RESINDUSTRY
Interreg Europe

European Union
European Regional
Development Fund

Market Analysis

of energy intensive industries and RES integration potential

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CONTENTS

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ABBREVIATIONS

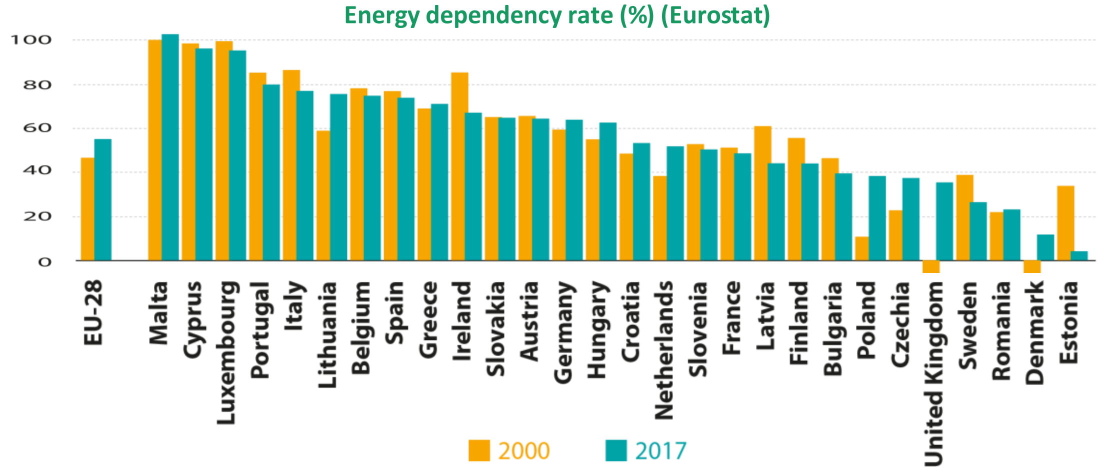
CAPEX	Capital Expenditure
CO^2	Carbon dioxide
DNI	Direct normal irradiance
EEA	European Environment Agency
EJ	Exajoules
EREC	European Renewable Energy Council
FTE	Full-time equivalent employment
GHG	Greenhouse gas
GJ	Gigajoules
GVA	Gross value added
GW	Gigawatt
GWh	Gigawatt-hour
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
IRENA	International Renewable Energy Agency
JRC	Joint Research Centre, European Commission
Kgoe - Koe	Kilogram of oil equivalent
kW	Kilowatt
kW e	Kilowatt electric
kW th	Kilowatt thermal
kWh	Kilowatt-hour
LCOE	Levelised cost of energy
M.A.	Market Analysis
MEAE	Ministry of Economic Affairs and Employment Finland
Mtoe	Million tonnes of oil equivalent
MW	Megawatt
MWh	Megawatt-hour
O&M	Operation and Maintenance
OECD	Organisation for Economic Co-operation and Development
OPEX	Operational expenditures
PJ	Petajoule
PV	Photovoltaics
RES	Renewable energy sources
TFC	Total final consumption
TJ	Terajoules
Toe	Tonne of oil equivalent
TPES	Total primary energy supply
TW	Terawatt
TWh	Terawatt -hour
USD	United States Dollar
WIFO	Austrian Institute of Economic Research

I. INTRODUCTION AND LOGIC OF THE ANALYSIS

I.I. INTRODUCTION TO THE TOPIC

In 2017, the EU imported 55,1% of all the energy it consumed, which creates a scenario of potential instability in the economic sectors with high dependency on the energy bill.

Energy dependency rate (%) (Eurostat)



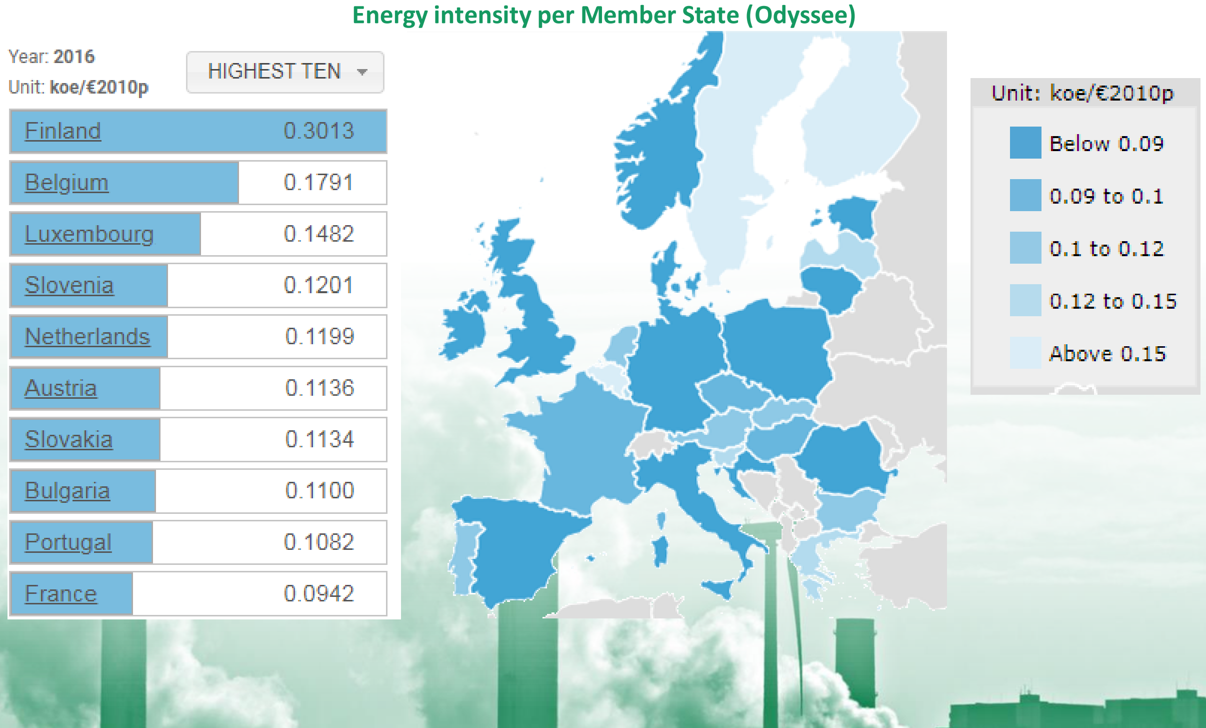
In 2017, the industry sector gathered the 24,6% of this European energy dependency, being one of the sector which can be more affected by external instabilities, where changes in the energy bill are directly transferred to the companies production, and thus jeopardizing their economic sustainability.

The EC has been deploying specific policies to avoid this energy dependency of the industry sector, by both increasing the energy efficiency of the sector and promoting the energy independency through RES integration in industry. Member States have been implementing the EC recommendations, but with quite different results across Europe.

The indicator "**Final energy intensity in industry**" has been established to measure the results of this double policy implementation, allowing to measure all over EU the energy consumption for a unit of value added in the industry.

Currently, there is a significant difference between the most energy intensive Member States, and the least energy intensive ones. Most of the MS have achieved to decrease energy intensity in industry in the last 10-15 years, but not all of them have achieved it, and especially not in the same proportion.

Energy intensity per Member State (Odyssee)



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Notable decreases of the energy intensity in industry have been registered in most of Central and Eastern EU countries such as Romania, Bulgaria, Czech Republic, Poland, Slovak Republic and Estonia, but even in these cases the general indicator is kept over the EU average.

The conclusion is that some countries have achieved larger reductions in the energy intensity, but a large part of the reduction is still pending until they reach the expected targets, while other countries are decreasing slower than expected or even increasing their dependency.

Energy intensity of industry (at purchasing power parities) of the **RESINDUSTRY** partners is a sample of the EU situation, with countries which have had good reductions rates on the last years, and others have even increased their energy intensity in industry.

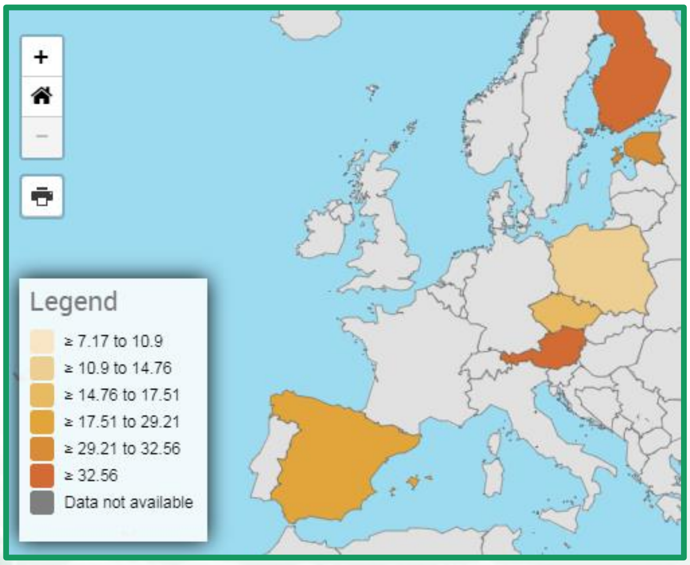
Energy intensity in industry, RESINDUSTRY countries (Eurostat)

Country	2000 (koe/€2010p)	2016 (koe/€2010p)	Rate
Czech Republic	0,2173	0,09	-59%
Poland	0,1553	0,0674	-57%
Estonia	0,1537	0,0684	-55%
Spain	0,0947	0,0702	-26%
Finland	0,363	0,3013	-17%
Austria	0,1059	0,1136	7%
Malta	0,0267	0,0304	14%
European Union	**0,1233**	**0,0912**	**-26%**

RESINDUSTRY project, funded by the Interreg Europe Program with European Regional Development Fund (ERDF) for 2014-2020, aims to increase the energy independency of the EU industry sector, by decreasing its energy intensity through a higher integration of RES.

The long-term objective of RESINDUSTRY is to increase the industry competitiveness of the industry by decreasing its energy bill, rising their energy independency, thus uncoupling their energy costs from geopolitical externalities. To achieve these long-term strategic objectives, the short-term objectives are to booster RES investment in industry by improving regional and national policies for RES promotion.

RESINDUSTRY MS, 2017 share of RES



RES integration in the selected regions is also diverse, with countries presenting good national RES integration, such as Extremadura (Spain), Vorarlberg (Austria) and Päijät-Häme (Finland), while other regions like Gozo (Malta) or Prague (Czech Republic) shows lower RES integration than the EU average.

The knowledge gathered in those regions which have good experience can support other regions and parts of Europe in faster developing more effective and efficient support tools to increase RES share in industry.

This is the logic of the project RESINDUSTRY, to analyse the departure line of every region, and to try to reach final destination by designing more effective policy tools which are based on the best experiences of other European regions.

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I.II. BACKGROUND TO THE MARKET ANALYSIS

In order to reach the long-term objective of RESINDUSTRY, rising the energy independency of the regional/national industries, the project focuses on improving the efficacy of public financing and public tools which support the RES implementation in the industry sector.

As public financing and support is limited, the objective of Managing Authorities is to create tools which can supply the highest impact on the sector with the smallest public resources investment, being as cost-effective as possible, and achieving the largest socio economic benefits to the space.

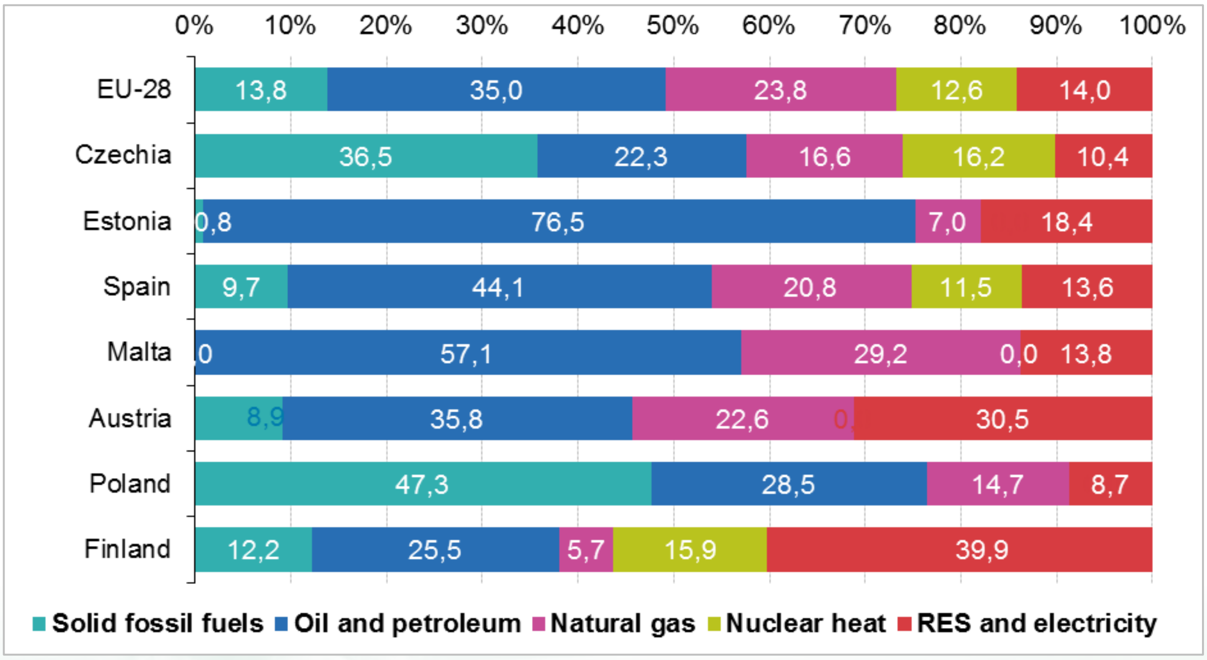
The first step in this process is to identify the current situation of the sector on the area to be influenced. The current situation analysis is called in many ways in the Interreg Europe community, such as regional identification, state of art, regional analysis, etc. and the name provided in Resindustry is Market Analysis.

The **Market Analysis** includes a macro analysis of the industrial sector, identifying the industry energy consumption profiles, and analysing the RES technologies with potential to be applied in the national industries. Both, the industry profiles and RES technologies, are analysed using macrodata, from national official sources, and they are completed when other official local or regional data is available or supplied by local actors.

The energy consumption of the industry, in each region and country, will defer greatly depending on the resources availability (gas, coal, nuclear, etc.), either national or from the neighbourhoods, while the future perspective will only depend on the natural resources available on the spot.

At EU level, the energy consumption in industry is currently lead by the natural gas, but it can swift to coal or electricity depending on the country and their resources. These national and regional peculiarities will influence the M.A. results and the defined Key Performance Indicators (KPI), because they have to take into account economic sustainability of the industries.

Share energy consumption by fuel, RESINDUSTRY countries (Eurostat 2017)



M.A. Objective.

The Market Analysis is also referred in the RESINDUSTRY project as a "Strategic Analysis of RES Technologies applied in industries". This analysis provides each partner with a report of energy and socioeconomic Key Performance Indicators (KPIs) which will be used to review grants management in the P.I., so the M.A. will improve the way thematic calls are organised and/or the way projects are selected.

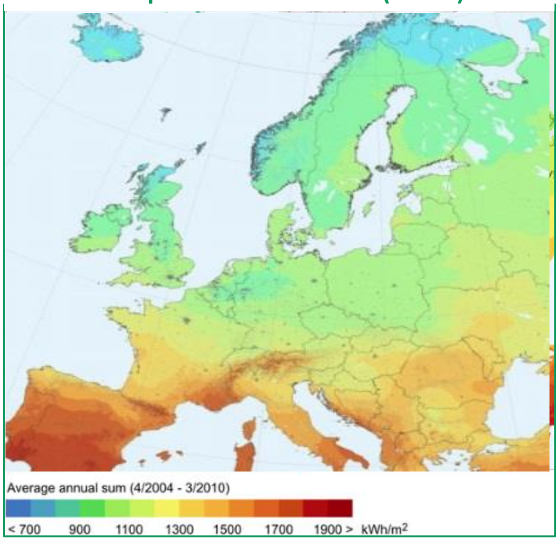
This analysis will provide, for each technology with capacity to be integrated in the national/regional industry, a description of KPI indicators in terms of energy generation, value-for-money, jobs creation, environmental impact, etc.

M.A. is the base source of information for the Regional Assessment, where the partners will integrate the information coming from the Best Practices and the M.A. data, and will obtain the final situation of the regions.

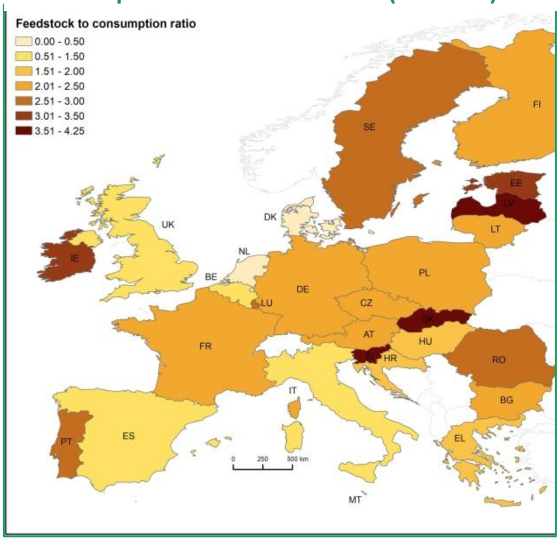
Key Performance Indicators (KPIs) will vary between partners, because they analyse the specific region necessities/resources, and provide customized solutions to confront the RES benefits vs the policy investment.

In a similar way than the current profile of the industry energy consumption will be a main baseline condition for the identification of RES technologies with best economic opportunities, the natural resources available in each region will influence on the efficiency of technologies, resulting in different KPIs for the different partners.

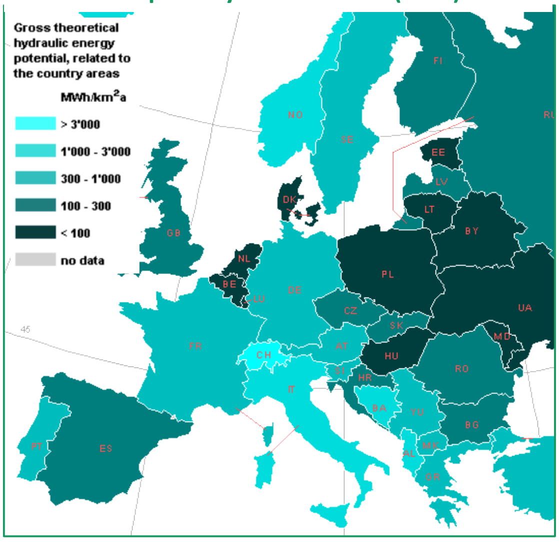
European solar resources (PVGIS)



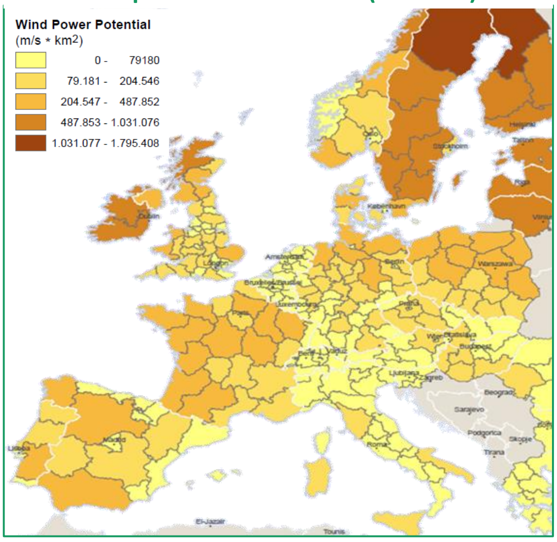
European biomass resources (Eurostat)



European hydro resources (WEC)



European wind resources (Eurostat)



M.A. Conclusions.
The M.A. will describe all the macrodata related to national industrial energy profiles (and, if official data exist, of the region), proposing a list of RES technologies and KPIs in the area.

The M.A., together with the Best practices, will feed into the Regional Assessment, that will be the departing point for the Action Plan, thus M.A. will directly feed in the AP. The Action Plan will use the information of the sectorial analysis to define new policy tools and design the actions to be implemented in phase 2.

The Policy Instrument will thus be influenced by the actions included in the Action Plan, which will be based on the conclusions of both M.A. and Regional Assessment.

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I.III. METHODOLOGY

The M.A. has followed a methodology structured in several phases where the data was gathered, processed, verified, agreed and delivered. The objective of the Methodology was to assure that the final product (M.A.) will support the partner in the Regional Assessment construction and final PI improvement. The final data, in addition to being technically reliable, will have to count with the review of the experts and the stakeholders in order to be integrated in the final Regional Assessment.

- **Desk analysis**

The Analysis was carried out at macro data, using statistical sources, mainly national statistic agencies, European statistic bodies or sectorial reports both at national and EU level.
These reports can provide most of the information related to the economic, education and industry sectors, their trends and SWOT, while in some cases they also provided energy data about consumption profiles, aggregated consumptions or energy market composition.
In terms of policies, they were also gathered in this stage, identifying the current targets and level of achievements for EU, National and regional policies.

- **Industry data gathering**

When necessary, deeper detailed information was analyzed from sectorial researches, or even on-site data gathering. For the detailed data gathering, specific tools were used for data collection.
This information allowed working on the details of the key performance indicators, together with additional information which was collected in the following stages.

- **Key performance indicators practice structure definition.**

Following the desk research, and based on some data gathering, the M.A. identified preliminary KPI to be analysed in depth in the following stages. These socio economic indicators were an initial measurement tool for the adequacy of the industries to be evaluated in the best practices.

- **Best practice structure definition and Best Practices edition.**

Consortium defined a template of data gathering for the industries to be analyzed in the Best Practices. This template was an extra tool to be used by the regional institution if necessary, to gather complementary data for the sectorial analysis. These templates included economic and environmental data, which were to be used on the BPs definition, and which will be compared with the KPIs calculated in the M.A.

The regional institution, supported by the external expert, gathered as much information as possible from regional industries in order to create the internal BPs. These BPs were added as annex to this MA, and a final comparison of KPIs was created, if the BPS had the necessary technical data to be comparable.

- **Validation process**

The KPIs from the M.A., based mainly in national reports and statistical data, were compared with the best practices results, in and additional comparison report added as an Annex in this M.A. document.
The Market Analysis, validated by partners, will be the base of the Regional Assessment, which will include the "Strategic Analysis of RES Technologies for regional industry" and KPIs report. The Regional Assessment will be based 90% on the present M.A. and the results from the internal BPs.

The best among the best practices were selected, in order to be proposed to the Policy Learning Platform of Interreg Europe.

- **Results**

The results and conclusions from the Market Analysis will be the base for the definition of the Action Plan structure, which will be based on the sectorial necessities of the industry in the region. Thus, the conclusions of this document will be aimed to the final integration in the Action Plan structure.

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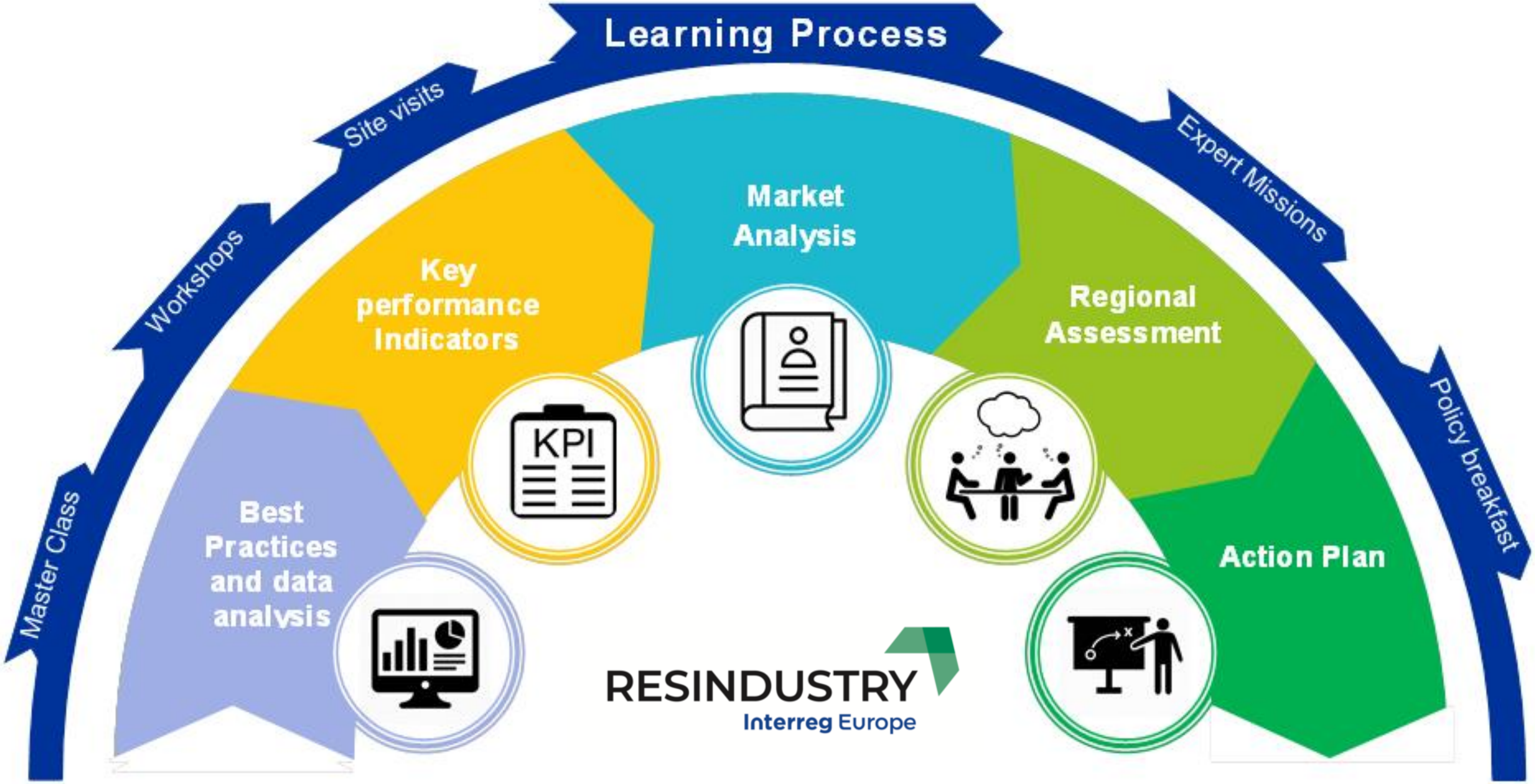
Learning Process
Master Class
Workshops
Site visits
Expert Missions
Policy breakfast
Best Practices and data analysis
Key performance Indicators
KPI
Market Analysis
Regional Assessment
Action Plan
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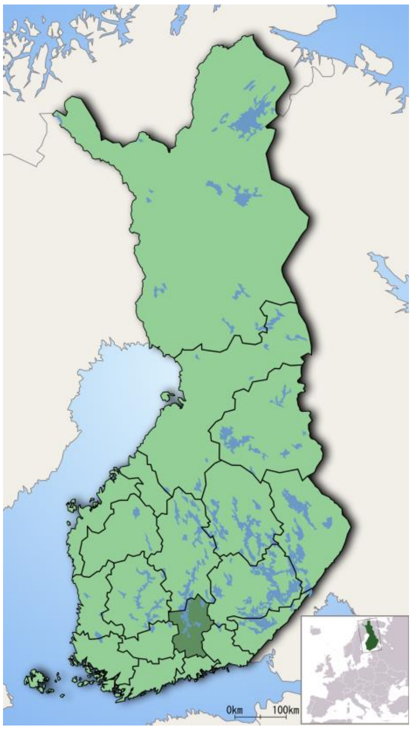
II. THE REGION UNDER ANALYSIS

Finland gained independence in 1917, following a very long period of foreign rule that included seven centuries as part of Sweden and one century as part of the Russian Empire.
As a consequence of the two wars against the Soviet Union in 1939–40 and 1941–4, Finland underwent a rapid and initially complicated economic and social transition. Having been an agrarian country until the 1930s, Finland experienced a period of rather rapid urbanisation and industrialisation from the early 1950s on.



The Finnish welfare state and its administrative institutions had begun to develop in stages already in the 1940s. Like the other Nordic countries, Finland gradually transferred responsibility for the provision of welfare services from central government to the municipalities. Therefore, Finland is a unitary state with a strong local government, clearly corresponding to the Nordic administrative tradition.

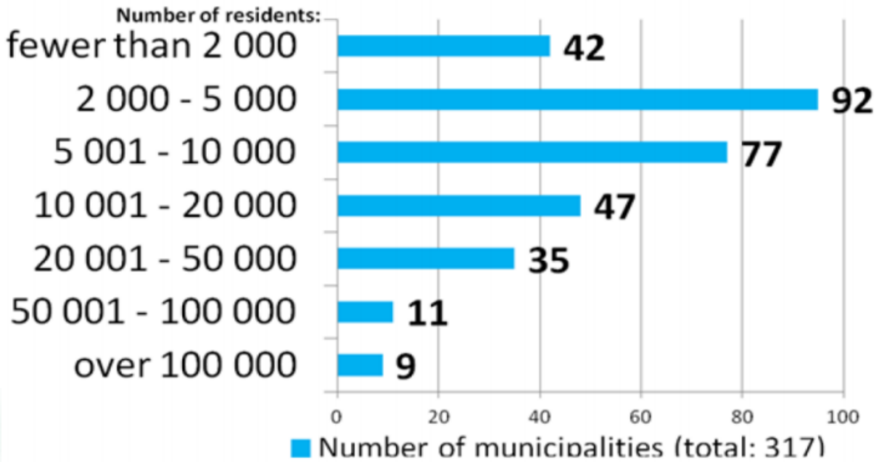
Today, Finland is characterised by a combination of strong central powers, extensive local autonomy and consensual processes of decision-making. As a result, Finland has been labelled a decentralised unitary state and primarily a consensus democracy.

In 2017, Finland is divided into:
- 19 regions (Finnish maakunta, Swedish landskap)
- the regions are divided into 70 sub-regions (Finnish seutukunta, Swedish ekonomisk region
- the sub-regions are divided into 311 municipalities (Finnish kunta, Swedish kommun).

The Finnish municipal system is characterised by a division into political and professional management. The local authorities can organise municipal government relatively freely.

Each municipality must have a municipal council, which is the main decision-making body, a municipal executive board, an auditing committee for auditing municipal administration and finances, and an election committee, which is responsible for organising elections.

Number of municipalities in Finland by population size 2015 (Congress of Local and Regional Authorities)



Regional Council of Päijät-Häme is one of the 19 Finnish Regional Councils. The main tasks of the Council are the regional plan for land use (including traffic) and the administration of the European Union Regional Funds. The Council also creates and manages the regional strategies with the stakeholders.

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The region of Päijät-Häme,

The city of Lahti represents the geographical and functional centre of the region of Päijät-Häme. It is situated 100 km north of the Finnish capital Helsinki. Today Lahti can be reached from the Helsinki City Centre by train or international airport Helsinki-Vantaa by bus in just 60 minutes.

The landscape in the region is dominated by green forests and unspoiled pure lakes enriched by undulating forms of the Salpausselkä ridge. The region of Päijät-Häme can be called the heart of Finland, as the life in the post ice age period started from the surroundings of Lake Päijänne in the rural area of Asikkala.

Twelve municipalities belong to the region of Päijät-Häme: the cities of Lahti, Heinola and Orimattila, and the municipalities of Hollola, Sysmä, Asikkala, Hämeenkoski, Hartola, Nastola, Kärkölä, Padasjoki and Artjärvi. Today the region of Päijät-Häme offers a balanced mixture of original Finnish traditions and a modern way of life.

Surrounded by a charming scenery about 200,000 people live here, half of them in the regional centre of Lahti. A fifth of the Päijät-Häme regions 6,295 km2 is covered by lakes. The third largest lake of Finland, Lake Päijänne, dominates the region with its natural beauty. Apart from its significance for the touristic development of Päijät-Häme, it is also an important drinking water reservoir for the whole Southern Finland.

Päijät-Häme geography and facts (Chamber of Commerce)

FACTS

- Location: Southern Finland
- Population: 200.000
- Area: 6.300 km2
- Area of water 1,125 km2
- Density: 39 inhabitants/m2
- Number of households: 94.491
- Number of businesses: 9.739
- Number of lakes and ponds approx. 1,000
- Coastline approx. 5,500 km

- Main cities: Lahti, Heinola and Orimattila
- Municipalities: Hollola, Sysmä, Asikkala, Hämeenkoski, Hartola, Nastola, Kärkölä, Padasjoki and Artjärvi.

- Language: Finnish about 96 %

- Main education hubs: LAB University of Applied Sciences, Salpaus Vocational School, Lahti University Campus
- Main tourist attractions: Lahti Ski Jumping Hills, Sibelius Hall, Radio & TV Museum, Motorcycle Museum of Finland, Musical Fountain

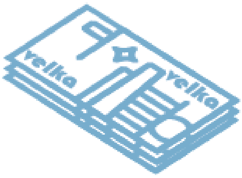
III. THE NATIONAL ECONOMIC CONTEXT

III.I. NATIONAL AND REGIONAL ECONOMIC TRENDS

Following a long and deep recession, Finland's economy is growing in 2019 healthily, although at a decelerating pace. Finland's current economic growth provides an opportunity to increase the economy's resilience and its growth potential amid rising macroeconomic risks.

Finland shows low social inequality and its education system is performing well. However, an ageing population weighs on Finland's potential growth for the future.

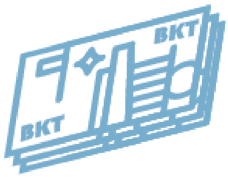
CENTRAL GOVERNMENT DEBT 2018



18 977
€/inhabitant

GDB 2018 preliminary data

42 340
€/inhabitant



MICRO ENTERPRISES [1)] 2017

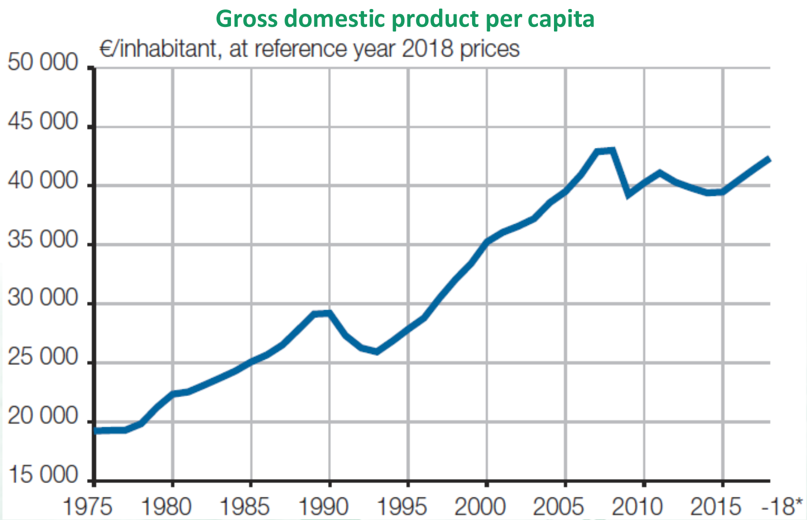
95%
of enterprises

BANKRUPTCY PETITIONS 2018

2 534

1) Number of employees under 10

Strong economic growth continued in 2018, with GDP eventually passing its peak of 2008. Real GDP is expected to have increased by 2.5 % in 2018. Solid growth was underpinned by robust domestic demand while the contribution from net exports, which was very strong in 2017, weakened.



Business investment is set to continue expanding, supported by rising profits and persistently low interest rates. Inflation remains below the EU average.

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The favourable economic cycle is helping the government further consolidate public finances, bringing the public debt ratio below 60 %.
Going forward, Finland's economic growth is projected to be moderate at an average annual rate of 1.8 %, from 2.6 % over the previous three years, particularly as international trade expansion gradually loses momentum.

The labour market continues to recover, showing early signs of tightening. The employment rate has now reached a new high, but is still lower than in other Nordic countries.
Employment growth accelerated in 2018, with more than half of new workers being previously inactive. This trend should continue in 2019 and 2020, albeit at a slower pace.

National population aged 15 to 74 by activity (Statistics Finland 2019)

	2000	2010	2017	2018
Population aged 15 to 74, thousand	3 901	4 043	4 114	4 124
Labour force	2 589	2 672	2 707	2 742
Employed	2 335	2 447	2 473	2 540
Unemployed	253	224	234	202
Inactive population	1 312	1 372	1 407	1 382
Labour force rate, %	66.4	66.1	65.8	66.5
Unemployment rate, %	9.8	8.4	8.6	7.4
Males	9.1	9.1	8.9	7.4
Females	10.6	7.6	8.4	7.3

The unemployment rate has declined, rapidly approaching its structural level. The latter improves, but remains relatively high, reflecting disincentives to take up work and growing matching problems in the labour market. Job vacancies are rising in certain sectors, due to skills shortages, mobility problems and the ageing population.

The region of Päijät-Häme,
In the Regional Council of Päijät-Häme strategic planning and management has been in focus during the recent years. The intension is to create a continuous, iterative strategic decision process which gives an opportunity to learn about the future and to define the strategy step by step.

Another ambitious objective is to connect better general guidelines, individual measures, projects and activities. The Päijät-Häme Strategy and the Provincial Program 2018-2021 merged into one documentary featuring the province's smart specialization, the EU's RIS3 process-based analysis of regional strengths.
The current Structural Fund program and the previous provincial program period, the smart specialization points (RIS3) previously defined for Päijät-Häme were updated. But these four cutting-edge environmental technologies, practice-driven innovation, design and well-being - are now being explored. In particular, the emergence of various aspects of tourism as business promises new business.

Päijät-Häme has followed a specialisation development approach for more than two decades (since the early 1990s), when it was decided to focus on environment and environmental competences, among other sectors.

The following themes have been sketched out at the cutting edge of smart specialization in the formulation phase of the Regional Strategy 2018-2021:
- Circular economy: see p. Provincial circular economy strategy
- Design: Industrial, Information Design, Service Design
- Event and Wellness Tourism.
The first two proposed tips continue the lines of the previous smart specialization strategy, while the third has merged the former well-being and emerging tourism.

The goal of RIS is to raise the overall innovation environment to a new level, in such a way that the strong points of the region become stronger, lead to innovative results that consequently foster growth and increase of productivity.

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III.II. REGIONAL BUSINESS ENVIRONMENT

Päijät-Häme is in Southern Finland, and has especially good connections to the metropolitan area. Päijät-Häme's largest town, Lahti, is about an hour's journey by train or car from the capital Helsinki.
The population of Päijät-Häme was 200 681 at the end of 2018. In recent years, the population has decreased slightly due to both net natural population growth and net migration between municipalities. The share of the total population under 15 years of age is below the national average, while the share of those over 64 is above the national average.

In 2018, the region's employment rate of 70.6 % (15- to 64-year-olds) was the lower than the national average (71.7 %). However, employment grew from the previous year. The unemployment situation is slightly weaker than the Finnish average. The share of unemployed jobseekers of the total workforce was 12.6 % in Päijät-Häme in 2018 (employment statistics from the Ministry of Economic Affairs and Employment), i.e. the second highest among all regions.

Päijät-Häme has a varied business structure, with many SMEs engaged in export activities. The diversified economic structure strengthens the transformation flexibility and vitality of the area in the changing operating environment.
The change in the economic structure has diversified business in the region as the traditional industries have become weaker and the services sector has grown. However, industrial sectors continue to be more significant in Päijät-Häme than the Finnish average. The industrial structure is also considerably more varied than the regional average.

Relatively strong sectors in the region are the cereal/food/beverage sectors and the wood products, plastics and technology industries. The top smart specialisation sectors are (cleantech), design, physical exercise and experiences (tourism). A factor in the varied business structure is the region's strong entrepreneurial tradition. Päijät-Häme is also Finland's strongest family business region. The area also has strong food processing companies, and the region is a nationally important producer of cereals. The processing of food cereals is also focused in Päijät-Häme. There is also potential for the further development of tourism in the region, such as lake and nature tourism. The aim is to further increase the number of tourists in the area.

The area's largest private employers (in terms of staff numbers) are Osuuskauppa Hämeenmaa, UPM Plywood Oy, Etteplan Design Center Oy, Suomen metsäkeskus, Koskisen Oy, L-Fashion Group Oy, Versowood Oy, Wipak Oy and Raute Oy.

MAIN BUSINESS AREAS AND CLUSTERS

- Mechatronics: 700 companies, over 7000 employees. Major companies include: Kemppi Oy, Raute Corp., Makron Oy, Oilon Oy, Peikko Group Corp.
- Construction and furniture: 2900 companies, 17 000 employees. Major companies include: Isku Oy
- Wood processing industry: Versowood Oy and Koskisen Oy which are known globally.
- Food & Beverage: 3500 employees. Major companies: Hartwall Oy, Viking Malt Oy, Fazer Mill and Bakery.
- Welfare technologies and services: 2200 companies, 5000 employees. Major companies: Merivaara Oy.
- Textile and clothing industry. Major companies include: L-Fashion Group, Eurokangas Oy

ECONOMIC COMPETITIVENESS AND ADVANTAGES

- Internationally renowned forerunner in industrial design
- One of Finland's most important hubs for cleantech business and research
- Prime location near the Helsinki Metropolitan Area: 6 million people within 3 hour radius; fast connection to Helsinki Airport (~1 hour) and St. Petersburg (2,5 hours), logistically efficient location
- Cost efficient business premises, industrial sites and workforce
- Committed, skilled workforce

ADDITIONAL INFORMATION

- Häme is one of the nine historical regions in Finland. The province of Häme is centrally located near largest population and economic centers in Finland. The positive aspects of city life are combined with unique scenery and clean nature.
- Thanks to its location, Häme is easily accessible – you can get there from Helsinki and Helsinki-Vantaa airport in an hour by car, bus and train.

- The region consists of a network of small and medium-sized towns and communities. The oldest inland settlements in Finland are found in Häme. Lively events and dynamic citizen activity are an integral part of the culture in Häme. The region also has a long tradition of textile and glass design
- The countryside in Häme has remained strong and viable, and offers an excellent opportunity to get acquainted with Finnish nature. The landscape is varied in topography, featuring a multitude of different types of forests, lakes, marshland and ridges.

III.III. EDUCATION, SKILLS AND CAPACITY BUILDING

Päijät-Häme offers a wide range of professional training and vocational education and higher education opportunities (LAB University of Applied Sciences). Lappeenranta–Lahti University of Technology (LUT University) also operates in Lahti. University education in the area is provided by the University of Helsinki and Aalto University.

The regional education system performs in a similar way than the national level, where educational outcomes have declined and gaps between different groups have increased.

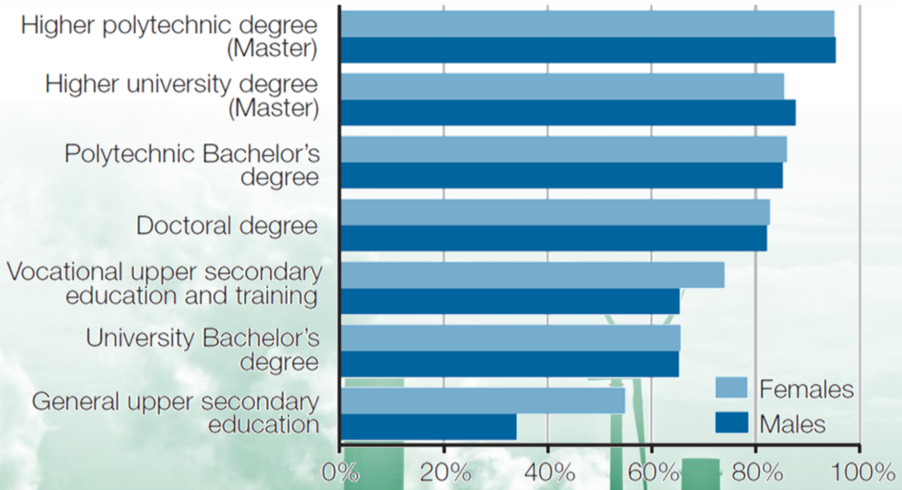
- Early school leaving increased slightly. It amounted to 8.2 % in 2017 compared to the EU average of 10.6 % with differences between young people in rural areas (10.1 %) and those in cities (7 %).
- The participation rate in early childhood education has improved. Between 2007 and 2016 it grew to 32.7 % for under 3-year-olds and to 87.4 % for those 4 years and older.
- Tertiary education attainment is high, but not for all social groups. 44.6 % of 30-34 year-olds have obtained tertiary education in 2017. The gender imbalance remains large and, in 2017, only 27 % of people not born in Finland had obtained tertiary education, much less than in other Nordic countries.
- The proportion of students in upper secondary education in vocational education and training remained stable in 2016 at the level of 71.3 %, which is well above the EU average of 49.3 %.

Population by level of education, 2017 (Statistics Finland 2019)

	Total	%	Females	%
Population aged 15 or over	4 622 706	100	2 358 607	100
Population with educational qualification, total	3 334 648	72.1	1 726 666	73.2
Upper secondary education	1 863 943	40.3	885 689	37.6
Post-secondary non-tertiary education	38 429	0.8	17 929	0.8
Lowest level tertiary education	436 426	9.4	268 435	11.4
Lower tertiary level	518 969	11.2	292 374	12.4
Higher tertiary level	431 146	9.3	241 915	10.3
Doctorate level	45 735	1.0	20 324	0.9
Only basic education	1 288 058	27.9	631 941	26.8

The national capacity to provide learning based on work experience is high and can be identified in the employability of the students after one year of training finalizations, where any level of training higher that secondary education achieves employment rates over 605 in the first year after graduation.

Employment of graduates one year after graduation, 2017 (Statistics Finland 2019)



IV. THE NATIONAL ENVIRONMENTAL CONTEXT

Finland is broadly on track to reach its Europe 2020 climate targets, but without further policy measures, it is expected to miss its 2030 climate target. Finland aims to reduce its greenhouse gas emissions in the non-Emission Trading Scheme sectors by 16 % by 2020 compared to 2005 (SWD(2019) 1025 final).

According to the latest national projections and taking into account existing measures, the 2020 target is expected to be missed by a small margin of 0.7 percentage point. However, under the Effort Sharing Regulation, the country has an objective of reducing non-Emission Trading Scheme emissions by 39 % by 2030 (from 2005 levels).

The decarbonisation of the energy intensive industry and the maintenance of a sustainable forest carbon sink are important challenges in a longer term perspective. Together, these will require significantly higher private and public investments in low carbon technologies and practices.

As transport emissions make up the largest — and growing — share (40 %) of the non- Emission Trading Scheme emissions, measures to decarbonise that sector are critical to meeting the 2030 climate-related objective.

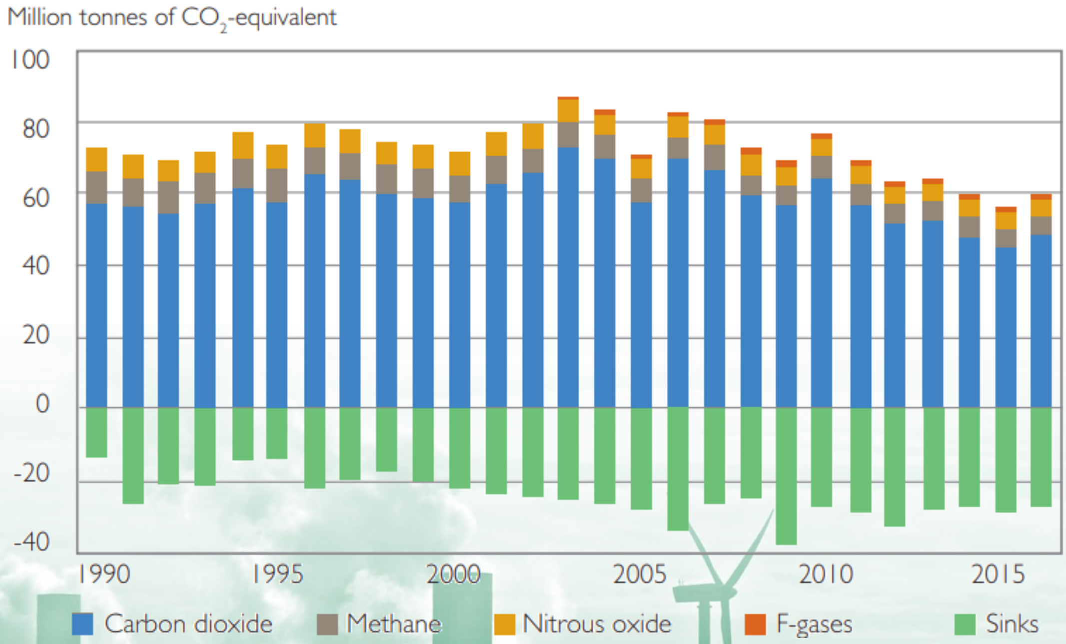
In 2018, Finland adopted a climate change policy plan and submitted a draft national energy and climate plan. In its national energy and climate plan to be adopted by 31 December 2019 in line with the Regulation on the Governance of the Energy Union and Climate Action, Finland will provide an overview of its investment needs until 2030. The investment needs on energy supply would reach close to EUR 3 billion, covering the further deployment of renewable electricity (EUR 600-750 million) and the ban of coal, a new interconnector with Sweden (EUR 200 million), public charging infrastructure for electric vehicles (EUR 415 million), data exchange solutions, and the development of biofuels notably in the transport sector (EUR 1.3 billion).

Greenhouse gases

Total emissions of greenhouse gases (GHG) in Finland in 2016 were about 18% lower than in 1990. However, according to Statistics Finland, emissions in 2016 had grown six percent compared with the previous year. One of the main reasons was growth in the consumption of coal and a decline of biofuels in transport.

According to Statistics Finland's preliminary data, the total emissions of greenhouse gases in 2017 correspond with 55.5 million tonnes of carbon dioxide equivalent (CO2 eq.), being 15.8 million tonnes less than in the comparison year 1990.
Emissions went down by almost five per cent from the previous year. The fall in emissions was most influenced by the decreased consumption of the main fossil fuels and the increased share of biofuels used in traffic.

Finland's greenhouse emissions and the net carbon sink of the land use sector in 1990–2016



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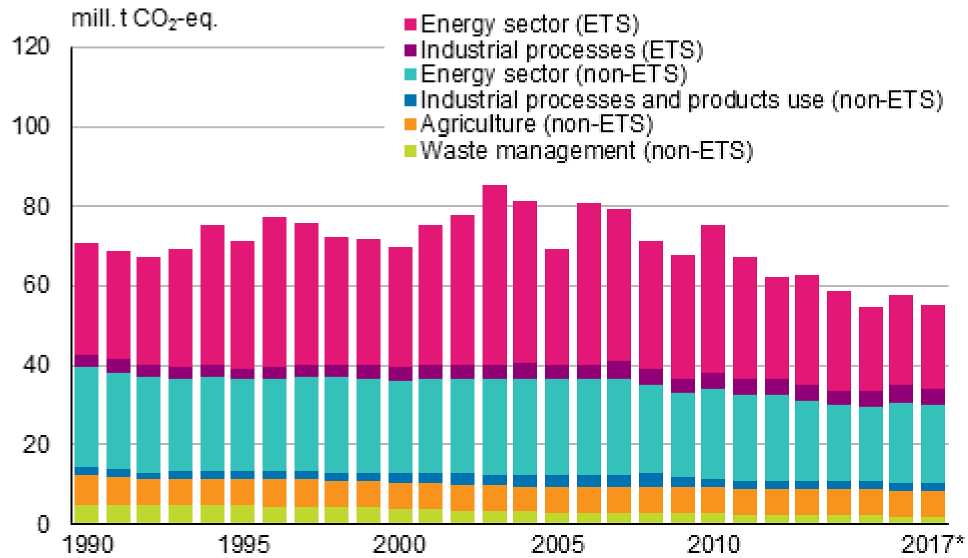
Total emissions of greenhouse gases in 2016 were 58.8 million tonnes CO[2] equivalent, excluding emissions and carbon sinks in the so-called LULUCF sector, linked with land use, land use change, and forestry.

The greatest emissions are caused by **energy** production and consumption. In 2016, 75 percent of total emissions were from the use of fossil fuels.
Industrial processes, the use of products, and agriculture cause about 11 percent of all emissions. Waste management accounted for 3 percent of emissions. Emissions from **waste management** have declined evenly from the early 1990s thanks to improvements in waste management.

