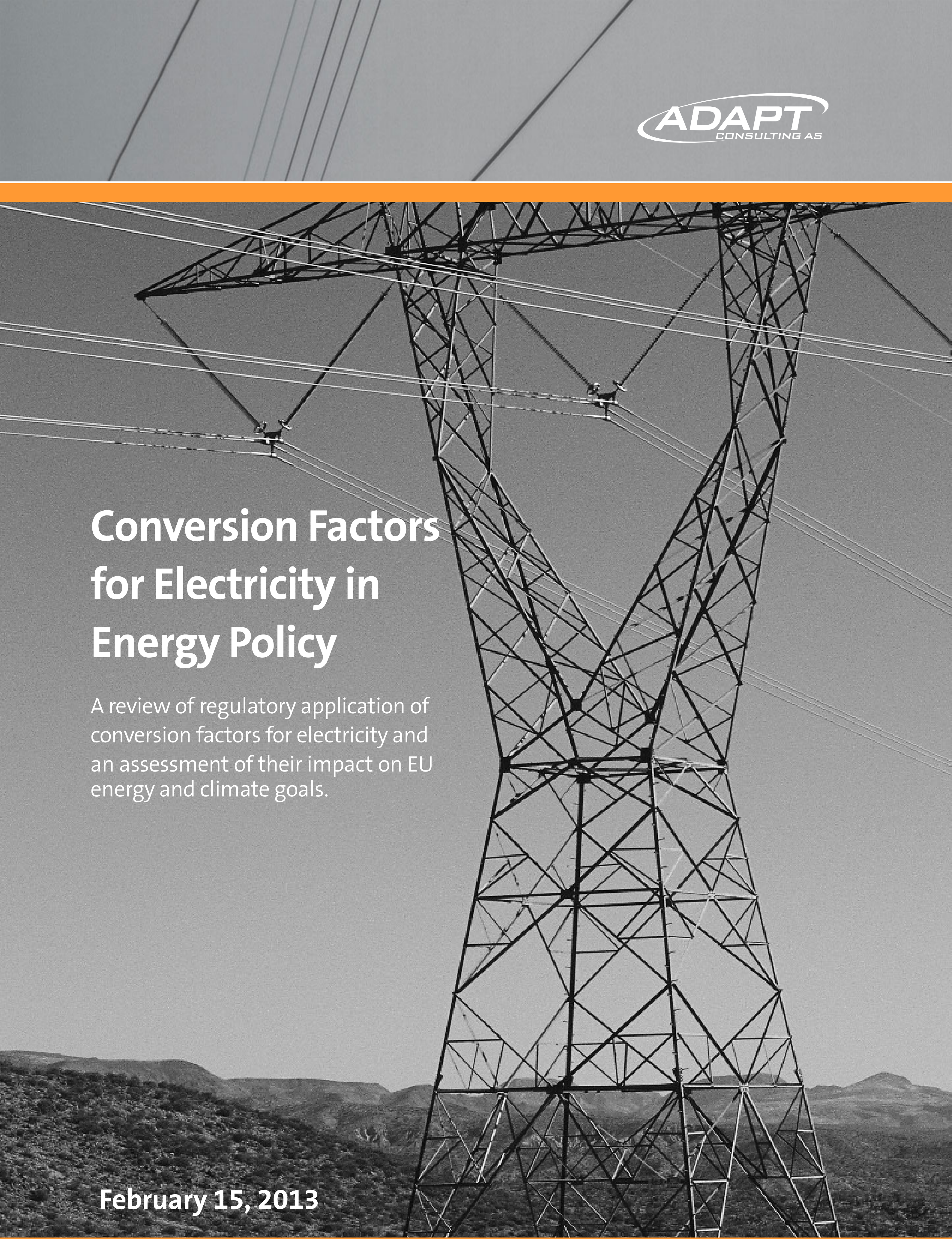

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Conversion Factors for Electricity in Energy Policy

A review of regulatory application of conversion factors for electricity and an assessment of their impact on EU energy and climate goals.

February 15, 2013

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Preface

Over the last decade, conversion factors or similar energy rating principles have been introduced in the energy legislative framework in Europe. Historically, conversion factors have been used for statistical purposes and in life cycle assessments (LCA) in order to calculate the total energy and climate impacts generated by products, individuals or a group of actors/sectors. However, applying conversion factors in the legislative framework will influence future consumer preferences and energy demand. As a result, energy prices and energy generation incentives will also be affected by the energy rating principles.

Energy Norway has, through various studies, highlighted the need to establish an energy policy framework that addresses the long-term energy and climate challenges. Since conversion factors alter the behaviour of energy market stakeholders, the organisation has raised the question of whether or not these behavioural changes are compatible with long-term energy and climate policy goals.

Energy Norway has therefore commissioned this study which highlights and discusses the use of conversion factors in the context of energy policy.

The report has been prepared for Energy Norway by ADAPT Consulting.

1. Introduction

The objective of primary energy factors and CO_2 emissions factors (hereinafter referred to as conversion factors) is to calculate the total energy consumption and greenhouse gas (GHG) emissions that arise in the entire energy value chain, based on final energy consumption data.

Making conversion factors part of the legislative framework is controversial. Conversion factors influence energy consumption and end-users' choice of energy carriers/fuels. Thus, the conversion factors and the choice of calculation method will alter the competition among different energy carriers/solutions, and thus potentially have a strong impact on energy system development. This raises the question of whether or not conversion factors in energy policy contribute to the realisation of the long-term energy and climate goals.

The report investigates whether or not regulatory use of conversion factors contributes to energy system developments that address the long-term challenges of climate change and energy security of supply. The report also describes how conversion factors are implemented in the EU energy policy framework.

Chapter 2-7 gives the main messages of the report. Annex 1 – 5 provides more detailed information on the following issues:

Annex 1:	Primary energy factors
Annex 2:	CO_2-emission factors
Annex 3:	Conversion factors and EU-legislation
Annex 4:	Conversion factors in the context of economic theory
Annex 5:	The impact of conversion factors on EU climate and energy policy

2. Requirements for the future energy system

The Intergovernmental Panel on Climate Change (IPCC) has stated that industrialised countries need to reduce their GHG emissions by 80-95% within 2050, in order to stabilise the increase in global temperature below 2 degrees Celsius. Meeting this long-term climate target will require fundamental changes in both energy production and consumption. Energy must be produced from low-carbon technologies, and nearly all stationary energy consumption must be based on CO_2-neutral energy carriers.

CO_2-neutral energy carriers available for final consumption are electricity, district heating and cooling, biofuels and hydrogen. Current technologies for GHG capture and storage (CCS) are not applicable for distributed small-scale installations and boilers. Energy policy regulation should therefore incentivise end-users to make the switch from the use of fossil energy carriers to electricity, heat and other CO_2-neutral energy carriers.

Electricity will have to play a central role in the low carbon economy. Consumption of electricity does not emit GHG, and it can be generated in large quantities from low-carbon technologies. If energy regulation, through the use of conversion factors, stimulates a shift from electricity to gas or other fossil energy carriers, it will not be possible to meet the long-term climate targets.

3. Primary energy factors and CO2 emission factors

Primary energy is energy in its original form. Primary energy can be converted and transported to end users as secondary energy, e.g. electricity or heat. A primary energy factor (PEF) indicates the amount of primary energy that is required to supply one unit of secondary energy. Primary energy factors are often calculated by dividing the energy content of primary energy with the energy content of secondary energy.

A CO2 emission factor indicates the relationship between GHG emissions and consumption of secondary energy. By multiplying the consumption of secondary energy with a CO2 emission factor, emissions that occur in the whole energy supply chain is calculated, both in terms of direct emissions and indirect emissions associated with extraction and conversion of primary energy and the transport of secondary energy to end-users.

Regulatory use of conversion factors can be found in a number of EU directives, regulations and also in national energy legislation acts, such as building codes and energy labelling schemes. Furthermore, there are a number of non-legislative government-funded initiatives that promotes the use of conversion factors.

Annex 1 and 2 describes various methods used for calculating primary energy factors and CO2 emission factors. Methods described for calculating primary energy factors are partial substitution method, the physical energy content method and the methods described in the CEN standard EN 15603. The outcome of the primary energy factor calculation will vary, depending on the method applied. Table 1 illustrates the calculated primary energy factor of electricity from the different methods for Norway, Sweden, Denmark and Scandinavia as a whole in 2010.

	Norway	Sweden	Denmark	Scandinavia
Partial substitution method	2,78	2,85	2,85	2,82
Physical energy content method	1,19	2,28	2,49	1,86
EN 15603:2008 – Non-renewable	0,6	1,79	2,96	1,45
EN 15603:2008 – Total	1,54	1,99	2,94	1,92

Table 1: Comparison of calculated PEF for the Scandinavian countries in 2010

Primary energy factor and CO2 emission factor calculations are based on a number of predefined variables. It can be a challenge to define variables that reflect reality. These variables include defining the geographical boundaries for the calculation, the handling of export and import of energy, efficiency in power and heat production, and the time horizon. By choosing different calculation methods and varying the choice of variables, it is possible to influence the size of the conversion factor calculated.

4. Regulatory use of conversion factors in the EU

The EU has implemented primary energy factors, CO2 emission factors or similar energy rating principles in a number of directives and regulations. Table 2 and Annex 3 give an overview over the legislative acts that support and promote these principles. The objective of these legislative acts are mainly to promote the EU target of 20 % primary energy savings, which is a part of the EU energy and climate package adopted in late 2008.

After the introduction of the EU emissions trading scheme (EU ETS), CO2 emission factors are no longer part of the EU regulatory framework. According to the guidelines established for the emissions trading directive, emissions should only be allocated to the emitting installations directly:

"All emissions from the combustion of fuels at the installation shall be assigned to the installation, regardless of exports of heat or electricity to other installations. Emissions associated with the production of heat or electricity that is imported from other installations shall not be assigned to the importing installation."1

Legislative act	Energy conversion principle	Description	Possible outcome
Energy services directive	Conversion coefficient of 2,5	The directive allows for the use of a conversion factor of 2,5 for electricity savings, making it easier to meet national energy savings target.	Regulatory measures, energy taxes and subsidies are based on the conversion coefficient
Energy efficiency directive	Conversion coefficient of 2,5	The directive allows for the use of a conversion factor of 2,5 for electricity savings, making it easier to meet a national energy savings target.	Regulatory measures, energy taxes and subsidies are based on the conversion coefficient
Energy performance of buildings directive (2002)	CO2 emission factor	The directive requires the Implementation a methodology for calculating energy performance of buildings. This methodology may include CO2 emission factors as an energy performance indicator.	Minimum energy performance requirements and energy certification of buildings may be based on calculated CO2 emissions.
Revised energy performance of buildings directive (2010)	Primary energy factor	The directive requires the Implementation a methodology for calculating energy performance of buildings. This methodology shall include primary energy as an energy performance indicator. Also, the definition of nearly zero energy buildings should include criteria related to the calculated consumption of primary energy.	Minimum energy performance requirements and energy certification of buildings may be based on calculated primary energy consumption.

[1] Source: European Commission. *Commission Decision of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.* (2007)

Regulation No 244/2012	Primary energy factor	Methodology framework for calculating cost-optimal levels of energy performance requirements in buildings. Requires Members States to determine a national primary energy factor.	No direct impact, but the regulation justifies regulatory use of primary energy factors.
Ecodesign directive	Conversion coefficient of 2,5	A common European conversion factor of 2,5 for electricity could form the basis for calculating the energy performance of products.	Electrical products may be excluded from the European market.
Energy labelling directive	Conversion coefficient of 2,5	A common European conversion factor of 2,5 for electricity could be the basis for calculating the energy performance of products.	Electrical products will be given an inferior energy label.

