RESEARCH REPORT

VTT-R-01205-19

Energy efficiency of Finnish pulp and paper sector - indicators and estimates

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Summary

The study assesses the energy efficiency of the Finnish pulp and paper sector, especially compared to other countries, and hereto related estimates presented by the IEA, JRC and ODYSSEE. The estimates have different weaknesses, as the study shows. It also shows that Finnish pulp and paper production's efficiency is well among its peers. Finnish facilities and processes are generally on par or better in comparison with the EU average, according to the simulation results by Fisher International Ltd. In total energy use, Finland is close to the EU average in each major grade.
Traditionally energy intensity, as energy use per gross domestic product or value added in a given sector, has been used as a simple indicator of energy efficiency. It is used by the IEA and JRC, but it is recognized, even by the IEA, as a mistake to use energy intensity as a proxy for energy efficiency. This is true especially for bulk producing energy intensive industry sectors. Finland's energy use per value added for the pulp, paper and printing branch is high compared to other countries because of the large share of low value, high energy pulp (and paper) production compared to the relative small share of high value, low energy printing.
The statistics based on ODYSSEE data corroborate the results from Fisher and show that the Finnish pulp and paper industry is competitive energy-wise. Finnish unit consumption of pulp and paper is 9% lower than the EU country average. Finland is one of the main producers of kraft pulp, which is very energy intensive. As it dominates the production mix and is even exported, Finnish energy use will be decidedly higher than for a country relying on recycled pulp and imported market pulp. The export of kraft market pulp has almost three folded in Finland in ten years and is, together with Sweden, dominating the European market. The share of kraft pulp production as well as its exports should always be taken into account in any energy efficiency assessments given their significance, although they generally are not. Factors such as product mix, product quality and climate should also be considered, which would improve Finnish energy efficiency competitiveness.
The disaggregate level of data is a major issue. To get understandable and well working indicators, we would need a deeper disaggregate level than what is available today, although confidentiality issues are recognized with this target. So, should results of any studies be taken at face value? No, rather not with the statistical data available now.

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Preface

VTT Technical Research Centre of Finland Ltd made a study (Koreneff 2018) of recently published energy efficiency country comparisons, both decomposition analyses by the IEA, JRC and ODYSSEE as well as ODYSSEE and MURE Scoreboards in the fall of 2018 for Motiva Oy. The results showed that what data is used and how has a strong impact on the results. The results for the industry were in many comparisons not very beneficiary to Finnish industry, but the study also showed major flaws or debatable points in the methodologies and data used. As the industry has such a major role in energy use in Finland, and as pulp and paper production dominates the industrial energy use, it was decided that it should be given a closer look.

The target was to find out how the energy efficiency of the pulp and paper sector in Finland compares to other countries. The steering group consisted of Ulla Suomi and Lea Gynther from Motiva Oy, Heikki Väisänen and Johanna Kirkinen from the Energy Authority of Finland, who financed the project via Motiva Oy, Tuomas Tikka and Maarit Lindström from the Finnish Forest Industry, who financed the sub-study made by Jarno Suojanen and Pirita Huotari from Fisher International Ltd, Timo Ritonummi from the Ministry of Economic Affairs and Employment of Finland, Pirita Mikkanen from Metsä Group, Pasi Svinhufvud from UPM Oyj and Ossi Ikonen from Stora Enso Oyj.

The author wants to thank all parties for their input, viewpoints and knowledge. The effort to get data from the industry directly turned out to be overwhelming, which is a good indicator of the difficulty to assess energy efficiency development from a top-down perspective. To have comparable data we need to have it from similar processes, and to be able to publish anonymised results we need data from at least three separate entities.

Espoo 31.12.2019

Göran Koreneff

Cover photo, courtesy by Pirita Mikkanen/Metsä Group: Äänekoski Bioproduct mill, in operation since 2017.

Contents

Acronyms and abbreviations

ADMT	air dry metric ton
BDMT	bone dry metric ton
BDT	bone dry ton
CEPI	The Confederation of European Paper Industries
CHP	combined heat and power
EU	The European Union
FEC	Final energy consumption
FMT	finished metric ton
GDP	gross domestic product
GJ	Giga Joule, 10^9 Joule
IEA	International Energy Agency
JRC	Joint Research Centre
MJ	Mega Joule
MTPD	Million TPD
MWh	Mega Watthour, 10^6 Watthour, 3.6 GJ
m2	square meter, m^2
NACE	Nomenclature des Activités Économiques dans la Communauté Européenne
T	ton
TAD	Through Air Drying
TPD	tons per day
Y	year

1. Introduction

1.1 Background

A recent study (Koreneff 2018) of decomposition based energy efficiency estimations by the International Energy Agency, IEA (2017), EU's Joint Research Centre, JRC (Economidou 2017) and ODYSSEE (2018a) as well as of ODYSSEE Scoreboards (ODYSSEE 2018b) showed generally the challenges with using too aggregate data and unsuitable methods for country comparisons. Decomposition is a methodology where energy use is split into separate components, usually at least activity, structure and energy efficiency. ODYSSEE Scoreboard is a country ranking scoreboard, where countries, i.e. EU-28 and Norway and Switzerland, get points as to how well they are doing on the energy efficiency front and are then compared with each other (ODYSSEE 2018b,c).

As the analysis by Koreneff (2018) showed, there is no single truth, and even when using the same data, the decomposition results might differ substantially. For Finland, the energy efficiency decomposition results for the industry are not that good. For example, in the JRC results, Finnish industry sector shows the worst trend in the EU with a negative energy efficiency development. Finland also fares rather poorly in the ODYSSEE Scoreboard for industry, with a rank of 24 for energy efficiency level, 29 for energy efficiency trend and an overall combined rank of 28. The weaknesses of the decomposition results and the Scoreboard were brought forward in the report. However, the results raised a need to check if Finland is as energy inefficient as presented. As pulp and paper production represents around half of the total industrial consumption, it was decided to look into this sector more closely.

1.2 Study goals

As (Koreneff 2018) showed, data availability and reliability form the basis of all energy efficiency analysis. Statistical data is only available on a quite aggregate level, whereas a more thorough analysis would demand more disaggregate data. The first goal of the study was to have forest industry utilities deliver more detailed product-level data time series, which then the Finnish Forest Industry would aggregate in order to secure confidentiality. The plan was to carry out a decomposition analysis based on this data. The aggregation of product data from Finnish utilities (for some products) turned out to be harder than expected as confidentiality had to be secured in all cases. No time series were thus generated, and the mission was aborted.

The second goal was to analyse the availability of pulp and paper statistical data and to estimate energy efficiency based on it. Energy use data at IEA, Eurostat and ODYSSEE were only on a very aggregate level, with subsector paper and pulp combined with subsector printing. As (Koreneff 2018) already showed, the aggregation of industrial subsectors and, further, combining industry and service sectors, as the IEA and JRC did in their decomposition analyses, results in unsuitable estimates for energy efficiency. The approaches by ODYSSEE in their decomposition analysis and in their Scoreboards were not that solid either. The methodological approaches, energy per value added by the IEA and JRC and energy per tons of paper by ODYSSEE, were studied in respect to the pulp and paper subsector, and compared to the most methodological sound approach, taking into account the available data.

The third goal was to have a product level country comparison, based on more detailed product group data from the Confederation of European Paper Industries (CEPI). However, CEPI was not able to give access to data at the desired level. Instead, Finnish Forest Industry got the opportunity to make use of Fisher International Ltd.'s (henceforth Fisher) expertise and global database for pulp and paper production sites. As a subcontract to this project, Fisher compared Finnish utilities' production processes to similar European utilities' processes for different product groups. Also here confidentiality was of importance, comparisons were done only to countries with several producers and to EU as a whole.

1.3 Report structure

In Chapter 2, we estimate the Finnish pulp and paper sector's energy efficiency based on statistical data.

In Chapter 3, we present the results from the Fisher sub-study comparing unit consumptions of major grades in different EU countries, with a special focus on the competitiveness of Finnish pulp and paper industry. Chapter 3 is written together with Jarno Suojanen and Pirita Huotari from Fisher.

In Chapter 4, we put together the highlights of factors that will affect the noted energy efficiency indicators of the pulp and paper sector in top-down analyses. These learnings will thus give us the necessary basis for an assessment of energy efficiency indicators and their validity.

In Chapter 5, we look at statistical data and data issues.

At the end, we present a summary and reiterate our conclusions.

2. Energy efficiency development

In this Chapter, we look at how the energy efficiency of Finnish pulp and paper has developed on the level of national statistics and at how it compares to other countries. Looking at the results using the best publicly available national statistical data provided by ODYSSEE (2019), Finnish energy efficiency is very compatible with that of other similar countries, especially when taking into account Finnish extensive market pulp production and cold climate. We will show that the approaches and methodologies taken by ODYSSEE in general (ODYSSEE 2018d, relevant up to end of 2019) and by decomposition analyses by the IEA and JRC give a distorted picture of energy efficiency.

2.1 Unit consumption of pulp and paper

The best national energy final energy consumption statistics are on the level of pulp and paper subsector (NACE 2008[1]/subsector 17), whereas international energy balances (IEA 2019, Eurostat 2019) and ODYSSEE (2019) only present pulp, paper and printing altogether (NACE 17+18). To be able to compare countries, we use the ODYSSEE (2019) database for data. ODYSSEE also provides paper and pulp production tons, allowing us to calculate unit consumptions.

Finnish unit energy consumption of pulp and paper is compared to other major pulp producing countries, that is, countries where the share of pulp is around 40% or above of all pulp and paper tons produced, in Figure 1. Unit consumption is calculated here as energy use per production of paper and pulp tons.

Finland, Sweden and Portugal have quite similar energy efficiencies. Finnish high value in 2000 stems from missing pulp production data.

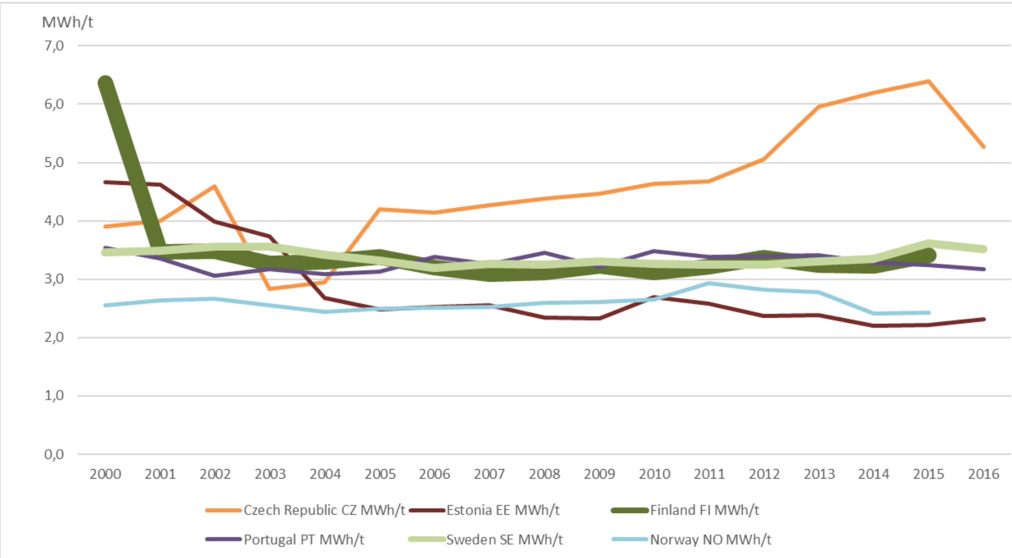

Figure 1. Unit consumption of pulp&paper for pulp countries 2000-2015. (Data source: ODYSSEE 2019)

Pulp in itself is not a homogenous product but can be mechanical, semi-chemical or chemical pulp, and even these can be further split into more narrow definitions. Generally, chemical pulp is the most energy intensive virgin pulp and mechanical and semi-chemical virgin pulp is

[1] NACE is the Statistical classification of economic activities in the European Community. NACE 2008 refers to how industrial subsectors are classified since 2008. Pulp and paper forms subsector 17 and printing and publishing subsector 18.

less energy intensive. Different sources give different estimates depending on what is included and what not and their data sources. E.g. Ecofys (2009) gives an energy consumption of 4-13 GJ per oven dry ton for mechanical pulp and 4-16 for semi-chemical pulp, and a heat use of 10-18 GJ/air dried ton for chemical pulp. Pöyry's (2016) net energy consumption estimates for Finnish products are 6-7 GJ/t for mechanical pulp, 3 GJ/t for semi-chemical pulp used in integrates, 13-14 GJ/t for chemical pulp used in integrates, 10 GJ/t for semi-chemical market pulp and up to 17 GJ/t for chemical market pulp.