Forests are an important carbon sink and the relative importance of forests as a carbon sink is greater than is generally the case in EU countries. The annual carbon sink level of our forests varied from 20 to 50 million tonnes of carbon dioxide between 1990 and 2015, especially depending on the amount of felling.

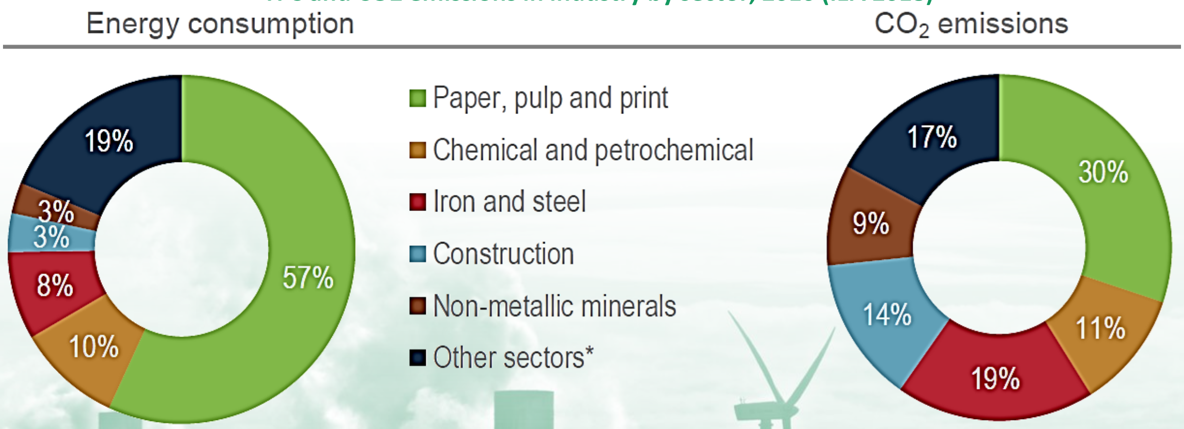
At its lowest it corresponded to about one third, and at its highest it was up to about a half of Finland's greenhouse gas emissions. Changes in the forest carbon sink and in carbon stored in wood products are monitored annually, as is the case with emissions from other types of land use.

Greenhouse gas emissions in the EU ETS and emissions not in the ETS by sector (SYKE)



Finland is a country rich in forest resources, which is reflected in industrial production. The paper, pulp and print industry is by far the largest in terms of energy consumption and accounted for 57% of TFC in industry in 2016. Thanks to a large reliance on biofuels, however, the paper industry accounts for less than one-third of industrial CO2 emissions. Other industry sectors that depend more on fossil fuels, such as construction, metals and minerals industries, are relatively heavy emitters.

TFC and CO2 emissions in industry by sector, 2016 (IEA 2018)

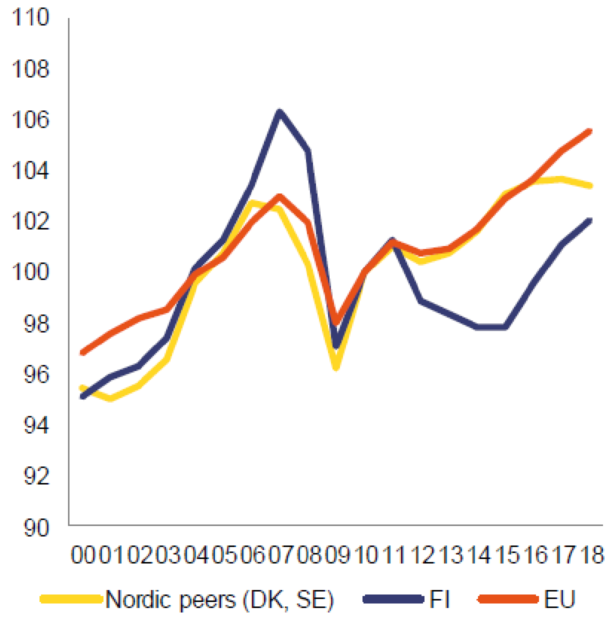


V. THE NATIONAL INDUSTRIAL CONTEXT

Labour productivity declined in Finland in 2008-2015, while in the EU and the euro area on average it slightly increased. The decline affected all sectors, in particular manufacturing, because of the setback of the electronics sector.
In 2016, labour productivity started recovering and increased across the board. In 2018, as recruitment accelerated, labour productivity growth slowed down to 0.6 %, far below its pre-crisis and 2017 levels (1.6 %).

Total factor productivity gains in Finland had been negative in 2008-2015, also reflecting the shift from high tech goods towards medium tech goods. As of 2016, total factor productivity started to grow, at a pace that eventually overtook Finland's Nordic peers.
Yet, in 2018, Finland's total factor productivity is still expected to be far from the peak it reached in 2007. This may reflect a still relatively low investment in equipment and intellectual property products.

Total factor productivity (EC 2019)



The relative demise of the country's electronics sector (specifically the mobile phone industry) has had a strong negative impact on the volumes of high tech products it exports. Among the best performing manufacturers in productivity terms in the EU, Finland currently has the lowest proportion of high tech exports. At the same time, a specialisation in exports of medium-to-low and medium-to-high tech exports has taken place.

In Finnish manufacturing firms, labour productivity grew at a solid pace until 2008, except for the least productive firms where it stagnated. After 2008, it has been relatively unchanged in the central parts of the productivity distribution, continued its fall in the lower end and continued to grow among the most productive firms.

The labour market continues to recover, showing early signs of tightening. The employment rate has now reached a new high, but is still lower than in other Nordic countries.

Employment growth accelerated in 2018, with more than half of new workers being previously inactive. This trend should continue in 2019 and 2020, albeit at a slower pace.

The industrial sector is covering 22% of the total employment in the country.

INDUSTRIAL STRUCTURE 2018
share of persons working, %

74 Services and administration
22 Industry and construction
4 Agriculture and forestry

The type of industrial sectors, together with the number of companies working on it, and their share of the GDP shows a good distribution of the national economy, with a manufacturing sector providing 1/3 of the national turnover and 1/5 of the total employment.

Industrial enterprises per sector, 2017 (Statistics Finland 2019)

Sector	Enterprises	%	Personnel Thousand	%	Turnover € mil .	%
Agriculture, forestry and fishing	77 580	21.3	49	3.4	2 464	0.6
Manufacturing	20 246	5.6	293	20.2	132 628	32.3
Construction	41 114	11.3	166	11.4	36 234	8.8
Wholesale and retail trade	41 911	11.5	235	16.1	117 620	28.6
Transportation and storage	20 132	5.5	121	8.3	23 638	5.7
Accommodation and food service activities	12 059	3.3	59	4.1	6 976	1.7
Information and communication	10 553	2.9	85	5.8	20 991	5.1
Financial and insurance activities	7 996	2.2	42	2.9	-	-
Real estate activities	29 327	8.0	20	1.4	10 221	2.5
Professional, scientific and technical activities	36 662	10.1	103	7.1	15 325	3.7
Administrative and support service activities	14 230	3.9	133	9.2	12 297	3.0
Human health and social work activities	18 387	5.0	76	5.2	7 391	1.8
Other industries	34 317	9.4	71	4.9	25 362	6.2
All industries	**364 514**	**100**	**1 453**	**100**	**411 147**	**100**

On the other hand, the analysis of industrial companies by number of employees shows that 94% of companies are smaller than 10 workers, which suppose less than 20% of national industrial turnover, while 115 of the biggest national companies can provide 24% of national turnover.

Type of industrial enterprises, 2017 (Statistics Finland 2019)

Size of personnel	Enterprises	%	Personnel Thousand	%	Turnover € mil .	%
0– 4	325 643	89.3	244	16.8	46 508	11.3
5– 9	18 975	5.2	123	8.5	25 030	6.1
10– 19	10 358	2.8	139	9.5	30 498	7.4
20– 49	6 015	1.7	181	12.4	49 277	12.0
50– 99	1 911	0.5	130	8.9	37 672	9.2
100–249	995	0.3	150	10.3	53 161	12.9
250–499	347	0.1	122	8.4	35 095	8.5
500–999	156	0.0	108	7.4	34 301	8.3
1 000–	114	0.0	256	17.6	99 606	24.2
Total	**364 514**	**100**	**1 453**	**100**	**411 147**	**100**

Economic restructuring of GVA

In 2000, the largest industry within secondary production — manufacturing (NACE code C) — reached its highest level (27.6 % of GVA) over the past 40 years. Although real production in manufacturing has decreased rapidly in recent years, the latest data shows that manufacturing still accounts for 16.6 % of GVA in Finland, which is slightly above the euro area average of 15.9 %.

The real GVA of manufacturing decreased by nearly 30 % between 2008 and 2012, mainly due to downsizing of **electronics**. In this period roughly two thirds of the electronics sector production disappeared, largely on account of the contraction of Nokia's handset unit.

The decline of the electronics sector has come to an end in 2013 when the industry was able to increase the GVA volume by 3.6 %. Although the changes in 2008-12 were significant and had negative economic effects, the electronics industry still produces twice as much real GVA than it did 20 years ago.

It has also generated a lot of accumulated knowledge and skills in the economy that could be reallocated to new companies and productive jobs either in manufacturing or for example in **ICT service industries**.

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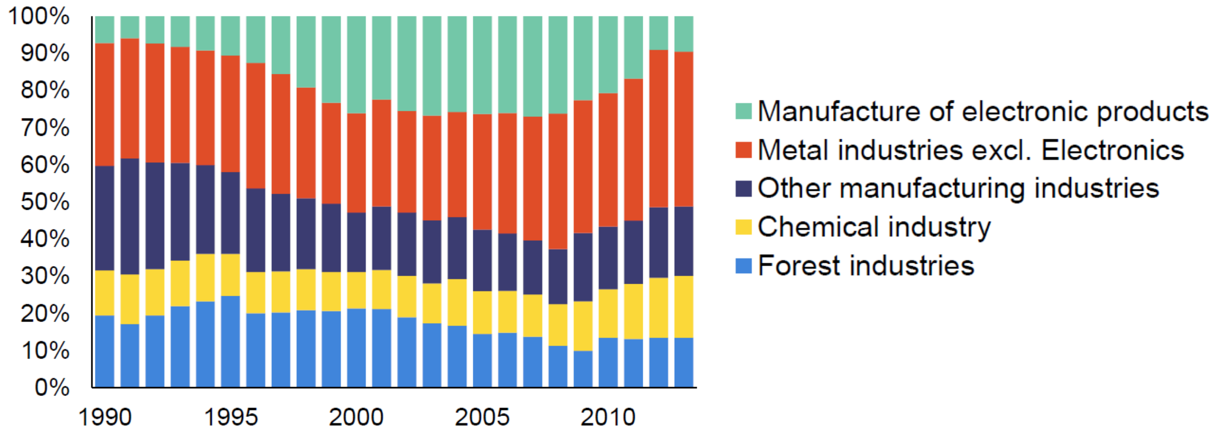
Real gross value added in basic prices in manufacturing (EC papers)



Forest industries (woodworking and paper industries) in Finland have reduced their production capacity between 2007 and 2012 as a response to lower global demand. This led to a 25 % loss of real GVA of this industry. However, the production of forest industries has remained rather stable since 2010.

Over recent years, forest companies have increased their R&D expenditure to close to 3 % of their gross value added. The R&D expenditure has thus roughly doubled compared with 2000 and as a result, new marketable products such as wood-based biofuels have already emerged.

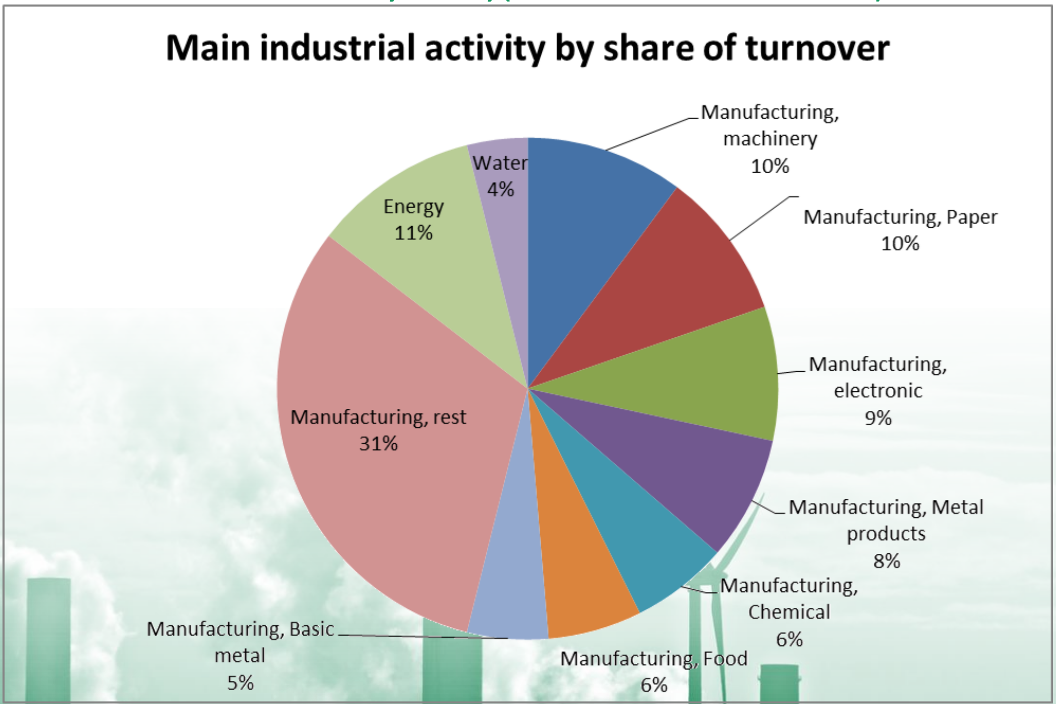
Furthermore, it is reasonable to assume that the most intensive downsizing period has passed in forest industries. In addition to the increase of the production of new forest based products, there are plans to increase the production of softwood pulp, for which the global demand is projected to increase.

Expanding industries are found in manufacturing and in the private services sector. Within manufacturing, the **chemical industry** has especially been growing steadily over recent years.

The **metal industry** has had difficulties since the global investment boom ended in 2009, but in 2014, among manufacturing industries, companies in the metal industry were able to increase their order books the most.

In the private service sector, the **information and communication services** industry has clearly been expanding. Its real GVA almost doubled between 2000 and 2013 and the 2008-09 recession went largely unnoticed by the industry.

Share of turnover by industry (Own from Statistics Finland 2019)



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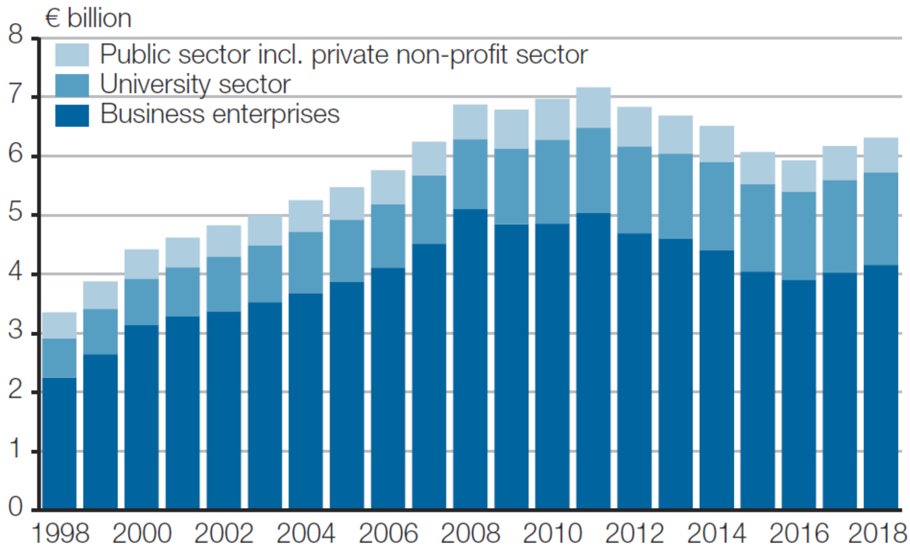
Research & development and innovation
Since 2009 business research and development intensity declined strongly. One of the reasons for the decline was disruptive technological change, which strongly affected the country's largest private research and development spender (Nokia) (Fornaro et al., 2018). As a result, Finland experienced the steepest drop in business expenditure on research and development among EU countries, from 2.7 % of GDP in 2009 to 1.8 % in 2016.
Consistently, investment in intellectual property in volume terms still declined in Finland in 2017. The decline was no longer limited to the electronics sector. Other sectors were affected as well, notably electrical equipment. Nevertheless, at 4.0 %, the share of investment in intellectual property in GDP in Finland remained slightly above the EU average (3.9 % of GDP).

The growth of firms in innovative sectors is an important factor for structural change of the economy. This is important for Finland, where a disruptive technological change has led to a decline of certain sectors of the economy (mobile phones, paper industry).
Despite various promotional activities, start-up rates in Finland remain below the EU average and there is potential for additional targeted policy action. In recent years, the availability of venture capital has declined considerably, compared to pre-crisis levels, but non-research and development innovation expenditure of firms has decreased as well (Eurostat, 2015).

In the European Innovation Scoreboard, Finland is an 'innovation leader' (European Commission, 2018). While its performance declined between 2010 and 2014, it improved every year since. High-quality human resources, attractive research and development systems, an innovation-friendly environment, relatively high levels of public and private funding of research and development and innovation, and intellectual assets lead to a good performance in the European Innovation Scoreboard and constitute favourable framework conditions for innovation. However, these conditions are not yet matched by corresponding economic outputs. Relatively low sales and employment impacts constitute Finland's weakest innovation dimensions in the European Innovation Scoreboard.

Research and development expenditure (Statistics Finland 2019)



VI. THE ENERGY CONTEXT

VI.I. SUMMARY OF THE CHAPTER

This chapter provides a general view of the energy consumption profiles of the industry, in order to establish a base of information which will feed into the later calculation of the Key performance indicators (KPI).

The chapter starts with the "EU energy and industry" by analyzing the main energy sources used in the industry at EU level, identifying countries with major energy intensity in industry and passing into the brakedown of energy consumption per type of industry in each country.

The chapter advance analyzing the type of energy demand in the industry, splitting it into heat demand and electricity demand, providing a view of which industries requires more types of energy in comparison with other industries.

Most of this data is provided for the main energy-consuming industries, which are common to most of RESindustry countries:

- Non-metalic
- Chemical
- Paper
- Steel
- Food
- Non- ferreus
- Wood
- Machinery
- Textile

Finally the end of the first subchapter analyse the current energy prices per country, for both electricity and gas, together with an explanation of the current implementation of RES in the industry around Europe.

The point "National energy figures" provide an overview of the energy situation in the country, the current energy sources, the energy consumed by sources, the energy dependency, etc. to pass into an analysis of the industry consumption of the country, detailing the industries which are more energy intense at national level. This point of the chapter closes with an identification of the current application of RES in the country, their capacity and share in the energy sector.

The point "Major energy consuming industrial sectors" provide a full review of the energy consuming profile of the most important energy consuming industries of the country. The analysis go into explanation of main energy sources consumed by industry, the critical producing points in terms of energy consumption, the energy process, the share of energy types, etc.

As the Market analysis provides KPI in terms of socio-economic indicators, the chapter also wanted to confirm the national capacity to develop the RES in the industry. At the end of the chapter, in the point "Energy education and capacity building" and "Energy Professional competences" the analysis review the current national capacity of the research and training sector, together with the strength of the renewable energy commercial tissue.

The "current initiatives and practices" wants to be a sample of current initiatives promoting the RES in the industry at national level, as a fount of inspiration to be taken into account in the future Action Plan to be designed by the Managing Authority.

The chapter closes with the "RES support and financing mechanisms" point, where a brief description of the current policies and financial supports is provided at national level.

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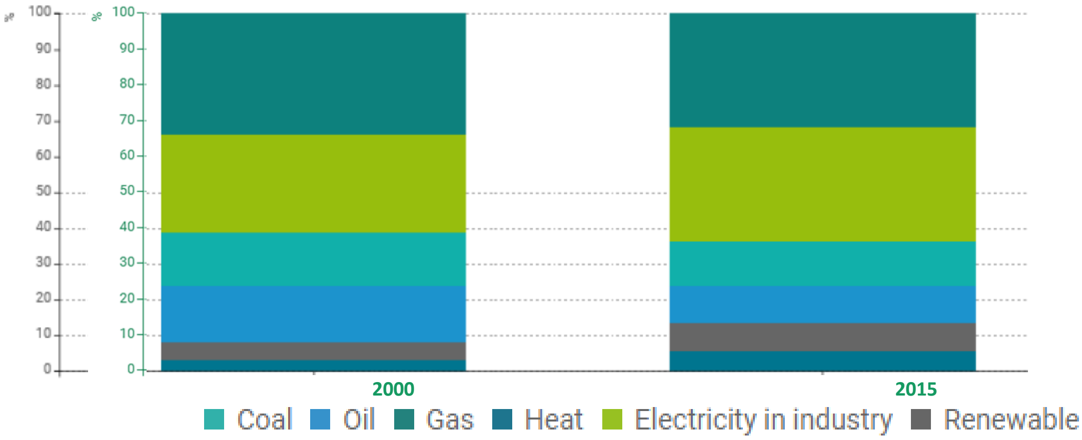
VI.II. EU ENERGY AND INDUSTRY

The industry sector in Europe has a mix of energy consumption strongly based on fossil fuels, but during the last 10 years a clear trend toward the electrification of the market and broader introduction of RES can be detected. From 2000 to 2015 these two fuels increased their share in nearly 10%, while the oil decreased its share (-6%) and the coal (-2%).
The electrification of the industry consumption is also a first step in the energy independency, due to this electricity, even if currently can be based in fossil, in the future could be supplied by a green mix.

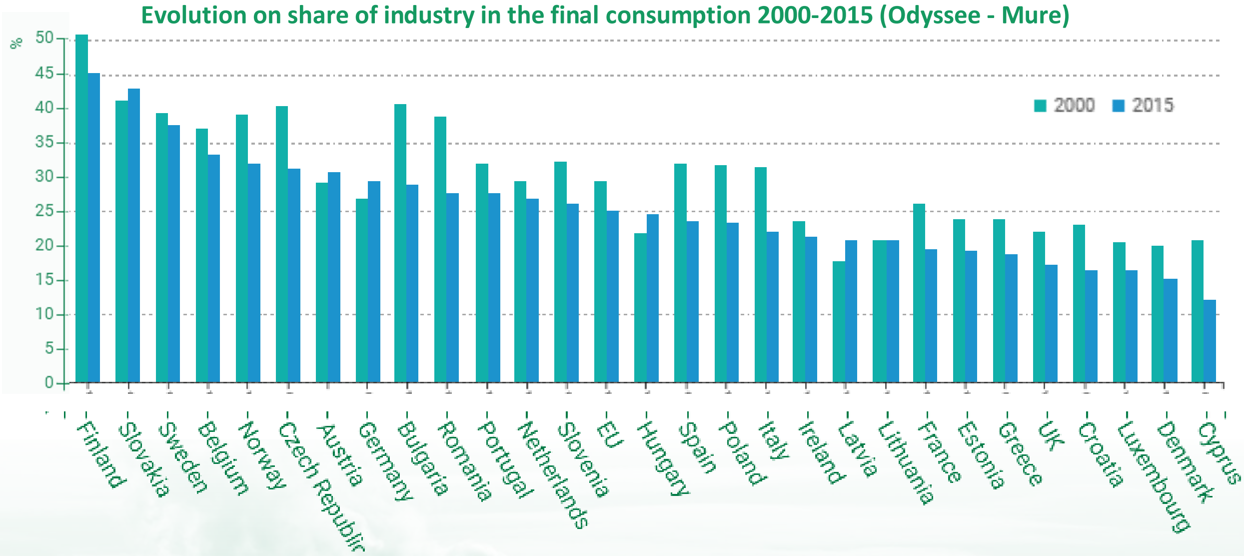
Change in fuel mix in industry 2000-2015 (Odyssee - Mure)



In Europe, the share of industry in the energy consumption is declining (-4% in 200-2015), being very significant (-10%) in countries which presented high 200 levels, such as Bulgaria, Romania, Spain, Poland, Czech Republic and Italy. However, other countries have increased their share of industry in the energy consumption in nearly 3% (Latvia, Germany, Austria, Slovakia and Hungary).

The result is that, while the EU average is 25%, there are important differences in the share of industry in final consumption among countries: from 40% in countries such as Finland or Slovakia to less than 20% in UK, Croatia, Luxembourg and Denmark.

Evolution on share of industry in the final consumption 2000-2015 (Odyssee - Mure)



In this share, there are some industries which are clearly more intense in energy consuming, due to their importance at EU level, or due to the specificities of the industrial processes, but the case is that some industries are covering a larger part of the industrial energy consumption in Europe and in every country.

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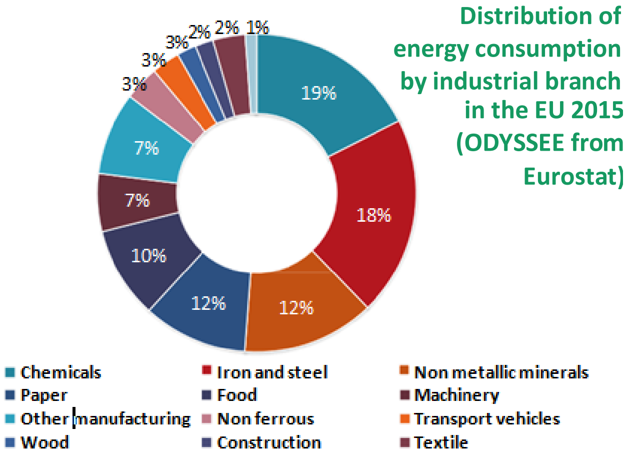
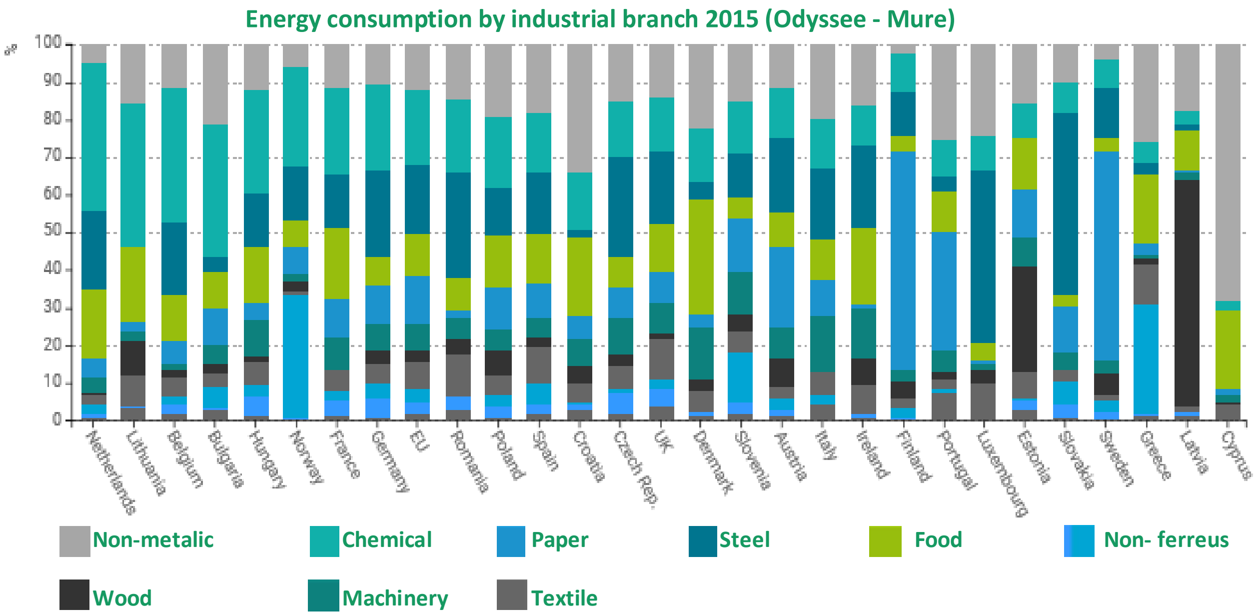
THE ENERGY CONSUMPTION PER TYPE OF INDUSTRY.

At EU level, the big consumers are the industries of chemical products and steel being top consumer on similar ranges.

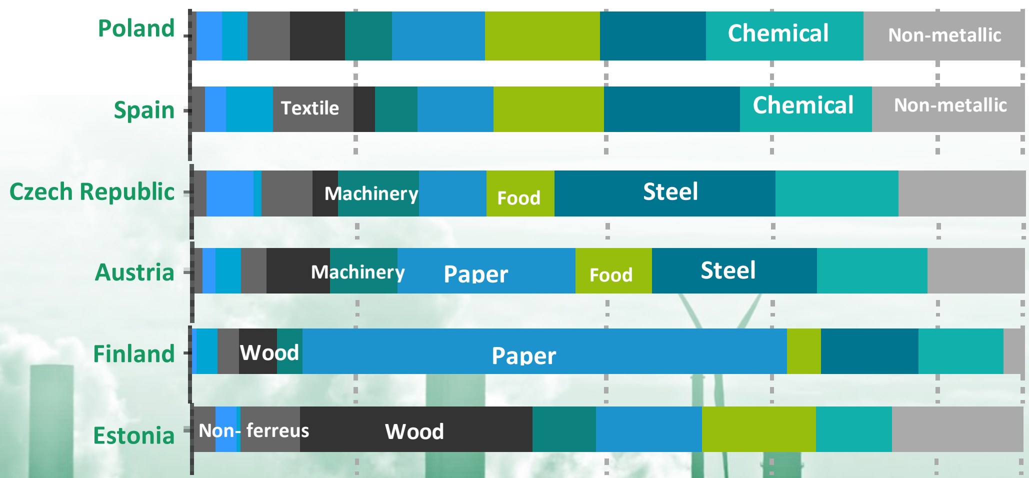
Paper and non-metallic minerals are the following industries, and between the 4 of them they cover the 60% of the EU energy consumption in the industrial sector.



However, consumption profiles differ greatly from one country to another, depending on the strength of the industry types in each country. Some countries, like Finland or Cyprus can have one industrial sector covering more than 50% of the consumption of all the country, while most of countries have a mix of consumption per industry type. Some of the most remarking data: pulp and paper industry plays the dominant role in Finland and Sweden (more than 50% of the consumption), whereas it is chemicals in the Netherlands (around 40%), non-metallic minerals in Cyprus (64%), Croatia and Portugal (around 30%), steel in Slovakia and Luxembourg (above 50%) and food in Ireland and Croatia (20%).



The countries of **RESINDUSTRY** shows different shares of energy consumptions per industry (see below), even if in all the countries the 4 main industries (chemical, steel, paper and non-metallic minerals) are always present and consuming more than 50% of total energy.



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At European level, and in every country analyzed, the energy consumption of any sector is measured by the energy intensity, which referrers to the amount of energy used per one unit of GDP. This measure allows to overcome the effect of a possible slowdown of the economy (which automatically leads to a lower energy consumption) and to show a decoupling of energy consumption and output growth.

Even if this indicator provides a more independent view of the energy consumed per sector, it is not fully objective as energy consumption is influenced by other factors such as structural changes of the economy, energy prices, climate, weather or even ageing of population.

Energy Intensity in industry allows to better analyse the impact of economic externalities in the real energy consumption of the industrial sector.

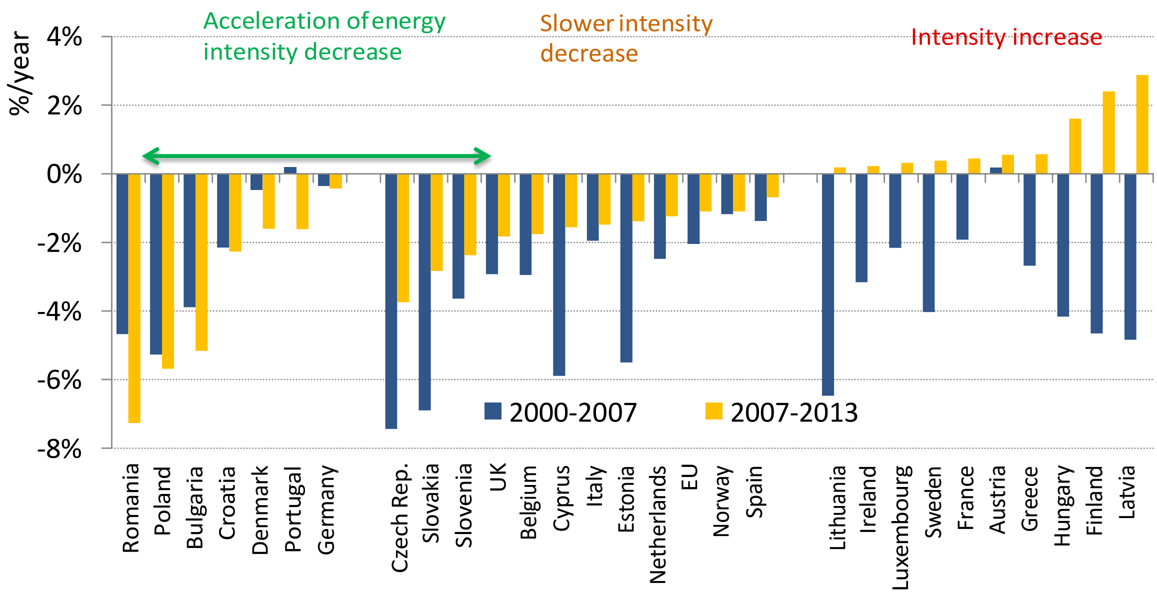
- Pre-crisis scenario.

Until 2007, the energy consumption of the industry grew less rapidly than the value added in all countries, which was reflected by a good rate on decreasing energy intensity of industry in every EU country.

- On-crisis scenario.

After the crisis 2007, in average for the entire EU, the **Energy Intensity in industry** decreased but at a slower rate, because the Gross Added Value of most countries decreased at even a higher velocity then the reduction of energy consumption of the industry. The impact of the crisis on the energy intensity trend affected three fourth of the EU countries.

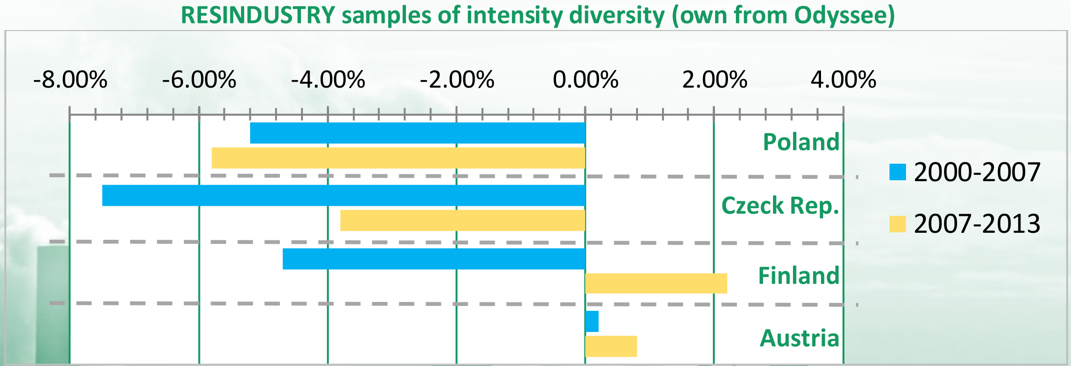
Trends in the energy intensities of industry (ODYSSEE)



- ➢ In 7 countries, generally countries with an industrial growth, the crisis did not affect the decreasing rate, on the contrary they achieved to keep reducing the energy intensity at a higher rate than before crisis.
- ➢ In 11 countries, the intensity continued to decrease but with a lower rate than in a pre-crisis scenario.
- ➢ In 10 countries, the crisis affected the pre-crisis scenario and the intensity trend was reversed.

In **RESINDUSTRY** project, again, the profiles of the countries provide different trends to analyse:

RESINDUSTRY samples of intensity diversity (own from Odyssee)



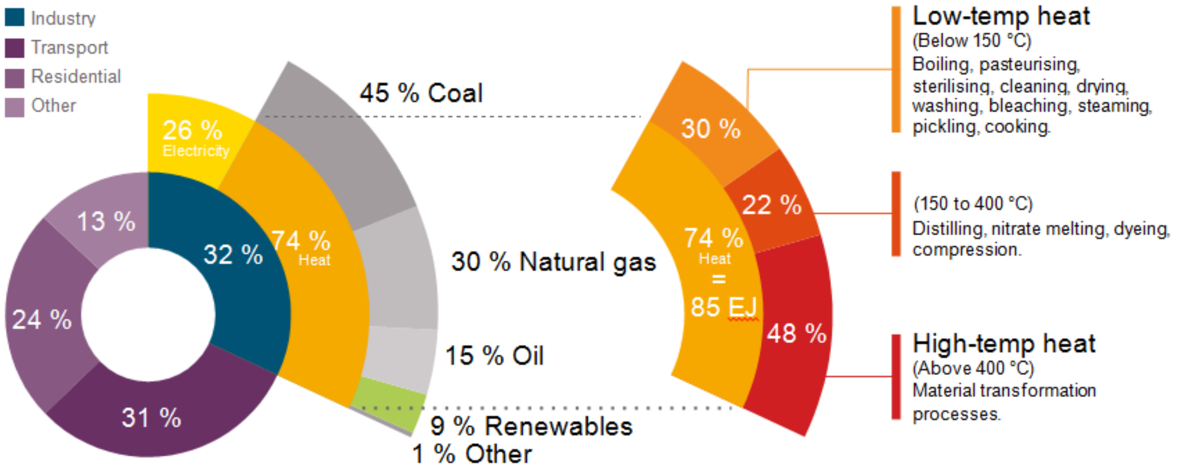
- Poland is one of the countries which has achieved to increase the negative rate of energy intensity in industry of the consortium.
- Czech Republic, similar to Spain or Estonia, has been affected by the crisis in a negative manner, and the energy intensity is not decreasing at the same speed as it was in pre-crisis years. The Energy intensity keep decreasing, but it is now decreasing at half the pace as before.
- Finland has been affected by a strong change in the energy intensity trend, where before 2007 the energy intensity was decreasing at a good pace, the current trend is of increased intensity every year.
- Austria shows unique trends, which was of increased energy intensity in the years before 2007 and keep increasing even after 2007.

THE HEAT DEMAND IN THE INDUSTRY

Three-quarters of the energy used in industry is process heat, the rest is for mechanical work and electricity (computers, lighting, etc.).

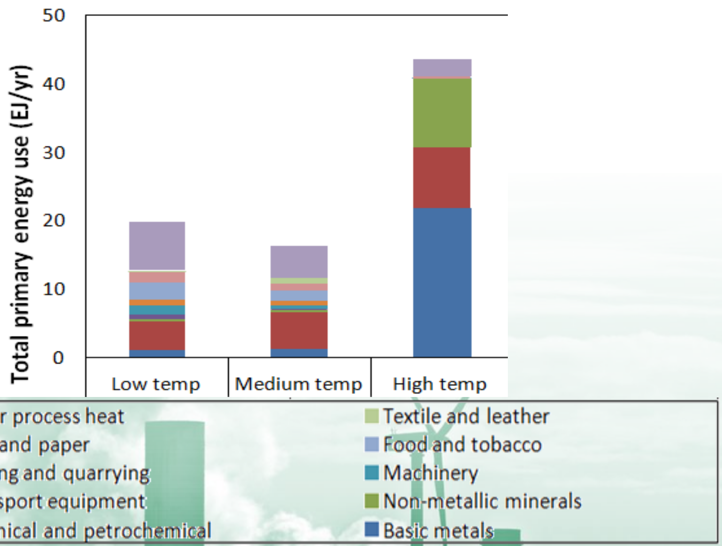
- 30% of process heat is "low-temperature" (below 150°C).
- 22% is "medium-temperature" (150°C-400°C).
- 48% is "high temperature" (above 400°C).
- About 10% of process heat is estimated to be electricity-based.

Share and breakdown of heat demand in industry (solar Paces)



The breakdown of industrial energy use by temperature levels is estimated to remain unchanged between 2009 and 2030. Thus, about half of the total industrial energy use will still be operated at high-temperature levels. The remaining energy use will be covered by low- and medium-temperature applications with a share of 27% and 23% of the total industrial energy use, respectively.

Total primary energy use in global industry with a breakdown by temperature levels, 2009-2030 (ODYSSEE)

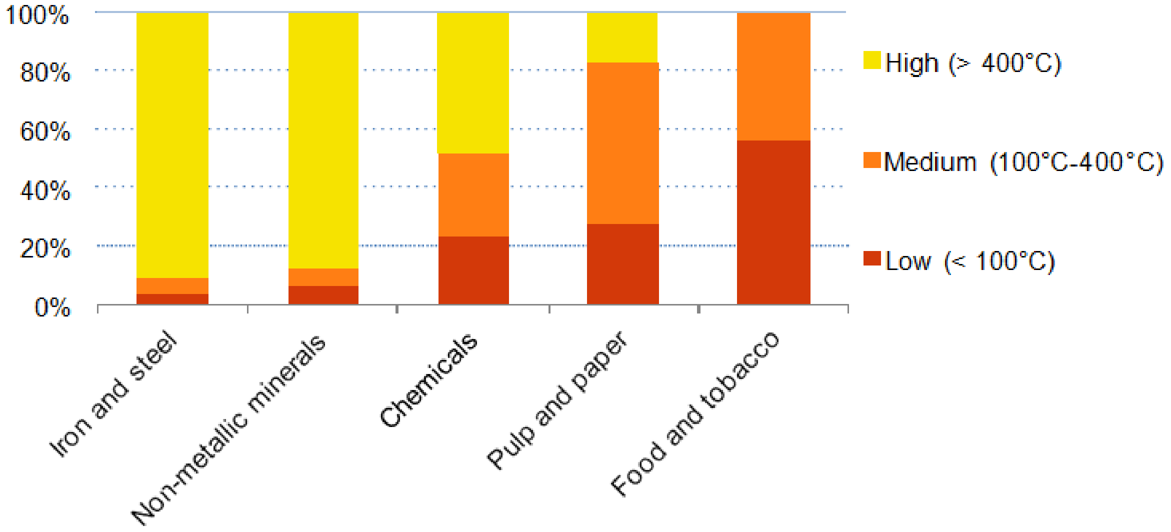


By sectors:

- In the iron and steel and non-metallic metals industries, around 90% of the heat demand is for high-temperature heat, used for iron-melting and steel production. The coke fed into the furnace acts not only as source for high-temperature heat, but also as a reducing agent. This means that any alternative fuel source would have to have similar reducing characteristics.
- In the chemical industry, the demand for temperature levels is more diverse, depending on the specific branch of the sector.
- The pulp and paper sector, as well as the food and tobacco industry, require mainly low- and medium-temperature heat for their production processes.

A fair share of the required heat is produced from process residues, making these sectors the leaders in renewable energy use for heat in industry.

Heat requirements by temperature range in different industry sectors (Euroheat & Power, the European Heat Market)



THE ELECTRICITY DEMAND IN THE INDUSTRY

Electricity demand is expected to continue to grow in the manufacturing industry, partly due to an electrification of production processes, as well as due to the production growth in electricity-intensive industries, such as the non-ferrous metals sector. Relocation of such industries next to renewable energy power plants is one option that would increase the renewable energy share in the electricity sector.

Electricity currently constitutes just over one-quarter of the total final energy used in industry. This share is expected to rise to around one-third in 2050 in all scenarios because of the greater share of electricity-using processes, for example, the production of iron and steel, and paper recycling rates.

Past increases are due to a number of reasons, such as: decreases in the relative price of electricity compared to fossil fuels; increased electricity demand in the food sector (hygiene and health policies); production growth in electricity-intensive non-ferrous metal sector; and higher rates of recycling.

The intensity of electricity use varies widely between sectors: for example it varies from 13% of total final energy in the cement sector to 56% in the aluminium sector.

In the Baseline scenarios, electricity use as a proportion of total final energy is expected to rise in 2050 to between 16% and 54% in different industry sectors and to 35% for industry as a whole. Other scenarios, this share will increase slightly to between 17% and 58% for the individual sectors and to 37% for industry as a whole.

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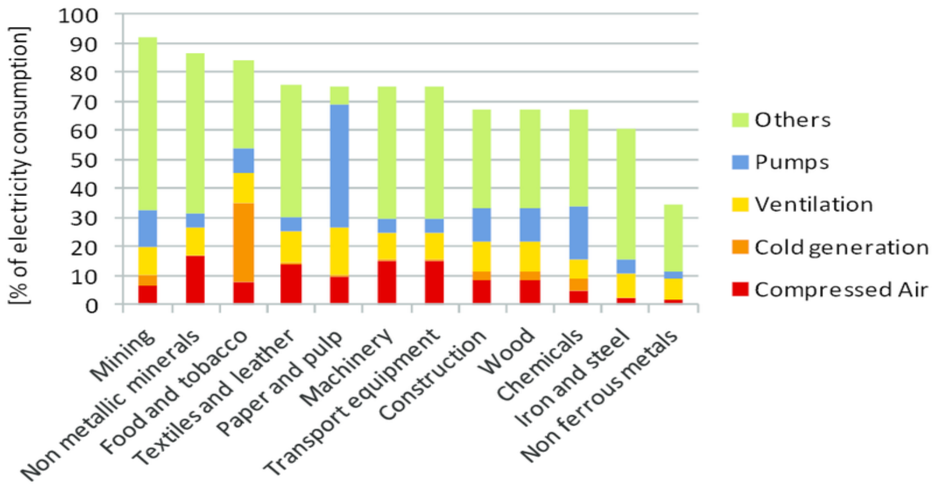
Share of electricity consumption by industry (IEA)

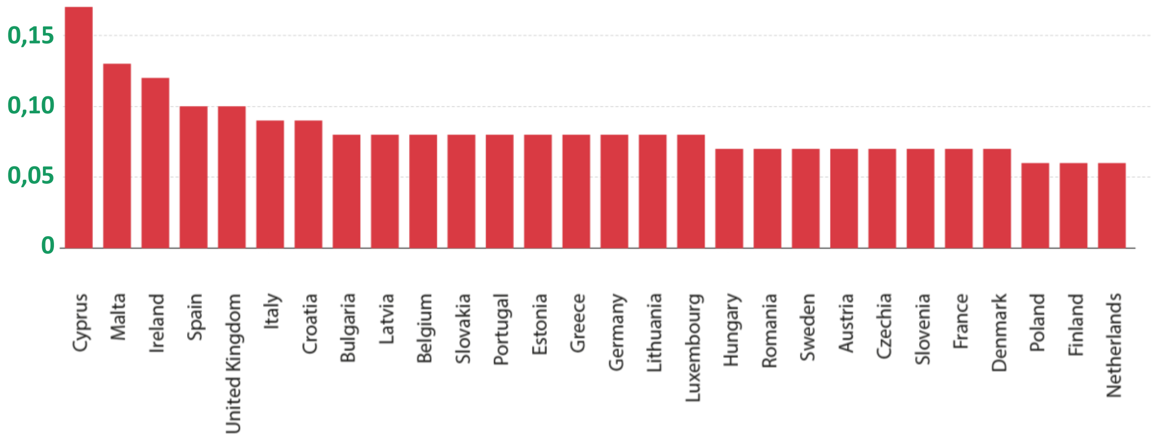


THE ENERGY PRICES AFFECTING THE INDUSTRY.

Electricity industry (non-household) prices have been falling since 2015 due to lower energy price components. Industry (for competitiveness reasons) is often exempt from or faces lower electricity taxes and levies than households and also faces lower network charges.

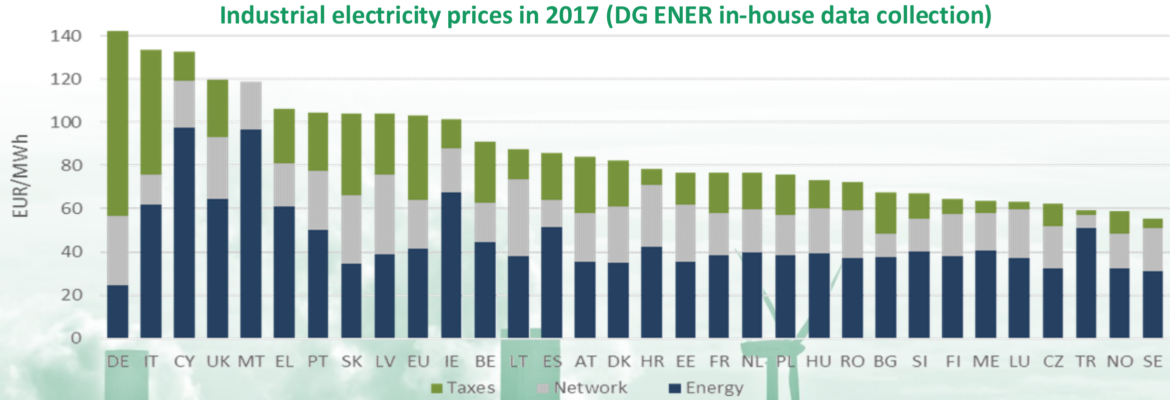
For non-household consumers, electricity prices (excluding VAT and other recoverable taxes and levies) in the second semester of 2018 ranged from 0.17 €/kWh in Cyprus and 0,13 €/kWh in Malta, to 0.06 €/kWh in the Netherlands, Poland and Finland.

Electricity prices 2018 for non-household €/kWh taxes excluded (DG ENER in-house data collection)



This information, however, is quite modified if the taxes are taken into account at EU level:

Industrial electricity prices in 2017 (DG ENER in-house data collection)



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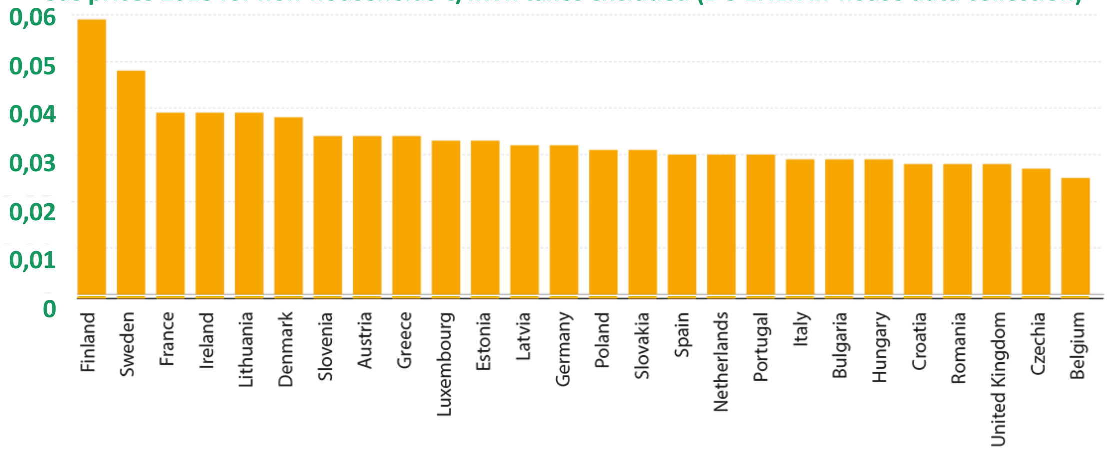
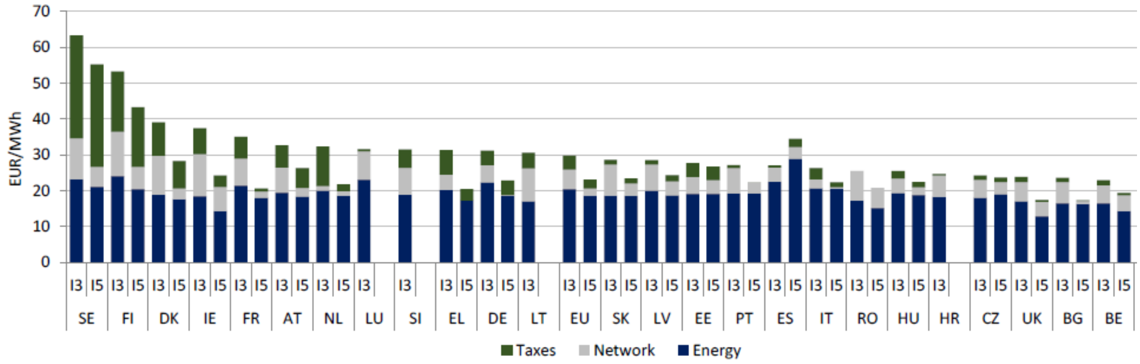
Gas prices. While electricity prices are partly set as a result of fossil fuel prices (with other, more national or regional factors also shaping price), natural gas prices are based on global fossil fuel prices. Clearly the great dispersion between gas prices in 2011-2014 has diminished with the growth of global LNG markets and other supplies; however more recently the economic recovery and rising oil prices have led to higher gas prices.
For non-household consumers, natural gas prices (excluding VAT and other recoverable taxes and levies) in the second semester of 2018 were highest in Finland (0,059 €/kWh) and Sweden (0.048 €/kWh) and lowest in Belgium (0.025 €/kWh).

