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Nordic energy and forest products market review and outlook

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Peterson paper mill in Moss May 5, 2008. The mill closed in 2012. Photo: Håkon Sparre, NMBU

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Preface

In this report, we try to summarize energy and forest product markets. We place emphasis on the effects of regional and global trends for Norwegian production and end-user markets. The report consists of three main parts: the Nordic power market, heat markets and non-energy forest products. Although these three sectors are interlinked – e.g. forest industries are power intensive and by-products from sawmills are used as input in heat production – we do not attempt to "draw the big picture" in this report. The report is mainly meant to be the backdrop for modelling the future using various energy system and forest sector models.

Torjus F. Bolkesjø is the main author of the section dealing with the Nordic power market, Eirik Trømborg is the main author of the heat section, while Per Kr. Rørstad is the main responsible for the non-energy forest product section.

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All opinions expressed in this report are the authors' own and do not reflect the views of the Faculty of Environmental Sciences and Natural Resource Management or the Norwegian University of Life Sciences.

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Ås, June 2019,

The authors

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1 Summary

1.1 The Nordic power market

The past has shown that some of the main power price drivers are quite unpredictable, while some major trends are quite certain. The joint Swedish – Norwegian green certificate system is well on track to reach the common goal of 28.4 TWh new renewable electricity production by 2020. The Swedish government has announced that it will prolong the green certificate system, while renewable support in Norway and Finland is uncertain after 2020. Still, wind investments are expected to continue at a fast pace beyond 2020 in the Nordic region. Although many hydropower projects have low costs, environmental restrictions in many rivers limit the potential. The main share of new hydropower will be small-scale run-of-river projects. The Swedish nuclear capacity is expected to decrease, while the capacity in Finland will increase. In total there will be a slight increase in the total nuclear power capacity toward 2030. We assume that fossil power generation will be phased out by 2030 in the Nordic countries. Despite low fossil fuel shares in the Nordic market, thermal power will continue to impact Nordic power prices through increasing exchange to/from the Continent and the UK.

Energy intensity in households has started to decline and this is expected to continue to 2040, due to new building standards. The expected growth in population in the Nordic area contributes, however, in the opposite direction. An increasing number of electric vehicles will contribute to an increase in consumption.

The Nordic countries have a large power intensive industry sector. The pulp and paper industry is currently consuming approximately 40 TWh annually. We expect a major transition of the forest industry away from paper production, contributing to a reduction in industrial consumption. A switch in the oil sector to electricity produced onshore may contribute to increasing demand. We also assume increasing demand from data centers in the Nordic region. Overall, the industry sector consumption represents the largest uncertainty in future demand.

The growth in (variable) renewable power on the Continent will make investments in interconnection capacity more attractive – due to short-term price variations. The export capacity in the Nordic region is expected to increase to 14 GW by 2030. This is about three times the current capacity. The power price is expected to increase continuously toward 2050, with the largest effect in Denmark. The uncertainty regarding future power prices is, however, substantial; with the most important aspects of uncertainties being the price of fossil fuel (gas and coal), CO_2-quotas price, the share of renewable energy in the power system, the capacity margins and the development in energy storage and consumer flexibility

1.2 Nordic heating and cooling markets

Future energy consumption in heating and cooling depends on several factors. Improved building standards and higher outdoor temperatures imply reduced heat demand whereas population growth, fewer people per households and increased cooling demand implies higher energy use for heating and cooling. The total effects are unclear and depend on policies and regulations, including future energy costs that influence the profitability of energy efficiency investments. The current changes are also relatively slow due to slow rehabilitation and replacement rates in the building sector.

The renewable share in heating and cooling is relatively low in many countries and replacement of fossil fuels with biomass represents the major potential for biomass in Europe. In the Nordic countries, replacement of fossil fuels in district heating in Denmark and Finland is important, whereas expansion of district heating is needed in Sweden and Norway as most of the existing district heating is based on renewables.

1.3 Non-energy forest products markets

Sawlog is the most important timber grade. In Norway it account for about 70% of the gross income to forest owners. The consumption, and thereby the production, is dependent on the construction activities (i.e. new houses) and the renovation of old ones. Data indicate a cyclic sawnwood sector, with roughly about 10 - 20 years cycles. The dissolution of the former Soviet Union around 1990 and the financial crisis in 2008 represents the two latest downturns in this segment. The short-term trend indicates a 3% p.a. increase in global sawnwood production. In the longer term, there is a large untapped potential in Europe in the sense that there is a large difference in per capita consumption of sawnwood across Europe. It is however not necessarily straight forward to change habits, building regulations etc, which may be needed in order to increase the use of wood in buildings.

Newsprint and other printing and writing paper is on the decline globally and in most of the market analyzed in this report. The demand for graphic paper will not vanish, but there are no indications that we will see a large increase in demand in the future. The main reason for the decline is the shift from printed to digital media. It is reasonable to believe that developing economies will jump right to digital media. The short-term decline in global newsprint production is estimated to 4.8% p.a., while the decline in printing and writing paper is estimated to be 1.0% p.a.

The products group "other paper and paperboard" comprises hygienic goods (e.g. tissue paper and disposable diapers) and packaging materials (e.g. paperboards), and the latter group is the dominant one. Except for the Americas where the production has been stable after the mid 90-ies, there has been increases in production in both Asia and Europe. Internet trade is probably the most important driver in the near past. The main drivers for hygienic products are economic development and age structure of the population. In the short term, we estimate the yearly increase to 3.0%.

Societal demands for mitigation and adaptation to climate change will have implications for the forest sector. EU energy and environmental policies have the potential to advance a paradigm change towards a forest-based bioeconomy. This could mean the production of a wide array of (chemical) products like textile fibers (viscose) or construction materials like cross-laminated timber.

2 Introduction

The main aim of this report is to analyze and discuss possible future developments in forest product markets. Since the forest industries are energy intensive and forestry at the same time is a supplier of energy, it is natural to include renewable energy sectors in the analyses. Although the focus primarily is on Norway, forest product markets are global and energy markets are (at least) regional. Hence, we need to discuss the issues at regional and global level.

During the past two decades, Norway has gone from being a net importer of pulpwood to being a net exporter. A number of pulp and paper mills have closed, and now, only three large mills are in operation. Sawmilling has been far more stable, and is the engine in the forest sector. The forest owner get roughly two third of their gross income from sales of sawlogs. The harvest in Norway has been quite stable over the past century. In real terms, timber prices has shown a falling trend since the 50-ies. During the same period, the growing stock has more than doubled – balancing the decline in prices.

One key question behind the present study is how the forest industry structure will look like in the future. Will there be new forest industry in Norway or will she continue to be a net exporter of pulpwood? Again, the forest sector cannot be seen in isolation from the energy sector. Thus, we need to look at the interaction between the developments in the energy sectors and forest sector. Timber and forest industry products are traded across borders and in some cases across oceans - calling for a global perspective. The aim of this report is to provide background information and analysis for scenario development. This in turn will be used in the modelling of the forest and energy sectors using the Nordic Forest Sector Model, NFSM, (Jåstad et al. 2019; Mustapha et al. 2017) and the energy system model Balmorel (Wiese et al. 2018).

The development in the energy and forest sectors surely depends on other sectors and the general development of societies. A handful of so-called megatrend analysis exists (EEA 2015; Ernst & Young 2016; KPMG 2012; PWC 2015). To some extent they differs in what trends are emphasized, but they seem to agree that climate change, resource scarcity (including water), population growth and urbanization are the major trends and challenges in the coming decades. We do not discuss these factors further, but they are underlying factors in the analyses in this report.

We have organized this report in the following way. The first section discusses the Nordic power market. Here we look at historic prices and discuss price drivers (supply side drivers, fuel and carbon prices and demand side drivers). The section concludes with some power price projections. The next section deals with heating and cooling in the Nordic countries. The historic development is also here the starting point for discussion of drivers and outlook. The last main section discusses production of non-energy forest products. We have divided this in five main product groups: coniferous sawnwood, newsprint, printing and writing papers, other papers and paperboards and finally, other emerging forest products.

3 The Nordic power market

3.1 Historical development

3.1.1 Prices

The development of Nordic power prices since the market de-regulation in 1997 is broadly speaking divided in three main phases. During the period of 1997-2005 prices were at relatively low levels most of the time, with an average price as low as 0.181 NOK/kWh [1]. For the years 2006-2011, the average price levels increased substantially and averaged at 0.353 NOK/kWh. A main reason for the price increase was the introduction of the European carbon market (EU ETS), causing a higher cost of coal and gas power generation. Increasing fuel prices also contributed to the firm price level in this period. From 2012, power prices have lingered at significantly lower levels again. In 2015, the annual average prices were as low as 0.185 NOK/kWh - less than 50% of the expected 2015-price in the futures market a few years earlier. Low fuel and carbon prices, caused primarily by the financial crisis and economic downturn, was the main reason for the price decrease, supported by high precipitation levels and increasing supply of wind and solar power on the Continent. In 2018, the Nordic power price has increased substantially compared to the past years. Very low precipitation levels, causing low hydropower supply, is a main reason, but even more important, the carbon prices have increased strongly (+ 360% in the twelve months period August 2017 to august 2018). As a result of these increasing carbon prices, the market expectations for the power price towards 2020 and 2025 has increased substantially the last 12 months.

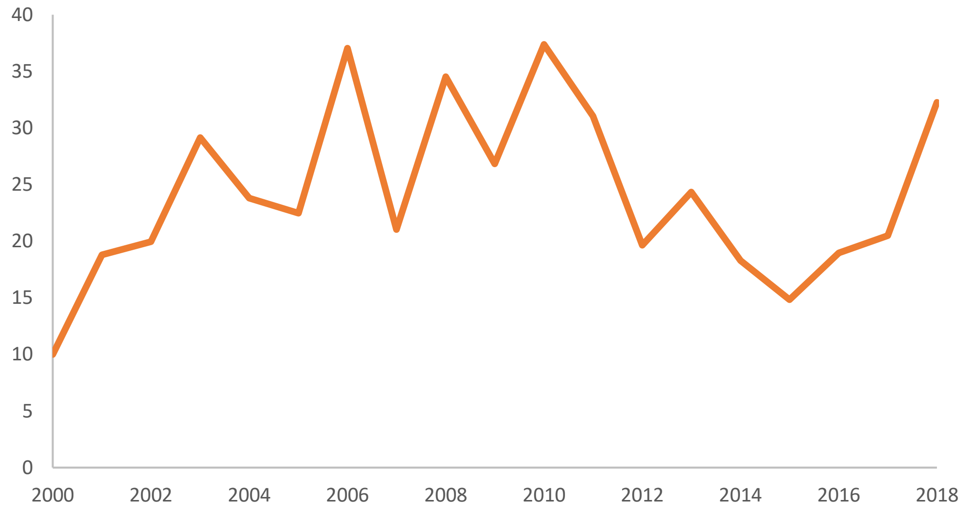

Figure 1. Real term (1997) power prices in the Nordic countries, 1997-2018 (øre/kWh).

3.2 Price drivers towards 2040

The following chapter will discuss the likely developments of the main power price drivers towards 2040. As the historical review above shows, some of the main price drivers are quite unpredictable, but some major trends and developments are quite certain.

[1] 1 Norwegian krone = 1 NOK = 100 øre, 1 € = 9.8 NOK (December 2018)

3.2.1 Supply

The North European power system is in a phase of transition with renewable power replacing coal, and in some countries gas and nuclear power, at high rate.

Renewables

Wind and solar PV generation capacities are growing fast in the Nordic region, as well as in rest of Europe. The learning effect of this increase in capacity contributes to lower costs of renewable power. Combined with ambitious targets for further emission reductions, the wind and PV capacities will likely continue to grow in the coming decades.

The joint Norwegian-Swedish green certificate system is well on track to support 28.4 TWh of new renewable electricity by 2020. On-shore wind power in Sweden, followed by hydropower in Norway, produces the largest shares of certificates. Other producers that take significate shares of certificates are Norwegian wind power and Swedish bio-power

In 2016, the Swedish government announced that it will prolong the green certificate system to subsidize an additional 18 TWh of new renewable power to 2030, while renewable support in Norway and Finland seems uncertain after 2020. Still, wind investments are expected to continue at a fast pace beyond 2020 in the Nordic region. Based on current investments levels and investments plans, political targets and resource availabilities we predict close to 80 TWh of wind power in the Nordic market by 2030 (Figure 2). From 2030 to 2040, we expect further increase in the woind power capacities and a larger share will come from off-shore wind power.

Although many hydropower projects have low costs, the potential for further growth is limited by environmental restrictions in many rivers. Still, due to new investments, as well as climate change, we assume that the hydropower generation in the Nordic region in a normal year will increase to 216 TWh/year by 2030. New hydropower capacity is assumed to have little or no degree of regulation – i.e. we assume run-of-river plants. Although there will be some modifications of existing regulated plants, the main share will be small-scale run-of-river.

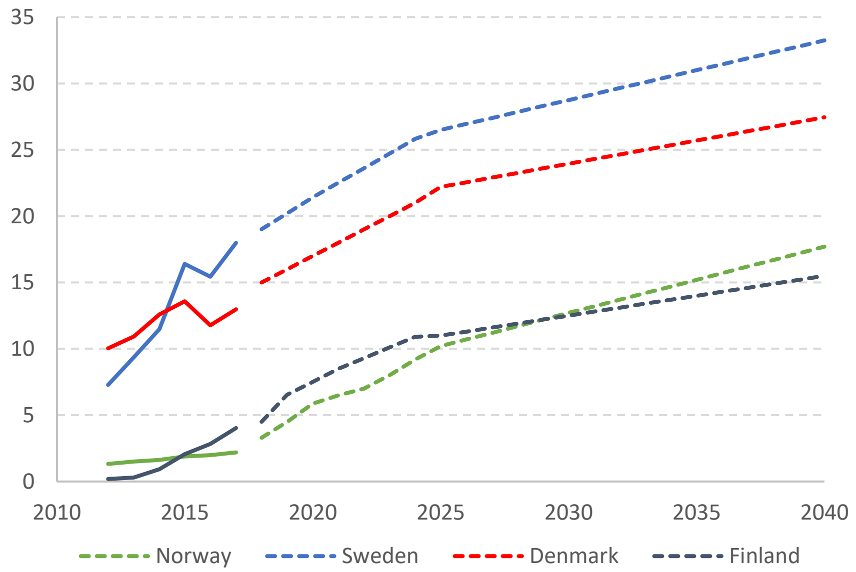

Figure 2. Historic and assumed future wind power generation in the Nordic countries (TWh/year).