As mechanical pulp uses less energy than chemical pulp, the production palette explains the differences quite well. The share of chemical pulp is 100% in Portugal. The share of chemical pulp is large also in Finland. It is approximately three times as large as the share of mechanical pulp. In Sweden, its share is approximately two times as large, whereas in Norway, on the contrary, mechanical pulp is produced five to six times as much as chemical pulp. Estonia's production has been mostly semi-chemical pulp since 2007, and one third is chemical pulp.

The EU country average of the unit energy consumption of pulp and paper was 3.7 MWh/t$_{p\&p}$ in 2015, and Finnish unit consumption was 9% lower, according to (ODYSSEE 2019) data.

Unit energy consumptions in the EU, according to Fisher (2019), of individual paper and board as well as pulp products are presented in Figure 2. Some examples of what some of the products are used for is presented in Appendix A. For sulphate chemical pulp (kraft[2] pulp), the estimated energy is presented for pulp used on-site in an integrated mill and for market[3] pulp. If mechanical or semi-chemical pulp is marketed, the unit energy use will increase similarly. Tissue TAD stands for Through Air Drying tissue production, which employs additional fuel directly in the TAD process, as opposed to wet-pressed tissue production. TAD tissues are of higher quality, with better absorbency and using less fibres.

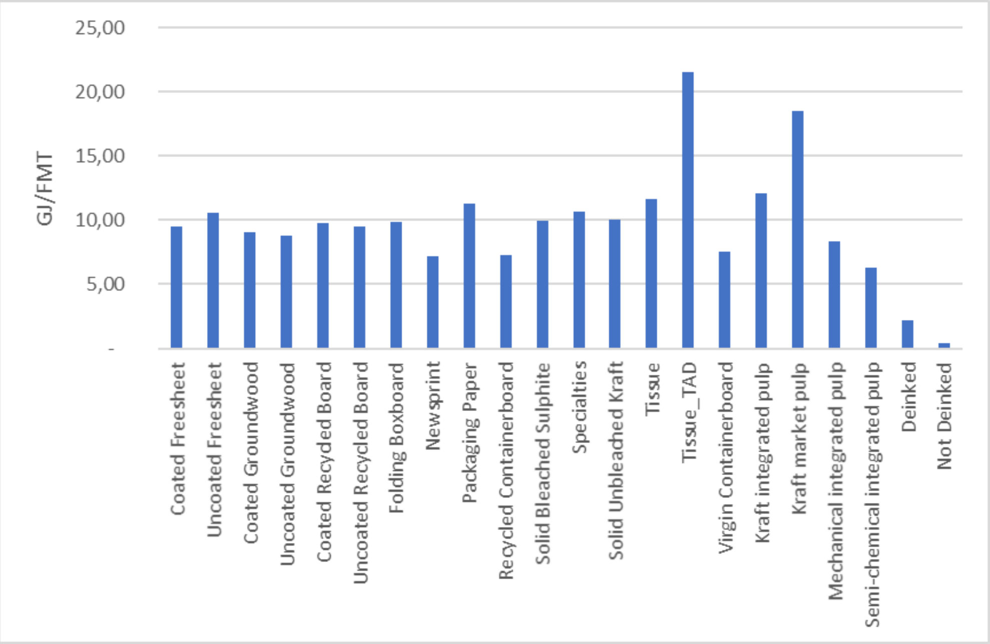

Figure 2. Average unit consumption[4] in the EU of different paper and pulp product groups. (Data source: Fisher 2019)

[2] Kraft refers to the sulphate chemical pulp process and the pulp it produces. Kraft pulp is the dominating chemical pulp process in use nowadays.
[3] Integrated pulp is used on-site in a paper mill and is not dried in between. Market pulp is dried and then marketed and transported to paper mills elsewhere.
[4] FMT = Finished metric ton

Aside from tissue, and especially TAD tissue production, chemical (kraft) pulp is the most energy intensive product and especially kraft market pulp. As Fisher (2019) left chemical recovery processes, including lime kilns out of the energy balances, kraft pulp is in reality even more energy intensive than presented here. As a consequence, **countries with large shares of market pulp and/or kraft pulp production are at a disadvantage in country comparisons.**

2.1.1 Pulp production and market pulp

Sweden, Finland and Portugal are the main producers of pulp of the 18 CEPI countries with market shares of 31%, 30% and 7%, respectively, see Figure 3.

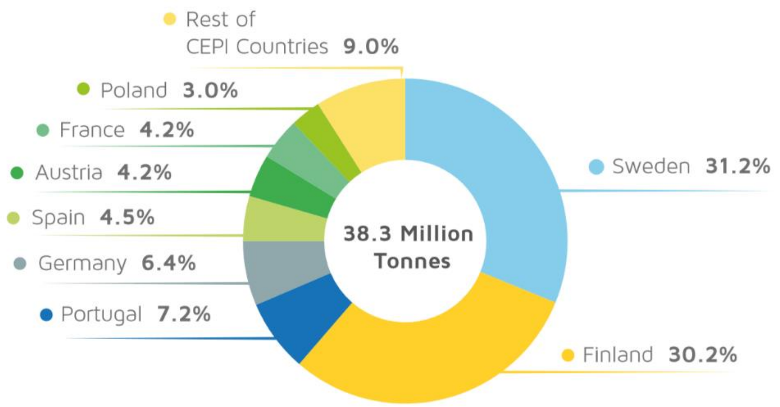

Figure 3. CEPI Total (integrated + market) pulp production by country in 2018 (Source: CEPI statistics 2019)

Although a lot of paper&board etc. in Europe is produced using recycled fibres, not all can be. New fibres are needed to replace losses, and, in addition, certain end products might require new fibres instead of recycled. **Countries with a high share of pulp production use more energy per paper ton than countries only using recycled fibres or imported market pulp.**

Especially, if market pulp is exported from one country to another (see info box), energy use is effectively transferred in the reverse direction, affecting country comparisons.

FINNISH EXPORT OF MARKET PULP
Energy use for market pulp compared to integrated pulp is approximately 20% larger for chemical pulp and three times as large for mechanical pulp according to product estimates by Pöyry (2016). Market pulp was to 94% bleached chemical pulp and only 6% mechanical pulp in 2014 (Pöyry 2016). In 2014, 27% of pulp produced in Finland was exported and mostly to Europe (Pöyry 2016). Export increased from 1.3 million tons in 2009 to 3.7 million tons in 2018 (FFI 2019). Increased market pulp production and export appear to show a less energy efficient production. **Export of market pulp is also an export of statistical energy efficiency to the receiving country:** • The receiving country does not have to use energy for pulp production. • The producing country has to dry the pulp for transport. • Due to hornification[5], paper production needs less energy if once dried pulp is used.

As different pulps have different strength, colour durability etc. properties, e.g. mechanical pulp has lignin in it and turns yellow and brittle with age, their usage is different, and they cannot be replaced that easily by

[5] When chemical pulp fibres are dried, either in sheet or pulp form, the internal fibre volume shrinks. If the fibres are resuspended in water, the original water-swollen state is not regained. The physical change manifested by this inhibited reswelling is termed "hornification". (Minor 1994)

each other. For example, chemical pulp fibres are stronger than mechanical pulp fibres, so they are used in paper and packaging qualities that need strength.

2.2 Energy intensity

The IEA (2017) and JRC (Economidou 2017) have made decomposition analyses of Finnish industry as a whole, and they have relied on energy intensity. This is not an optimal solution, but for very diverse branches perhaps the only practical solution data-wise. However, value added is not a very good measure of the energy efficiency of the industry. Bulk industries like pulp&paper usually have lower value added and higher energy consumption, but that does not mean that they are energy inefficient. In addition, even if the value added is tied to the value of money of a given year, global bulk goods' and energy prices are much more volatile.

As can be seen in Figure 4, export volume and export value occasionally move in the opposite directions, e.g. in 2011/2012, 2013/2014 and 2015/2016.

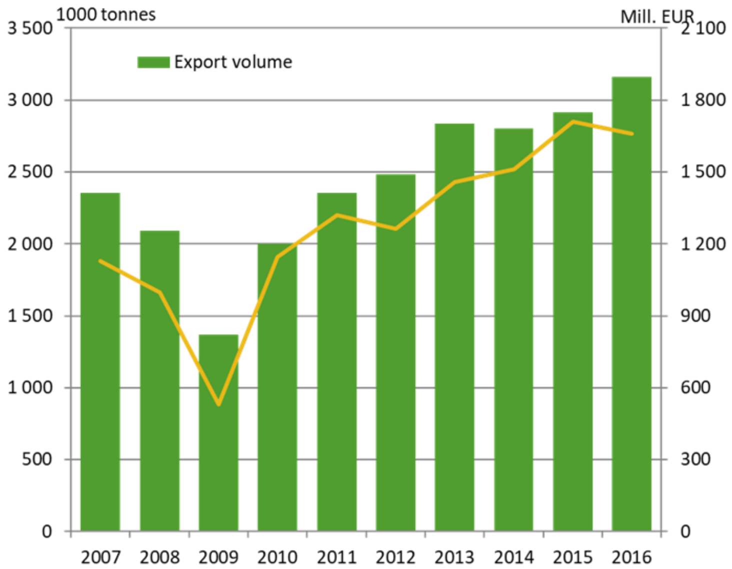

Figure 4. Export volumes and values of Finnish chemical pulp. Source: FFI 2019.

The IEA (2014) notes that energy intensity, as measured by energy consumption per value added or the GDP, is often used as a proxy for energy efficiency and exclaims that it is a mistake, as energy intensity does not necessarily correspond to energy efficiency. Process level indicators are of most interest to energy efficiency analyses. However, their use is still limited due to a general lack of available data, or by the difficulties in allocating energy consumption to specific physical output values, when outputs are heterogeneous in the same establishment. In any case, indicators based on physical output are always recommended for energy efficiency analyses. (IEA 2014)

2.3 ODYSSEE unit consumption

As an energy efficiency database, ODYSSEE is often brought forth when we want to know how energy use develops and what the reasons are for it. Whereas a value added based intensity approach gives unsatisfying results, ODYSSEE (2018d, 2019) uses production tons and unit consumptions per physical production as a measure, which is a good thing.

The results in Figure 5 differ from those in Figure 1. Only Sweden, Portugal and Czech Republic fare worse than Finland. However, energy use of the pulp, paper and printing subsector is compared against only paper production volumes, not paper and pulp production volumes in ODYSSEE! As already noted, this is quite wrong, as pulp production is usually more energy consuming than paper manufacturing, and thus those tons have to be added.

To our knowledge, ODYSSEE is changing the calculation method to include pulp tons. New and improved results were due by December 2019 but were not published yet at the time this report was being prepared.