Gas prices 2018 for non-households €/kWh taxes excluded (DG ENER in-house data collection)



In the gas case, the information, is not modified as far as electricity when the taxes are taken into account at EU level:

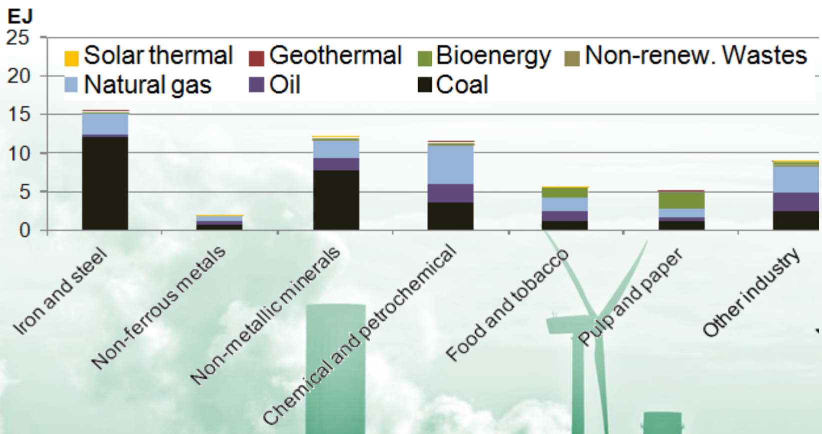
Industrial gas prices in 2017(DG ENER in-house data collection)



RENEWABLE APPLICATIONS IN INDUSTRY

The iron and steel sector is the largest consumer of energy for heat, followed by the non-metallic minerals industry and the chemical and petrochemical industry. In these sectors the RES are residual.
The pulp and paper sector was the largest consumer of renewable energy for heat in industry, sourcing 43% of its heat demand from biomass, thanks to the availability of biomass process residues.
The food and tobacco sector also meets a considerable share of its energy needs with renewable sources, with 23% of its energy use for heat provided from biomass.

Industrial heat coverage per industry and per energy source 2017 (DG ENER in-house data collection)

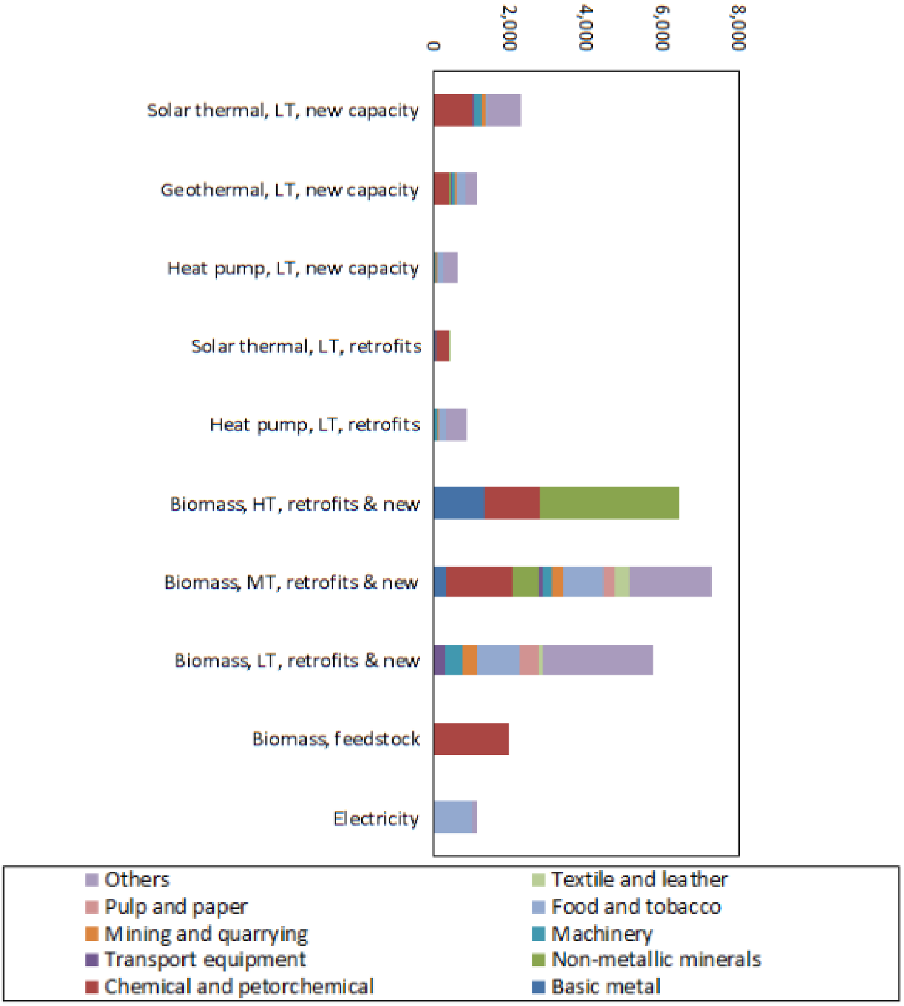


The pulp and paper sector in particular is well placed to take advantage of promising new biomass and waste technologies that would allow the sector to become a net supplier of energy. As the power sector increasingly decarbonises over time, research may create new opportunities for industry to reduce its CO^2 intensity through electrification, stimulated by the introduction of appropriate carbon reduction incentives.

Already some primary aluminium smelters use renewable energy power generation to provide the required electricity. For example, a considerable share of the electricity demand of the aluminium smelters in Africa and Iceland are already met with large-scale hydropower plants.

Despite the relatively long life of plants in the aluminium sector (~60 years), it is projected that about a quarter of the sector's energy demand in 2030 will come from new capacity built between today and 2030. These plants can benefit from re-location to sites where hydro power plants exist, providing up to 1 EJ realisable potential for renewable electricity in the non-ferrous metals sector.

Potential application of RES technologies per industry PJ/year (IEA)



Electrification of industrial processes that currently run based on process heating creates further opportunities. One of the building blocks for the chemical and petro- chemical sector is hydrogen, which is commonly pro- duced via steam reforming or gasification of hydrocar- bon feedstocks. Electrolysis today offers an important alternative for hydrogen production, but the process requires significant amounts of electricity. Thus elec- trolysis is viable only if it uses renewable electricity and if the process efficiency is improved in the near future.

VI.III. NATIONAL ENERGY FIGURES

Key energy data (IEA last country review 2017)
Energy production: 18.2 Mtoe (biofuels and waste 53.2%, nuclear 32.1%, hydro 7.0%, peat 4.0%, wind 2.3%, heat 1.1%, oil 0.4%), +12,8% since 2007

TPES: 34.4 Mtoe (biofuels and waste1 28.5%, oil 26.3%, nuclear 17.0%, coal 8.3%, natural gas 5.6%, electricity imports 5.1% and heat imports 0.6%, hydro 3.7%, peat 3.7%, wind 1.2%), -6.8% since 2007

TPES per capita: 6.2 toe/cap (IEA average: 4.1 toe)

TPES per unit of GDP: 158 toe/USD million PPP (IEA average: 106 toe)

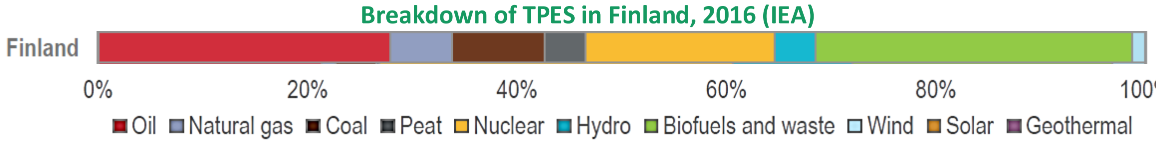
TFC (2016): 26.0 Mtoe (industry 47.8%, residential/commercial 35.6%, transport 16.6%)

ENERGY SUPPLY AT NATIONAL LEVEL

In 2017, TPES supply was 34.4 Mtoe, a decline of 6.8% since 2007. Biofuels (including waste) and oil form the largest shares of fuels in energy supply, together accounting for over half of TPES, but have developed at different rates. Since 2007, the supply of biofuels and waste increased by 30.1% whereas oil supply dropped by 8.6%.

The supply of other fossil fuels (coal, natural gas and peat) fell even more dramatically and nearly halved over the last decade, leading to the overall decline in TPES. Nuclear energy represents the third-largest share in TPES that has been stable at around 6 Mtoe for many years. Hydropower varies around 1 Mtoe and wind power has started growing rapidly, however from very low levels. Electricity imports, mainly from Sweden, account for over 5% of TPES and represent nearly a quarter of total electricity supply.

Breakdown of TPES in Finland, 2016 (IEA)

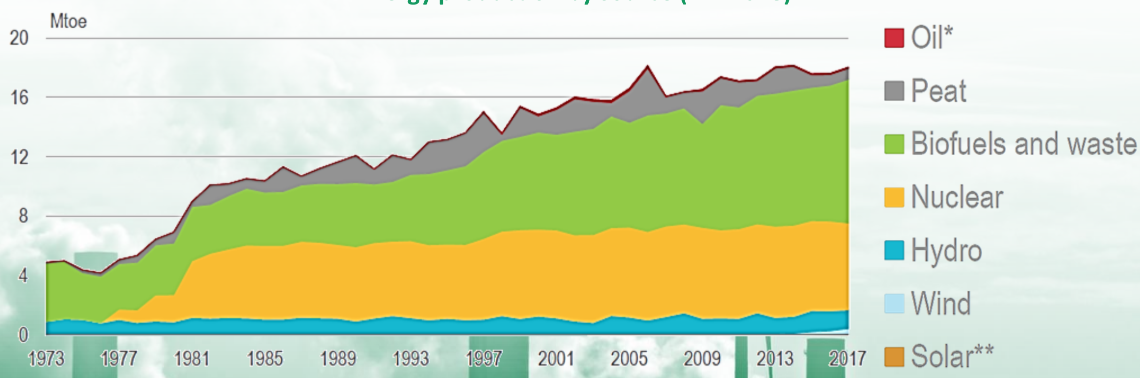


Thanks to its large shares of biofuels and nuclear, Finland has the second-lowest share of combustible fossil fuels in its TPES among all IEA member countries, behind Sweden. The share of biofuels and waste is the second-largest in the comparison. Behind Ireland, Finland has the second-highest share of peat in its energy supply. Peat plays an important role as fuel in combined heat and power (CHP) plants.

In 2017, Finland domestic energy production was 18.2 Mtoe, covering just over half the TPES.

- Biofuels and waste accounted for over 53% of total domestic energy production and has increased steadily for over two decades.
- Nuclear accounted for a third of total production.
- Remaining share comes mainly from hydro and peat, and a small share of wind.
- Finland has no domestic production of coal or natural gas, and a very small production of oil. Russia is the largest supplier of oil and coal, and the sole supplier of natural gas to Finland.

Energy production by source (IEA 2018)



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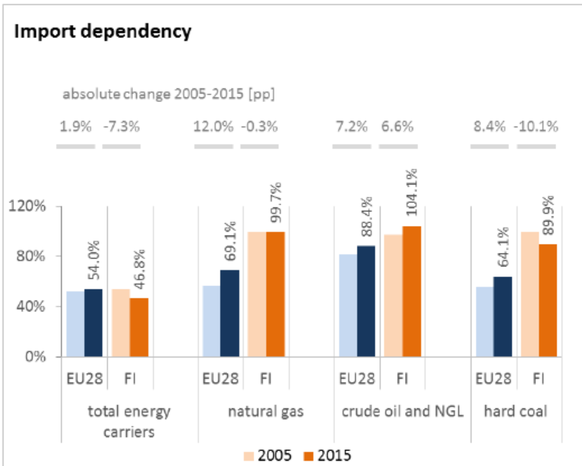
THE ENERGY DEPENDENCY

46.8 % of Finland's energy consumption is covered by import, less than the EU average. This is due to the high importance of domestic renewables and nuclear energy in the energy mix4, which together meet almost half of the country's energy needs.
The overall import dependency of Finland recorded a decrease of about 7.3 percentage points (p.p.) between 2005 and 2015, whilst at the EU level, import dependency increased by 1.9 p.p. over the same period. However, Finland imported almost all its natural gas, oil and hard coal in 2015.

Russia was the sole supplier of natural gas to Finland, being also the dominant supplier of crude oil (83 %) and hard coal (approximately 63 %). The associated risk is only partly alleviated by the below EU average share of natural gas in the country's energy mix.

Nuclear power is considered domestic in the Eurostat statistics although the nuclear fuel is imported. In Finland, in 2015, 35 % of the imported nuclear fuel came from Russia, 32 % from Germany and 32 % from Sweden. 27 % of the electricity supply was produced by nuclear power.

Import dependency and main energy suppliers of Finland (Eurostat Factsheet)



2015: Top non-EU suppliers for main energy carriers*

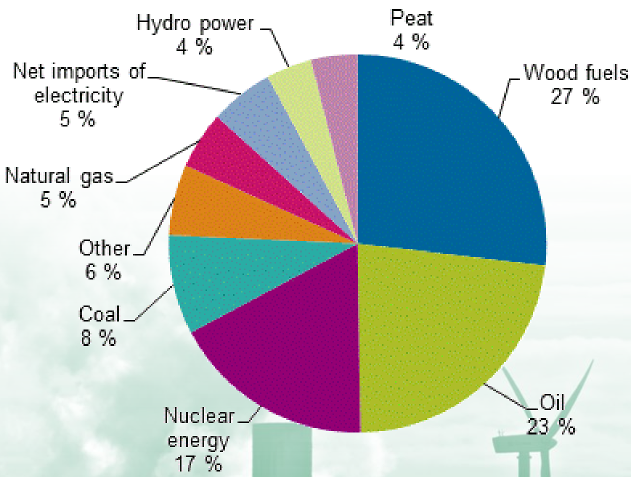
Natural gas		Crude oil and NGL		Hard coal	
FI	EU28	FI	EU28	FI	EU28
Russia 100.0%	Russia 37.3%	Russia 83.0%	Russia 28.8%	Russia 62.6%	Russia 29.1%
	Norway 32.8%	Norway 5.7%	Norway 12.4%	Canada 14.6%	Colombia 24.3%
	Algeria 10.7%		Nigeria 8.3%	United States 11.8%	United States 16.0%

*share in total imports for the MS and in total non-EU imports for the EU28

NATIONAL ENERGY DEMAND PROFILE

Total demand of energy in Finland amounted to 1.35 million terajoules (TJ) in 2017, which corresponded to a fall of one cent compared with the previous year. The consumption of electricity totalled 85 terawatt hours (TWh), which was on level with the year before.
Renewable energy sources covered 37 per cent of total energy consumption and according to preliminary data, over 40 per cent of final use. Their use grew by 6%while consumption of fossil declined by 6%.

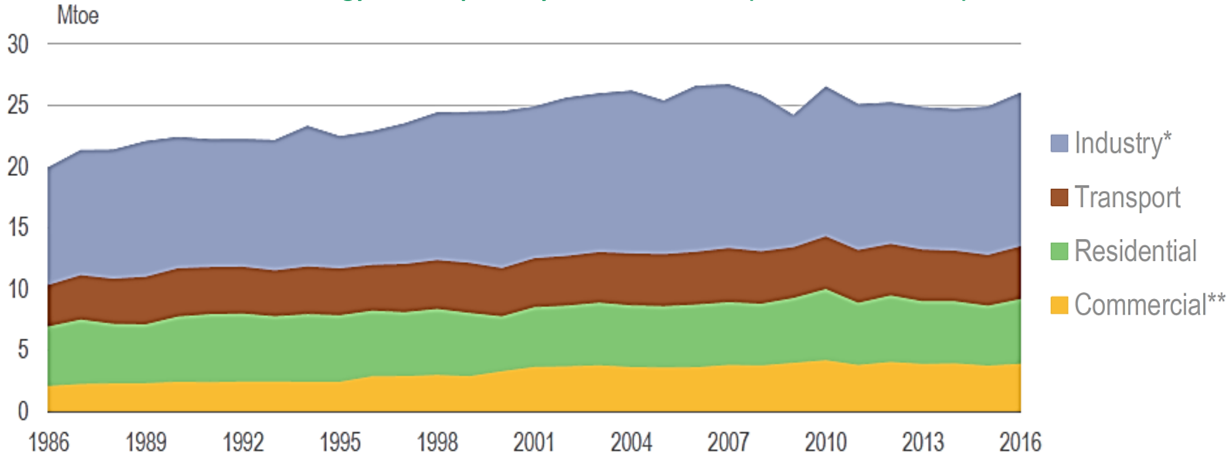
Finland total energy consumption 2017 (Statistics Finland 2019)



Energy consumption increased from around 20 Mtoe in the mid-1980s to around 25 Mtoe from the early 2000s. In 2016, consumption was 26.0 Mtoe, a decline by 2.2% since 2006 but an increase by 4.5% since 2015. Oil, electricity, biofuels and waste, and district heating are the largest components of final consumption and together accounted for 96% of TFC in 2016.

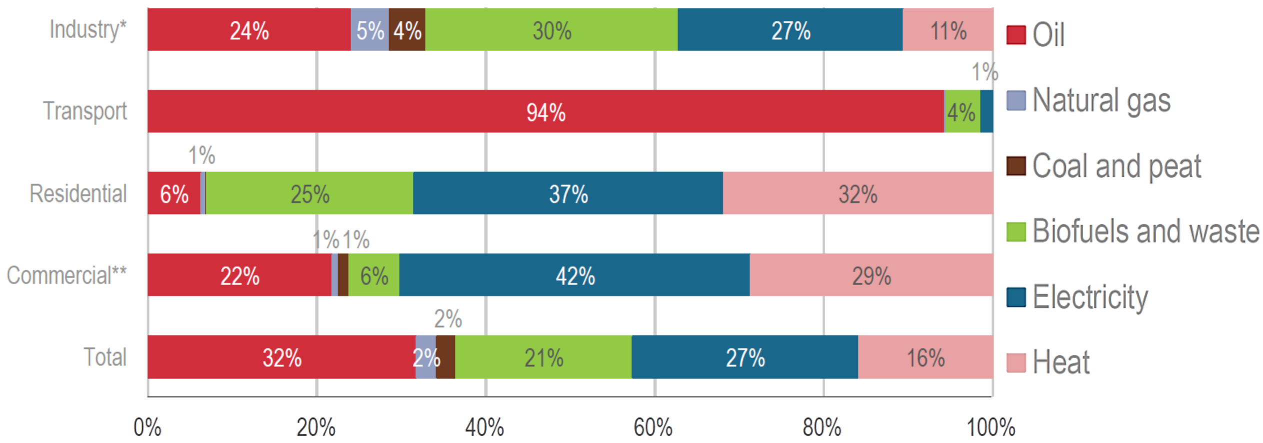
- The **industry** sector is the largest energy consumer in Finland, and accounts for nearly half of TFC. The residential, transport and commercial sectors share the remaining consumption relatively equally.

Final energy consumption by sector in Finland (Eurostat Factsheet)



- The industry sector uses a large share of biofuels and waste, and residential and commercial buildings consume large amounts of electricity and district heating.
- The transport sector is still largely dominated by oil fuels, although the share of biofuels has grown rapidly in the last decade.
- The other sectors have a bigger spread among different fuels.

Final energy consumption by sector and source in Finland (Eurostat Factsheet)



NATIONAL INDUSTRY ENERGY DEMAND PROFILE

Facts:

- Final energy consumption in industry: 12.4 Mtoe (biofuels and waste 29.9%, electricity 26.6%, oil 24.1%, heat 10.5%, natural gas 4.5%, coal 3.0%, peat 1.3%), decrease by 7.7% since 2006
- Share of total final consumption: 47.8%
- Share of energy related CO2 emissions: 16.4%

The industry sector is the largest energy consumer in Finland, accounting for nearly half the total final consumption (TFC). Large shares of biofuels, electricity (nuclear) and district heating in the energy supply make the industry sector a relatively small emitter of carbon dioxide (CO2), compared to the heat and power, and transport sectors.

In 2016, energy consumption in industry was 12.4 Mtoe, which represented 47.8% of TFC in the country. Energy consumption peaked in 2006, and has since dropped by 7.7%. Non-energy use accounted for 14% of the industrial consumption, mainly oil consumed in chemical industries.

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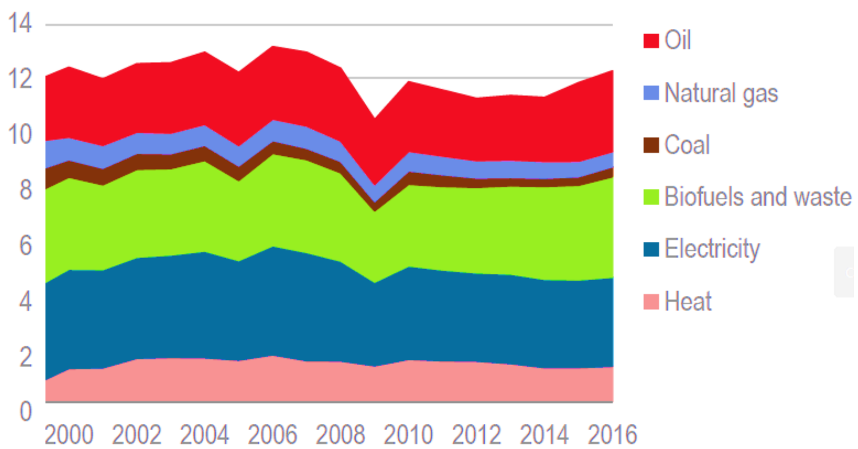
- Biofuels and electricity are the fuels most used in industry, together accounting for 57% of total energy demand in the sector.
- Oil is the third-most used fuel, accounting for around 24% of consumption, of which half is for non-energy use.
- District heating accounts for 11% of energy use in industry,
- Remaining consumption is made of small shares of natural gas, coal and peat.

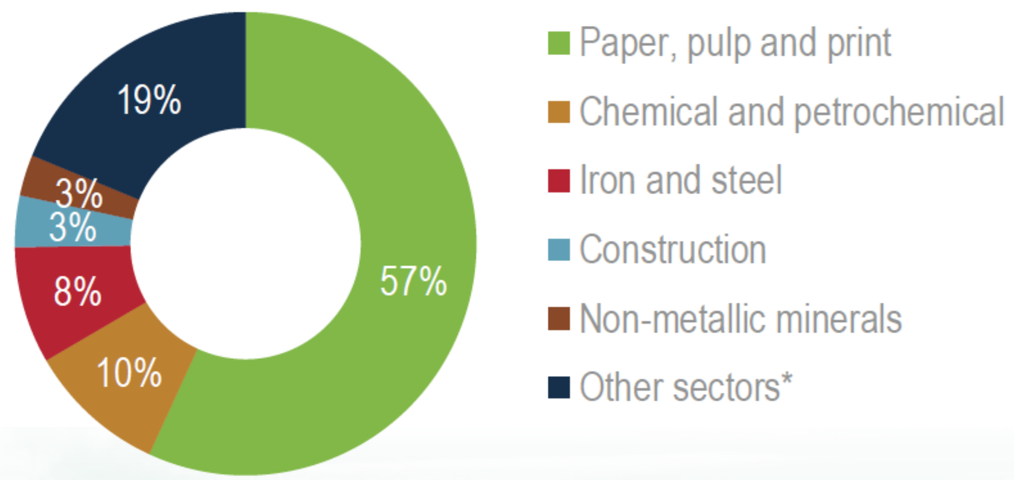
Finland industry mix demand evolution Mtoe (Eurostat)



Finland is a country rich in forest resources, which is reflected in industrial production. The paper, pulp and print industry is by far the largest in terms of energy consumption and accounted for 57% of TFC in industry in 2016. Thanks to a large reliance on biofuels, however, the paper industry accounts for less than one-third of industrial CO_2 emissions. Other industry sectors that depend more on fossil fuels, such as construction, metals and minerals industries, are relatively heavy emitters.

Finland's tax policy has affected the competitiveness of natural gas, and gas use in CHP/district heating is not affordable compared to coal, peat and bioenergy (energy tax, including the CO_2 tax, for natural gas has sharply increased since 2011).

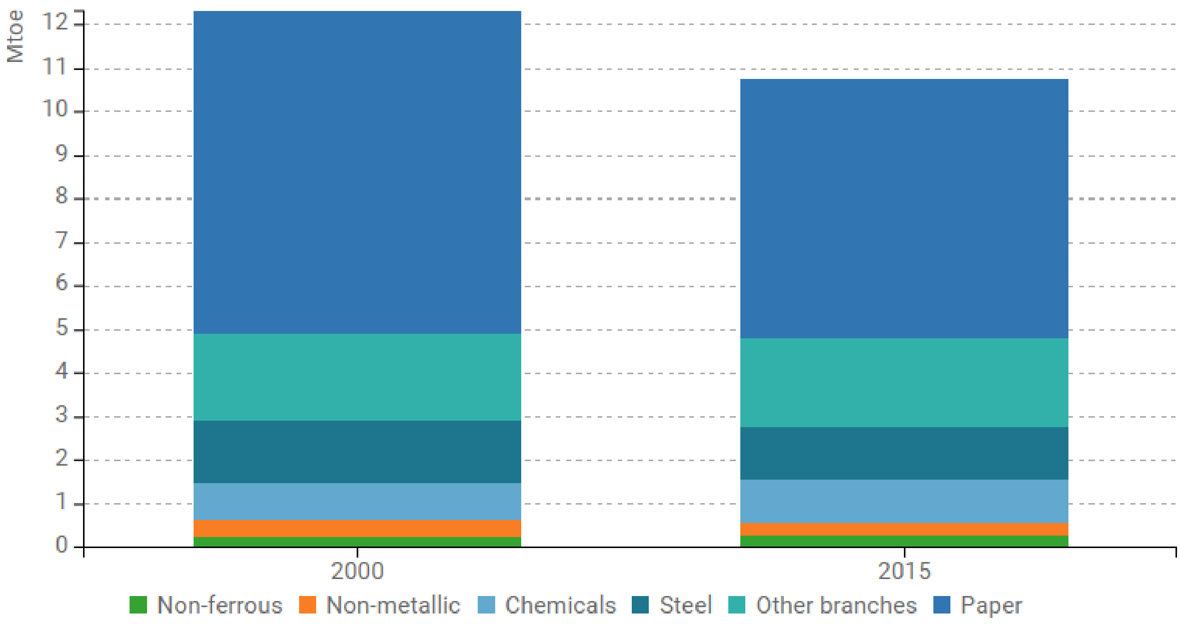
Final energy consumption by industrial sector 2016 in Finland (IEA 2018)



ENERGY SHARE OF INDUSTRIES IN THE NATIONAL ENERGY DEMAND

In 2015, energy consumption in industry was 11 Mtoe, i.e. 15% under the 2000 level. The energy-intensive pulp and paper, steel and chemical industries are the largest energy consumers, with 55%, 11% and 9% shares, respectively. However, structural changes have reduced the absolute consumption of paper industry from 7.4 Mtoe in 2000 to 5.9 Mtoe in 2015.

Final energy consumption by industry branch (ODYSSEE)



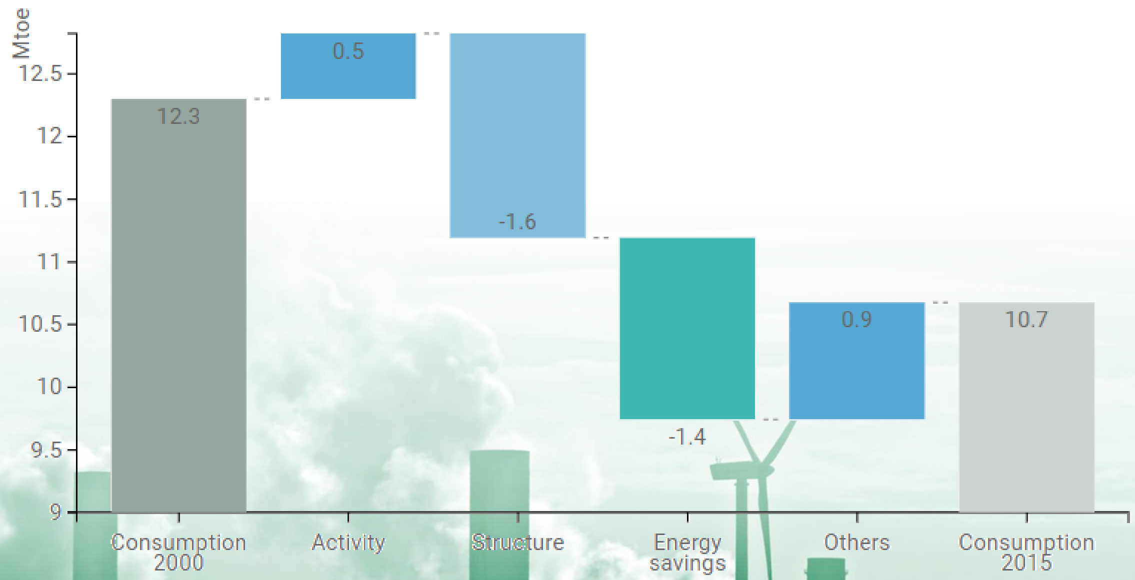
The specific energy consumptions of both paper and steel production are at lower level than in 2000 but portray very different trends inside the time period.

- Unit consumption of steel peaked a year after when the economic crisis started but declined thereafter.
- Unit consumption of paper declined until 2009, increased rapidly until 2012 but took a downward turn thereafter.

In industry, energy consumption is not directly proportional to product output because it cannot be fully adjusted to dropping demand. The observed decline in industrial energy consumption in 2000-2015 is driven by energy savings together with structural changes towards less energy consuming branches.

Since 2000, many factors contributed to decrease in industrial energy consumption (-1.6 Mtoe). Structural changes (-1.6 Mtoe) and energy savings (-1.4 Mtoe) compensated increase in energy consumption due to higher activity effect (0.5 Mtoe) and others.

Main drivers of the energy consumption variation in industry (ODYSSEE)



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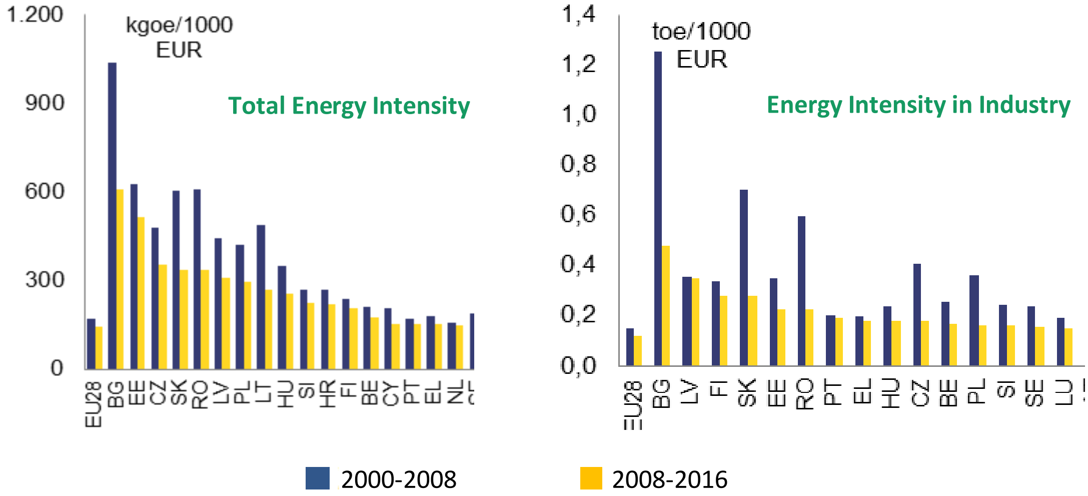
ENERGY INTENSITY IN INDUSTRY

In Finland, although primary energy intensity decreased over the 2005-2015 period, it remains above EU average and it decreased at a slower pace.

A sectoral assessment shows that the **energy intensity of Finland's industry** is one of the highest in the EU, and has been quite stable over the last ten years. This is also, to a lesser extent, true in the services sector, and the energy intensity of households is also above the EU average.

Comparison Total Energy Intensity and Energy Intensity in Industry (Eurostat, DG Economy)

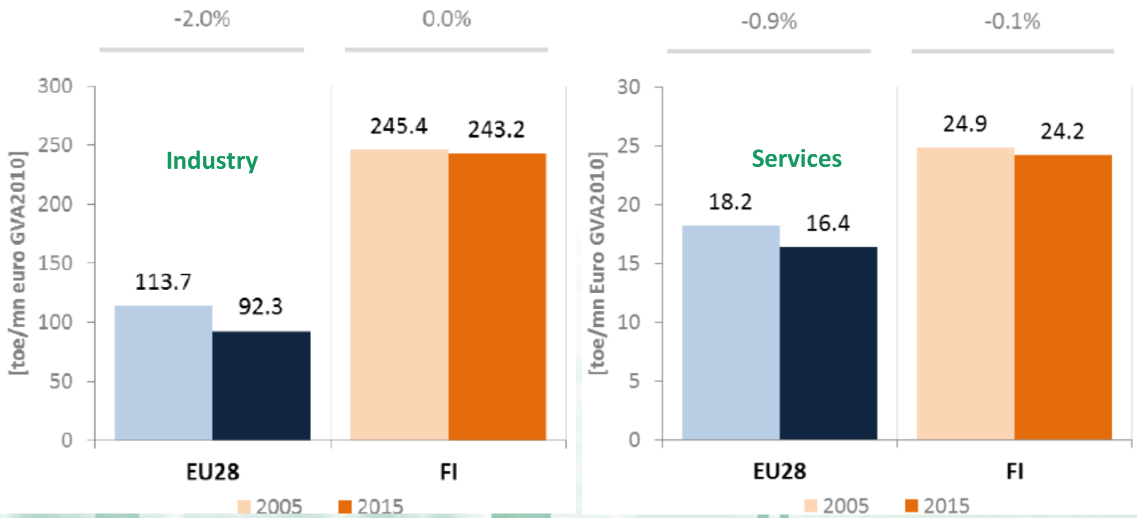


Additional efforts could therefore be envisaged to improve energy intensity in these various demand sectors, but keeping in mind that certain industrial processes (i.e. steel) are already very efficient and so the potential for additional improvements remains limited.

A positive development concerns the use of European Funds for Strategic Investments (EFSI) funds to finance various nearly zero-energy building projects. The use of EU Cohesion policy funds in energy efficiency demonstrations in public infrastructure and in SMEs in Finland, in line with its operational programme, is also expected to bring benefits.

Energy efficiency agreements (voluntary agreements) are used to promote energy savings in a broad range of industrial sectors and local communities. New agreements for the period 2017-2025 have just been signed and are expected, according to government's estimates, to contribute for about half of Finland's energy savings obligations linked to the implementation of the EU Energy Efficiency Directive.

Final energy intensity of global industry and services in Finland (DG Energy)



Between 2000 and 2015 industrial energy intensity decreased by 1.5 percent/year. Efficiency gains were mainly reported in the cement industry (1.7 percent/year decrease in the energy consumption per ton of cement).

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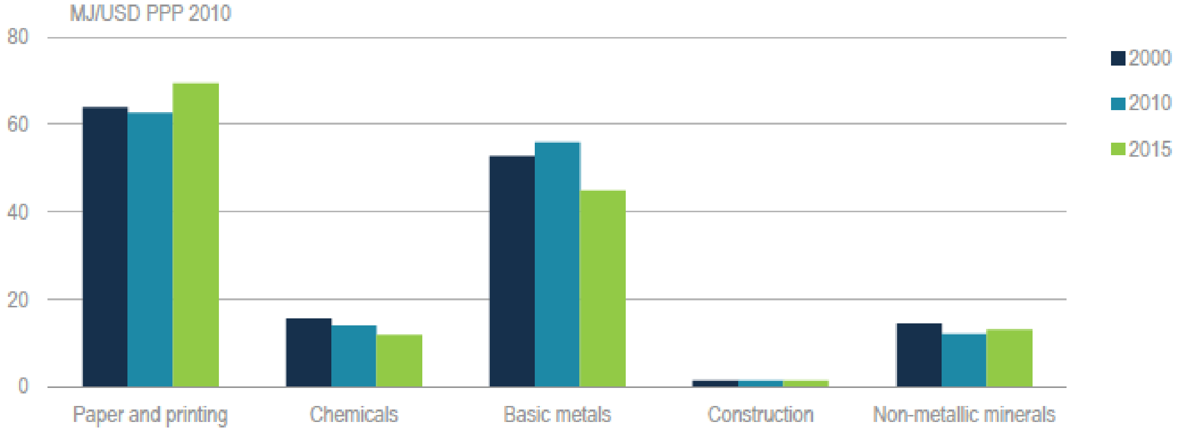
However, a slight increase was seen in the unit consumption of the two largest energy-intensive branches, namely paper (1 percent/year hike between 2000 and 2010) and steel (+0.7 percent/year).

Energy intensity in terms of energy consumption per value added in industry differs a lot for different industry sectors. Overall, the energy intensity in manufacturing industries has declined over the last decade and a half, indicating more efficient production.

In certain sectors such as the paper industry, however, the trend has been increased energy intensity. This can be explained by structural changes in industry, as demand for more expensive printing paper is declining while demand for cheaper packaging material is increasing. In 2016, sales of printing paper fell by 7.3% compared to the previous year, whereas paperboard sales increased by 8.9% (FFI, 2017).

Energy intensities in manufacturing by industry sector Finland (IEA 2018)



While the overall energy intensity of industry is gradually decreasing, this does not apply to all sectors. Metals, Mining and quarrying and Wood increased their energy intensity over the period 2000-2013.
It is also interesting to identify that the sectors with the highest energy intensities cover only a small share of gross value added.

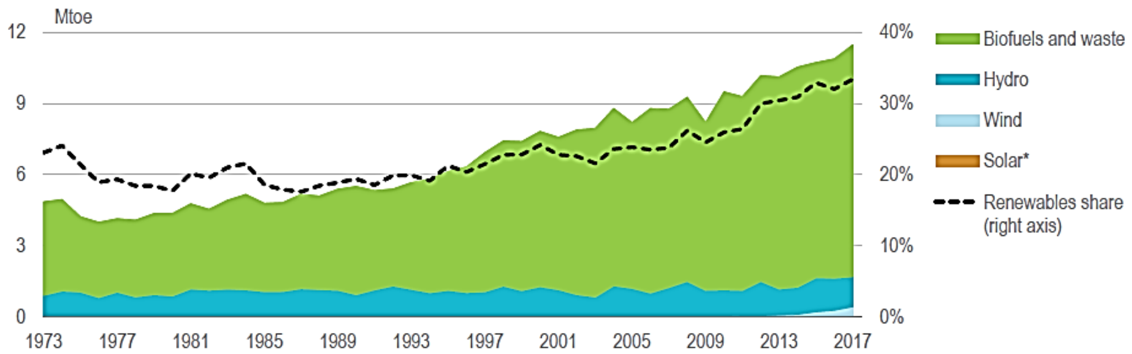
Energy intensities trend in manufacturing by industry sector 2000-2013 (Eurostat)

	Energy intensity (toe/1000 €)	GVA share
Metals	1,68	3%
Chemical and Petrochemical	0,65	4%
Non-Metallic Minerals	0,63	4%
Paper, Pulp and Print	0,51	3%
Wood and Wood Products	0,33	2%
Food and Tobacco	0,22	6%
Textile and Leather	0,23	1%
Transport Equipment	0,06	20%
Machinery	0,06	30%
Non-specified (Industry)	0,12	10%
Mining and Quarrying	0,10	2%
Construction	0,03	16%
Total Industry	0,19	100%

RENEWABLE ENERGY IN THE NATIONAL CONTEXT

The share of renewable energy in TPES has been on a steady growth path. Over the last decade, biofuels and waste supply grew on average by 2.7% per year.

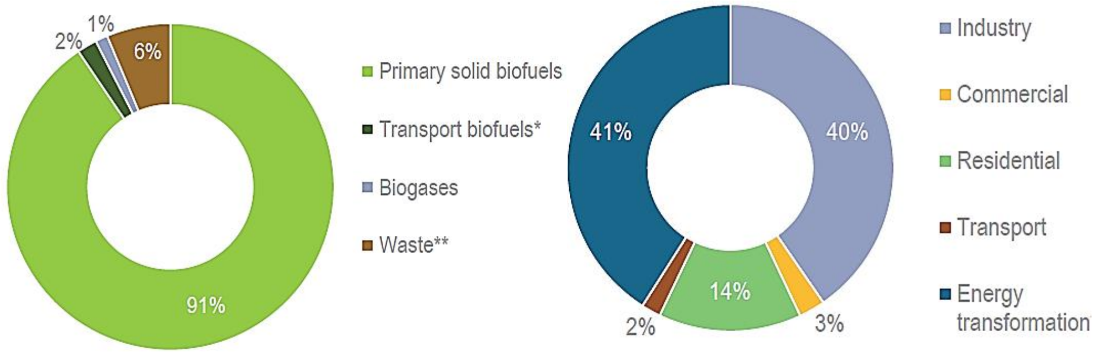
Evolution of Finland renewable energy generation in TPES, 1973-2017 (IEA 2018)



Solid biofuels are mainly used in heat and power generation, industry and residential sectors. Biofuels and waste were introduced in heat and power generation in the 1980s, and have rapidly become an essential part of energy supply. In 2016, biofuels and waste accounted for 45% of district heat production.

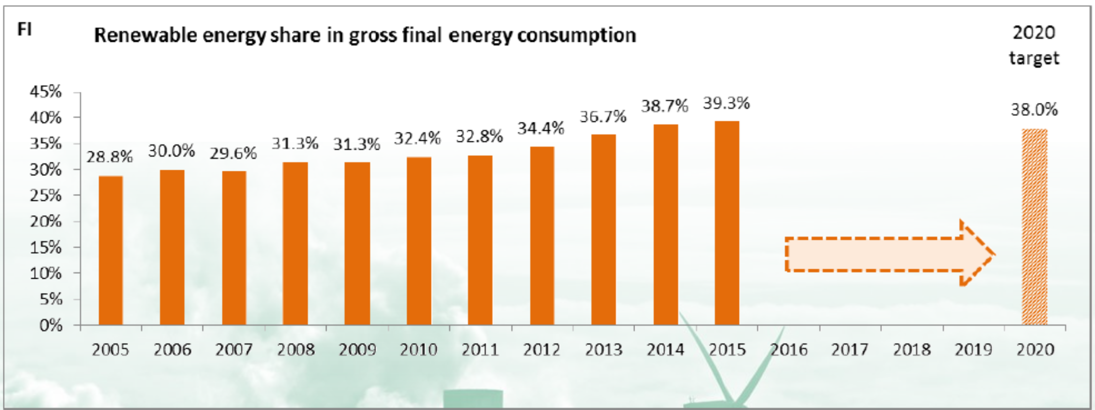
In 2017, Finland had 33.4% renewables in TPES, which was the fifth-highest share among IEA member countries, with 28.5% covered by biofuels, the second highest share in the IEA. Biofuels together with hydropower and a growing share of wind power accounted for 47% of electricity generation.

Supply and demand of biofuels, 2016 (IEA 2018)



Finland's renewable energy share, expressed in percentage of gross final energy consumption, was 39.3 % in 2015, already above its 2020 target.

Renewable energy share of Finland final energy consumption (Eurostat-SHARES)



Finland is among the few EU Member States which already achieved the renewable energy share in transport, reaching 22 % in 2015. The renewable energy share is more than 50 % in the heating and cooling sector and about a third in electricity generation.

Finnish supporting mechanisms:

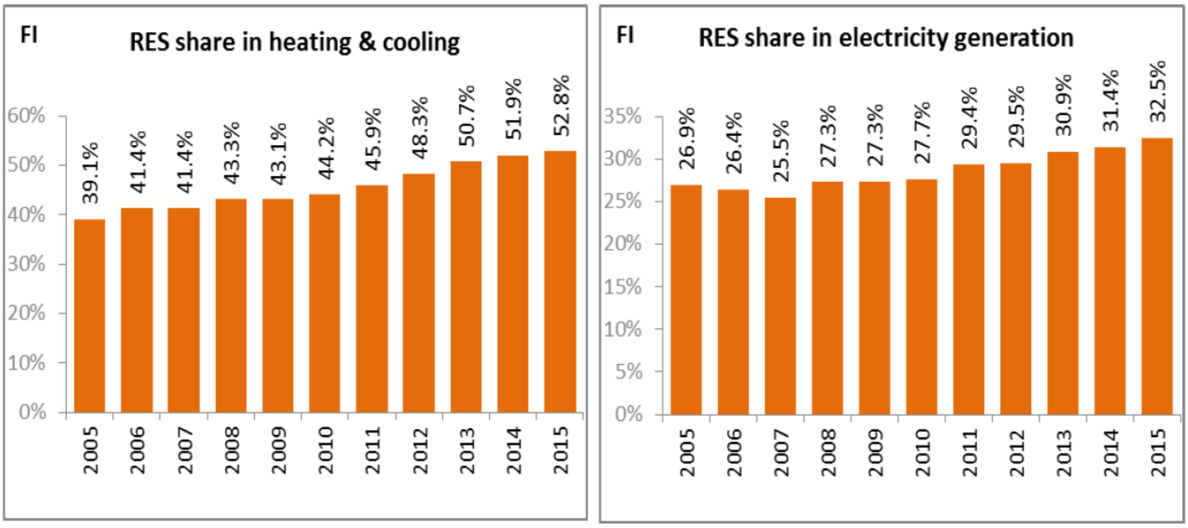
- Electricity from renewable energy sources is mainly promoted through a feed-in premium. It applies to electricity produced from wind, biomass and biogas, but is not available to small producers and PV power producers. Instead, an “energy aid”, a state grant for investments in RES production facilities, is proposed.

- The main support mechanism for heat produced from renewable energy sources is a “heat bonus” allocated to Combined Heat and Powerplants working on biogas and wood fuel.

- The cost of renewables support schemes is financed by the state budget rather than being passed onto final consumers.

- In transport, the main incentive for renewable energy use is a quota system. This system obliges fuel vendors to ensure that biofuels make up a defined percentage of the company’s total annual sale of fuel. Furthermore, the use of biofuels is supported through tax regulation.

Finnish RES share in heating and cooling, and electricity (Eurostat-SHARES)

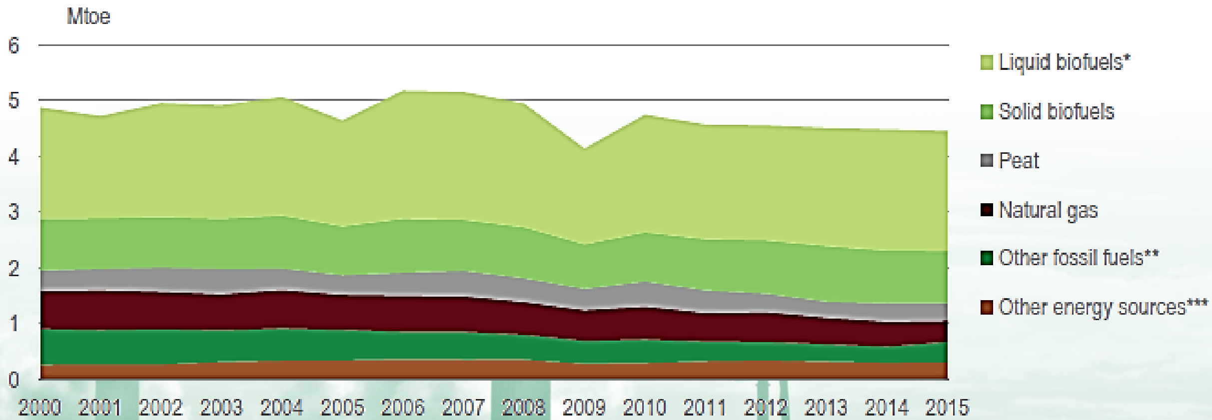


Thanks to the consistent deployment of renewables since 2005, it is estimated that Finland has reduced in 2015 by about 16 % its fossil fuels consumption. In addition, it is estimated that GHG emissions are 14 % lower. This is mostly due to a strong substitution of petroleum products with renewable energy (oil represents more than half of all fossil fuels substituted in Finland), and therefore linked to the use of renewable energy in transport.

RENEWABLE ENERGY USE IN INDUSTRY

Biofuels account for the largest share of TFC in the industry sector. Most energy consumed in industries, with the exception of electricity, is used for producing heat to heat up processes and buildings.

Industrial heat production by source, 2000-15 (Statistics Finland 2017)



Industrial heat production is heavily dominated by biofuels, of which black liquor accounts for the largest share. Black liquor is mainly produced and used internally in pulp and paper industry processes.

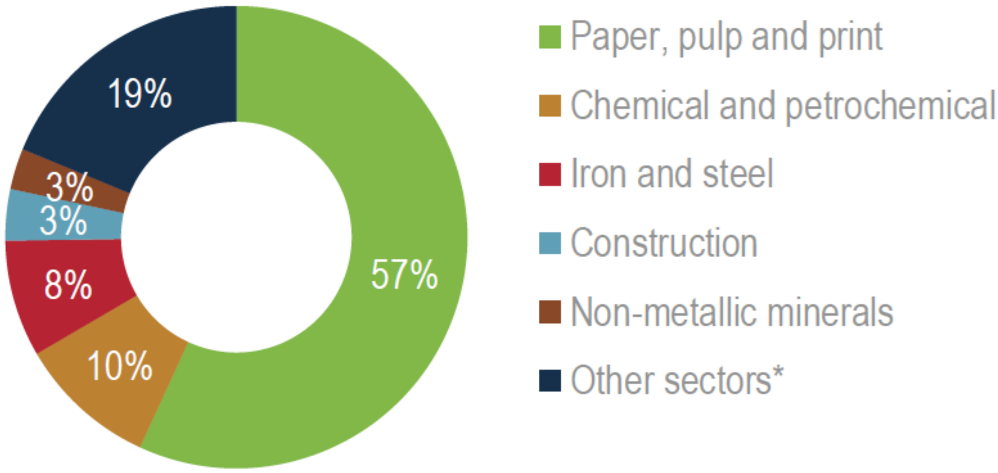
In 2015, liquid biofuels accounted for 47% of total heat produced in industries, and solid biofuels for another 21% (Statistics Finland, 2017).

The share of biofuels has increased from 60% in 2000 to 70% in 2015. However, 24% of industrial heat is still produced with fossil fuels. There is potential for further growth in biofuels, e.g. to replace peat, which accounts for 7% of heat production in industries.

Analysis of national energy consumption and intensity in industry

The analysis of the different energy consumer sectors of the national industry will provide a necessary view of the energy potential to integrate renewable energies in these industries.

