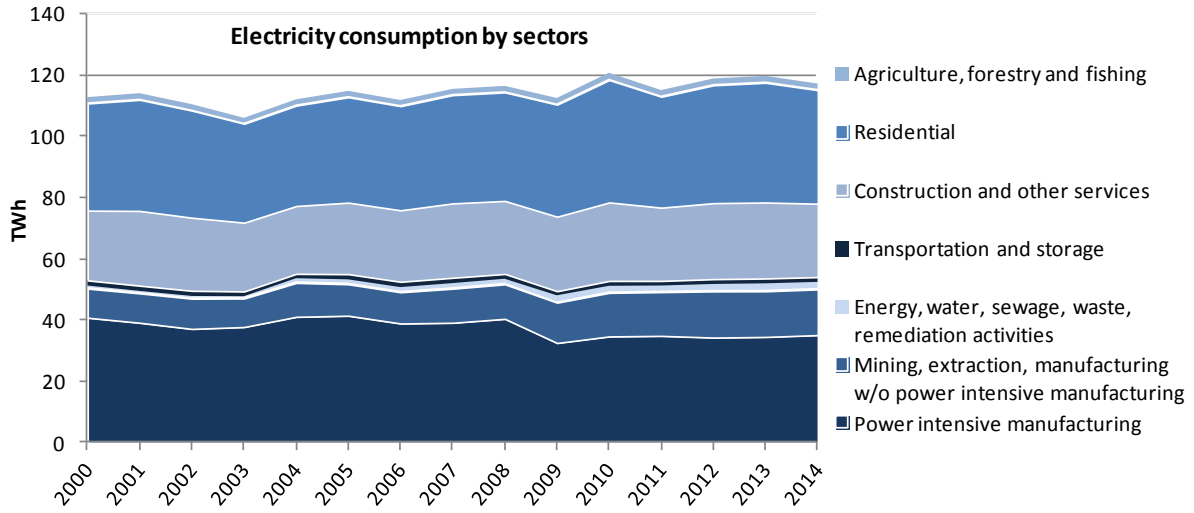


Figure 1: Electricity demand in Norway [source: Statistics Norway]

In 2013, according to Statistics Norway, total gross electricity production in Norway was 134 TWh and this increased to 142 TWh in 2014. The difference between gross and net consumption figures is due to losses (around 8 TWh in 2013), net exports (around 5 TWh in 2013) and pump storage

[3] Net consumption: domestic production – exports + imports – pump storage, other own consumption, losses
[4] https://www.ssb.no/en/energi-og-industri/statistikker/elektrisitet/aar/2015-12-22?fane=tabell&sort=nummer&tabell=250566
[5] Electricity-intensive industry according to Statistics Norway: "pulp and paper production, industrial chemicals, iron, steel and ferro-alloys in addition to primary aluminium and other metals"
[6] https://www.ssb.no/statistikkbanken/selectvarval/Define.asp?subjectcode=&ProductId=&MainTable=NtoForbKraftGrFyl&nvl=&PLanguage=1&nyTmpVar=true&CMSSubjectArea=energi-og-industri&KortNavnWeb=elektrisitet&StatVariant=&checked=true
[7] Idem
[8] https://www.ssb.no/en/energi-og-industri/statistikker/elektrisitet/aar/2015-12-22?fane=tabell&sort=nummer&tabell=250568

consumption (around 1 TWh).[9] Most electricity was generated by hydropower (129 TWh, 96% of the energy mix). The remainder was covered by thermal power generation (2.5%, essentially gas-fired power for self-consumption at the industrial facility of Melkøya) and wind power (1.5%).[10] Historically, hydropower is the main source of electricity in Norway and has constantly generated around or above 95% of total generation for several decades. Thermal generation peaked at 4.9% in 2010, while wind power is steadily increasing, from 0% in 2000 to 0.4% in 2005 and 0.7% in 2010.[11]

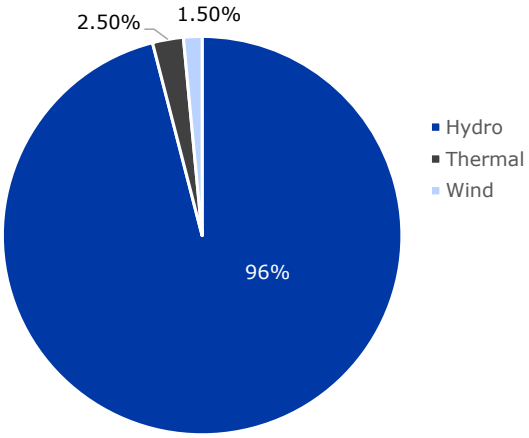


Figure 2: Sources of electricity generation in Norway, 2014 [source: Statistics Norway]

2.2 Electricity market

The largest producer of electricity in Norway is Statkraft Energi AS (Statkraft), with a 36% share of total installed capacity in 2013. Statkraft is fully owned by the Norwegian State. Other relevant power producers are E-CO Energi AS (9% of total capacity), Norsk Hydro (6%, for self-consumption in its aluminium plants), Agder Energi Produksjon (6%), BKK Produksjon (5%), and Lyse Produksjon (5%). E-Co Energi is fully owned by the municipality of Oslo; Norskhydro is partly owned by the state. Overall, municipalities, county authorities and the State own about 90% of Norway's electricity production capacity.[12]

The Energy Act, which provides the overall framework for organising the power supply in Norway, follows the principle of market-based power trading. Norway is part of a joint Nordic power market together with Sweden, Denmark and Finland, and the Baltic countries. In this market, 84% of power production was traded on the Nord Pool Spot power exchange in 2013.