Table 2: Application of conversion factors for electricity in EU legislative acts

5. How do conversion factors influence EU energy and climate targets?

The main EU energy and energy and climate policy objectives in the long-term perspective are:

- A reduction in EU GHG emissions of 80-95 % below 1990 levels within 2050
- A reduction in future energy import dependency

The EU has not issued any scientific or economic study on how conversion factors in energy policy influence long-term primary energy consumption, GHG emissions or energy costs. Annex 4 in this report discusses the use of primary energy factors from an economic perspective. Through this analysis, two main observations have been made:

1. Energy policy should address long-term energy and climate challenges. Therefore, primary energy factors should reflect long-term electricity generation mix. New electricity generation capacity investments are made according to projected long-term demand. Conversion factors in energy policy influence long-term demand, and will therefore have an impact on future generation capacity investments. Future investments are also influenced by other energy and climate policy measures (such as the EU ETS and national support schemes for renewables). Therefore, it can be argued that long term primary energy factors should be based on future low-carbon technology investments. However, considering that it is not possible to accurately predict future electricity generation, it is also impossible to calculate long-term conversion factors.

2. Conversion factors only influence end-use of electricity and the choice of energy carriers for consumption. Conversion factors will therefore not provide electricity generators with any incentives to change the production mix towards low-carbon technologies. If the objective is to make the transition towards renewables or other energy efficient technologies, is more rational to regulate the consumption of primary energy directly, rather than aiming measures at electricity end-users. Indirect regulation of final energy consumption results in lower primary energy savings at a higher economic cost.

On the basis of the economic analysis in Annex 4 it is evident that regulatory application of conversion factors for electricity does not contribute to a rational realization of the long-term energy and climate policy objectives.

Regulatory use of conversion factors is a bottom-up regulatory approach, and it is a less preferable alternative to more efficient direct top-down measures, e.g. CO2 taxes or emissions trading. Concerning GHG emissions, the EU has already applied a top-down regulatory approach through emissions trading (EU ETS). As emissions are limited by cap and trade, marginal changes in electricity consumption will not influence total GHG emissions. In fact, influencing final electricity consumption through CO2 emission factors will only create obstacles for a well-functioning emission trading market, as allowances are less likely to be allocated to the sectors and installations that generate the highest socio-economic welfare. Regulating end-use consumption with CO2 emission factors contradicts the polluter pays principle; as emissions are allocated to individuals who are unable reduce emissions directly through electricity generation fuel switch or implementation of low-carbon technologies.

Influencing electricity consumption with primary energy factors is also a bottom-up approach that is inefficient compared to more rational top-down measures. If the aim is to reduce primary energy consumption, inefficient technologies should be regulated directly. This would imply direct taxes or restrictions on electricity generation from certain low-efficient technologies.

The long-term EU climate goals require a switch from final consumption of fossil fuels to electricity or other CO2-neutral energy carriers. This will potentially trigger large emission reductions, especially in the transport and heating sectors. Current EU legislative acts, however, are aimed at the short-term targets for 2020. EU legislation that influences final consumption through the use of conversion factors provides end-users with an incentive to use natural gas instead of CO2-neutral energy carriers. This may create lock-in effects that are in conflict with long-term targets for 2050. If the 2050 climate target is to be met, virtually all fossil final energy consumption for stationary purposes must be phased out. Investments in buildings and infrastructure that are made today will influence energy consumption and GHG emissions for decades to come. As long as investments prior to 2020 are aimed at facilitating end-use consumption of gas, it will be more difficult to make a future fuel switch to electricity or other CO2-neutral energy carriers within 2050.

Example: The fuel and carbon efficiency of electric vehicles
The transport sector, principally road transport, account for 28 % of EU GHG emissions. According to EU energy roadmap 2050, electricity could provide 65 % of energy demand by passenger cars and light duty vehicles within 2050, thus contributing significantly to EU emission abatements in the transport sector. Furthermore, electric motors are far more fuel efficient than traditional combustion engines, thus having the potential of limiting Europe's energy import dependency.

Primary Energy conversion: The introduction of conversion factors may alter the perception that electric vehicles are fuel and carbon efficient. An electric vehicle consumes 0,188 kWh/km (Source: Tesla motors, Model S). Multiplying the electricity consumption with a conversion factor of 2,5 (Source: Energy Efficiency directive) results in an energy consumption of 0,47 kWh/km. A new diesel vehicle (Toyota Avensis) consume 0,045 litres/km, which equals to 0,45 kWh/km.

Applying the conversion factor makes the electric vehicle appear less fuel efficient that the diesel vehicle.

CO2 emission conversion: According to Covenant of Mayors (2010) the CO2 emission factor for electricity in Germany is 624 g/kWh. Applying this factor means that the electric vehicle causes emissions of 117 gCO2/km. According to Toyota, the Avenis emits 119 gCO2/km, which is almost equal to the calculated emissions caused by the electric vehicle. Applying emission factors on electricity may therefore create obstacles for making the necessary transition to electricity consumption in the transport sector. Unlike motor combustion engines, electricity generation may be based on renewable energy and other low-carbon technologies.

Example: Electricity for heating purposes
The EU Energy Roadmap 2050 explores different pathways to a low-carbon society in 2050. All scenarios show that electricity will have to play a much greater role than now (almost doubling its share in final energy demand to 36-39% in 2050) and will have to contribute to the decarbonisation of heating/cooling. However, the consumer choices regarding energy heating solutions reflect current energy policy measures, and investments made today may lock-in emissions for decades to come.

Consider an example where a new building owner considers whether to use an electric heat pump or gas for heating purposes. Modern high efficiency condensing boilers convert approximately 88 % of their fuel into heat. This means that for each kWh heat generated, the boiler consumes 1,14 kWh of gas. Electric heat pumps may have a seasonal COP of 2,4 (air to water), which equals to a consumption of 0,42 kWh electricity for each kWh heat generated. Presuming equal energy price-levels, end-users are likely to choose the electrical heat pump. However, introducing regulatory measures based on energy conversion factors for electricity may alter consumer behaviour.

Primary Energy conversion: When introducing energy policy measures based on a primary energy factor of 2,5 for electricity, one may argue that the electric heat pump consumes an almost equal amount of energy as the gas boiler (1,04 kWh primary energy for each kWh heat generated), thus giving the building owner an increased incentive to install the gas boiler.

CO2 emission conversion: In the UK, the Environment Agency operates with CO2 emission factors of 541 g/kWh for electricity and 183,6 g/kWh for natural gas. Presuming generation efficiencies of 88 % and 240 % for gas and electric heat pumps, one may calculate the following GHG emissions: The gas boiler causes emissions of 209 gCO2 for each kWh heat generated, while the electrical heat pump causes emissions of 225 gCO2/kWh.

7. Conclusions and Recommendations

Energy efficiency and increased share of electricity in final energy consumption are important prerequisites for meeting the long-term energy and climate policy goals. Current EU legislative acts are designed to meet short-term 2020 goals, and they do not necessarily contribute to fulfilling these prerequisites.

The energy service directive, energy performance of buildings directive and the energy efficiency directive are largely based on the principles of primary energy conversion factors. The EU has not examined how these factors influence actual primary energy consumption, GHG emissions, and energy costs. Nor have there been developed guidelines on how conversion factors should be calculated at a national level.

The introduction of conversion factors for electricity in EU legislation creates confusion about the increased role of electricity in a future sustainable low carbon society. Conversion factors for electricity do not contribute to the reduction of GHG emissions from the electricity sector, as long as the sector is subject to the EU ETS. At best, conversion factors will only contribute to a false perception of reduced GHG emissions. At worst, it will trigger behavioural changes that will lock in emissions in the long term.

Regulatory application of conversion factors is not transparent. There are a number of different calculation methods that can be applied, and there is a lack of consistency between the methods. Therefore, it is possible to influence the size of the conversion factor calculated, depending on various political motives.

The use of conversion factors may to some extent be justified for certain statistical purposes. However, the use of conversion factors should be avoided in a regulatory context if direct regulation of primary energy consumption is possible. Current national support schemes for renewables and emission trading suggests that this direct approach is possible.

In order to meet the 2050 climate target, the current EU regulatory framework must be redesigned in order to ensure that electricity, heat, biomass and hydrogen are carbon-neutral energy carriers available to end-users. Combustion of fossil fuels must only take place in large installation where CCS technology is available.

To ensure that all community interests are taken into account when implementing regulatory use of conversion factors, it is only natural that European and national authorities initiate cooperation with the energy industry and other interested parties in order to develop guidelines, policies and recommendations on the use of conversion factors in public and regulatory contexts.

Annex 1: Primary energy conversion factors

1.1. Primary energy, secondary energy and primary energy factors

Primary Energy is defined as energy in its original form that has not been subjected to any conversion or transformation process. Examples of primary energy sources are coal, crude oil, natural gas, uranium, biomass, solar energy, wind or falling water (hydro).

Primary energy sources have no use when lying in reservoirs or existing in nature. The energy must be extracted, processed, converted and transported to end users in the form of secondary energy (often referred to as an energy carrier). Examples of secondary energy sources are electricity, heat and hydrogen.

When primary energy is converted into secondary energy and transported to the end user, energy losses will occur throughout the energy value chain. This is illustrated in Figure 1.1. The illustration may, for example, represent the production of electricity from natural gas, where there is an energy loss during the extraction of natural gas, production of electricity in a power plant and transportation of electricity through electrical grids. Prior to the extraction of the primary energy source, the energy index is 100 %. The index is reduced to 40% when secondary energy Is delivered to the end user, which means the energy system efficiency is 40 %.

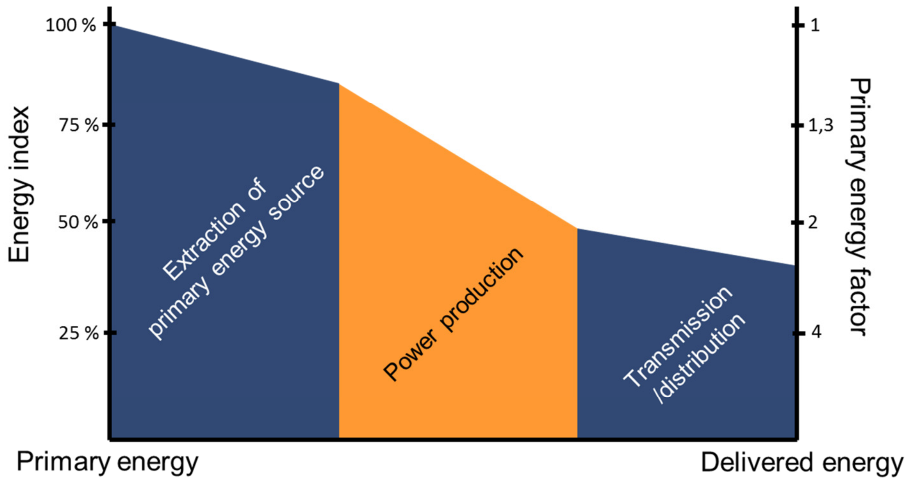

Figure 1.1 Illustration of energy losses in the energy value chain

A primary energy factor (PEF) can be defined as the relationship between the energy content of primary energy and secondary energy sources. It is calculated by dividing the energy content of primary energy with the energy content of secondary energy. The PEF is used to calculate primary energy consumption which is indirectly caused by the consumption of secondary energy.

System efficiency and primary energy factors are applied in order to calculate changes in the consumption of primary energy as a result of changes in consumption of secondary energy, or vice versa. This can be illustrated mathematically as follows:

Primary energy x System efficiency = Secondary energy
Secondary energy x Primary energy factor = Primary energy

1.2. Methods for calculating primary energy factors

Although the definition of PEF is often perceived as universal, there are a number of different methods that can be applied in order to calculate the PEF. In addition to these methods, there are also national variations of the methods, and also variations where the methods are adapted to specific purposes.

In international statistics, mainly two approaches are used to calculate PEF. These are (i) partial substitution method) and (ii) physical energy content method. The basic difference between these methods is how they calculate the primary energy factors from nuclear power and renewable energy (hydropower, solar power, geothermal power, etc.). The partial substitution method is for example used by BP in their annual publication, "Statistical Review of World." On the other hand, both IEA and Eurostat have applied the physical energy content method in their publications. Both methods are described in the report "Renewables information," published by the IEA in 2010.