Final energy consumption share by industrial sector 2016 in Finland (IEA 2018)



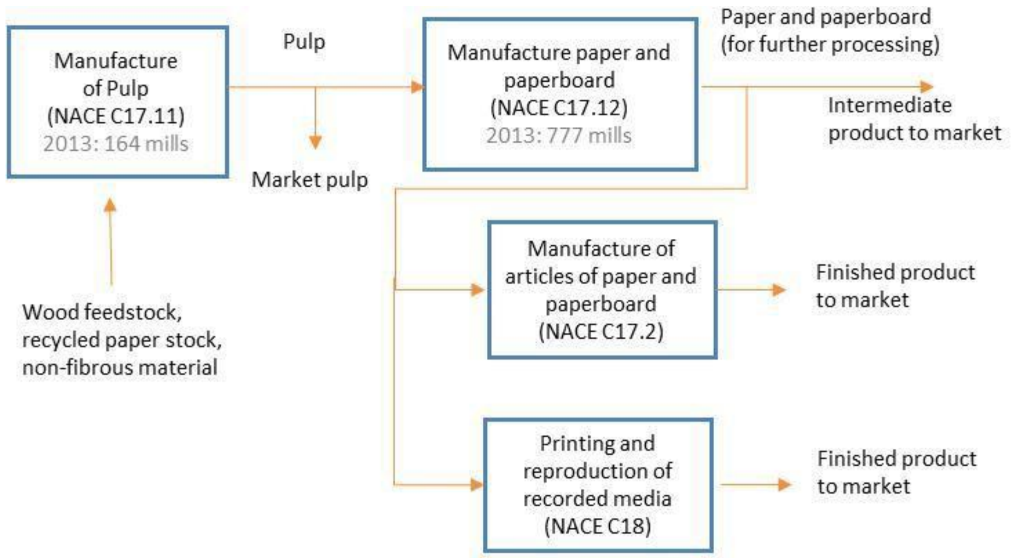
Next chapter develops the process and energy analysis of the following major energy consuming sectors of the industry:

- Paper
- Chemical
- Steel and metals
- Non-metallic
- Food

PAPER

It is estimated that manufacturing of pulp, paper and paperboard consumes over 98% of the overall final energy consumption reported for the pulp, paper and print sector. This is mainly attributed to the upstream processes of producing pulp, paper and paperboard, which is much more energy intensive in comparison with the downstream process in of printing and reproduction of recorded media.

Structure and product flow of pulp, paper industry Eurostat NACEs (ICF)



Pulp. This includes:

- Manufacture of bleached, semi-bleached or unbleached paper pulp by mechanical, chemical (dissolving or non-dissolving) or semi-chemical process
- Manufacture of cotton-linters pulp
- Removal of ink and manufacture of pulp from waste paper.

Pulp quality is graded according to the method of production (e.g. mechanical or chemical wood pulp), wood source (e.g. soft or hard wood) and level of processing (e.g. bleached or unbleached). Pulp can be divided into 2 main principal categories; mechanical and chemical pulp.

Paper and paperboard. The output of this class of product is intended for further industrial processing before taking form as the end-use product. This includes:

- Further processing of paper and paperboard:
    - Coating, covering and impregnation of paper and paperboard
    - Manufacture of crinkled paper
    - Manufacture of laminates and foils (if laminated with paper or paperboard)
- Manufacture of newsprint and other printing or writing paper
- Manufacture of cellulose wadding and webs of cellulose fibres
- Manufacture of carbon paper or stencil paper in rolls or large sheets
- Manufacture of handmade paper
- Paper and paperboard Finnishing can be coated or uncoated.

Share Final energy demand per subsector (Eurostat)

Sector Description	Estimated share of final energy demand
Manufacture of pulp, paper and paperboard	90 – 98%
Manufacture of articles of paper and paperboard	
Printing and reproduction of recorded media	2 – 10%

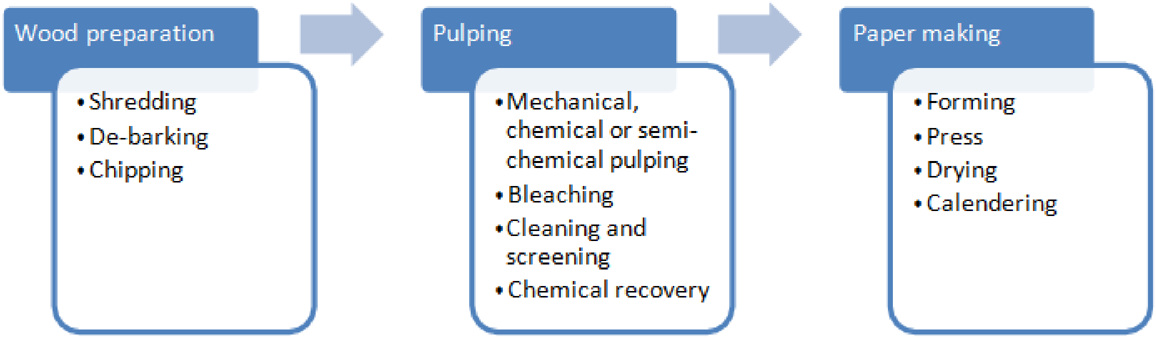
<u>The paper energy process</u>

Three main energy consuming processes are defined.

- Wood Preparation
- Pulping

– Paper making

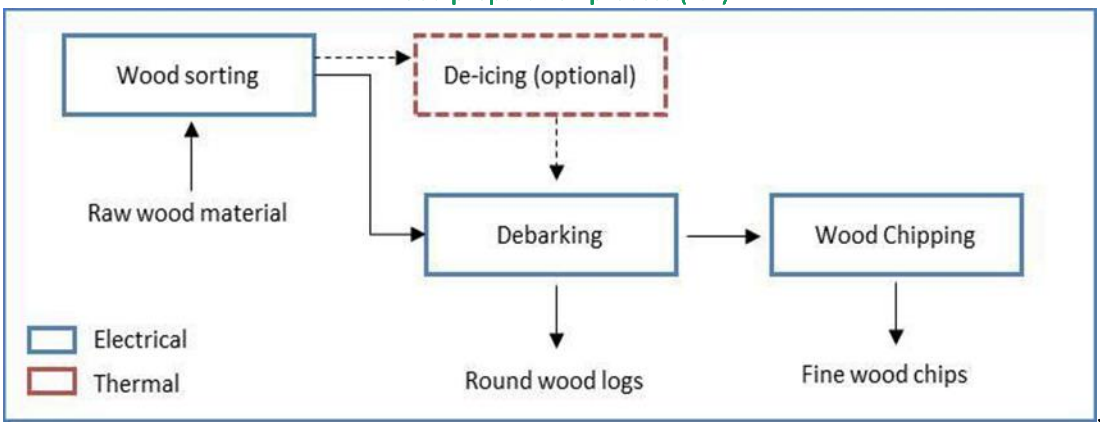
Main process categories of pulp, paper and paperboard production (ICF)



Wood Preparation

This process converts raw wood material into forms (logs or wood chips) which are suitable for pulping. The raw wood material is first sorted and cut to size. It is then transported to the debarkers, a mechanical process of removing barks from the logs through abrasion. Chain conveyors are typically used to transport the raw wood material. Following this, the wood logs are ready for the chipping process. Wood chippers are typically use discs or knives to break the logs into wood chips. The wood preparation process uses electrical energy almost entirely. The main energy end users are conveyor motors, debarking operational motors and wood chipping motors. Thermal energy is only required in some mills, where hot water is used to de- ice the wood logs before it is debarked.

Wood preparation process (ICF)



Pulping – Mechanical and Semi-Chemical

Based on 2012 CEPI statistics, 29% of pulp produced within the EU is made up of mechanical pulp and Semi-Chemical pulp. Mechanical consist of Groundwood pulp and Thermo Mechanical Pulp (TMP) and Chemical Thermo Mechanical Pulp (CTMP).

Pulping – Chemical

Based on 2012 CEPI statistics, 71% of pulp produced within the EU is made up of Chemical pulp. Of this 71%, 92% are made up of Kraft pulp and remaining 8% are made up of Sulphite pulp. Kraft pulp has surpassed Sulphite pulping mainly because of its limitation in wood feedstock, lower pulp strength and less efficient in chemical recovery.

Pulping – Semi Chemical

Semi chemical pulping process combines aspects of both mechanical and chemical pulping. The wood feedstock is fed into a digester for mild chemical cooking, a lower temperature and cooking period in comparison with chemical pulping process, which results in partial delignification of the feedstock. Thereafter, the blow tank transfers the feedstock into the mechanical defibering device, usually disc or conical refiners, which separates the partially cooked feedstock. The resulting pulp is then washed, screened and thickened, similar to chemical pulping process.

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Paper making
Paper making process is where the pulp fibres is processed to take form of paper and paperboard, through blending and processing of other non-fibrous additive.

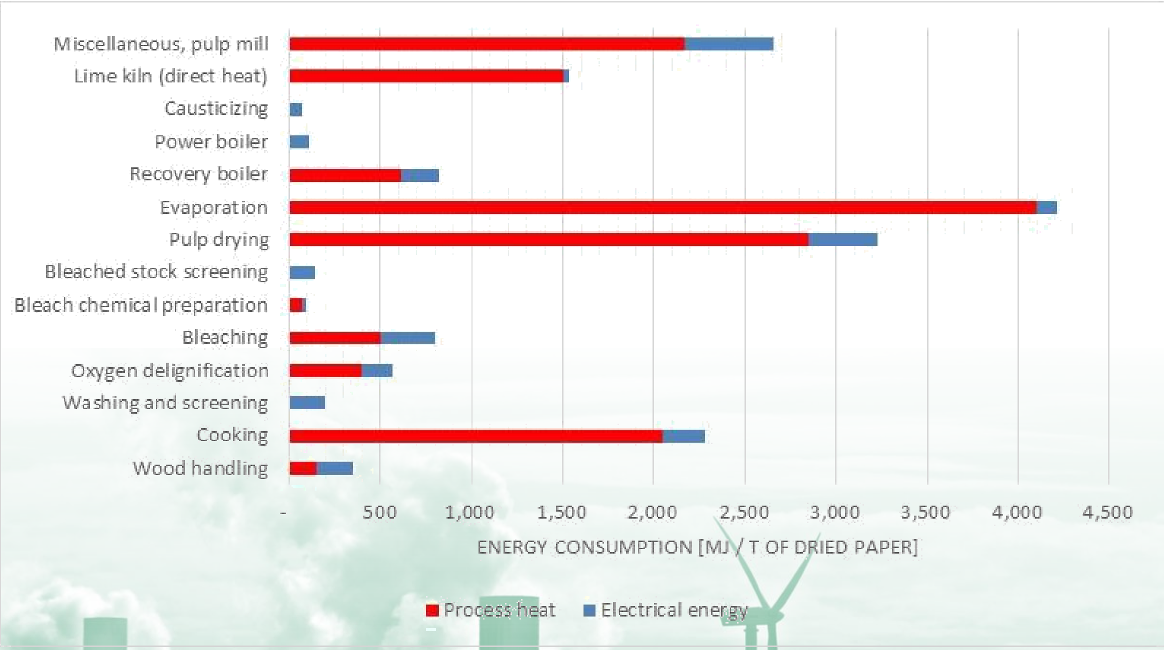
An **overview of the final energy** consumed by key processes in a typical Kraft pulp mill based in Sweden [BREF, 2001]. The energy intensity for the plant amounts to 17,136 MJ/t, of which thermal energy attributes to 84% while the remaining 16% is electrical energy.

This is very much in line with the EU average intensity and that majority of EU pulp mills are Kraft pulp mills. EU average intensity amounts to 16,926 MJ/t of pulp, paper and paperboard produced in 2012, of which 78% attributes to thermal energy while the remaining 22% is electrical energy.

Energy intensity for key processes of a Swedish bleached Kraft pulp mill (IEA)

Process	Process Heat [MJ / t]	Electrical Power [MJ / t]	Total Energy [MJ / t]	% of total [%]
Wood handling	150	198	348	2.0%
Cooking	2,050	234	2,284	13.3%
Washing and screening		198	198	1.2%
Oxygen delignification	400	162	562	3.3%
Bleaching	500	299	799	4.7%
Bleach chemical preparation	70	22	92	0.5%
Bleached stock screening	-	144	144	0.8%
Pulp drying	2,850	378	3,228	18.8%
Evaporation	4,100	108	4,208	24.6%
Recovery boiler	610	216	826	4.8%
Power boiler	-	108	108	0.6%
Causticizing	-	72	72	0.4%
Lime kiln (direct heat)	1,500	36	1,536	9.0%
Miscellaneous, pulp mill	2,170	490	2,660	15.5%
Effluent treatment	-	72	72	0.4%
Total per ton of pulp	**14,400 (84%)**	**2,736 (16%)**	**17,136 (100%)**	

Thermal and electrical energy intensity breakdown of a Pulp mill (IEA)



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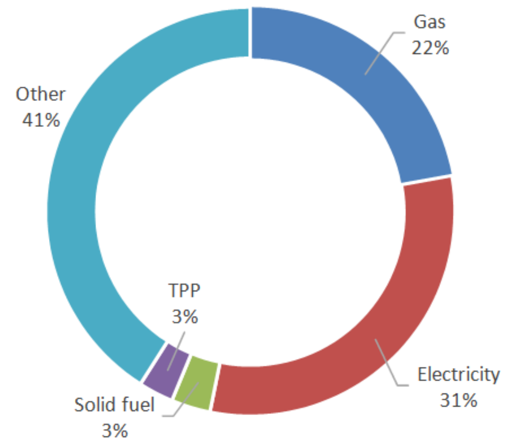
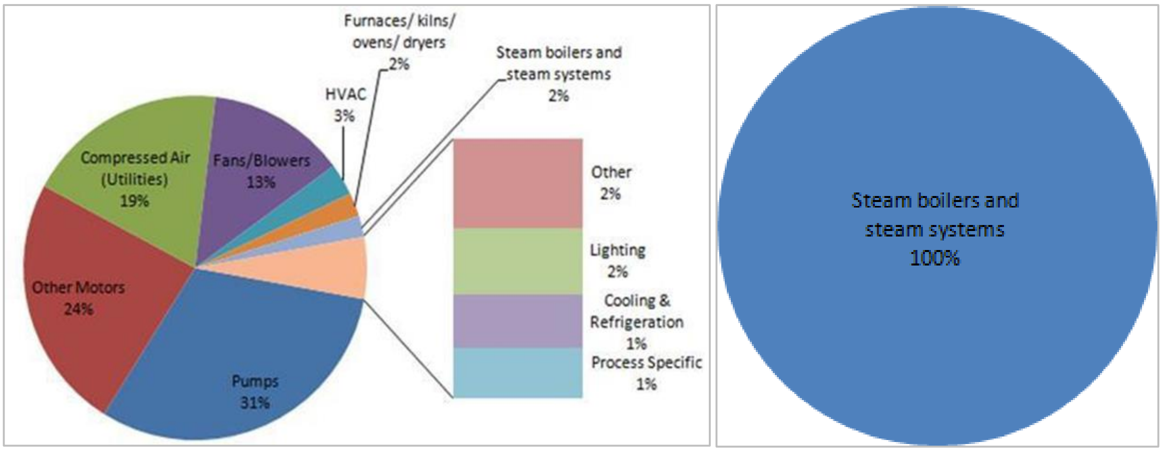


The energy mix of this process is covered by gas, electricity and solid fuels. Source: EUROSTAT, Dec 2014.

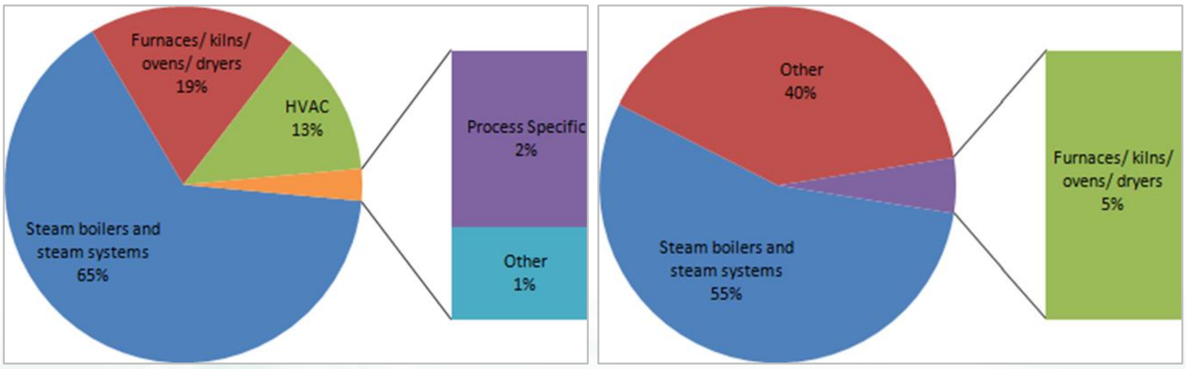
Based on the estimated share of energy consumption amongst the paper sector, the following figures present an aggregate energy use profile for the primary energy sources:

- Electricity use profile
- Natural gas use profile
- Coal use profile
- Other fuel use profile

Electricity use profile and coal profile (ICF)



Electricity use profile and Natural gas use profile (ICF)



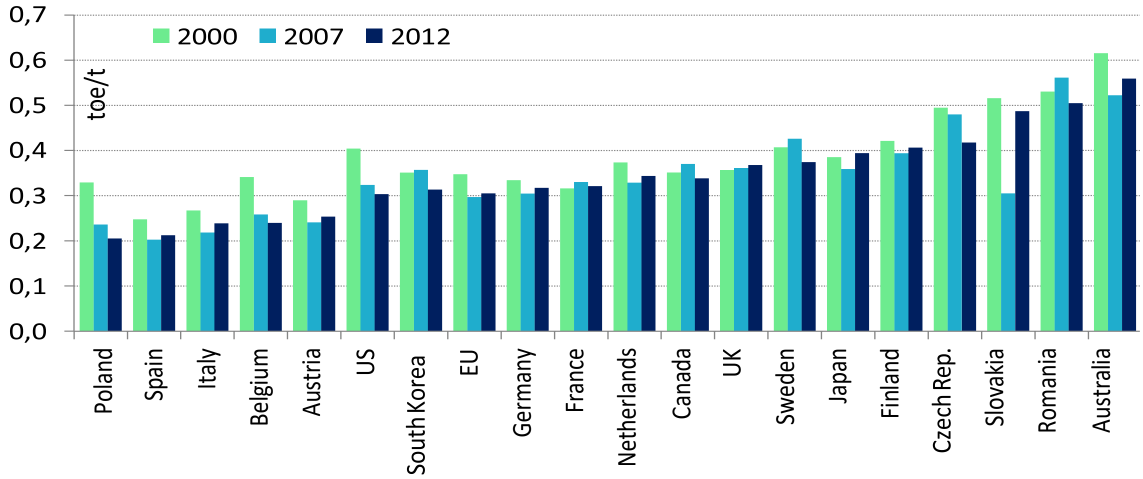
STEEL AND METALS

Over the period 2000-2013, Metals recorded one of the highest increases of energy intensity among manufacturing sectors while its share in total GVA declined at the quickest pace. This countermovement could possibly be explained by some fixed energy inputs when decline in energy use cannot fully reflect the decline in output (Metals recorded the largest decline in GVA of all industrial sectors).

Until 2007, the average specific consumption per tonne of steel has been decreasing in most countries (by 2.2%/year at EU level). Since 2007, there has been a slight increase in this specific consumption in half of countries and at EU level (by 0.5%/year for the EU average).

This deterioration of energy efficiency since 2007 is mainly explained by a lower rate of utilisation of the steel factories. In some EU countries however, this specific consumption has still been decreasing (e.g. Poland, Belgium, France, Romania and the Czech Republic), as a result of an increased penetration of electric steel, the less energy intensive process4, and the closure of old and less efficient steel mills.

Specific energy consumption per tonne of steel (Odyssee for EU, IEA for the other countries)



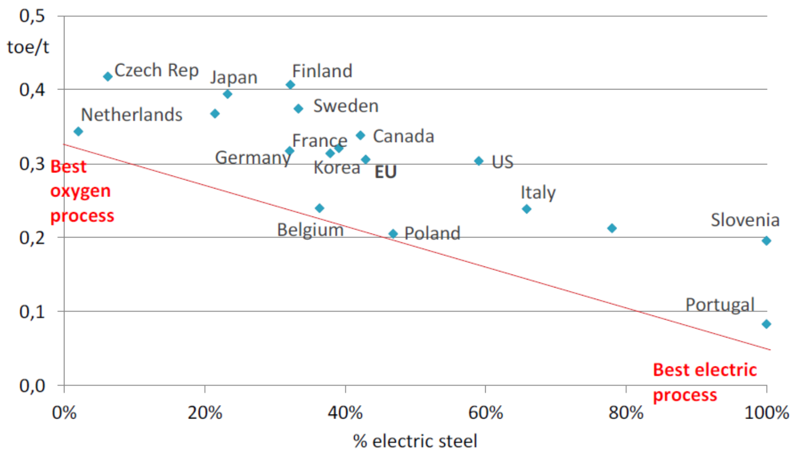
Energy consumption per ton of steel and process mix (2012) compares the specific consumption per ton of steel in relation to the share of electric steel in total crude steel production.

Next figures provide this benchmark.
The vertical distance from the world benchmark (shown by the red line) shows the possible improvement with the present process mix.

The distance to the 100 % electric process shows the potential theoretically open to process substitution. In reality, this might be restricted by the availability of iron scrap and quality requirements of the steel produced.

Benchmarking of countries should be done at similar process mix: for instance, for countries in a range of 30-35% share of electric steel, Belgium represents the benchmark countries.

Energy consumption per tonne of steel and process mix (ICF)



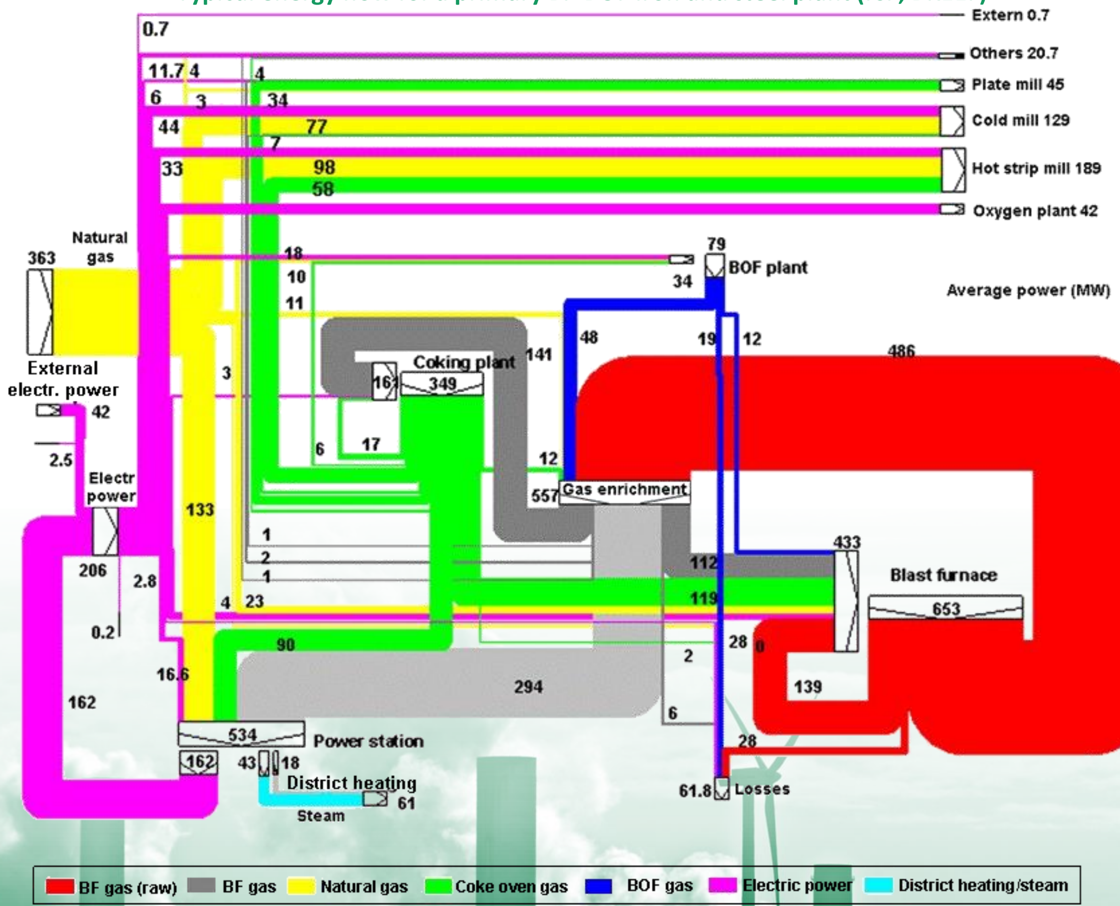
The steel energy process

The interrelationship between primary fuel (coal and heavy oil) and energy input creates a rather complex energy balance within the iron and steel industry.

- Firstly, the primary resource input utilized in the coal pyrolysis process produces coke and Coke Oven Gas (COG). Coke is then used as feedstock for the iron making process and COG is utilized as an energy resource after cleaning.
- Secondly, the coke consumed in the Blast Furnace for iron ore reduction process produces hot metal and Blast Furnace Gas (BFG), which is also utilized as energy resource after cleaning.
- Thirdly, the gasses produced from the Basic Oxygen Furnace during the hot metal oxidation process produces crude steel and BOF Gas, containing large amounts of Carbon Monoxide rich flue gas which can be cleaned for subsequent use as fuel.

The application and quality of these 3 gasses as fuel will vary depending on plant specifics (integrated or non-integrated, technology employed, etc.) and ultimately impact the amount it is able to supplement primary fuel used in the Coke Oven, BF, BOF and on-site generation plants.

Typical energy flow for a primary BF-BOF iron and steel plant (ICF, BREEF)



Iron and steel production is produced through 2 main routes, primary or secondary. Currently, the primary route involves the production of steel through the Blast Furnace – Basic Oxygen Furnace route.

Primary iron and steel making involves the following key stage processes:

- Raw material preparation. During this stage, coal is converted into coke through a pyrolysis process in a coke oven plant, producing coke and liquids.
- Iron making process. The raw material (coke, sinter / pellets, lump ore) is fed into the Blast Furnace (BF) which reduces the iron oxides to metal iron. The liquid iron (hot metal or 'pig iron') is collected and continuously caste. This process also produces BF gas which is collected and utilized as fuel.
- Steel making process. The key objective of this stage is to regulate the impurities within the hot metal feedstock. Undesirable impurities are burned in the Basic Oxygen Furnace (BOF). The liquid molten steel from the BOF is the casted into crude steel forms (slabs, blooms, billets).
- Finnishing. There are 2 main classification of Finnished steel products; flat and long. Long products goes through further Finnishing products to form seamless pipes, bars, rolls and wires. Flat products goes through further Finnishing process to form cold rolled sheets, steel plates, welded pipes, etc.

Key stage processes in steel, using BF-BOF and EAF methodologies (ICF, BREEF)

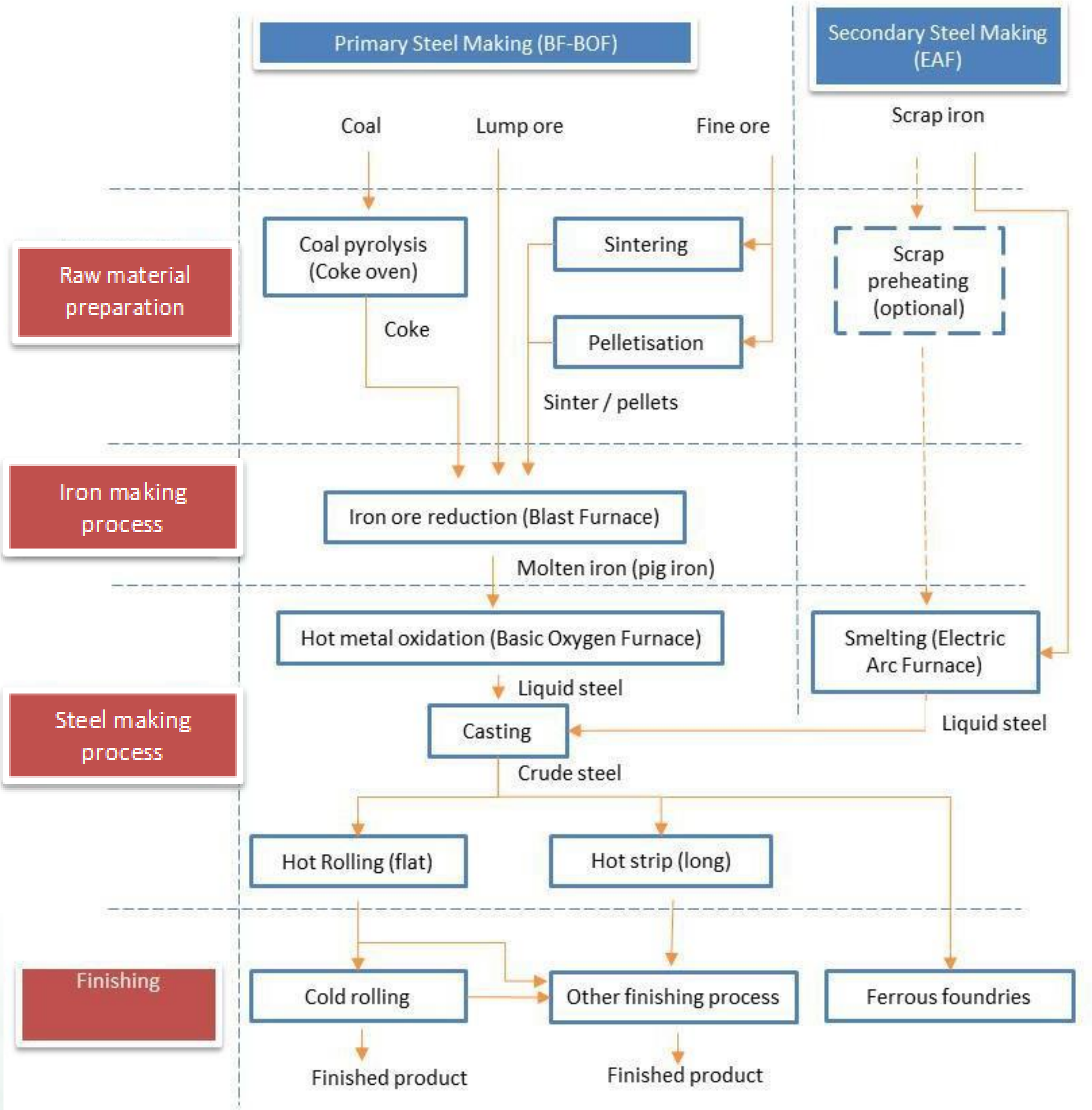
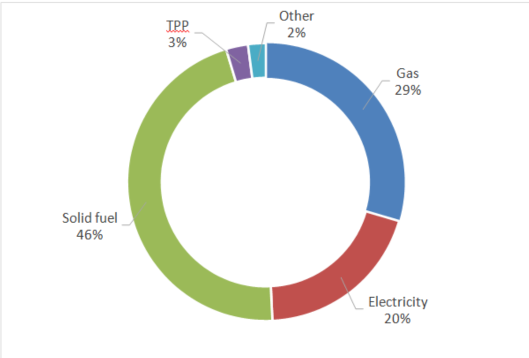


Table below presents the best practice **energy intensity** of key processes within the production process of iron and steel production through primary (BF-BOF) route.

The energy figures present the final energy consumed during the process and the figures are expressed with reference to per tonne of crude steel produced. The final energy consumed takes manufactured gas into account (Coke Oven Gas, BF Gas and BOF Gas).

Best practice energy intensity of key processes in primary primary iron and steel production (BF-BOF route)

Process	Thermal [GJ / tonne]	Electricity [GJ / tonne]	Final Energy [GJ / tonne]
Material Preparation			
Coke production (Coke Oven)	0.7	0.1	0.8
Sintering	1.7	0.2	1.9
Iron Making Process			
Iron ore reduction (Blast Furnace)	12.1	0.1	12.2
Steel Making Process			
Hot metal oxidation (Basic Oxygen Furnace)	0.12	0.1	0.22
Continuous cast	0.05	0.05	0.1
Hot rolling - strip	1.3	0.3	1.6
Hot rolling - bar	1.6	0.3	1.9
Hot rolling - wire	1.7	0.4	2.1
Cold rolling	0.2	0.3	0.5
Total	**15.9**	**0.8**	**16.7**

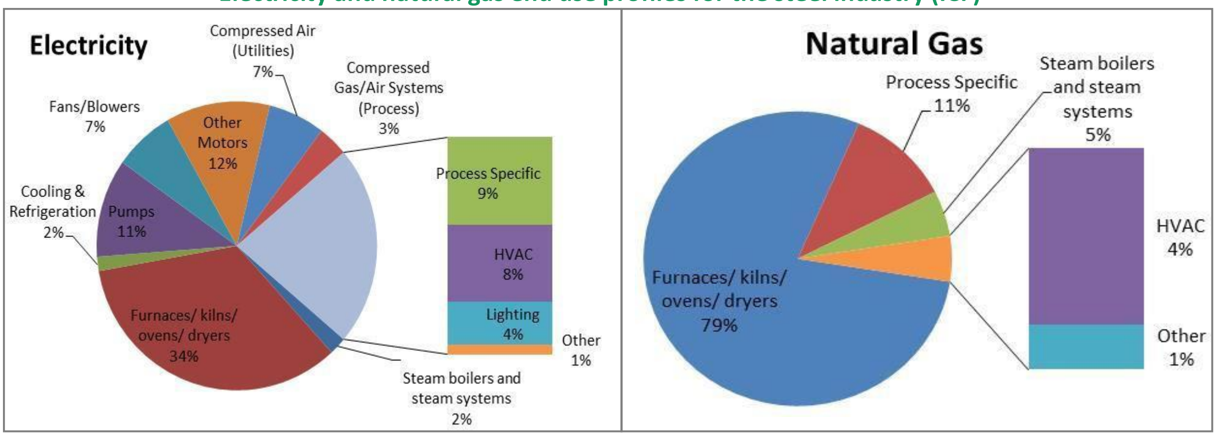


The energy mix of this process is covered by solid fuel (mainly coal), gas and electricity. Source: EUROSTAT, Dec 2014.

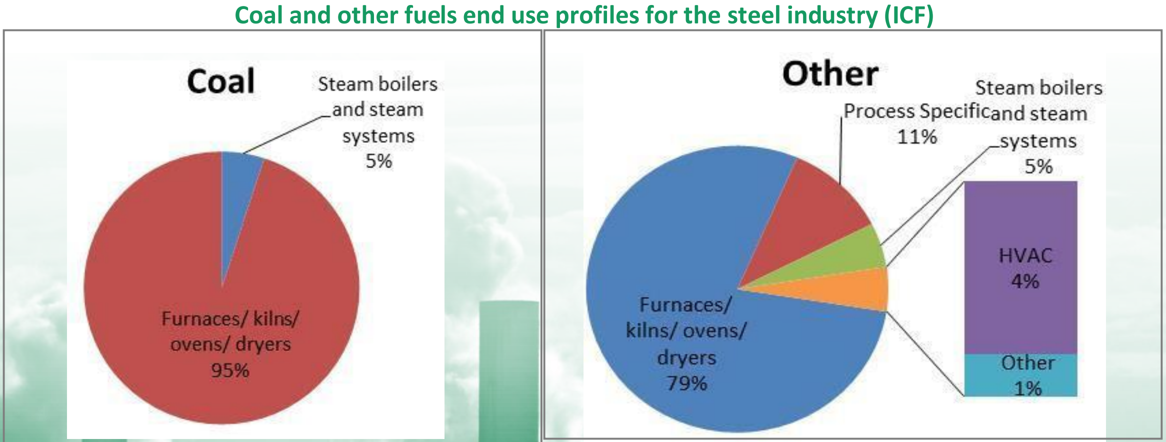
Based on the estimated share of energy consumption amongst the iron and steel sector, the following figures present an aggregate energy use profile for the primary energy sources:

- Electricity use profile
- Natural gas use profile
- Coal use profile
- Other fuel use profile

Electricity and natural gas end use profiles for the steel industry (ICF)



Coal and other fuels end use profiles for the steel industry (ICF)



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CHEMICAL

Key energy consumption are delivered by 2 key groups: Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms; and Manufacture of pharmaceutical preparations which accounted for 70% of total production value.

The petrochemicals and basic inorganic subsectors account for 72% of the energy use in the chemicals sector and reflect the high energy requirements to produce the primary feedstock for the downstream subsectors (polymers, specialty and consumer chemicals).

Chemicals and pharmaceuticals sector share of energy demand (ICF)

Sector Description	Share of final energy demand
Petrochemicals	47%
Basic inorganic	25%
Polymers	12%
Specialty chemicals	8%
Consumer chemicals	2%
Pharmaceutical products	6%
Petrochemicals	47%

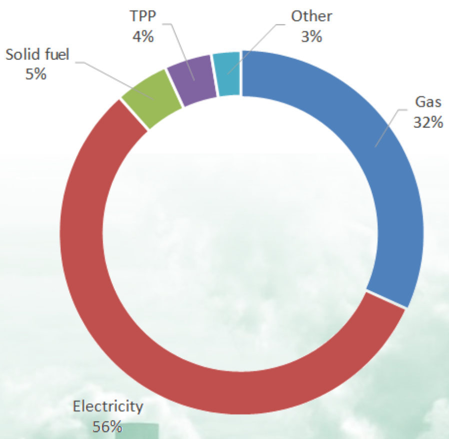
The chemical energy processes

The chemicals sector incorporates the manufacture of numerous products, including base chemicals (e.g., plastics, polymers, fertilizers, industrial gases); specialty chemicals (e.g., paint, ink, dyes); and consumer chemicals (e.g., soaps, detergents, cosmetics).

The chemicals subsector is characterised by the considerable use of fossil fuels and biomass for energy and feedstock. The bulk of energy and feedstock use occurs in a few key production processes.

Steam cracking; ammonia production; and chlorine production, which occur in the petrochemicals and basic inorganics upstream manufacturing subsectors, are estimated to account for over 30% of energy use in the chemicals and pharmaceutical sector

Petrochemicals and basic inorganics have the highest energy intensity within the chemicals subsector. Unlike downstream manufacturing, which requires energy to support reactions and mechanical processes (e.g., drying, mixing, rolling), upstream production requires significant quantities of energy (heat) to break and transform organic and inorganic molecules.
For example, polymer production is approximately 5 times less energy intensive per unit of production than petrochemical.

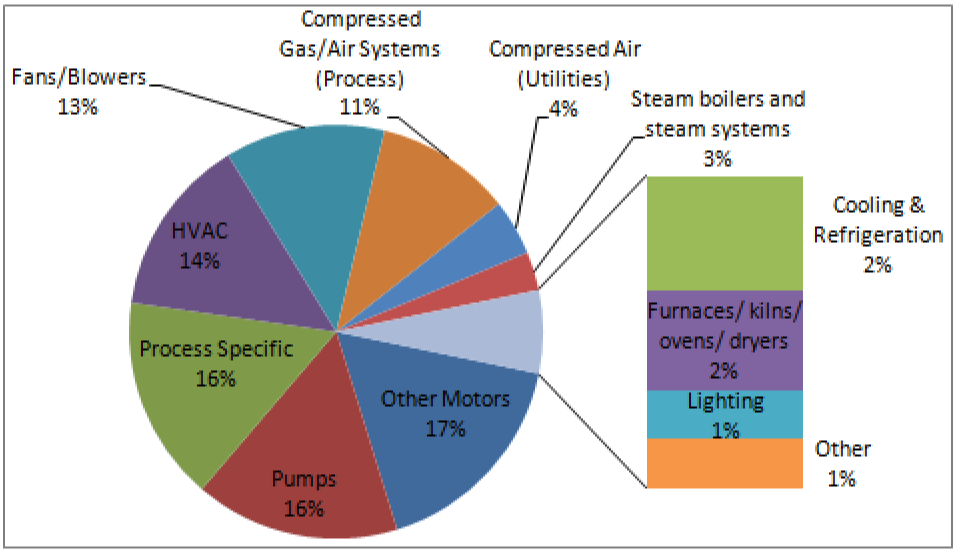


The energy mix of this process is covered by electricity, gas and other fuels. Source: EUROSTAT, Dec 2014.

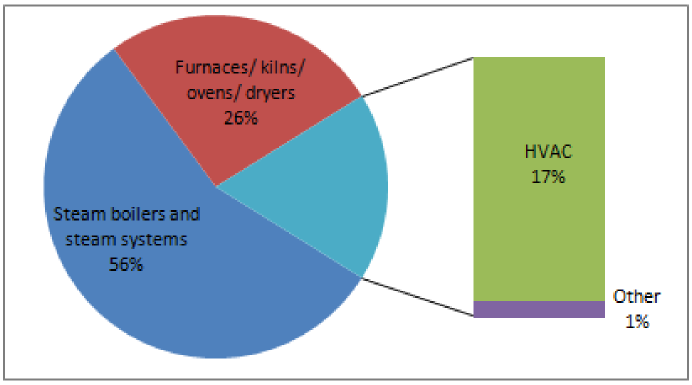
Based on the estimated share of energy consumption amongst the chemical and pharmaceutical sector, and the fuel mix profiles, the following figures present an aggregate energy use profile for the primary energy sources, including:

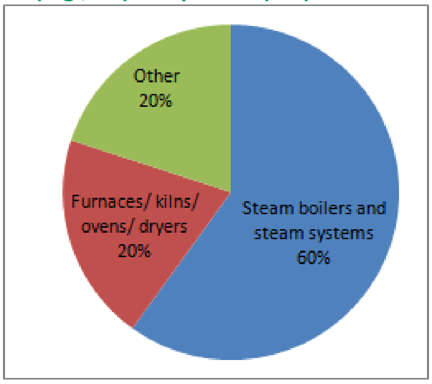
- Electricity use profile
- Natural gas use profile
- Petroleum use profile
- Coal use profile
- Other fuel use profile

Electricity use profile and Natural gas use profile (ICF)

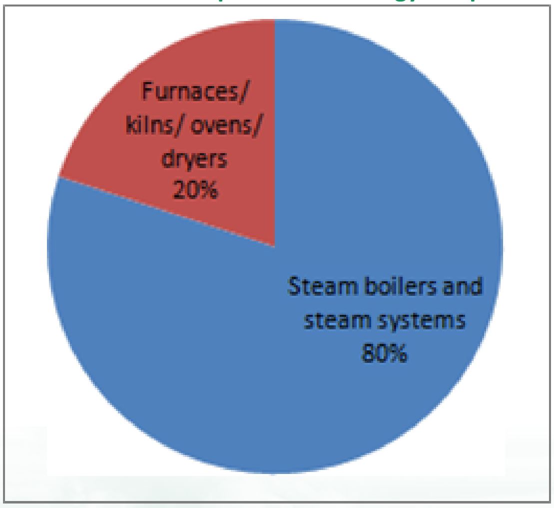


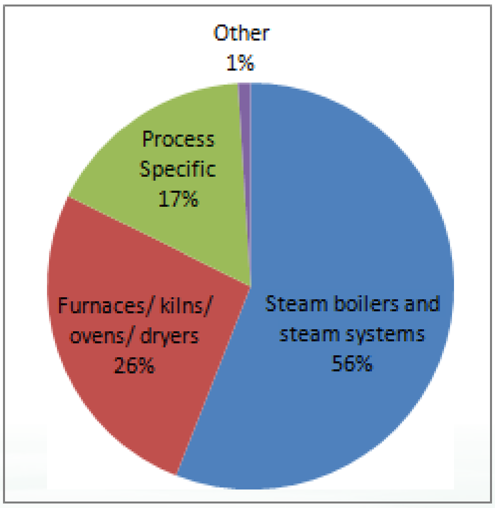
Electricity use profile and Total petroleum product (e.g., oil) use profile (ICF)





Coal use profile and Energy use profile for other sources; i.e., biomass (ICF)





NON- METALLIC

Glass is one of the main subsector, in terms of production and consumption. The majority of glass production is for container packaging (60%); and flat glass for building, automotive and solar-energy panels (30%). The remainder is consumed in the domestic glass market (e.g., tableware, cookware); in glass fibre applications for the automotive and transportation (such as aircrafts), communication, and electronic sectors.

Ceramics products include, wall and floor tiles, bricks and roof tiles, household ceramics, refractory products, and expanded clay aggregates. The main products, with 80% of energy consumption, is associated with the production of bricks, wall, floor, and roof tiles.

Cement and Lime. Cement is widely used in construction and building industry; it is an important component in the production of mortar and concrete. Cements are typically characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to be used in the presence of water.

The following table provides an estimated overview of the share of energy consumption between the subsectors based on statistics from various sources, including EUROSTAT, the European Cement Association, Glass Alliance Europe, and the European Lime Association.
Cement production accounts for nearly 60% of the energy use in the non-metallic minerals sub-sector. However, the most energy intensive part of the non-metallic minerals industry is the production of ceramic materials.

Share of energy consumption between the subsectors (IEA)

Sector Description	Share of final energy demand
Manufacture of glass and glass products	17%
Manufacture of ceramics and ceramic products	19%
Manufacture of cement	58%
Manufacture of lime	6%

<u>The non-metallic energy process</u>

The production of non-metallic minerals (glass, ceramic, cement and lime) is characterised by the use of intense heat to either melt (glass), sinter (ceramics, cement) or thermally decompose (lime) raw materials. As such, the key energy intensive process in these industries is the kiln or furnace, which can operate at temperatures exceeding 1,000°C. Electricity use, in comparison, is minimal (e.g., in lime production it is on the order of 1 to 2%). Tables provide a summary of the energy intensities associated with the production of glass, ceramics, cement and lime.

Glass production comprises the six process steps. First, silica (high quality sand), soda (Na2CO3) and potash are mixed with stabilizers, such as lime (CaO), magnesium oxide (MgO) and aluminium oxide (Al2O3), to reduce weathering effects. Following this batch mixing and preparation step, the raw materials are melted, homogenized in a furnace, which operates up to temperatures of 1,600°C.
After, the molten glass moves to the forming process, where depending on the final product, it passes through different blowing and pressing methods. For the glass, the split between heat and power is approximately 85% and 15%, respectively.

Energy intensity of glass production (Ecofys)

Product	Electricity Use kWh/t (GJ/t)	Production contribution
Flat glass	203 (0.73)	25%
Container packaging	372 (1.34)	70%
Tableware	unknown	2%
continuous filament fiber	1,110 (4)	2%
Specialty glass	unknown	1%

Ceramic production takes place in different types of kilns, with a wide range of raw materials and in numerous shapes, sizes and colours; however, the general process is uniform. All ceramics start as a mixture of powdered base material (Zirconia, etc.), binders and stabilizers. This mixture is "formed" into shapes and then fired (sintered) in kilns at temperatures between 1800°C - 2000°C for days or weeks at a time, depending on the ceramic and process details.

Kilns used in the production of brick, roof, wall and floor tiles represent the largest contributor to energy consumption in the EU ceramics industry.

Energy intensity of ceramic production (BREEF)

Product	Energy Use (GJ/t)	Production contribution
Brick and roof tiles	2.31	38%
Wall and floor tiles	5.6	42%
Refractory products	5.57	7%
Sanitary-ware	21.87	3%
Vitrified clay pipes	5.23	1%
Table and ornamental-ware	45.18	6%
Technical ceramics	50.39	2%

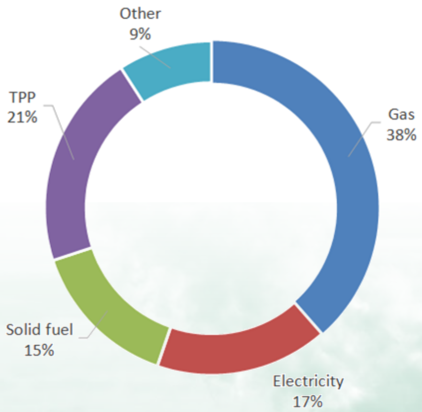
Cement production is a two-step process. First, clinker is produced from raw materials (calcium oxide (65%), silicon oxide (20%), alumina oxide (10%) and iron oxide (5%)) by heating in a rotary kiln at temperatures of up to 1,500°C. This step can be a dry, wet, semi-dry or semi-wet process according to the state of the raw material. After the clinker is produced, the second step involves gypsum (calcium sulphates) and possibly additional materials, such as coal fly ash, natural pozzolanas being added to the clinker.
These are then ground to a fine and homogenous powder in a cement grinding mill.

Dry kilns represent the majority of clinker kilns used in the EU (92%), with 5% semi-dry, and 4% long dry. As such, the specific energy consumption of the EU cement industry is approximately as follows.

Energy intensity of cement production (ABB; BCG)

Product	Energy Use (GJ/t)	Production contribution
Vertical shaft kilns	5	?
Wet kilns	5.8 – 6.7	?
Long dry process	4.4 – 4.5	4%
Semi wet/semi dry kiln	4.0	5%
Dry kiln (four stages pre-heater)	3.2 – 3.7	92%
Dry kiln (six stages pre-heater and pre- calciner)	2.8 – 3.4	

Furnaces used in the production of glass consume natural gas and/or oil as the primary fuel source. Solid fuels, such as coal or lignite are not typically used as they would result in the production of molten ash in the glass phase, which would reduce product quality. In the ceramics industry, natural gas is the primary energy source for kiln firing; accounting for approximately 85% of total energy consumption. The remainder is made up electricity.

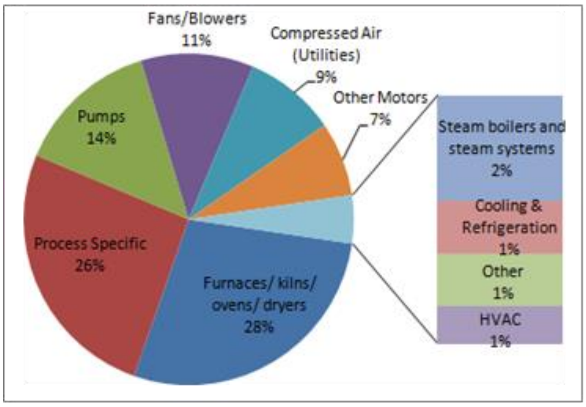


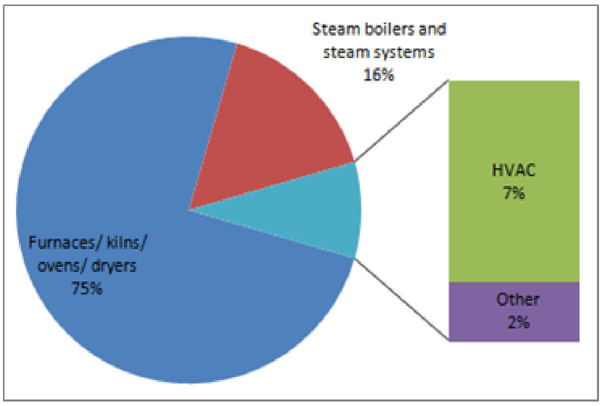
The energy mix of this process is covered by gas, electricity and solid fuels. Source: EUROSTAT, Dec 2014.

Based on the estimated share of energy consumption amongst the non-metaillic sector, the following figures present an aggregate energy use profile for the primary energy sources:

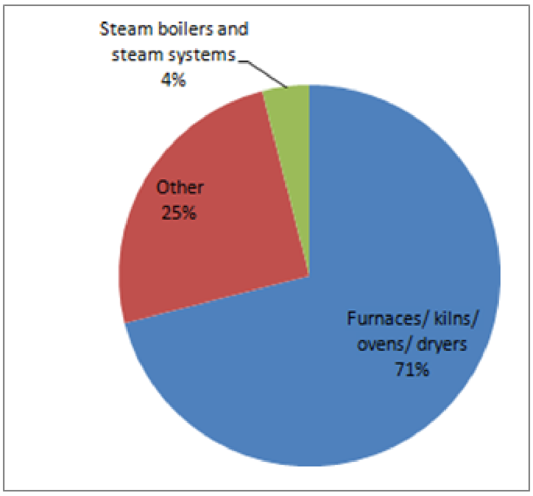
- Electricity use profile
- Natural gas use profile
- Coal use profile
- Other fuel use profile

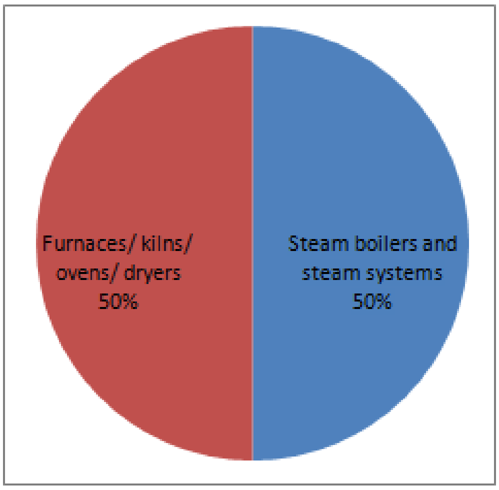
Electricity use profile and Natural gas use profile (ICF)





Petroleum products use profile and coal use profile (ICF)





FOOD

The final energy consumption data, due to the diversity of products and processes involved within the sector, is extremely difficult to estimate the share of subsector energy consumption.