[9] https://www.ssb.no/statistikkbanken/selectvarval/saveselections.asp
[10] https://www.ssb.no/statistikkbanken/selectvarval/Define.asp?subjectcode=&ProductId=&MainTable=ProdElKraft&nvl=&PLanguage=1&nyTmpVar=true&CMSSubjectArea=energi-og-industri&KortNavnWeb=elektrisitet&StatVariant=&checked=true
[11] https://www.ssb.no/statistikkbanken/SelectVarVal/Define.asp?subjectcode=01&ProductId=01&MainTable=ProdElKraft&SubTable=1&PLanguage=1&nvl=True&Qid=0&gruppe1=Hele&VS1=&mt=0&KortNavnWeb=elektrisitet&CMSSubjectArea=energi-og-industri&StatVariant=&checked=true
[12] https://www.regjeringen.no/globalassets/upload/oed/faktaheftet/facts_energy_water.pdf

2.3 Electricity exchange

Norway is interconnected to most of its neighbouring states. In 2013, around 10 TWh of electricity were imported, while 15 TWh were exported. In 2014, imports stood at 6 TWh, exports at 22 TWh. The total trading capacity between Norway and other countries is currently about 6100 MW. Norway's interconnections are mainly with Sweden (around 3500 MW), but also with Denmark (1700 MW), the Netherlands (700 MW interconnector, operational since 2008), Finland (100 MW), and Russia (100 MW).[13] Two subsea interconnectors to Germany and the UK are currently under construction after the decision to invest was taken in 2015. Each has a transmission capacity of 1.4 gigawatts and both are expected to be completed by 2020 and 2021, respectively. Norway has been a net exporter of power in most years. However, in certain years, it became a net importer, when low reservoir levels restricted hydropower generation. This has happened in 2003, 2004 and 2010.[14]

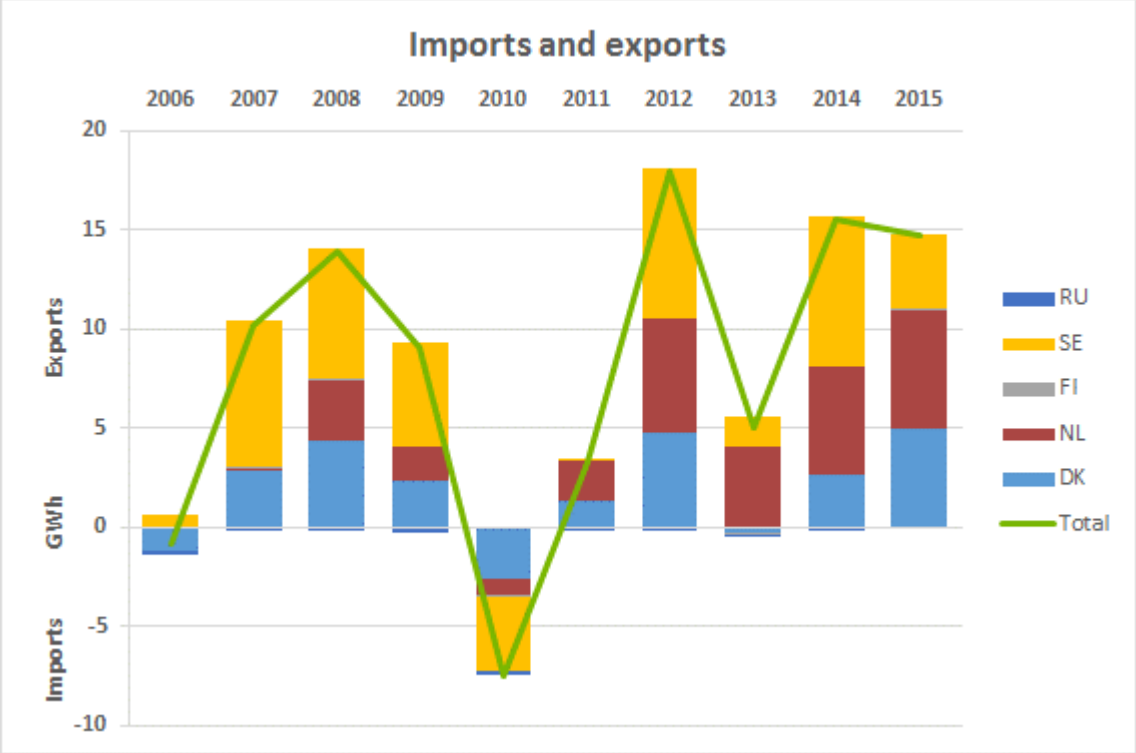


Figure 3: Imports and exports per country and total (source: Statnett)

2.4 Electricity purchase price

Norway is divided into 5 bidding areas (East, South West, Mid, North and West). Price differences occur when there is not enough transmission capacity between the areas to equate prices. For instance, Central Norway had higher prices than South West Norway 42% of the time in 2013. Over

[13] https://www.regjeringen.no/contentassets/fd89d9e2c39a4ac2b9c9a95bf156089a/facts_2015_energy_and_water_web.pdf and https://consultations.entsoe.eu/system-development/regional-investment-plans/user_uploads/regional-investment-plan-2015---rg-bs---for-consultation.pdf and http://www.iea.org/media/training/presentations/Day_4_Session_3c_Case_study_Nordic_Pool.pdf

[14] https://www.regjeringen.no/contentassets/fd89d9e2c39a4ac2b9c9a95bf156089a/facts_2015_energy_and_water_web.pdf

the year, price differences between bidding areas within Norway are generally around 10-15%. In 2013, the spot prices of the 5 bidding areas averaged between 3.73 and 3.90 ct/kWh (31.27 to 32.66 øre/kWh); in 2014, between 2.73 and 3.15 ct/kWh (22.88 to 26.40 øre/kWh); and in 2015, between 1.99 and 2.13 ct/kWh (17.93 to 19.22 øre/KWh).[15] Besides the regional spot market prices, the Nordic system price is an important reference price for trading and clearing most financial contracts and is used for electricity supply contracts as well. Together with Sweden, Norway has the lowest prices within the Scandinavian electricity market. Prices in Denmark and Finland are higher. Figure 4 depicts the regional spot prices in Norway as well the spot price of a selected region in Denmark (DK1) and one in Sweden (SE1), and the Nordic system price (SYS). While the spot price in Denmark is above the Nordic system price, spot prices in Sweden (SK1), Oslo and Kristiansand range around or slightly below the Nordic system price.