The European Committee for Standardization (CEN) has agreed on a method that is described in a standard applicable for national implementation of the first EU directive on the energy performance of buildings (2002). The aim of this method is to calculate the primary energy consumption caused by buildings.

The choice of calculation method has a significant impact on the size of the primary energy factor. Sub-chapter 1.2.1, 1.2.2 and 1.2.3 describe the three different approaches mentioned in the above. In order to illustrate how the PEF varies with the choice of calculation method, we have calculated primary energy factors for electricity in Norway, Sweden and Denmark in 2010 based on the three methods. The Scandinavian countries base their electricity production on very different primary energy mixes, which makes this comparison interesting. Figure 1.2 shows the electricity mix in the three countries in 2010.

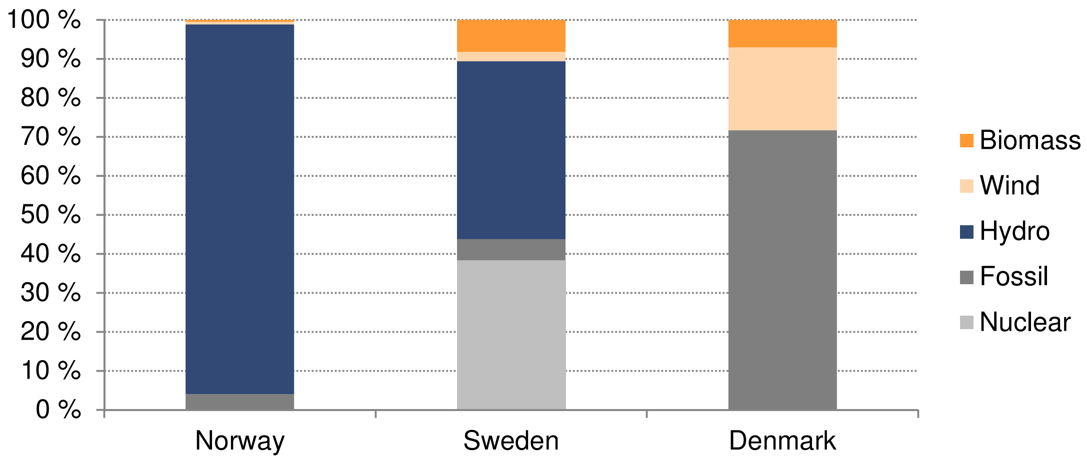

Figure 1.2 Electricity generation mix in Scandinavia in 2010 (Source: ENTSO-E/NVE)

1.2.1. *Partial substitution method*

The calculation of primary energy factor for electricity is usually based on the consumption of primary energy sources associated with the different production technologies in the electricity mix. However, renewable energy sources and nuclear power makes this approach a challenge. For example, it may not be possible to quantify the energy content in the wind or the sun that serves as a fuel for wind and solar power plants. In conventional nuclear power plants, only 10% of theoretical energy content in the fuel is converted to electricity, but if the waste is reprocessed, it can be possible to recover large portions of the energy content.

The partial substitution solves this challenge by focusing on the theoretical energy content of traditional fossil fuels (coal, gas and oil). PEF for electricity produced from these sources is calculated by dividing the energy content of the fuel (input) with electricity production (output). For renewable and nuclear power, the partial substitution method calculates how much primary energy this amount of electricity would require if it were generated by fossil fuels.

As Norway's electricity production is mainly based on hydropower, the principle of partial substitution has a major impact on the calculation of the PEF for electricity. This is illustrated in Table 1.1. Calculations for Sweden and Denmark are shown in Table 1.2 and 1.3. As a basis for the calculations, we have assumed an efficiency rating of 40% when using fossil fuels, and 30% when using biomass, including network losses of 10%.

Norway	Generation (TWh)	Generation efficiency	Primary energy (TWh)
Nuclear	0	40 % (partial substitution)	0
Fossil	5	40 %	12,5
Hydro	117,9	40 % (partial substitution)	294,8
Wind	0,9	40 % (partial substitution)	2,3
Biomass	0,6	30 %	2
Total	**124,4**		**311,6**

Table 1.1 Calculation of primary energy consumption in electricity generation in Norway in 2010 using partial substitution method

Sweden	Generation (TWh)	Generation efficiency	Primary energy (TWh)
Nuclear	55,6	40 % (partial substitution)	139
Fossil	7,8	40 %	19,5
Hydro	66,2	40 % (partial substitution)	165,5
Wind	3,5	40 % (partial substitution)	8,8
Biomass	11,9	30 %	39,7
Total	**145**		**372,5**

Table 1.2 Calculation of primary energy consumption in electricity generation in Sweden in 2010 using partial substitution method

Denmark	Generation (TWh)	Generation efficiency	Primary energy (TWh)
Nuclear	0	40 % (partial substitution)	0
Fossil	26,3	40 %	65,8
Hydro	0	40 % (partial substitution)	0
Wind	7,8	40 % (partial substitution)	19,5
Biomass	2,6	30 %	8,7
Total	**36,7**		**94**

Table 1.3 Calculation of primary energy consumption in electricity generation in Denmark in 2010 using partial substitution method

Table 1.4 lists the primary energy factors for the three Scandinavian countries, based on a calculation using the partial substitution method. We can see that this method results in small variations in the size of the primary energy factors between the countries. The reason for this is that the partial substitution of hydro, wind and nuclear power has a huge impact on the total primary energy consumption calculation. Since all the Scandinavian countries have a large share of these energy sources in their electricity generation mix, this method can give a misleading impression of real primary energy consumption. IEA abandoned the use of the partial substitution method in their statistics in 2004, partly because it is not considered to be applicable for countries with a large share of hydropower in the production mix.

	Generation (TWh)	10 % grid losses (TWh)	Consumption (TWh)	Primary energy (TWh)	PEF
Norway	124,4	12,4	112	311,6	2,78
Sweden	145	14,5	130,5	372,5	2,85
Denmark	36,7	3,7	33	94	2,85
Scandinavia	306,1	30,6	275,5	778,1	2,82

Tabell 1.4 Calculation of PEF in Scandinavian countries in 2010 using partial substitution method

1.2.2. Physical energy content method

This method differs from the partial substitution model in that it uses a different approach in quantifying primary energy use in hydro, wind and nuclear power generation. The calculation of primary energy factor for nuclear and geothermal power generation is based on the thermal energy content of the steam boiler operating the power plant turbine. For nuclear power it is estimated a 33% generation efficiency, and 10 % for geothermal power generation. For other renewable energy sources such as hydro, wind and solar, the primary energy consumption is set equal to gross electricity production.

Table 1.5, 1.6 and 1.7 shows a calculation of primary energy consumption in the generation of electricity in the Scandinavian countries in 2010, using the physical energy content method.

Norway	Generation (TWh)	Generation efficiency	Primary energy (TWh)
Nuclear	0	33 %	0
Fossil	5	40 %	12,5
Hydro	117,9	100 %	117,9
Wind	0,9	100 %	0,9
Biomass	0,6	30 %	2
Total	**124,4**		**133,3**

Table 1.5 Primary energy consumption in electricity generation in Norway in 2010 using physical energy content method

Sweden	Generation (TWh)	Generation efficiency	Primary energy (TWh)
Nuclear	55,6	33 %	168,5
Fossil	7,8	40 %	19,5
Hydro	66,2	100 %	66,2
Wind	3,5	100 %	3,5
Biomass	11,9	30 %	39,7
Total	**145**		**297,4**

Table 1.6 Primary energy consumption in electricity generation in Sweden in 2010 using physical energy content method

Denmark	Generation (TWh)	Generation efficiency	Primary energy (TWh)
Nuclear	0	33 %	0
Fossil	26,3	40 %	65,75
Hydro	0	100 %	0
Wind	7,8	100 %	7,8
Biomass	2,6	30 %	8,7
Total	**36,7**		**82,3**

Table 1.7 Primary energy consumption in electricity generation in Denmark in 2010 using physical energy content method

	Generation (TWh)	10 % grid losses (TWh)	Consumption (TWh)	Primary energy (TWh)	PEF
Norway	124,4	12,4	112	133,3	1,19
Sweden	145	14,5	130,5	297,4	2,28
Denmark	36,7	3,7	33	82,3	2,49
Scandinavia	306,1	30,6	275,5	513	1,86

Table 1.8 Calculation of PEF in Scandinavian countries in 2010 using physical energy content method

Table 1.8 gives an overview of the primary energy factor for electricity in the three countries in 2010, when using the physical energy content method. If we compare the PEF calculation using the physical energy content method with the partial substitution method, we see that the choice of method has a significant impact on the size of the calculated PEF. This is especially true for Norway, which has a large share of hydropower in the generation mix. Sweden has a large share of hydro power as well. However, due to the large share of nuclear power, the PEF remains high compared to Norway. Denmark gets a lower PEF when using the physical energy content method since the country does not have any nuclear power, but a significant share of wind power in the electricity mix.

The physical energy content method gives a more accurate estimate of primary energy consumption in electricity generation, compared to the partial substitution method. This is partly the reason why most organizations prefer this method, including the IEA and Eurostat.

1.2.3. European standard on energy performance of buildings (EN 15603:2008)

A calculation of PEF for electricity can also be done with a method described in the European standard EN 15603:2008 (Energy performance of buildings – Overall energy use and definition of energy ratings). In addition to calculating primary energy factors and primary energy consumption in buildings, the standard can also be used to calculate other energy performance indicators, including CO2 emissions, energy costs or other energy policy indicators.

The standard describes two alternative approaches to calculate PEF. These are (i) total primary energy factor, and (ii) primary resource energy factor. The difference between the methods is that the latter does not include any consumption of renewable energy. Furthermore, a national PEF for electricity may be based on either the average electricity generation mix or the marginal electricity generation. A marginal factor only takes into account generation units that are affected by changes in demand.

Annex E of the standard provides default PEF for different energy sources, including electricity from different generation technologies. The factors listed in the annex were calculated by the ETH Zurich in 1996. In table 1.9, some of these factors are listed.

	PEF Non-renewable	PEF Total
Fuel oil	1,35	1,35
Beech log	0,07	1,07
Gas	1,36	1,36
Hydro power	0,5	1,5
Nuclear power	2,8	2,8
Coal power	4,05	4,05

Table 1.9 Primary energy factors (Source: EN 15603)

Table 1.10 shows calculations of the PEF for the Scandinavian countries in 2010 based on default values derived from the Annex E of EN 15603. Since there is no default value for electricity produced from biomass, oil or gas, we have assumed generation efficiencies and grid losses of 30%, 30% and 50%.

	Non-renewable PEF	Total PEF	Norway (share/ PEF)	Sweden (share/ PEF)	Denmark (share/ PEF)	Scandinavia (share/PEF)
Nuclear	2,8	2,8	0 %	38,3 %	0 %	18,2 %
Coal	4,05	4,05	0 %	0,6 %	43,6 %	5,5 %
Gas	2,72	2,72	4 %	2,5 %	21,5 %	5,4 %
Other fossil	3,89	3,89	0 %	2,3 %	6,5 %	1,9 %
Hydro	0,5	1,5	94,8 %	45,7 %	0 %	60,1 %
Wind	0,5	1,5	0,7 %	2,4 %	21,3 %	4,0 %
Biomass	3,57	0,23	0,5 %	8,2 %	7,1 %	4,9 %
Average non-renewable PEF			**0,6**	**1,79**	**2,96**	**1,45**
Average Total PEF			**1,54**	**1,99**	**2,94**	**1,92**

Table 1.10 PEF Calculations using informative reference values in EN 15603

The standard also allows for calculating marginal PEF, rather than the average values as done in Table 3. If electricity consumption is reduced, not all power stations are affected equally. If one assumes that marginal changes in demand results in reduced coal power generation, the marginal PEF is 4.05, according to Table 1.9.