The following table provides a breakdown share of energy consumption between manufacture of food products and manufacture of beverages.

Share of energy consumption between food and beverage sector (Eurostat)

Sector	Share of energy consumption
Manufacture of food products	84%
Manufacture of beverages	16%

The food sector is categorised into 9 groups:

- Processing and preserving of meat and production of meat products. This also includes rendering of animal fats and production of non-edible products (originating from the slaughterhouse) like hide, skin, wool, feathers and down.
- Processing and preserving of fish, crustaceans and molluscs. The processes include freezing, drying, cooking, smoking, canning and etc for human consumption or animal feed.
- Processing and preserving of fruit and vegetables.
- Manufacture of vegetable and animal oils and fats. This also includes non-edible animal oils and fats.
- Manufacture of dairy products. The activity of this group involves manufacture of dairies and cheese products including fresh liquid milk. This group also includes the manufacture of ice cream and edible such as sorbet.
- Manufacture of grain mill products, starches and starch products. This group also includes wet milling of corn and vegetable and production of starch and starch products.
- Manufacture of bakery and farinaceous products.
- Manufacture of other food products.
- Manufacture of condiments and seasoning (spices, sauces, mayonnaise, mustard, vinegar, salt, etc). Manufacture of prepared meals and dishes.
- Manufacture of prepared feeds for farm animals.

Subsector energy intensity expressed in a ratio of energy cost per value added generated (Energy Cost / Value Added) in 2011 (Eurostat).

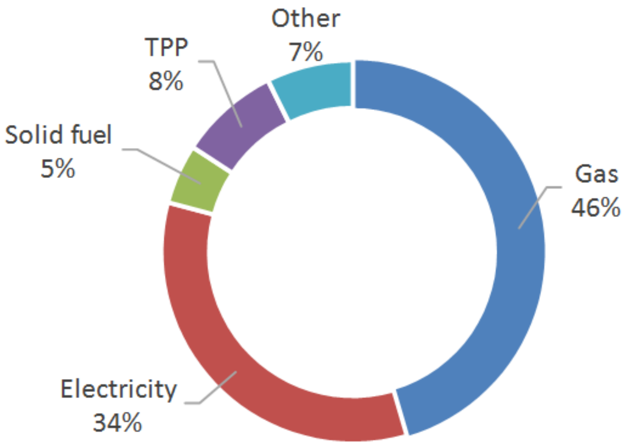
Sector Description	Ratio [%]
Manufacture of food products	**10%**
Processing and preserving of meat and production of meat products	10.0%
Processing and preserving of fish, crustaceans and molluscs	9.4%
Processing and preserving of fruit and vegetables	10.9%
Manufacture of vegetable and animal oils and fats	14.9%
Manufacture of dairy products	10.9%
Manufacture of grain mill products, starches and starch products	16.3%
Manufacture of bakery and farinaceous products	8.3%
Manufacture of other food products	8.6%
Manufacture of prepared animal feeds	15.9%
Manufacture of beverages	**4.6%**

The food energy process

The food process can be aggregated in the following steps:

- Materials reception and preparation. This includes materials handling and storage, sorting and screening, peeling, washing and thawing.
- Size reduction, mixing and forming. This includes cutting, clicing, chopping, mincing, pulping, pressing, mixing, blending, homegenisation, conching, grinding, milling, crushing, forming, moulding and extruding.
- Separation. This includes extraction, de-ionisation, fining, centrifugation and sendimentation, filtration, membrane separation, crystallisation, removal of free fatty acids by neutralisation, bleaching, deodorisation by steam stripping, decolourisation and distillation.

– Product processing. This includes soaking, dissolving, solubilisation/alkalising, fermentation, coagulation, germination, brining, curing, pickling, smoking, hardening, sulphitation, carbonation, coating, spraying, enrobing, agglomeration and ageing.
– Heat processing. This includes melting, blanching, cooking and boiling, baking, roasting, frying, tempering, pasteurisation, sterilisation and Ultra High Temperature processing.
– Concentration by heat. This includes evaporation (liquid-to-liquid), drying (solid-to-solid) and dehydration (solid-to-solid).
– Chilling processes. This includes cooling, chilling, cold stabilisation, freezing, cryoextraction, concentration (through chilling), freeze drying and lyophilisation.
– Post processing operations. This includes packing, filling, gas flushing and storage under gas.

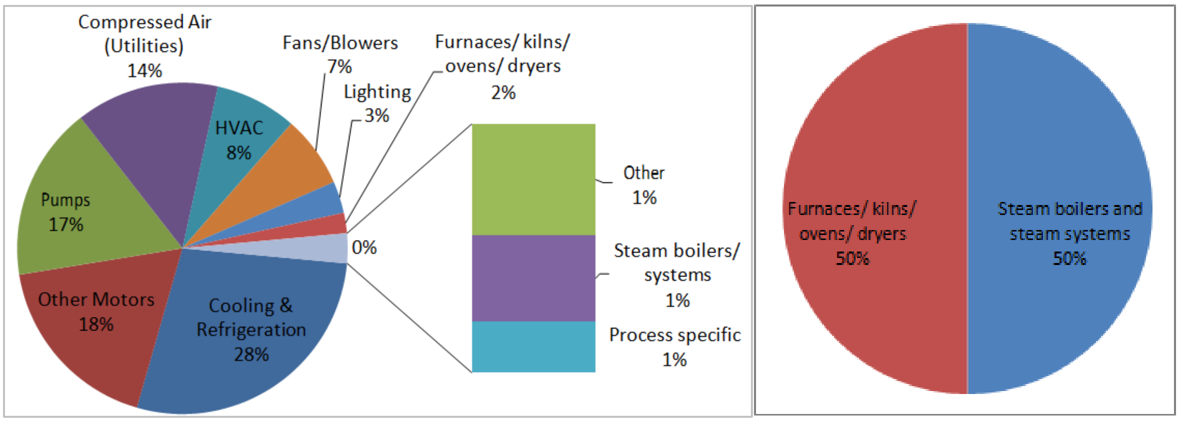


The energy mix of this process is covered by gas, electricity and solid fuels. Source: EUROSTAT, Dec 2014.

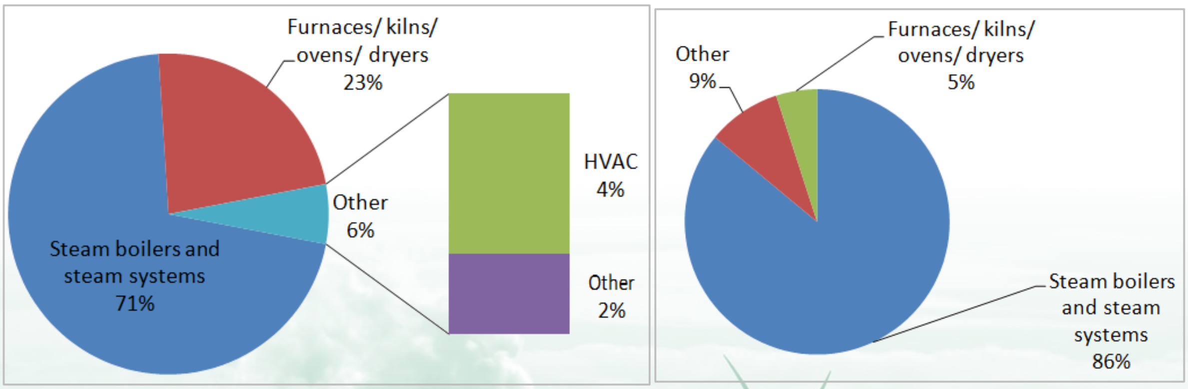
Based on the estimated share of energy consumption amongst the food sector, the following figures present an aggregate energy use profile for the primary energy sources:

- Electricity use profile
- Natural gas use profile
- Coal use profile
- Other fuel use profile

Electricity use profile and coal profile (ICF)



Electricity use profile and Natural gas use profile (ICF)



VI.V. ENERGY INSTITUTIONS AND MAIN ACTORS

Over the time, it is frequent to have a Ministry with specific responsibilities and duties in developing Finland's general energy policy. This Ministry is in charge of energy policy and oversees the Energy Department which remains an integral part of the Ministry. The Energy Department leads on energy markets, energy efficiency and emissions trading, renewable energy, nuclear energy and fuels.

It co-ordinates energy environment-related matters, including climate change, between ministries, such as the Ministry in charge of the Environmental policies, the Ministry in charge of Economy policies for implementing energy taxation, the Ministry in charge of agriculture and forestry for biomass and land use, land use change and forestry (LULUCF) issues, and the Ministry in charge of transport and communications for non-ETS sector emissions, which also oversees the promotion of energy efficiency in the transport sector.

The Energy Authority (EMA) is the independent national energy regulator. It is also the national emissions trading authority and promotes energy efficiency and the use of renewable energy.

The Finnish Funding Agency for Innovation (Tekes) finances research and development projects of companies and universities in Finland as well as international technology initiatives.

Motiva Oy is a state-owned company that implements government policies on energy conservation and on the promotion of renewable energy sources. The Finnish Safety and Chemicals Agency (Tukes) is in charge of the market surveillance of both the EU Ecodesign Directive and the Energy Labelling Directive.

The Natural Resources Institute Finland (Luke) is a research and expert organisation that works to promote the bioeconomy and the sustainable use of natural resources. Luke monitors natural resources, produces data on greenhouse gases (GHGs), supports natural resource policies and produces Finland's official food and natural resource statistics.

For nuclear power, the Radiation and Nuclear Safety Authority (STUK) is tasked with nuclear safety and radiation monitoring.

The National Emergency Supply Agency (NESA) is a network of ministries and industries that maintains and develops security of supply on the basis of public–private partnership initiatives.

Finland has a strong energy industry sector with large players active across the Nordic markets.
Fortum is the major electricity producer and the second-largest heat producer in Finland (with major operations also in Russia and in the Nordic market). It also operates in power and heat sales; it is 50.8% government-owned. Fortum Power and Heat Oy owns the Loviisa site on which two nuclear power plants operate (LO1 and LO2), and also provides waste management services.
Teollisuuden Voima Oyj (TVO) is a Finnish nuclear power company owned by a consortium of power and industrial companies. The biggest shareholders are Pohjolan Voima, whose majority shares are held by paper and pulp industries, and Fortum. TVO owns two nuclear reactors and the third nuclear plant (OL3), which was expected to be ready in 2009 but has been delayed once again to 2019.
Posiva Oy, a nuclear waste management company, is co-owned by both Fortum Power & Heat Oy (40%) and Teollisuuden Voima Oyj (60%).

Fingrid is the national grid operator that manages the national power balance and the electricity system.
Neste owns and operates the two oil refineries in the country which are specialised in processing Urals heavy crude. Neste is also the largest producer of biodiesel in the world. It is 50.1% government-owned.

Production aid for electricity from renewable energy sources

The sliding feed-in tariff system for the production of electricity from renewable energy sources came into force in Finland on 25 March 2011. The aid scheme concerns government support for electricity production based on wind power, biogas and small-scale CHP (wood fuels). The aid scheme has been phased out: It was closed for new power plants from 1 November 2017 for wind power and for biogas and small-scale CHP plants from 1 January 2019. However, the plants under the scheme will receive the aid up to 12 years from the start of production.

In May 2018, Parliament approved the Act on the Amendment of the Act on Production Aid for Electricity from Renewable Energy Sources (laki uusiutuvilla energialähteillä tuotetun sähkön tuotantotuesta annetun lain muuttamisesta 441/2018), which lays down provisions on the new premium system. The premium system is based on a competitive tendering process and investments in different renewable energy sources compete with each other so as to take into account the cost-effectiveness target. An auction was held in 2018 and decisions were made in March 2019. The aid was granted for seven projects within total of 1.36 TWh/a worth of annual electricity production. All of the projects concerned wind power. The power plants are expected to start production from 2021 onwards.

Under the Energy and Climate Strategy, no new operating aid schemes will be introduced or auctions held.

Aid for the use of forest chips

Finland promotes the use of forest chips in combined heat and power generation (CPH) with operating aid for electricity from forest chips. The aid is granted to compensate for the higher production costs of electricity from forest chips compared to fossil fuels. The maximum aid for electricity produced from forest chips has been EUR 18/ MWh. However, the aid depends on the price of the emissions allowance and has thus been in decline since the beginning of 2018.

When the price of the EU ETS is above EUR 23.7/CO2 tonne, no aid is paid, which has recently been the case. At the beginning of 2019, 53 power plants were within the scope of the aid. New power plants can be approved to the scheme until 1 February 2021 and the aid is paid for up to 12 years from the start of production.

Energy Aid Scheme

Renewable energy is also promoted through the Energy Aid Scheme (investment subsidy). Aid is primarily targeted at the commercialisation of new technologies and to the non-ETS sector, including plants producing advanced biofuels for transport, and non-ETS electricity and heat production of companies. Aid is paid up to 30% for mature technologies and up to 40% for new technology projects. However, aid levels are typically much lower, especially for mature technologies. The objective is that aid for different technologies will be phased out as a technology develops, the costs are reduced and competitiveness improves.

The typical annual budget has been EUR 30–40 million and this trend is expected to continue in future. However, decisions concerning the state budget are made annually. Since the start of 2019, there has been a separate budget (2019: +EUR 40 million) allocated for large demonstration projects. A similar additional budget has been proposed for 2020. In addition, an aid scheme totalling EUR 90 million has been planned for the early phase out of coal use in energy production. If approved, the aid scheme will be in force 2021–2023.

Promotion of the use of biofuels

The Act on Promoting the Use of Biofuels in Transport (laki biopolttoaineiden käytön edistämisestä liikenteessä 446/2007) has been in force since 2008. Under the Act, the share of the energy content of biofuels in the total energy content of the petrol, diesel oil and biofuels delivered by distributors for consumption (i.e. quota obligation) will steadily increase to 20% by 2020, taking into consideration the double counting rule. The biofuels included in the quota obligation must meet EU sustainability criteria.

By 2030, the share of biofuels in road transport will be increased from a physical share of about 13.5% of energy content by 2020, as required under current legislation on the biofuels quota obligation, to 30%. An act for increasing the quota obligation came into force on 1 April 2019.

Furthermore, the quota obligation has been extended to apply to light fuel oil used in heating and machinery so that the share of bioliquids must be at least 10% by 2028.

Energy taxation

Renewable energy is also promoted through taxation. While, renewable fuels are not taxed on heat production, fossil fuels are taxed according to their energy content as well as CO2 content. Energy taxation provides an incentive for the use of bioenergy in CHP production and building-specific heat production.

In 2015, a legislative change reducing the taxation of small-scale electricity production entered into force. Electricity production plants with a nominal output below 100 kVA and plants larger than that but with an annual production of at most 800,000 kWh were exempted from the obligation to pay electricity tax. These producers may themselves use at the site tax-free the electricity they have generated. If the electricity produced is distributed through the electricity network, the system operator distributing the electricity for consumption will collect the electricity tax on it.

Transport

The measures in transport have been listed above (Promotion of the use of biofuels) and in Chapter 3.1.1 under the heading 1) “Replacing fossil fuels with renewable and low-emission fuels and power sources”.

Energy advisory services

The funding allocated to energy advisory services is directed to regional activities (promoting energy efficiency and the use of renewable energy in counties) and communication about demand-side response to consumers. The target groups in the counties are companies, local authorities and citizens. The advisory services implemented in the counties include the promotion of energy efficiency agreements and energy audits, the promotion of municipal renewable energy audits in municipalities and companies, energy advisory services for consumers and also support for the strategic promotion of work related to energy and climate issues.

VII. STRATEGIC AND POLICY CONTEXT

The current chapter analyses the existing EU and national policies which influence in the implementation of RES in industry. These policies are to be taken into account for the definition of the supporting tool of the Managing Authority in the RESindustry project.

VII.I. EU POLICY

The main EU policies related to energy consumption in industry are:

- Renewable Energy Directive
- Energy Efficiency Directive
- Emissions Trading Directives
- Eco-Design Directive
- Industrial Emissions Directives

RENEWABLE ENERGY DIRECTIVE

The Directive 2009/28/EC covers (large scale) renewable energy production, as part of the energy supply sector, as well as (small scale) production at the end-users place. For industry, the Directive contains a few provisions such as including the consumption of other energy from renewable sources in industry in calculating the gross final consumption of energy from renewable sources for heating and cooling in a member state. This renewable production decreases the delivery of (fossil) energy through the grid, in the same way as energy savings do.

Article 14.3 of the Directive requires Member States to ensure that certification schemes or equivalent qualification schemes are were in place for installers of small-scale renewable technologies by 31 December 2012. They also need to recognize each other's certification. Information must be given on the certification/qualification schemes a list of certified/qualified installers may be published.

There are also other provisions for information dissemination. Guidance must be available for planners, architects and other relevant actors, so they are able to plan for and design the optimal combination of renewable energy, energy efficiency, district heating and cooling for new and renovated industrial and residential buildings and areas. The countries shall develop suitable information, awareness-raising, guidance and/or training programmes for citizens about the benefits and practicalities of acquiring and using renewable energy installations.

ENERGY EFFICIENCY DIRECTIVE

The Energy Efficiency Directive 2012/27/EU (EED) repealed both the Energy Services Directive (2006/32/EC) and the CHP Directive (2004/8/EC) on 4th December 2012. The EED establishes a common framework of measures for the promotion of energy efficiency within the Union in order to ensure the achievement of the 2020 20% target on energy efficiency and to pave the way for further energy efficiency improvements beyond that date. The energy efficiency target is that the Union's energy consumption should not exceed 1 474 Mtoe primary energy consumption or 1 078 Mtoe of final energy consumption in 2020. With the accession of Croatia the target was revised to 1 483 Mtoe primary energy consumption or 1 086 Mtoe of final energy consumption. The requirements laid down in the Directive are minimum requirements and it is not to prevent any Member State from introducing more stringent measures. However, such measures should be compatible with the Union law.

The EED addresses the industrial sector as well, both specifically and within cross-cutting provisions. The EED entered into force on 4 December 2012. For the transposition into national law, the Member States had a transposition period of 18 months, i.e. until 5 June 2014. The progress on transposing the Energy Efficiency Directive is examined by the European Commission in all Member States. Up to June 2015, 27 Member States (all except Malta) have received a letter of formal notice for failing to fully transpose the Directive by the June 2014 deadline (EU Commission 2015). So far, the Commission issued eight reasoned opinions to Member States where full transposition was still not achieved (Austria, Portugal, Bulgaria, Croatia, Ireland, Romania, Latvia and Germany) and has referred two Member States to EU Court of Justice for failing to transpose the Energy Efficiency Directive (Hungary and Greece).

EMISSIONS TRADING DIRECTIVE

EU emissions trading scheme (ETS) is basically governed by two Framework Directives i.e. Directive 2003/87/EC and Directive 2009/29/EC. The EU ETS is the world's largest emissions trading system and the first of its kind for CO^2 emissions trading. When it was first introduced, the EU ETS covered about 50% of Europe's CO^2 emissions and 40% of its total greenhouse gas emissions.

Member States were mandated to ensure that from January 1st, 2005, no installation commence any activity mentioned in directive 2003/87/EC resulting in emissions specified in regards to that operation unless its operator holds a permit issued by a responsible authority. The responsible authority issues a GHG emissions permit granting allowance to emit greenhouse gases from the installation.

For the three-year period beginning January 1st, 2005, each Member State was to make a decision about the total quantity of the allowances it would allocate for that period and the allocation of those allowances to the operator of each installation. According to the amended Directive 2009/29/EC, the Community-wide quantity of allowances which are issued each year starting in 2013, decreased in a linear fashion starting from the mid-point of the period from 2008 to 2012. The quantity shall decrease by a linear factor of 1.74 % compared to the average annual total quantity of allowances issued by Member states in compliance with the Commission Decisions on their national allocation plans for the period from 2008 to 2012. The box below shows two country examples for the national implementation of the EU-ETS.

ECO-DESIGN DIRECTIVE

The Eco-design Directive for energy-related products (Directive 2009/125/EC) was adopted on 21 October 2009. It is a Framework Directive which is implemented by regulations given by the Commission and by voluntary agreements with the manufacturers.

Several products which are covered by implementing decrees are utilized on the commercial scale and have therefore impact in the industrial sector. However, in some product groups and in some countries the minimum requirements are equal to or very close to the market averages meaning that they do not change much and more stringent regulations are needed to induce market changes.

INDUSTRIAL EMISSIONS DIRECTIVES

The Industrial Emissions Directive 2010/75/EU (repealing the Industrial Pollution Prevention Directive (2008/1/EC) covers industrial activities with a major pollution potential, defined in Annex I to the Directive (energy industries, production and processing of metals, mineral industry, chemical industry, waste management, rearing of animals, etc.). The Directive shall contain special provisions for the following installations:

- combustion plants (≥ 50 MW);
- waste incineration or co-incineration plants;
- certain installations and activities using organic solvents;
- installations producing titanium dioxide.

The Directive mandates the industrial installations for the use of the best available technologies to achieve a high general level of protection of the environment as a whole, which are developed on a scale which allows implementation in the relevant industrial sector, under economically and technically feasible conditions. The European Commission is responsible to adopt BAT conclusions containing the emission levels associated with the BAT. These conclusions will serve as a reference for the drawing up of permit conditions. The permit must provide for the necessary measures to ensure compliance with the operator's basic obligations and environmental quality standards. These measures should include at least:

- emission limit values for polluting substances;
- rules guaranteeing protection of soil, water and air;
- waste monitoring and management measures;
- requirements concerning emission measurement methodology, frequency and evaluation procedure;
- an obligation to inform the competent authority of the results of monitoring, at least annually;
- requirements concerning the maintenance and surveillance of soil and groundwater;
- measures relating to exceptional circumstances (leaks, malfunctions, momentary or definitive stoppages, etc.);
- provisions on the minimisation of long-distance or transboundary pollution;
- conditions for assessing compliance with the emission limit values.

VII.II. NATIONAL POLICY

Finland's Integrated Energy and Climate Plan

Finland's Integrated Energy and Climate Plan contains Finland's national targets and the related policy measures to achieve the EU's 2030 energy and climate targets. The Energy and Climate Plan addresses all five dimensions of the EU Energy Union: decarbonisation, energy efficiency, energy security, internal energy markets and research, innovation and competitiveness.

The EU has set Finland a 2030 national target for reducing greenhouse gas emissions in the non-emissions trading sector by 39 % compared to 2005. At the same time, emissions from the land-use sector should be kept lower than the computational reduction in emissions from sinks. Finland also aims to increase the share of renewable energy to at least 51 % of the final energy use and to 30 % of the final energy use in road transport. With regard to energy efficiency, the target is that the final energy consumption does not exceed 290 TWh.

The Finnish Energy and Climate Plan outlines the impact of existing policy measures on the projected evolution of greenhouse gas emissions, renewable energy and energy efficiency up to 2040. In addition, the plan describes the effects of the planned policy measures on the energy system, greenhouse gas emissions and sinks, economic development, the environment and public health. The Plan also assesses the impact of planned and existing policy measures on investment.

Targets under the EU Climate and Energy Framework 2020

Under the EU 2020 goals and regulations, Finland is implementing GHG emissions reduction targets, and goals for the share of renewable energy in final energy consumption and energy efficiency. By 2020, Finland aims to reach at least 38% of renewables in final consumption and a 16% reduction in GHG emissions in the non-Emissions Trading System (non-ETS) sector below their 2005 levels, alongside the goal of keeping final energy consumption at 310 terawatt-hours (TWh). While the binding renewable energy target for the transport sector set by the European Union is 10%, Finland has decided on a higher target of 20% by 2020 (which includes double counting of the sustainably produced share).

The share of renewables has increased and the minimum target of 38% has already been met in 2014. The trend also looks positive for the future, and the government expects the share to exceed 40% before the end of its term. The 10% biofuels target was also reached in 2014 thanks to the supply obligation applied to distributors of road transport fuels.

In the first three years of the period 2013 to 2020, Finland's annual emissions have been below the targeted volumes trajectory as a result of warm weather and unfavourable economic circumstances. The trajectory cannot necessarily be achieved towards the end of the period without resorting to flexibility mechanisms. Taking the entire period in consideration, however, Finland expects to meet its emissions reduction obligations under the EU Effort-Sharing Decision by means of domestic emissions reduction measures and by banking and borrowing allowances.

The National Energy and Climate Strategy for 2030

The key pillars of Finland's energy strategy up to 2030 are defined in the Government Programme of Prime Minister Sipilä (Prime Minister's Office, 2015), with the following headline goals for the period 2020-30:

- a share of renewable energy above 50% of final energy consumption
- level of self-sufficiency above 55% (decrease of imports)
- he phase-out of coal in energy production
- halving the domestic use of imported oil
- share of renewable fuels in transport up to 40%.

The 2016 National Energy and Climate Strategy for 2030 (MEAE, 2016) sets out the actions that will enable Finland to attain these national targets alongside the EU targets for 2030, gradually setting the course for achieving an 80% to 95% reduction in GHG emissions by 2050, as elaborated in the 2014 Energy and Climate Roadmap to 2050. The Strategy also examines the possibility of shifting to an energy system based on 100% renewable energy by 2050. The Strategy foresees the mandatory blending of 10% biofuels into light fuel used in space heating and working machinery by 2030.

In September 2017, the government, under the lead of the Ministry of the Environment released the Report on Medium-term Climate Change Policy Plan (MCCP) 2030 (ME, 2017) as a complement to the Strategy. This MCCP recommends a set of additional measures on how Finland could meet its ambitious 39% GHG emissions

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Low-carbon economy

reduction target in the non-ETS sectors, under the EU 2030 Energy and Climate Framework and the Burden-Sharing Regulation. The MCCP 2030 puts forward additional measures towards Finland's stated objective to be a carbon-neutral society by 2035. For the transport sector, it includes:

- improved energy efficiency in the transport system (e.g. developing new transport services, influencing modes of travel and transport, using intelligent transport methods)
- accelerated vehicle stock renewal with a minimum of 250 000 electric vehicles and 50 000 gas-fuelled vehicles in 2030
- the share of biofuels in all fuels sold for road transport to be increased to 30% by 2030 (below the 2015 headline target).

Under the EU 2030 climate and energy framework, there are no more national targets. Finland is preparing an integrated energy and climate plan (by the end of 2018 with the final plan by the end of 2019), as part of the EU Energy Union Governance Regulation which requires the adoption of national plans to monitor and ensure that the EU member states together achieve the overall EU 2030 energy and climate targets. Such an integrated energy and climate plan will cover the five key dimensions of the EU Energy Union: 1) energy security; 2) the internal energy market; 3) energy efficiency; 4) decarbonisation; and 5) research, innovation and competitiveness. The plan will also include an analytical base with projections and impact assessments.

Reform of renewable energy support

In 2018, the government adopted legislation for a reformed renewable energy support in favour of a sliding premium based on competitive auctions in 2018 and 2019 for mature renewable energy technologies (1.4 TWh per year by 2020). The government has reduced the targeted annual renewable electricity production (from the planned 2 TWh per year), as Finland has already met its target, in favour of the inclusion of efficient and low-carbon heat production that promotes an early phase-out of coal already by 2025 and other innovative technologies. The owner of the largest onshore wind power project (Viinamäki, 5x4.2 MW) in the Nordic region, built without subsidies, has taken a final investment decision with expected generating costs of below EUR 30 (Euros) per MWh.

During 2011-18, Finland applied a feed-in premium scheme for renewable electricity produced from wind power, biogas, forest chips and wood fuels (6 TWh of annual wind power production and an annual use of forest chips to reach 25 TWh by 2020). The production support scheme consisted of two different premiums:

- A sliding premium tariff for new investments in wind power, power from biogas (landfill gas excluded) and power from small CHP production plants using wood fuel. The tariff was dependent on the market price of electricity, i.e. the difference between the target price in the legislation and the spot price of electricity. A heat premium is paid on top of the basic tariff for biogas and wood fuel plants that produce also heat with certain efficiency.
- A sliding premium tariff for electricity produced from wood chips, dependent on the EU emissions allowance price and tax rate on peat. The tariff compensated the difference in running costs between using peat and using wood chips in CHP. As the tariff did not compensate the plant's capital costs, the tariff was paid also to existing power plants.

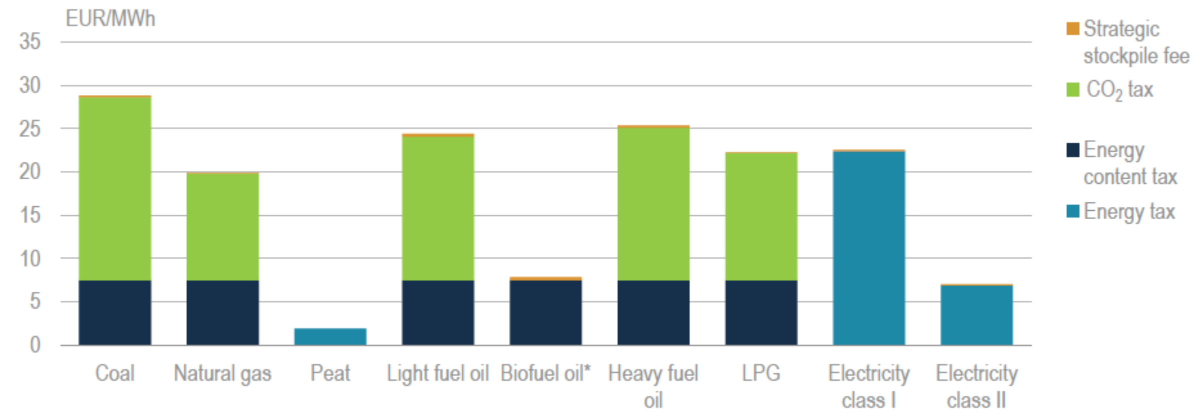
Energy taxation

In 2011, the government carried out a major revision of the energy taxation framework with the objective to better reflect environmental aspects and the energy and carbon dioxide (CO_2) content of fuels in energy taxation. In Finland, energy fuel taxation consists of i) the energy component, ii) the CO_2 component and iii) the strategic stockpile fee.

The energy content of fuels is based on their calorific values and levied on fossil fuels and on biofuels with the main objective to increase energy efficiency. Heating fuels are taxed at a lower level than motor fuels, and diesel has a lower tax than petrol (however, an additional annual propelling force tax applies to diesel-fuelled passenger cars).

The CO_2 tax is proportional to the energy content. Biofuels are classified in three categories: i) biofuels that fail to meet sustainability criteria are subject to the same CO_2 tax as fossil fuels; ii) sustainable biofuels (first generation, agricultural origin) are subject to 50% of the CO_2 tax on equivalent fossil fuels, and iii) second-generation biofuels (waste, lignin cellulose, etc.) are exempt from CO_2 tax.

Tax rates on heating fuels and electricity, 2018 (Ministry of Finance, 2018)



The tax on electricity has two levels, a general tax class 1 level and a lower tax class 2 level for industry, mining, data centres and agriculture. There is also a partial energy tax refund for energy-intensive industries and for agriculture.
Input fuels to electricity generation are exempted from energy taxation. For CHP production, the CO2 tax is halved when energy products are used in CHP to avoid overlaps with ETS (as both electricity and heat fall under the EU-ETS) and to promote energy efficiency.

Transport taxation is composed of i) a car tax for passenger cars, vans and motorcycles based on CO2 emissions of the vehicles; ii) an annual vehicle tax with a basic tax on passenger cars and vans based on CO2 emissions and a tax on propelling force based on the mass of the vehicle and iii) a tax on the energy use of motor vehicles (energy content tax and CO2 tax).

The government decided to decrease car taxation gradually in four phases over 2016-19. These tax decreases are targeted on cars with low CO2 emissions. Some tax expenditures (tax relief and exemptions, for example) in car taxation were also abolished or reduced in 2015. The vehicle tax was increased in 2012, 2016 and at the beginning of 2017.

Nordic collaboration
Finland is an integral part of the Nordic Energy Market, in terms of both its economy and its energy sector. The Nordic Council of Ministers for Business, Energy and Regional Policy commissioned in 2017 Nokia's former Chief Executive Officer Jorma Ollila to conduct a strategic review of how Nordic energy co-operation could develop over the next 5 to 10 years (Ollila, 2017). The report contains a series of concrete proposals that would further enhance co-operation among the Nordic countries, such as adopting a new vision for Nordic energy co-operation, with a programme of strategic goals and targets for 2018–2021, conducting Nordic peer reviews before decisions are taken on implementing national policies, as well as accelerating Nordic research activities through mapping and streamlining, and positioning Nordic energy solutions globally.

Making the most of the Nordic leadership in the decarbonisation of the economy, Nordic countries are well placed "to create the smartest energy system in the world and to find the most cost-efficient solution in moving towards the low-carbon green economy." (Ollila, 2017).

VIII. DEFINITION OF KEY PERFORMANCE INDICATORS

SUMMARY OF THE CHAPTER

One of the goals of the analysis is the definition of a series of energy indicators in which the total energy consumption of the industries can be disaggregated by potential RES technology. These indicators are called Key Performance Indicators (KPI) and they are useful in order to make easier the comparisons with the energy consumptions of other factories which operate in the same field, and with other technologies.

A typical KPI used in the industrial field is defined as the primary energy consumption scaled on the number of factory outputs (KPIa), so that the energy consumptions of the factory can be correlated directly to the number of outputs produced. In most of cases the primary energy consumption tends to decrease with the increase of the output production, being the evidence of a primary energy consumption independent from the industrial production volumes. However, this KPIa has to be identified industry to industry and cannot be generally calculated.

There is a range of well-developed and sustainable renewable technologies that can provide electricity and heat in a cost effective way when conditions are favourable. Such sources can provide electricity and heat directly to an industry through on-site technologies, or via centralised district networks. The main sources of renewable energy sources to be analysed at national level are:

- solar thermal energy
- bioenergy
- solar photovoltaic energy

Regarding KPIs of every technology, and potential savings to be achieved, there are several main aspects to consider that have a bigger impact on the comparable costs of the energy produced by technologies, when placed in the same location. These are the initial cost of the system, the lifetime of the system, the cost of maintenance or the system performance.

Moreover, production will depend on the location (affecting climate, insulation, taxes, cost of living, etc.) and quality of the system (affecting performance, lifetime and cost). This can vary significantly from region to region or from country to country, so the specific analysis has to take into account these parameters.

The Market analysis has selected a minimum of KPIs that are required to be known for each selected technology. These KPIs provides a common ground of analysis for the technologies. The KPI selected are:

CAPEX, measured as €/kWth or KWp depending on technology	Direct labor intensity, measured as FTE/MW of installed power, either thermal or electric
OPEX, measured as €/kWth or KWp depending on technology. But expressed as a % of CAPEX	Indirect labor intensity, measured as FTE/MW of installed power, either thermal or electric
Fuel supply cost, measured as €/MWh, for those technologies requiring fuel provision	Emissions, measured as kg CO2/kWh for the different fuels to be replaced
LCOE, measured as €/MWh, either thermal or electric	Lifetime (years)

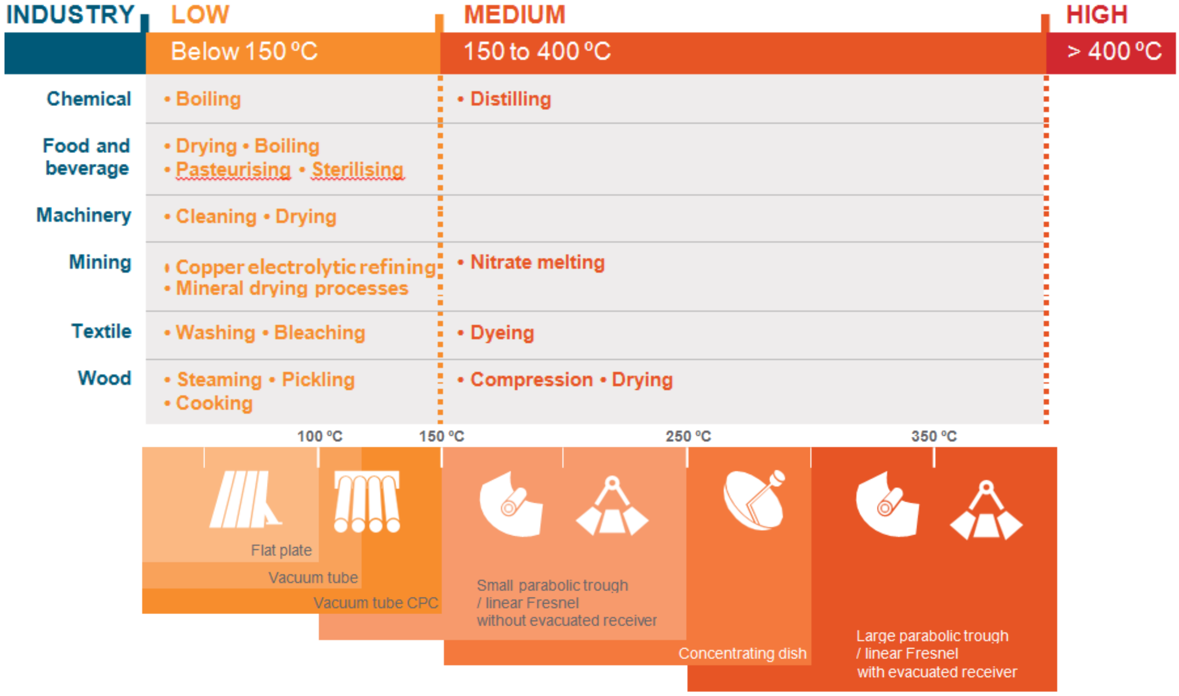
As the analysis has to be made from the point of view of the public administration, where public funding is to be allocated to leverage private investment, in the "conclusions" chapter, these KPIs have been transformed into impacts for each public euro invested. The conclusions have provided final KPIs for the public administrations in reference to every 1.000€ invested of public money:

KPI indicator (for every 1.000€ of public funding)
RES supported (kWth)
RES produced (kWh th)
Full-time employment (FTE)
Avoided emissions (Ton CO2)

SOLAR THERMAL ENERGY

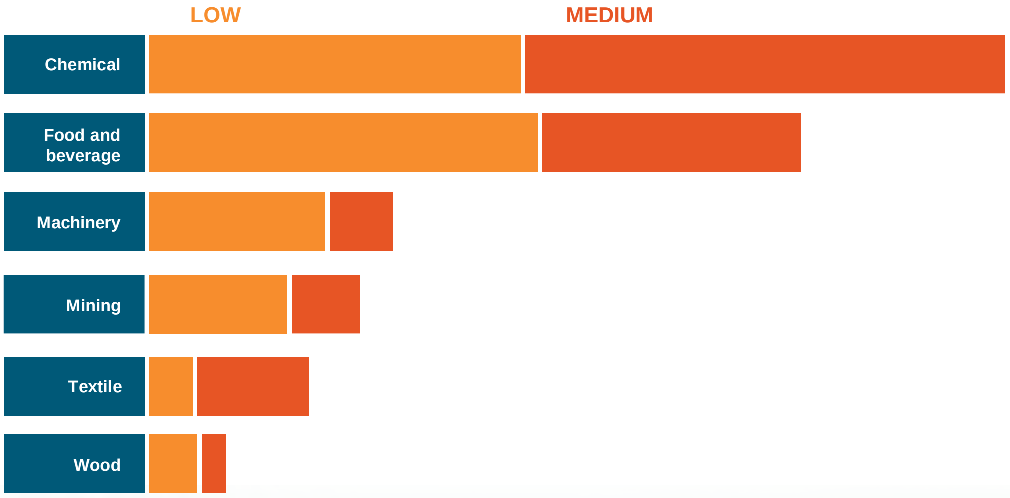
With low and medium temperature heat accounting for 50% of total industrial process heat use, solar thermal systems have a large potential.

Market applications of solar thermal technologies (IEA /Solar Payback)



High initial capital costs, low operation hours and land requirements at site form the main barriers, but cost reductions can be achieved with an increase in solar thermal deployment. Some industries are already using solar technologies for most of their industrial processes.

Industries with tendency of solar thermal applications (IEA /Solar Payback)



In order to analyse the potential implementation of solar thermal energy in the national industry, a number of data has to be assumed based on previous national and EU analysis, such as: Solar resource values (DNI) kWh/m2; lifetime of installation; Operational expenditures (OPEX); discount rates; investment cost units; etc. Some of these parameters can be obtained by official national or EU databases, others are based on national experiences and projects described in this report.

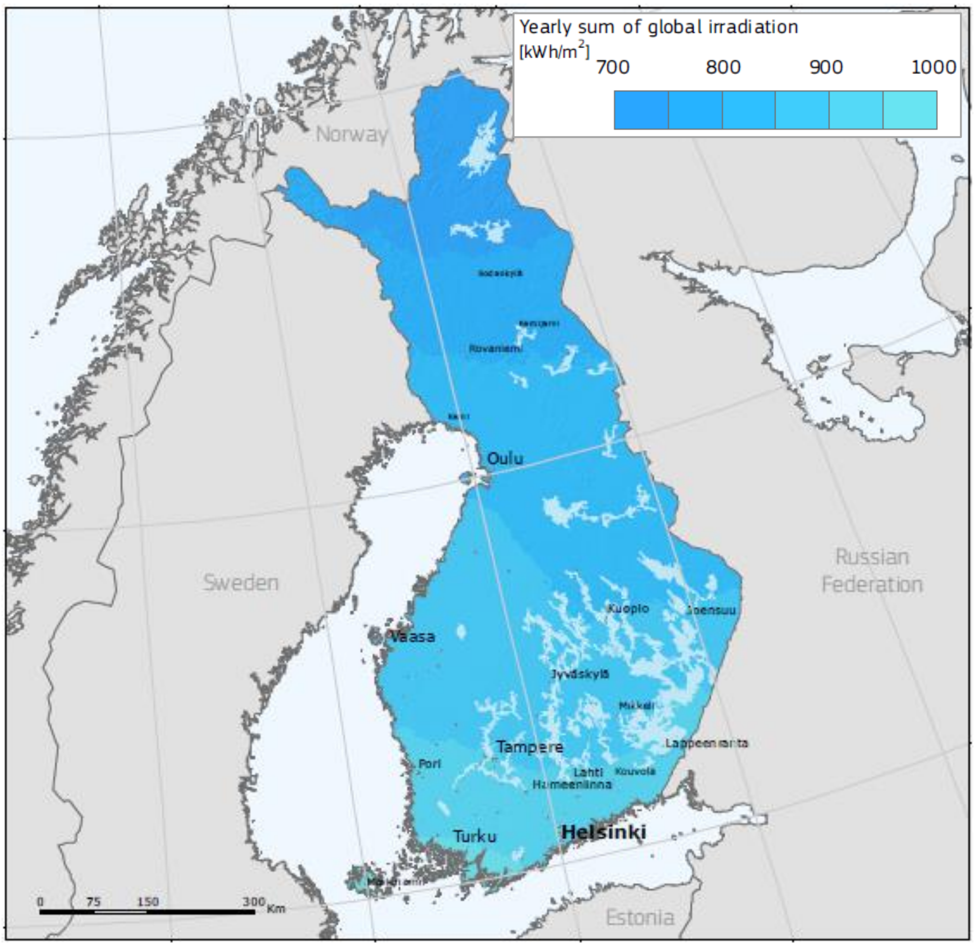
Lifetime

Lifetime of installation, properly planned and maintained, is currently set in 22-25 years for most of sources when referring to solar installations, even if the values are increasing and some current references set the lifetime to 30 years in solar heat decentralize systems.

Direct Normal Irradiation (DNI) kWh/m2

In Finland DNI average is 850 kWh/m2 with variations of 10% depending on specific locations. These values are calculated for horizontally mounted modules, but it can be improved in 150 kWh/m2 if the modules are placed in optimally-inclined position.

Global irradiation and solar electricity potential in horizontal (JRC – EC)



Operational expenditures (OPEX)

OPEX is established in most of cases as reference to the initial capital expenditure or CAPEX, as a % of this amount. Values in references vary slightly:

- Most references mentioned OPEX is at 2% CAPEX/year (Fraunhofer ISE).
- For solar heat decentralized systems OPEX is set at 1,3% CAPEX/year (Fraunhofer ISE).
- For solar heat centralized systems OPEX is set at 1,4% CAPEX/year (Fraunhofer ISE).

Discount rates

Discount rates also vary from project to project, depending on

- Solar heat in centralized systems: from 7% to 9%.
- Solar heat system decentralized: 6% to 7%.

Capital Expenditure (CAPEX)

The costs of solar thermal process heat installations in Europe range from 180 up to 500 Euro / m2, depending on the system concept, the size of the system, the selected components (e.g. the choice of the collector type) and on country-specific factors (e.g. salaries).

The cost is the total turn-key cost for all components (collectors, store, pipes, pumps), installation, and process integration to realize a plant, inclusive of any locally available subsidies or financial support mechanisms. The project investment will vary widely based on technology choice, integration difficulty, thermal store size, and installer expertise.

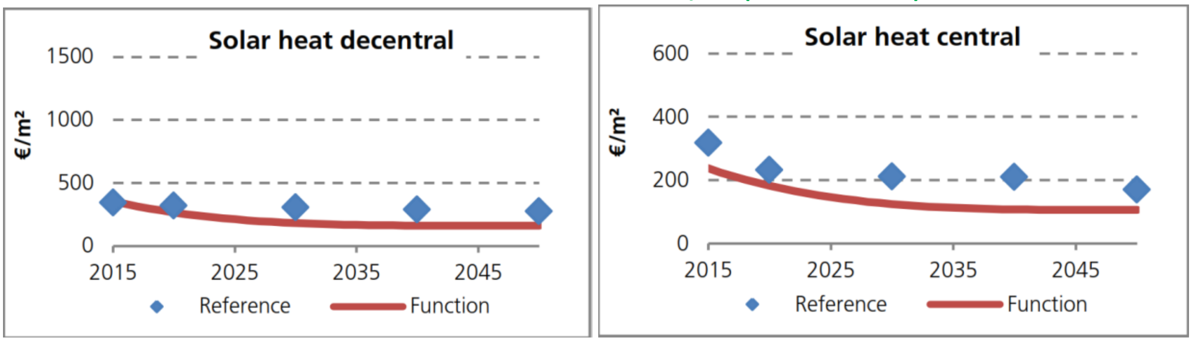
The European Technology Platform on Renewable Heating and Cooling, analyzed the current state of art on the RDT solar projects and foresaw that, in 2020 the cost of technology would be as shown in the bellow table:

Temperature	Concentrating systems	Storage included	€/m2
< 100°C	non-concentrating system	Included	350
< 250°C	Concentrating system	Excluded	400

Another source provides different ranges of CAPEX based on real experiences, such as the Fraunhofer Institute For Solar Energy Systems ISE, Freiburg in the report "Pathways for transforming the German energy system by 2050".

- Solar heat in centralized systems: set on 265€/m2 in 2015, with a foreseen 200 €/m2 in 2020.
- Solar heat system decentralized: set on 405€/m2 in 2015, with a foreseen 350 €/m2 in 2020.

CAPEX for solar heat installations in €/m2 (Fraunhofer ISE)

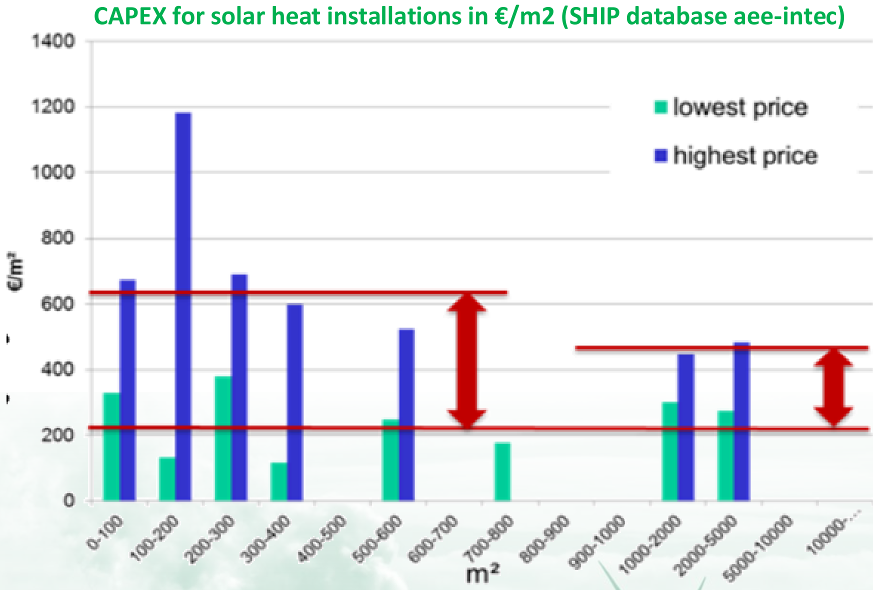


ISES Solar World Congress 2017 provided different industry values which can range from:

- Less than 250 €/m2 for plants >10.000 m2
- Over 800 €/m2 for smaller installations with high quality collectors.
- But typical values are 300-600 €/m2 for plants >500 m 2 (BAFA, 2016).

Another important source of solar information is the Solar Heat for Industrial Processes (SHIP) database, which has been created in the framework of the IEA Task 49/IV. This online database contains a worldwide overview on existing solar thermal plants which provide thermal energy for production processes for different industry sectors. This database, analyzed by aee-intec provided the following results.

CAPEX for solar heat installations in €/m2 (SHIP database aee-intec)



Levelized Cost of Energy (LCoE)

Using the Levelized Cost of Energy (LCoE) or Levelized Cost of Heat (LCoH) developed by the IEA SHC Task 54 from Fraunhofer Institute for Solar Energy Systems. The LCoH calculation method was developed to determine the economic impact of evaluated improvements by comparisons between reference and optimized systems. Values for domestic water were around 0,1 €/kWh and 0,12 €/kWh.

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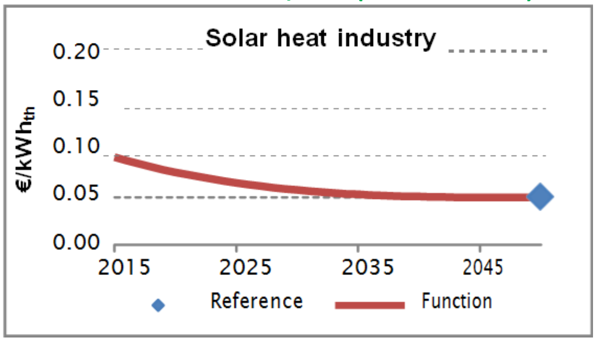
	LCOH (€/MWh)		
	Solar	Conventional	Entire system
Conventional reference system at SFH	-	97	97
Conventional reference system at MFH	-	72	72
Reference system for solar hot water preparation at SFH	119	105	107
Reference system for solar space heating and hot water preparation at SFH	152	109	120
Reference system for solar hot water preparation at MFH	56	73	71

In ISES Solar World Congress 2017 Veynandt some sample calculations for solar thermal installations where produced for central Europe, which had resulted in an LCOH of 0,06 and 0,067 €/kWh for central installations compared to 0,125 and 0,105 €/kWh for a single installations.

These references are similar in other analysis of the Institute, when applied to specific facilities in central Europe industries. Current values of solar heat in industry can be obtained between 0,10 €/kWh and 0,8 €/kWh.

Solar Heat costs in €/kWh (Fraunhofer ISE)



These references are however, based on central Europe values of PVGIS registers, with Yearly sum of global irradiation on optimally inclined surfaces, which values differs greatly from Päijät-Häme potential:

- 1,280 kWh/(m²·a) @34° in Wurzburg, DE
- 1,290 kWh/(m²·a) @40° in Copenhagen, DK
- 1,460 kWh/(m²·a) @37° in Graz, AT
- 950 – 1.000 kWh/(m²·a) in Päijät-Häme, FI

Finally, SO-PRO Guide to Solar Thermal System Design for Selected Industrial Processes decreased the price even more, going to solar heat generation costs for low temperature processes between 0,02 and 0,08 €/kWh, highly depending on location, supported processes and temperature levels.

These values are aligned with the expectations of the European Technology Platform on Renewable Heating and Cooling, which analyzed the state of art on the RDT solar projects and foresaw that, in 2020 the cost of technology would be as shown in the bellow table:

Temperature	Concentrating systems	Storage included	€/kWh
< 100°C	non-concentrating system	Included	0,03-0,06 €/kWh
< 250°C	Concentrating system	Excluded	0,04-0,07 €/kWh

By 2017, the SHIP roadmap pathway should achieve solar heat costs in the range of 0,07-0,09 €/kWh.