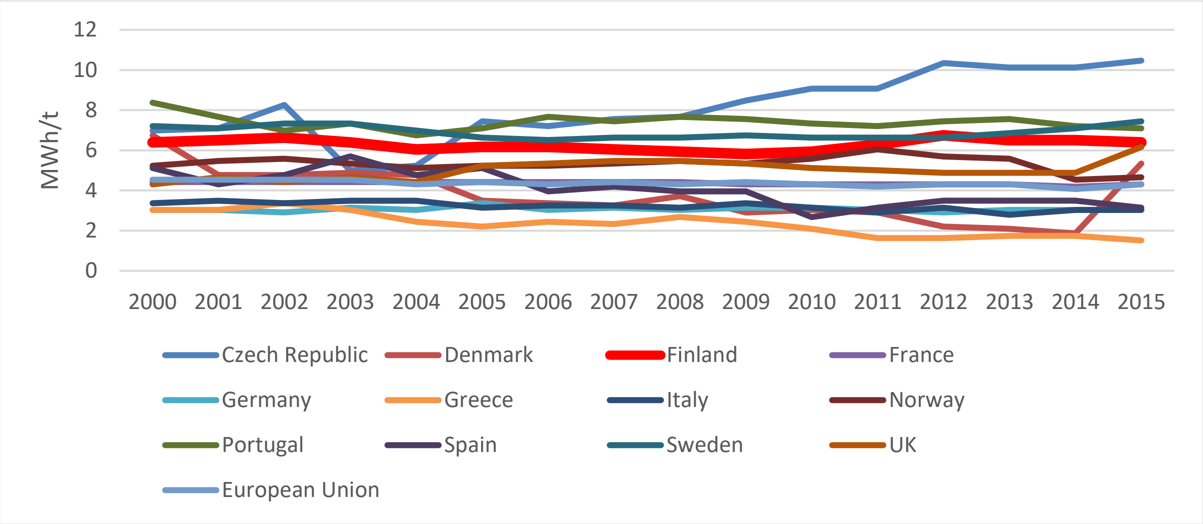

Figure 5. Unit consumption as given by ODYSSEE. (Data source: ODYSSEE 2019)

2.4 Methodology comparison

Three different approaches were analysed in Koreneff (2018) for some countries, see Table 1. The table shows the unit consumption and energy intensity as indicator of energy efficiency level and (in brackets) the changes in the indicators from 2000 to 2015. Finland and Sweden are much better situated in comparison with the other countries, if we use the most correct alternative, the unit consumption of pulp and paper. UK is the only country to have null (0) pulp production in the ODYSSEE (2019) statistics, so it is a good comparison of how the different approaches affect pulp producers compared to non-producers. Lithuania is the country with the second[6] lowest unit consumption for paper, so it is chosen as to show how the difference to the best case varies. Italy is selected as a mainly paper producing country, representing the majority of the countries in Europe.

A comparison of unit consumption of pulp, paper and printing energy per ton of paper, as given by ODYSSEE (2019), to unit consumption per ton of pulp and paper, as calculated from database raw data, is shown for EU countries in Figure 6. The data is for 2015 (ODYSSEE 2019). Malta, Cyprus, Luxembourg and Ireland[7] are not included because of no production data. As can be seen, pulp producing countries are faring better using the unit consumption per ton of pulp and paper, as could be expected.

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[6] Greece is the best performer, but the unit consumption of paper is 40% lower than that of the second best, and in addition, the year to year (statistical) fluctuations are strong, so it was not selected.
[7] Ireland has paper production, but the last year in the ODYSSEE (2019) database to have volume data is 2014.

Without detailed knowledge, it is hard to say what is behind the result for the Czech Republic. It may be due to the Czech statistics. The unit consumption per ton of pulp and paper has increased from 3.9 MWh/t in 2000 to 6.4 MWh/t in 2015.

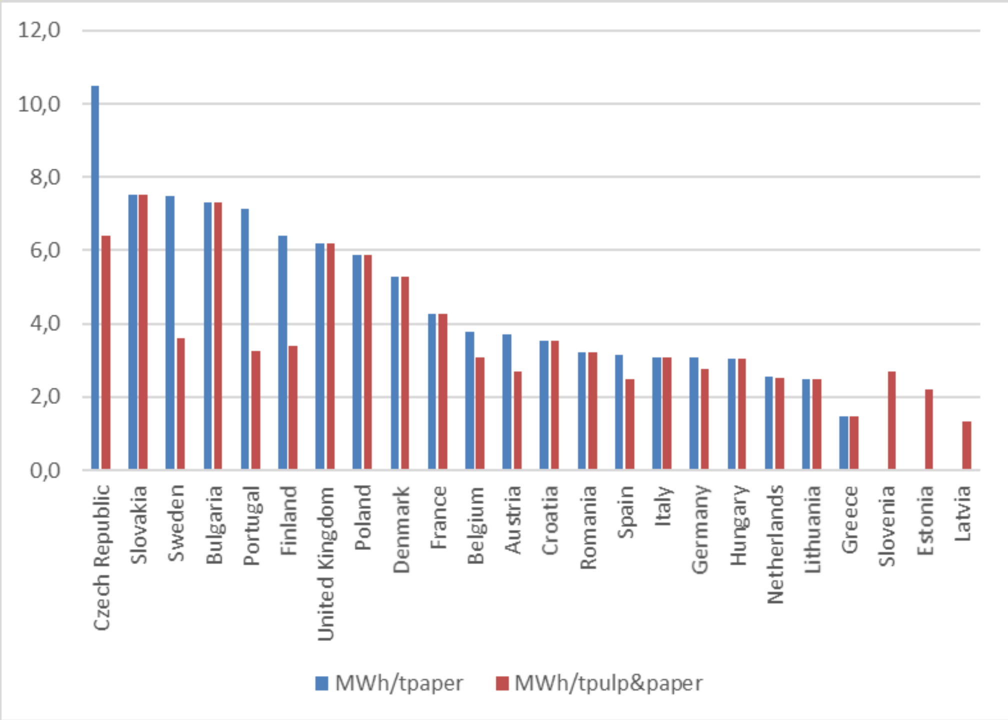

Figure 6. Unit consumption per paper tons compared to unit consumption per pulp and paper tons in EU countries 2015 (Data source: ODYSSEE 2019)

The energy intensity based approach used by the IEA and JRC in their decomposition analyses gives a much more negative impression of the Finnish industry's energy efficiency than a more accurate analysis would result in. **As long as energy intensity (MWh/€) is used in analyses, the results should be viewed with a great deal of caution, and countries should not be compared with each other.**

Results based on ODYSSEE (2019) approach (first column) are better than those using energy intensity, but they still fall short. For Finland, aside from level issues, for example, the unit consumption per paper ton shows a growing trend, whereas per pulp and paper ton it is negative. Changes to be made to the ODYSSEE methodology in this respect must be seen as a most welcome corrective step.

From the table, we can deduce that Lithuania and Italy, similar to the UK, have no reported pulp production. Looking at the raw data, we see that there is no (or none is reported) Italian pulp production after 2004, which explains the difference in unit consumption change 2000-2015 between the first and the second column.

Table 1. Unit consumptions and energy intensity of the pulp and paper sector in 2015 and in parenthesis the change from 2000 to 2015 (Source: Koreneff 2018)

	Unit consumption of paper, MWh/t	**Unit consumption of pulp and paper, MWh/t**	**Energy intensity of pulp, paper and printing[8], MWh/1000€**
Finland	6.61 (0.9%)	3.41 (-1.8%)	20.66 (-8.7%)
Sweden	7.47 (4.3%)	3.61 (4.3%)	17.80 (62.9%)
Italy	3.08 (-9.4%)	3.08 (-3.4%)	2.87 (-3.7%)
Lithuania	2.48 (-73.2%)	2.48 (-73.2%)	1.00 (-80.8%)
UK	6.18 (43.5%)	6.18 (43.5%)	2.10 (7.7%)

If we give scoreboard points in the same fashion as ODYSSEE Scoreboard[9] for the results in Table 1, Finnish score is much more competitive when we use the most correct indicator (i.e. unit consumption of pulp and paper) compared to using the worst, energy intensity, see Table 2. For country comparisons, it is a big thing if Finland gets 0.0, 0.17 or 0.75 points for its dominating industry subsector.

Table 2. Finnish "Scoreboard" type of results for alternatives in Table 1

	Unit consumption of paper, MWh/t	**Unit consumption of pulp and paper, MWh/t**	**Energy intensity of pulp, paper and printing, MWh/1000€**
Finland	0.17	0.75	0.00
Sweden	0.00	0.69	0.15
Italy	0.88	0.84	0.90
Lithuania	1.00	1.00	1.00
UK	0.26	0.00	0.94

[8] Value added of paper and printing / Final consumption of paper, pulp and printing industry.
[9] Score = (1 - (value-min)/(max-min))

3. Fisher estimation results

If we need to compare energy efficiencies of pulp and paper sectors of different countries, consultant companies like Fisher, AFRY (previously ÅF Pöyry) and RISI offer deeper insights, better branch knowledge and a higher disaggregation level than more general top-down analyses performed by the IEA, JRC or ODYSSEE. However, it is not sure to what extent they could provide a time series of the development of the energy efficiencies.

The results in this Chapter are based on the sub-study made by Fisher International Inc. (Fisher 2019) for this study. The sub-study assessed the energy efficiency of the Finnish paper industry and its specific characteristics. The estimate of the energy efficiency of the Finnish paper industry compared to other EU countries is done on major grade and pulp class level. This analysis is based on the processes of individual mills and products, aggregating results to major grades. As there is no statistical data of energy use of product groups available, the results here is the closest we get to acceptable country comparisons.

Fisher collects information about every pulp and paper mill in the world via its FisherSolve™ Next platform. For more than 30 years, Fisher's full-time researchers have collected data covering every pulp and paper producing country in the world using primary and secondary research methods. The capacity in the report describes the planned annual capacity (as known in the autumn of 2019) of each machine line and finished product during a normal run, so the results are simulation-based estimates and not realisations. As a privacy principle, if there are fewer than four producers per grade, results are not shown for that country.

The energy consumption numbers in this report are based on Fisher's benchmarking model, modelling mass-energy balance and manufacturing prices of each mill producing over 50 tons per day. The energy balance is calculated separately for pulp production (slush pulp) and paper and market pulp production (paper machine or pulp dryer).

In this comparison, all energy consumption of pulp production is calculated by ton of slush[10] pulp, not taking into account side streams like lignin, tall oil and others. Market pulp is classified as an end product similar to paper.

Paper production energy calculation is starting at stock preparation for paper machine or pulp dryer and ending at jumbo rolls (no converting involved) or pulp bales. Steam consumption is presented in three classes

- Co Gen = Steam from mill internal CHP production
- No Co Gen = Steam from boilers used only for steam production, no electricity production involved
- Direct Fuel = Direct fuels at paper machine used to power e.g. flash dryers, yankee hoods, coaters, or TAD dryers.

Chemical recovery is excluded from pulp energy consumption in these simulations. In kraft mills, the share of renewables in energy production is generally high due to chemical recovery process utilising wood solids from black liqueur. The lime kiln is a process in chemical recovery requiring straight fuel to operate, although in modern facilities, also lime kiln fuel can be internally produced from black liquor extracts or bark.

3.1 Finnish pulp and paper mills

Finnish pulp and paper mills on average are big, efficient and modern in comparison to the EU's average. Profile of production in Finland and Sweden differ considerably from other EU countries, and the majority of EU's kraft pulp is produced in Finland and Sweden.

[10] slush = pulp in water solution from fibre line

Virgin fibre is used extensively as raw material in Finland and Sweden, whereas in European countries, in general, recycled fibre is the main raw material for paper products.

In general, the energy efficiency of Finnish mills is either on par or better in comparison to the EU average. Utilization of co-produced electricity and steam is high in Finland, improving energy efficiency of the whole site, although that cannot be seen in the final energy consumption of the end-use sector in energy balance statistics. 99% of sites with recover boilers in Europe utilise recovery boiler steam for electricity production.