1.3. Challenges when calculating primary energy factors

In section 1.2, we describe three different methods for calculation of primary energy and primary energy factors that are used internationally. One will get different results depending on the calculation method used. In Table 1.11 we compare the calculated PEF from the three models for Norway, Sweden, Denmark and Scandinavia in 2010.

	Norway	Sweden	Denmark	Scandinavia
Partial substitution method	2,78	2,85	2,85	2,82
Physical energy content method	1,19	2,28	2,49	1,86
EN 15603:2008 Non-renewable PEF	0,6	1,79	2,96	1,45
NS-EN 15603:2008 Total PEF	1,54	1,99	2,94	1,92

Table 1.11 Comparison of PEF calculations for the Scandinavian countries in 2010

Varying results for each country in the table above reflects inconsistencies in the different calculation methods. Furthermore, each method also allows for adjustments and choice of different assumptions, which allows for the calculated PEF to be manipulated.

When secondary energy is produced in small energy systems, it may be possible to accurately calculate PEF by measuring the input in terms of primary energy and the energy content of the output. This can be the case for local district heating networks. Calculating PEF for larger systems is a more challenging task due to the complexity of the systems. The main challenges are described in the following subsections.

1.3.1. Geographical boundaries and mix of generation technologies

The power markets in Europe are integrated through interconnectors. If one is to calculate the relevant primary energy factor for one country or a smaller region within the country, it can be argued that electricity flows freely across borders. The different methods for calculating PEF sets no restrictions on whether to apply a local, national, regional, European or global power market perspective. The choice of geographical boundaries will have a significant impact on the level of the calculated PEF.

1.3.2. Cross-border power flows

The methods presented in Section 1.2 provide no guidance on how to take into account import or export of electricity when calculating a PEF. It may be argued that the local or national generation mix must be adjusted for cross-border flows, since it is the primary energy associated with the end-use of electricity that one seeks to determine.

If one decides to adjust the PEF for exports and imports, new challenges arise because the generation mix that is exported and imported has to be determined. To add to the complexity, the imported generation mix may also be adjusted for cross border-flows to other countries.

1.3.3. Efficiency in power generation

Using methods described in Section 1.2 assumes that the efficiency for each production technology is known. In reality, it is a complex task to determine exact values for generation efficiency. As an example, gas power plants can have a generation efficiency ranging from 20% to 60%. When gas is converted to electricity, the generation efficiency depends on the turbine technology (eg. simple cycle or combined cycle gas turbines) and production patterns. If the power plant used to cover base load, production efficiency can be optimised. If the power plant output is regulated up or down to accommodate variations in load, the efficiency is often reduced. Other factors, e.g. carbon capture and storage and the quality of the fuel, will also affect the generation efficiency of a single plant. Thus, all power plants have different and varying degrees of efficiency. Trying to determine the average efficiency in a larger geographical area with many production units is a very complicated task.

1.3.4. Combined heat and power

Most combined heat and power (CHP) plants use carbon-based fuels (biomass or fossil) to generate both electricity and heat. It is possible to measure the energy content of the generated heat and electricity. However, there is no common approach on how the energy generation loss should be divided between the two energy carriers. If energy generation loss is allocated to the heat, a better efficiency of electricity production is calculated. If one allocates energy loss to electricity, a better PEF for heat will be calculated.

None of the methods described in Section 1.2 address the challenge of how to allocate energy loss in CHP generation. This allows for different approaches and different results when calculating PEF.

1.3.5. Time horizon for PEF calculations

Historically, PEF have only been used for statistical purposes. Now, PEF are implemented in energy policy framework with the purpose to influence developments in energy production and consumption. However, the PEF will continuously vary as a result of changes in energy production and consumption patterns. This means that PEF based on historical data will not be relevant over time. Thus, future energy production and consumption may be taken into account when calculating PEF.

PEF can only be precisely determined through measurements of energy production and consumption, and therefore it is not possible to determine the exact PEF in real time. Future forecasts of development of the PEF will always be associated with varying degrees of uncertainty. For example, the choice of heating system in buildings constructed today will have an impact on the consumption of energy in the building's lifetime (50 years or more). The real primary energy factor over the next 50 years will depend on many factors, including development of renewable electricity generation capacity, (which will lower the PEF using physical energy content method) and the construction of fossil power generation plants with CCS (which will increase the primary energy factor).

Considering that it is not possible to precisely determine future PEF, one should be careful to introduce these factors in energy policy regulation as a means to influence consumer behaviour. If the end-users are subject to repeated changes in the PEF, this will lead to regulatory uncertainty.

1.3.6. Marginal or average PEF

As mentioned in 1.3.5. PEF is implemented in energy policy framework. The main purpose is often to place a tax or restriction on the final energy consumption, which reflects the primary energy consumption throughout the energy value chain.

In the energy markets, supply and demand is balanced through energy prices. Electricity producers will look at the spread between marginal costs and energy prices in order to determine if they shall produce or not. If regulatory use of PEF lowers electricity demand, reductions in primary energy consumption will not reflect average production mix. The real reduction of primary energy will be come from the generation power plants with the highest marginal costs.

To address this issue correctly, many argue that regulatory use of PEF should be based on marginal factors. However, this will create new challenges as different generation technologies will make up the marginal production over time.

The most common regulatory approach is to use average values for the PEF, despite the fact that average values have little effect on the real output changes that is achieved by regulating final consumption.

1.3.7. Uncertainties summarized

As shown in section 1.2, the choice of PEF calculation method will make a significant impact on the size of the PEF. In addition, as shown in 1.3.1-1.3.6, there are a number of challenges that must be addressed when calculating PEF within each model. In practice, all assumptions will be subjecct to a certain degree of uncertainty, and many assumptions will largely depend on subjective assesments. Consequently, the PEF calculations are rarely reliable and transparent, and there is a risk that the size of the PEF can be manipulated.

Annex 2: CO_2-emission factors

A CO_2 emission factor indicates the relationship between greenhouses gas (GHG) emissions and the consumption of secondary energy. The factor may well include other GHG than CO_2, but these are converted into CO_2-equivalents in terms of how much they contribute to global warming. The purpose of calculating CO_2 emission factors is to determine emissions related to energy end-use, including direct emissions and indirect emissions associated with extraction of primary energy, conversion and transmission/distribution of secondary energy sources to end-users.

In small energy systems (eg. a local district heating networks) it will be possible to calculate a CO_2 emission factor that reflects the actual relationship between consumption of secondary energy use and GHG emissions. For larger systems, such as the electricity network, it is a more challenging task. The challenges are exactly the same as when calculating the PEF. These are described in Annex 1, chapter 1.3.

In a European context, CO_2 emission factors are applied for different purposes, both statistical and regulatory. However, after emission trading was established in the EU, there are no requirements to apply CO_2 emissions factors for regulatory purposes in the EU legal acts. However, CO_2-factors are widely applied for statistical reporting of emissions reductions. One example is the organization "Covenant of Mayors". The organization is led by the European Commission and serves as a platform for cooperation on climate issues between cities. The cooperation consists mainly of members from EU countries, but also non-EU countries are participating in the collaboration. All member cities are committed to reduce their GHG emissions equivalent to the EUs climate targets or above.

Section 2.1 describes different methods that can be applied to calculate national CO_2-factors for electricity.

2.1. Methods for calculation CO_2 emissions factor

2.1.1. Intergovernmental Panel on Climate Change (IPCC) guidelines

Intergovernmental Panel on Climate Change (IPCC) has issued guidelines on how to calculate CO_2 emissions factors. According to the guidelines, factors can be calculated at different levels of complexity. The methods are expressed in three tiers of increasing complexity.

The ‘Tier 1’ method uses default emission factors only. The CO_2 emission factor for electricity is calculated by multiplying default factors for each electricity generation technology with its share in the national mix. The “Tier 2” method uses more specific national emission factors for each fuel source that is used in electricity generation. The “Tier 3” method requires knowledge of the generation efficiency in the generation plants in the country.

Methods with higher level of complexity give more accurate results. However, the "Tier 2" and "Tier 3" methods require greater knowledge of the types of processes and specific process conditions that apply in the country.

2.1.2. *Life Cycle Assessment (LCA)*

Life cycle assessments aim to identify environmental impacts throughout the project life cycle from production of materials, construction process, operation and disposal. An LCA has a considerably broader scope than other CO2 emission calculation methods which only seek to identify emissions in the production phase. Moreover, an LCA seeks to identify a series of environmental impacts and is not limited to GHG emissions. Other environmental impacts may be local air pollution, water consumption, primary energy consumption, nuclear waste, etc.

There are two international standards that describe the framework for conducting an LCA. These are ISO 14040:2006 and ISO 14044:2006 that respectively standardizes the principles and guidelines for LCA.

According to ISO 14040, an LCA is carried out in four phases. The four phases are interdependent, so that the results in one phase will inform how other phases should be completed. This approach is illustrated in Figure 2.1.

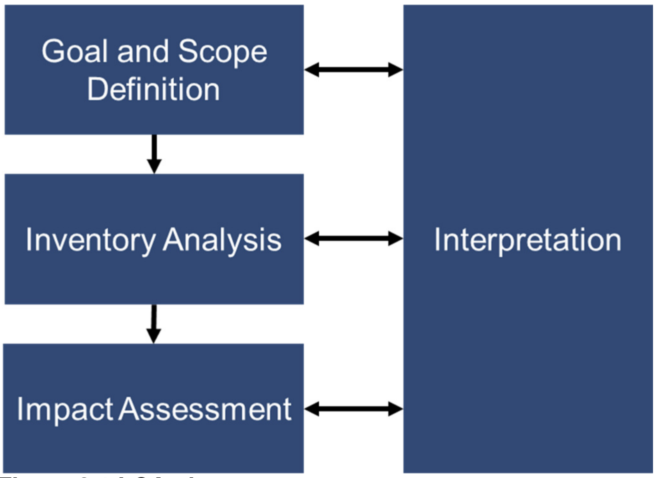

Figure 2.1 LCA phases

The aim of the first phase is to define the objectives and scope of the LCA. This means that one defines what precisely is being studied, and what results are to be communicated. This may for example be electricity consumption and the impact on global warming.

The objective of the second phase, inventory analysis, is to determine the consumption of various resources and the inventory flow from and to nature for a product system. The inventory flow consists of various substances/emissions to air, water and land.

The third phase is the impact assessment, which is to identify the environmental impacts arising as a result of inventory analysis. For example, to assess the impact GHG emissions has on global warming.

The last phase is an interpretation of the assessments made in the other three phases. For instance one has to determine if the results of impact assessment is relevant to the defined objectives and scope. If the interpretation shows a lack of correlation between the phases, one must go back and correct the assessments that have been made in the earlier phases.

2.1.3. European standard on energy performance of buildings (EN 15603:2008)

The standard EN 15603:2008 describes a method for calculating indirect GHG emissions related to energy use in buildings. According to the standard, the national CO2 emission factors can be determined on the basis of consumption of primary energy. Default CO2 emission factors, is given in Annex E of the standard. A selection of the CO2 emission factors listed in the standard is shown in Table 2.1.

	CO2 emissions factor (kg/MWh)
Fuel oil	330
Beech log	4
Gas	277
Hydro power	7
Nuclear power	16
Coal power	1340

Table 2.1 Reference CO2 emissions factors in Annex E of EN 15603

2.2. CO2 emission factors applied by Covenant of Mayors

Covenant of Mayors has estimated indicative national and European values for CO2 emission factors for electricity based on guidelines from the Intergovernmental Panel on Climate Change (IPCC) and LCA. These are shown in Table 2.2.

The table reveals large differences in the CO2 emission factors between the two models. The main reason for this is that LCA considers emissions in a broader “cradle-to-grave” perspective, including emissions caused by the construction and disposal of production facilities. The IPCC guidelines only take into account emissions during the operational phase of electricity generation.