Nuclear power

The Swedish nuclear capacity is expected to decrease the coming years. Oskarshamnverket 1 and 2 are permanently closed and we assume Ringhals 1 to close by the end of 2020 and Ringhals 2 by the end of 2019 in our central scenario. These closures remove close to 3 GW of baseload capacity from the Nordic market. For the remaining Swedish reactors we expect operation until a lifetime of 60 years. In Finland, we assume Olkilouto 3 to be online from 2019, and another unit of 1600 MW in operation from 2029. The last German reactor will close in 2023. The assumed nuclear generation capacity in the Nordic region towards 2030 is shown in Figure 3.

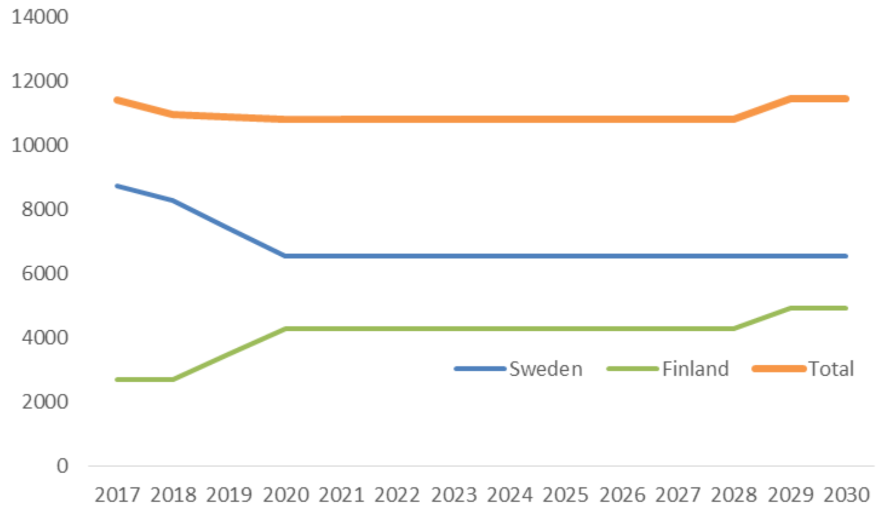

Figure 3. Expected development of total capacity of nuclear power in Sweden and Finland (MW).

Fossil fuel power plants

Low power prices, strong support of renewables and political targets to phase out fossil fuels will cause a further decline in the fossil fuel production capacity and generation levels in the Nordic countries. In Denmark, the coal generation more than halved from 2006 to 2016, partly due to conversion to biomass combustion. The transmission operator Energinet aims to phase out coal by 2020, eyeing the main option to be biomass conversion. The current installed capacity is at 2 GW. In Finland, coal-fired power generation accounted for 7 percent of all electricity production last year, with 45 percent coming from renewable sources and 34 percent from nuclear. Coal will likely remain in the Finnish electricity mix longer than in Denmark, but we assume full coal phase out by 2030. Sweden, on the other hand, has close to fossil free power generation and has only one coal plant with 0.3 GW installed capacity left. The coal phase out will contribute to extend the lifetime and increase the full load hours of existing gas power plants. From 2025 onwards, gas power is gradually increasing its importance as price setter in the Nordic market. Despite low fossil fuel shares in the Nordic market, thermal power will continue to impact Nordic power prices through increasing exchange to/from the Continent and the UK. The development of thermal capacity in Germany and UK is hence a larger uncertainty factor and of larger importance to Nordic power prices than the remaining internal fossil fuel capacity in the Nordic countries.

3.2.2 Fuel and carbon prices

Despite reduced shares of fossil power in the Nordic region, coal and gas power will remain vital to the price levels in the Nordic countries through the 2020ies. In our projections for coal and gas prices we make use of internal expertise, as well as external analyses. For carbon prices, this model run is based on the long term price outlook from Thomson Reuters from fall 2017. The numbers are shown in figure 4.

Coal

Coal prices decreased rather steadily in the period 2011 to early 2016, from a level of 120 $/ton in early 2011 to 40 $/ton in early 2016 – a level below the long-term marginal costs of coal extraction and transportation to Europe. The primary reasons for the price decline were the diminishing demand in China and the healthy supply situation. The coal price reached the bottom in January 2016 and has strengthened considerably during 2016 and 2017, primarily due to increasing demand from Asia. In early November 2017, the API2 coal price was trading around 90 $/t. The forward market is, however, in strong backwardation and the 2020 price is trading around 70 $/t. The long-term projections for the coal price have softened considerably in recent years, but the uncertainty is still large. Demand from the power sector will likely decline in the long run as renewables are largely replacing coal-fired capacity. On the other hand, coal supply may also decrease as the market is reluctant to invest in greenfield projects. In our central scenario, we assume that the forward market prices as of November 2017 will materialize to 2020. From a review of long term energy market outlook studies[2] it seems that the most likely scenario is a slight increase in the coal prices towards the long run marginal costs (LRMC) of coal extraction towards 2030 (around 60 $/ton).

Gas

European gas prices fell to levels below 10 €/MWh after the financial crisis, but rose thereafter to levels around 25 €/MWh in 2013/2014. Due to lower oil prices and increased supply from shale gas and LNG, prices dropped markedly during 2013 to 2016. During 2017, European gas has regained some strength. As of November 2017, European gas prices are trading around 17-18 €/MWh. As for the other fuels, we apply the forward market as basis for the model assumptions to 2020. The forward market expects prices to remain around 17 €/MWh the coming years as a result of healthy LNG supply combined with stagnating Asian demand. Beyond 2020, most predictions expect the current global over-supply to diminish and a slightly rising price level.

Carbon

The EU Emissions Trading System (ETS) rules for the next trading period (2021-2030) were decided in November 2017 and was finally approved and entered into force in early 2018. Having agreed during phase 3 (2013-2020) on backloading as a temporary measure to tackle the oversupply haunting the system, and the Market Stability Reserve (MSR) as a structural long-term solution, phase 4 was the time for an overarching reform to align the ETS with EUs 2030 climate ambitions. Carbon prices have increased substantially since fall 2017 and by May 2018 it is trading in the 25 €/t range. A review of 41 power market outlook studies reveals that the uncertainty regarding future carbon prices is very high (figure 4), but most studies assume higher carbon prices in the future than in the past years.

[2] Chen Y.K., Hexeberg A., Rosendahl K.E., Bolkesjø T.F. (2019). Review on Long-Term Trends of North-West European Power Market (in review).

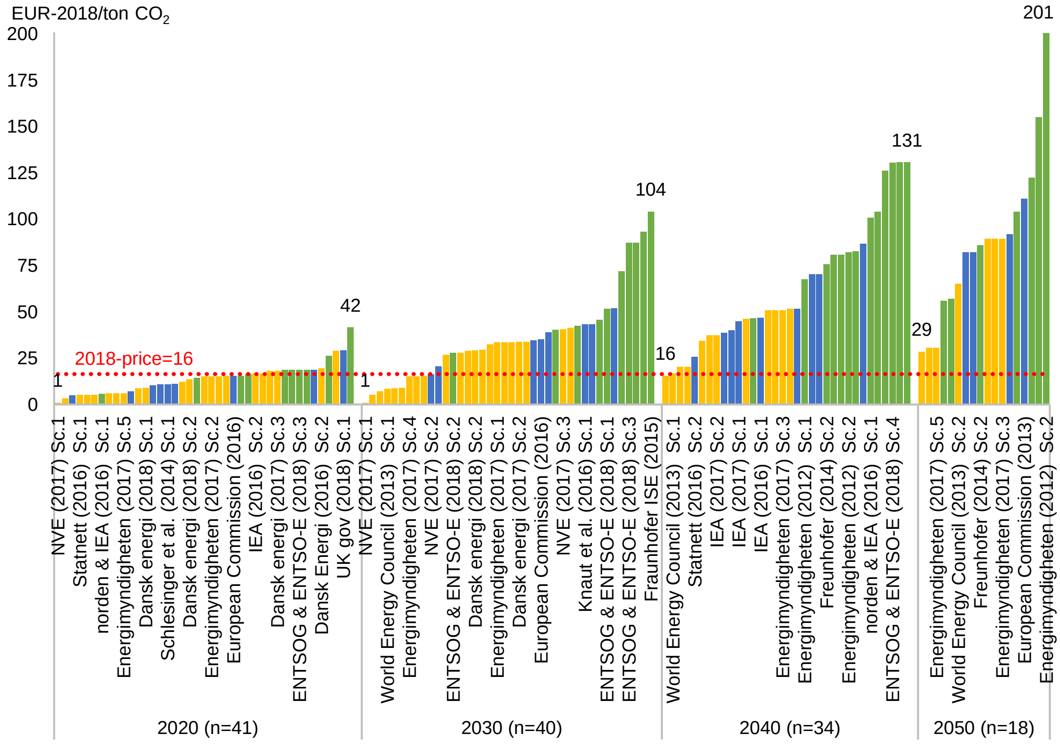

Figure 4. Prognosis of carbon prices from the reviewed studies (bars) in ascending order and carbon price level in 2018 (dash-line). N-values are numbers of prognosis prices found. Prognosis prices are displayed in different colors by scenario category: blue = predictive, yellow = explorative and green = normative.

3.2.3 Demand

Energy intensity in households has started to decline and is expected to continue to 2040, due to new building standards. The expected growth in population in the Nordic area contributes, however, in the opposite direction. Also, with relatively low power prices the coming 10 years and a positive export surplus, more electricity will likely be used in the heating sector – especially in district heating in Sweden, Finland and Denmark. An increasing number of electric vehicles will also contribute to an increase in consumption, especially in the latter half of the forecasting horizon.

With the exception of Denmark, the Nordic countries have a large power intensive industry sector. The power intensive industries experience strong competition from producers in countries with lower cost levels. The pulp and paper industry is currently consuming approximately 40 TWh annually. We expect a major transition of the forest industry from paper production to bio-refineries producing biofuels and having excess energy (in the form of power and/or heat), contributing to a reduction in industrial consumption. On the other hand, a revitalization of the Nordic power intensive industries is also possible, as the general macro-economic development may increase Nordic industries' competitiveness. For example, the planned aluminum production unit at Karmøy in Norway will have an annual power consumption of almost 4 TWh.

A switch in consumption in the oil sector from electricity produced offshore to electricity produced onshore may also contribute to increasing market demand; the planned electrification of Utsira (oil fields in the North Sea) will require approximately 3 TWh/year. Investments in data centers are one example of possible “new demand” with a large potential, and we assume increasing demand from data centers in the Nordic region. Overall, the industry sector consumption represents the largest uncertainty in future demand. In our central scenario, we assume that in 2030 the annual industrial consumption will increase by 15 TWh/year from the current level (Figure 5). After 2030, we expect no additional industrial growth (Figure 6).

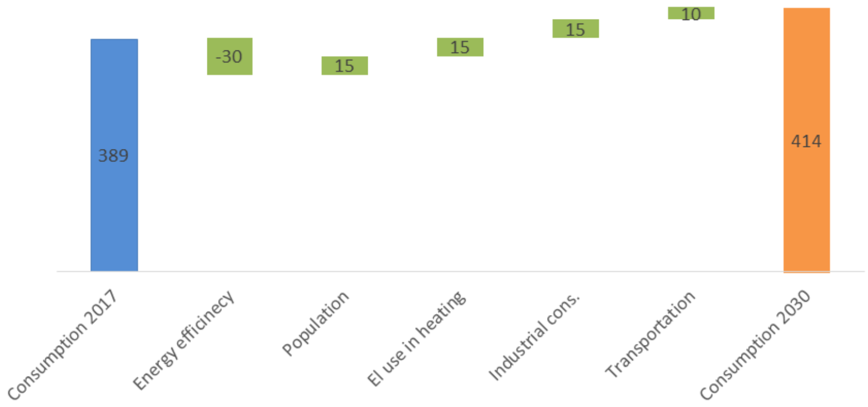

Figure 5. Consumption in 2017, development of main consumption drivers and expected consumption in 2030 (TWh)

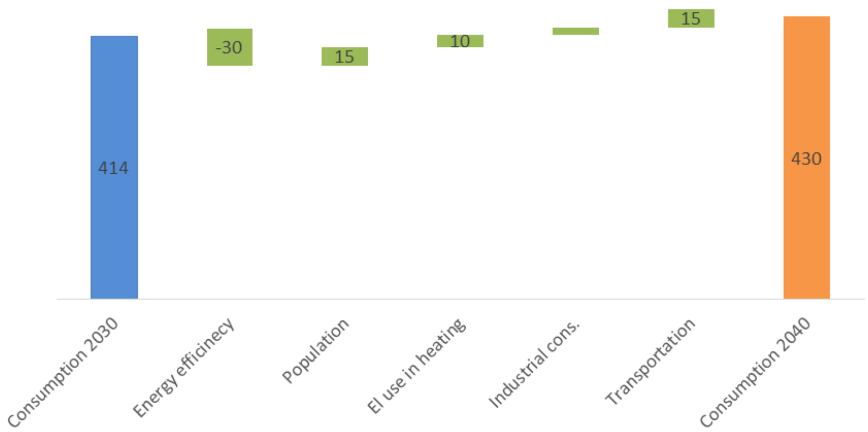

Figure 6. Assumed development of main consumption drivers from 2030 to 2040 (TWh).

3.3 Interconnectors

The growth in renewable power, and decline in coal and gas, implies larger short-term price variations on the Continent. This makes interconnection capacity investments more attractive. Since interconnector investments has a long lead time, our assumed commissioning of new interconnections is in line with the latest grid plans from the Nordic Transmission System Operators (TSOs) and the European Network of Transmission System Operators for Electricity (ENTSO-E). The export capacity is expected to increase according to the development shown in Figure 7, implying a total of about 14 GW of export and import capacity in 2030.

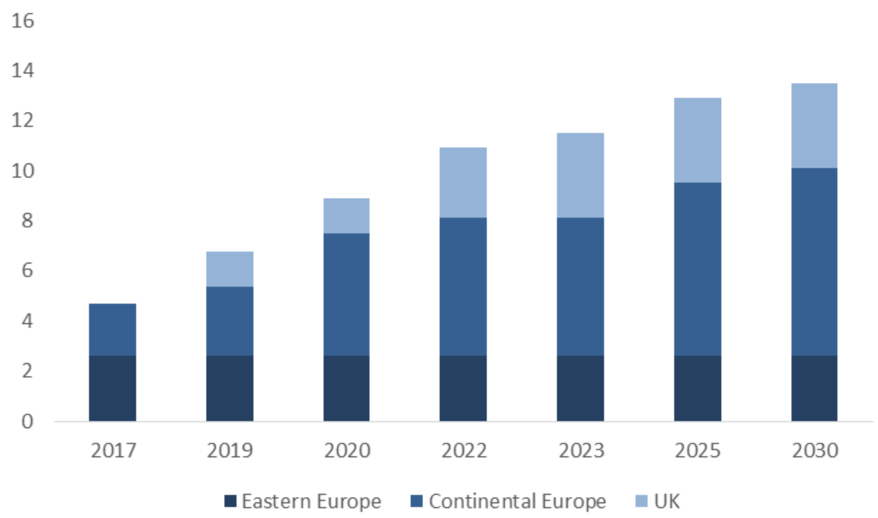

Figure 7. Expected export capacity from the Nordic region in selected years, 2017-2030 (MW).eastern Europe is not continental? Explain which countries you use in which category

Beyond 2030, increasing short term price variations will likely make more interconnector line investments profitable. There seems, however, to be a growing domestic resistance to these projects in exporting countries as they increase prices and households' electricity bills and reduce industry's competitiveness. At the same time, other flexibility options, like increased demand response and storage, may contribute to reduce the price variations.