In some packaging and fine paper grade level comparisons, Finland's energy consumption per ton is higher than EU average due to differences in the furnish, i.e. material used for the product, and end product properties:

- Finland has a larger share of high-value end products.
- Market pulp production in Finland is the most energy efficient in EU, despite the need for additional heating due to colder climate.
- New and modernised biomills produce energy surplus and a variety of side products.

3.2 Paper and board market

Top 3 producing countries make about half of the EU's paper and market pulp in 2019. Germany stands for 21%, Finland 15% and Sweden 13%. Total estimated production is 119 Million metric tons. The biggest grade is containerboard, 28%, followed by printing and writing 21%, market pulp 15%, carton board 13% and tissue and towel 7%

Finnish virgin fibre production integration is second only to Sweden among main producing countries. Finland and Sweden have high average productions by site, i.e. the plants are big, and the most efficient paper machines are to be found in Finland, see Figure 7.

Steam consumption of the paper machine is affected by several factors:

- Furnish, i.e. input material, affects how easily the paper web can be dried. Recycled fibre and grades using high amounts of pigments need less steam for drying.
- Machine technology affects steam consumption, e.g. shoe press and multilayer headbox.
- High technical age increases steam consumption in the model.
- Non-integrated mills using market or recycled pulp are benefitting from the hornification effect, making water removal from once-dried fibres easier, thus reducing steam consumption.
- Virgin integrated mills benefit from steam from fibre production that can be utilised at the paper machine.

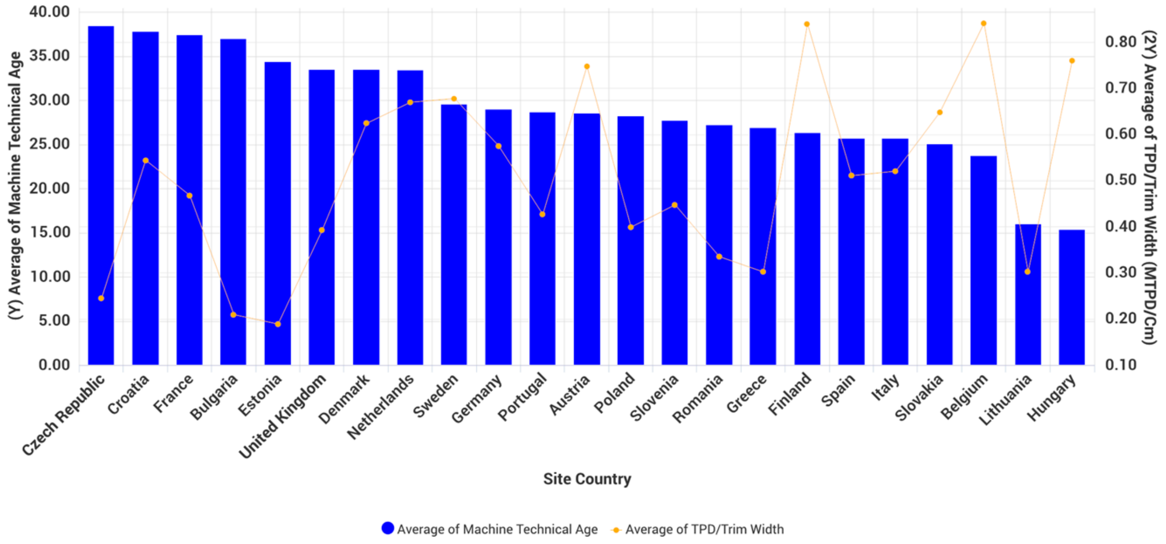

Figure 7. Technical age and tons per day (TPD) production by trim width of paper machines in EU 2019 (Source: Fisher 2019)

The average technical age of paper machines is quite high through Europe, for most parts well above 25 years.

As for fibre lines, Finland has the 2nd highest daily production in the EU, see Figure 8. As was the case with paper machines, fibre lines are also quite old on average throughout Europe with notable exceptions for Lithuania, Estonia and Denmark.

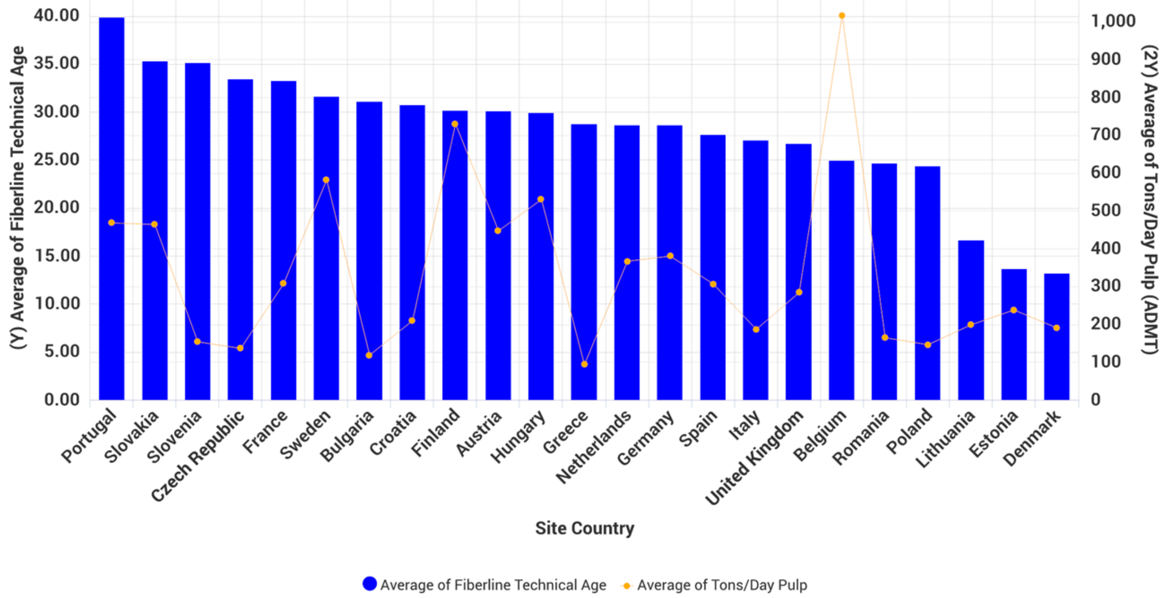

Figure 8. Technical age and production volumes of pulp lines in EU 2019 (Source: Fisher 2019)

In total energy use, Finland is close to the EU average in each major grade, see Figure 9. A comparison to individual countries is shown in Figure 10. As can be seen, Finland has a high share of steam produced by combined heat and power plants (CHP). The large share of direct fuel use in Finland for market pulp comes mainly from pulp flash dryers producing specialty pulp grades like fluff (used in e.g. diapers).

If we look at steam use per product area, Finnish results are better than in terms of steam use per ton. Figure 11 shows the results for communication papers. Finnish unit energy use per ton was higher than that of Austria, Belgium, France and Germany and now the roles are reversed.

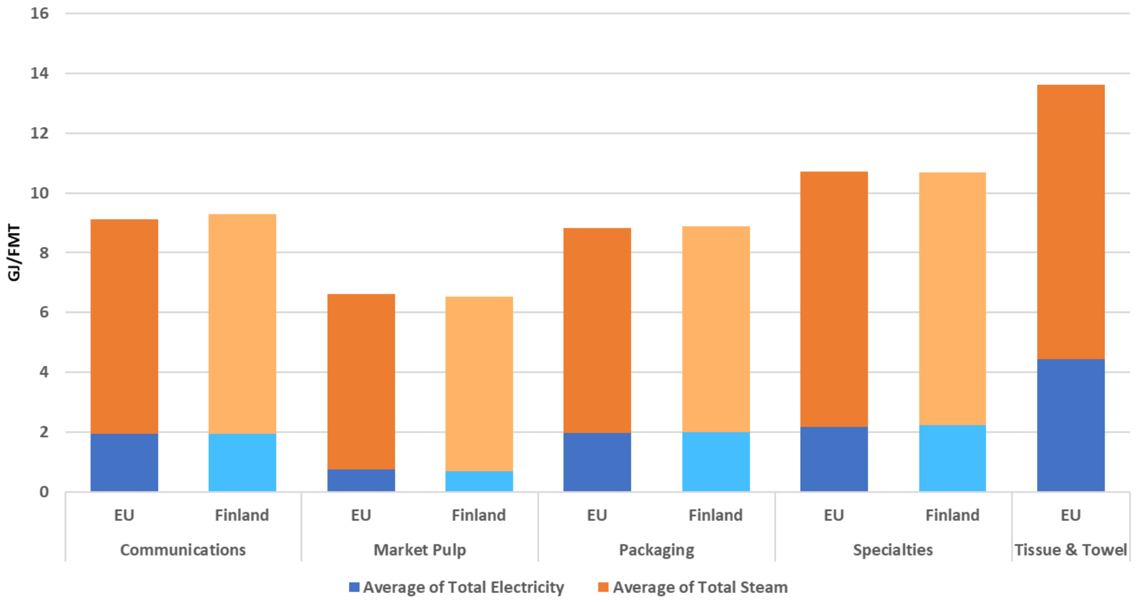

Figure 9. Total energy use in the EU and Finland by major grade 2019 (Source: Fisher 2019)

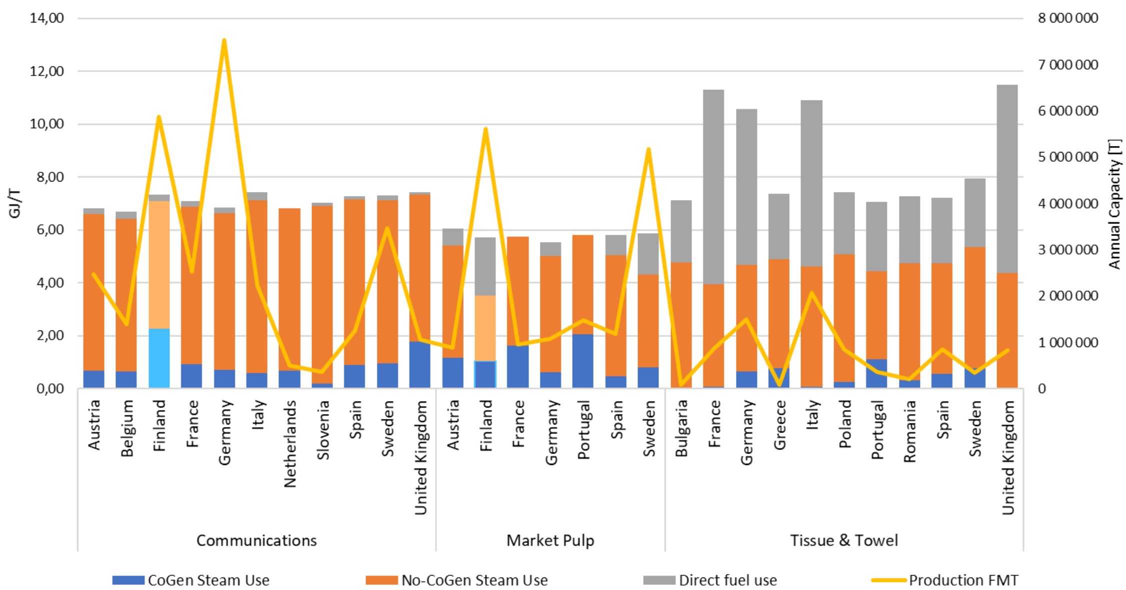

Figure 10. Steam consumption of communications, market pulp, tissue & towel 2019 (Source: Fisher 2019)