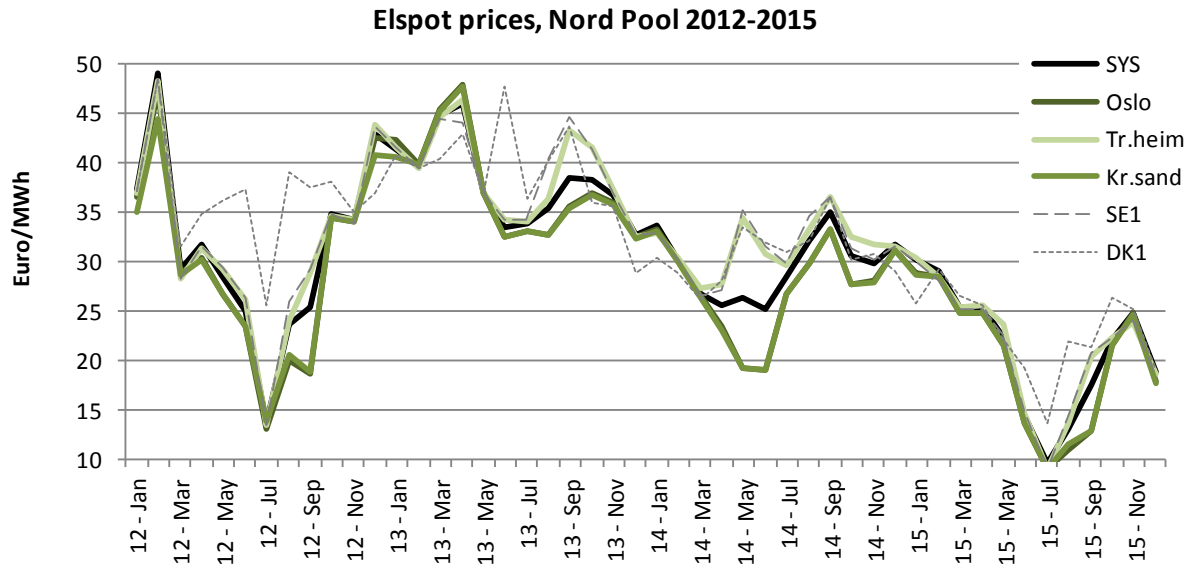


Figure 4: Elspot prices in 3 Norwegian regional electricity markets and the Nordic system price (source: Nord Pool).

Note: Three Norwegian bidding markets are selected out of five to keep the figure clearly presented.

2.5 Situation and costs of the network

The electricity network is divided into three levels: the central grid (transmission system), the regional grid and the distribution network. Norway's national transmission grid operator, Statnett, operates the Norwegian high-voltage grid and interconnectors. According to figures from ENTSO-E, the transmission tariff (central grid level) in Norway was 0.383 ct/kWh in 2013 in the 'base case' (which corresponds to 5000 hours utilisation time per year and a maximum power demand of 40 MW). There are differences in tariffs due to location and utilisation. For example, the power intensive industry (load of 15 MW+ and utilization time of 7000+ hours) receives a reduced load

[15] http://www.nordpoolspot.com/Market-data1/Elspot/Area-Prices/NO/Daily1/?view=table

tariff. The reduction is about 50% (2013; 70% in 2015) compared to regular load.[16] [17] Because only a few energy-intensive companies are direct customers in the central grid, a large part also pays distribution fees. There are around 160 DSOs at local and regional level. Most DSOs are wholly or partially owned by municipalities. According to Eurostat, total network (distribution and transmission) charges are 0.6 ct/kWh in 2013 in Norway for consumption between 70 GWh and 150 GWh. However, actual network costs for companies with large consumption (above 150 GWh) may differ from this network charge due to particular calculations not reflected in available statistics; fees for this consumption level are not provided by Eurostat.

Statnett has been reviewing its tariff strategy for the period 2014-2018 as it sees a considerable need for more flexibility in the power system in the future and wants to adapt the tariff structure accordingly. Transport costs for energy-intensive industry will then be differentiated with up to 90%-95% reductions in tariffs according to localisation and flexibility of demand.[18] However, this is not relevant for 2013 tariffs.

2.6 Electricity tax

The Norwegian electricity consumption tax reached 11.59 øre/KWh in 2013 (1.38 €ct/kWh), having increased steadily from 10.5 øre/KWh in 2008. Manufacturing, mining, waste, district heating and data centres benefitted in 2013 from a reduced rate of 0.45 øre/KWh (0.05 €ct/kWh), which has since increased to 0.48 øre/KWh in 2016 (sector-based exemptions). Chemical reduction, electrolysis, metallurgical and mineralogical industrial processes, greenhouses, industry and rail transport are exempt from the tax (process- and product-based exemptions).[19]

2.7 Promotion of renewable energy sources

Renewable energy sources are supported by a joint scheme of Norwegian-Swedish green certificates. Producers of electricity based on renewable energy sources receive an income from the sales of electricity certificates in addition to the income from selling electric energy. The joint market permits trading of both Swedish and Norwegian certificates, and certificates to be held for renewable electricity production in either country. 28.4 TWh from new renewable energy projects are expected by 2020, of which Sweden finances 15.2 TWh, and Norway 13.2 TWh. The payment for electricity certificates is included in end users' total electricity bills. The average cost was 1.2 øre/kWh in 2013 as calculated by the Norwegian Water Resources and Energy Directorate (NVE).[20] Several sectors are exempted from the costs of certificates, similar to the electricity consumption tax exemption: chemical reduction, electrolysis, metallurgical and mineralogical industrial processes, greenhouses, industry and rail transport. Other activities such as paper and

[16] The special tariff is based on a so-called k-factor model (ENTSO-E 2013).
[17] https://www.entsoe.eu/publications/market-reports/Documents/SYNTHESIS_2013_UPDATED_140703.pdf
[18] The rebate in the central grid for companies meeting specific requirements has an upper limit of 90 % (or 95 % if additionally qualified for the general rebate to customers in surplus areas).
[19] https://lovdata.no/dokument/SF/forskrift/2001-12-11-1451#KAPITTEL_3
[20] http://www.energimyndigheten.se/globalassets/fornybart/elcertifikat/sv-norsk-marknad/electricity_certificate_market_annual_report_2013.pdf

pulp, chemical and metals which are not already exempted, can apply to NVE for exemption on a case-by-case basis.

Enova fee

Enova is a public enterprise founded in 2001 and owned by the Norwegian Ministry of Petroleum and Energy. Enova is charged with promoting efficient energy use and new forms of renewable energy. A large share of its budget is dedicated to projects in industry and non-industrial plants and facilities (supporting the introduction of new technology or new (renewable) energy). For instance, Enova provided 1555 million NOK in 2014 (96 GWh contracted energy result) to construct an industrial pilot plant for next generation energy-efficient primary aluminium production (Hydro Aluminium). With this pilot production facility, the specific electricity consumption of primary aluminium ranges around 12300 kWh/t aluminium, but further technological advances are expected to reduce electricity input to 11500 kWh/t.[21] Activities of the state-owned enterprise Enova are financed through an energy fund with income from a levy (parafiscal charge on the electricity distribution tariff). This levy is set at 1 øre/KWh for households, while there is a fixed amount of 800 NOK per metering point for businesses. As this amount is negligible for energy-intensive companies, we have not included it in the cost calculation.