3.4 Power price outlook

The power prices in the Nordic countries are expected to rise continuously toward 2050. The uncertainty regarding future power prices is, however, substantial. Several aspects influence the power prices in the long term. The most important aspects of uncertainties are the price of fuel and CO_2-quotas, the share of renewable energy in the power system, the capacity margins and the development in energy storage and consumer flexibility. Other aspects that will affect the power price is the power balance over the year and the share of intermittent energy production in the Nordic countries, as well as more transmission capacity out of the area (Bøhnsdalen et al. 2016).

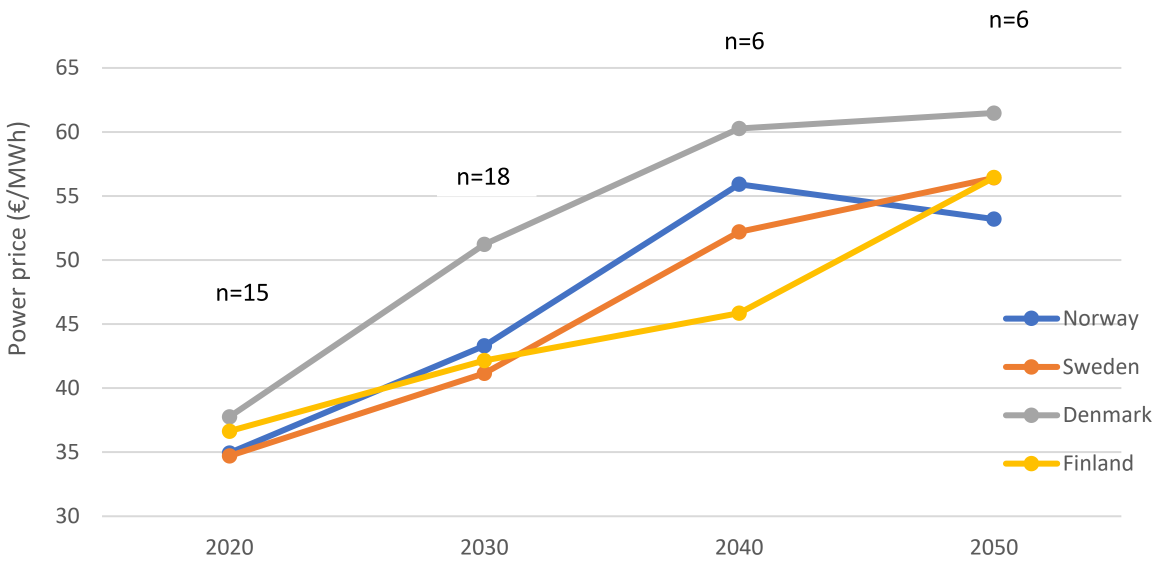

Figure 8. Power price outlook for Nordic countries, average of different studies, 2020-2050, €/MWh. N=x gives the number of prices that are included in the average. For 2020: n=15, 2030: n=18, 2040: n=6 and 2050: n=6.

Denmark is expected to have a higher power price than the rest of the Nordic countries, which is seen in Figure 8. This is because Denmark is closer connected to the European continent in transmission of power than the other Nordic countries. Since the power price on the European continent is higher it will also influence the power price in Denmark. New transmission cables between the Nordic countries and the European continent will increase the power prices in all Nordic countries.

4 Heating and cooling in the Nordic countries

4.1 Developments in heat consumption and prices

4.1.1 Historical developments

Derived heat covers the heat production in heating plants and in combined heat and power plants. In the EU (28) it has decreased from final a consumption of 640 TWh in 1990 to 534 TWh in 2015 (Figure 9), corresponding to 19.5% of the total electricity consumption[3]. 46% of the derived heat was consumed in the residential sector, 20% in the service sector and 33% by the industry (Eurostat 2017).

The total heat market in the Nordic countries is close to 240 TWh, of which around 43% is district heating[4]. The production of derived heat in the Nordic countries has been stable the last 10 years, except for in 2010 when it increased with about 20% due to a cold winter. The derived heat consumption in 2015 was 126.5 TWh, of which the Norwegian consumption was 4%, increasing from a 2% share in 2006.

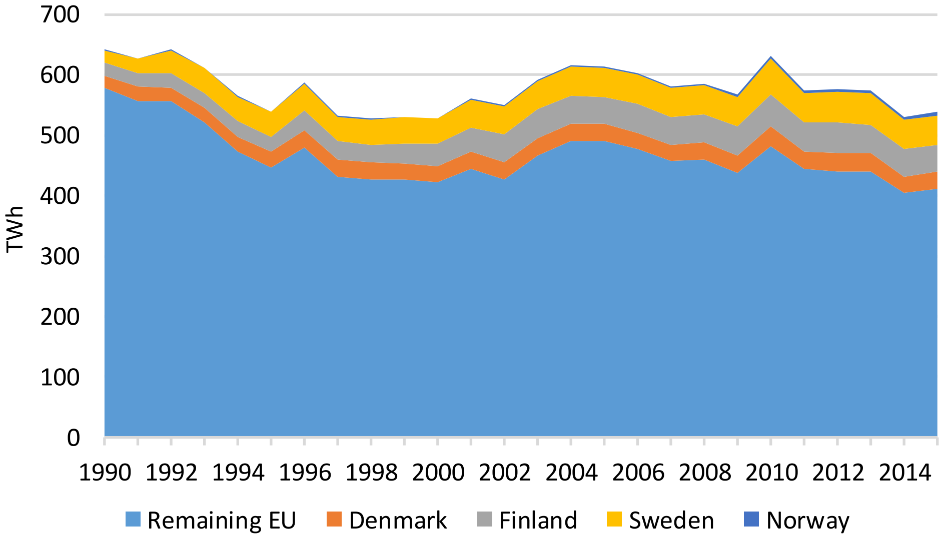

Figure 9. Final energy consumption of derived heat 1990-2015.Source: Eurostat (2017), table [nrg_106a]

Heat is a heterogeneous product due to different heating technologies, such as direct space heating, water born heating, heat pumps and wood stoves. Heat prices (or heat costs) are thus in practice alternative cost for different technologies and energy carriers. District heating can be viewed as a relatively homogenous product with observed prices collected and reported by statistical agencies like for Norway from Statistics Norway[5]. As district heating is a monopoly for a certain technology within a given area, the price is set by alternative heating options and is often regulated. The heat prices also vary between sectors due to different volumes and sector specific energy taxes. The average natural gas price in the EU (28) including taxes and levies are about

[3] http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_and_heat_statistics
[4] http://www.iea.org/etp/nordic/
[5] https://www.ssb.no/en/energi-og-industri/statistikker/fjernvarme/aar

50% higher for households than for non-households. Denmark and Sweden have gas prices 69 and 74% above the EU average for non-household and 46 and 77% above for households.

Figure 10 shows electricity prices compared to gas prices. EU electricity prices are threefold the gas prices for both households and non-household consumers. The electricity prices in EU (28) are 35% higher for households with annual consumption between 2,500 and 5,000 MWh than for non-household consumers. Within the selected countries, especially Denmark shows higher electricity prices than average in EU for non-households, whereas Finland, Sweden and Norway have prices below the EU average. The electricity prices show an increasing trend up to 2015, but are since then stable or declining in most countries.

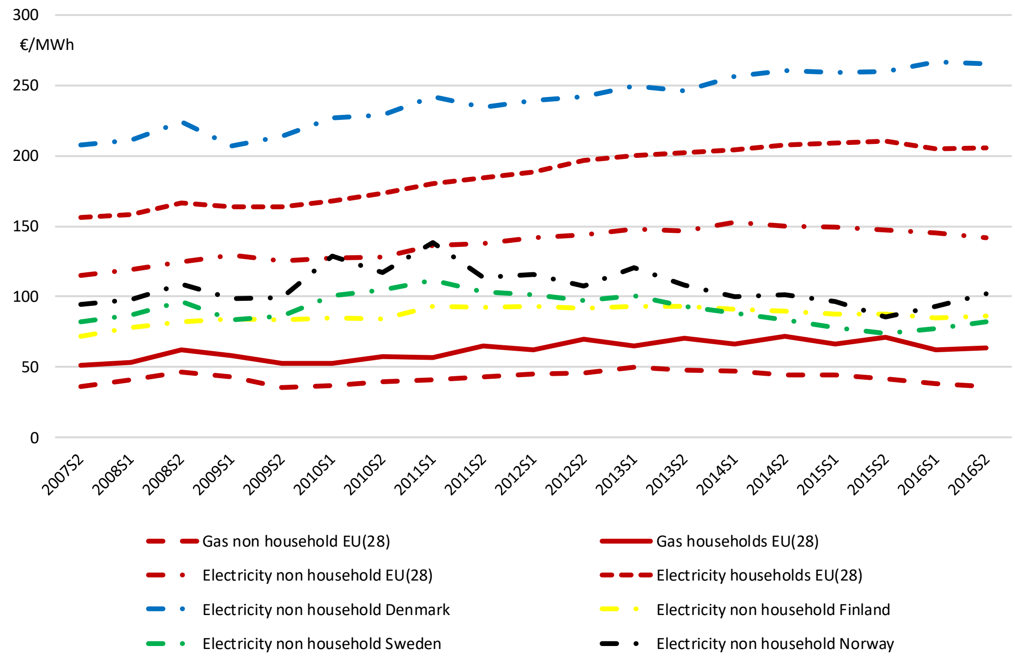

Figure 10. Natural gas prices inclusive taxes and levies for non-household in EU (28) and electricity prices inclusive taxes and levies for non-household consumers with consumption between 500 and 2,000 MWh for EU(28) and selected countries. Source: Eurostat (2017) table [nrg_pc_202], [nrg_pc_203], [nrg_pc_204] and [nrg_pc_205]

Electricity costs constitutes of power price, grid tariffs, taxes and levies. Electricity taxes vary significantly between countries. EU has a minimum rate for electricity of 0.5 Euro per MWh for business and 1.0 Euro per MWh for non-business (the rates are 0 for Kerosine and LPG)[6]. The current rates for electricity is 15.37 Euro per MWh for business use and 20.5 for non-business use in Denmark, 7.03 and 22.53 in Finland, 0.5212 and 30.75 in Sweden[7].

The current el-tax in Norway is NOK 163.2/MWh. Electricity used for heat production in district heating has a lower tax of NOK 4.8/MWh, similar to electricity for industrial use[8]. Grid rent and taxes are steadily increasing, however limited in real terms as shown in Figure 11. The grid rent for the service sector shows a similar trend.

6 https://ec.europa.eu/taxation_customs/business/excise-duties-alcohol-tobacco-energy/excise-duties-energy/excise-duties-energy-tax-rates_en

7 https://ec.europa.eu/taxation_customs/sites/taxation/files/resources/documents/taxation/-excise_duties/energy_products/rates/excise_duties-part_ii_energy_products_en.pdf

8 http://www.skatteetaten.no/globalassets/saravgifter/avgiftsrundskriv/2017-elektrisk-kraft.pdf

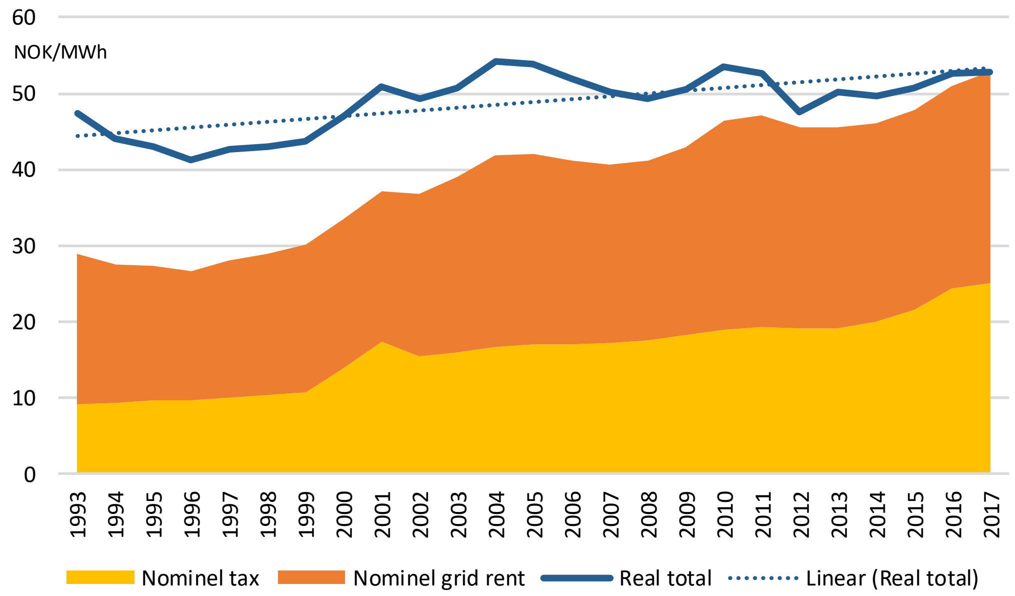

Figure 11. Grid rent and taxes for households with annual consumption of 20 MWh. Source: NVE (2017)[9]. Nominal and real 2017-prices.

District heating (DH) is a long-term and capital-intensive investment and is often considered a natural monopoly and the market can also be regulated by concessions. Consumers in Denmark are protected from monopoly pricing by a profit cap for DH producers, forcing producers to set the DH price such that only the necessary costs are covered. In Norway, the DH price cannot exceed the total electricity price if connection to district heat is mandatory for the given consumer. In Finland and Sweden, competition rules apply (Sandberg et al. 2018). Table 1 shows district heating prices in the Nordic countries and Figure 12 shows district heating prices in Norway.