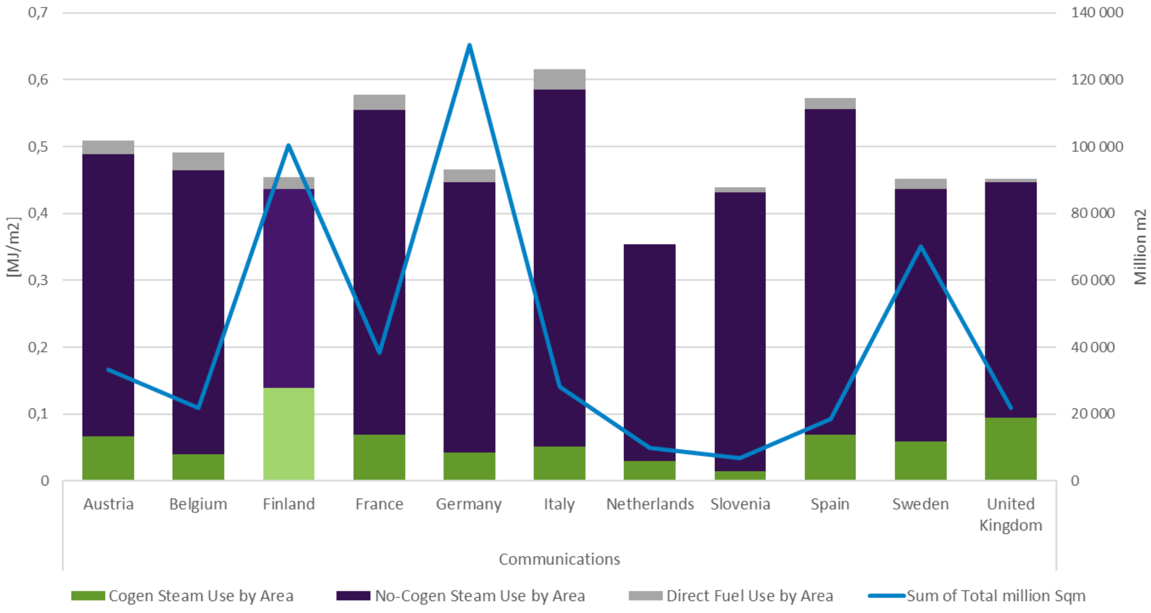

Figure 11. Steam use by area produced of communication papers in the EU 2019 (Source: Fisher 2019)

In packaging and speciality grades, Finland's steam consumption is higher than the EU average. Country comparisons are shown in Figure 12. Finland is better than Sweden in both cases and better than Germany for packaging.

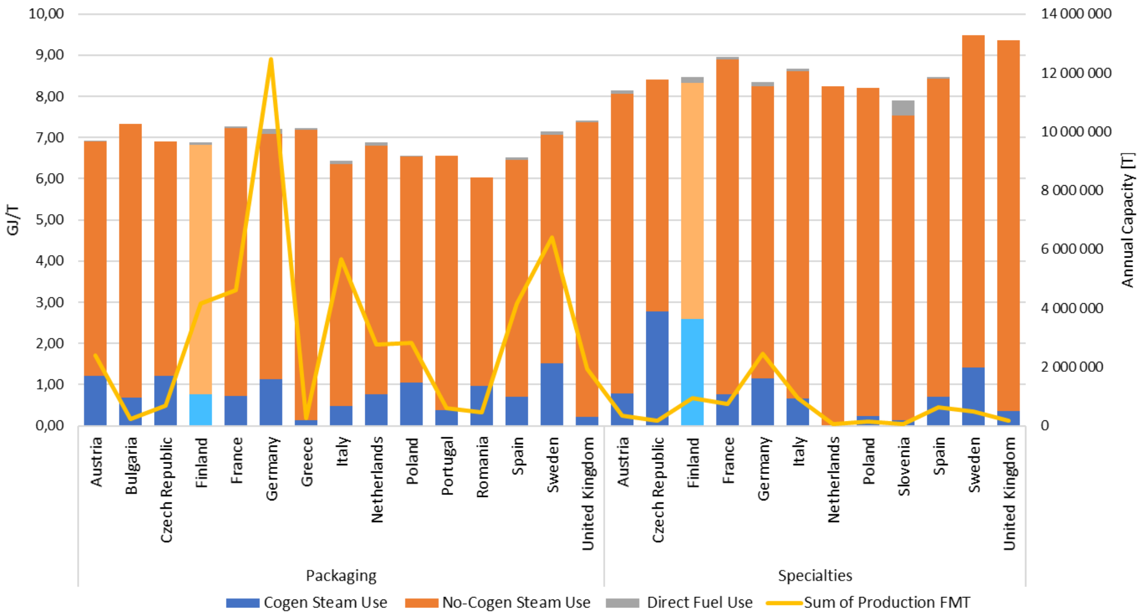

Figure 12. Steam consumption of packaging and specialities in EU 2019 (Source: Fisher 2019)

Electricity use in paper production offers small differences, at best circa 0.03 MWh/t, except for tissue & towel grades, where the difference can be up to 0.5 MWh/t, and packaging, where the difference can be up to 0.2 MWh/t. Packaging offers a high variance, which is mostly influenced by the type of finishing. Finland and Sweden produce packaging grades mostly from virgin fibre, requiring more refining than recycled pulp, while other countries mainly use recycled fibres.

3.3 Pulp production

Pulp production is 89 Million air-dry metric tons (ADMT), whereof recycled pulp constitutes 54%, chemical pulp 36% and mechanical pulp 10%. TOP-10 pulp producers in EU 2019 are shown in Figure 13. **Finland and Sweden produce together 61% of EU's virgin pulp.**

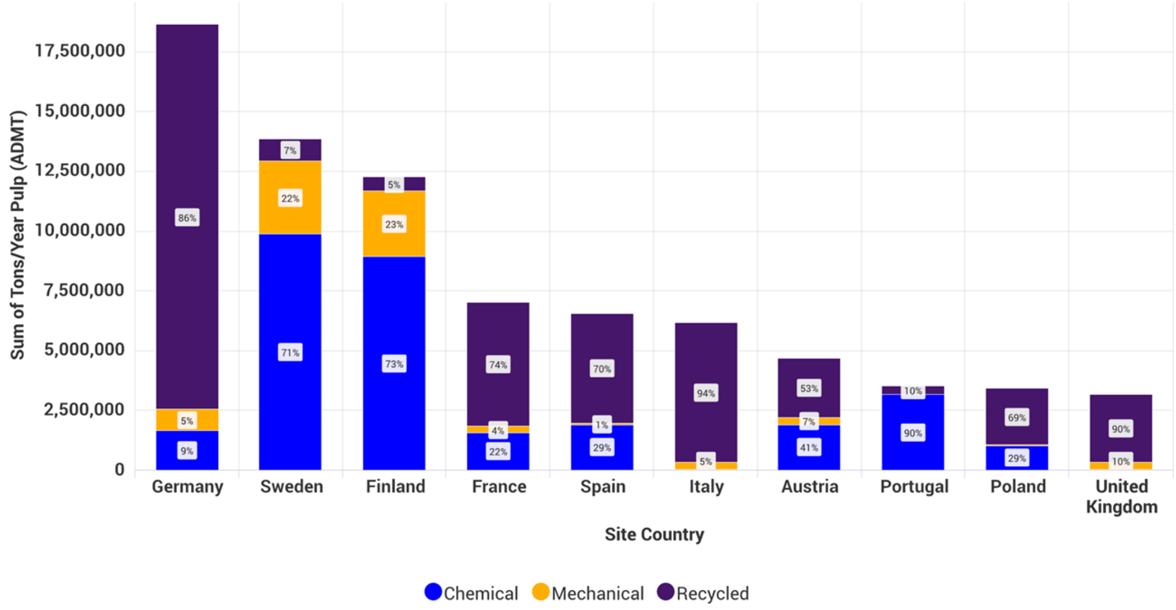

Figure 13. TOP-10 pulp producers in EU 2019 (Source: Fisher 2019)

Finland is the second most energy efficient producer of kraft pulp, better than Germany and Sweden. Energy use for kraft pulp production is shown in Figure 14.

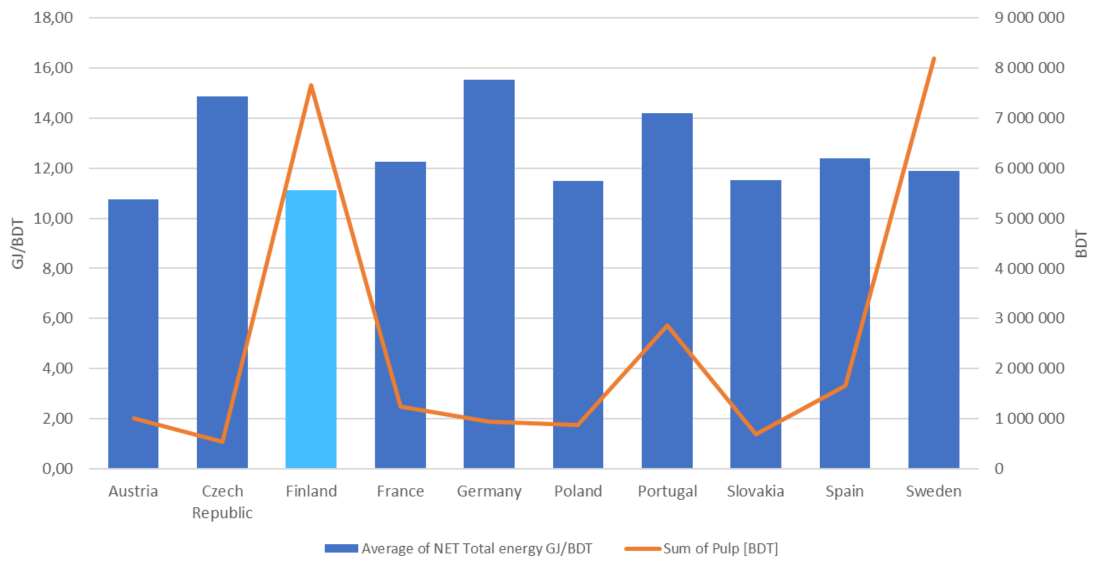

Figure 14. Energy use of kraft pulp production in EU, 2019 (Source: Fisher 2019)

The heating of buildings, incoming logs and process water affects the energy consumption in the northern hemisphere. Heating of water in kraft paper mills has the largest effect on mill energy balance. Kraft mills in Finland use on average 10% of their total net steam on water heating, whereas mills in Portugal use 4%. The difference is explained by climate. Energy consumption of pulp in the EU and Finland is shown in Figure 15. Finland's energy consumption in semi-chemical grades is below the EU average, above for mechanical pulp.