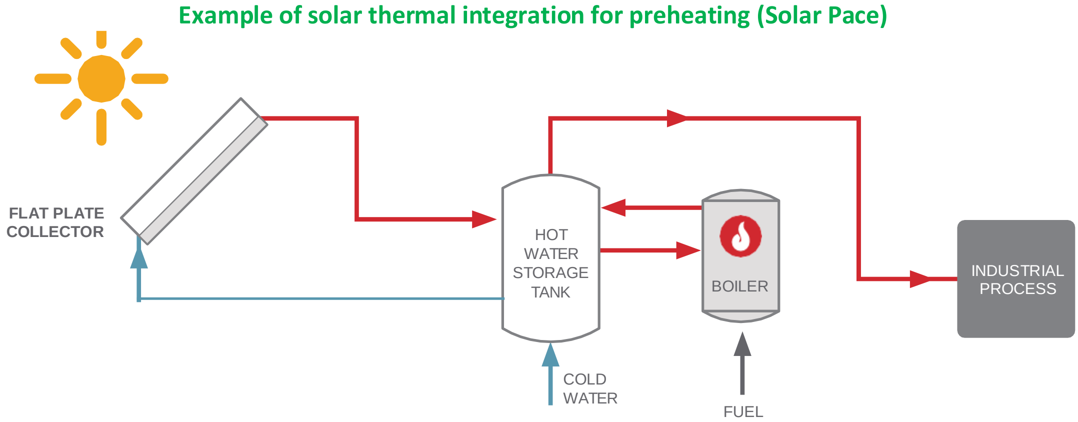
Any of the considered values have to be increased between 20% and 25% in Päijät-Häme due to the lower yearly sum of global irradiation, getting values between 0,09-0,11 €/kWh.

Industrial solutions for Solar heat integration

Solar heat can be provided at different integration points. Preheating is the most common method of incorporating solar heat into the production cycle. However, it can also be used to generate steam or fed directly into the process loop.

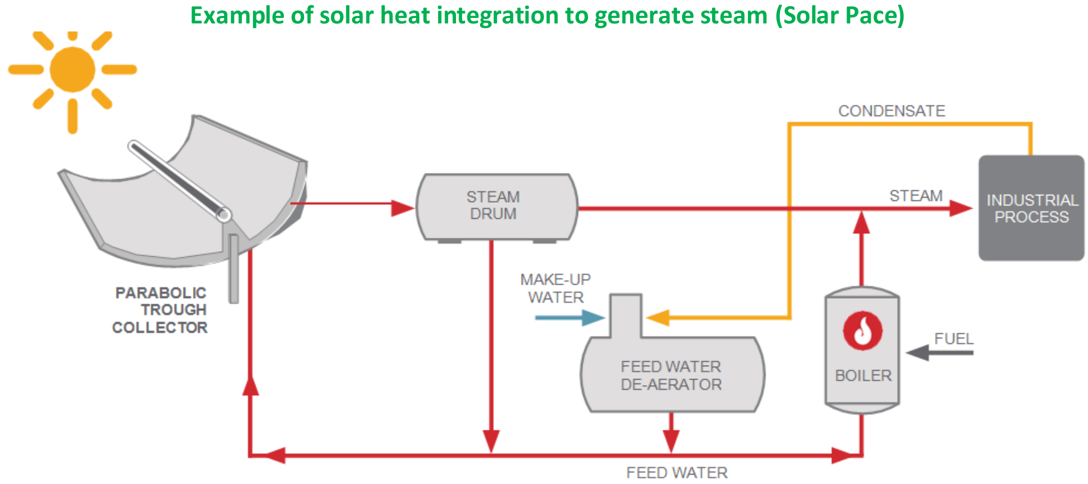
- Preheating. Cold water is preheated in the solar field and fed into a storage tank where it is heated up by a fossil fuel boiler to the required temperature of the production process.

Example of solar thermal integration for preheating (Solar Pace)



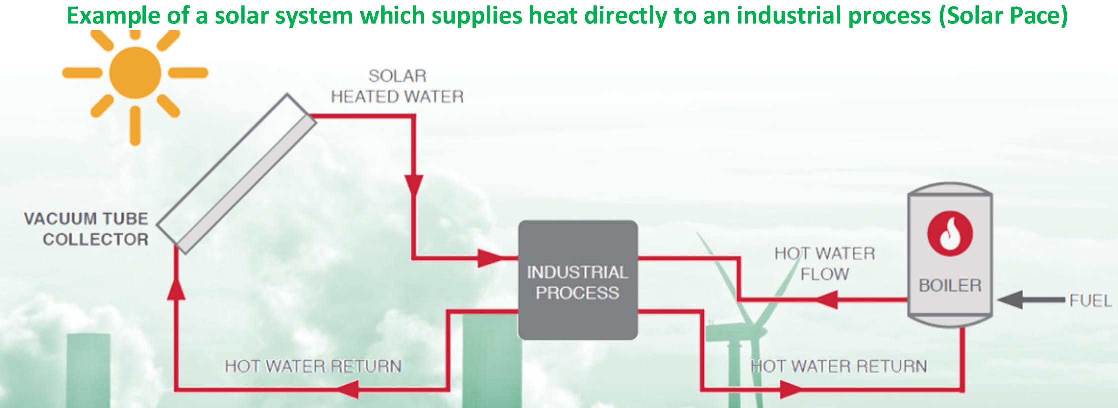
- Direct steam generation. Water is partly evaporated in the concentrating collectors. The solar-heated steam is then separated from the remaining water in the steam drum before being supplied to the industrial process or the steam network. The treated condensate is fed back to the collector field.

Example of solar heat integration to generate steam (Solar Pace)



- Process heating. The solar field provides heat at a certain temperature to maintain the temperature of a bath or a thermal separation process. Additional heat is provided to the production process by a fossil fuel boiler. Both circuits are closed so that the cooled off water returns to the collector field or the boiler.

Example of a solar system which supplies heat directly to an industrial process (Solar Pace)



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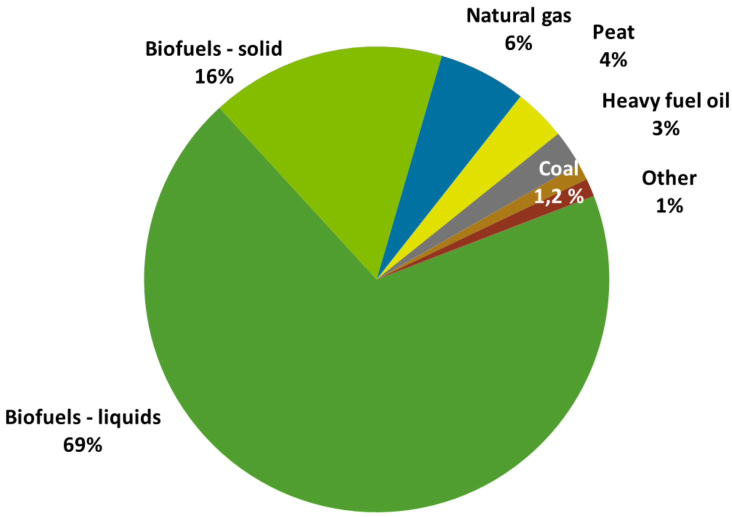
BIOMASS ENERGY

Biofuels and waste (mainly solid biomass) accounted for 85% of Finland's total renewable energy in 2017, and the supply of biofuels has increased steadily. With 28.5%, Finland has the second-highest share of biofuels in TPES in comparison among IEA countries, where biofuels and waste are referred to solid biomass and liquid biofuels, biogases, industrial waste and municipal waste.

Forestry has a special role, as it provides raw materials for forests industries, substitute fossil and other non-renewable raw materials, and acts as a carbon storage and sink.
Annually, the net forest carbon sink (quantity of CO2 that is sequestrated as the forests grow and released in harvesting) corresponded to between 30% -60% of Finland's total emissions. Despite increased investments in the forest industry and the extensive use of wood, the growth of forests still exceeds harvesting volumes.

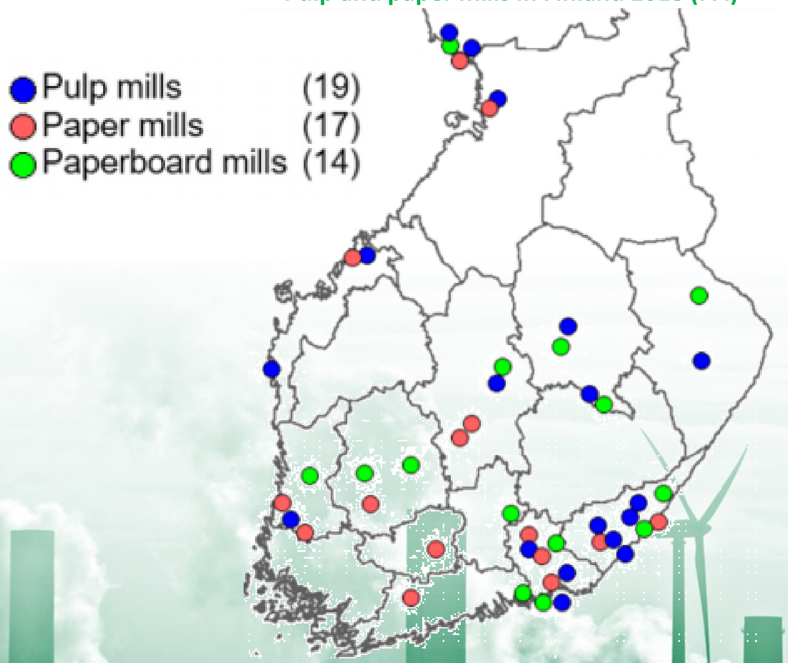
Due to its large forest reserves, the pulp and paper industry is one of the most important industry sectors in Finland. The export value of pulp and paper industry was over 9 billion € in 2017 (total exports of Finland 60 billion €), and the sector is an important employer especially in rural regions of Finland. As an important part of the Finnish bioeconomy strategy, the sector is aiming for renewal.

Share of different fuels at mills (pulp, paper and paperboard) 2017 (FFI)



The forest industry in Finland uses mostly bioenergy to cover its energy consumption, and over 60% of the total renewable produced in Finland comes from the forest industry (Statistics Finland 2018). The principal energy sources are the residual streams of the industry, such as black liquor, bark, and other residues.

Pulp and paper mills in Finland 2018 (FFI)



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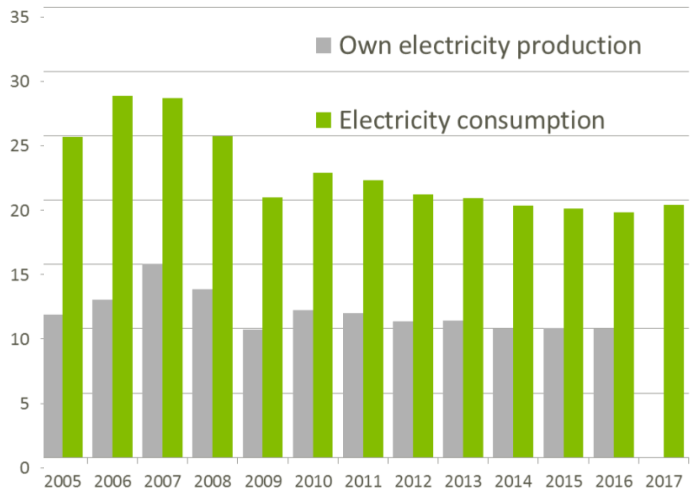
Typically, wood energy resources are used in highly efficient district heating (DH) systems and combined heat and power (CHP) plants. Most of these rely on direct combustion, but the most modern CHP plants use fluidised bed boiler or circulating fluidised bed technology to gasify a wider range of low-quality forest residues, reducing operating costs. Gasification also allows forest residues to displace coal in coal-fired CHP plants, which cannot use residues directly.

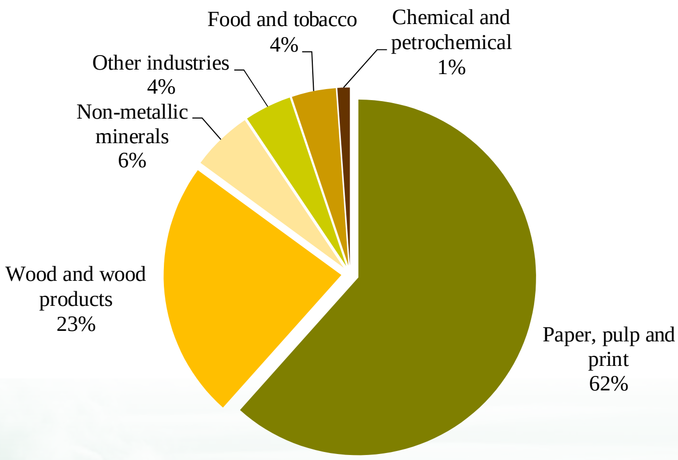
Electricity production and consumption in the Finnish forest industry TWh (FFI)



In 2017 the industrial sectors that consumed the most solid biomass for process heat are those that generated biomass residues, such as the pulp, paper and wood products industries, which were responsible for 85% of the industrial biomass final energy consumption.
Of some relevance is the non-metallic mineral sector, which, despite not generating biomass residues, accounted for 6% of the biomass consumption for process heat.

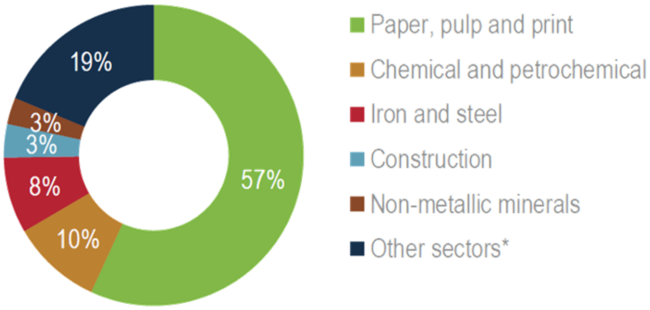
Additionally to heat, some industrial establishments are autoproducers and produce electricity and heat, which is in part delivered to users outside the plant. This is common, for example, in the pulp and paper industry, and in the production of wood-based panels, where solid biomass is often used in CHP systems.

Solid biomass use as final energy consumption for process heat by industrial sectors 2017 (Eurostat)



Bioenergy applications

Energy consumption share by industrial branch (2015)



The 5 main energy consumer industrial branches can apply this resource:

- Pulp and paper

The industry requires essentially heat between 100 and 200 °C, CHP production is common in this sector, and it already uses a significant amount of solid biomass. For example, recovery boilers are both used to recover chemicals contained in black-liquor and to produce process steam. In EU28, the share of biomass in the final energy consumption of this sector was 38% in 2017.
The pulp and paper industries can use biomass instead of fossil fuels and extend their traditional products to 'green' power and torrefied biomass in order to increase the efficiency and profitability of their traditional core business. Implementing new technologies can reduce the energy intensity of the pulp and paper industry and the utilization of by-products can result in a carbon neutral sector.

- Food and beverages

The industry requires essentially heat below 200 °C (83% of the process heat demand is below this level).
Presently, the industry produces significant amounts of bio-wastes that can be converted into energy, however, in most cases, these feedstocks have high moisture content and are unsuitable for thermo-chemical conversion processes. In this case, anaerobic digestion is a very interesting possibility.
Nevertheless, within this sector there are industries that have abundant low-moisture solid biomass resources suitable for combustion (e.g., rice husks, olive stones, nut shells or pine cones).
Although some projects are economically attractive, generally, a major barrier for the implementation of solid biomass energy systems in the food and beverages industries are the high investment costs.

- Non-metallic minerals

In terms of energy consumption, this sector is dominated by the cement industry, with a share of almost 60% in final energy demand, but glass, brick, tile and refractory production is also very important. Almost 73% of the process heat demand within this sector is above 500 °C, while the key energy-intensive processes are above 1000 °C.
The main cement producers are already using solid biomass as a substitute for fossil fuels. For cement kilns, a 20% substitution rate of fossil fuels by biomass is recommended, and generally the cement industry presents no technical barriers to an increase in the use of solid biomass.

- Iron and steel

The industry requires primarily heat above 500 °C (94% of the process), and the use of direct heating dominates the sector.
In EU28, almost no biomass is used for energy in the iron and steel industry. However, the partial substitution of coal and coke with biomass in iron-making processes is one of the few options that are both economically and technically viable in the short and medium-term.

There is a high potential of biomass use in the sector, and in certain conditions with benefits over the use of coal. The most promising ways are by: i) gasifying biomass to generate gas for reduction or heating, ii) injecting it into the blast furnace (recommended option), iii) incorporating biomass into coal blend for cokemaking.

However, today in Europe, for the iron and steel industry, biomass cannot compete with fossil fuels in economic terms. Recent studies conclude that carbon taxes would be important for the use of biomass in the iron and steel industry, as well as a reduction of the costs of upgraded biomass.

- Chemical and petrochemical

The industry requires essentially heat above 500 °C (67% of the process). Presently, the industry does not obtain much of its energy through biomass (0.5%).
Undesirable physicochemical properties arise when using solid biomass as feedstock in this sector. Currently, sugar and starch based biomass is the most widely used route to produce chemical feedstock from biomass. However, in the future, woody biomass could be used in order to replace the large quantity of petrochemicals currently produced.

Lifetime
Lifetime of installation, properly planned and maintained, is currently set in 20-22 years for most of sources when referring to biomass installations.

Discount rates
Discount rates also vary from project to project, and from technology to technology:

- Wood boiler systems: from 4%.
- Biomass boiler for industry: from 7%.

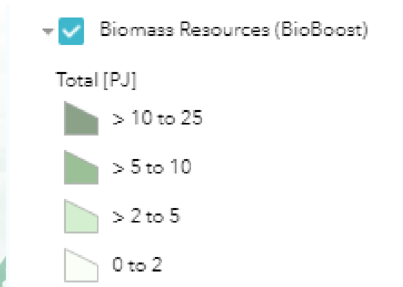
Biomass resources availability
Forest biomass is considered to be crucial for Finland's economy as a raw material for renewable energy and will be in the future. According to the National Energy and Climate Strategy for 2030 the majority of forest-based energy will continue to be produced on market terms from the side streams of other wood use.

Plenty of wood material is produced in forestry management operations and timber harvesting that is not suitable as raw material for wood processing, or for which there is not enough demand. By means of different policy measures, this forest biomass will be channelled to replace imported fossil fuels in heating, CHP production and biofuels for transport.

The National Energy and Climate Strategy for 2030 is based on a round-wood removal scenario in which the annual total removal of round wood is estimated to grow to 79 million cubic metres (Mm3) per year by 2035. This is consistent with the target level set in the National Forest Strategy for 2025 and with the government's target of increasing annual wood use by 15 Mm3 from the current values. The increased felling of round wood would reduce the yearly carbon sink to 13.5 MtCO2-eq. by 2030. For the Kyoto Protocol second commitment period (2013-20), Finland set the forest management reference level of −19.3 MtCO2-eq (without harvested wood products [HWP]) and −20.4 MtCO2-eq, including HWP.

Biomass resources available Finland and Päijät-Häme region (Heat Roadmap Europe 4 HRE4)

Technical and economically available biomass Päijät-Häme region	
NUTS3 ID	FI1C3
NUTS3 region size in km²	6,252
Straw [PJ]	0.71
Pruning residues [PJ]	0.00
Forest residues [PJ]	4.04
Biowastes [PJ]	0.21
Total [PJ]	4.96



The Heat Roadmap Europe 4 (HRE4) is an EU programme aiming at developing low-carbon heating and cooling strategies, called Heat Roadmaps, by quantifying resources and implementing changes at the national level for 14 EU Member States, which together account for approximately 85-90% of total heating and cooling in Europe. The HRE4 has an interactive map showing the resources available at national level.

Operational expenditures (OPEX)
A relevant factor for biomass utilization by the industry is its price. There is a large variation of prices according to the energy system location, or biomass type, quality and quantity acquired. Additionally, predicting future costs of biomass is challenging and dependent on many factors such as local supply chains, resource availability, sustainability criteria, policy choices or competing uses for biomass.
Currently, different entities such as report several commercial price indexes, which cover different fuels (e.g., wood pellets, wood chips, forest biomass residues, saw logs and birch logs).

The European Technology Platform on Renewable Heating and Cooling, analyzed the current state of art on the RDT biomass projects and foresaw that, in 2020 the cost for biomass supply:
Biomass supply costs from forest biomass:

- 20-25 €/MWh=5.6 – 6.9 €/GJ (Nordic countries, Eastern EU)
- 25-35 €/MWh = 6.9 – 9.7 €/GJ (Central and Southern EU)

Biomass supply costs for agrobiomass residues like prunings and straw:

- 5 – 21€/MWh

Additionally to the cost of the biomass supply, O&M cost for the biomass system can be considered as 3% of CAPEX.

Capital Expenditure (CAPEX)
The costs of biomass combustion systems for the production of heat are quite variable depending on the conversion technology and type of emission control equipment used, feedstock storage capacity and whether or not pre-processing of biomass occurs (e.g., size or moisture reduction). Other factors that can influence the total cost of the biomass systems are related to piping, electrical and civil works

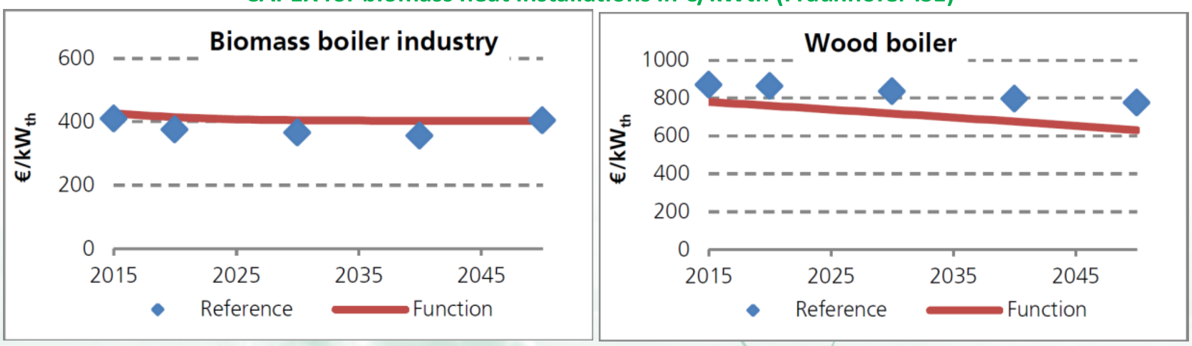
Some sources provide ranges of CAPEX based on real experiences, such as the Fraunhofer Institute For Solar Energy Systems ISE, Freiburg in the report "Pathways for transforming the German energy system by 2050".

- Solid biomass boiler system industry: set on 468€/m2 in 2015, with a foreseen 405 €/m2 in 2020.
- Wood/biomass boilers systems: set on 788€/m2 in 2015, with a foreseen 631 €/m2 in 2020.

Additionally, the European Technology Platform on Renewable Heating and Cooling established foreseen prices for new CHP boilers in:

- CHP boilers: 2500 – 3000 €/kWe

CAPEX for biomass heat installations in €/kWth (Fraunhofer ISE)



The following figure presents the compilation of specific investment costs of biomass heating systems versus installed capacity. The data refers to different locations and years and is presented in nominal values (i.e., the original data was used, only converted to Euros when needed). The values are illustrative, but clearly indicate that higher system capacities lead to lower specific investments.

These amounts are not far from the EIA bioenergy Roadmap, which provide for different technologies:

CAPEX (€/kW)	Domestic (12 kWth)	Small commercial (100-200 kWth)	Large commercial (350-1 500 kWth)	Small industry (100-1 000kWth)	Large industry (350-5 000kWth)
2012	850 -1 200	500 -1 100	500 -720	550 -650	500 - 550
Future	600 -9 000	350 -800	350 - 550	400 - 550	320 - 410

National references from VTT in “Nordic heating technology solution pathways” increase values to 800 to 1.100 €/kWth, while National Pöyry Management Consulting provides 800 €/kWth which is finally selected as average.

Supply cost

At present, approximately 25 mills produce wood pellets in Finland. In 2017, a total of 324 000 tonnes (5.4 PJ) of wood pellets were produced, being one fifth more than in the previous year and the third highest in history. The wood pellet consumer price in 2018 was around 270 eur/t (57 €/kWh).

However, for industrial purposes, the two most important biomass sources in Finland are bark from forest industry and the logging and harvesting residues origination from forest management and industrial wood cuttings.

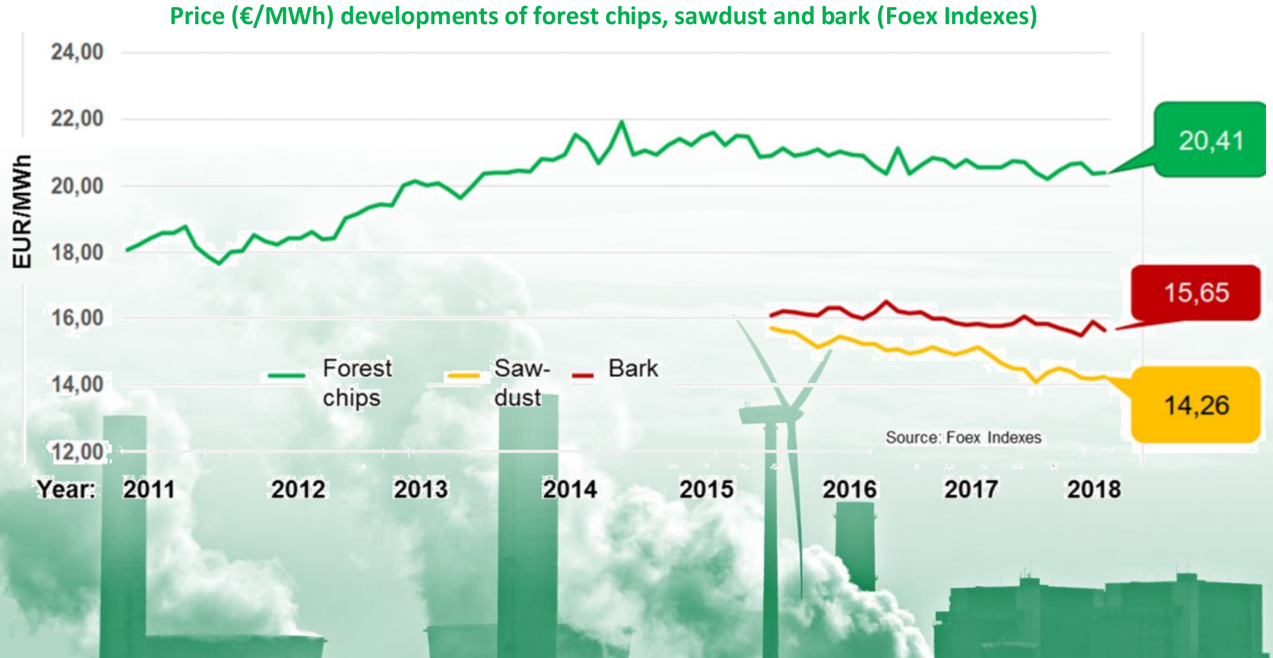
Summary of potential feedstocks in Finland (VTT Technical Research Centre of Finland)

Bioenergy source	Potential TWh	Present use %	Typical price at the plant site €/kWh	Properties
Bark	22	100 aprox	0,005-0,015	Moisture 40-60%, no major challenges
Saw dust	5	100 aprox	0,010-0,015	Moisture 40-55%, no major challenges
Chips and cuttings	2	100 aprox	0,015-0,020	Moisture 10-55%, no major challenges
Logging residues from final cuttings	13	50 aprox	0,010-0,015	Moisture 40-55%, no major challenges
Forest wood from young stands and first thinnings	14	50 aprox	0,018-0,025	Moisture 40-55%, no major challenges

In 2020, the availability of forest biomass residues will be 32 TWh (115 PJ) in total divided as follows:

- Logging residues from final felling, 13 TWh (46.9 PJ) based on cost level 11-14 €/MWh (3.0 – 3.9 €/GJ)
- Stumps and roots, 5,1 TWh (18.4 PJ) based on cost level 14-18 €/MWh (3.9 – 5 €/GJ)
- Forest wood from young stands and first thinning, 13,9 TWh (50 PJ) based on cost level 18-25 €/MWh (5 – 7 €/GJ)

Price (€/MWh) developments of forest chips, sawdust and bark (Foex Indexes)



Levelized Cost of Energy (LCoE)

As examples of costs of heat generation, it has to be separated the use of solid biomass to produce heat at:

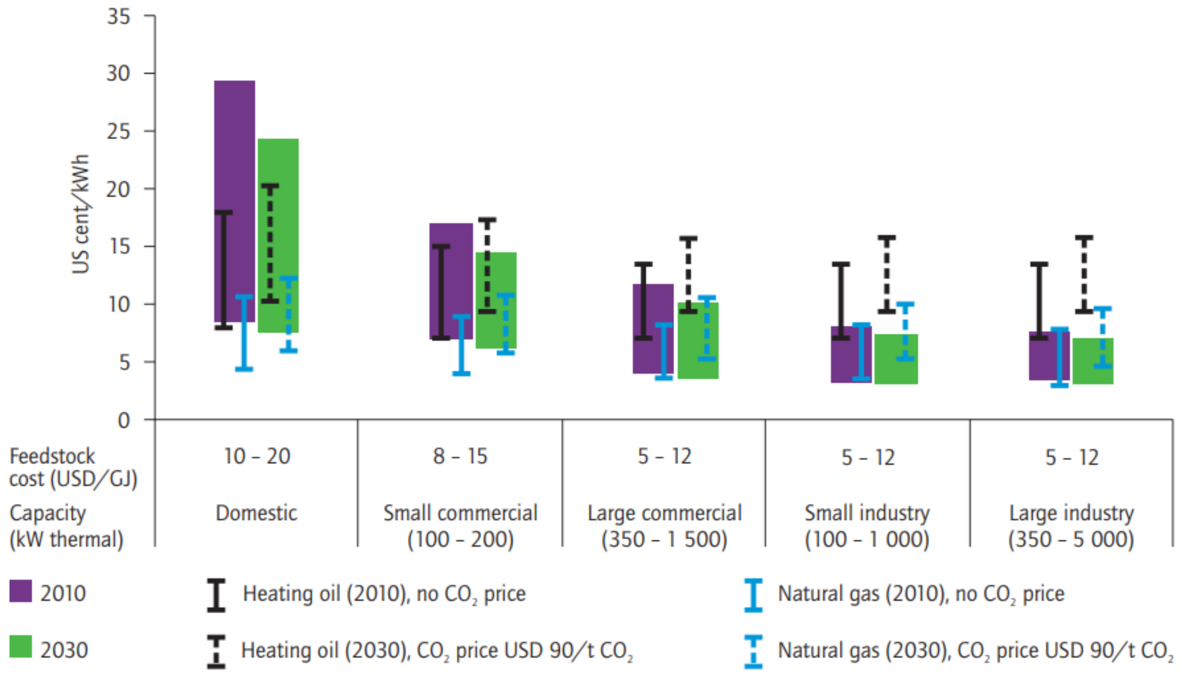
- domestic scale
- commercial institutional level or for district heating (largely for space and water heating)
- industry

The critical difference between these applications is the constancy of the heat load, which is much lower for smaller space heating applications than for industrial purposes. Generally, it is assumed that the smaller scale applications use wood pellets as feedstock, and the larger applications wood chips. Indicative capital and operating costs for heat production are shown in the table.

Energy cost (EIA bioenergy Roadmap)

	Domestic (12 kWth)	Small commercial (100-200 kWth)	Large commercial (350-1 500 kWth)	Small industry (100-1 000 kWth)	Large industry (350-5 000 kWth)
Feedstock	pellets	pellets	wood chips	wood chips	wood chips
Typical full load hours per year	700 -1 500	1 400 -1 750	1 800 - 4 000	4 000 -8 000	4 000 -8 000

Samples of LCOE for biomass applicatoins (EIA bioenergy Roadmap)



The following analysis shows the different values of energy cost achieved by method of the levelized cost of energy (LCOE). The classifications illustrate the order of the lowest cost to the highest, but do not specify the cost differences between the technologies.

Energy costs for technologies (Statistic Finland 2019)

	Electric heating	Light fuels	Heat district	Wood pellets
LCOE costs (€/MWh)	138	94	81	58

National references to LCOE in industrial biomass boiler using chips provide different scenarios depending on the Weighted Average Cost of Capital going from very positive 40 €/MWh to 78 €/MWh.

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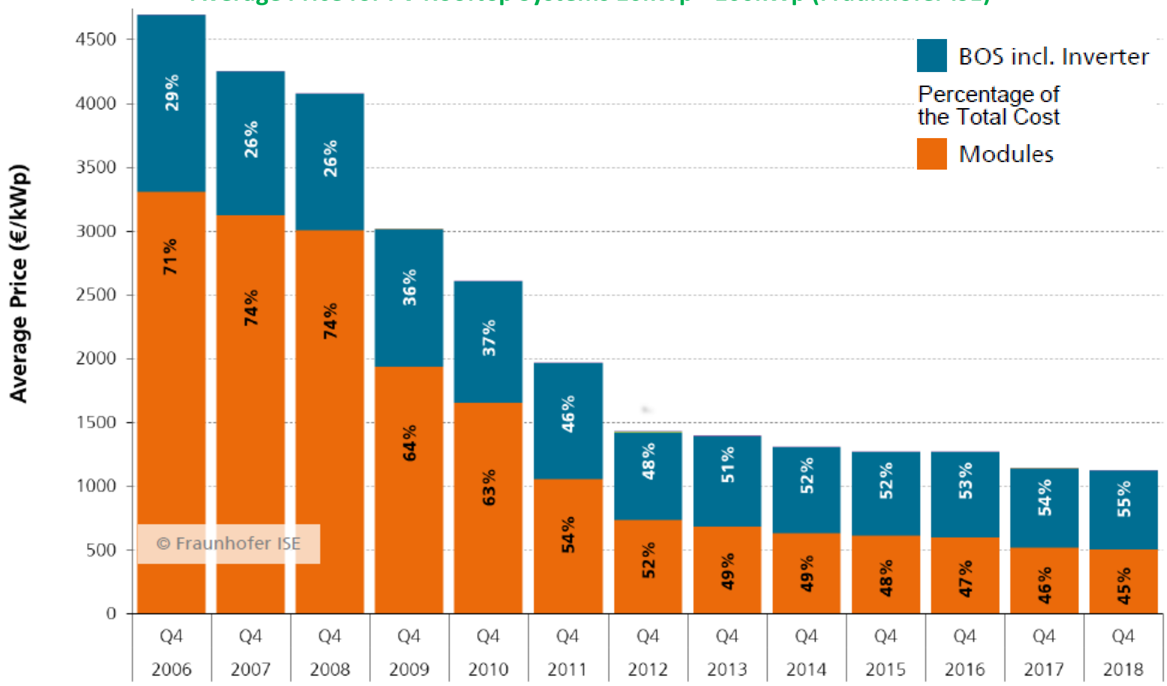
CAPEX

Based on the PV Status Report 2019 (JRC), in general, global CAPEX for PV solar systems have converged, even if significant differences still exist due to differences in market size and local competition and factors like import taxes, local content rules or existing tax credits.

Between 2008 and 2014, PV module prices have decreased rapidly by more than 80 %, then 2015 saw a short levelling out due to industry consolidation and increasing markets. However, since the beginning of 2016 module prices have again seen a sharp decrease in prices. In 2019, the cost share of solar modules in the benchmark PV system has dropped below 30 %.

PV system prices have followed the lowering of module prices but at a slower pace. The share of the non-technical costs has steadily increased over the years, despite an overall cost reduction.
For the technical components of a PV system there is a global market, e.g. modules, inverters, cables, etc., and these prices are very similar worldwide, if we do not consider taxes and duties. However, prices for installed PV systems still vary depending on the size, type of installation and country where it is installed.

Average Price for PV Rooftop Systems 10kWp - 100kWp (Fraunhofer ISE)



In 2020 CAPEX values based on LUT, Solar PV - ground-mounted are around 900 €/kWp, while Solar PV – rooftop CAPEX in Finland goes to an average 1.200€/kWp.

OPEX

With a cost of direct current (DC) electricity generated by a PV module dropped below 0.02 €/kWh in many places, the influence of CAPEX on Levelised cost of electricity (LCOE) of solar PV electricity has decreased significantly and other costs like O&M (operations and maintenance) costs, permits and administration, fees and levies as well as financing costs play a more dominant role.

The optimisation of solar PV electricity plant design and operation has direct effect on the O&M costs, which play an important role for the economics of the PV installation. With the continuous decrease of hardware CAPEX, the non-technical costs, linked to permit applications and regulations are representing an increasing share of the total costs and need to be reduced as well.

The annual OM cost is estimated as a percentage of the initial capital investment. The values more accepted in Finland are 1%, to more conservative 2%.

Lifetime

The current solar cell technologies are well established and provide a reliable product, with a guaranteed energy output for at least 30 years. About 95 % of current production uses wafer-based crystalline silicon technology.

Levelised cost of electricity (LCOE)

A common measure for cost comparison of power-generation technologies is the concept of the LCOE. LCOE is the price at which electricity must be generated from a specific source to break even over the project's lifetime. It is an economic assessment of the cost of the energy-generating system, including all the costs over its lifetime: initial investment, operations and maintenance including land rent if applicable, end-of-life management, cost of fuel, and cost of capital.

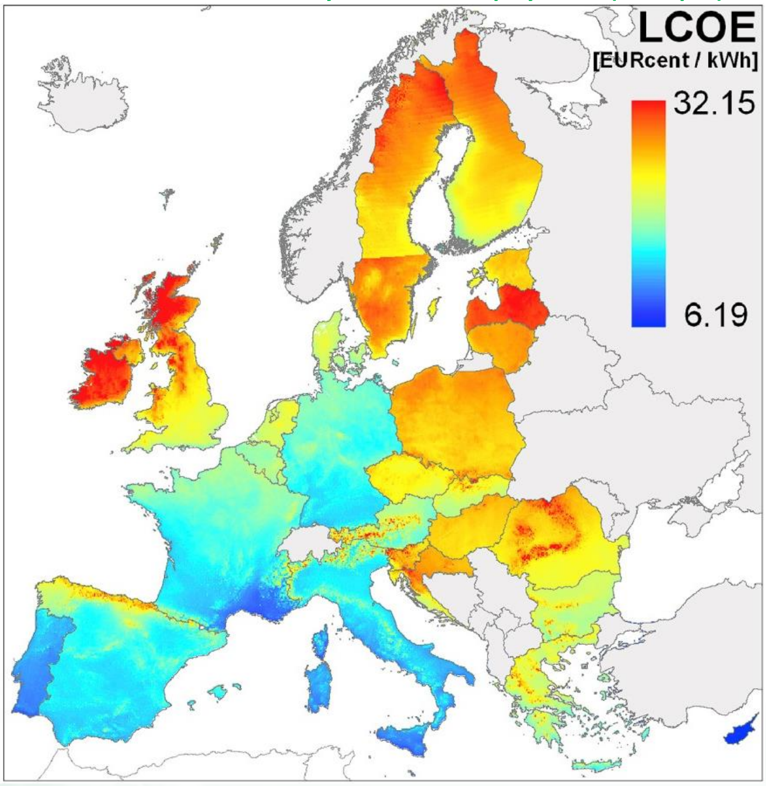
With a cost of direct current (DC) electricity generated by a PV module dropped below 0,02 €/kWh in many places, the influence of CAPEX on LCOE of solar PV electricity has decreased significantly and other costs like O&M (operations and maintenance) costs, permits and administration, fees and levies as well as financing costs play a more dominant role.

The following sample, from Joint Research Centre (JRC), Ispra, Italy in 2019 LCOE values were calculated for rooftop PV systems in the European Union.

The following results are based on:

- CAPEX for an installed PV system 1.100 €/kWp.
- Study did not consider the additional VAT costs.
- OPEX as 3% of CAPEX
- Electricity generation calculated for every location using the PVGIS methodology.

Levelised cost of electricity for PV Rooftop Systems (JRC Ispra)

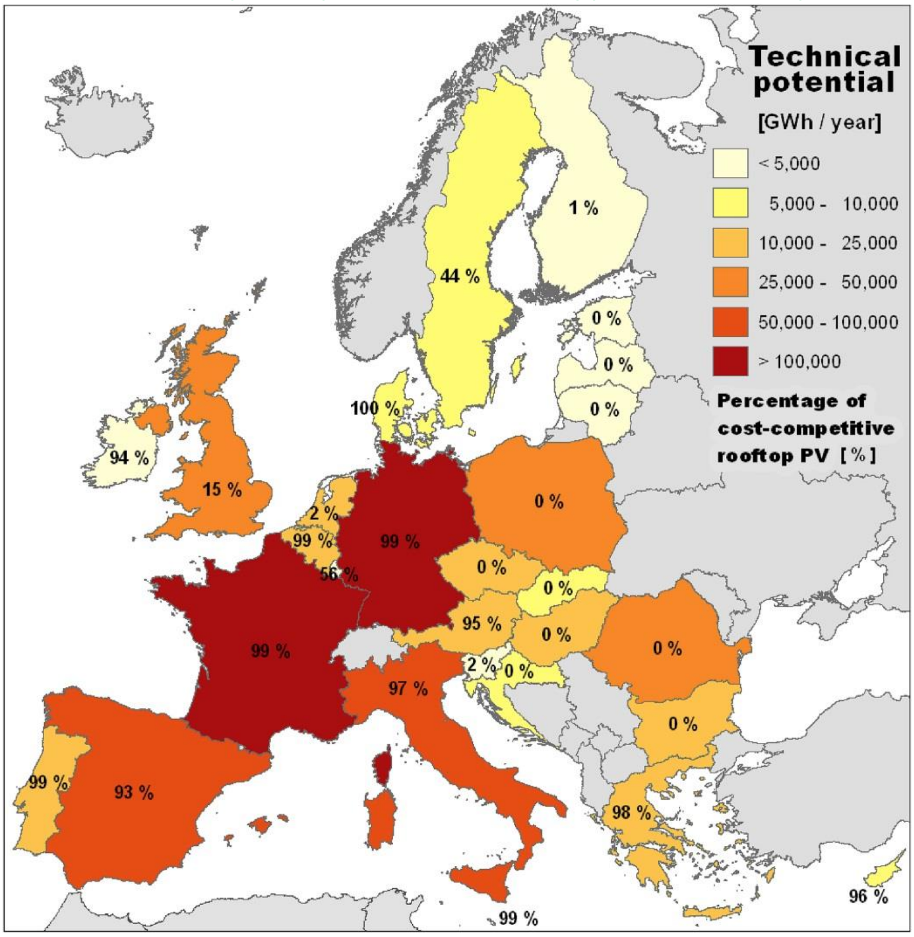


The LCOE, however, is not a flat indicator which can provide the effectiveness of PV application in one industrial sector or one specific country. In that sense, national retail electricity prices act as a reference for defining the economic potential of investment, making the assumption that the comparison of LCOE and electricity price defines the cost-competitive systems. Despite the limitations of such a simplification, retail electricity prices are the best available indicator to assess the solar PV systems' competitiveness.

Next map provides the technical potential of each country and the total expected electricity output (GWh/year), if fully developed.

Numbers show the share of the economic potential as a proportion of the technical one for each country. They provide the percentage of rooftop systems that are cost-competitive and produce electricity at a lower cost than the latest available (2017) retail electricity prices in the analysed countries.

Share (%) of the cost-competitive potential and electricity potential of rooftop PV (JRC Ispra)



The values show that solar irradiation is not the primary factor in determining the economic competitiveness of rooftop PV electricity. Neighborhood countries with similar solar resources have very different economic potential, especially as result of different retail prices.

- Specific countries such as Germany, France, Italy, Spain stand out in the maps as they host the highest economic potential due to higher retail electricity prices for Germany, Spain, Italy and France at 0,30 0,23 0,21 and 0,16 €/ kWh, respectively in 2017.

- Contrary to this case stand countries of Eastern EU (Bulgaria, Hungary, Romania, Estonia) mainly due to their low retail prices (0,095–0,12 €/kWh).

- The analysis points out that grid parity is not presently possible in Eastern EU (Romania, Poland, Hungary, Czech Republic, Slovakia, Croatia, Lithuania, Latvia, Estonia). This observation is surprising for countries having favourable solar resource (e.g. Romania, Croatia, Bulgaria).

In this scenery, the Finland, and Päijät-Häme region, showing LCOE values going from 0,21 €/kWh to 0,28 €/kWh, is not well placed to compete the electricity retails price in order to provide self-electricity.

EMPLOYMENT AND ENVIRONMENTAL KEY PERFORMANCE INDICATORS

Labor intensity.

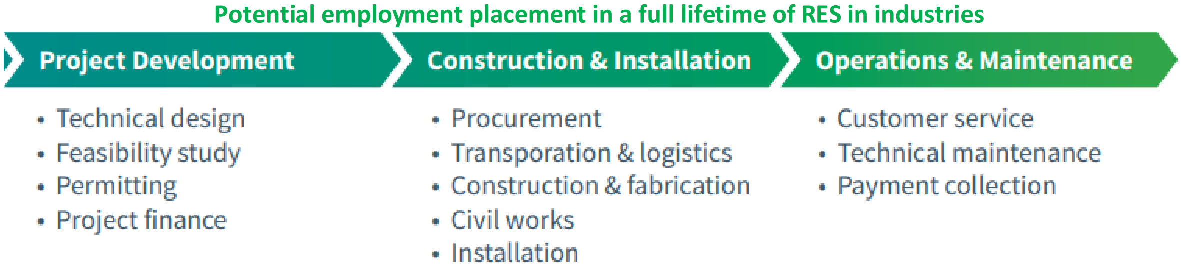
Most of literature in the current analysis refers to jobs creation per sector of renewable energy (labor intensity). Labor intensity, to be used as the KPIs in RESINDUSTRY, is most often defined as jobs/MW (or FTEs/MW), and it will be later transferred into jobs per € of CAPEX, due to it will be a standar referrence to allocation of potential ERDF grants.

<u>Employments created per technology</u>

The gross employment effect is defined as the direct and indirect employment related to the yearly investments in newly added RES capacity, O&M and exploitation of RES capacity and, in the case of biomass technologies, the production of biomass feedstock. Direct employment includes manufacturing of equipment, construction, consulting and engineering, financial services, O&M and biomass supply. The indirect employment refers to employment from secondary activities, such as transport and warehousing.

- Direct jobs are those created through contractual or non-contractual engagement with an incorporated company
- Indirect jobs are the formal and informal jobs created by vendors and suppliers who serve the sector upstream or provide services for day-to-day operations either with or without a contract.
- Induced jobs are those created through forward linkages as workers in the sector spend salaries on goods and services throughout the larger economy. For example, during the construction of a mini-grid plant, induced jobs are created for food vendors and water fetchers at the construction site.

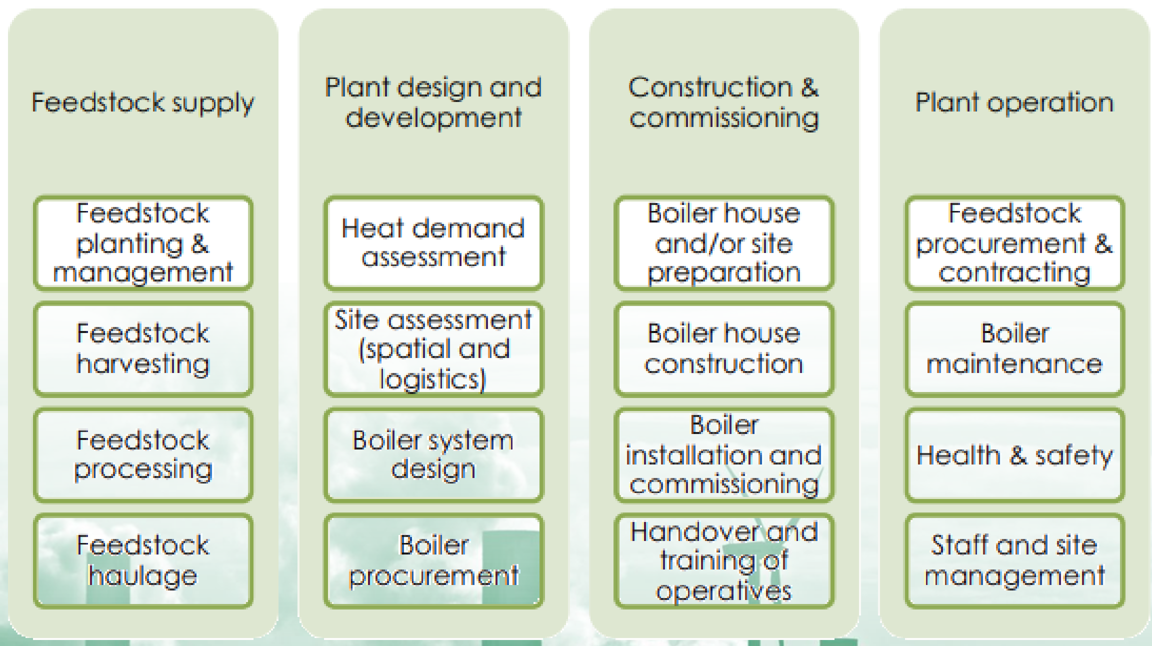
Potential employment placement in a full lifetime of RES in industries



Solar electricity and heat will accommodate to the previous employment placement, just presenting different ratios of employment creation in each process.

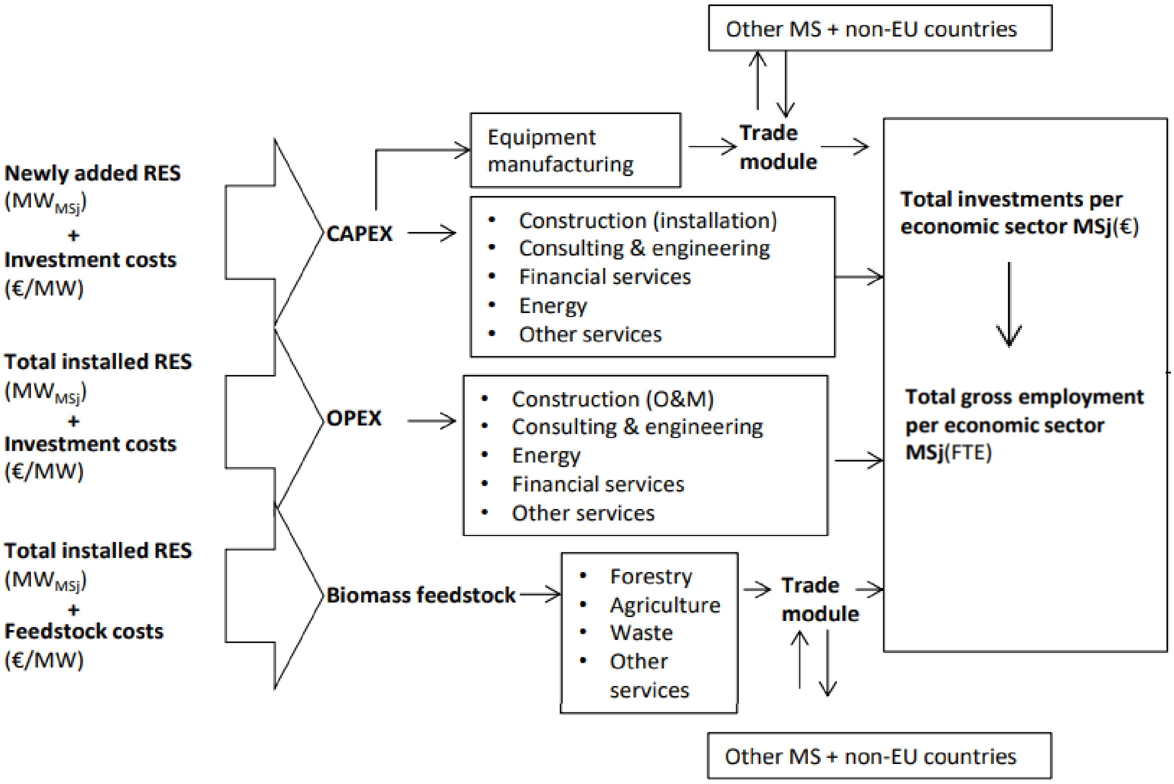
Biomass analysis of employment, however, will present additional job creation structures, especially in the fuel supply side, which will have important impacts in the final job creation factors.