CO_2 compensation scheme

Norway established a scheme to compensate energy-intensive industry for the indirect CO_2 costs linked to the EU ETS on 1 July 2013. Estimates using general assumptions that are linked to the activity level and average electro-intensity of the aluminium sector show an impact of around 0.2€ct/kWh. Given that the compensation only started in the second half of the year 2013, its impact over the whole year was around half of that amount. Payments to companies started in 2014. Therefore in 2013, there were no impacts on costs (i.e. payments). As a consequence, the indirect CO_2 compensation is not included when calculating the energy procurement costs for aluminium producers in 2013.

2.8 Conclusion

The list of current electricity price components in Norway is relatively short compared to other European countries. As a result, the price structure for the industrial sector is less complex than in other major European economies such as Germany, the UK, Italy or France. Transmission grid costs amount to 0.383 ct/kWh in 2013 in the 'base case', and to 0.6 ct/kWh according to Eurostat when including distribution grid fees, but may be reduced for energy-intensive industries. The exemption system for the electricity tax is clear and simple, as eligibility is based on the sector of activity: energy-intensive industry is largely exempted. Similar rules apply to exemptions from the costs of promoting renewable energies with additional case-by-case exemption possibilities. The CO_2 compensation scheme showed its first impacts in 2014, and is therefore not included in the analysis of 2013.

[21] Annual Report Enova, Results and Activities 2014

3 Comparison of electricity retail price components

3.1 Calculation of the energy component

The price paid by companies for electricity (without taxes, levies and network charges) depends on the size and procurement strategy of the respective company. Industrial companies with a relatively small absolute consumption normally obtain their power from a power utility company. The power utility company passes on the procurement costs and a margin via the price of electricity. To a certain extent, the procurement price will depend on the negotiating power of individual companies. Eurostat figures are used to derive the procurement price for **small electricity end consumers** (≤ 150 GWh) in European countries (see Table 1).

ENERGY PROCUREMENT COSTS (ct/kWh)	DE	NL	FR	IT	DK	UK	NO
Enterprises with a consumption of 70 to 150 GWh per year	4.91	5.56	4.42	7.41	3.93	7.72	3.57
Enterprises with a consumption of 20 to 70 GWh per year	5.15	5.46	4.29	8.3	3.93	8.00	3.82
Enterprises with a consumption of 2 to 20 GWh per year	5.59	5.69	4.42	9.02	3.93	8.18	3.87
Enterprises with a consumption of 0.5 to 2 GWh per year	6.08	5.96	5.00	9.27	3.98	8.72	3.93

Table 1: European power procurement costs for different consumption classes in Eurostat (2013)

The energy procurement costs in Norway are lower than in any other of the reviewed European states for all consumption classes. They are only marginally lower than in Denmark, because of the integrated Nordic power market, but they are significantly lower compared to other countries: The energy procurement costs in Norway are roughly half those in Italy and the UK. In 2013, they were around 50% lower than in the Netherlands, 30% lower than in Germany, and 20% lower than in France.

For 2013, Eurostat reported procurement prices of 3.57 ct/kWh (28.8 øre/KWh) – compared to 3.01 ct/kWh (25.4 øre/KWh) in 2014 – for industrial consumers with an annual demand between 70 and 150 GWh. Prices for this category have been fluctuating between 2.63 and 3.57 ct/kWh since 2008 (21.6 to 28.8 øre/KWh). For household consumption between 2500 and 5000 kWh/year, the 2014 price was 4.6 ct/kWh (39 øre/KWh), a decrease compared to the 2013 price of 5.2 ct/kWh (42 øre/KWh) and the 2010 peak of 6 ct/kWh (48 øre/KWh).

Statistics are not available for companies with high consumption over 150 GWh for most countries. Norway does not report data for this highest consumption class either. In the liberalised European electricity markets, many of these big companies trade electricity among themselves or through intermediaries at power exchanges.

To assess electricity prices for **large European industrial consumers** that buy their electricity on the stock exchange either directly or through an intermediary e.g. in Germany, the spot price plus a

spread for forwards is applied to assess the electricity prices. This assumption of a spread is based on interviews with German industry representatives, who reported that typical purchasing strategies consist of about 80% long-term contracts (1-5 years) and 20% spot market purchase. This was confirmed in a study by the Belgian regulator, CREG, published in 2015.[22] Therefore declining or rising prices on the spot market do not have an immediate impact on the procurement costs of large industrial companies. In Norway, long-term contracts run for 7 to 20 years and may be indexed to LME product prices and exchange rates. For example, in 1999, Alcoa (primary aluminium producer) entered a long-term power contract covering 90% of its anticipated power requirements up to 2020. The power price is linked to the primary aluminium price and the US dollar exchange rate.

Therefore, the assessment of **electricity prices (EU) in energy-intensive industries** is based on different assumptions depending on the country:

- in Germany, the UK and the Netherlands: The demand structure and the purchasing strategy of each company strongly affect the reference price. The power exchange rates for countries with liquid electricity trading are applied as a basis. Long-term contracts comprise one third with an amortisation period of two years, one third with one year, and one third with less than one year. The day-ahead prices in each country are used as spot market prices. The reference price is made up of the average price of long-term contracts with a weight of 80%, and the spot market price weighted at 20%. Data from the power exchanges EEX, EPEX and APX form the basis. For Germany, forward prices are based on futures prices that can be found on the EEX electricity exchange. For the Netherlands and the UK, it will simply be assumed that the electricity prices in long-term contracts are 10% higher than the average day-ahead prices in the same year, as no other data were available. This assumption is justified by the few isolated data that are available.
- in France, electricity prices are based on long-agreements between industry and generators. Trade on the electricity market is rather insignificant because of the market power of the monopolist EDF. An agreement between EDF and energy-intensive companies guarantees a long-term supply (24 years) of 7 TWh per annum for an upfront payment of about 1.75 billion Euros (Exeltium[23]). Furthermore, a law guarantees that alternative electricity suppliers can buy nuclear electricity at a price of 42 euro/MWh. This value was used in the calculations as a wholesale price, even though bilateral contracts could provide electricity at lower prices.
- Italy is an exception because its law provides large industrial companies with priority access to interconnector capacity. These companies can benefit from lower prices in neighbouring countries, but they must pay in advance. Since Eurostat features a statistical value for electricity prices paid by large companies, this value is used for Italy.
- in Denmark, electricity prices are based on the development of prices on the Nordic electricity ex-change Nord Pool. According to the regulator, this determines about 90% of the price. The remaining 10% are distribution costs including margins, or the framework within which the providers can compete. The average quoted price for the two Danish price areas was about 3.46ct/kWh in 2013. Due to the lack of statistical data for companies > 150 GWh, the same value is used as for the underlying class (70-150 GWh), namely 3.93 ct/kWh for 2013.