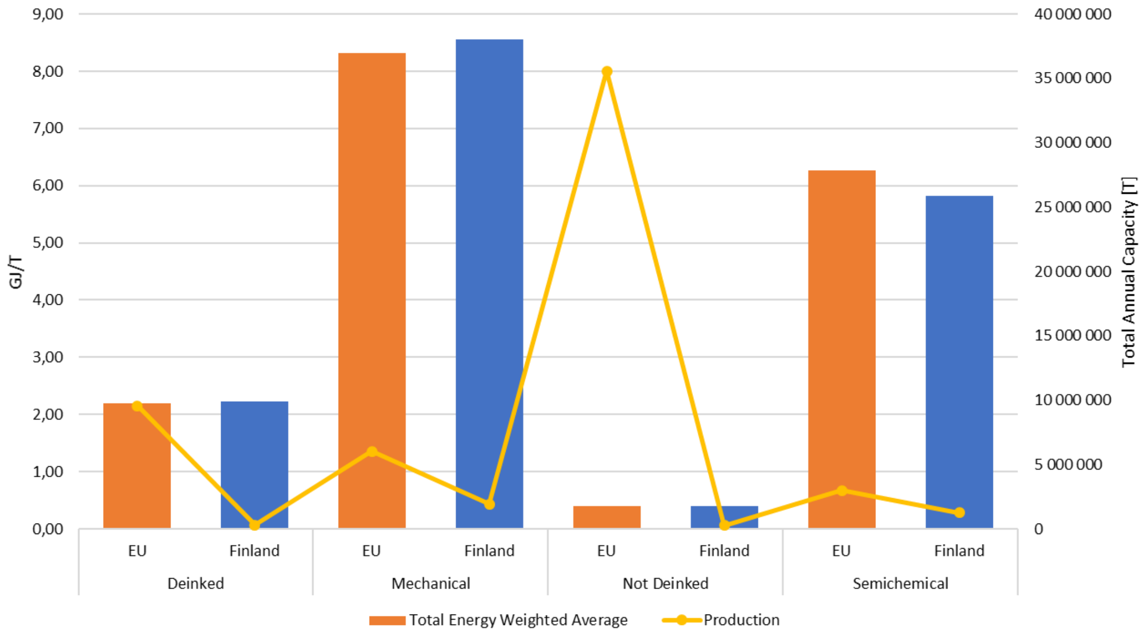

Figure 15. Energy Consumption of Pulp Production in the EU and Finland 2019 (Source: Fisher 2019)

Differences in energy consumption are largely explained by differences in end product quality, which is modified by the refining rate. In modern mechanical pulp facilities, steam is recovered from the refiners and utilized at the paper machine. This is extensively done in Finland and Sweden, where 25% and 50%, respectively, of electricity use is recovered as steam. The recovered steam is not reducing the energy consumption of pulp production in these simulations but is shown as co-generated steam in the paper grade comparison. **When we reduce the recovered steam from the energy consumption of mechanical pulp, as we should, Sweden exhibits the lowest energy use and Finland second lowest.**

The technical age is a factor in energy efficiency. Mechanical communication grade mills have received limited investments in recent years due to declining demand.

Energy consumption by country of mechanical and semi-chemical pulp 2019 is presented in Figure 16. The figure shows how energy efficient Austria's new assets in mechanical pulp production are.

The variation in the energy consumption of recycled grades in different countries is small.

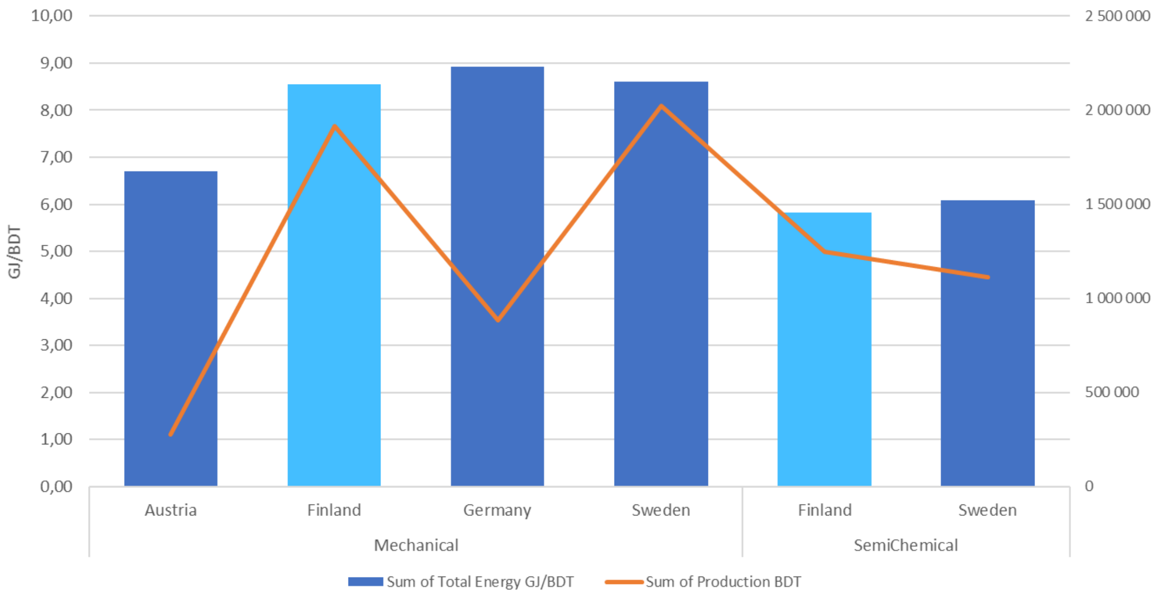

Figure 16. Mechanical and semi-chemical pulp: energy consumption by country 2019 (Source: Fisher 2019)

Overall, energy efficiency of Finnish pulp and paper production is generally on par with the EU average. For some grades, Finnish energy efficiency seems a bit lower than the EU average, but when we change our indicator to be relative to produced paper area, it is better. For mechanical pulp, energy efficiency in Finland is better than in Austria or Germany, when we take into account the heat produced in the grinding process and used in a neighbouring paper mill.

4. Energy efficiency of pulp and paper sector- highlights that affect the interpretation of indicators

When we analyse the unit consumption of the pulp and paper sector of different countries or look at decomposition results or ODYSSEE scoreboards, **the most important aspect to take into account is the product mix**. Different needs require different products. With similar energy efficiency, unit consumptions of different end products in the pulp and paper sector differ significantly. If we do not have disaggregate enough data at our disposal in our analyses, we miss out on this. The product mix does not only affect the unit consumption level of a country, it also has a tremendous effect on the energy efficiency development as well.

For the pulp and paper sector, the production of pulp is an essential part of the energy use. Not every product can be made of recycled fibres, and, in addition, new fibres are needed to replace lost, damaged and worn down recycled fibres.

If the share of exported market pulp were taken into account correctly, Finland's and Sweden's placement in Table 1 would surely be even better. As noted earlier, market pulp has to be dried, and that uses lots of energy.

Although recycling of paper and paperboard is a high 66% in Finland, 95% of paper and paper board production is exported, mostly to Europe (Finnish Forest Industry 2018). Only 6% of the pulp produced in 2014 was based on recycled fibres. The rest was based on virgin fibres: 27% of all pulp was mechanical pulp, 5% chemi-mechanical pulp and 62% chemical pulp (Pöyry 2016).

Other aspects to take into consideration when analysing energy efficiency development or comparing countries:

- With the high aggregation level used, many notable **structural changes are seen as energy efficiency changes**. For example, newsprint, being less energy intensive than printing and writing paper or soft tissue, is experiencing the strongest cutbacks in Finland (Pöyry 2016). Similarly, there has been a continuous decline in European printing & writing capacity and a capacity increase in the less energy intensive board grades. Recycled containerboard represented 90% of announced capacity growth in Europe for 2018 (Fisher 2018).

- **The climate is a significant factor**, with icy logs etc. For example, energy consumption of chemical pulp production increases with roughly 5% if the inflow water is 10 °C colder according to utility representatives. This temperature difference might well be found between Southern Europe and colder Finland.

- **The thinness of the product is also a factor**. If we get the same functionality with a thinner and lighter product, energy use per ton might be higher but energy use per square meter lower, which is the case for Finnish uncoated freesheet and groundwood paper grades. In addition, a more material efficient, thinner product uses less pulp. Finnish paper machines are generally modern and able to produce thin qualities.

- **Thicker papers might have the benefit of a mechanical shoe press** squeezing off water and reducing the need for drying heat whereas such a press would not be as efficient and thus cost efficient with thinner paper qualities.

- **Bleaching uses energy**.

- Feedstock residues, for example bark, can sometimes be cumbersome to use and with less energy efficiency than natural gas, but according to Ecofys (2009), different energy use values also apply for the gas based process and the oil based process. If bark is unused and transported to a waste heap, one could assume it is calculated as part of the feedstock. If **bark is gasified** and used as fuel for the lime sludge reburning kiln, it is a statistically less energy efficient process than letting it rot and using natural gas instead, but it is decidedly a more sustainable solution. The share of renewables in lime kilns is estimated at 53% in Finland and 44% in the EU in 2019 (Fisher 2019).

- **Different feedstock requires different energy use**. From (Pöyry 2016) results, we can make the assessment that softwood pulp requires 5.4% (integrated mill) or 8.5% (market pulp) more energy to produce than hardwood pulp in Finland. Different feedstock result in different fiber qualities, so the selection of feedstock is not only a question of energy efficiency, profitability or availability. The end product can also set demands on the fibres.

- **Integrate mills** allow for using surplus pulp production steam and heat in the paper manufacturing process, **reducing the overall energy use**. They also surpass the need for drying the pulp, which otherwise would increase energy consumption.

- **Deinked recycled fibres use more energy** than not-deinked. However, this more of an issue for countries relying more heavily on recycled fibres than Finland.

5. Data

In this Chapter we look at data and several issues related to it. Of concern are, i.a., data availability, uncertainties, disaggregation level, discrepancies and other reliability factors, and the system boundary issues concerning final energy consumption, energy production and feedstock.

5.1 Data target and data availability

Looking at energy use of pulp and paper production, there are notable differences in energy use per ton depending on what kind of ton is produced[11]. Mechanical pulp[12] is the most electric energy intensive but chemical pulp the most overall energy intensive product. And, of course, use of recycled paper as raw material results in a very low energy intensity, only 10% or less compared to chemical pulp.

One target of this study was to gather and combine product (group) specific time series data from utilities via Finnish Forest Industries to be able to assess the development of the Finnish pulp and paper industry’s energy efficiency. This proved to be too difficult taken into count the need for confidentiality. Another difficulty is the question of how to allocate energy between pulp and (possibly heterogeneous) paper in an integrated mill. Process control systems are concerned with wood flows but do not necessarily care if the flow is categorized as feedstock or energy input. This all led to the necessary decision to abandon the plan and focus on available statistical data.

5.2 Data definition issues

Eurostat energy balance guidelines (Eurostat guide 2019) state that although the transformation of energy is generally executed by energy industries, many entities that are not a part of energy industries are also involved in the transformation and production of energy products. This is to satisfy their own needs or to deliver (sell) these products to third parties. Consequently, this transformation of energy products is recorded in the energy balances in the energy transformation sector (transformation input and transformation output) and not in the final energy consumption block. The most typical example is companies producing their own electricity and or heat (so called autoproducers), and thus the energy transformation sector includes all quantities of fuels used to produce electricity and the proportional part of fuels used to produce heat sold in CHP units/plants. The proportional part of fuels used to produce heat that was not sold (auto-consumed heat) is included in the specific sector’s final energy consumption based on NACE classification, so it depends on plant ownership. Please note that heat not sold but delivered to other entities under non-financial agreements or entities with different ownership is reported on the same principle as heat sold.

The IEA follows the same guidelines. ODYSSEE, however, does not reduce the fuels used for heat sold from the energy use of industry. The fastest and least costly way to improve statistical energy efficiency of the pulp and paper sector would be to outsource CHP plants and heat-only boilers to companies belonging to the energy sector. All heat production losses would thus be outsourced. As a special case, if ODYSSEE is used as indicator, a reduction

[11] Unit consumptions in Finland 2014 (Pöyry 2016): Newsprint 6.8 GJ/t, coated fine paper 8.0 GJ/t, tissue 11.3 GJ/t, folding boxboard 7.5 GJ/t, ground pulp 6.5 GJ/t, bleached sulphate pulp 16.7 GJ/t, de-inking pulp 1.6 GJ/t and other recycled fibre pulp 0.7 GJ/t.
[12] Mechanical pulp has a much better material efficiency than chemical pulp, so with same amount of wood input, much more pulp is produced, even up to 95% of the input.

in heat production for sales would increase the energy efficiency of the pulp and paper sector.

Pulp and paper industry is filled to the brim with electricity autoproducers, especially in chemical pulp production where black liquor is burned back to white liquor.

Some of Finnish statistics (e.g. Energy use in manufacturing by industry (StatFin 2017a, 2018a)) calculate the real use of energy in an industrial sector, which is why autoproducers have higher fuel consumptions and lower electricity net inputs than what is presented in the energy balances according to the IEA and Eurostat method.