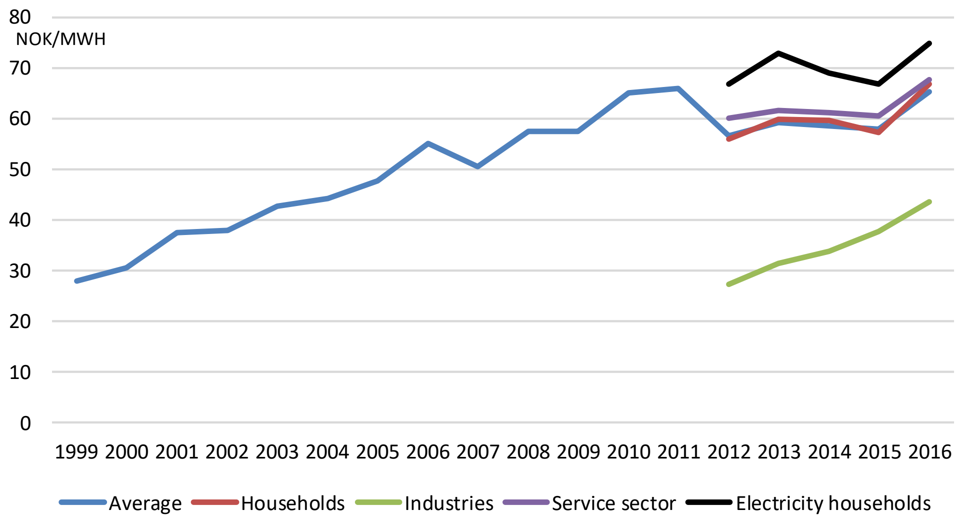

Figure 12. Average district heating prices in Norway excluding VAT for different sectors and electricity price including grid rent and electricity tax but excluding VAT for households 1999-2016. Source: Statistics Norway (2017) District heating statistics and electricity statistics.

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[9] https://www.nve.no/elmarkedstilsynet-marked-og-monopol/nettjenester/nettleie/nettleiestatistikk/

Table 1. Nominal district heating prices in the Nordic countries. Source: Sandberg et al. (2018).

Averaged DH price (€/MWh, excl. VAT)	2016	2015	Source
Denmark	75	72	Danish District Heating Association
Finland	59	59	Statistics Finland
Norway	72	64	Statistics Norway
Sweden	80	60	Swedish Energy Agency

4.1.2 Drivers in heat demand and prices

The energy use for heating and cooling is driven by the following main direct drivers:

- Building numbers and size (the amount of commercial floor space and the numbers and size of homes)
- Service demands and preferences (activities, indoor temperatures, heating requirements)
- Building standards
- Outdoor temperatures
- Heating and cooling systems

Indirect drivers that influence the direct drivers are:

- Population, which drives the number of homes, schools, and other community buildings
- Economic growth (real GDP), which is a major driver of new floor space in offices and retail buildings as well as industrial activities
- Technological developments
- Real energy prices
- Policies and regulations

Better insulation, more efficient equipment and higher outdoor temperatures have reduced the energy shares used for heating and cooling the last decades. As an example, space heating and air conditioning together accounted for about 58% of total residential energy use in the United States in 1993. By 2011, they made up only 48%, thanks to more efficient equipment, better insulation in walls and windows, and population migration to warmer regions. However, total home energy consumption rose during the same period, owing in large to a substantial increase in the demand from appliances, electronics, and lighting, as well as an increase in the average to-be-heated volume of single-family homes[10].

In general, lower *U*-values and higher air-tightness of the building envelope lead to reduced heat transport out of (or into) the building and thus less heating (cooling) energy consumption than in a comparable building with a lower energy standard.

The domestic sector is the most susceptible to temperature fluctuations as space heating, water heating and cooling account for 60-70 per cent of final energy consumption. Short-term changes in consumption have generally shown the effects of mean interannual air temperature fluctuations. The number of heating degree days (HDD) has shown a significant a negative trend in Europe since 1980, whereas the number of cooling degree days (CDD) is increasing[11].

For hourly variation, time of use and calendric information are also important for estimates of heat demand. Kipping and Trømborg (2016) found that outdoor temperature, dwelling type, floor

[10] http://needtoknow.nas.edu/energy/energy-efficiency/heating-cooling/
[11] https://www.eea.europa.eu/data-and-maps/daviz/trend-in-heating-and-cooling-1#tab-dashboard-01

space, and number of residents are the most important variables for modeling energy consumption in Norwegian dwellings. In the service sector, the type of building/activity is also important.

Year of construction is often used as a proxy for energy standard, since building codes have become gradually stricter over the course of the last decades. However, since renovation and rehabilitation of a building may take place several times during its lifetime – often improving its energy standard – the year of construction alone does not necessarily reflect the current energy standard.

The development of the above-specified drivers decides future heat demand. Major uncertainties in estimates of future heat demand are: a) the level and location of population growth and the influences on the number of buildings of different categories, b) the renewal rate and c) the efficiency of the buildings and the activity in heat consuming industries. Technological developments and policy decisions on international and national levels will influence these factors.

4.2 Heating technologies and biomass for heating

4.2.1 Historical developments

In Europe, the production of derived heat from coal continued its long-term decreasing trend: since 1990 it decreased by 57 % and reached a record low of 624 561 TJ/173 TWh in 2015. Oil products showed a similar trend for heat production: a decrease of 78 % since 1990 with a record low of 104 298 TJ in 2015. While natural gas significantly increased and peaked in 2005, the use decreased by 23 % by 2015. However, in 2015 natural gas was still 62 % above its 1990 level. Renewable energy continues its long term increasing trend. Since 1990 heat produced from renewable sources increased by 633 %, however in total the renewable energy sources contribute only 23 % of total derived heat generation in 2015. Figure 13 shows the gross heat production from solid biofuels in CHP and heat only district heating plants in the EU and the Nordic countries from 2006 to 2015. About 10% of the solid biomass used for energy in EU is used in district heating plants, but the biomass use has increased by 80% from 2006 to 2015.

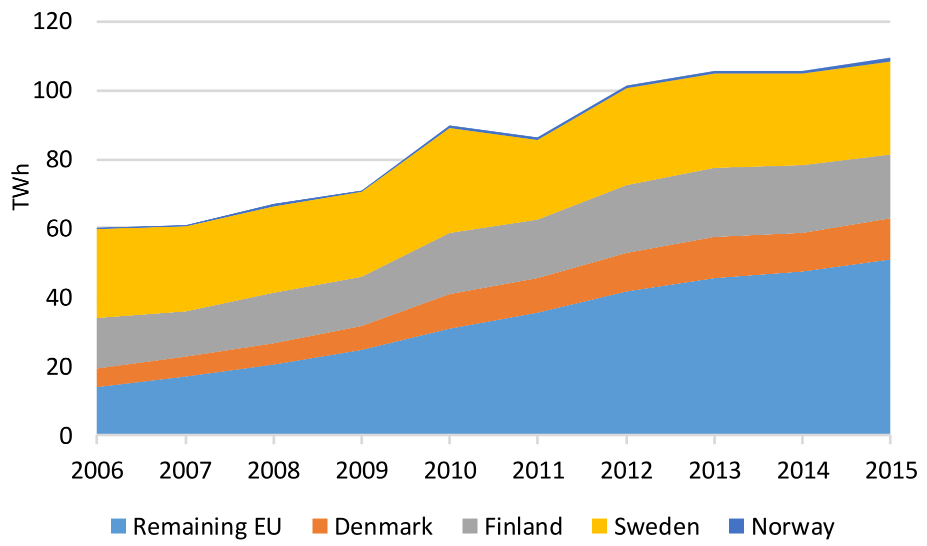

Figure 13. Gross heat production from biomass (excluding charcoal) in district heating plants from 2006 to 2015. Source: Eurostat (2017).

The use of biomass for heating in Norway has been declining the last decade. This is mainly because of reduced production and use of biomass residues in the pulp and paper industries, but also reduced use of firewood in households because of increased use of air-to-air heat pumps and milder winters. The use of solid biomass in the district heating is steadily increasing from 0.6 TWh in 2007 to 2.1 TWh in 2016. In total, consumption of solid biomass is reduced from 14.6 TWh in 2010 to 10.4TWh in 2016[12].

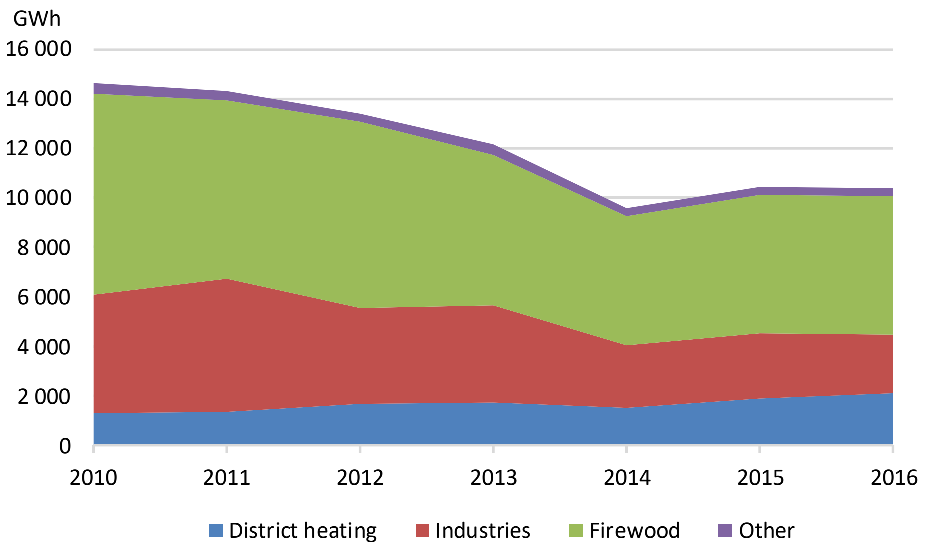

Figure 14. Consumption of solid biomass in Norway. Source: Statistics Norway, Energy balance and wood firing statistics (2017) [13]*.*

4.2.2 Drivers for biomass demand in the heat sector

Within the expected or estimated heat demand, the technology and energy carrier to be used might change. Due to a low renewable energy share in heating and district heating, increased use

[12] SSB Energy balance 2017. https://www.ssb.no/energi-og-industri/statistikker/energibalanse/aar-endelige Table 11561
[13] https://www.ssb.no/en/energi-og-industri/statistikker/fjernvarme/aar

of renewables, including biomass and electricity from renewable energy sources, can be expected. The technology mix in the future heat supply often depends on policy driven technological developments. Policies that support specific technologies, not only make the given technology more profitable and more used in the short run, the increased use enhances technological learning and reduces costs. Overall GHG targets and specific targets for GHG reductions within the heat sector, development of biomass heat technologies, as well as the costs of other renewable technologies and relative prices, will define the demand for biomass in the heat sector. Electricity prices and the cost of heat pump technologies are likely to be especially important for the future use of biomass in the Nordic countries. The main potential for biomass in district heating in Denmark and Finland is replacement of fossil fuels, whereas in Sweden and Norway, with already high renewable shares, increased biomass use is to a large extent dependent of expansion of district heating[14].

4.3 Outlook

The Nordic Energy Technology Perspectives (NETP 2016)[15] presents technology pathways towards a near-zero emission Nordic energy system. Space heating and cooling is expected to reduce by about 50% towards 2050 and he heat generation in district heating is expected to reduce gradually from close to 160 TWh in 2013 to 140 TWh in 2015 in the climate neutral scenario (CNS). By contrast, under the four degree scenario (4DS), district heating demand could increase by as much as 10%, given growth in total floor area relative to improvements in building thermal demand intensities.

The bioenergy use for heat and power is slowly reduced and drops by approximately 10% during 2013-2050. In the building sector, the final energy demand of bioenergy is reduced to one-third of its 2013 level (Figure 15). This amount is a large relative reduction, but in absolute terms (some 27 TWh reduction between 2013 and 2050), it is less significant compared to the changes in the transportation sector. To sum up, over the period 2013-2050, the bioenergy use for transportation grows nine-fold to surpass buildings and industry and equal the demand from heat and power. In all low-carbon scenarios in NETP (2016), competition increases and the sustainable biomass resource remaining in Nordic countries is not sufficient to meet demand from both. Almost 100% of estimated sustainable biomass potential is used in the two degree scenario (2DS), and bioliquids need to be imported to decarbonize transport after 2030 – which implies an upward pressure on biomass prices. Given the lack of alternatives and the possibilities in the power and heat sectors, it appears highly likely that biomass use in the transportation and industrial sectors will get priority.

[14] See Sandberg et al. (2018) for fuel composition in district heating in the Nordic countries.
[15] http://www.iea.org/etp/nordic/

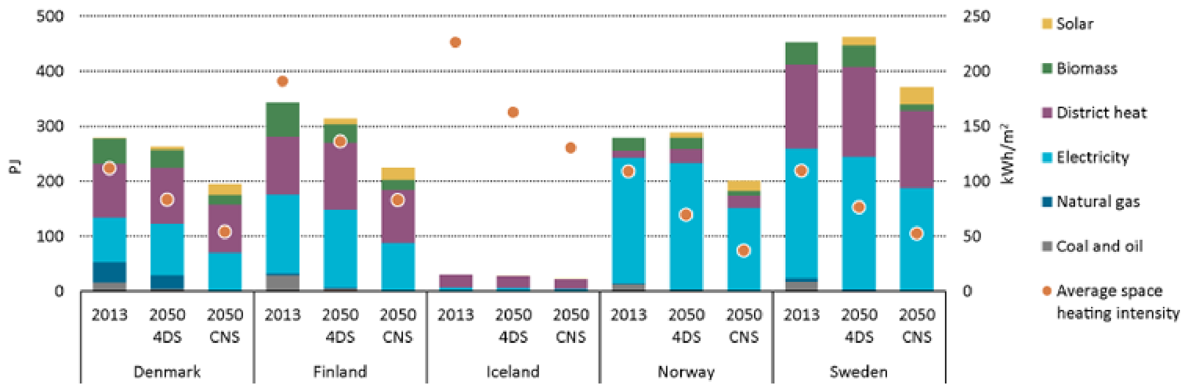

Figure 15. Buildings sector energy by fuel and space heating intensities to 2050 in NETP (2017). Note that biomass is also a significant fuel in district heating. CNS = the Carbon Neutral Scenario, 4DS = the 4-degree scenario.

CeNSES[16] projected energy consumption in Norway towards 2050. In the residential sector, the reduction in heat energy consumption per building, area and person is out-weighed by the assumed increase in population. in the medium population growth scenario The total energy consumption for heating in the residential sector is estimated to grow from 32 TWh in 2010 to 39 TWh in 2040, when it stabilizes. For the service, agricultural and building and construction sectors the growth rate in building area is assumed to be 1.6 times the population growth towards 2025 and 1.0 thereafter. It is further assumed that 2% of the buildings are renovated annually and that new buildings use 20% more energy than theoretical estimates, but that energy use for heating is 20% lower than existing buildings. The heat consumption is estimated to reduce in some sub-sector towards 2030 but increase in others. In total, the stationary energy consumption in the service, agricultural and building and construction sectors is found to increase from 35.3 TWh in 2010 to 41.6 TWh in 2050 of which the heat increase is a major share. CeNCES estimated a small growth in both electricity consumption and overall energy consumption in the industrial sector towards 2050 but stated significant uncertainty in the estimates.