[22] CREG (2015): Etude sur la fourniture des grands clients industriels en Belgique en 2014 http://www.creg.info/pdf/Etudes/F1453FR.pdf
[23] http://www.exeltium.com/le-projet/#rendre-de-la-visibilite-aux-industriels-electro-intensifs

- For Norway, the methodology used to calculated the prices in Germany, The Netherlands and the UK cannot be used. Indeed, calculating the electricity price for large consumers on the basis of stock market prices, results in an assumed electricity price of 4.13 ct/kWh for 2013. However, this does not accurately reflect the situation for energy-intensive industries in Norway, where long-term contracts run for much longer than in the rest of Europe. Furthermore, this would result in a higher price than the procurement price reported by Eurostat for industries with an annual demand between 70 and 150 GWh. As we expect that industries with higher consumption pay a lower price, and that long-term contracts are indexed to globally-traded products and currencies, we do not use the spot market price for Norway. Although for companies with high consumption (above 150 GWh) the figures and statistics are not necessarily representative, the Eurostat procurement price of 3.57 ct/kWh for the underlying consumption class (70 – 150 GWh) is applied, because no other data were publicly available.

Based on these assumptions, the energy procurement prices of major industrial consumers in Europe are assessed as if they contracted power in 2013. The results are depicted in Table 2. However, different bilateral term contracts, purchasing strategies, market development etc., lead to a variety of agreed procurement prices. Real data on these prices are not available. In addition, self-generation, especially of energy-intensive industries involves even lower prices. For example, (aluminium) power production at one of Hydro's locations displayed direct production costs of six to seven euro/MWh (source: Hydro Annual Reports).

ENERGY PROCUREMENT COSTS (ct/kWh) under 2013 contracting conditions	DE	NL	FR	IT	DK	UK	NO
Enterprises with a consumption of more than 150 GWh per year	4.69	5.50	4.20	6.21	3.93	7.57	3.57

Table 2: Energy procurement costs for large energy consumers in Europe under 2013 contracting conditions, 2013

Statistical data available in Europe is generally more robust than in **non-European countries**. In the US, Canada, and China, there are different parallel market systems and regulatory frameworks that vary according to the province or state. In Canada, China, Korea, and Japan, price formation is not standardised or transparent and does not differentiate between grid and energy costs:

- For the US, the current prices were analysed for two industrial states, Pennsylvania and Texas. Both are part of larger market areas: Pennsylvania is part of the market of the system operator PJM, and in Texas, the market is organised by ERCOT. Both system operators charge nodal prices, whereas in Germany, there is one single price for the entire market area. To calculate an electricity reference price analogous with the European prices, information is used from two regional hubs: PJM for West Pennsylvania, and South ERCOT for Texas.
- For Canada, the electricity price for the state of Quebec is used in calculations. Quebec's power generation structure produces particularly cheap electricity that can be exported so it supplies a large proportion of the electricity needed by the power-intensive industry in Canada. The electricity market in Quebec is highly regulated. Electricity tariffs for companies including network charges and any taxes on connection capacity, electricity supply, and voltage level, are uniformly defined and published. Exemptions are not known, but bilateral private agreements

cannot be excluded. The published price of electricity is used here, which includes network fees as well.

- In Korea, the electricity tariffs for companies are approved by the state and vary according to power connection, electricity supply and voltage level. The published rates are used.
- In Japan, there are six regional monopolies that also publish their tariffs. The tariffs of the TEPCO utility, whose monopoly covers the Greater Tokyo area, are used in this analysis.
- In China, an electricity price is set nationally. Provinces can ensure that their electricity prices are above or below the national electricity price via subsidies and price premiums. The national value is used for the calculations performed here.

Table 3 depicts the procurement prices for energy-intensive businesses in Pennsylvania, Texas, Canada, Korea, China, and Japan. As prices in Canada, Korea, China, and Japan depend on the connected load, total consumption and voltage level, the prices of a very large company with a uniform demand structure are used. This could, for example, be an aluminium smelter. It should be noted that markets, contract strategies and durations differ greatly from company to company, so that actual procurement prices might deviate strongly from the depicted value. But no detailed information is available

ENERGY PROCUREMENT COSTS (€ct/kWh)	PA	TX	CA	KR	CN	JP
Electricity price for energy-intensive industry	3.78	2.94	3.24	5.82	6.37	12.42

Table 3: Energy procurement costs for energy-intensive industries in countries outside of Europe, 2013

Overall, even though the underlying statistical electricity price of energy-intensive industries in Norway is not assumed to be representative (too high), Norway's energy intensive industries have lower energy procurement costs than all the other countries except Canada (Quebec), and Texas in the US. Figure 7 in Annex provides an overview of energy procurement and network costs for large consumers.

3.2 Network component

In Norway, the statistical values (Eurostat, ENTSO-E) for network charges seems to be lower than in all the other European countries studied. According to Eurostat, network costs (transportation and distribution) for the band 70 – 150 GWh/year were 0.0483 NOK/kWh in 2013 (0.60 ct/kWh)[24]. Transport fees are differentiated according to localisation and flexibility. According to figures from ENTSO-E, the 'base case' transmission tariff (central grid) in Norway was 0.383 ct/kWh in 2013.[25] The ENTSO-E report also points out that energy-intensive industries may benefit from a discount: "Load of 15 MW+ and utilization time of 7000+ hours receive a reduced load tariff. The reduction is about 50% (2013) compared to regular load." Given that the load component makes up 66% of the transmission tariff[26], this reduction on the load component means a 33% reduction on the overall

[24] It is assumed that the distribution grid costs of energy-intensive industries were negligible as in many other European countries.
[25] https://www.entsoe.eu/publications/market-reports/Documents/SYNTHESIS_2013_UPDATED_140703.pdf
[26] https://www.entsoe.eu/publications/market-reports/Documents/SYNTHESIS_2013_UPDATED_140703.pdf

transmission tariff. As a consequence, we can assume that network transmission costs (central grid) for energy-intensive industries in Norway equal 0.257 ct/kWh (or 0.0207 NOK/kWh). In addition, network distribution costs accrue. Total network costs of large consumers (< 150 GWh) are about 0.6 ct/kWh (Eurostat, 2013). But due to special calculation and contract schemes, these fees may vary across large power consumers. As no other information were available for network transmission and distribution charges, the Eurostat network fees of 0.6ct/kWh is applied as reference fee.