Koreneff (2018) discusses how the fuel in an autoproducer's CHP is and should be handled. Fuel allocation is mostly done in proportion to produced useful electrical and thermal energy, i.e. using the energy method. This means that both heat and power is thought of as produced with the plant's overall efficiency. The overall efficiency of CHP plants is high, but a bit lower than that of heat-only boilers, so the energy method tends to favour power production and disfavour heat production, which, for the same amount of output heat, leads to higher statistical fuel use in CHP than in similar boiler. Fuel allocation using the benefit allocation method (a.k.a. alternative generation method, see Grauss&Worrell 2011) would be fair and would divide the benefits of CHP equally to power and heat. For example, Statistics Finland produces statistics with both methods. Without a closer study, it is hard to say how widespread the use of the benefit allocation method is yet in European country statistics.

Pulp and paper sector is also abundant with integrates producing both pulp and paper products, which can make it difficult to allocate energy uses to the right end products. The pulp sector also uses feedstock, wood, which can likewise be used as an energy source. The dual character of the feedstock puts an extra burden on the statistics. How energy is calculated and allocated depends a lot on the intended use of the data.

5.3 Data aggregations

Using NACE Rev.2 (2008) classification for the industry subsectors, where NACE 16 is wood products, NACE 17 is pulp and paper and NACE 18 is printing, there is not much data purely for NACE 17. IEA (2019) Energy balance, ODYSSEE (2019) database and Eurostat (2019) Energy balance provide end-use energy use for industrial subsector Pulp, paper and printing, NACE 17+18. For energy efficiency studies, this is not so good. The subsector Printing (NACE 18) is highly valuable, forming in most countries roughly 40 to 50%[13] of the value added of Pulp, paper and printing but in Finland and Sweden only roughly 15%, according to value added data in ODYSSEE (2019). Printing is not nearly as energy consuming as Pulp and paper. For example in Finland, energy use for printing is around a half per cent of the energy use for pulp and paper, thus only around 5% of the energy intensity of Pulp and paper as measured by energy use per value added. This means that it really muddles the energy intensity results comparing countries using NACE 17+18, as countries with a larger share of printing automatically express lower energy intensities and countries with a low share of printing do not compare well.

Finnish statistics by Statistics Finland provide a variety of energy time series, but a lot of them provide data for the forest industry, NACE 16+17, and not for the pulp, paper and printing industry, NACE 17+18, as the energy balance does. Energy balances at Statistics Finland are available for the year 2017 (StatFin 2018b) and before that, for the year 2013, so

[13] In Spain, value added of pulp and paper is larger than that of pulp, paper and printing in the period from 2000 to 2005 and similarly in Sweden in 2012, indicating either negative value added for printing or misunderstanding by either author or data deliverer.

there are some gaps. The idea of Statistics Finland might be that for energy balance needs, Eurostat data can and should be used.

5.4 Data consistency and reliability

Are data consistent across different platforms? We take a closer look at data presented by different sources for year 2015, see Figure 17.

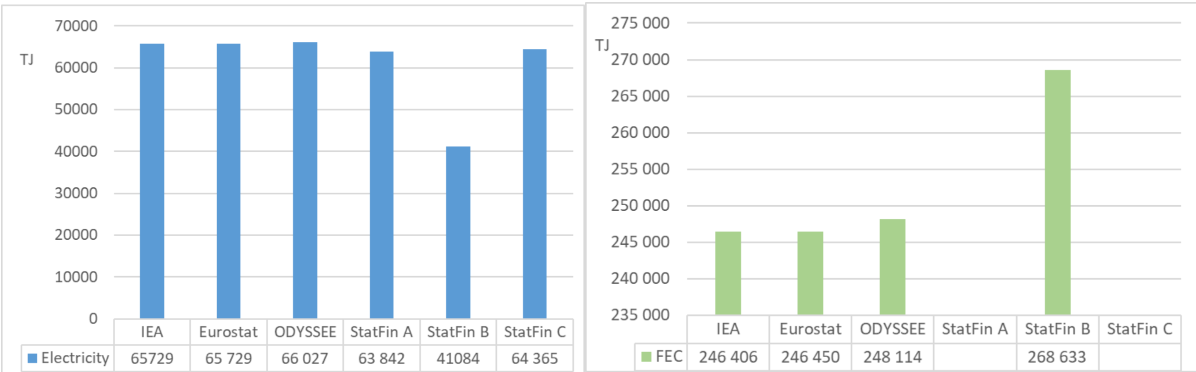

Figure 17. Electricity use, to the left, and final energy consumption (FEC), to the right, of Pulp and paper in Finland 2015. (Data sources: ODYSSEE 2019[14], IEA 2019, Eurostat 2019, StatFin 2015a,b, 2018c)

The values for StatFin B in the figure illustrate the aforementioned conundrum of autoproducers. The figure presents the real fuel use, also for electricity production, while the value of the electricity consumption is the net input from outside. StatFin A and C present the total electricity use, including own generation. As can be seen, total energy use as by ODYSSEE is larger than by the IEA and by Eurostat. This is assumingly because of produced and sold heat, which is not subtracted from the industry in ODYSSEE energy use. **This results in a circa 1% too high unit consumption for Finnish pulp and paper industry compared to other countries that do not sell heat**.

If we compare data from ODYSSEE with data from the IEA and Eurostat (they are quite well bundled) see Figure 18, we see that Finnish data converge nicely after 2007, German data are mostly similar with a few noticeable exceptions and Swedish data differ decidedly. Swedish IEA and Eurostat data for 2014 appears to be flawed.

In Table 1 presented in Chapter 2, some numbers are so large that they are not in any way “believable” from an energy efficiency perspective. Sweden’s 63% increase in energy intensity is an example: if we compare Finnish and Swedish numbers, common sense tells us that this is not a realistic assessment of the energy efficiency development. The first explanation that comes into mind is that the product assortment has changed towards a more energy intensive and less valuable production, a.k.a. pulp production. Looking at the statistics, this is not the case, so the truth is to be found deeper, in the products and product groups. UK’s 44% increase in unit consumption is not a reasonable measure of energy efficiency development either but might be the result of installing TAD to tissue mills. Lithuanian decrease in unit consumption could be explained by a shutdown of old and inefficient paper mills and the building new ones instead. Figure 7 and Figure 8 in Chapter 3 tell us that Lithuanian pulp and paper production facilities are comparably young. Lithuania has one of the lowest unit consumptions for paper. The unit consumption of pulp and paper is very low, especially if it encompasses any kind of pulp production. Pulp production volumes are not reported separately for Lithuania in ODYSSEE (2019). The question arises,

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[14] The expected update to ODYSSEE values for Finland will be 65 729 TJ for electricity and 248 938 TJ for total final energy consumption.

how are the energy inputs and outputs calculated for Lithuania in ODYSSEE statistics? Is the pulp production volume added to the paper production volume? From ODYSSEE raw data we do notice that bioenergy is just about not used, mainly electricity and gas. Is all wood use accounted for as feedstock and none as energy input?

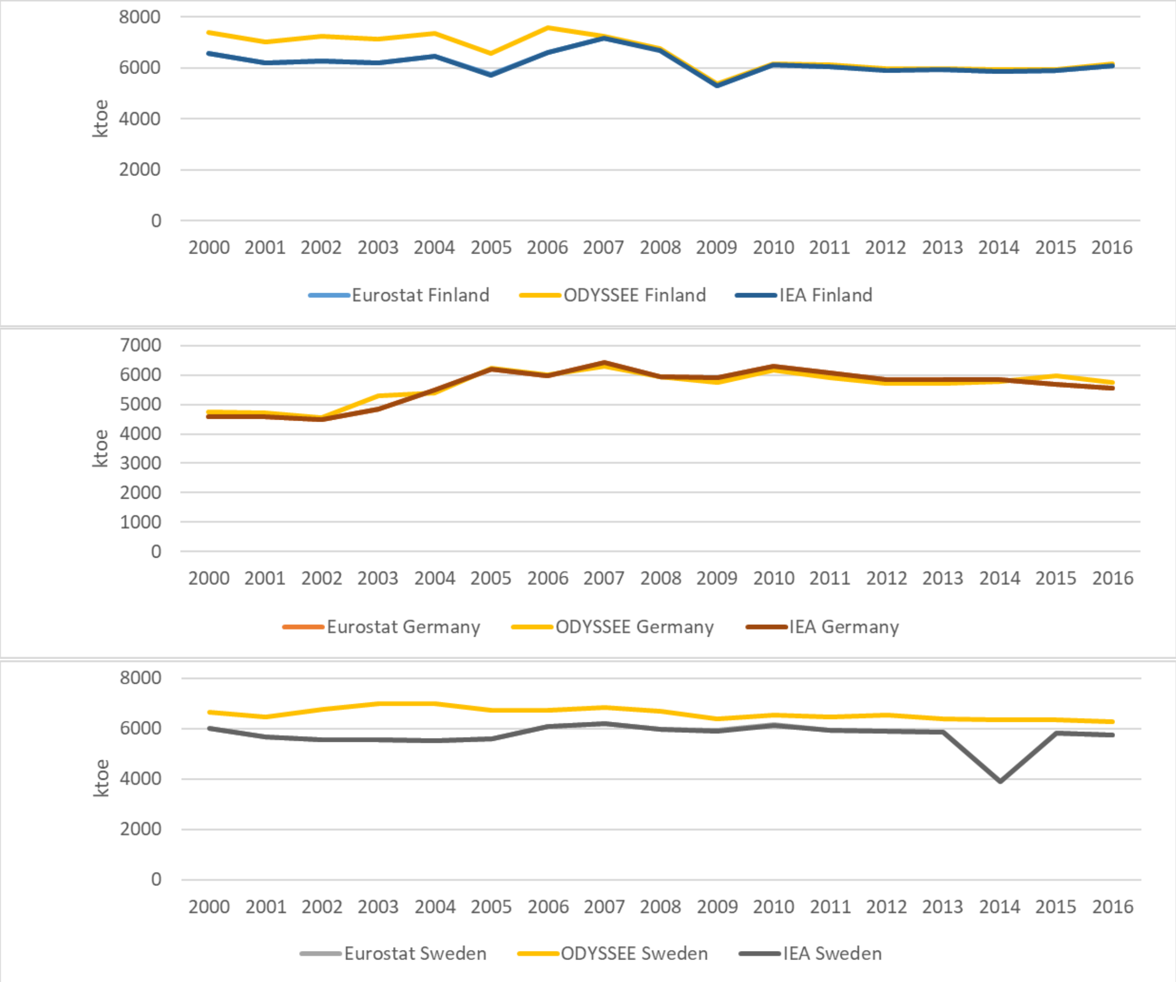

Figure 18. Final energy consumption of paper, pulp and printing between 2000 and 2016 in Finland (top), Germany (middle) and Sweden (bottom) according to the IEA, Eurostat and ODYSSEE. Data sources: IEA 2019, Eurostat 2019, ODYSSEE 2019.

5.5 Data summary

In conclusion, available data is not ideal. To be able to properly estimate changes in energy efficiency, we would need much more disaggregate data. That printing energy is combined with the energy needed for pulp and paper production is already disturbing, especially when comparing subsector intensities between countries, but we really would need more product specific data. For example, chemical pulp energy use differs from that of mechanical pulp, paper production needs less energy than chemical pulp production and tissue production is more energy intensive than newsprint production. Confidentiality issues form a hindrance if we demand data from at least 3 to 5 utilities before it can be published. Most countries may not have that many producers for most of the products. Nevertheless, without such disaggregate data, any bold statements on energy efficiency development should be avoided as structural change or activity might be more prominent explainers of energy use fluctuations.

Data series break points can be seen, which is to be expected, but this weakens the use of longer time series. And, data that should be similar, is not; either due to different definitions or sometimes even due to errors. In addition, the data input is not that trustworthy for all countries or sources in all cases, as these few studied examples already bring to light (negative value added for printing, strange statistical dips in energy use in some sources).