The use of district heating for households in Norway is expected to increase from the current 1 - 5 TWh towards 2050 in the CeNSES scenarios. The use of firewood and bio boilers remains relatively constant. The use of heat pumps increases and direct electric heating reduces. The use of district heating is expected to increase significantly in the service, agriculture and construction sectors from the current 3 to 7 TWh by 2050. The use of bio boilers in smaller scale area-based heating for the service sector is expected to increase by about 4TWh in 2050. The use of biomass in the industry is expected to decrease slightly. If we assume a 50% share of solid biomass in the future district heating, the total use of solid biomass for heating in Norway will increase by about 7 TWh in 2050 in the CENSES analyses.

Based on analyses of residential energy use in Norway up to 2010, Vestlandsforskning[17] made scenarios for the energy use towards 2030 based on population scenarios from Statistics Norway and annual growth in floor space per capita. In their base scenario with 0.5% annual increase in

[16] https://www.ntnu.no/documents/1261967833/0/CenSES-Energiframskriving+Rapport_final.pdf/2761b615-ad7b-4893-818d-2270166f5fd2

[17] http://www.vestforsk.no/sites/default/files/migrate_files/vf-rapport-13-2011-nve-energibruk-i-norske-husholdninger.pdf

floor space per person, they estimate the energy use in residential buildings to increase by 10 TWh by 2030.

The use of biomass for heating in the future renewable energy system depends on biomass costs and technologies compared to electricity prices and costs of electricity based heating technologies.

The consumption of firewood in Norway 1990-2016 shown in Figure 16 illustrates how these factors affect biomass consumption. Since 2010 declining electricity cost, milder winters and increased use of heating pumps have reduced the firewood consumption significantly[18]. As many households use firewood mainly on cold days, use of lower base temperature than 17 could improve the accuracy of the model. Firewood prices are not easily available on a national level but are excepted to vary with consumption. The number of heating pumps has flattened out and electricity costs increased from 2015 to 2016, hence the use of firewood can be expected to be stable in a normal temperature year, but fluctuate according to number of cold days.

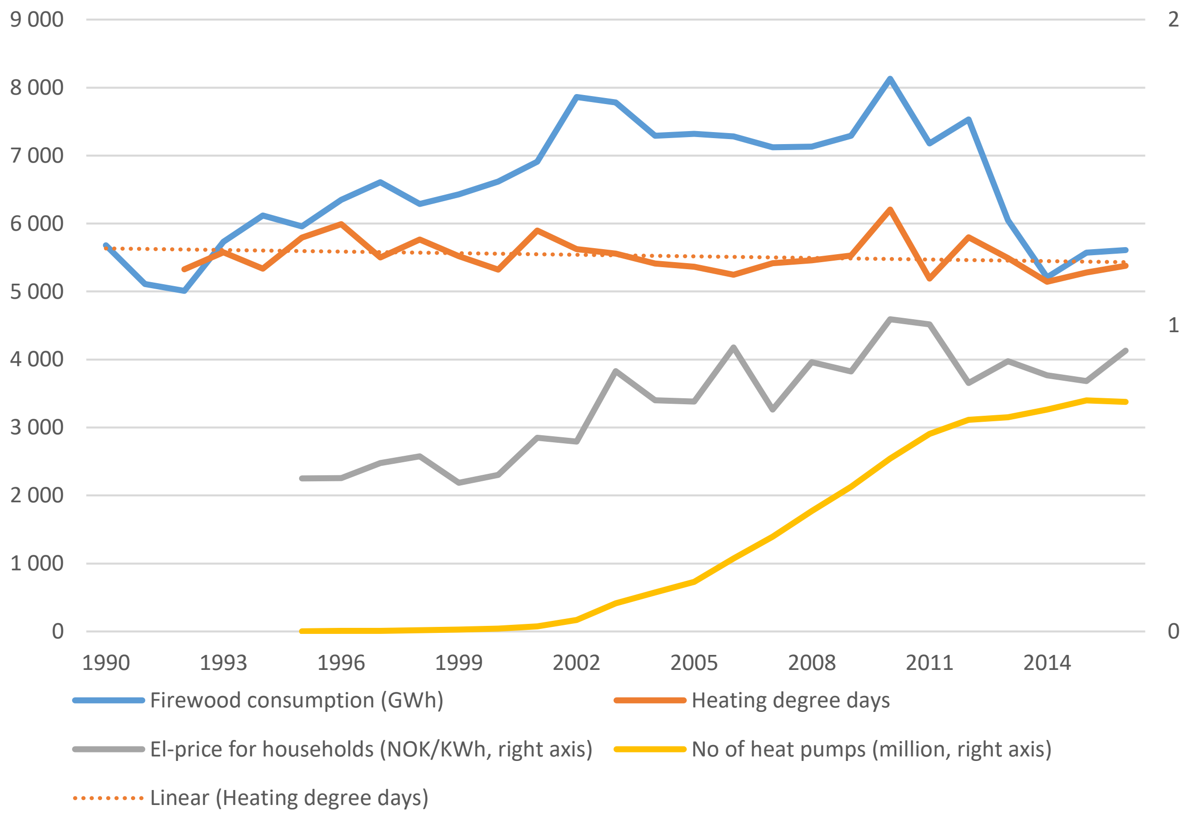

Figure 16. Annual firewood consumption in Norway 1990-2016 and factors that affect firewood consumption. Sources: Statistics Norway, Enova and NOVAP[19]

4.4 Conclusions

Future energy consumption in heating and cooling depends on several factors. Improved building standards and higher outdoor temperatures imply reduced heat demand whereas increased population, fewer people per households and more cooling implies higher energy use for heating

[18] The multiple regression model with these variables has adjusted R^2 of 0.94 and P-values below 1%. A life time of 10 years is used for the aggregated number of heat pumps.
[19] https://www.novap.no/artikler/veksten-fortsetter-for-varmepumper-i-norge

and cooling. The total effects are unclear and depend on policies and regulations, including future energy costs that influence the profitability of energy efficiency investments. The changes are also relatively slow due to slow rehabilitation and replacement rates in the building sector.

The renewable share in heating and cooling is relatively low in many countries and replacement of fossil fuels with biomass represents the major potential for biomass in Europe. In the Nordic countries, replacement of fossil fuels in district heating in Denmark and Finland is important, whereas expansion of district heating is needed in Sweden and Norway as most of the existing district heating is based on renewables.

5 Non-energy forest products

5.1 Coniferous (i.e. softwood) sawnwood

5.1.1 Historical development

Sawnwood and sawmills are the engines of the forest sector – at least in the northern hemisphere. In 2016, sales of sawlogs constituted about 70% of the gross timber income for Norwegian forest owners while accounting for about 50% of the volume harvested[20]. Almost needless to say, the consumption, and thereby also the production, of sawnwood is dependent on the construction activities (new houses) and renovation of old houses. These activities in turn depend on a range of factors, but in general, the global economic condition. We will return to the drivers in more detail below.

We used the R package strucchange (Zeileis et al. 2002) to estimate structural changes in the different main markets analyzed. The routine estimate the time for breaks given different number of breaks during the data period. The number of breaks that minimizes the Bayesian information criterion is used in the further analyses. Simple time trends, i.e. production of sawnwood as a function of time, are then estimated for each of the time segments using ordinary least squares.

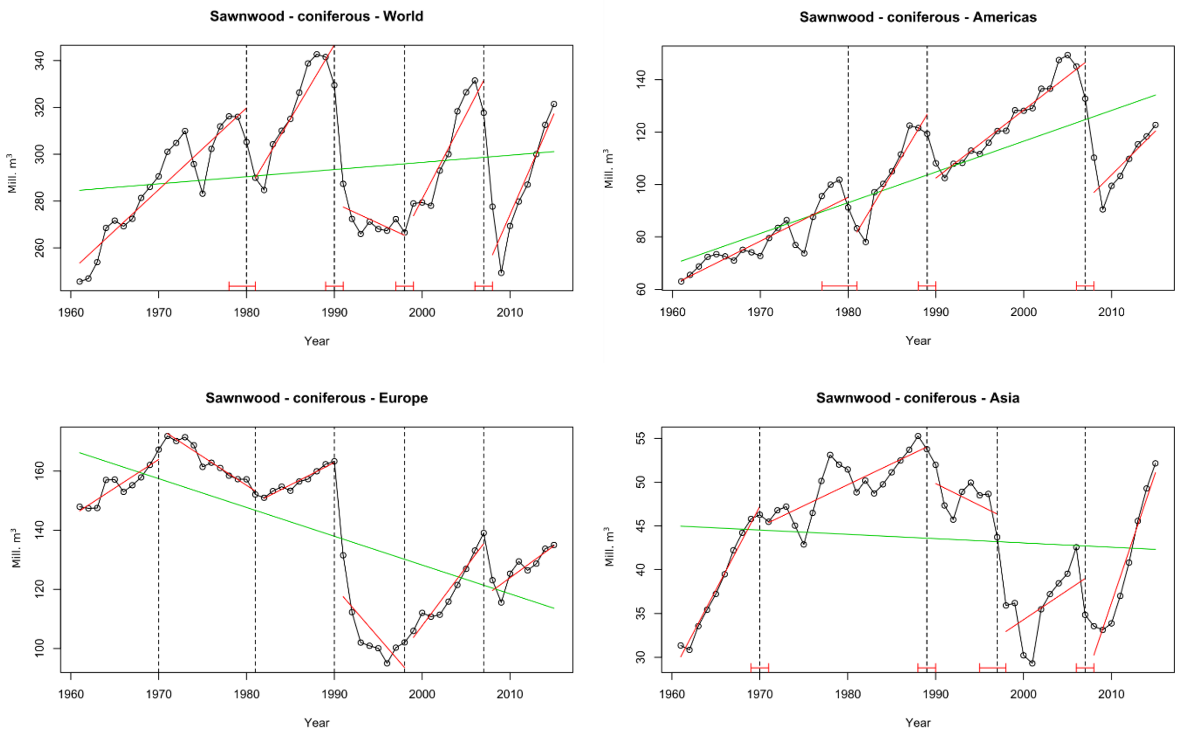

Figure 17. Development of sawnwood production. Vertical dashed lines are estimated structural breaks. Red lines are trends within each structural period, while green lies are trends without regards to structural change. Note different scales on the vertical axis. Datasource: FAO.

Figure 17 shows the sawnwood production in the three major world regions and the world as a whole for the period 1961 – 2015. The vertical dashed lines represents structural breaks with confidence intervals as red bars , the red lines are the trend lines within each “structural period”

[20] https://www.landbruksdirektoratet.no/no/statistikk/skogbruk/tommeravvirkning

and the green lines are trend lines without taking any structural changes into account. Parameter estimates etc. are shown in the appendix. As can be inferred from the figures, the fit – in terms of r^2 – is good in all cases. Only in one case is it below 0.9. Except in a few cases, the parameters are statistically significant at an acceptable level.

The estimated structural changes may be attributed to major events at regional or world scale. If we take Europe[21] as an example: the first structural change may be due to the oil crisis starting in late 1973, which lead to a down-turn in sawnwood production. The second structural break (1981) seems hard to attribute to one single event, but it had a positive influence on production in both Europe and Americas. Around 1990, the dissolution of Eastern Europe clearly had an impact. Especially the development in Soviet Union (USSR) was drastic. Between 1990 and 1991 sawnwood production dropped by about 25%, and the sawnwood production in Russia dropped by about two third from 1992 to 2000 (Moiseyev 2003). The production prior to the dissolution was more than 100 mill m^3, hence, the sudden change was visible at all scales. The trend turned positive around year 2000, until the setback brought about by the financial crisis in 2008. The last 5 – 6 years there has been an increase in production in all markets. This short review indicates that the markets are affected by (more or less) sudden events that are hard to foresee in addition to the more traditional business cycles.

Sawnwood prices show less clear trends and structural breaks than sawnwood production. The figure below shows export prices of European sawnwood in different markets (left) and domestic prices (right). It is also important to note that prices changes much over a short period. For example, the price in Japan fell from about 400 to about 275 US$/$m^3$ (- 31%) over a two year period.

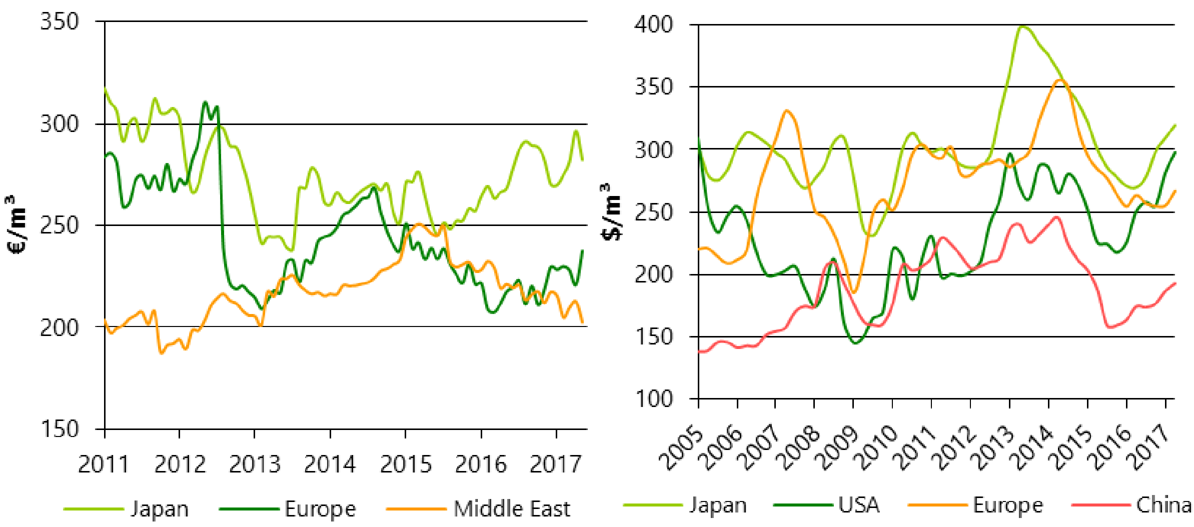

Figure 18. Left: European sawn softwood prices (€/m^3) in Japan, Europe and the Middle East, 2011-2017. Right: Quarterly prices (US$/$m^3$) for sawn softwood in China, Europe, Japan and the US, 2005-2017. Source: Taylor et al. (2017).

The global sawlog prices showed similar variations to the ones in the figure above, although these seem to be affected more by the 2008 financial crisis (Ekström 2017).

[21] The strucchange package did not manage to estimate confidence intervals for Europe.