County	CO2 emission factor IPCC (g/kWh)	CO2 emission factor LCA (g/kWh)
Belgium	285	402
Bulgaria	819	906
Denmark	461	760
Estonia	908	1593
Finland	216	418
France	56	146
Greece	1149	1167
Ireland	732	870
Italy	483	708
Cyprus	874	1019
Latvia	109	563
Lithuania	153	174
The Netherlands	435	716
Poland	1191	1184
Portugal	369	750
Romania	701	1084
Slovakia	252	353
Slovenia	557	602
Spain	440	639
UK	543	658
Sweden	23	79
Czech Republic	950	802
Germany	624	706
Hungary	566	678
Austria	209	310
EU-27	460	578

Table 2.2 CO2 emission factors for electricity (Source: Covenant of Mayors, 2010)

2.3. Example of regulatory use of GHG emission factor: CRC scheme in the UK

CRC Energy Efficiency Scheme in United Kingdom is a mandatory scheme aimed at improving energy efficiency and cutting emissions in public and private organizations. The scheme is administered by the Environment Agency, Scottish Environment Protection Agency (SEPA) and Northern Ireland Environment Agency (NIEA). It applies to all organizations that have half-hourly metering and electricity consumption greater than 6 000 MWh per year.

According to the scheme, organizations calculate emissions corresponding to their energy consumption, including indirect emissions associated with electricity purchased. Organizations must then order, pay for and surrender allowances (CRC) to cover their annual emissions in tonnes of CO_2 (tCO_2). One CRC allowance equals one tCO_2. For 2011/12 and 2012/13, the cost of one CRC is £12/ tCO_2.

In order to calculate emissions, the Environment Agency has issued a table with conversion factors. Table 2.3 shows examples of emission factors and their corresponding cost for consumption of energy.

Energy carrier	CO_2 emission factor (g/kWh)	Cost of CRC £/MWh
Electricity	541	6,49
Natural Gas	183,6	2,20
Fuel oil	268,7	3,22

Table 2.3 CO_2 emission factors for energy carriers (Source: Environment Agency)

Table 2.3 shows us that the scheme gives organizations an economic incentive to switch from electricity to fossil fuels. This will in fact increase global GHG emissions, since emissions in the electricity supply sector are already covered by emissions trading in the EU (EU ETS).

Annex 3: Conversion factors in EU climate and energy legislation

3.1. Introduction to EU legal acts

EU law consists of primary and secondary legislation. EU primary law includes of a series of treaties, where the most important is the Maastricht Treaty, the Rome Treaty and the Lisbon Treaty. EU secondary legislation is founded on the primary legislation and it includes directives, regulations and decisions.

Directives contain overall objectives and requirements to be met or complied with by member states. Directives often provide for great flexibility in how these objectives /requirements must be met. An example is the renewables directive which defines national targets on the share of renewable energy in final consumption, but at the same time is flexible in terms of how these targets are met.

Regulations are legislative acts that set binding requirements for all member countries. The wording of the regulations is to be implemented point by point. Example of a regulation is the ecodesign regulation on residential lighting. This Regulation sets mandatory minimum energy performance requirements of lighting sources that are used in residential buildings.

Decisions are equally binding legislative acts, but they only apply to specific parties. Such parties may be a single country, a single organization or individuals. An example of a decision that applies to member states is the EU decision that place restrictions on national GHG emissions in non-ETS sectors. En example of a decision that applies to a single organization is the EU decision that requires Microsoft to provide users of Windows free choice of web-browser.

3.2. EU legal acts that promote the use of conversion factors for electricity

Conversion factors are applied to electricity end-use in order to assess the primary energy consumption and GHG emissions. Therefore, conversion factors are generally implemented in regulatory acts that regulate end-use energy consumption.

As a part of the energy and climate package, EU has adopted an indicative target to reduce primary energy consumption in the EU by 20% in 2020 compared to projected levels. EU uses the PRIMES model make scenario projections for future development of energy consumption. Developments without additional energy efficiency policy measures are referred to as a baseline scenario (BLS). In 2020 the BLS suggests that EU consumption of primary energy will be 1842 Mtoe. Energy savings required to reach the 20 % goals is thereby 386 Mtoe.

Currently EU has not decided on mandatory national targets for energy efficiency. This is contradictory to the mandatory targets for renewable energy (renewable directive) and GHG abatements (Decision 406/2009/EC). The Commission has announced that the realization of the indicative energy efficiency target will be the most elusive of the three 2020 goals. According to the recently adopted energy efficiency directive, the Commission will during the course of 2014 consider whether it should be designed mandatory national targets for energy efficiency in order to ensure progress.

Energy efficiency and savings policy is covered by several EU legislative acts. The various directives and regulations cover different segments of the energy supply chain. The main legal acts are listed below:

- Directive 2006/32/EC on energy end-use efficiency and energy services
- Directive 2012/27/EU on energy efficiency
- Directive 2010/31/EC on energy performance of buildings
- Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products (and subsequent ecodesign regulations
- Directive 2010/30/EC on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related productions (and subsequent labelling regulations).
- Directive 2004/8/EC on promotion of cogeneration

With the exception of CHP-directive (2004/8/EC) all of these regulatory acts include elements of conversion factors and energy rating principles.

3.2.1. Directive 2006/32/EC on energy end-use efficiency and energy services

The energy services directive was adopted in the EU in 2006. The directive requires all member states to set an indicative (non-mandatory) national energy efficiency target of at least 1% of final energy consumption in the period 2008-2016. As a consequence, minimum energy savings target in 2016 should be 9 %. All sectors are covered by the directive, with the exception of energy consumers subject to the emissions trading directive.

The directive also requires member states to prepare a national energy efficiency action plan, including measures that will meet the national target. Member States enjoys considerable flexibility on how to achieve the target, and they may introduce informative, regulatory, and/or fiscal policy measures.

The directive also requires Member States to carry out a number of public sector measures, such as information campaigns, introducing financial instruments for energy efficiency and developing institutional framework. There is also a requirement for energy suppliers/distributors to provide customers with information about their energy consumption and facilitate energy efficiency.

As the directive aims to increase efficiency in final energy consumption, the use of conversion factors is not mandatory. However, in an annex to the directive (annex 2) there is a table showing the energy content of various fuels. A footnote to the table states that Member States may use a coefficient of 2,5 for the electricity, reflecting an estimated 40 % power generation efficiency in the EU. Other coefficients may also be used if member states can justify it. The text is reproduced here:

For savings in kWh electricity Member States may apply a default co-efficient of 2,5 reflecting the estimated 40 % average EU generation efficiency during the target period. Member States may apply a different co-efficient provided they can justify it.

There is no obvious reason of why the directive allows for the use of a coefficient for electricity, without giving similar conversion factors for other energy carriers. Using a factor of 2,5 for electricity will make it easier for Member States to reach the 2016 target of 9 % through reductions in the use of electricity. Although the directive does not provide specific guidance on the use of conversion factors, the member states have an incentive to use this coefficient, since it makes it easier to reach the target of 9 % energy efficiency. As an example, using the conversion factor will allow the member states to report significant energy savings by converting electricity consumption to gas.

3.2.2. Directive 2012/27/EU on energy efficiency

In November 2010, the EU Commission published the report, Energy 2020, which reviewed implementation progress of the EU energy and climate package (20-20-20 goals). The main findings was that the member states were on course to meet their renewable targets and emission abatement targets, but that only 50 % of the energy efficiency target would be met with existing legislative measures. As a result, on 22 June 2011 the Commission submitted a proposal for a new energy efficiency directive, and a revised proposal was adopted by the EU in October 2012. The directive repeals the energy services directive and the CHP directive. The purpose of the new energy efficiency directive is to secure that the EU target of 20% primary energy savings in 2020 is fulfilled.

According to the directive, all Member States must set a national energy savings target for 2020. The targets should be set taking into account the overall EU target of 20% primary energy savings, and it may be based on either primary or final energy consumption, primary or final energy savings, or energy intensity. It will be possible for Member States to set a primary energy savings target, and with the use of primary energy factors report significant savings in the end-use sectors.

According to the energy efficiency directive the following measures must be implemented:

- Renovating central government buildings (3 % of floor space annually)
- Central governments must purchase only products, services and buildings with high-energy efficiency performance
- Set up an energy efficiency obligation scheme
- Promote energy audits
- Promote individual metering and informative invoicing
- Prepare a national action plan for heating and cooling
- Promote technologies for efficient cogeneration and district heating
- Ensure that national energy regulatory authorities pay due regard to energy efficiency when carrying out the regulatory tasks
- Ensure that energy tariffs promote energy efficiency

In order to calculate primary energy savings when reducing electricity consumption, the directive refers to a table in an annex (Annex IV). This is similar to the table in Annex 2 to the energy services directive. A footnote to the table states that electricity savings may be multiplied with a coefficient of 2, 5. Member States have a strong incentive to adopt this conversion factor, as it will make it easier to achieve a national goal of primary energy savings.

3.2.3. Directive 2002/91/EC on on energy performance of buildings

The energy performance of buildings directive was adopted in the EU in 2002. In 2010 it was repealed and replaced by a revised directive. However, it is still applicable to Norway, Iceland and Liechtenstein through the EEA agreement. The directive requires Member States to implement the following measures:

1. Implement a methodology for calculating energy performance of buildings
2. Establish minimum energy performance requirements for new buildings and renovations.
3. Implement an energy labelling scheme for buildings
4. Establish regular inspection of air-conditioning systems and boilers

The energy performance of buildings can be expressed through several different indicators. Examples are indicators for energy consumption, CHG emissions, energy costs, or energy policy. The directive gives no specific guidance on which indicator to be applied when setting minimum energy performance requirements. However, article 3, which refers to the establishment of a calculation methodology, includes the following wording:

The energy performance of a building shall be expressed in a transparent manner and may include a CO2 emission indicator.

The directive allows for the use of CO2 emission factors when setting up minimum energy performance criteria. However, this is no binding approach.

3.2.4. Directive 2010/31/EC on energy performance of buildings

The revised EPBD entered into force in EU in June 2010, repealing the previous directive from 2002. The revised directive sets an additional requirement that all new buildings from 2020 should be nearly zero-energy buildings (2018 for public buildings). Furthermore, the four main policy measures in the original directive have been reinforced. The most important change is that the minimum energy performance requirements should apply to a larger share of the building stock (a previous threshold of 1,000 m² has been lowered). Also, the minimum energy performance requirements should as a minimum reflect cost optimal levels. The Directive also strengthens the requirements regarding the quality of the scheme for energy certification of buildings.

Regarding the use of energy conversion factors, an Annex to the Directive (Annex 1) set specific requirements for the energy performance of buildings calculation methodology. The methodology should be able to calculate the building's primary energy consumption through the use of primary energy factors. The text contains the following wording (our emphasis):

The energy performance of a building shall be expressed in a transparent manner and _shall include an energy performance indicator and a numeric indicator of primary energy use, based on primary energy factors per energy carrier_*, which may be based on national or regional annual weighted averages or a specific value for on- site production.*

The methodology for calculating the energy performance of buildings should take into account European standards and shall be consistent with relevant Union legislation, including Directive 2009/28/EC.

According to wording above, the methodology for calculating the energy performance of buildings shall include a primary energy indicator. However, Member States are free to decide which indicators they wish to apply in the requirements for energy performance and in the energy performance certificates.

Member States shall ensure that minimum energy performance requirements for buildings are set with a view to achieving cost-optimal levels. In January 2012 the Commission published Regulation 244/2012, laying down principles for the calculation to define the cost optimal level of energy performance requirements. According to this Regulation, primary energy factors should be determined at national level.

The only specific requirement for regulatory use of a primary energy factor is laid down in article 9, regarding nearly zero-energy buildings. According to the article, Member States should develop a national plan to increase the number of nearly zero-energy buildings. Article 9 contains the following wording (our emphasis):

The national plans shall include, inter alia, the following elements:
(a) the Member State's detailed application in practice of the definition of nearly zero-energy buildings, reflecting their national, regional or local conditions, and _including a numerical indicator of primary energy use expressed in kWh/m 2 per year. Primary energy factors used for the determination of the primary energy use may be based on national or regional yearly average values and may take into account relevant European standards;_

The definition of nearly zero-energy buildings should be expressed in terms of primary energy consumption, calculated with the use of primary energy factors. However, Member States are free to adopt national primary energy factors for different energy carriers.