Potential employment placement in a full lifetime of biomass installation in industries



The EurObserv'ER project has launched a methodology for calculating the employment effects on renewable energy both in EU and in the Member States.
The methodology to calculate the gross employment effect of renewable energy technology deployment, uses the so-called 'follow-the-money' approach. The employment effect is determined by following the revenue streams, generated from investments and exploitation of RES deployment, that flow to different economic sectors, and subsequently calculate the amount of employees.

Overview methodology employment effect of RES for MSj (EurObserv'ER)



Biomass results from application of methodology for calculation of full-time equivalent employment (FTEs).
The application has been made taking into account that the level of employment necessary for the construction and commissioning of the plant will not be sustained throughout the lifetime of the plant. Rather it will peak during the initial construction phase, which for biomass heat has been assumed to be up to a maximum of 2 years but in most cases will be much less.
Similarly, employees associated with plant design and development are also unlikely to be involved during the lifetime of the project, but instead for a shorter period leading up to the commissioning of the plant. Hence the contribution from these sectors to the figure for total jobs has been reduced to account for the fact that these employees are likely to move on to work on new projects roughly every 2 years (less often for larger scale plant).

Full-time equivalent employment for biomass heat and biomass power (own after NNFCC data)

	FTE / MWth biomass heat			FTE / MWe biomass power		
Employment placement	FTE /MWth	Construction (2 years)	25 years	FTE /Mwe	Construction (2 years)	25 years
Plant design/development	0,2	0,4	0,4	0,19	0,38	0,38
Construction and commissioning	1,49	2,98	2,98	2,46	4,92	4,92
Operation & maintenance	1,33		33,25	0,87		21,75
Fuel supply	0,55		13,75	0,48		12
TOTAL		**3,38**	**50,38**		**5,3**	**39,05**

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Other sources provide different allocations in the employment placements, but affording similar results in terms of total employment in the life time of installations, with values going from 50 FTE in the UK NNFCC report, to 60 FTE in UNEP or 65 FTE in Greenpece report.

Full-time equivalent employment for biomass heat (own after UNEP 2008 data)

	FTE / MWth biomass heat		
Employment placement	FTE/MWth	Construction (2 yrs)	25 years
Plant design/development	14	28	28
Construction and commissioning		0	0
Operation & maintenance + fuel	1,5		37,5
TOTAL		28	65,5

Full-time equivalent employment for biomass heat (own after Greenpeace/EREC/GWEC 2012 data)

	FTE / MWth biomass heat		
Employment placement	FTE/MWth	Construction (2 yrs)	25 years
Plant design/development	0,4	0,8	0,8
Construction and commissioning		0	0
Operation & maintenance + fuel	2,4		60
		0,8	60,8

As an average data, the indicator can be considered around 60 FTE / MWth installed for an operation of 25 years.

Solar results from application of methodology for calculation of full-time equivalent employment (FTEs).
For PV, on average, 30 full-time equivalent (FTE) jobs are created for each MW of solar power modules produced and installed. While there are discrepancies between countries, between companies and between technologies, it is a useful estimate that represents a world-wide average. However, this value cannot be considered for the analysis due to most of PV production is not placed in the country of analysis.
Several studies shows values of FTE for installation and O&M as follows:

Full-time equivalent employment for PV (own after UNEP 2008 data)

	FTE / MWp PV		
Employment placement	FTE/MWp	Construction (1 year)	25 years
Design, construction, installation	5,76	5,76	5,76
Operation & maintenance	1,2		30
		5,76	35,76

Full-time equivalent employment for PV (own after Greenpeace/EREC/GWEC 2012 data)

	FTE / MWp PV		
Employment placement	FTE/MWp	Construction (1 year)	25 years
Design, construction, installation	11	11	11
Operation & maintenance	0,3		7,5
TOTAL		11	18,5

Full-time equivalent employment for PV (own after IRENA 2014 data)

	FTE / MWp PV		
Employment placement	FTE/MWp	Construction (1 year)	25 years
Design, construction, installation	17,9	17,9	17,9
Operation & maintenance	0,3		7,5
TOTAL		17,9	25,4

2019 JRC analysis describes how O&M rates have decreased importantly in the last years, and provides about 0.17 full time work equivalents (FTE) per MW and year of installed PV systems were needed for operation and maintenance (O&M) in 2018. However, this number is more related to big PV systems placements, where 3.5 FTE per MW are expected in coming years and general costs will decrease over the next decade due to increased automation and digitalisation of O&M activities.
Total FTE in 25 years will not reach 10 FTE/MWp for big PV plants in years coming after 2020.

However, in the industrial installation and services, mainly placed in rooftop systems, the quantification is more difficult as these jobs are more dependent on local regulations and building codes. Values for rooftop are higher and will require higher FTE in both installation and maintenance, with a global average estimated around 15 FTE.

Solar thermal employment has been expressed in the same unit than CAPEX in order to have it aligned with the final KPIS.

Full-time equivalent employment for solar heat (own after IDAE 2015 data)

	FTE / 1.000 m2 solar heat		
Employment placement	FTE/1.000 m2	Construction (1 year)	25 years
Design, construction, installation	15,1	18,64	18,64
Operation & maintenance	1,7		41,94
TOTAL		**18,64**	**60,58**

Indirect employment

Typically, there is a positive relationship between direct and indirect employment, with indirect employment approximated as a "multiplier" of direct employment. Most national statistical offices publish data on sector specific multipliers. Given that renewable energy industries range across classical economic sectors, the multiplier in the renewables sector is a mix of the input sectors.

It appears that the number of indirect jobs is lower than the number of direct jobs for all RETs, with biomass having the highest multiplier and geothermal pumps having the lowest. Multipliers would typically be larger for countries with a larger share of manufacturing, although more research is needed here.

Conversion rate direct into indirect FTE per RES (IDAE 2015)

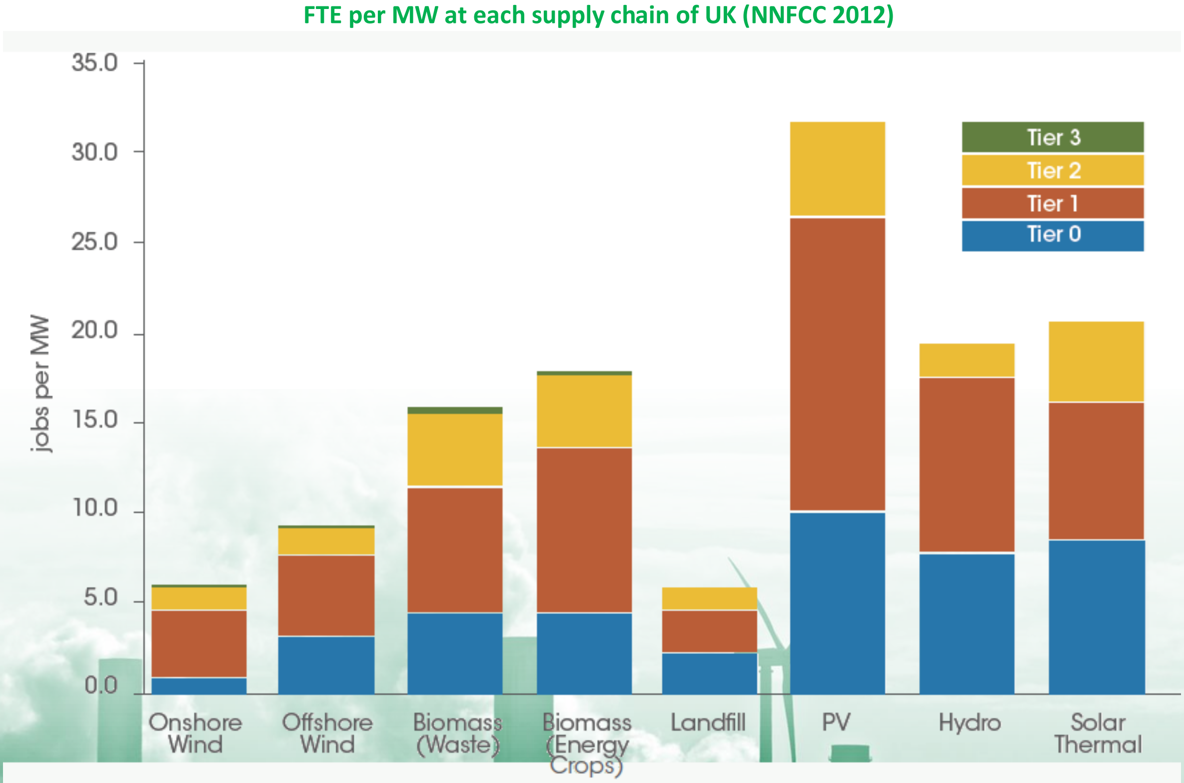
	Solar PV	Solar heat	Biomass	Wind	Hidro	Geothermal	Heat pumps	Sea
Rate	0,45	0,45	0,87	0,8	0,45	0,39	0,45	0,52

FTE in the supply chain

Even if the information will not be taken into consideration for the analysis due to the complexity to identify the supply chain in the country, the supply chain also have a final influence in the employment generated, in addition to the indirect employment.

As example, the picture shows the analysis made from NNFC for the UK national market. The tiers represent the different stages of production and services, from the upstream provision of raw materials to the renewable energy production itself.

FTE per MW at each supply chain of UK (NNFCC 2012)



Environmental KPIs

Renewable energy sources can contribute to improving air quality and human health, for instance by supplying electricity or heat without combustion. Technologies such as solar PV electricity, geothermal energy, heat pumps or solar thermal energy are therefore most effective at cutting the air pollutant emissions that are associated with most burning processes.

CO^2 emissions per kWh energy generated by type of fuel (EEA 2016)

For homes and businesses	Kg of CO^2 Per Million Btu	Kg of CO^2 Per kwh
Propane	63.07	0,215
Butane	64.95	0,222
Butane/Propane Mix	64.01	0,218
Home Heating and Diesel Fuel (Distillate)	73.16	0,250
Kerosene	72.30	0,247
Coal (All types)	95.35	0,325
Natural Gas	53.07	0,181
Gasoline	71.30	0,243
Industrial fuels and others not listed above	**Kg of CO^2 Per Million Btu**	**Kg of CO^2 Per kwh**
Flared natural gas	54.70	0,187
Petroleum coke	102.10	0,348
Other petroleum & miscellaneous	72.62	0,248
Coal by type	**Kg of CO^2 Per Million Btu**	**Kg of CO^2 Per kwh**
Anthracite	103.70	0,354
Bituminous	93.30	0,318
Subbituminous	97.20	0,332
Lignite	97.70	0,333
Coke	114.12	0,389
Other	**Kg of CO^2 Per Million Btu**	**Kg of CO^2 Per kwh**
Geothermal (average all generation)	7.71	0,026
Municipal Solid Waste	41.69	0,142
Tire-derived fuel	85.97	0,293
Waste oil	95.25	0,325

Emissions due to electricity consumption

In 2016, low-carbon energy sources (i.e. renewables and nuclear energy) continued to dominate the electricity mix for the second year in a row, together generating more power than fossil fuel sources. Fossil fuels (i.e. coal, natural gas and oil) were responsible for 43 % of all gross electricity generation in EU 2016.

The share of electricity generated from renewable sources has grown rapidly since 2005, but the pace of growth has slowed down after 2014. In 2016, renewable electricity reached almost one third (29 %) of all gross electricity generation in the EU. As such, renewable sources generated more electricity in 2016 than nuclear sources or coal and lignite.

Nuclear energy sources contributed roughly one quarter (26 %) of all gross electricity generation in 2016.
The transition from fossil fuels to renewable fuels, together with improved transformation efficiencies in electricity generation, led to an average annual 2.6 % decrease in CO^2 emissions per kWh between 2005 and 2016.

CO^2 emissions per kWh electricity generated by RESINDUSTRY country energy mix (EEA 2016)

Country	kg CO^2 per kWh
EuropeanUnion(currentcomposition)	0.296
Austria	0.085
Czechia	0.513
Estonia	0.819
Finland	0.113
Malta	0.648
Poland	0.773
Spain	0.265

IX. SWOT ANALYSIS

IX.I. STRENGTHS

Finland's energy policy is a result of its geographic location, its innovative business sector and commercial strongholds. With over one-third of its territory located above the Arctic Circle, the country is largely rural and sparsely populated, except for its southern tip. Finland has long, cold winters, and is 72% covered with forests. It has a large energy-intensive business sector.

Finland has a strong forest industry and developed a domestic supply chain, from timber to pulp and paper, woodchips for energy production and second-generation biofuels. The forestry sector accounts for about 20% of GDP. At the same time, the country can rely on a significant role of forestry as a carbon sink.

Finland's energy supply rely on nuclear energy and biomass for electricity and heat production, on oil for transport and extensive use of CHP production based on a mix of coal, natural gas, peat and biomass. Biomass has grown steadily, reducing the contributions of coal and natural gas.

IX.II. WEAKNESSES

The Finnish forestry industry is investing in future timber and pulp production. The increased felling of round wood would reduce the yearly carbon sink to 13.5 MtCO -eq. by 2030. This will decrease the forest's function as carbon sink during the years 2020s before they return to the current level in 2035.

IX.III. OPPORTUNITIES

The Government wants to work to ensure that Finland is carbon neutral by 2035 and carbon negative soon after that. They will do this by accelerating emissions reduction measures and strengthening carbon sinks.

The Government is committed to reforming the climate policies of the European Union and Finland so that Finland can do its part to limit the global mean temperature increase to 1.5 degrees Celsius. Finland aims to develop the EU's long-term climate measures so that the EU can achieve carbon neutrality before 2050. This means tightening the emissions reduction obligation for 2030 to at least 55% below the 1990 emissions level.

Finland has already adopted legislation to phase out the use of coal in energy production by 2029. The Government Programme also foresees i.a. a stepwise phase-out of the use of oil for heating by the beginning of the 2030s and a halving of the use of peat in energy production by 2030.

Despite the phase out of coal, the country continues to rely on peat as a domestic security of supply resource; the National Energy and Climate Strategy for 2030 sets out the share of peat to amount to 20 TWh in 2020 and 15 TWh in 2030. These fundamentals make Finland's energy mix unique in Europe.

In the National Energy and Climate Strategy for 2030, the government expects nuclear capacity to nearly double and wood fuels to increase by 30% towards 2030, together covering nearly 60% of total energy consumption by 2030, while phasing out coal in energy production and halving domestic use of oil by 2030.

The Government keeps a Nordic climate and energy cooperation in order to achieve carbon neutrality and works to strengthen the position of the Nordic countries as leaders in international climate policy. In addition, the Government Programme states: Electricity and heat production in Finland must be made nearly emissions-free by the end of the 2030s while also taking into account the perspectives of security of supply.

There is significant scope for using carbon taxation across the economy. The IEA sees ample opportunities for further aligning taxation and subsidies to climate and energy objectives, for instance in the taxation of natural gas and peat, and CO2 tax reduction and feed-in premium for the use of wood chips used in CHP generation.

The reform of the subsidy scheme in 2018 with half the investment aid given to innovative and new technologies is a welcome step since the market for flexibility needs to evolve as higher shares of renewable energy are being deployed and consumer preferences are changing.

The tax reform of 2011 overhauled energy taxation, taking into account the energy content, CO2 emissions and local air pollution. Since then, no major structural changes to the energy taxation regime have been performed, but regular adjustments were made to tax levels and structure. The government has begun to more closely analyse the effects and justification of specific rules in energy taxation on incentives to invest in clean energy.

There is scope to evaluate actions that will accelerate the energy sector's transition to net-zero emissions up to 2045 and 2050. Finland is part of the Nordic collaboration on energy, placing the region in an excellent position to take the lead in global energy system transformation. Finland is also a member of the Clean Energy Ministerial (CEM), joined Mission: Innovation (M:I) in 2016, and is well placed to contribute to a strong Nordic research, development and innovation agenda.

IX.IV. THREATS

While the medium-term reliance on biomass and nuclear is a confirmed strategy of the government, such an approach could be compromised by delays in nuclear development or low availability of sustainable biofuels. It could also be overtaken by the fast pace of energy technology development and deployment across the Nordic markets, bringing about significant cost reductions, notably in wind power, electric vehicles and batteries.

Finland has a large and ageing forest, which is a source of economic growth for the forest management. However, old trees have limited ability to absorb CO2. The size of the forest carbon sink (the quantity of CO2 that is sequestrated as the forests grow and released in harvesting) has varied between some 20 and 50 MtCO -eq in 1990–2013. Annually, the net sink of the Finnish forests has corresponded to between 30% and 60% of Finland's total emissions, a very high amount by international comparison. National policies have to promote a sustainable forest industry, where old trees can be replaced by new, and thus the sink will be levelled by 2035.

There is concern that the targets set for the use of renewable energy will raise the price of timber and steer the small-diameter timber suitable as the raw material of pulp and paper industry into use as energy wood. Forest industry, for example, has expressed the opinion that it makes more sense to first process the timber into commodities, to recycle a high proportion of them and to burn the biomass in them only after recycling. In this way, the timber could be used as material several times before being used for bioenergy.

Finnish forest owners, on the other hand, consider that they have the right to sell their timber wherever they can get the best price. The forest owners consider that it should be possible to sell the timber for energy use if the forest industry is not able to buy it.

It is required to guide the energy system towards a low-carbon future towards 2050 through adaptive and robust policy frameworks that enable businesses to take long-term investment decisions, notably in energy technology innovation.

It is necessary to coordinate with Nordic and Baltic neighbours on the design and implementation of climate and energy policies, including a broad technology innovation agenda.

It Is required to review the energy fuel taxation and subsidies to reflect their full carbon content to accelerate the switch to low-emission technologies, notably in combined heat and power generation and the transport sectors.

The Government needs to adopt a comprehensive package of policies and measures (taxation, supply and blending obligations, among others) in the transport sector to ensure that Finland can achieve the targeted emissions reduction in transport and halve oil consumption by 2030.

X. CONCLUSIONS

The cold climate, low population density, energy-intensive structure of the industry and natural resources of the country have affected the development of the Finnish energy system. The notable indigenous energy resources are hydropower, wood, peat and wind energy.

At the moment, Finland imports 23% of the electricity needed (13 000 MW; TEM, 2019). The CHP units have played a strong role in decentralized national electricity production, but more than 40% of the current CHP electricity capacity will be phased out by 2030 at the end of its technical lifespan. Low market price for electricity does not make CHP investments profitable and CHP capacity is replaced with the heat boilers (Rämö, 2017).

The goal of the Finnish government's energy and climate program (TEM, 2016) is to maintain the conditions for combined heat and power production as it is also an integral part of the system-level energy efficiency. In the future, concrete measures are needed to prevent the decline in CHP production and to encourage new investments.

Finland national energy trend has been set and the strategic carbon neutrality includes the following objectives:
1. Finland will achieve carbon neutrality by 2035
2. Finland aims to be the world's first fossil-free welfare society
3. Finland will strengthen carbon sinks and stocks in the short and long term.

In addition, the Government wants that electricity and heat production in Finland must be made nearly emissions-free by the end of the 2030s.

Target	Target year
Reduce greenhouse gas emissions in the effort sharing sector by 39%	2030
Total emissions in the LULUCF sector not to exceed the calculated sinks	Period 2021–2025 Period 2026–2030
Renewable energy share of final energy consumption at least 51%	2030
Renewable energy share of final energy consumption 30% in road transport	2030
Energy efficiency target: final energy consumption not more than 290 TWh (corresponds to approximately 405 TWh of primary energy consumption)	2030

BIOMASS IN FINLAND

In Finland bioenergy has a key role in the production of renewable energy. Bioenergy production is largely integrated into forestry and forest industry.

Wood is the most important source of bioenergy in Finland. Forestland covers almost 90% of the country's land area, and the national forest industry sector is extensive. Almost 80% of the wood-based energy is recovered from industrial by-products and residues. Due to the forest industry, black liquor represents the largest source of wood energy. The forest industry is also the most important user of wood fuels: almost 70% of wood fuel consumption takes place in the forest industry.

The indigenous production potential of bioenergy is not utilised in its entirety. Forest chips from logging residues, stump and root wood and small-diameter energy wood constitute the largest underutilised biomass potential. There is also potential to increase the use of agrobiomass and biogas, but not on the same scale as forest chips.

Modern paper and pulp factories and sawmills operate with integrated approach using waste liquors and residues such as black liquor, bark, sawdust and process waste and recycled wood, for the production of heat and power or biofuels and bioliquids. As a result of the positive trend in the forest industries, the consumption of roundwood in Finland is higher than before, meaning that more by-products are also available for energy production. In recent years, the growth in the consumption of wood fuels in Finland has been based especially on an increase in burning forest industry by-products and wood residues.

KPI indicators for biomass

CAPEX for <1MWth (€/kWth)	800
CAPEX for >1MWth (€/kWth)	350-500
OPEX (% of CAPEX)	3%
Supply cost (€/MWh)	20-40
LCOE (€/MWh)	78

Labor intensity (FTE/MWth)	60
Lifetime (years)	25
Indirect labor intensity (FTE/MWth)	52,2
Emissions (kg CO2/kWh) avoiding coal	0,325
Emissions (kg CO2/kWh) avoiding natural gas	0,181

If the analysis is made from the point of view of the public administration, where public funding is to be allocated to leverage private investment, the KPIs have to be shown as **impacts for each public euro invested**.

KPI indicator	KPI on lifetime
Public investment	1.000 €
RES supported (kWth)	2
RES produced (kWh th)	300.000
Full-time employment (FTE)	5,61
Avoided emissions (Ton CO2)	1.358

SOLAR ENERGY IN FINNISH INDUSTRY

Solar thermal can fulfill a substantial amount of heat demand in a wide range of industries in Finland. However most of opportunities are already covered for more cost-effective technologies such as the biomass.

For processes not requiring high temperatures, there is place for analysis, when not already covered by District Heating network providing low price heat (either from fossil or biomass fuels).

For small- and medium-size enterprises, rooftop space and finance opportunities for the upfront costs are the key barriers, so the opportunity is to integrate solar thermal heating plants during the construction of new industrial plants. The challenge is to maximise the share of heat provided by solar heating. This means that solar heating needs to be accompanied by storage to allow process heating during non-sun hours.

Cost-effective opportunities are, however, limited due to the low solar resources in some locations, if compared with other heating technologies.

KPI indicators for solar thermal heat.

CAPEX for <10.000m2 (€/m2)	800
CAPEX for >10.000m2 (€/m2)	600
OPEX (% of CAPEX)	2%
Supply cost (€/MWh)	0
LCOE (€/MWh)	97

Labor intensity (FTE/MWth)	60,58
Lifetime (years)	25
Indirect labor intensity (FTE/MWth)	27,26
Emissions (kg CO2/kWh) avoiding coal	0,325
Emissions (kg CO2/kWh) avoiding natural gas	0,181

If the analysis is made from the point of view of the public administration, where public funding is to be allocated to leverage private investment, the KPIs have to be shown as **impacts for each public euro invested**.

KPI indicator	KPI on lifetime	KPI on lifetime
Public investment	1.000 €	1.000 €
RES supported (m2 & kWth)	2,2	1,56
RES produced (kWh th)	47.222	47.222
Full-time employment (FTE)	4,88	4,88
Avoided emissions (Ton CO2)	214	214

For **PV electricity**,

The consumer price of electricity for households in Finland is below the EU average. In 2017, Finnish households paid on average 16 cents per kWh for electricity (EU average 20 cents per kWh).
The price of electricity for others than households, such as industry, in Finland was about 7 cents per kWh (EU average 11 cents per kWh).

These prices make difficult to achieve electricity generation with other technology in a cost effective way. However, without speaking of fed-in tariff, the competitiveness of an individual industry in terms of the price of energy also partly depends on the granted electricity tax reliefs and refunds.

In Finland energy intensive industry is entitled to a tax refund, if a company has paid fuel and electricity consumption taxes of more than 0.5% of its annual value added. It can apply for an 85% refund on the share of paid taxes which exceeds 0.5%. In addition the refund will be paid only on the share which exceeds 50.000€ and it excludes excise taxes on motor fuels.

KPI indicators for solar PV electricity.

CAPEX for industrial site (€/kWp)	1.200	Labor intensity (FTE/MWp)	15
OPEX (% of CAPEX)	1%	Lifetime (years)	30
Supply cost (€/MWh)	0	Indirect labor intensity (FTE/MWp)	6,75
LCOE (€/MWhe)	260,0	Emissions (kg CO2/kWhe) avoiding electricity	0,191

If the analysis is made from the point of view of the public administration, where public funding is to be allocated to leverage private investment, the KPIs have to be shown as **impacts for each public euro invested**.

KPI indicator	KPI on lifetime
Public investment	1.000 €
RES supported (kWp)	1,0
RES produced (kWhe)	25.500
Full-time employment (FTE)	0,65
Avoided emissions (Ton CO2)	146

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TECHNOLOGY INDICATORS COMPARISON BASED IN PUBLIC INVESTMENT

Once every technology has been shown in terms of similar KPIs, a comparison can be made among the different impacts achieved by technologies when they are supported in a similar way by public funding.

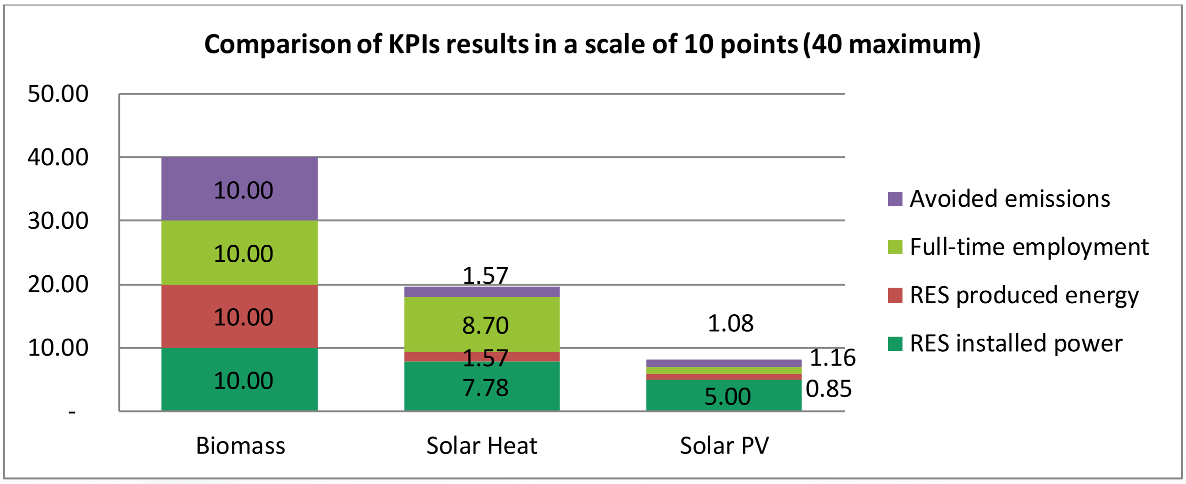
KPI indicator (values on lifetime)	Biomass	Solar Heat	Solar PV
Public investment	1.000 €	1.000 €	1.000 €
RES power (kW th; kW th; kWp)	2,00	1,56	1,00
RES produced (kWh th; kWh th; kWhe)	300.000	47.222	25.500
Full-time employment (FTE)	5,61	4,88	0,65
Avoided emissions (Ton CO2)	1.357,50	213,68	146,12

I	RES installed power (kW th; kW th; kWp)	RES produced energy (kWh th; kWh th; kWhe)	Full-time employment (FTE)	Avoided emissions (Ton CO2)
Biomass	2,00	300.000	5,61	1.357,50
Solar Heat	1,56	47.222	4,88	213,68
Solar PV	1,00	25.500	0,65	146,12

If a simple conversion system is applied to the technologies and their achieved indicators, trying to compare the results achieved, by providing 10 points to the highest impact achieved and applying a simple lineal conversion rule of three to the other impacts, the following values result.

	RES installed power	RES produced energy	Full-time employment	Avoided emissions	TOTAL
Biomass	10,00	10,00	10,00	10,00	40,00
Solar Heat	7,78	1,57	8,70	1,57	19,62
Solar PV	5,00	0,85	1,16	1,08	8,09

Graphically, the results are clearly favoring the biomass technology in every KPI, while solar heat get a second position with half the impacts of the biomass, while Solar PV remains in third position with close to ¼ of the impacts achieved by biomass.



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FINLAND BEST PRACTICES

of industries with RES

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Low-carbon economy

CONTENTS

SUMMARY OF BEST PRACTICES AND COMPARISON WITH CALCULATED KPI

Good practices in the Interreg Europe Programme

Interreg Europe is a capacity-building programme dedicated to policy learning and policy improvements. In particular, it is dedicated to the exchange and transfer of good practices in order to improve the effectiveness of regional development policies.

Interreg Europe projects build on the good practices identified within their partnership. They are the source of inspiration when preparing the action plans and improving the performance of their policies.

In the context of Interreg Europe, a good practice is an initiative carried out under one of the programme's topics. It can be for example a methodology, project, process or technique which has some evidence of success in reaching its objectives. There are already tangible and measurable results of the initiative. Moreover, a good practice has the potential to be transferred to other geographic areas.

According to the Interreg Europe programme manual, a good practice is supposed to "proved to be successful in a region and which is of potential interest to other regions".

Proved successful means that the good practice has already provided tangible and measurable results in achieving a specific objective." Since Interreg Europe is dedicated to regional development policy improvements, a good practice is usually related a public intervention. A private initiative may be considered as a good practice only if there is evidence that this initiative has inspired public policies.

Best practices in RESIndustry

The project good practices have to aim to the identification of renewable technologies implemented in industries, especially if they have been supported by public funds.

The samples are expected to focus on the local resources and available technologies, so the results will differ between countries and partners, but the global results will allow the comparison and the transfer of knowledge among the regions.

The best practices are expected to show a minimum of information in order to create a baseline of comparison among country practices and among project practices. Moreover, practices in the Interreg Europe database have also be selected in order to compare it with the project practices.

Some of the expected data are:

- Identification of the current energy baseline (fuels, energy consumption, etc.)
- RES technology definition (fuel, installed power, generated energy, CAPEX, simple payback, etc.)
- Results in terms of energy, economic and environmental achievements.

Unfortunately, the investment, even if supported by public funds, are usually private, thus the source of data are private promoters which sometimes are no easy to reach or provide partial information. In these cases, the best practices had been filled with the available data and the comparison is not that simple to carry out.

Key Performance Indicators (KPIs), calculated in the M.A. were calculated on official available data, while the best practices are real data from practical samples on the region or the country.

There is an opportunity to adjust the KPI by comparing the results from the Market analysis with the results from the best practices, however data can finally not to show relation with the calculated KPI.

In RESINDUSTRY, the KPI had vary between partners, because they analyse the specific region necessities/resources, and provide customized solutions to confront the RES benefits vs the policy investment. Even inside the country KPIs, vary also among locations, type of industries or year of application.

The final comparison of the best practices in RESindustry tries to balance the results found by the Market Analysis, by the best practices and by other good practices in the Interreg Platform, in order to reach final KPIS.

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Good practice process of validation

The practices have followed 2 steps of validation in order to be included in the Interreg Platform, first step being the internal project evaluation, both through the consortium, through the stakeholders and through the external evaluators. Moreover, the best practices, if selected to be sent to the Interreg Platform, will follow the platform validation process.

Project validations

- Best practices have been designed by the partners in accordance to an internal project template. In many of the cases, data has not been fully defined, due to lack of information. Each partner has to identify and deliver 10 best practices.
- The BP have been summarized and 5 of them are presented in the 2nd interregional workshop, while the total 10 are presented in the 3rd interregional workshop.
- The comparison and selection of practices is made in the 3 Interregional Workshop, linked to the Master Class of Regional Assessment. From the 70 total practices, just 10 have to be selected.
- From these 2 activities, a selection of best practices is made with the 10 practices with more potential to be included in the Interreg Platform.

Platform validation

- Once an author submits a good practice connected to an Interreg Europe project, the project web administrators receive a notification email.
- The project web administrators decide whether the good practice is complete and should be published on the project website.
- Once a project web administrator approves a good practice,
- it appears on the project website. A notification is sent to the joint secretariat for the next validation step.
- The joint secretariat checks the good practice against the indicators in the project progress report and on its overall quality (description).
- Once the joint secretariat approves the good practice, they might send it to a Platform experts for the next validation step. Experts consider the good practice on its value as a source of inspiration and learning for European policymakers.
- If the Platform expert validates the good practice, a comment will be added, and the practice will be included in the Platform good practice database.

Best practices selected by the partner

The partner has been able to afford 10 best practice, which are listed below.

Title of practice	Place	Key words	RES
Concept for a carbon neutral grocery store	Lahti	climate change, carbon emissions, renewable energy, solar energy	PV
Biofuel production from food industry residues	Lahti	biofuel, bioethanol, renewable energy sources, food industry, resource efficiency	Biofuels
Hybrid solar thermal and air heat pump system for district heating	Puumal a	Solar power, renewable energy, heating, solar thermal, heat pump, low-carbon	ST + HP
Biomass Heating Production in Food Industry	Lahti	biomass, low-carbon, bioenergy	Biomass
Geothermal heating of factory using heat pumps	Lahti	Heat pump, energy efficiency, low-carbon	Geothermal
Solar power plants integrated efficiently with commercial real estate	Lahti	Solar energy, renewable energy, low carbon	PV
Utilization of biowaste streams - bio-based industrial symbiosis as RES	Lahti	climate change, roadmap, greenhouse gas emissions, strategy, heat pump	Biogas
District heating production from renewable sources	Lahti	climate change, bioenergy, carbon neutrality, heat production	Biomass CHP
Biogas from wastewater sludge as replacement for fossil support fuels in biomass burning	Heinola	Renewable energy, biogas, biomass, paper, pulp	Biogas
Biomass boiler for efficient drying process	Lahti	Biomass, food production, renewable energy, climate change	Biomass

Additionally, 2 practices have been found in the Interreg Platform with dedicated information on technologies for Finland, and the data has been included in the comparison:

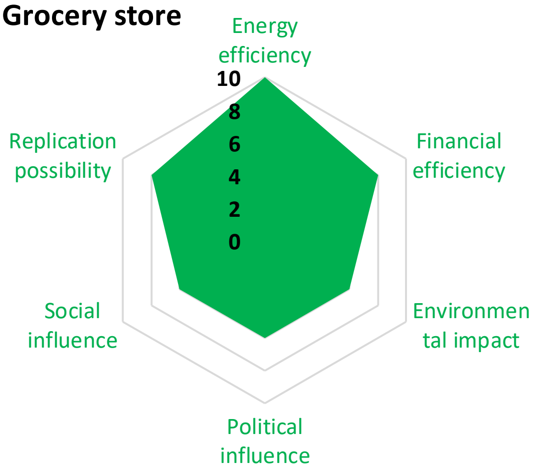
Title of practice	Place	Key words	RES
Alava farm	Kitee	Solar energy, renewable energy, low carbon	PV
Kuittila farm		climate change, bioenergy, carbon neutrality, heat production	Biomass CHP

On-farm solar energy
Alava dairy farm is among the first farms in North Karelia, Finland, to generate electricit...
Location: Pohjois- ja Itä-Suomi, Finland (Suomi)
18/06/2020

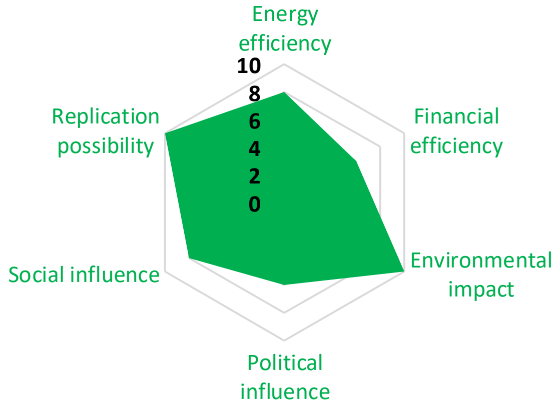
Energy self-sufficient Kuittila farm
Kuittila farm has been almost energy self-sufficient since 2012 when the farm invested i...
Location: Pohjois- ja Itä-Suomi, Finland (Suomi)
19/05/2020

The potential importance of the best practices has been analysed based on the document information, rating from 0 to 10, being 10 the maximum, and using the existing scoring of the practices. The results are:

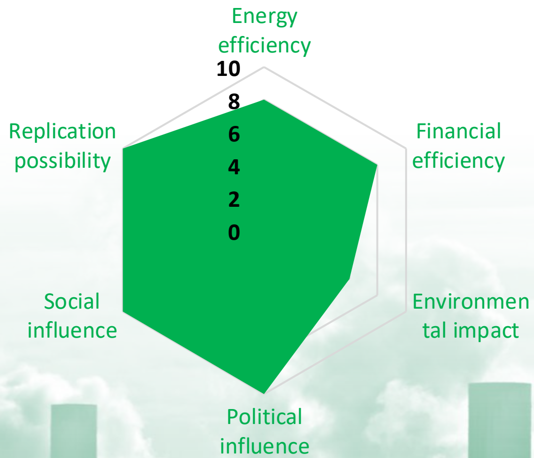
Grocery store



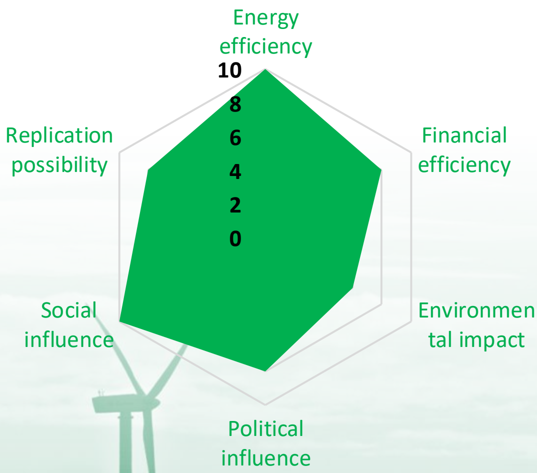
Biofuel from food



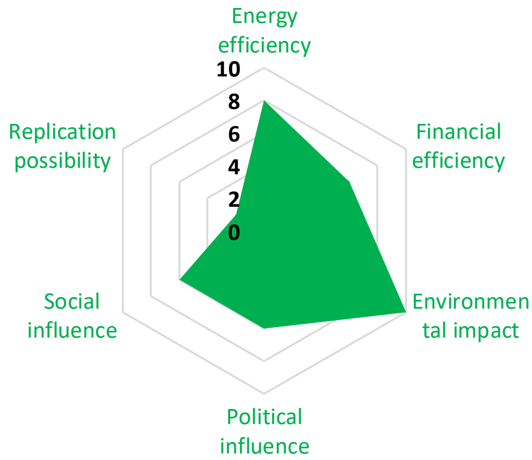
Solar thermal + air heat pump



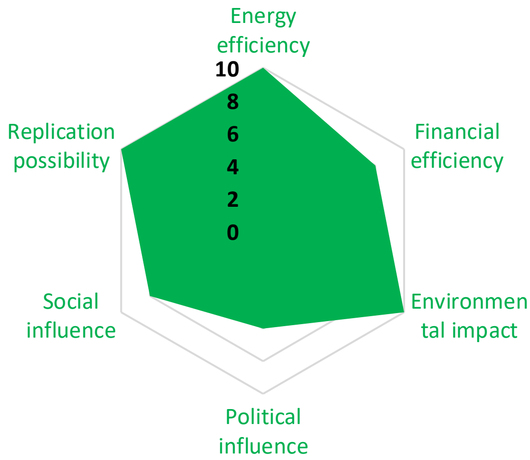
Biomass in Food Industry



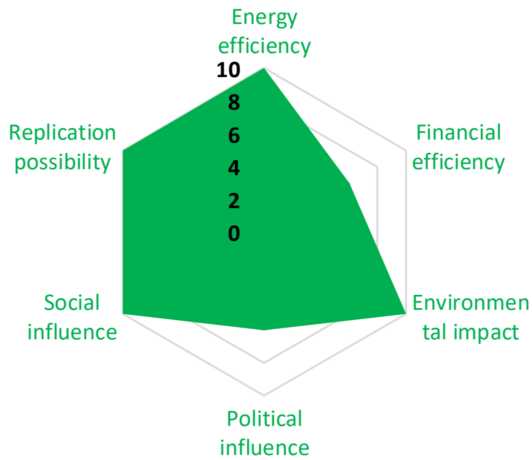
Geothermal heat pumps



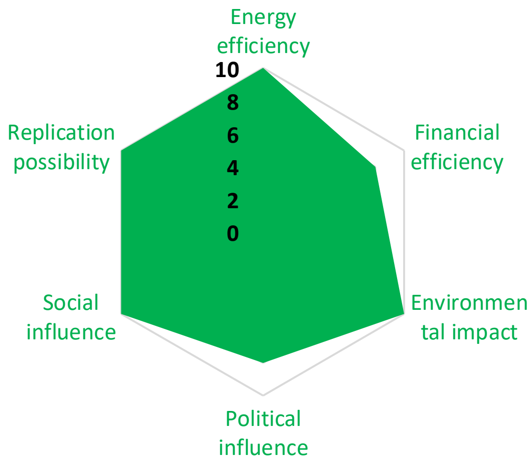
Solar in real estate



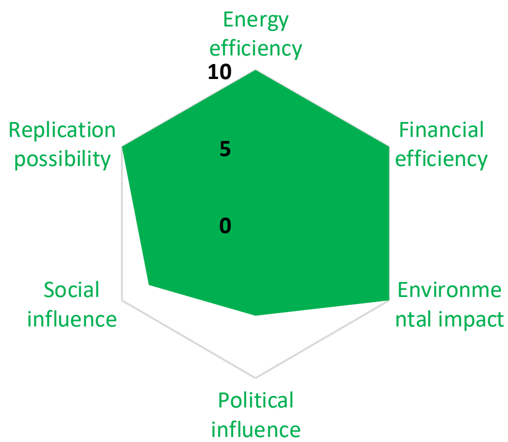
Biowaste streams



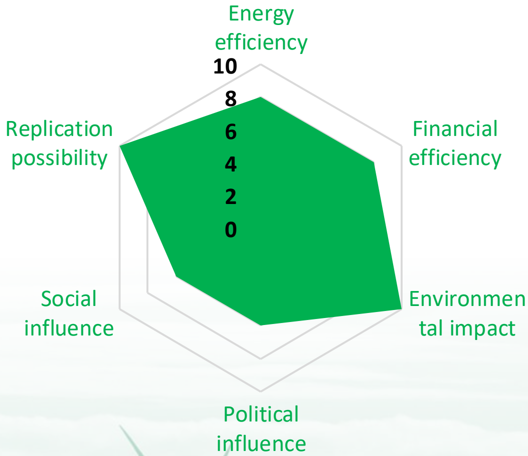
Biomass district heating



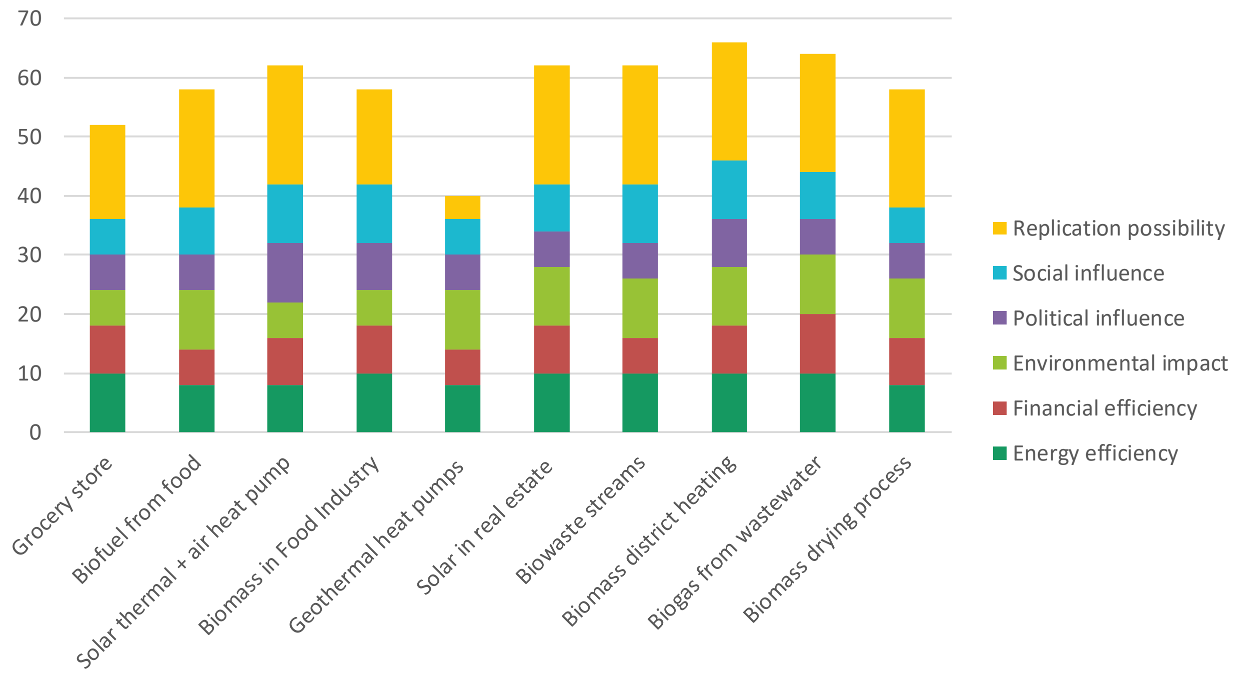
Biogas from wastewater



Biomass drying process



If the best practices are compared among each other, in a regular base just adding the scoring of the different evaluation criteria, the results of the below chart are achieved. In a general view, the practices show similar total scoring, but if a leverage factor of 2 is applied to the criteria “Replication possibility” some practices stand out of the rest, as can be seen in the chart.



Summary table of the scoring provided per practice and the leverage factor affecting the criteria “Replication possibility” some

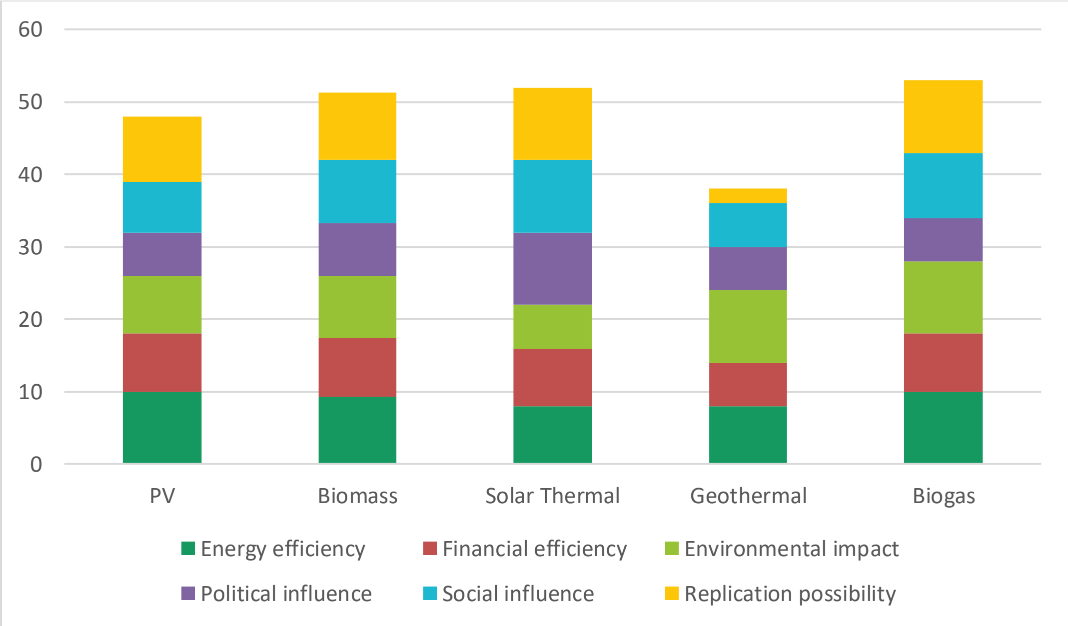
Title of practice	Energy efficiency	Financial efficiency	Environmental impact	Political influence	Social influence	Replication possibility
Grocery store	10	8	6	6	6	16
Biofuel from food	8	6	10	6	8	20
Solar thermal + air heat pump	8	8	6	10	10	20
Biomass in Food Industry	10	8	6	8	10	16
Geothermal heat pumps	8	6	10	6	6	4
Solar in real estate	10	8	10	6	8	20
Biowaste streams	10	6	10	6	10	20
Biomass district heating	10	8	10	8	10	20
Biogas from wastewater	10	10	10	6	8	20
Biomass drying process	8	8	10	6	6	20

Technology selected by the partner
In terms of technology, the replication potential has been calculated as an average of the 10 practices and the 2 practices from the Interreg Platform.

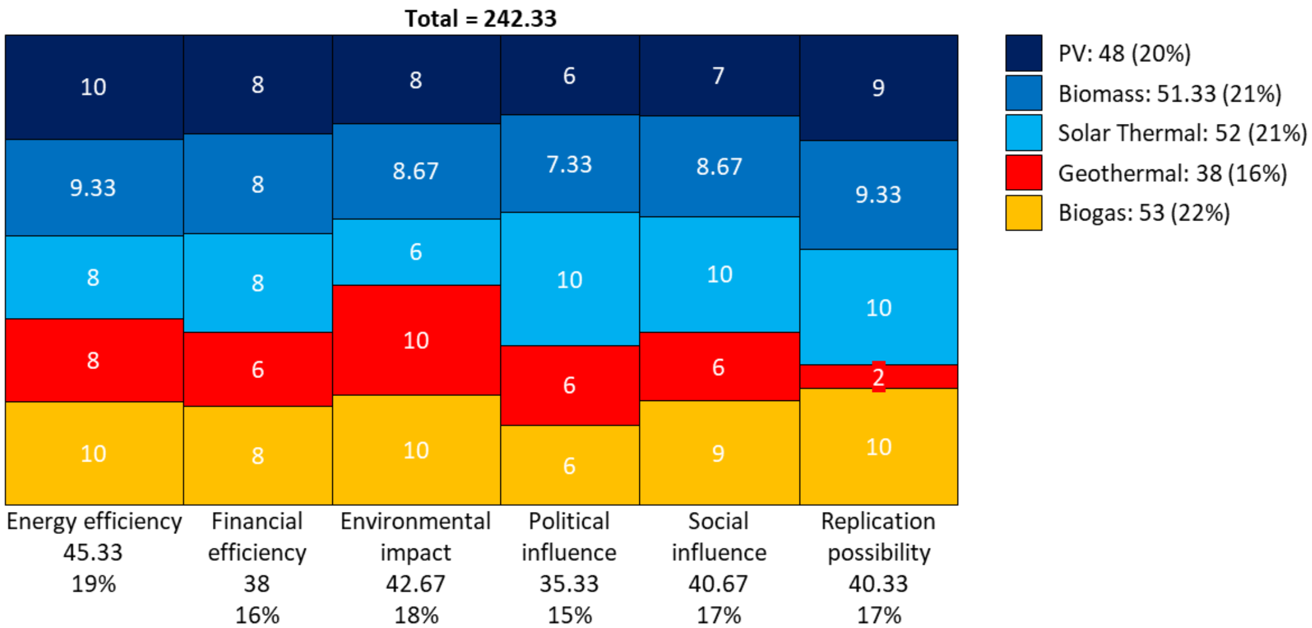
	Energy efficiency	Financial efficiency	Environmental impact	Political influence	Social influence	Replication possibility
PV	10	8	8	6	7	9
Biomass	9,33	8,00	8,67	7,33	8,67	9,33
Solar Thermal	8	8	6	10	10	10
Geothermal	8	6	10	6	6	2
Biogas	10	8	10	6	9	10

Per technology, and without application of any leverage factor, the results show that biomass technology and solar thermal technologies reach higher scoring than the rest of technologies, being PV and biogas just after the 2 first.