5.1.2 Drivers

The consumption of sawnwood is clearly linked to the construction of new houses and renovation/remodeling of old ones. This in turn is linked to income, and prices. Research (Hurmekoski et al. 2015a) show a large regional difference in the drivers of sawnwood consumption across Europe. In densely forested and scarcely populated regions, per capita sawnwood consumption is larger than in southern parts of Europe (see figure below). This could be due to cultural differences and institutional factors such as building regulations.

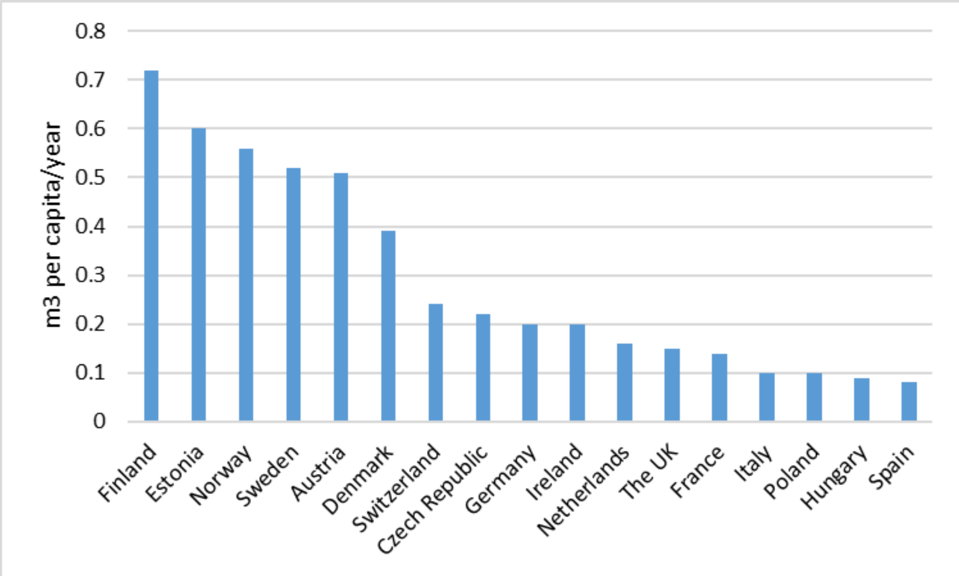

Figure 19. Mean per capita coniferous sawnwood consumption in the period 1981 – 2012. Source: Hurmekoski et al. (2015a) based on FAOSTAT.

Most megatrends analyses list urbanization, climate change and resource scarcity among the major challenges in the future (EEA 2015; Ernst & Young 2016; KPMG 2012; PWC 2015) – see the appendix for a summary of these megatrends. Almost all of the population growth in Norway the last 50 years has been in and around the larger urbanizing centers (in Norwegian terms,(Meld. St. 29 (2016 – 2017)). To what extent further urbanization and population growth will be a driver for sawnwood consumption depend primarily on the building regulations. Building of multi-story wood frame or massive timber (e.g. cross laminated timber, CLT) is not commonplace, although the use is increasing. In some countries, building codes, e.g. fire safety requirements, have to be changed in order to allow wood high-rise buildings.

The potential resource scarcity mentioned by the megatrend studies may give sawnwood a comparative advantage: it is renewable and in large supply. The figure above shows that there is a large potential for increased use of sawnwood in Europe. Certainly, a wide range of factors will influence to what degree this potential will be realized. Hurmekoski et al. (2015a) mention a range of possible drivers, including regulations, cost competitiveness, attitude towards nature and wood use and consumer preferences.

Sawnwood from sustainable managed forests is, in itself, climate friendly as it stores carbon over a long period. Forests provide other ecosystem services and there may be concerns about the effects on such from timber harvest. The attitude toward forestry in general may affect the demand and use of sawnwood in construction activities in addition to the more direct attitudes toward the use of wood in construction and renovation.

Climate concerns may affect sawnwood trade. If stricter emission regulations are introduced, e.g. some sort of a global CO_2tax, transportation cost will increase and thereby reduce foreign demand. In 2016, 46% of the European soft sawnwood production was exported, while the import accounted for 72% of the exported volume. Russia exported more than 72% of the soft sawnwood production in 2016, with China as the receiver of more than 50% of the Russian export (Taylor et al. 2017). Changes in transportation cost may thus change the international trade and production of sawnwood.

5.1.3 Outlook and conclusions

In the short term, none of the drivers mentioned above seems to indicate a reduction in the demand for sawnwood. Based on the same data as in Figure 17 and methodology described above, the short-term trends, i.e. yearly change in soft sawnwood production for the last time segment, were estimated. Table 2 shows these estimates. Specification of the estimated equations and the complete sets of parameter estimates and test statistics can be found in the appendix.

Table 2. Short-term trend estimates for coniferous sawnwood production. Data source: FAO.

	Linear trend, mill m^3/year	Exponential trend, %/year
World	+8.60	+3.0
Americas	+3.35	+3.1
Europe	+2.16	+1.7
Asia	+2.97	+7.2

In the longer term, Figure 19 indicates a rather large technical potential in the sense that there is a large variation between countries. The per capita coniferous sawnwood consumption in Finland is seven times the consumption in Spain. To what extend the potential will be realized, depend on the industry's ability to accommodate the expected growth in demand for factory-made, energy-efficient construction components (Jonsson 2011; Jonsson 2013). This means that the industry must continue to develop new products. The rather rapid growth in the use of cross-laminated timber (CLT) shows that it is possible.

5.2 Newsprint

5.2.1 Historical development

The internet era has, to a great extent, impacted the newsprint market. In 2005, 16% of the world population (i.e. about 1 billion people) had access to the internet, while the estimated percentage of internet user in 2016 was 46%[22]. In the same period, the global production of newsprint fell by more than 35% (Figure 20). The figure also shows reduction in the production in all the three major markets over the last 8 – 13 years.

One should of course be careful when interpreting these types of correlations (i.e. the correlation between internet penetration and reduction in newsprint consumption). One alternative interpretation could be that the economic setback after the financial crisis led to reduced demand and that the demand has not recovered. However, the figures above show that the structural breaks did not occur at the same time. The change started earlier in the Americas than in Europe and Asia.

[22] https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

The major factor for the reduced production and consumption of newsprint is that fewer people read newspapers (i.e. printed papers). There has also been a reduction in the weight of newsprint and many papers have changed to tabloid format. In addition, advertisements have moved from newspapers to digital media. These factors has led to fewer and “smaller” pages and thus reduced the overall demand for newsprint (Hänninen et al. 2014).

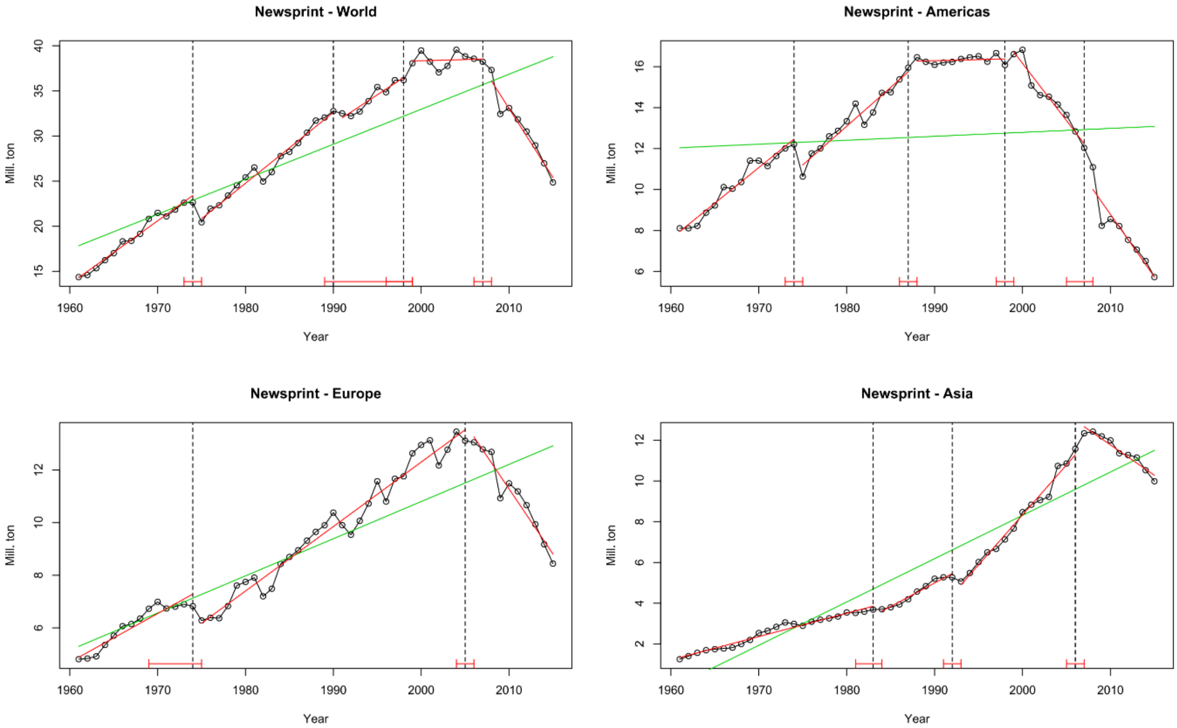

Figure 20. Development of newsprint production. Vertical dashed lines are estimated structural breaks. Note different scales on the vertical axis. For details of estimation methods etc., see section 5.1.1. Source: FAO.

5.2.2 Drivers

Traditionally, there has been an assumption that economic growth (normally expressed in terms of GDP growth) is the major driver for newsprint demand. Although this may have been a reasonable assumption earlier, the ICT-revolution is the most likey cause for a reduction in the influence of GDP growth.. Now it seems more plausible to assume that the wealthier people get, the more is read on digital platforms and less is read in printed newspapers. Hurmekoski and Hetemäki (2013) find that in the US the correlation between newsprint consumption and real GDP was +0.98 in the period 1961 – 1987 and -0.81 in the period 1988 – 2012. Economic growth may still be viewed as a driver, but with the opposite sign of what was assumed earlier (i.e. negative).

5.2.3 Outlook and conclusions

There are no reasons to believe that the demand for newsprint will increase in developed and “mature” economies. For emerging economies and developing countries there might be an increased demand – mainly due to population growth. However, the figure above shows that even in Asia, the demand for newsprint is falling. For developing countries and least developed countries (LDC) it seems plausible to assume that they will skip the stage of printed media and jump directly to digital media (e.g. cellphones and tablets). The cost of consumer electronics is low, and about 20% of individuals in LDCs have already access to mobile broadband (see footnote 22).

With this said, newspapers in printed format will probably not disappear in the near future. The location of the newsprint production is however not necessarily given. From the figure above, the reduction in production is lower in Asia than the other markets. It is thus reasonable to believe that a larger share of the global production will happen in Asia, where the cost level also is lower[23]. This would imply reduced production in Europe and Americas (esp. USA and Canada).

Based on the data from FAO, we have estimated the short-run trends for newsprint production. The results are shown in Table 3. See previous sections and the appendix for details on results and estimation procedures.

Table 3. Short to medium-term trend estimates for newsprint. Data source: FAO.

	Linear trend, mill ton/year	Exponential trend, %/year
World	-1.53	-4.8
Americas	-0.61	-7.7
Europe	-0.49	-4.3
Asia	-0.30	-3.0

If taken literally, the linear trend estimates at global level means that newsprint production will vanish in 16 years. Using the more probable exponential trend estimates, the production estimates for 2030 and 2050 are 13 and 5 mill ton, respectively. This represents a reduction of about 50% and 80% compared to the production level in 2015 at about 25 mill ton.

5.3 Printing and writing papers

5.3.1 Historical development

To some extent, printing and writing papers show the same trends as newsprint (Figure 21). For estimation details etc., see section 5.1.1.

The reduction in production since the middle of the previous decade is for most regions lower here than for newsprint. In Asia, the production is still increasing, but it seems to be at a lower rate compared to earlier. In the Americas and Europe, the downward trend started around the time of the financial crises – without any obvious direct links. Reduced economic activities in general may reduce the need for advertising material and thereby reduce the demand for this category of paper products. As the economies have recovered, any increase in ads may have shifted to digital platforms. The sale of books in Norway was rather stable throughout the 90'ies, it increased towards the year 2007, but has since been showing a downward trend. The sales in 2014 (in terms of number of books sold) were 83% of the number of books sold in the 2007.[24]

[23] One argument against this is the lack of softwood in Asia and in general lower forest resource availability. Import from the boreal forests is possible.
[24] http://medienorge.uib.no/statistikk/medium/boker/141

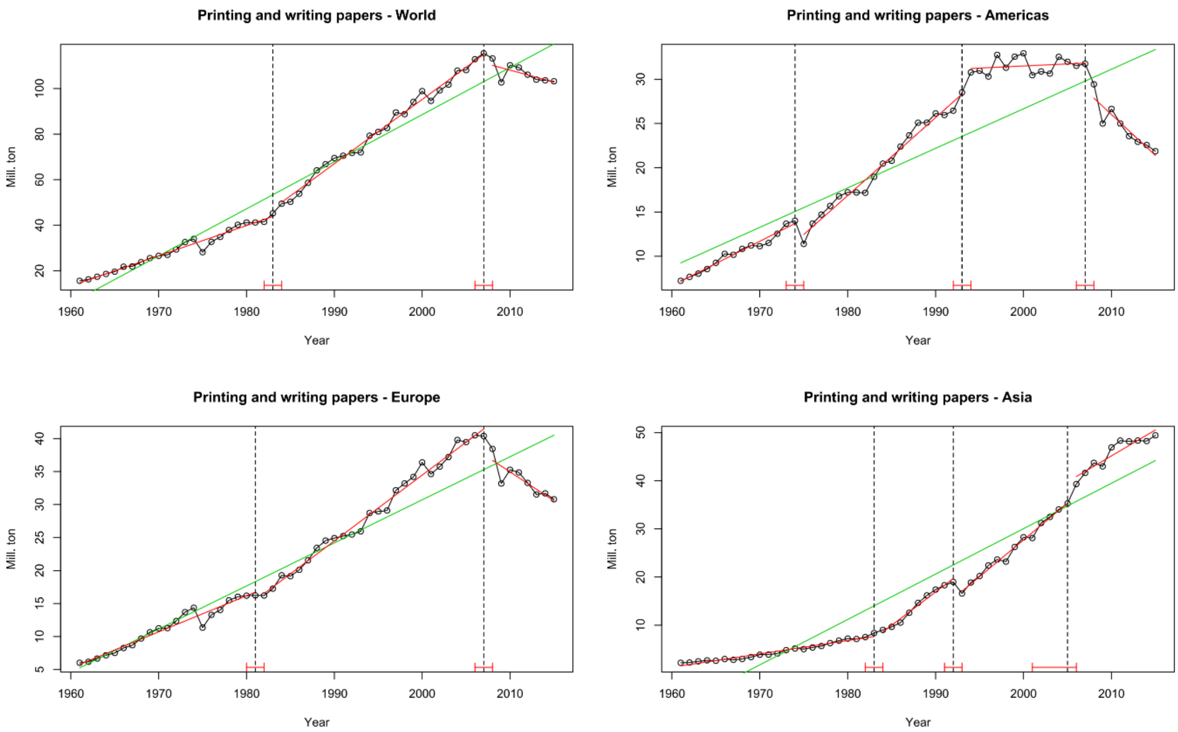

Figure 21. Development of printing and writing papers production. Vertical dashed lines are estimated structural breaks. Note different scales on the vertical axis. Source: FAO.