Differentiated grid charges are also used in other European countries. The differentiation of companies' network charges is often linked to technical characteristics, in particular the voltage level of their grid connection. The hours of electricity use as well as the timing of demand and peak loads within one year are also factored into the calculation of network charges. Lower fees do not necessarily mean that companies are privileged compared to other customers, but reflect, if anything, the lower cost of power usage per kWh for companies. Since network charges depend on the time of demand, among other things, the quantification relies on published data when possible.

Other schemes that involve reduced network charges or exemptions apply in Germany, for example, to customers with more than 7,000 hours of use and an annual consumption of more than 10 GWh. In addition to network charges, concession fees, and the Section 19 surcharge for avoided network charges are calculated for Germany.

In France, network charges for households and businesses are broken down into various components such as billing, metering, transport, etc., and calculated according to peak load and installed capacity. Network charges for energy-intensive businesses are listed in a study of the French Energy Agency (CRE[27]). They amount to between 0.6 and 0.65 ct/kWh for the study sample, as these companies are connected directly to the high-voltage line and therefore do not use the distribution network.

In the UK, regional network charges vary greatly. While they are very low in the north of the country, customers in London pay very high network charges. The Netherlands has relatively low network charges compared to the other regions studied.

NETWORK COSTS (ct/kWh)	DE	NL	FR	IT	DK	UK	NO
Enterprises with a consumption of 70 to 150 GWh per year	1.53	1.34	0.90	0.86	3.83	2.62	0.60

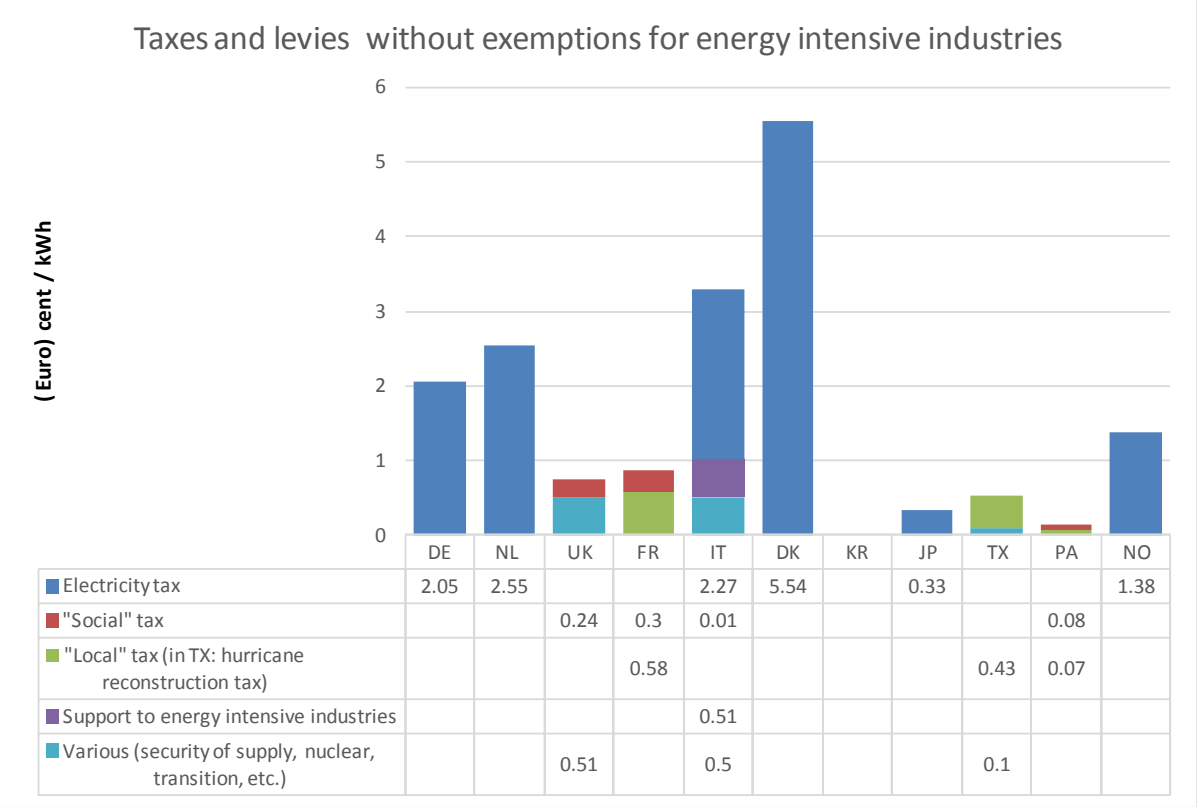
Table 4: Network costs for companies with a consumption of 70 to 150 GWh per year, Eurostat 2013

Given the Eurostat figures for network charges, Norway has the lowest network costs for large electricity consumers (70-150 GWh) among the analysed European countries. In Canada (Quebec), Japan and China, network costs are included but not explicitly depicted in the respective power tariffs.

[27] http://www.cre.fr/documents/publications/etudes/analyse-de-la-competitivite-des-entreprises-intensives-en-energie-comparaison-france-allemagne: Analyse de la compétitivité des entreprises intensives en énergie : comparaison France-Allemagne, 25/06/2013

3.3 Taxes and levies

Figure 5 shows the maximum rates of taxes and levies for industrial consumers identified in 2013. These often correspond to the tariffs for households as well. Some taxes are due to compensate for social support costs such as social electricity tariffs or contribution to pensions ("social" tax), others are used for state or community specific purposes ("local" tax). A detailed list of taxes and levies is provided by Table 5 in Annex.