Used data series always have a starting year. If selected “badly”, it can distort the trend results. For example, 2000 was a very warm year in Finland, which can have its ramifications for weather dependent energy uses. For Finnish pulp and paper, the year 2005 is unfortunate as there was a six weeks long pulp and paper industry shutdown because of a skirmish with the labour union. This affected both value added and energy use of the pulp, paper & printing sector. Pulp, paper and printing energy use is nearly 60% of the overall energy use of the manufacturing industries, so this aberration is noticeable at all levels of Finnish statistics. The deep financial recession put a remarkably clear notch in 2009 energy usage and value added data, on all levels.

6. Conclusions

This study shows that Finnish pulp and paper production is well among its peers efficiency-wise. Finnish facilities and processes are generally on par or better in comparison with the EU average, according to the simulation results. Finnish pulp and paper mills on average are big, efficient and modern in comparison to the EU's average. In total energy use, Finland is close to the EU average in each major grade. For example, Finland is the second most energy efficient producer of kraft pulp, better than Germany and Sweden, despite the need for additional heating due to colder climate. The cold climate increases the need for steam up to 6% compared to Portugal and around 1% compared to Sweden. Market pulp production is the most energy efficient in the EU.

Traditionally energy intensity, as energy use per gross domestic product or value added of a given sector, has been used as a simple indicator, but decision-makers are more and more being taught that it is not such a good indicator. It is a lousy indicator for bulk producing energy intensive industry sectors. In fact, the IEA and others have noted that and are stating it. While Finland's unit consumptions of pulp and paper are very good in comparison with other countries, energy use per value added for the pulp, paper and printing branch is quite bad compared other countries. This is because of the large share of low value, high energy pulp (and paper) production compared to the relative small share of high value, low energy printing in Finland.

The statistics show that the Finnish pulp and paper industry is competitive energy-wise. A country with no pulp production and only recycled fibres and pulp imports can very well show better energy efficiency, but it does not mean that the processes are more energy efficient than in Finland. The EU country average of the unit consumption of pulp and paper is 3.7 $MWh/t_{pulp\&paper}$, and Finnish unit consumption is 9% lower.

Low rankings in ODYSSEE's Industry Scoreboards is not a result of inefficient production but of a badly designed indicator. As chemical pulp production especially is more energy intensive than board or paper production, there is no way we can leave produced volumes of pulp out of the equation, as ODYSSEE has been doing up to the end of 2019, without seriously harming the result's trustworthiness. The results would show a bias against all countries also producing pulp, as the energy is counted but not the physical production. As the pulp and paper sector has such a tremendous importance for Finnish industrial energy use, a methodological shortcoming such as this would seriously affect the comparability and usability of any result.

Aside from product assortment, which explains a lot of the differences between countries, the share of kraft market pulp is also a big issue for energy efficiency assessments. The export of market pulp has almost three folded in Finland in ten years, and that leaves a mark on the energy efficiency development. In addition, climate, feedstock and end-product quality (thinness/unit weight, finishing etc.) all impact the energy use and thus the scored energy efficiency. If we harmonised the energy uses according to all of these explaining factors, it is safe to assume that Finnish energy efficiency would be very competitive compared to most other countries.

The disaggregate level of data used is a major issue. To get understandable and well working indicators, we would need a deeper disaggregate level for the statistical data than what is available today. For example, pulp and paper production should be separated and analysed based on production at an adequate level, at least for major grades. On the other hand, the deeper we try to burrow into the data, the less trustworthy it becomes, and the more it will hit the wall of confidentiality, not a good thing either. If we demand data from at least 3 to 5 utilities before it can be published, most countries may not have that many producers for most of the major grades. Studies based on mill process data, as collected and done by consultants, give deeper insights than the top-down statistical analyses that can be made with today's data, and if possible, should be preferred for country comparisons.

There are other data issues than availability at desired disaggregate level, both regarding correctness and continuity. Should the results of any studies be taken at face value? No, rather not, although the more a study is specialised on some subsector, the better chance there is that the errors are minimal.

Recommendations and fast-forward actions

Generally, the main benefit of energy efficiency study results is that they raise questions: “That is strange, why is this number for this country this high?” The answer to that takes us deeper into the data until we find the underlying reason. It is not so seldom a data, statistics or analysis structure issue. That is a reason for cautionary words. Indicators are only indicators, not the truth. The better the indicator has been planned and executed, the more usable the results, but as it is, the data and indicators for industry branches and subsectors that we have at our disposal do not warrant any too deep going conclusions.

To compare countries with each other is something that should not be made without excellent and detailed tools and those are not yet made. Especially the possibility to improve the energy efficiency of a pulp or paper mill with the flick of a pen, by outsourcing onsite energy production and thus losses, is very relevant today, but perhaps should not be in the future?

The collection of more disaggregate statistical data together with stricter data definitions could and would improve energy efficiency analyses in Finland and the rest of Europe. The organisation of such a task would include authorities, statisticians, industry interest organisations and industries themselves and researchers.

References

CEPI statistics 2019. The Confederation of European Paper Industries. Key statistics 2018. European pulp & paper industry. http://www.cepi.org/system/files/public/documents/publications/Final%20Key%20Statistics%202018.pdf

Ecofys 2009. Ecofys, Fraunhofer Institute for System and Innovation Research and Öko-Institut. Methodology for the free allocation of emission allowances in the EU ETS post 2012. Sector report for the pulp and paper industry. November 2009, by order of the European Commission, study contract 07.307/2008/515770/ETU/C2.

Economidou M. 2017. Assessing the progress towards the EU energy efficiency targets using index decomposition analysis, EUR 28710 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-71299-9, doi:10.2760/675791, JRC106782.

Eurostat 2019. Eurostat database. Complete energy balances [nrg_bal_c].Data last extracted on 22.11.2019

Eurostat guide 2019. Energy balance guide (31.1.2019). Methodology guide for the construction of energy balances & Operational guide for the energy balance builder tool.

FFI 2019. Finnish Forest industries, Statistics of Pulp and Paper industry. Website. https://www.forestindustries.fi/statistics/pulp-and-paper-industry/

Fisher 2018. The European Containerboard Market. Fisher webinar 12.4.2018. http://www.fisheri.com/fi-insight/the-european-containerboard-market/

Fisher 2019. Fisher International: Energy Efficiency of Paper Industry in EU. Study for Finnish Forest Industries. 2019

Graus, W., Worrell, E. 2011. Methods for calculating CO2 intensity of power generation and consumption: A global perspective. Energy Policy, 2011. 39(2): p.613-627.

IEA 2014. Energy Efficiency Indicators: Fundamentals on Statistics. OECD/IEA.

IEA 2017. Energy Efficiency Indicators: Highlights. OECD/IEA 2017.

IEA 2019. "Extended world energy balances", IEA World Energy Statistics and Balances (database), https://doi.org/10.1787/data-00513-en (accessed on 24 November 2019).

Koreneff, G. 2018. Energy efficiency: can we easily compare countries? Espoo, VTT. 78 p + app. 4p. VTT Research report VTT-R-07000-18. https://cris.vtt.fi/ws/portalfiles/portal/22787003/VTT_R_07000_18.pdf

Minor, J.L. 1994. Hornification—its origin and meaning. Progress in Paper Recycling, Feb 1994, 3:93–95.

ODYSSEE 2018a. Decomposition tool. Interactive web site, last visited 30.11.2018. http://www.indicators.odyssee-mure.eu/decomposition.html

ODYSSEE 2018b. ODYSSEE Scoreboard -interactive web site. Last visited 9.12.2018. http://www.indicators.odyssee-mure.eu/energy-efficiency-scoreboard.html#scoreboard

ODYSSEE 2018c. ODYSSEE Scoreboard methodology. Short memorandum found at web site. Last downloaded 19.11.2018. http://www.indicators.odyssee-mure.eu/php/odyssee-scoreboard/documents/methodology-odyssee-scoreboard.pdf

ODYSSEE 2018d. Definition of data and energy efficiency indicators in ODYSSEE data base. Documentation at website, last downloaded 27.11.2018.

ODYSSEE 2019. ODYSSEE database, October 2018 version. Interactive web site, last visited 22.11.2019. https://odyssee.enerdata.net/database/

Pöyry 2016. Pöyry Management Consulting Oy. Suomen metsäteollisuus 2015 – 2035. Loppuraportti 19.1.2016 Työ- ja elinkeinoministeriölle. [In Finnish; Finland's forest industry 2015-2035. End report 19.1.2016 to the Ministry of Economic Affairs and Employment of Finland.]. https://tem.fi/documents/1410877/2772829/P%C3%B6yry_Suomen+mets%C3%A4teollisuus+2015-2035.pdf/ac9395f8-8aea-4180-9642-c917e8c23ab2

StatFin 2015a. Official Statistics of Finland (OSF): Energy use in manufacturing [e-publication].ISSN=1798-7776. 2015, Appendix table 3. Total electricity consumption in manufacturing 2015. Helsinki: Statistics Finland [referred: 1.10.2019]. Access method: http://www.stat.fi/til/tene/2015/tene_2015_2016-11-03_tau_003_en.html

StatFin 2015b. Official Statistics of Finland (OSF): Energy use in manufacturing [e-publication]. ISSN=1798-7776. 2015, Appendix table 2. Energy use in manufacturing by industry 2015. Helsinki: Statistics Finland [referred: 1.10.2019]. Access method: http://www.stat.fi/til/tene/2015/tene_2015_2016-11-03_tau_002_en.html

StatFin 2017. Official Statistics of Finland (OSF): Energy use in manufacturing [e-publication]. ISSN=1798-7776. 2017, Appendix table 2. Energy use in manufacturing by industry 2017. Helsinki: Statistics Finland [referred: 22.11.2019]. Access method: http://www.stat.fi/til/tene/2017/tene_2017_2018-11-19_tau_002_en.html

StatFin 2018a. Official Statistics of Finland (OSF): Energy use in manufacturing [e-publication]. ISSN=1798-7776. 2018, Appendix table 2. Energy use in manufacturing by industry 2018. Helsinki: Statistics Finland [referred: 22.11.2019]. Access method: http://www.stat.fi/til/tene/2018/tene_2018_2019-11-01_tau_002_en.html

StatFin 2018b. Energy year 2017. Table 1.9.1. Energy balance sheet 2017. At Energy 2018 table service, https://pxhopea2.stat.fi/sahkoiset_julkaisut/energia2018/ .

StatFin 2018c. Energy year 2017. Table 6.2. Electricity consumption by branch of industry. At Energy 2018 table service, https://pxhopea2.stat.fi/sahkoiset_julkaisut/energia2018/ .

Appendix A. Grade definitions for packaging and communication

Table A1. Grade definitions for packaging and communications grades (Fisher 2019).

Major Grade	Grades	Definition
Packaging	CRB	Coated Recycled Board, used as coated folding cartons (cereal boxes etc.)
	FBB	Folding Boxboard contains mechanical pulp, contains e.g. liquid packaging boards, cup&plate, folding carton
	Packaging Paper	Kraft paper products, e.g. bags and wrapping papers
	Recycled Containerboard	Recycled liner and recycled corrugated medium, used to make boxes
	SBS	Solid Bleached Sulphite, made 100% from chemical pulp. Contains liquid packaging boards, cup&plate, folding carton
	SUK	Solid Unbleached Kraft contains <50% of recycled fiber. Products are Folding Carton, Chipboard and Tube and Core
	URB	Uncoated Recycled Board
Communications	Virgin Containerboard	Contains kraftliner and virgin corrugated medium contain >50% of virgin fiber
	Groundwood	Coated and uncoated papers used in offset printing, containing mechanical pulp. Referred in Europe as mechanicla grades. Products are e.g. LWC, SC
	Freesheet	Coated and uncoated high quality printing papers ("Fine Papers") containing < 10% of mechanical pulp. E.g. Copy paper, art paper