The short-term trend estimates in Table 4 show a global decreasing trend of about 1% p.a. or about one million tons per year. The decrease seems to be of the same magnitude in Europe and the Americas – both in absolute and relative terms. The production in Asia seem to be flattening out, but in absolute terms, the increase is still about 1 million tons per year.

Table 4. Short to medium-term trend estimates for printing and writing papers.

	Linear trend, mill ton/year	Exponential trend, %/year
World	-1.04	-1.0
Americas	-0.92	-3.7
Europe	-0.88	-3.1
Asia	+1.04	+1.8

5.3.2 Drivers

Digital media have an impact on all printed forms of communication (Hänninen et al. 2014). The development of digital media will therefore be the main driver for the development of the consumption of printing and writing papers. The development and influence might be different for the different segments, e.g. magazines (mainly coated mechanical and wood-free papers), business and office forms (uncoated wood-free paper), and home delivered advertisements (mainly uncoated mechanical paper). The underlying main driver for the trends is the economic development. Although there will always be some need for printing and writing papers, the rapid increase in digital media will limit the growth potential. The cost of digital media, e.g. cellphones and tabs, may be an important driver in emerging economies.

5.3.3 Outlook and conclusions

The trend analysis above shows that the global production of printing and writing paper has been declining since the financial crisis. While the production still is growing in Asia, although at a slower pace than earlier, it is declining in both the Americas and Europe. There are no reasons to believe that the trend in Europe and the Americas will turn. Further, there are no reasons to believe that the consumption in LSD will affect the production significantly in the coming decades. Economic development and increase in welfare in these countries will probably not lead to a significant increase in paper consumption. This is due to the low cost of digital media. In conclusion, we think the world production and consumption of printing and writing papers will continue to fall about 1% per year.

5.4 Other paper and paperboard

5.4.1 Historical development

This group of paper products comprises hygienic goods (e.g. tissue paper and disposable diapers) and packaging materials (e.g. paperboards). In 2010 the global production of the latter was about seven times the production of the former (Hänninen et al. 2014).

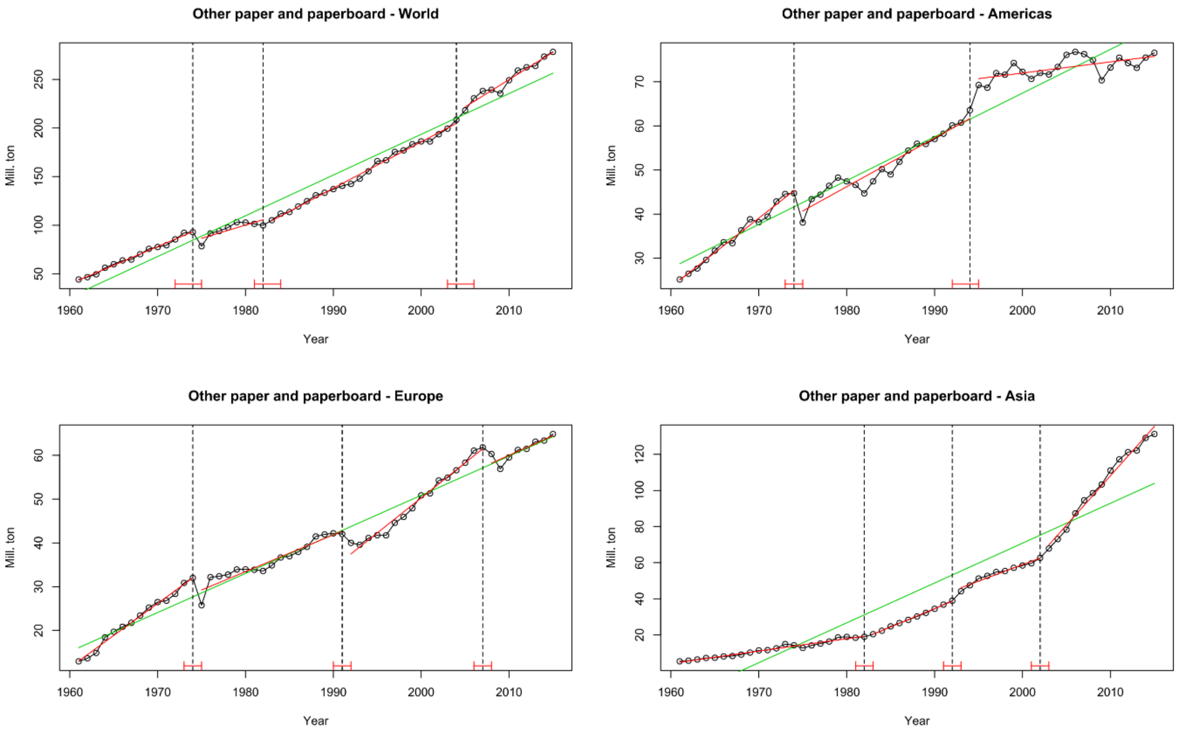

Figure 22. Development of other paper and paperboards production. Vertical dashed lines are estimated structural breaks. Note different scales on the vertical axis. Source: FAO.

From the figure above we see that the global production has been close to linearly increasing in the whole period covered by the data we have used. While the production in the Americas levelled out in the middle of the 90'ies, there has been a steady increase in the production in especially Asia, but also Europe. Largely, the development is linked to international trade. As an example, in 2016, the total value of all exports from China was 12 times the value in 1998[25]. According to

[25] https://data.oecd.org/china-people-s-republic-of.htm

Hänninen et al. (2014) the rapid increase in production in Asia in the late 90'ies lead to a clear decline in prices.

At current, the estimated yearly changes in production in Asia is about five times the combined increase in the two other regions evaluated here (Table 5).

Table 5. Short to medium-term trend estimates for other paper and paperboard.

	Linear trend, mill ton/year	Exponential trend, %/year
World	+5.63	+3.0
Americas	+0.25	+0.3
Europe	+0.90	+1.5
Asia	+5.47	+4.5

5.4.2 Drivers

The most important drivers for packaging materials are economic development, population growth, lifestyle trends, environmental concerns and technological development regarding packaging (World Packaging Organisation & PIRA International Ltda 2008). Global trade in general, and internet trade in particular, will also be a major driver. To some extent, this may be seen as an indirect driver since trade will be affected by economic development and population growth. Global trade may conflict with environmental concerns to some extent. Price seems to be the most important feature in package product choice (Mishra et al. 2017), and environmental features seems to play an increasing role (Martinho et al. 2015; Rokka & Uusitalo 2008).

Regarding tissue and hygienic products, the main drivers are economic development and the age structure of the population. A growing population of elders will increase the demand for hygienic products.

Due to rather high transportation costs, package material and hygienic products are most profitable to produce near the consumers (Hänninen et al. 2014; Näyhä et al. 2014). This will affect the location of new production capacity.

5.4.3 Outlook and conclusions

Currently North America is the largest market for tissue and hygiene products. Asia Pacific is expected to surpass North America the coming decade. This "can be attributed to rising urbanization coupled with a growing geriatric population demanding more personal hygiene products."[26]

Looking at paperboard (and other packaging materials), we see that the consumption per capita (Figure 23) is much lower in emerging economies (e.g. Asia and Latin America) than Europe and North America.

[26] https://www.persistencemarketresearch.com/market-research/tissue-and-hygiene-market.asp

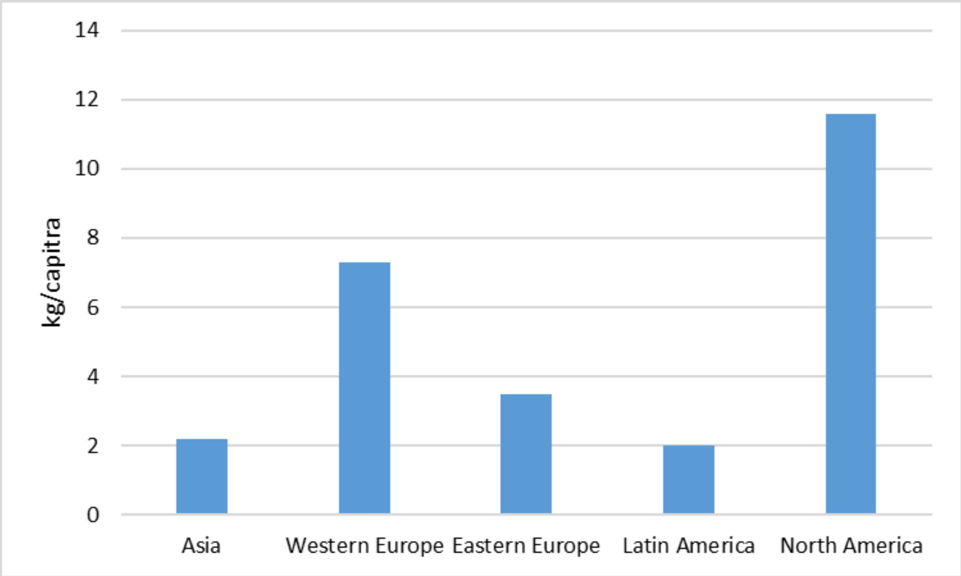

Figure 23. Per capita paperboard consumption in 2010. Source: Hänninen et al. (2014).

A further increase can be expected globally in other paper and paperboard production for the coming decade. The simple trend analysis above indicates a low growth rate in the Americas as a whole, but higher growth in emerging economies in South America. Asia will likely experience the highest growth, currently at 4.5% p.a.

5.5 Other - emerging - forest products

5.5.1 Engineered wood products - CLT

The European forest sector has set ambitious aims for 2030: wood-based construction in Europe should tripled its market share, compared to the 2010 level, and a double the value added of the woodworking industry (Hurmekoski et al. 2018; The European Technology Platform for the Forest-based Sector 2013). There are of course many possible ways to fulfill this ambition, cross-laminated timber (CLT) being one of them. The European CLT production in 2016 was 680.000 m^3, while production in 2020 is estimated to be 1.250.000 m^3 (Gaston & Pahkasalo 2017). The major producing countries are Germany, Austria and Switzerland (about 80% of the global production in 2015), but production capacity is being built up also elsewhere[27]. Figure 24 shows the development in CLT production.

[27] https://www.timber-online.net/holzbau/2015/02/cross-laminated_timbergoesglobal.html

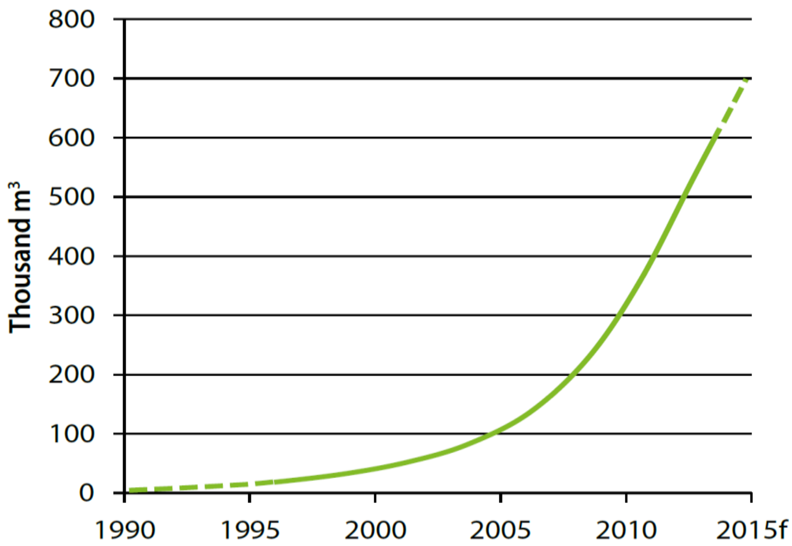

Figure 24. Global production of cross-laminated timber (CLT), 1990-2015. Source: Pahkasalo et al. (2015).

A wide range of factors may affect the diffusion of CLT, as shown in Figure 25. There might be some trade-offs between the different factors. For example, the willingness to pay may be higher for CLT compared to other materials, if CLT has a better environmental performance.

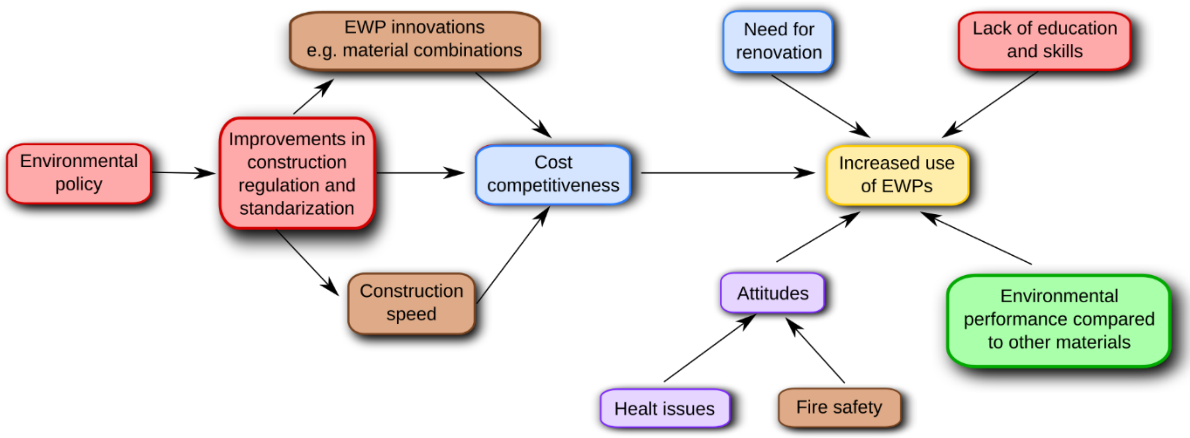

Figure 25. Relationship between major drivers and possible impacts on engineered wood products (EWP) development. Adapted from Manninen (2014).

CLT has somewhat other attributes than other buildings materials, e.g. concrete and steel. Many places the building regulations are not adapted to CLT – without affecting comfort and safety. The regulatory framework and the change of this is therefore of importance. Further, the structure in the construction industry – in terms of the whole value change – need to change. When analyzing wood-framed multi-story constructions (WMC), Hurmekoski et al. (2015b) find that the risk averse nature of the industry seems to be a larger obstacle for increased use of WMC than competition from alternative building methods.