	DE	NL	UK	FR	IT	DK	KR	JP	TX	PA	NO
Electricity tax	2.05	2.55			2.27	5.54		0.33			1.38
"Social" tax			0.24	0.3	0.01					0.08	
"Local" tax (in TX: hurricane reconstruction tax)				0.58					0.43	0.07	
Support to energy intensive industries					0.51						
Various (security of supply, nuclear, transition, etc.)			0.51		0.5				0.1		

Figure 5: Electricity price component taxes and levies for large electricity consumers without exemptions

Note: TX: Texas (US); PA: Pennsylvania (US)

Norway is the country with the fifth highest taxes and levies among all countries analysed, given that no exemptions for energy intensive industries are taken into account. However, within Europe, only the UK and France have lower taxes and levies than Norway, while Germany, the Netherlands and Denmark have higher taxes.

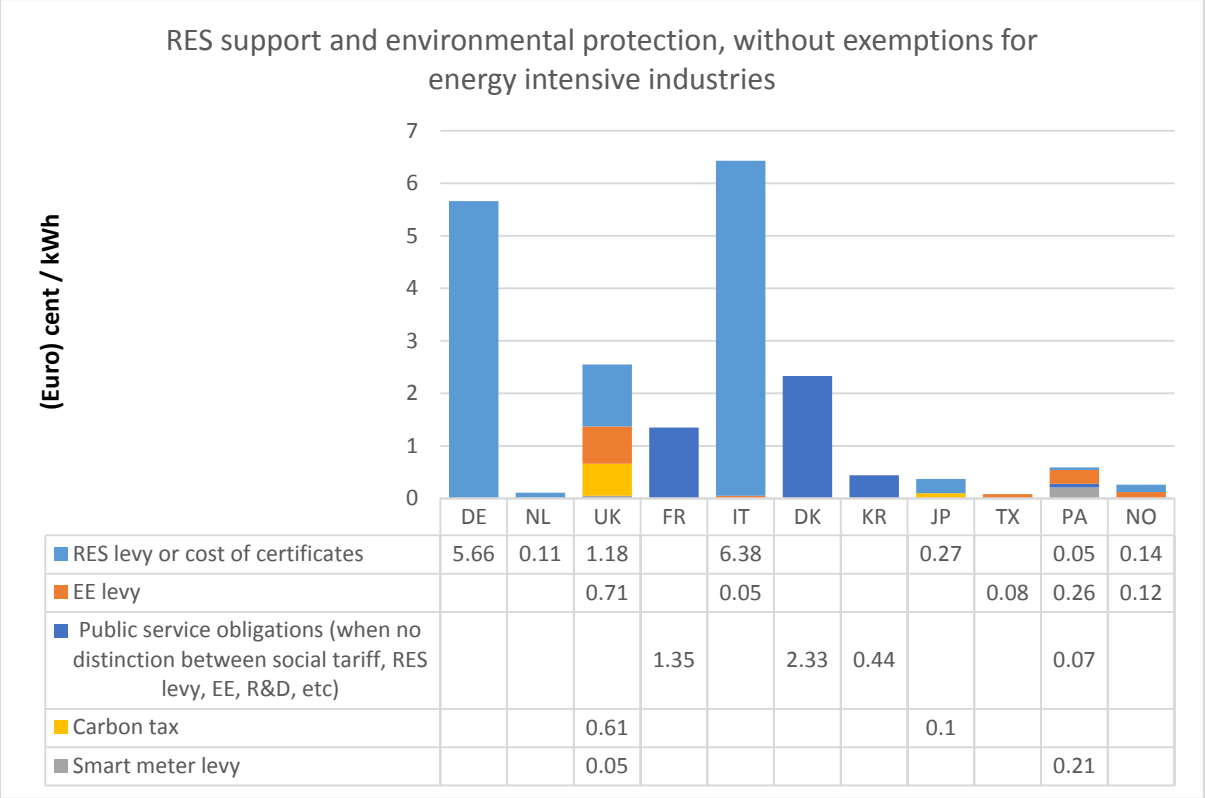
3.4 Promotion of RES, energy efficiency and environmental protection

The financing of renewable energy policies can be passed through in two different ways: 1) RE-levy as a billed additional retail price component or 2) included in electricity purchase price.

As RE-levy: It is an officially published, transparently calculated add-on to the electricity price, e.g. in Germany, the Netherlands and France, all support costs (feed-in payments etc.) are published and levies are assessed based on a published calculation scheme. The levy is then added to the electricity costs and billed as an additional charge for RE.

As pass-through in the electricity purchase price: In the North American countries, the United Kingdom and Norway, certificate systems and/or Feed-in Tariffs (FIT) are applied and the expenditures are borne by utilities, first. The utilities then pass through these costs due to certificates or FIT to the electricity purchase price. For these countries, estimates of the premiums on electricity prices from official bodies or the published accounting rates of large electricity suppliers are used if available.

Figure 6 shows the different types of payments for promoting RES and environmental protection. A detailed overview on this electricity price component is given in Table 6 in Annex.



	DE	NL	UK	FR	IT	DK	KR	JP	TX	PA	NO
RES levy or cost of certificates	5.66	0.11	1.18		6.38			0.27		0.05	0.14
EE levy			0.71		0.05				0.08	0.26	0.12
Public service obligations (when no distinction between social tariff, RES levy, EE, R&D, etc)				1.35		2.33	0.44			0.07	
Carbon tax			0.61					0.1			
Smart meter levy			0.05							0.21	

Figure 6: Electricity price component RES support and environmental protection costs for large electricity consumers without exemptions

Note: TX: Texas (US); PA: Pennsylvania (US)

Norway has the fourth lowest level of renewables and environment-related electricity fees among the group of countries studied, if exemptions for energy intensive industries are not included. Only the Netherlands, Switzerland and Texas in the USA are lower.

4 Conclusion

Regarding energy expenditures, Norway's electricity-intensive industry operates under favourable conditions. Increasing global competition puts also Norwegian companies under pressure. However, they display a strong competitiveness, which depends partly on electricity prices, but also on firm strategies e.g. self-generation, contracting and innovations:

- Electricity prices in Norway are among the lowest in Europe due to the favourable availability of resources (hydro);
- Levies, taxes on electricity and network fees are low for large consumers;
- Besides a favourable electricity supply, large consumers dispose to some extent of self-generation facilities allowing generation of electricity under competitive costs/prices for electricity.
- In addition, to reduce price risk exposure and maintain competitiveness in times of low global product prices, long-term contracts up to 20 years and indexed on global product prices and currencies are concluded. Subsequently, regional input prices (electricity) are linked to global prices and price risks are shared by energy suppliers.
- Although from a global perspective electricity prices in Norway are low, companies in the manufacturing sector seem also to invest in innovations, e.g. energy efficient technologies to further reduce their energy expenditures. This is supported by the company Enova.
- Beyond energy costs and savings, energy intensive companies ensure their input supply, specialisation and market position through vertical integration.