3.2.5. Directive 2009/125/EC establishing a frameworkfor the setting of ecodesign requirements for energy-related products

In 2009 the EU adopted the revised ecodesign directive. The directive establishes a framework for determining minimum energy, climate and environmental performance of energy-related products in households, industry and service sectors. The definition of an energy-related product is any product that affects energy consumption, directly or indirectly.

The directive lays down principles for the ecodesign requirements, while the actual product requirements are adopted through ecodesign regulations.

At the beginning of 2012, EU had adopted 12 ecodesign product regulations. The products subject to ecodesign requirements are electro-technical, which means that requirements only affect electricity consumption. However, new product regulations define minimum requirements for products that may use alternative energy carriers other than electricity.

The EU is currently developing a number of new regulations that will set minimum requirements for products that can use different energy carriers. These new product regulations cover heating systems, ventilation systems, washing machines, dishwashers, dryers, etc. Two of the new regulation proposals have been subject to considerable debate, due to the use of conversion factors for electricity. One sets requirements for boilers and combi-boilers (gas/oil/electric), and the other regulates water heaters. The conversion factor is in the regulations' working document is defined as follows:

conversion coefficient' (CC) means a coefficient reflecting the estimated 40 % average EU generation efficiency, as established in Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services; the value of the conversion coefficient shall be CC = 2,5.

When calculating the energy efficiency of products subject to these regulations, electricity consumption is multiplied 2,5. As a result, the calculated energy performance of electrical products will significantly higher than alternatives that use other energy carriers. Although the Commission does not use the term "primary energy factor", the explanation of the conversion factor is similar to primary energy calculation principles; the coefficient should reflect the average energy loss that occurs when primary energy is converted into electricity.

Introducing the conversion coefficient for electricity in eco-design can ultimately result in the exclusion of certain electrical products from the European market, as long as products that can utilize other energy carriers are available on the market.

3.2.6. *Directive 2010/30/EC on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products*

The revised energy labelling directive was adopted in the EU in 2010. The directive requires that appliances are labelled according to their energy performance in such a manner that it is possible to compare the efficiency with that of other models. The products categories regulated by the labelling directive will in time mirror consumer products regulated by ecodesign. Specific product-related information requirements are laid down relevant product-specific regulations.

Energy labelling regulations use the same calculation methodology to assess the energy performance of products as the corresponding ecodesign regulations. When implementing a conversion coefficient for electricity in the energy performance calculation, electrical products will get a lower energy performance rating than similar products that use other energy carriers.

This will have an impact on consumers' behaviour and alter competition between energy-related products.

3.2.7. EU regulatory use of conversion factors for electricity

Table 3.1 gives an overview of EU legislative acts that in some way promotes regulatory use of energy conversion factors, mainly in the form of primary energy factors. In the first EPBD from 2002, the use of a CO2 emission factor was promoted. However, in the revised directive, the CO2 emission factor is replaced with primary energy factors.

There have been no official statements from any EU institution on why they have moved away from CO2 emission factors in EU energy policy, and are now focusing on primary energy factors. However, a likely reason for this may be the establishment of emissions trading in the EU (EU ETS). Under ETS, GHG emissions are allocated directly to electricity generators. According to the guidelines for emissions trading directive, CO2 emissions shall not be allocated to consumers of electricity. The following wording is taken from these guidelines adopted in 2007 (our emphasis):

All emissions from the combustion of fuels at the installation shall be assigned to the installation, regardless of exports of heat or electricity to other installations. <u>Emissions associated with the production of heat or electricity that is imported from other installations shall not be assigned to the importing installation.</u>

The use of energy conversion factors in EU legislative acts seems somewhat random and not very coordinated. The energy services directive and the proposed energy efficiency directive allows for implementing a conversion factor of 2,5 in the national energy policy framework. Product regulations related to ecodesign and energy labelling will probably implement a common mandatory conversion factor of 2,5. The EPBD requires Member States to determine national primary energy factors.

To our knowledge, conversion factors have been implemented in the EU legislative acts without any scientific justification or socio-economic analysis. There are no official studies on how conversion factors in the regulatory framework influence developments on energy, climate and competition-related issues.

Legislative act	Energy weighting principle	Description	Possible outcome
Energy services directive	Conversion coefficient of 2,5	The directive allows for the use of a conversion factor of 2,5 for electricity savings, making it easier to meet national energy savings target.	Regulatory measures, taxes and subsidies are based on the conversion coefficient
Energy efficiency directive	Conversion coefficient of 2,5	The proposed directive allows for the use of a conversion factor of 2,5 for electricity savings, making it easier to meet a national energy savings target.	Regulatory measures, taxes and subsidies are based on the conversion coefficient
Energy performance of buildings directive (2002)	CO_2 emission factor	The directive requires the Implementation a methodology for calculating energy performance of buildings. This methodology may include CO_2 emission factors as an energy performance indicator.	Minimum energy performance requirements and energy certification of buildings may be based on calculated CO_2 emissions.
Revised energy performance of buildings directive (2010)	Primary energy factor	The directive requires the Implementation a methodology for calculating energy performance of buildings. This methodology shall include primary energy as an energy performance indicator. Also, the definition of nearly zero energy buildings should include criteria related to the calculated consumption of primary energy.	Minimum energy performance requirements and energy certification of buildings may be based on calculated primary energy consumption.
Regulation No 244/2012	Primary energy factor	Methodology framework for calculating cost-optimal levels of energy performance requirements in buildings. Requires Members States to determine a national primary energy factor.	No direct impact, but the regulation justifies regulatory use of primary energy factors.
Ecodesign directive	Conversion coefficient of 2,5	A common European conversion factor of 2,5 for electricity could be the basis for calculating the energy performance of products.	Electrical products may be excluded from the European market.
Energy labelling directive	Conversion coefficient of 2,5	A common European conversion factor of 2,5 for electricity could be the basis for calculating the energy performance of products.	Electrical products will be given an inferior energy label.

Table 3.1 Application of conversion factors for electricity in EU legislative acts

Annex 4: Conversion factors in the context of economic theory

In chapters 3 we examined the use of conversion factors for electricity in EU legislation. As mentioned, there has not been conducted any studies on how the use of weighting principles influence the development of energy supply and consumption in a socio-economic perspective.

In this annex we investigate to what extent the use of conversion factors in a regulatory context provides for rational incentives in the consumption and production of electricity. The analysis is based on economic theory.

4.1. Primary energy factors in a short and long term perspective

When considering the changes in supply and demand for electricity it is important to distinguish between a short-term and long-term perspective. Electricity producers are more flexible and able to adapt to changes in energy prices over the long-term than a short-term perspective.

If we reduce demand for electricity and consider the change in production volume and production mix within a few years or less, we are looking at changes in a short-term perspective. In the short-run, capacity constraints in existing generation facilities limit the producers' ability to accommodate increases in price and demand. For certain production technologies (e.g. wind and solar power), the short-term price elasticity (the ability to adjust production to changes in price) is approximately equal to zero. Other technologies (e.g. thermal electricity production) are more flexible and able to increase output in the short term if the price incentive is strong enough. Increased short-term demand will increase electricity prices, which in turn will be able to justify the increased fuel costs and increased electricity production volume.

According to economic theory, long-term is equal to the time it takes for producers to fully adjust production volumes in response to a new price level. In the longer term, the producers of renewable electricity (wind and solar) are able to build new facilities to meet increased consumer demand and changes in price. There are no technical limitations on how much wind and solar power capacity that can be commissioned in the long term. As a result, the supply curve looks completely different when we separate the short- and long-term perspective.

The difference between short-and long-term price elasticity is illustrated in Figure 4.1. Wind power production in the short-term is limited by installed capacity in existing facilities. As wind power has no fuel costs, producers are willing to produce at full capacity almost independent of energy prices. In the long-term, however, wind power producers can invest in new facilities if electricity prices over time will pay for the investment costs. Supply of electricity from thermal power generation (e.g. gas or coal) depends to a greater extent on fuel costs. Increased thermal production drives up the prices of fuel, both in the short- and long-term.

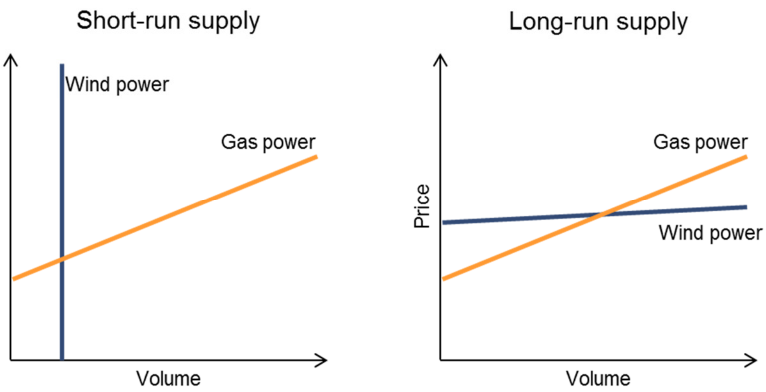

Figure 4.1 Difference between short and long-run price elasticity of electricity generation

It is important to assess the long-run consequences of choices made when implementing new energy and climate policy. For instance, both the EU carbon roadmap and energy roadmap set targets for 2050. In order for energy conversion factors to reflect long-run developments, they should be calculated on the basis of long-run supply and demand. This is a challenging task, especially since the long-run production mix will be dependent on other energy policy measures. Mechanisms like emission trading and support for renewable energy will play a crucial role in this context.

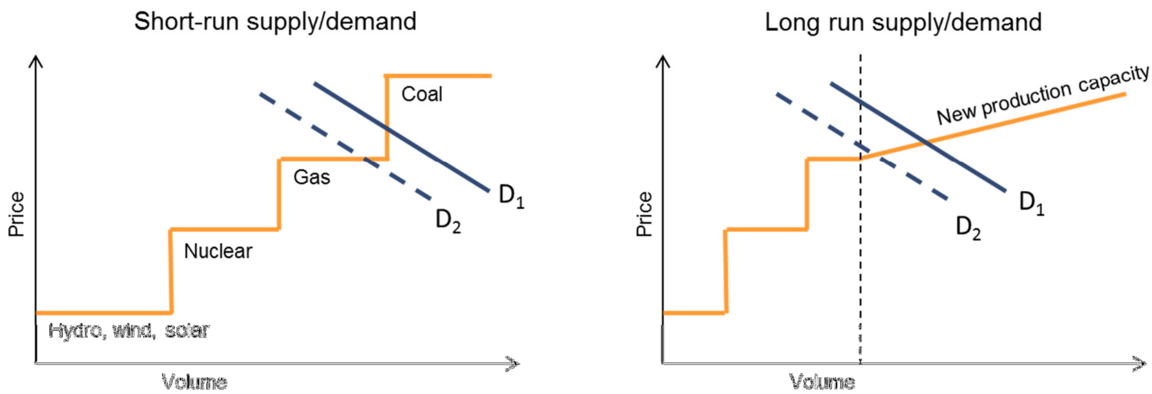

Figure 4.2 Difference between short and long-run electricity supply and demand

The difference between short-and long-run supply/demand for electricity is illustrated in figure 4.2. The figure shows an example of an electricity system consisting of a mix of different production technologies with varying marginal costs. In the example, a reduction in the demand from D1 to D2 results in a marginal decrease in the electricity production from gas in the short term. Hence, in this example a short-run marginal primary energy factor should be based on electricity from gas. In the long-run, however, some of the existing production facilities will be decommissioned, and new capacity investments will be made according to projected long-run demand. If we in the long-run reduce demand from D1 to D2, the result will be less electricity production in new plants. Thus, the long-run primary energy factor must reflect the efficiency of new production facilities.