The production levels of CLT and other EWPs are currently low compared to the global sawnwood production – less than 1% (see Figure 17). The use will increase, but it seems unlikely that they will play a significant role globally, in the short to medium term.

5.5.2 Biobased products

Cellulose-based fibers (e.g. viscose, rayon, modal, Tencell, Lyocel) constitute a little under 7% of the global fiber consumption in 2016 – as shown in Figure 26. More than 80% of the production is in Asia (Clark et al. 2014). Dissolving pulp is the raw material for the production of these fibers. Two third of the dissolving pulp produced globally is used in viscose production according to Pöyry (2014).

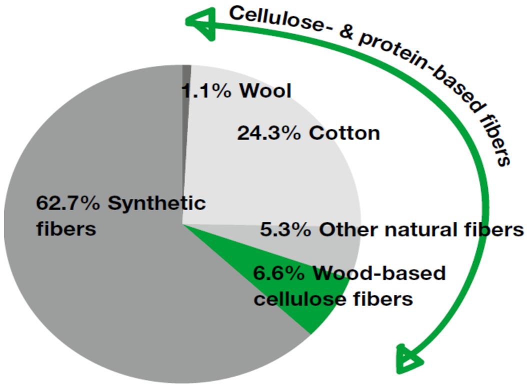

Figure 26. Global fiber consumption in 2016 by type of fiber (basis = 99 million tons). Source: Lenzing Group (2016).

The global fiber market is expected to grow further (Figure 27). Hämmerle (2011) projected the global production of cellulose-based fibers in 2015 to be at 6.2 mill tons, which is close to the observed level. Estimated consumption in 2030 is about threefold this level or almost 13 mill ton fibers.

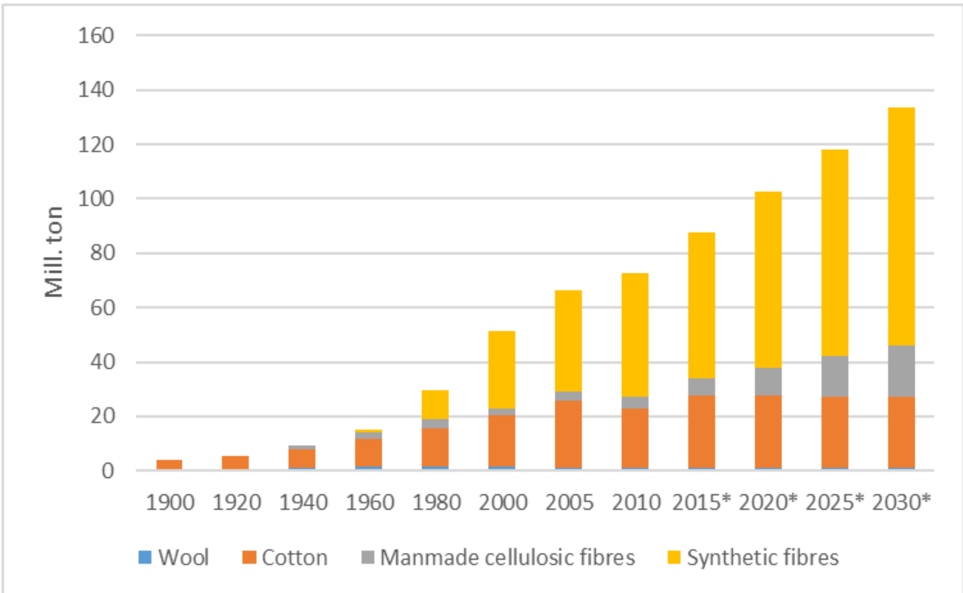

*Figure 27. Historical and future development of fiber and filament consumption. * = estimates. Source: Hämmerle (2011).*

Raw material may come from different sources including trees and bamboo. So far, most of the expansion has happened in Asia. It is likely that the expansion will continue in Asia, but the raw material – dissolving pulp – may well be produced elsewhere. Thus, there is scope for increased production in Europe and the Americas.

5.5.3 New products – outlook and conclusions

According to Hetemäki and Hurmekoski (2016) the global forest sector is in the phase of Schumpeterian creative destruction. Such a phase "revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one" (Schumpeter 1954). Although this is phrased somewhat pompously, a rather major change in the sector appears likely. Societal demands for mitigation and adaptation to climate change will have implications for the forest sector. EU energy and environmental policies have the potential to advance a paradigm change towards a forest-based bioeconomy (Pätäri et al. 2016).

We already see investments in new plants in Sweden and Finland. The pulp and paper industry will produce more diversified products, focus on higher added-value products, and aim at consumer segments with higher environmental awareness (Toppinen et al. 2017). In Norway there seem to be less willingness to invest, due to current market conditions and specialization (Damvad Norge 2012).The conservative organizational culture and lack of financing, may be a barrier for the development of new products (Näyhä & Pesonen 2014).

6 Appendix: Trend analyses - estimates

In the trend analyses presented above we have used two specifications for the functional form: linear and exponential. The figures above show the linear trends, while the tables present short-term trends also for the exponential specification. All estimations are done in R using the strucchange package (Zeileis et al. 2002) using OLS. Data for all estimations are from FAOstat. The linear specification is as follows:

$$y = \alpha_1 + \sum_{i=2}^{n} d_i \alpha_i + \beta_1 t + \sum_{i=2}^{n} d_i \beta_i t$$

Where y is the dependent variable (e.g. coniferous sawn wood production in million tons per year), n is the number of breakpoints estimated, t is time (four digit year), d_2 – d_n are dummy variables indicating time segment, α_1 – α_n and β_1 – β_n are parameters to be estimated. For the last period, the marginal change in yearly production, i.e. trend, equals $\beta_1 + \beta_n$.

The number of structural changes, n, and the corresponding break points (i.e. year for the estimated structural change) vary to some extent between regions and product group. Please refer to the figures in section 5 for these.

The exponential model is similar to the linear model with the difference that we have taken the natural logarithm of the dependent variable, i.e. regresses the right hand side variables of the above equation on log(y). With this specification, $(\beta_1 + \beta_n)*100$ is the percentage pro annum change in production in the last period.

Table 6. Linear trends - coniferous sawn wood: parameter estimates with corresponding significance levels and share of explained variance (r^2).

	World		Americas		Europe		Asia	
	Estimate	Sign	Estimate	Sign	Estimate	Sign	Estimate	Sign
α_1	-6588.72	***	-3215.43	***	-3641.20	***	-3713.45	***
α_2	-5645.43	**	-7839.97	***	7646.34	***	2813.29	***
α_3	10303.89	***	-1848.07	**	788.75	-	4754.62	***
α_4	-7581.33	**	-3413.06	.	10586.39	***	2404.74	**
α_5	-10412.58	***	-	-	-4183.60	**	-2227.86	*
α_6	-	-	-	-	-570.77	-	-	-
β_1	3.49	***	1.67	***	1.93	***	1.91	***
β_2	2.83	*	3.95	***	-3.88	***	-1.43	***
β_3	-5.22	***	0.92	**	-0.42	-	-2.41	***
β_4	3.74	**	1.68	.	-5.36	***	-1.24	**
β_5	5.11	***	-	-	2.03	**	1.06	*
β_6	-	-	-	-	0.23	-	-	-
r^2	0.89		0.95		0.98		0.91	

Sign codes **** < 0.1%, ** < 1%, * < 5%, . < 10%, - > 10%

Table 7. Exponential trends - coniferous sawn wood: parameter estimates with corresponding significance levels and share of explained variance (r^2).

	World		Americas		Europe		Asia	
	Estimate	Sign	Estimate	Sign	Estimate	Sign	Estimate	Sign
α_1	-18.65	***	-22.68	***	-6.15	-	-86.21	***
α_2	24.40	*	-69.53	***	25.32	***	85.46	***
α_3	-1.73	-	-0.49	-	85.44	***	124.68	***
α_4	50.50	***	-21.16	-	-40.78	***	66.33	**
α_5	-9.82	-	-	-	-9.48	-	-41.40	.
α_6	-21.85	*	-	-	-	-	-	-
β_1	0.02	***	0.02	***	0.01	***	0.05	***
β_2	-0.01	*	0.04	***	-0.01	***	-0.04	***
β_3	0.00	-	0.00	-	-0.04	***	-0.06	***
β_4	-0.03	***	0.01	-	0.02	***	-0.03	**
β_5	0.00	-	-	-	0.00	-	0.02	-
β_6	0.01	*	-	-	-	-	-	-
r^2	0.91		0.95		0.97		0.91	

Sign codes **** < 0.1%, ** < 1%, * < 5%, . < 10%, - > 10%

Table 8. Linear trends - newsprint: parameter estimates with corresponding significance levels and share of explained variance (r^2).

	World		Americas		Europe		Asia	
	Estimate	Sign	Estimate	Sign	Estimate	Sign	Estimate	Sign
α_1	-1361.00	***	-673.52	***	-358.03	***	-223.30	***
α_2	-169.60	-	-63.41	-	-120.00	*	-231.30	***
α_3	119.80	-	669.49	***	1363.87	***	-750.00	***
α_4	1346.00	***	1808.93	***	-	-	834.20	***
α_5	4467.00	***	1911.41	***	-	-	-	-
β_1	0.70	***	0.35	***	0.19	***	0.11	***
β_2	0.08	-	0.03	-	0.06	*	0.12	***
β_3	-0.06	-	-0.34	***	-0.68	***	0.38	***
β_4	-0.67	***	-0.91	***	-	-	-0.41	***
β_5	-2.23	***	-0.96	***	-	-	-	-
r^2	0.99		0.99		0.98		1.00	

Sign codes **** < 0.1%, ** < 1%, * < 5%, . < 10%, - > 10%

Table 9. Exponential trends - newsprint: parameter estimates with corresponding significance levels and share of explained variance (r^2).

	World		Americas		Europe		Asia	
	Estimate	Sign	Estimate	Sign	Estimate	Sign	Estimate	Sign
α_1	-72.08	***	-52.33	***	-74.10	***	-105.80	***
α_2	16.92	**	11.91	.	117.33	***	67.85	***
α_3	47.97	***	65.20	***	40.70	***	8.65	-
α_4	171.66	***	149.40	***	176.10	***	1.17	-
α_5	-	-	223.08	***	-	-	181.60	***
β_1	0.04	***	0.03	***	0.05	***	0.06	***
β_2	-0.01	**	-0.01	.	-0.06	***	-0.03	***
β_3	-0.02	***	-0.03	***	-0.02	***	0.00	-
β_4	-0.09	***	-0.08	***	-0.09	***	0.00	-
β_5	-	-	-0.11	***	-	-	-0.09	***
r^2	0.99		0.99		0.98		1.00	

Sign codes **** < 0.1%, ** < 1%, * < 5%, . < 10%, - > 10%

Table 10. Linear trends – printing and writing paper: parameter estimates with corresponding significance levels and share of explained variance (r^2).

	World		Americas		Europe		Asia	
	Estimate	Sign	Estimate	Sign	Estimate	Sign	Estimate	Sign
α_1	-2587.00	***	-978.08	***	-1068.00	***	-541.10	***
α_2	-2962.00	***	-749.46	***	-891.90	***	-2195.00	***
α_3	4795.00	***	915.56	***	2864.00	***	-2478.00	***
α_4	-	-	2861.75	***	-	-	-1572.00	***
β_1	1.33	***	0.50	***	0.55	***	0.28	***
β_2	1.50	***	0.38	***	0.45	***	1.11	***
β_3	-2.37	***	-0.46	***	-1.42	***	1.25	***
B_4	-	-	-1.43	***	-	-	0.80	***
r^2	1.00		0.99		0.99		1.00	

Sign codes **** < 0.1%, ** < 1%, * < 5%, . < 10%, - > 10%

Table 11. Exponential trends – printing and writing paper: parameter estimates with corresponding significance levels and share of explained variance (r^2).

	World		Americas		Europe		Asia	
	Estimate	Sign	Estimate	Sign	Estimate	Sign	Estimate	Sign
α_1	-100.60	***	-80.42	***	-121.00	***	-110.30	***
α_2	15.87	*	8.12	-	50.83	***	-69.24	***
α_3	56.40	***	95.70	***	72.96	***	6.59	-
α_4	138.50	***	171.64	***	201.10	***	91.52	***
β_1	0.06	***	0.05	***	0.07	***	0.06	***
β_2	-0.01	*	0.00	-	-0.03	***	0.03	***
β_3	-0.03	***	-0.05	***	-0.04	***	0.00	-
β_4	-0.07	***	-0.09	***	-0.10	***	-0.05	***
r^2	1.00		0.99		1.00		1.00	

Sign codes **** < 0.1%, ** < 1%, * < 5%, . < 10%, - > 10%

Table 12. Linear trends – other paper and paperboard: parameter estimates with corresponding significance levels and share of explained variance (r^2).

	World		Americas		Europe		Asia	
	Estimate	Sign	Estimate	Sign	Estimate	Sign	Estimate	Sign
α_1	-7498.37	***	-3033.01	***	-2855.00	***	-1340.00	***
α_2	2175.58	*	895.38	***	1224.00	***	-2672.00	***
α_3	-1849.42	***	2599.07	***	-295.80	-	-2256.00	***
α_4	-3573.43	***	-	-	1115.00	**	-9545.00	***
β_1	3.85	***	1.56	***	1.46	***	0.69	***
β_2	-1.11	*	-0.46	***	-0.62	***	1.35	***
β_3	0.92	***	-1.31	***	0.14	-	1.14	***
β_4	1.79	***	-	-	-0.57	**	4.78	***
r^2	1.00		0.99		0.99		1.00	

Sign codes **** < 0.1%, ** < 1%, * < 5%, . < 10%, - > 10%

Table 13. Exponential trends - other paper and paperboard: parameter estimates with corresponding significance levels and share of explained variance (r^2).

	World		Americas		Europe		Asia	
	Estimate	Sign	Estimate	Sign	Estimate	Sign	Estimate	Sign
α_1	-96.04	***	-71.67	***	-160.00	***	-138.30	***
α_2	54.39	***	46.50	***	133.10	***	29.63	***
α_3	-	-	82.81	***	112.90	***	74.31	***
α_4	-	-	-	-	148.50	***	66.10	***
β_1	0.06	***	0.05	***	0.09	***	0.08	***
β_2	-0.03	***	-0.02	***	-0.07	***	-0.02	***
β_3	-	-	-0.04	***	-0.06	***	-0.04	***
β_4	-	-	-	-	-0.08	***	-0.03	***
r^2	1.00		0.99		0.99		1.00	

Sign codes **** < 0.1%, ** < 1%, * < 5%, . < 10%, - > 10%

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