Overall, albeit low electricity prices, electricity-intensive industries do not solely rely on low prices but further strengthen their competitiveness through diverse strategies.

5 Annex

TAXES AND LEVIES (€ct/kWh)	D	NL	UK	F	IT	DK	KR	JP	TX	PA	NO
Electricity tax	2.05	2.55			2.27	5.54		0.33			1.38
TCCFE				0.3							
TDCFE				0.23							
TICFE				0.05							
Utility Gross Receipt Tax									0.02		
Transition to Competition Charge									0.08		
Hurricane Reconstruction Cost charge									0.43		
State tax adjustment clause										0.07	
UNIVERSAL SERVICE FUND CHARGE										0.08	
CTA				0.3							
Warm Home Discount			0.24								
Climate Change Levy			0.51								
Levy to support security in nuclear					0.16						
Levy to support the state railway company					0.23						
Levy to support small energy suppliers					0.06						
Levy to support security of supply					0.01						
Levy to support research in the electricity industry					0.04						
Levy to finance reduced electricity tariffs					0.01						
Levy to support energy-intensive industries					0.51						
Tax to support agriculture and grid extension											
Total	2.05	2.55	0.75	0.88	3.29	5.54	0	0.33	0.53	0.15	1.38

Table 5: Electricity price component taxes and levies without privileges (Source: Own calculations)

RENEWABLES AND ENVIRONMENT (ct/kWh)	D	NL	UK	F	IT	DK	KR	JP	TX	PA	NO
EEG-Levy	5.28										
Off-shore liability levy	0.25										
CHP-levy	0.13										
SDE+		0.11									
CSPE				1.35							
Renewables Obligation			0.94								

RENEWABLES AND ENVIRONMENT (ct/kWh)	D	NL	UK	F	IT	DK	KR	JP	TX	PA	NO
Climate Change Levy (only for business)			0.61								
Energy Company Obligation (only hh)			0.71								
FIT			0.24								
Smart Meter And Better Billing			0.05								
Smart Meter Cost Recovery surcharge										0.21	
Recovery of Alternative Energy Portfolio Standard Costs										0.05	
Efficiency and conservation programme										0.26	
Energy Efficiency Cost Recovery Factor									0.08		
Tax Accounting Repair Credit										0.07	
Consumer Education Plan Costs										0	
EPIDF							0.44				
PSO-Tariff						2.33					
Energy efficiency support					0.05						
Renewable energies support					6.38						
Tax to support renewable energies											
Tax to support a hydro project											
Levy to finance desulphurisation in coal power plants											
Global Warming Tax								0.1			
Levy to finance feed-in-tariffs for renewable energies								0.24			
PV-levy								0.03			
Enova fee (energy efficiency and new RES)											0.12
Estimated cost of RES certificates											0.14
Total	5.66	0.11	2.55	1.35	6.43	2.33	0.44	0.37	0.08	0.59	0.26

Table 6: Electricity price components to support renewable energies, energy efficiency and environmental protection

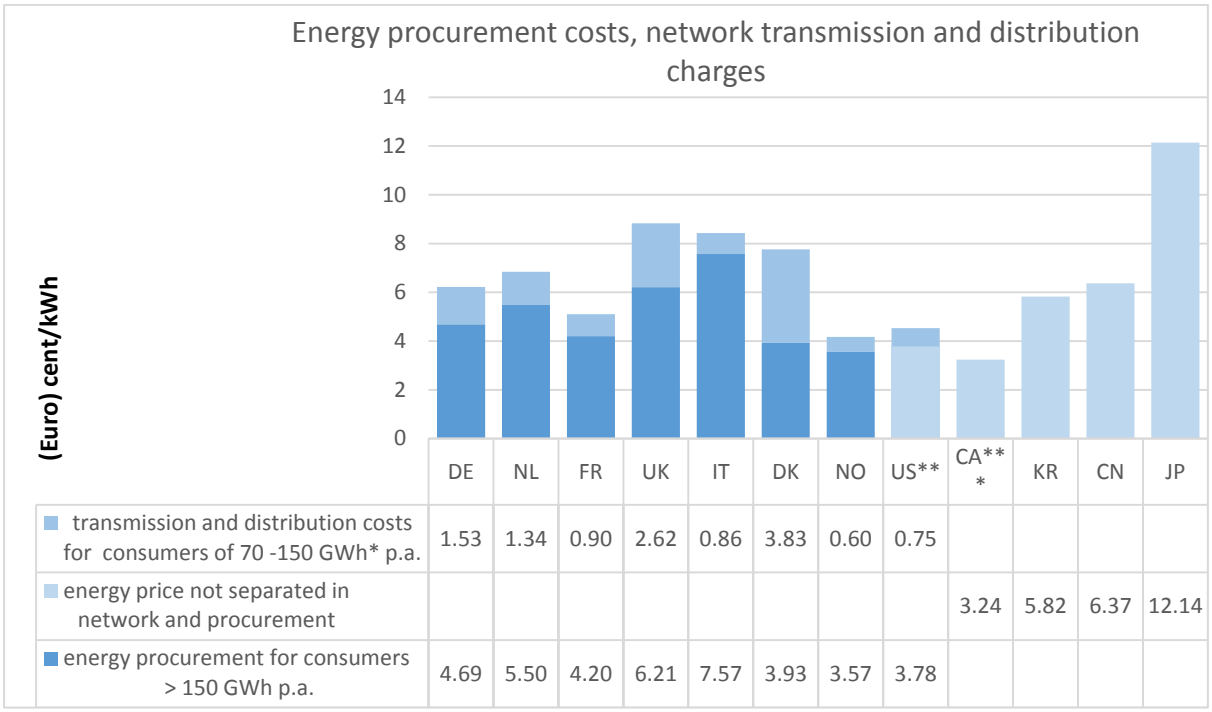


Figure 7: Electricity procurement costs and network charges for large electricity consumers

Source: Eurostat 2013 (network components), country reports and own compilation. Note: * network charges for consumers above 150 GWh are not available in Eurostat 2013; US**: Texas; CA***: Quebec;

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