The long-run primary energy factor must therefore reflect the efficiency of new generation facilities to be commissioned in the future. Since emission trading effectively will cap emissions from traditional coal and gas power plants in the long-run, future production capacity will probably be based on low-carbon technologies, such as fossil electricity generation with CO2 capture and storage (CCS), nuclear power and renewable power. Furthermore, support schemes for renewables will likely increase future supply of renewable electricity. Finally, due to continuous research and development, low-carbon technologies should be even more competitive in the long-run. Since the long-term energy policy framework for 2050 is still under development, it currently not possible to make predictable calculations of long-run primary energy factors in the EU. However, it is very likely that long-run supply of electricity will be more environmental friendly than today.

To support of the argument that long-run energy conversion factors are different from the short-run, one can look at the development of new electricity capacity in Europe today. Figure 4.3 compares new capacity commissioned in Europe with existing total production capacity in 2011. Approximately 70 % of new capacity commissioned in 2011 was based on renewable energy sources. Due to national support schemes for renewables, it is natural to assume that the share of renewables in the total electricity mix in Europe will gradually increase until 2020. In the period 2020-2050, other technologies will probably have a larger impact on the mix, such as nuclear power and CCS, depending on commercial availability, price of emission allowances, and other energy policy framework.

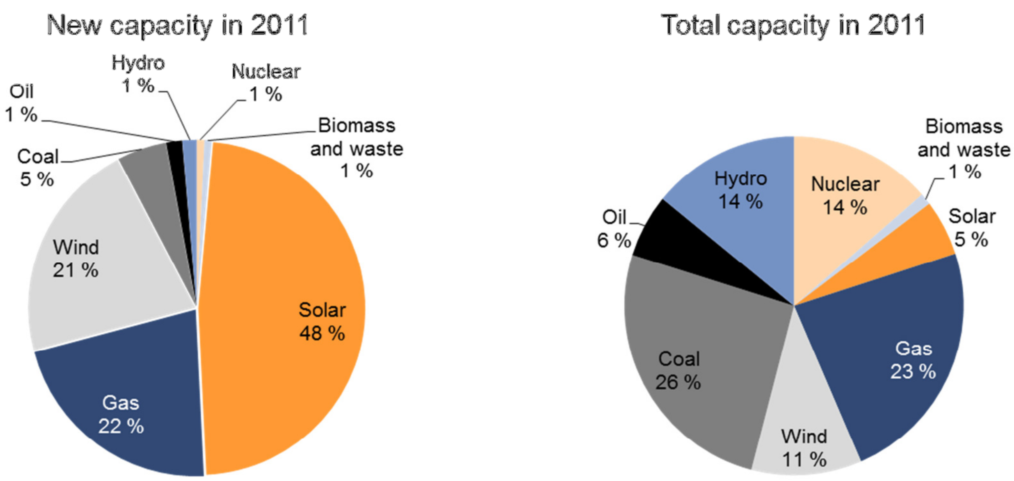

Figure 4.3 Share of new generation capacity (GW) and total capacity (GW) in EU in 2011 (Source: EWEA, 2012)

4.2. Market impact of regulatory application of energy conversion factors

The purpose of implementing primary energy factors in the regulatory framework is to influence the behaviour of end users in order to reduce primary energy consumption. As described in Annex 3, conversion factors based on average production mix are often being used.

Figure 4.4 gives an example of an electricity system where supply consists of both fossil and renewable electricity production technologies. The supply curves for renewables and fossil generation are identical (may for example represent electricity generation from biomass and oil).

A price level of 40 will result in the production of 40 units of renewable electricity and 40 units of fossil electricity, totalling 80 units. We further assume that the primary energy factor for fossil electricity is 3, while the primary energy factor for renewable electricity is 1.

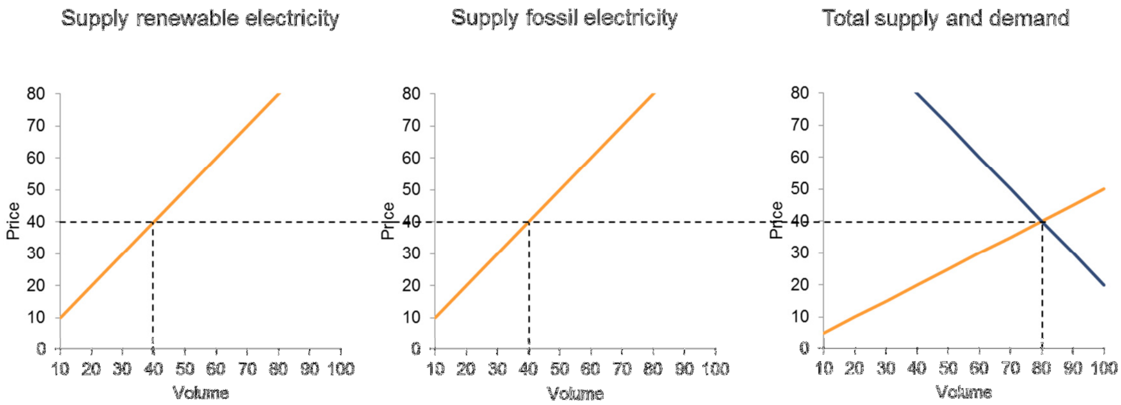

Figure 4.4 Example - Supply and demand of electricity

In order to reduce primary energy consumption in this example, one can either A) regulate demand through a tax on electricity consumption, or B) one can regulate supply through a tax on production.

A) Tax on electricity consumption: We assume that we want to influence the demand for electricity through an end-user tax based on primary energy factors. An average primary energy factor for electricity will be PEF=2 (average of fossil power with PEF=3 and renewable power with PEF=1). If we add a tax equal to 5 on the primary energy consumption by end users, the demand curve shifts down 10 units on the price axis (tax of 5 multiplied by PEF of 2). We then get a new equilibrium price on the supply and demand curve as indicated in Figure 4.5.

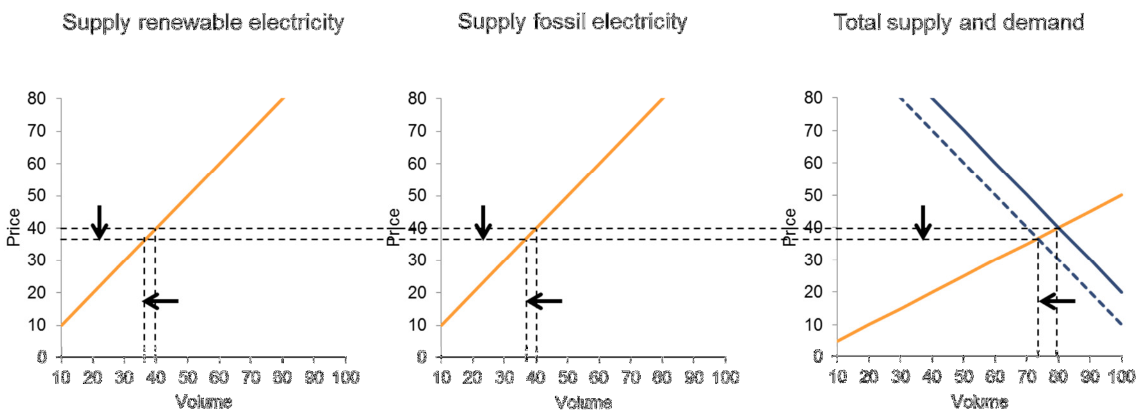

Figure 4.5 Changes in supply and demand as a result of primary energy tax on consumption

Figure 4.5 illustrates that the introduction of an end-user electricity tax results reductions in both fossil and renewable electricity production. If we multiply the reduction in renewable and fossil electricity production with primary energy factors of 1 and 3 we find out that the tax results in an overall reduction in primary energy consumption of 13.

B) Tax on production: Another approach to influence primary energy consumption would be to introduce a tax on production directly. If we introduce a production tax of 5 on the primary energy, the price of renewable electricity will be increased with 5 units as the primary energy factor is 1. The Primary energy factor for fossil power is 3, which means that a primary energy tax of 5 increases the price of fossil electricity with 15. The introduction of a direct tax is illustrated in Figure 4.6.

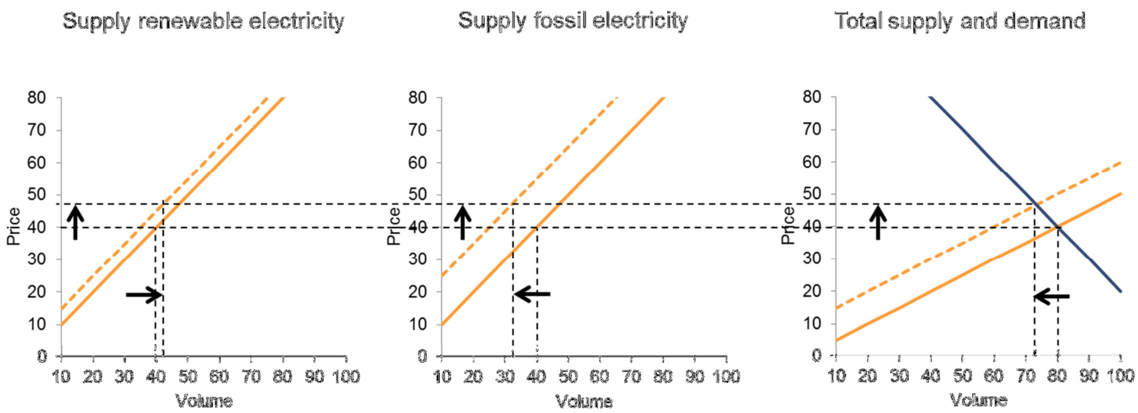

Figure 4.6 Changes in supply and demand as a result of primary energy tax on production

Implementing direct taxes, as shown in figure 4.6, results in more rational adjustments in the production mix when the aim is to reduce primary energy consumption. We see that fossil electricity production will be reduced more than the total reduction in end-use consumption. Renewable energy production will in this case actually increase as a result of the direct tax burden.

If we multiply the change in the renewable and fossil power generation in figure 4.6 with the primary energy factors of 1 and 3, the result is total primary energy savings of 23. Therefore, a direct tax on production results in significantly higher primary energy savings than indirect taxation of end-use consumption (which only gives overall primary energy savings of 13).

The example illustrated above shows that a tax on end-use of electricity (Figure 4.5) does not motivate producers to invest in energy-efficient technologies. Adding a tax on end-use consumption will only reduce overall demand for electricity, which means that the tax indirecty place a burden on all production technologies equally, independent of their primary energy efficiency.

End-user taxes based on primary energy factors does not effectively reduce actual primary energy consumption. For energy policy measures to be effective, the party responsible for consuming primary energy sources should be responsible for the paying the tax directly.

Annex 5: The Impact of Conversion Factors on EU Climate and Energy Policy

5.1. The objectives of EU energy and climate policy

The EU faces a number of challenges when addressing future energy needs and environmental concerns. On average, 50 % of EU annual energy consumption is based on imports. Together with increasing volatility of fossil fuel prices, this causes concern about future security of supply. Furthermore, the EU has taken a leading role in combating climate change. The EU climate and energy package was adopted in late 2008 and contains three objectives to be met by 2020. In addition, EU has committed to reduce greenhouse gas emissions by 80 to 95% in 2050 compared to 1990 levels. Overall, the EU's energy and climate targets can be summarized as follows:

- A 20% reduction in primary energy use within through energy efficiency measures within 2020 compared with projected levels
- 20% of EU final energy consumption should come from renewable resources within 2020
- A reduction in EU GHG emissions of at least 20% below 1990 levels within 2020
- A reduction in EU GHG emissions of 80-95% below 1990 levels within 2050
- A reduction in future energy import dependency

5.2. EU energy and climate policy measures

The main legislative acts, implemented by EU in order to meet the targets of renewable energy and reduced greenhouse gas emissions, are the emission trading directive (2003/87/EC) and the renewables directive (2009/28/EC).

The renewables directive lays down national targets for the share of renewable energy in final energy consumption. The directive also describes what measures member states may adopt to meet the targets, e.g. support schemes for renewable energy production.

The emissions trading directive lays the framework for emissions trading in the EU (EU ETS). Emission trading creates a cost on GHG emissions from electricity production (reflected through the cost of emission allowances). With the introduction of emissions trading, indirect allocation of GHG emissions to end-users through the use of CO_2 emission factor is superfluous. Indirect allocation of emissions is not consistent with the official guidelines to the emissions trading directive (described in annex 3).

To this date, there are no mandatory national targets for energy efficiency, similar to those imposed in the case of renewable energy and reduction of GHG emissions. The Commission has indicated that implementation of energy efficiency policy goals remains the most difficult and elusive among the three “2020s” and that it may propose binding national targets in the future to ensure progress is made. Energy efficiency is covered by several legislative measures, each addressing specific segments/issues of the supply chain. Of these, the most relevant is the energy efficiency directive which requires member states to adopt an indicative (non-mandatory) energy savings target.

The use of primary energy factors (or equivalent energy rating principles) in energy policy lacks a scientific footing. It is likely that conversion factors have been introduced in EU legislative acts in order to address specific challenges. For instance, when developing ecodesign legislation, it has been necessary to establish a methodology that makes it possible to compare the overall energy performance of products that use either gas or electricity. The recently adopted directive on energy efficiency outlines measures aimed at the end-use sectors, but the overall objective is to reduce primary energy consumption. Thus, member states must be able to calculate primary energy savings as result of reduced consumption of secondary energy. Having the need for some methodology that makes this calculation possible, the EU has endorsed the existing methodologies that have been designed for statistical purposes.

5.3. Do primary energy factors provide market players with rational incentives to reduce primary energy consumption?

5.3.1. The difference between top-down and bottom-up regulation

EU policy for sustainable development is largely based on the principle that the polluter pays. This principle is carried out using the direct regulation of GHG emissions through emissions trading. Similarly, the renewables directive promotes the use of support schemes for renewable energy production. These are examples of top-down regulation, where those responsible for the social costs or benefits are directly subject to a financial cost or subsidy. Top-down regulation provides a rational incentive structure because those who are able to influence social cost/gains incorporate these in their investments and operating decisions. Direct regulation of energy producers will also have an impact on final energy consumption, as energy prices increase and provide incentives for energy efficiency.

Regulating final energy consumption through the use of energy conversion factors is an example of bottom-up regulation. This approach does not provide the market players with rational incentives. The parties who are subject to a tax or a regulatory restriction do not have the ability to make the behavioural adjustments that is optimal in a socio-economic perspective. For example, end-users of electricity are unable to influence the composition of inputs in electricity supply. Bottom-up regulation should only be applied in absence of any top-down regulatory measures. When it comes to energy production and energy consumption, top-down regulation is both possible and currently being used in order to reduce GHG emissions and increase production of renewable energy. Annex 4 in this report shows how indirect regulation of primary energy consumption (bottom-up), through the use of primary energy factors, fails to achieve the overall objectives in a cost-efficient manner.

All types of energy conversion factors (e.g. CO2-emission factors or primary energy factors) provide identical incentives to adjustments in end-use consumption and overall development of supply and demand. It is solely the size of the factor that will influence developments, regardless of what is the objective of the energy rating principle.

5.3.2. *The role of electricity in energy and climate policy*

The use of electricity conversion factors in energy policy can prevent the structural change of the power supply sector which is needed in order to meet the EU long-term objectives presented in roadmaps for climate[2] and energy[3] in 2050. According to the roadmaps, electricity must play a much greater role in future energy supply, in order for the goal of a sustainable low carbon society to be realized. The argument presented is that consumption of electricity does not emit CO2, it can be produced from low-carbon technologies and it can potentially replace fossil energy in transport and for heating/cooling. For example, in the report Energy roadmap 2050, the Commission suggests that electricity could provide 65 % of future energy demand from passenger cars and light duty vehicles.

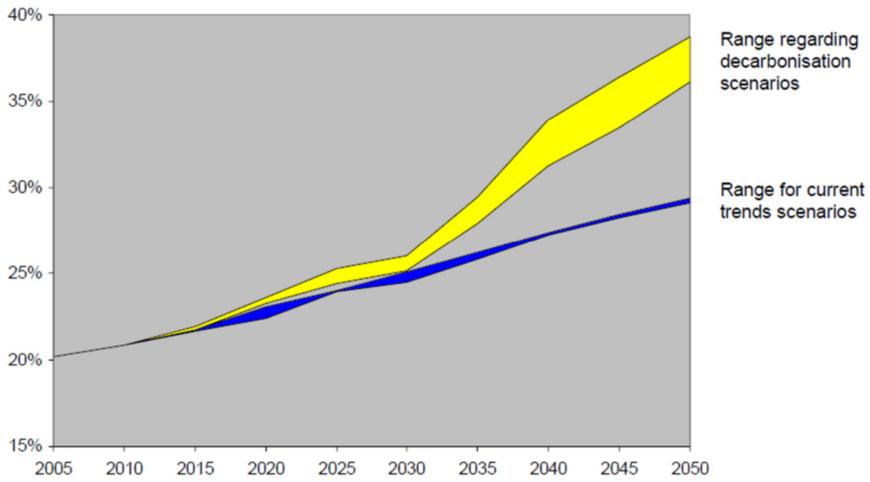

Figure 5.1 Share of electricity in current trend and decarbonisation scenarios in % of final energy demand (Source: COM(2011) 885/2)

Converting fossil energy consumption to electricity will increase future electricity demand. This is illustrated in figure 5.1, which shows that electricity will play an increasingly dominant role in future energy supply. According to EU estimates, the share of electricity in final energy demand will be almost doubled from 22% to 28-39% in 2050.

5.3.3. *Primary energy factors provide lock-in effects that are incompatible with long term energy and climate objectives*

As mentioned above, the EU has set long-term energy and climate goals for 2050 in the roadmaps for climate and energy. In order for the goals to be realized, electricity will play a much greater role in future energy supply.

[2] COM(2011) 112/4, *A Roadmap for moving to a competitive low carbon economy in 2050*
[3] COM(2011) 885/2, *Energy Roadmap 2050*

Figure 5.2 is taken from the EU climate roadmap. It illustrates the projected path of GHG emissions from today until 2050 if the climate target is to be met. The figure shows that the electricity sector, as well as the residential and tertiary sectors, must be nearly carbon-neutral in 2050.

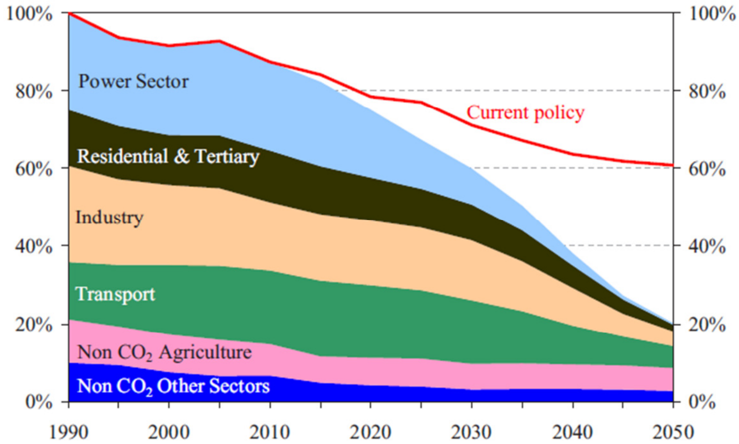

Figure 5.2 EU GHG emissions towards an 80 % domestic reduction scenario (Source: COM(2011) 885/2)

In the report World Energy Outlook 2011, the International Energy Agency (IEA) addresses possible challenges related to long-term lock-in effects. The IEA concludes that investments made today will have an impact on GHG emissions of for decades to come, due to a long technical lifetime of the installations. Electricity generation and the industry sectors exhibit the largest lock-in of emissions, but there are also significant lock-in effects in buildings. Lock-in of emissions in buildings is caused by poor energy performance of buildings, but also through investments in technical installations and energy systems that will influence the energy consumption in the building for several decades.

Reaching the EU climate target for 2020 does not require the drastic structural change of the electricity supply sector that is needed in order to meet the climate target in 2050. For example, a switch from coal to gas in electricity generation could make a significant contribution to the short-term target. However, to avoid lock-in effects in electricity supply that will prevent the long-term target, one must make sure that new electricity plants are able to retrofit post-combustion CCS technologies.

Combustion of gas in the building and industry sectors is also consistent with the EU 2020 emissions target. On the other hand, as shown in figure 5.2, the climate targets for 2050 does not allow for combustion of fossil fuels in end-use sectors, especially not in buildings. Post-combustion CCS technologies will not be technically compatible with distributed boilers or small district heating systems. The current legislative acts of the EU aim to meet 2020 targets and provide strong incentives to facilitate distributed consumption of gas rather than electricity. Therefore, current energy policy will create lock-in effects that can potentially prevent the EU from reaching its long-term climate target.

5.4. Conflicting regulatory framework

EU's energy and climate roadmaps describe developments needed in order to realize GHG-abatements in the range of 80-95% compared with 1990 levels. Important developments are increased energy efficiency, increased use of renewable energy, switching fossil energy consumption to electricity and GHG-abatements in electricity generation through low-carbon technologies such as CCS and nuclear power. The EU also aims to reduce future energy import dependency. Looking at the current EU legislative acts, we find that they do not consistently contribute to these developments.

Table 5.1 gives an overview of whether or not certain measures in EU energy policy contribute to the needed developments. Measures considered are primary energy savings through the use of conversion factors on end-use electricity consumption, renewable energy support schemes, and emissions trading.

Needed developments towards 2050	Primary energy savings through the use of conversion factors on electricity consumption	Support schemes for renewable energy production	Emissions trading
Energy savings	Yes	No	Yes
Increased renewable energy	No	Yes	Yes
Reduced fossil electricity generation	Yes	Yes	Yes
CCS	No	No	Yes
Nuclear power	No	No	Yes
Switch from fossil fuels to electricity	No	Yes	No
Reduced import dependency	Yes	Yes	No

Table 5.1 Assessment of how EU legislative framework contributes to needed developments

Emissions trading contribute greatly to needed long-term developments considering EU's long-term climate goal. However, emissions trading do not contribute to a switch from fossil fuels to electricity in non-ETS sectors, mainly households and the tertiary sector. Therefore, supplementary legislative measures must be established in order to secure GHG-abatements in these sectors.

Renewable energy support schemes and energy efficiency measures will reduce the EU's energy import dependency. However these measures will simultaneously create obstacles for other development goals. For example, energy savings will result in reduced electricity prices, thus leading to reduced profitability of investments in renewable energy, nuclear power and CCS. Furthermore, implementation of primary energy weighting in the regulatory framework may prevent a necessary switch from the use of fossil fuels to electricity. CCS will reduce GHG emissions, but CCS will also reduce generation efficiency in electricity plants and increase primary energy consumption. This may result in increased energy import dependency.

The use of conversion factors on electricity in the regulatory framework stimulates end-users to switch from electricity to other energy carriers with lower conversion factors. If the switch is made to fossil fuels, GHG emissions will increase as electricity generation is covered by emissions trading (cap and trade). Reduced electricity demand will also result in reduced demand for emission allowances, thus reducing incentives to invest in low-carbon generation technologies such as CCS and renewables.

Conflicting policy instruments do not provide for a rational development of energy supply. For example, renewable energy support schemes will discourage investments in energy efficiency due to falling energy prices. Likewise, promoting energy savings will reduce energy demand, which counteracts the goal of increasing renewable energy generation. It is beyond the scope of this report to recommend an optimal combination of energy policy measures. However, it is evident that current legislative acts should be reviewed in light of long-term goals and necessary developments.

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