Replication indexes per technology based on the BPs selection of the partner



Replication indexes per technology based on the BPs selection of the partner, Mekko chart



The relation between the technologies and the criteria used for scoring, shows again the biomass and solar as higher scored, but also provides that the energy efficiency and the environmental impact are the criteria which afford higher benefits in the best practices, being the financial efficiency one of the less influencing criteria. The following Sankey chart shows the relations among the technologies and their influence on the different criteria.

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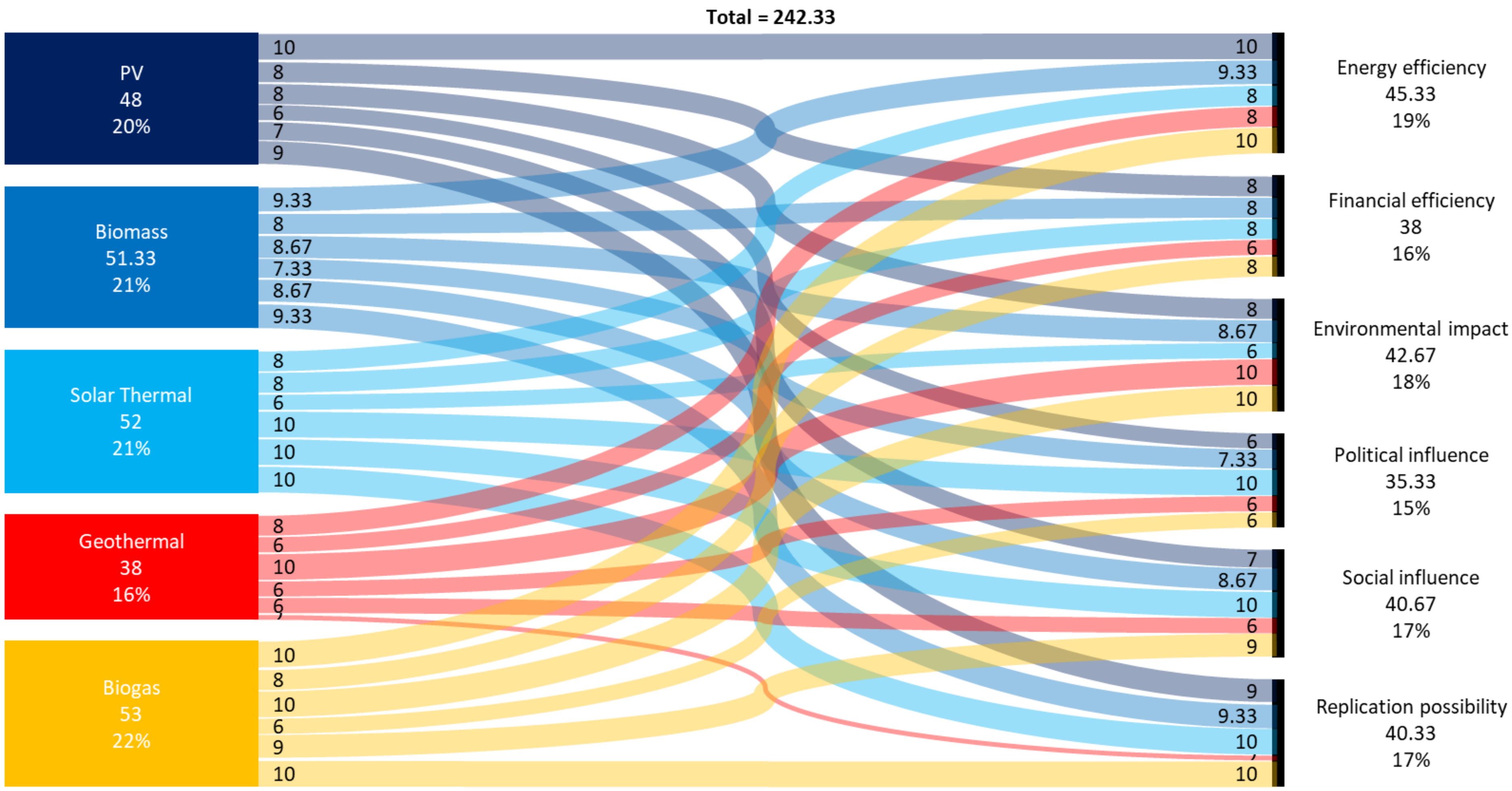
Influence of each technology in the replication indexes based on the BPs selection of the partner, Sankey chart



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INFLUENCE OF BEST PRACTICES IN SOME KPIS.

For most KPIs, the data provided has not provided any review on the proposed indicators of the Market analysis, thus the results remain the same for many KPIs:

- Kg CO^2 avoided
- RES produced (kWhe or kWhth)
- Full-time employment (FTE)
- Avoided emissions (Ton CO2)
- OPEX (% of CAPEX)
- Supply cost (€/MWh)
- LCOE (€/MWhe)

CAPEX for industrial site (€/kWp)

The Best Practices have provided data for 5 technologies, which together with the 2 good practices from the Interreg database, have produced the following results.

	€/kw					€/kw		
	BP 1	BP 2	BP 3	BP 4	Average	Interreg 1	M.A.	M.A. review
PV	833	806			820	1.364	1.200	1.001
Biomass	1.000	947	750		899	1.571	500	1.067
Solar Thermal	1.300				1.300		700	1.000
Geothermal	1.759				1.759			
Biogas	2.159	7.500			4.829			

This review of CAPEX for the different technologies have influenced in the KPI indicators calculated from the point of view of the public administration, where public funding is to be allocated to leverage private investment, the KPIs have been shown as **impacts for each public euro invested**.

Again, if the KPIS are calculated in the base of influence achieved for every 1.000€, the following new KPIs are resulted:

SOLAR PV	M.A.	M.A. Revision
KPI indicator	KPI on lifetime	KPI on lifetime
Public investment	1.000 €	1.000 €
RES supported (kWp)	0,8	1,0
RES produced (kWhe)	21.250	25.475
Full-time employment (FTE)	0,54	0,65
Avoided emissions (Ton CO2)	122	146

SOLAR THERMAL	M.A.	M.A. Revision
KPI indicator	KPI on lifetime	KPI on lifetime
Public investment	1.000 €	1.000 €
RES supported (kW th)	1,6	1,4
RES produced (kWh th)	30.357	21.250
Full-time employment (FTE)	3,14	2,20
Avoided emissions (Ton CO2)	137	96

BIOMASS	M.A.	M.A. Revision
KPI indicator	KPI on lifetime	KPI on lifetime
Public investment	1.000 €	1.000 €
RES supported (kW th)	2,2	0,9
RES produced (kWh th)	333.333	140.581
Full-time employment (FTE)	6,23	2,63
Avoided emissions (Ton CO2)	1.508	636

1. CONCEPT FOR A CARBON NEUTRAL GROCERY STORE

1. General information		
Title of the practice	**Concept for a carbon-neutral grocery store**	
Does this practice come from an Interreg Europe Project	**No**	

Please select the project acronym	**RESINDUSTRY**

Specific objective	**Renewable energy sources used for industry**	
Main institution involved	LAB University of Applied Sciences	
Geographical scope of the practice	*Select National/Regional/Local* regional	
Location of the practice	Country	*Drop-down list* Finland
	Region	*Drop-down list* Päijät-Häme
	City	*Drop-down list* Lahti
Keywords related to your practice	climate change, carbon emissions, renewable energy, solar energy	
Upload image		

2. Author contact information	
[Technical: Contact information comes from your community profile. You can edit it by visiting your user dashboard] [Ideally, the owner of the good practice should fill in the form. Indeed, if you submit a good practice, your personal and organizational profile in the Interreg Europe community will be linked to it.]	
Name	*Paavo Lähteenaro*
Email	*paavo.lahteenaro@lab.fi*
Telephone	*+358 469 232 738*
Your organisation	
Country	*Finland*
Region	*Päijät-Häme*

3. Detailed description	
Short summary of the practice	*[160 characters]* Since the beginning of 2017, all electricity purchased by Kesko group in Finland is renewable. Part of the energy is produced by the solar energy built into K-Group's properties.

Detailed information on the practice	*[1500 characters] Please provide information on the practice itself. In particular:* *1. What is the problem addressed and the context which triggered the introduction of the practice?* *2. Please briefly technically describe the practice. Also state the motivation of the owner for the installation and the decision process.* *3. How does the practice reach its objectives and how it is implemented?* *4. Who are the main stakeholders and beneficiaries of the practice?* 1. Objective: carbon-neutral food store. Food stores and food warehouses consume a lot of electricity in refrigeration. K-Group accounts for approximately 1% of all electricity consumed in Finland. Transfer to renewable electricity supports the K-Group's commitment to the Paris Climate Agreement's targets and the UN Sustainable Development Goal 'Affordable and clean energy' and Goal 'Climate action'. K-Group with Granlund has developed an energy recycling model that can reduce heat consumption by as much as 95%, turning a property almost carbon-neutral in terms of energy. The energy recycling system combines a very low-emission refrigeration system that uses natural refrigerants, a heat pump and recovery systems for energy recycling. It utilizes the condensation heat of cooling in heating the property. The innovation can reduce a property's heat consumption by 90%, making a store almost carbon-neutral. 2. From 2016. K-Group has significantly increased its production and use of solar power. In 2016, Finland's biggest rooftop solar power plant was completed on the rooftop of K-Citymarket Tammisto, Helsinki. By summer 2017, K-Group had four even bigger solar power plants than Tammisto and there will be as many as 16 solar power plants operating on the rooftops of stores. The investments make K-Group Finland's biggest producer and user of solar power. Currently, K-Group in Finland has 34 solar power plants totalling 12 MW. 3. For the fifth year in a row, Kesko ranks as the most sustainable trading sector company in the world on the Global 100 list. Kesko has committed to goals of international climate summits and set ambitious emission targets for its operations and supply chain. All electricity bought by Kesko in Finland for Kesko properties is from renewable sources, and K-Group is the biggest producer and user of solar power in Finland. 4. Stakeholders include the stores, manufacturers and the electric grid as there is potential to sell electricity into the grid as well.
Resources needed	*Estimated 20 % of project costs covered by Business Finland energy aid. Systems require some maintenance staff.*
Resources used	Business Finland energiatuki (Energy aid). Energy aid that can be granted to energy efficiency, renewable energy or any other project that reduces carbon emissions. Aid is paid as a percentage of project costs depending on the type of system. For solar power, aid is usually 20 %.
Policy instrument used	
Total project costs (EUR)	NA (Estimated 10 Million Euros total based on public funding)
Net present value of the investment (EUR)	NA

Internal rate of return on investment (%)	NA
Payback period (y)	NA
Lending rate (%)	NA
Timescale (start/end date)	2016 – 2025 (Fully carbon-neutral goal)
Installed capacity (kW)	12 000
Fraction of renewable energy consumed (%)	100
Investment costs per installed kW (EUR/kW)	*NA*
RES type used	Purchased electricity is produced via the bioenergy, solar and wind. The renewable energy produced in stores is produced via solar panel solutions.
Evidence of success (results achieved)	*[500 characters] Why is this practice considered as good? Please provide factual evidence that demonstrates its success or failure (e.g. measurable outputs/results).* Combined with energy savings from Granlund´s heat recovery system, a store can be turned fully carbon-neutral in practice.
Challenges encountered (optional)	*The ability of roofs to be able to hold up the weight of solar panels varies due to old preexisting buildings not having been designed with solar panels in mind. The strength of roofs has to be considered when building rooftop solar.*
Potential for learning or transfer	*[1000 characters] Please explain why you consider this practice (or some aspects of this practice) as being potentially interesting for other regions to learn from. This can be done e.g. through information on key success factors for a transfer or on, factors that can hamper a transfer. Information on transfer(s) that already took place can also be provided (if possible, specify the country, the region – NUTS 2 – and organization to which the practice was transferred)* *[Technical: A good practice be edited throughout a project life time (e.g. to add information on the transfers that have occurred)]* The potential to use practice like this is even greater the further south one goes as the usefulness of solar panels increases in warmer countries.
Further information	*https://www.kesko.fi/media/uutiset-ja-tiedotteet/porssitiedotteet/2020/keskon-vuosiraportti-2019-on-julkaistu/*

Please enter the value scaled from 1 – best, 2 – good, 3 – neutral, 4 – bad, 5 – worst:

Criteria	Description	Value
Energy efficiency	*Please rate the energy efficiency of the practice on the scale of 1 to 5.*	*1*
Financial efficiency	*Please rate the financial efficiency on the scale of 1 to 5.*	*2*
Environmental impact	*Were there any challenges connected to the e.g. visual impact of the practice?*	*3*
Political influence	*Does the project in any way influence the political situation in the surroundings of the installation?*	*3*
Social influence	*Is there any social influence on the industry or the local municipality?*	*3*
Replication possibility	*Please clarify how can this practice be replicated.*	*2*

Low-carbon economy

2. BIOFUEL PRODUCTION FROM FOOD INDUSTRY RESIDUES

1. General information	
Title of the practice	**Biofuel production from food industry residues**
Does this practice come from an Interreg Europe Project	**No**

Please select the project acronym	**RESINDUSTRY**

Specific objective	**Renewable energy sources used for industry**	
Main institution involved	*Technical: The name of the institution and location of the practice are per default those of the practice author. They remain editable.]* LAB University of Applied Sciences	
Geographical scope of the practice	*Select National/Regional/Local* regional	
Location of the practice	Country	*Drop-down list* Finland
	Region	*Drop-down list* Päijät-Häme
	City	*Drop-down list* Lahti
Keywords related to your practice	biofuel, bioethanol, renewable energy sources, food industry, resource efficiency	
Upload image		

2. Author contact information	
[Technical: Contact information comes from your community profile. You can edit it by visiting your user dashboard] [Ideally, the owner of the good practice should fill in the form. Indeed, if you submit a good practice, your personal and organizational profile in the Interreg Europe community will be linked to it.]	
Name	*Paavo Lähteenaro*
Email	*paavo.lahteenaro@lab.fi*
Telephone	*+358 469 232 738*
Your organisation	
Country	*Finland*
Region	*Päijät-Häme*

3. Detailed description	
Short summary of the practice	Biofuel produced from food industry process residues producing renewable energy

Detailed information on the practice	*Please provide information on the practice itself. In particular:* 5. *What is the problem addressed and the context which triggered the introduction of the practice?* 6. *Please briefly technically describe the practice. Also state the motivation of the owner for the installation and the decision process.* 7. *How does the practice reach its objectives and how it is implemented?* 8. *Who are the main stakeholders and beneficiaries of the practice?* The plant is a symbiosis of energy company St1 and beverage company Hartwall where residues from Hartwell's drinks manufacturing are used as material for bioethanol production. By locating the plants next to each other, the leftover yeast and other liquid waste containing sugar and alcohols can be directly pumped to the bioethanol plant, accounting for up to 40 % of the raw material required by the ethanol plant, with rest shipped from other locations. As part of the European Union's RES-directive, in Finland, fuel sold for transport must contain an aggregate percentage of biofuels, the obligation in 2020 being 20 %. This has led to the creation of various novel bioethanol production efforts in Finland, including many by St1. The plant's fermentation system uses a variety of waste biomass from failed beverage batches, yeast, leftover bread from stores and other waste from bakeries and biowaste from stores. Etanolix plants as a concept were born out of a desire to make bioethanol production more local moving it out of the third world and into Europe and not being dependent on food crops by using waste instead. The produced fuel is mixed into transport fuel and sold, making the stakeholders of the practice the transport sector as well as commuters. From the supply side, drinks manufacturers, bakeries and stores are all beneficiaries. The yeast leftover is also further processed into feed for pigs, making farmers another stakeholder group. Heat for the process is supplied from gas boilers of the Hartwall plant, which uses mixture of natural and biogas in the form of landfill gas which fills approximately 10 % of the energy demand of the brewery, biorefinery and district heating production of the total of 24 MW boiler capacity.
Resources needed	*[300 characters] Please specify the amount of funding/financial resources used and/or the human resources required to set up and to run the practice.* The plant in Lahti employs only 2 full-time operators and additionally a few other employees on an hourly basis. St1 shares its maintenance and laboratory functions between all seven of its bioethanol plants in Finland. The plant is operated remotely during nights and weekends as, during normal operation, no on-site crew is required at all.
Resources used	*Institutional / Structural EU funds (describe the program used) / Other* None
Policy instrument used	*State the name of the policy instrument and briefly sum up its specifications.*
Total project costs (EUR)	NA (Multiple million Euros)
Net present value of the investment (EUR)	NA
Internal rate of return on investment (%)	NA
Payback period (y)	NA
Lending rate (%)	-
Timescale (start/end date)	1/2009-11/2009
Installed capacity (kW)	*Hard to quantify, energy for the refining is produced in boilers of the adjacent brewery.*
Fraction of renewable energy consumed (%)	10 % (biogas portion of the brewery energy use)

Investment costs per installed kW (EUR/kW)	*Review the total investment costs per installed kW of renewable energy source in euros per kW.*
RES type used	*biomass energy*
Evidence of success (results achieved)	*[500 characters] Why is this practice considered as good? Please provide factual evidence that demonstrates its success or failure (e.g. measurable outputs/results).* The St1's Etanolix plant in Lahti is able to produce 1,3 million litres of bioethanol in a year. The cooperation of St1 and local food industries is a successful example of turning waste into valuable material. The Etanolix plant treats bio-based by-products of nearby industries, and thus reduces the amount of produced waste. Emissions of the fuel are reduced by 70 % compared to equivalent fossil fuels.
Challenges encountered (optional)	*The wide variety of raw material used by the plant creates challenges for production. The amount of quality of waste the plant receives varies temporarily which complicates optimization of the production process. On the other, this had led to a fast ability to react to changes in production. The plant has over the years proven to be small, with newer plants built currently being several times larger in production capacity offering better economy of scale. More biowaste is available than the plant is able to take.*
Potential for learning or transfer	*[1000 characters] Please explain why you consider this practice (or some aspects of this practice) as being potentially interesting for other regions to learn from. This can be done e.g. through information on key success factors for a transfer or on, factors that can hamper a transfer. Information on transfer(s) that already took place can also be provided (if possible, specify the country, the region – NUTS 2 – and organization to which the practice was transferred)* *[Technical: A good practice be edited throughout a project life time (e.g. to add information on the transfers that have occurred)]* A similar system could be implemented in other places with breweries and so it has much potential. The EU member states also must require fuel suppliers to supply a minimum of 14% energy consumed in road and rail transport by 2030 as renewables. the share of biogas and advanced biofuels, such as the bioethanol produced by St1 Etanolix plant, must increase to 1% by 2025 and 3.5% by 2030. Therefore, we can foresee potential for similar plants across Europe in order to fulfil this goal.
Further information	https://www.st1.com/about-st1/company-information/areas-operations/advanced-fuels-waste

Please enter the value scaled from 1 – best, 2 – good, 3 – neutral, 4 – bad, 5 – worst:

Criteria	Description	Value
Energy efficiency	*Please rate the energy efficiency of the practice on the scale of 1 to 5.*	*2*
Financial efficiency	*Please rate the financial efficiency on the scale of 1 to 5.*	*3*
Environmental impact	*Were there any challenges connected to the e.g. visual impact of the practice?*	*1*
Political influence	*Does the project in any way influence the political situation in the surroundings of the installation?*	*3*
Social influence	*Is there any social influence on the industry or the local municipality?*	*2*
Replication possibility	*Please clarify how can this practice be replicated.*	*1*

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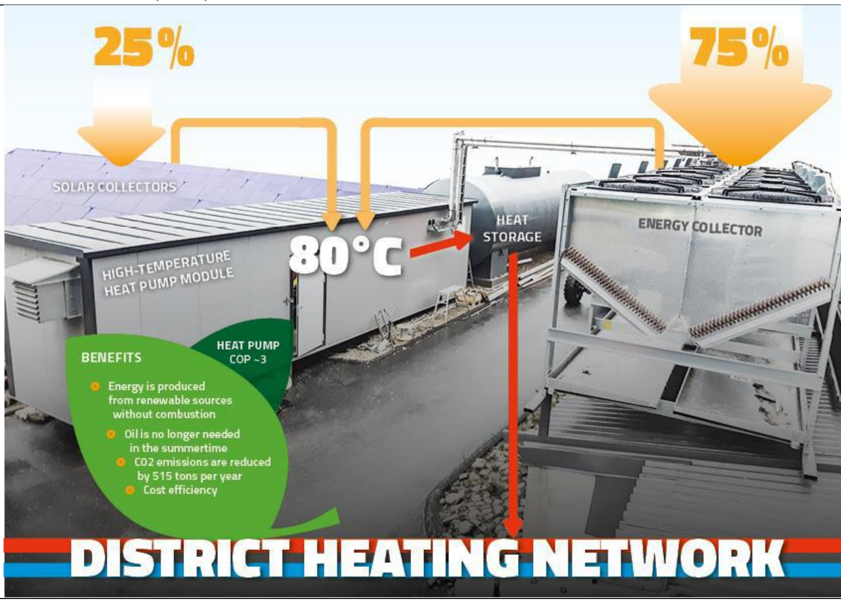
Low-carbon economy

3. HYBRID SOLAR THERMAL AND AIR HEAT PUMP SYSTEM FOR DISTRICT HEATING

1. General information	
Title of the practice	Hybrid solar thermal and air heat pump system for district heating
Does this practice come from an Interreg Europe Project	**no**

Please select the project acronym	**RESINDUSTRY**

Specific objective	**Renewable energy sources used for industry**	
Main institution involved	*Technical: The name of the institution and location of the practice are per default those of the practice author. They remain editable.]* LAB University of Applied Sciences	
Geographical scope of the practice	*Local*	
Location of the practice	Country	*Finland*
	Region	*Etelä-Karjala*
	City	*Puumala*
Keywords related to your practice	*Select existing keywords or add Solar power, renewable energy, heating, solar thermal, heat pump, low-carbon*	
Upload image		

2. Author contact information	
[Technical: Contact information comes from your community profile. You can edit it by visiting your user dashboard] [Ideally, the owner of the good practice should fill in the form. Indeed, if you submit a good practice, your personal and organisational profile in the Interreg Europe community will be linked to it.]	
Name	*Paavo Lähteenaro*
Email	*paavo.lahteenaro@lab.fi*
Telephone	*+358 469 232 738*
Your organisation	
Country	*Finland*
Region	*Päijät-Häme*

3. Detailed description	
Short summary of the practice	A hybrid solar thermal and air heat pump system replaces oil fired boiler for producing district heating during low summer month loads.

Detailed information on the practice	Suur-Savon Sähkö, a local energy company, had a problem with their biomass heating plant. The plant was covering the local district heating need in winter but the heating load in summer was so low that the large plant could not be run at such a low partial load. Therefore, in the summertime, the small heating load had to be covered by an older oil-fired boiler. To cover the small summertime load, a new hybrid solar thermal system was devised by Calefa Oy, a Päijät-Häme based energy efficiency systems provider, which uses panels that gather solar heat which is then used as a heat source for a heat pump. The heat pump is devised so that it can also use ambient air as a heat source and is fitted with a heat storage tank so that it continues to function with high efficiency even in the night-time when temperatures cool down and sun no longer shines. The main stakeholders of the project are the energy company, its customers and the municipality of Puumala, as well as, the local parish that donated the land on which the solar collectors are placed.
Resources needed	*[300 characters] Please specify the amount of funding/financial resources used and/or the human resources required to set up and to run the practice.* The system runs itself almost maintenance-free. Design and delivery by an external energy efficiency system turnkey solutions provider Calefa.
Resources used	Business Finland energy aid for novel energy systems totalling 170 000 €
Policy instrument used	Business Finland energiatuki - energy aid that can be granted to energy efficiency, renewable energy or any other project that reduces carbon emissions. The aid is paid as a percentage of project costs depending on the type of system. For new technology, the aid can be 30-40 %.
Total project costs (EUR)	650 000
Net present value of the investment (EUR)	NA
Internal rate of return on investment (%)	7 %
Payback period (y)	Estimated originally 15 years but has proven in use to be less
Lending rate (%)	NA
Timescale (start/end date)	6/2019 – 11/2019
Installed capacity (kW)	500
Fraction of renewable energy consumed (%)	79%
Investment costs per installed kW (EUR/kW)	1300
RES type used	Solar power
Evidence of success (results achieved)	Oil use has reduced by 30 000 litres a year and CO2 emissions by 515 tons per year. The system has proven to work even in the wintertime if the weather is sunny.
Challenges encountered (optional)	*[300 characters] Please specify any challenges encountered/lessons learned during the implementation of the practice.* Placement of the solar collector field, due to lack of space around the previous heating plant. Eventually, the land was acquired for rent from cooperation with the local church. Having both design and delivery supplied by a single company, Calefa Oy, was proven vital for success in integrating machinery designed by multiple manufacturers.
Potential for learning or transfer	A system like this has the potential to work even better in countries with longer summers than in Finland. Addition of a heat pump makes solar

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	thermal heating much more efficient and allows for higher temperatures to be achieved while still being very energy efficient. However, countries with better solar thermal potential also have less demand for heating. However, the company points out that the system would be even more efficient if coupled with a demand for cooling, which the heat pumps could supply simultaneously with heating. Also as the heat pumps benefit from cheap electricity, the system is well suited to exploit power-to-X, producing heat during periods of cheap electricity, which can also be stored in the heat storage, making it cheaper to run and increasing return on investment. Similar systems could be used for heating industrial processes by combining solar thermal collectors with heat pumps. New high-temperature heat pumps such as the one used in this plant open up much new potential for heat pump applications.
Further information	https://vuosikertomus.sssoy.fi/2019/liiketoiminta/energian-tuotanto

Please enter the value scaled from 1 – best, 2 – good, 3 – neutral, 4 – bad, 5 – worst:

Criteria	Description	Value
Energy efficiency	*Please rate the energy efficiency of the practice on the scale of 1 to 5.*	*2*
Financial efficiency	*Please rate the financial efficiency on the scale of 1 to 5.*	*2*
Environmental impact	*Were there any challenges connected to the e.g. visual impact of the practice?*	*3*
Political influence	*Does the project in any way influence the political situation in the surroundings of the installation?*	*1*
Social influence	*Is there any social influence on the industry or the local municipality?*	*1*
Replication possibility	*Please clarify how can this practice be replicated.*	*1*

4. BIOMASS HEATING PRODUCTION IN FOOD INDUSTRY

1. General information	
Title of the practice	**Biomass Heating Production in Food Industry**
Does this practice come from an Interreg Europe Project	**No**

Please select the project acronym	**RESINDUSTRY**

Specific objective	**Renewable energy sources used for industry**	
Main institution involved	*Technical: The name of the institution and location of the practice are per default those of the practice author. They remain editable.]* LAB University of Applied Sciences	
Geographical scope of the practice	*Select National/Regional/Local* regional	
Location of the practice	Country	*Drop-down list* Finland
	Region	*Drop-down list* Päijät-Häme
	City	*Drop-down list* Lahti
Keywords related to your practice	biomass, low-carbon, bioenergy	
Upload image		

2. Author contact information *[Technical: Contact information comes from your community profile. You can edit it by visiting your user dashboard]* *[Ideally, the owner of the good practice should fill in the form. Indeed, if you submit a good practice, your personal and organizational profile in the Interreg Europe community will be linked to it.]*	
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Telephone	*+358 469 232 738*
Your organisation	
Country	*Finland*
Region	*Päijät-Häme*

3. Detailed description	
Short summary of the practice	*[160 characters]* The biomass-fired heating facility from factory's own oat hull side streams.

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Detailed information on the practice	Reducing emissions is a direct means of reducing the climate impacts of food production, and renewable energy plays an important role in cutting emissions. The Finnish bakery and confectionery Karl Fazer Oy (Fazer) are participating actively in the work to curb climate change and is investing in sustainable food production. Fazer's sustainability approach consists of four ambitious core goals by 2030: 50 % fewer emissions, 50 % less food waste, to be 100 % sustainably sourced and more plant based. Fazer together with Lahti Energia Oy (the regional energy company) is building a biomass-fired heating facility located directly in Fazer's factory area in Lahti. The facility will replace the previous natural gas-based heating, which has been getting increasingly expensive as taxes are raised on fossil fuels. The facility is expected to be ready in autumn 2020. Produced bioenergy (heat and process steam) will be used by the Fazer mill, bakery and rye crisp production lines as well as the new xylitol production facility, for heating the facilities and can also be used for heating the rest of the city by feeding heat into the district heating network. The fuel for the new heating facility will be derived from the production sidestreams in the factory area, mainly from the oat hulls which will be leftover following the Xylitol production process. Stakeholders for such project are the energy company, the factory, district heating customers and grain markets.
Resources needed	*[300 characters] Please specify the amount of funding/financial resources used and/or the human resources required to set up and to run the practice.* Xylitol factory in total creates 30 new jobs.
Resources used	*Institutional / Structural EU funds (describe the program used) / Other* - *none*
Policy instrument used	*State the name of the policy instrument and briefly sum up its specifications.* - none
Total project costs (EUR)	8 000 000
Net present value of the investment (EUR)	Na
Internal rate of return on investment (%)	Na
Payback period (y)	NA
Lending rate (%)	NA
Timescale (start/end date)	February 2019 – expected to be ready in autumn 2020
Installed capacity (kW)	8000 kW
Fraction of renewable energy consumed (%)	The biomass boiler will produce all the heating of the facility and is 100 % renewable.
Investment costs per installed kW (EUR/kW)	1000
RES type used	biomass energy
Evidence of success (results achieved)	*Fazer's bioenergy-producing method supports the concept of a modern circular economy. Both the Xylitol and bio heating production processes are uniquely combined to use the raw material which, until now, has not been commercially utilised.*
Challenges encountered (optional)	Equipment deliveries were delayed due to quarantines imposed by COVID-19

Potential for learning or transfer	Similar industrial synergies could be utilized in other places with the grain-based food industry and a district heating network. The energy produced is not only renewable but also material that would otherwise go to waste.
Further information	https://www.lahtienergia.fi/fi/ajankohtaista/tiedotteet/lahti-energia-toimittaa-fazerille-uuden-energiantuotantolaitoksen

Please enter the value scaled from 1 – best, 2 – good, 3 – neutral, 4 – bad, 5 – worst:

Criteria	Description	Value
Energy efficiency	*Please rate the energy efficiency of the practice on the scale of 1 to 5.*	*1*
Financial efficiency	*Please rate the financial efficiency on the scale of 1 to 5.*	*2*
Environmental impact	*Were there any challenges connected to the e.g. visual impact of the practice?*	*3*
Political influence	*Does the project in any way influence the political situation in the surroundings of the installation?*	*2*
Social influence	*Is there any social influence on the industry or the local municipality?*	*1*
Replication possibility	*Please clarify how can this practice be replicated.*	*2*

For more information, please contact:
Taina Lampela-Helin, Manager, Communications, Fazer Group, taina.lampela-helin@fazer.com

5. GEOTHERMAL HEATING OF FACTORY USING HEAT PUMPS

1. General information			
Title of the practice	*Geothermal heating of factory using heat pumps*		
Does this practice come from an Interreg Europe Project	**No**		

Please select the project acronym	**RESINDUSTRY**

Specific objective	**Renewable energy sources used for industry**	
Main institution involved	LAB University of Applied Sciences	
Geographical scope of the practice	*Local*	
Location of the practice	Country	*Drop-down list Finland*
	Region	*Drop-down list Päijät-Häme*
	City	*Drop-down list Lahti*
Keywords related to your practice	*Select existing keywords or add* *Heat pump, energy efficiency, low-carbon*	
Upload image		

2. Author contact information *[Technical: Contact information comes from your community profile. You can edit it by visiting your user dashboard]* *[Ideally, the owner of the good practice should fill in the form. Indeed, if you submit a good practice, your personal and organisational profile in the Interreg Europe community will be linked to it.]*	
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Telephone	*+358 469 232 738*
Your organisation	
Country	*Finland*
Region	*Päijät-Häme*

3. Detailed description	
Short summary of the practice	*[160 characters]* The ground heat pump is used for heating the factory buildings.

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Detailed information on the practice	Halton Marine wants to stand at the forefront of combating climate change and the company had a goal that all its operations around the world will be carbon neutral by 2025. In Haltons factory in Lahti, heat pumps are used replaced the previous natural gas heating. Changing to heat pumps will save money as the price of natural gas keeps rising and also replace the aged cooling system at the same time. The geothermal heat pump system consists of 22 heat wells, 310 to 330 meters deep, drilled into the land surrounding the plant. The ground stays at a steady temperature all year round allowing for heat to be captured in winter and transferred by the heat pump into the heating system of the factory. During summertime, the same heat pumps are used for cooling. With the new heat pumps, the cooling capacity is increased enough that it can replace both the old process cooling and also cool the factory halls, thus improving working conditions. In addition to the new system, Halton Lahti has invested in other energy-saving measures and signed a contract to only buy renewable electricity.
Resources needed	The system is delivered by external turnkey solutions provider and requires no extra workforce for the company. System was paid directly by the company with no loans involved. Land needed for wells to be dug in.
Resources used	Business Finland energy aid program covered 15 % of the investment costs.
Policy instrument used	Business Finland energiatuki - energy aid that can be granted to energy efficiency, renewable energy or any other project that reduces carbon emissions.
Total project costs (EUR)	607 000
Net present value of the investment (EUR)	-
Internal rate of return on investment (%)	10-13 %
Payback period (y)	8-10 years
Lending rate (%)	- (0%)
Timescale (start/end date)	1/2020-11/2020
Installed capacity (kW)	. 345
Fraction of renewable energy consumed (%)	100 %
Investment costs per installed kW (EUR/kW)	1759,42 €/kW
RES type used	Ground heat
Evidence of success (results achieved)	1.8 – 2.5 M€ Lifetime savings estimated for the system by saving money on gas. 90% reduction in emissions from heating adding to 103 tons/CO2 per year. 35 % savings on heating energy Money saved on buying a new separate cooling system. Cooling workspaces improves productivity in summer.
Challenges encountered (optional)	A similar system was planned for another Halton factory in Kausala but wells could not be dug because of the risk of groundwater contamination. Must be built in the area with no groundwater.
Potential for learning or transfer	Heat pumps are good option for any country with low electricity prices and need for heating. However, they are not profitable if electricity is too expensive.
Further information	https://www.halton.com/fi_FI/marine/news/-/asset_publisher/0MPAlnpYu8cu/content/halton-plant-introduces-geothermal-solution-in-lahti?redirect=https%3A%2F%2Fwww.halton.com%2Ffi_FI%2Fmarine%2Fnews%3Fp_p_id%3D101_INSTANCE_0MPAlnpYu8cu%26p_p_lifecycle%3D0%26p_p_state%3Dnormal%26p_p_mode%3Dview%26p_p_col_id%3Dcolumn-1%26p_p_col_count%3D2

Please enter the value scaled from 1 – best, 2 – good, 3 – neutral, 4 – bad, 5 – worst:

Criteria	Description	Value
Energy efficiency	*Please rate the energy efficiency of the practice on the scale of 1 to 5.*	*2*
Financial efficiency	*Please rate the financial efficiency on the scale of 1 to 5.*	*3*
Environmental impact	*Were there any challenges connected to the e.g. visual impact of the practice?*	*1*
Political influence	*Does the project in any way influence the political situation in the surroundings of the installation?*	*3*
Social influence	*Is there any social influence on the industry or the local municipality?*	*3*
Replication possibility	*Please clarify how can this practice be replicated.* *Can be installed anywhere with heating demand and bedrock to drill into if there is no risk of ground water contamination.*	*5*

6. SOLAR POWER PLANTS INTEGRATED EFFICIENTLY WITH COMMERCIAL REAL ESTATE

1. General information	
Title of the practice	*Solar powerplants integrated efficiently with commercial real estate*
Does this practice come from an Interreg Europe Project	**No**

Please select the project acronym	**RESINDUSTRY**

Specific objective	**Renewable energy sources used for industry**	
Main institution involved	*Technical: The name of the institution and location of the practice are per default those of the practice author. They remain editable.]* LAB University of Applied Sciences	
Geographical scope of the practice	*Regional*	
Location of the practice	Country	*Drop-down list Finland*
	Region	*Drop-down list Päijät-Häme*
	City	*Drop-down list*
Keywords related to your practice	*Select existing keywords or add solar energy, renewable energy, low carbon*	
Upload image		

2. Author contact information *[Technical: Contact information comes from your community profile. You can edit it by visiting your user dashboard] [Ideally, the owner of the good practice should fill in the form. Indeed, if you submit a good practice, your personal and organisational profile in the Interreg Europe community will be linked to it.]*	
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Telephone	*+358 469 232 738*
Your organisation	
Country	*Finland*
Region	*Päijät-Häme*

3. Detailed description	
Short summary of the practice	*[160 characters]* Solar power production integrated into various commercial properties.

Detailed information on the practice	Systems were contracted from Lahti Energia, a local power company. The motivation for adopting solar power was the desire to take part in the common good and appeal to customers as well as financial as the company estimated they would gain significant savings. The panels directly feed into the power system of the store which uses nearly all of the energy consumed with only small amounts sold into the grid, allowing for higher efficiency as grid losses are negated. For grocery stores, solar power is advantageous as the peak production and peak load are at the same time. Power production peaks are midday in summer when the weather is hottest which is simultaneously the peak load for grocery stores as hot weather drives up cooling demand. Also, unlike residential buildings which consume more energy in the evening as people come home from work, grocery stores mostly consume energy during the day thus getting maximum use out of solar energy. Additionally, the same corporate group that runs the properties owns a share of wind farms, which supply 65 % of the electricity purchased from the grid giving an even higher fraction of renewables used.
Resources needed	The system was delivered by an external energy company that also is contracted for monitoring and upkeep. The instalments only took few weeks per building and required approximately 5 people. The system is almost maintenance-free and doesn't employ any people full time to run it.
Resources used	Business Finland energy investment aid covered 20 % of project costs as a part of a commercial energy efficiency agreement.
Policy instrument used	Business Finland energiatuki - Energy aid that can be granted to energy efficiency, renewable energy or any other project that reduces carbon emissions.
Total project costs (EUR)	5 000 000
Net present value of the investment (EUR)	NA
Internal rate of return on investment (%)	12,5
Payback period (y)	8
Lending rate (%)	NA
Timescale (start/end date)	5/2016- On going
Installed capacity (kW)	6,2 MW
Fraction of renewable energy consumed (%)	70,25 %
Investment costs per installed kW (EUR/kW)	800
RES type used	solar power
Evidence of success (results achieved)	CO_2 emissions reduced by 540 tons- New panels cover 15 % of the energy consumed by the stores. 3780 MWh of production per year.
Challenges encountered (optional)	Hämeenmaan Kiinteistöt is starting to run out of roof space to put the panels in at the current time. Experiments with using solar thermal failed as the time when heating is required is also the time when solar heating is least effective and vice versa, leading to the use of solar power instead. Recommendation for systems to be as simplified as possible after a redundant loose switch caused a fire at one store.
Potential for learning or transfer	Installation of a system like this is very fast only 1-3 weeks and should be very easy to copy. As the energy is mostly used up in cooling and the usefulness of solar panels goes up in warmer countries, the potential to use practice like this is even greater the further south one goes.
Further information	https://www.sttinfo.fi/tiedote/hameenmaalle-13-aurinkovoimalaa-yhteistyossa-lahti-energian-kanssa?publisherId=68574224&releaseId=69859702

Please enter the value scaled from 1 – best, 2 – good, 3 – neutral, 4 – bad, 5 – worst:

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Criteria	Description	Value
Energy efficiency	*Please rate the energy efficiency of the practice on the scale of 1 to 5.*	*1*
Financial efficiency	*Please rate the financial efficiency on the scale of 1 to 5.*	*2*
Environmental impact	*Were there any challenges connected to the e.g. visual impact of the practice?*	*1*
Political influence	*Does the project in any way influence the political situation in the surroundings of the installation?*	*3*
Social influence	*Is there any social influence on the industry or the local municipality?*	*2*
Replication possibility	*Please clarify how can this practice be replicated.*	*1*

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7. UTILIZATION OF BIOWASTE STREAMS - BIO-BASED INDUSTRIAL SYMBIOSIS AS RES

1. General information	
Title of the practice	**Utilization of biowaste streams - bio-based industrial symbiosis as RES**
Does this practice come from an Interreg Europe Project	**No**

Please select the project acronym	**RESINDUSTRY**

Specific objective	**Renewable energy sources used for industry**	
Main institution involved	*Technical: The name of the institution and location of the practice are per default those of the practice author. They remain editable.]* LAB University of Applied Sciences	
Geographical scope of the practice	*Select National/Regional/Local* regional	
Location of the practice	Country	*Drop-down list* Finland
	Region	*Drop-down list* Päijät-Häme
	City	*Drop-down list* Lahti
Keywords related to your practice	*Select existing keywords or add* climate change, roadmap, greenhouse gas emissions, strategy, heat pump	
Upload image		

2. Author contact information	
[Technical: Contact information comes from your community profile. You can edit it by visiting your user dashboard] [Ideally, the owner of the good practice should fill in the form. Indeed, if you submit a good practice, your personal and organizational profile in the Interreg Europe community will be linked to it.]	
Name	*Paavo Lähteenaro*
Email	*paavo.lahteenaro@lab.fi*
Telephone	*+358 469 232 738*
Your organisation	
Country	Finland
Region	Päijät-Häme

3. Detailed description	
Short summary of the practice	Heating the production of biogas and fertilizer from biowaste streams and wastewater sludge with heat pumps and composting waste heat.

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Detailed information on the practice	*[1500 characters] Please provide information on the practice itself. In particular:* *1. What is the problem addressed and the context which triggered the introduction of the practice?* *2. Please briefly technically describe the practice. Also, state the motivation of the owner for the installation and the decision process.* *3. How does the practice reach its objectives and how it is implemented?* *4. Who are the main stakeholders and beneficiaries of the practice?* The amount of biowaste is growing. Previously it was landfilled causing difficulties with methane gas creation under anaerobic conditions, odour and most of all, landfilling contributed to a valuable resource and energy loss. LABIO Ltd biogas and the composting plant is a joint venture owned by Päijät-Häme Waste Management Ltd and the public water service provider Lahti Aqua Ltd. It produces biogas and fertilizer from industrial and municipal biowaste, wastewater sludge and biodegradable material from farming, forestry and fisheries. LABIO Ltd, the largest biogas production and refining plant in Finland is part of the industrial symbiosis in Kujala Waste Treatment Centre in Lahti. Biogas generated in the dry digesters is transported through the pipes to the nearby operator for upgrading and distribution in the gas grid. The digestate is processed with other biowaste in the composting facility to produce compost, soil and other growing solutions used in agriculture, cultivation and gardening. Heat energy from the composting process is captured from outgoing hot air using three 750 kW heat pumps and used to heat the biogas facility and the biogas reactors by means of heating water pipes. Stakeholders: Facilities and industry producing organic waste, biogas traffic, renewable fertilizer users and citizens are all stakeholders.
Resources needed	*[300 characters] Please specify the amount of funding/financial resources used and/or the human resources required to set up and to run the practice.* The plant was financed through public companies Päijät-Häme Waste Management Ltd, Gasum and Lahti Aqua Ltd with total investments of 17 M€. The investment in the plant was made based on the owners' waste treatment needs and to follow public strategy. The number of employees in the year 2020 was 14.
Resources used	*Institutional / Structural EU funds (describe the program used) / Other* Business Finland energy aid was given to the project covering 28 % of investment costs.
Policy instrument used	*State the name of the policy instrument and briefly sum up its specifications.* Business Finland energiatuki - energy aid that can be granted to energy efficiency, renewable energy or any other project that reduces carbon emissions.
Total project costs (EUR)	17 000 000
Net present value of the investment (EUR)	NA
Internal rate of return on investment (%)	4
Payback period (y)	25
Lending rate (%)	NA
Timescale (start/end date)	1/2010 – 10/2014
Installed capacity (kW)	7875
Fraction of renewable energy consumed (%)	*NA*
Investment costs per installed kW (EUR/kW)	*Review the total investment costs per installed kW of renewable energy source in euros per kW.*

	2158,73
RES type used	biomass energy
Evidence of success (results achieved)	*[500 characters] Why is this practice considered as good? Please provide factual evidence that demonstrates its success or failure (e.g. measurable outputs/results).* LABIO Ltd is an independent company financing all costs through selling waste treatment services and biogas. The turnover in 2017 was 5,8 M€ consisting of gate fees 4,8 M€ and biogas income 1 M€. The operating profit was 0,6 M€. Landfilling of biowaste has finished and combustion decreased significantly. Odour emissions and greenhouse gas emissions are considerably lower. At the same time, renewable energy is produced the nutrients utilized. Also, the plant has not had a single day out of operation in 15 years.
Challenges encountered (optional)	*[300 characters] Please specify any challenges encountered/lessons learned during the implementation of the practice.* The plant was not delivered as a turnkey solution but rather as a constant negotiation between the manufacturer and the company, allowing problems to be solved as it was implemented. This they consider the only reasonable way to make such a plant. The construction process involved 10 different nationalities causing communication issues.
Potential for learning or transfer	*Biogas production helps to decrease the greenhouse gas emissions, and it does not cause any fine particulate emissions. The odour emissions are <500 ou/m3. The carbon footprint of the production chain is 11 000 tons CO2e/a negative (biogas compensation and nitrogen and phosphoric compensation taken into account). The carbon footprint of the nitrogen fertilizer is 300-500% lower than of mineral fertilizers.* *The plant is almost exactly the same as another plant built in Austria by the same manufacturer showing the potential to copy such system across borders.* *An advantage worth pointing out is the 4 separate reactors for biogas making, while 3 are usually enough to cover production. This allows for nonstop operation as one can always be worked on without interrupting production.* *Originally, LABIO Ltd served only to the needs of the Päijät-Häme region, but now it is also offering services for the whole Southern Finland due to increased competition between the growing number of biogas facilities. Too much subsidization of biogas can lead to competition for resources which can lead to a skewed market.*
Further information	*http://www.labio.fi/en/*

Please enter the value scaled from 1 – best, 2 – good, 3 – neutral, 4 – bad, 5 – worst:

Criteria	Description	Value
Energy efficiency	*Please rate the energy efficiency of the practice on the scale of 1 to 5.*	*1*
Financial efficiency	*Please rate the financial efficiency on the scale of 1 to 5.*	*3*
Environmental impact	*Were there any challenges connected to the e.g. visual impact of the practice?*	*1*
Political influence	*Does the project in any way influence the political situation in the surroundings of the installation?*	*3*
Social influence	*Is there any social influence on the industry or the local municipality?*	*1*
Replication possibility	*Please clarify how can this practice be replicated.*	*1*

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8. DISTRICT HEATING PRODUCTION FROM RENEWABLE SOURCES

1. General information	
Title of the practice	**District heating production from renewable sources**
Does this practice come from an Interreg Europe Project	**No**

Please select the project acronym	**RESINDUSTRY**

Specific objective	**Renewable energy sources used for industry**	
Main institution involved	LAB University of Applied Sciences	
Geographical scope of the practice	*Select National/Regional/Local* regional	
Location of the practice	Country	*Drop-down list* Finland
	Region	*Drop-down list* Päijät-Häme
	City	*Drop-down list* Lahti
Keywords related to your practice	*Select existing keywords or add* climate change, bioenergy, carbon neutrality, heat production	
Upload image		

2. Author contact information *[Technical: Contact information comes from your community profile. You can edit it by visiting your user dashboard]* *[Ideally, the owner of the good practice should fill in the form. Indeed, if you submit a good practice, your personal and organizational profile in the Interreg Europe community will be linked to it.]*	
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Email	*paavo.lahteenaro@lab.fi*
Telephone	*+358 469 232 738*
Your organisation	
Country	*Finland*
Region	*Päijät-Häme*

3. Detailed description	
Short summary of the practice	*[160 characters* Lahti Energia replaces its old coal power plant with a new biomass burning heat plant freeing the company entirely from coal use.

Detailed information on the practice	*[1500 characters] Please provide information on the practice itself. In particular:* *9. What is the problem addressed and the context which triggered the introduction of the practice?* *10. Please briefly technically describe the practice. Also state the motivation of the owner for the installation and the decision process.* *11. How does the practice reach its objectives and how it is implemented?* *12. Who are the main stakeholders and beneficiaries of the practice?* The motivation for the plant was the plan of the city of Lahti to reduce its carbon emission and to abandon coal for energy production. The price of coal has continued to rise due to the rise of taxes on fossil fuels and the cost of emissions allowances too. New bio-heating plant with the main fuel of certified PEFC or FSC-certified, wood-based biofuel meaning the wood used is lumber industry waste consisting of forestry residues and waste from sawmills. The plant will be built as a high-pressure steam boiler with the possibility of adding a turbine for electricity production if the price of electricity rises. The power plant is also equipped with a heat recovery system, which increases the efficiency of the plant. The system can recover about 30-45 megawatts of thermal energy from the flue gases. The resulting condensates are also highly purified and used in the boiler and as district heating water making the plant water independent and fly ash captured by the scrubber is recycled back into the forests as fertilizer. Stakeholders for such plant are biomass producers, renewable fertilizer users, district heat users.
Resources needed	*[300 characters] Please specify the amount of funding/financial resources used and/or the human resources required to set up and to run the practice.* The total investment of renewable energy plant is 180 million EUR. The employment effect of the project is approximately 1,000 man-years and the plant's domesticity is approximately 40%. The institution employs around 100 people directly or indirectly.
Resources used	*Institutional / Structural EU funds (describe the program used) / Other* The flue gas scrubber condensate purification process has been selected as one of the supported energy spearhead projects by the Finnish Ministry of Employment and the Economy. The scrubber has received energy aid money from Business Finland, a government funding agency.
Policy instrument used	Business Finland energiatuki - energy aid that can be granted to energy efficiency, renewable energy or any other project that reduces carbon emissions.
Total project costs (EUR)	The total investment of renewable energy plant is 180 million EUR
Net present value of the investment (EUR)	NA
Internal rate of return on investment (%)	NA
Payback period (y)	NA
Lending rate (%)	NA
Timescale (start/end date)	01/2018 – 1/2020
Installed capacity (kW)	190 000 kW
Fraction of renewable energy consumed (%)	New facility. The energy produced is 100 % renewable.
Investment costs per installed kW (EUR/kW)	947,37

RES type used	biomass energy
Evidence of success (results achieved)	Kymijärvi III will allow total replacement of coal in energy use in the city of Lahti while at the same time fulfilling the City of Lahti goals for reduction of greenhouse gas emissions. CO2 emissions reduced by 600 tons/year.
Challenges encountered (optional)	No problems with the technology used came up as it is mostly conventional and well tested in other similar plants. Only regular project management issues of large building projects were encountered.
Potential for learning or transfer	Kymijärvi III is evidence of how coal can be replaced by biomass in large plants. Any country with forest industry will have forest biomass that is unsuitable for lumber or pulp production, but which can be utilized as energy biomass. As such, Kymijärvi III is an example of what can be done with what could otherwise go to waste.
Further information	https://www.lahtienergia.fi/fi/lahti-energia/energian-tuotanto/kymijarvi-iii

Please enter the value scaled from 1 – best, 2 – good, 3 – neutral, 4 – bad, 5 – worst:

Criteria	Description	Value
Energy efficiency	*Please rate the energy efficiency of the practice on the scale of 1 to 5.*	*1*
Financial efficiency	*Please rate the financial efficiency on the scale of 1 to 5.*	*2*
Environmental impact	*Were there any challenges connected to the e.g. visual impact of the practice?*	*1*
Political influence	*Does the project in any way influence the political situation in the surroundings of the installation?*	*2*
Social influence	*Is there any social influence on the industry or the local municipality?*	*1*
Replication possibility	*Please clarify how can this practice be replicated.*	*1*

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9. BIOGAS FROM WASTEWATER SLUDGE AS REPLACEMENT FOR FOSSIL SUPPORT FUELS IN BIOMASS BURNING

1. General information	
Title of the practice	*Biogas from wastewater treatment as replacement for fossil support fuels in biomass burning*
Does this practice come from an Interreg Europe Project	**no**

Please select the project acronym	**RESINDUSTRY**

Specific objective	**Renewable energy sources used for industry**	
Main institution involved	*Technical: The name of the institution and location of the practice are per default those of the practice author. They remain editable.]* LAB University of Applied Sciences	
Geographical scope of the practice	*Local*	
Location of the practice	Country	*Finland*
	Region	*Päijät-Häme*
	City	*Heinola*
Keywords related to your practice	*Renewable energy, biogas, waste water treatment, COD, paper, pulp*	
Upload image		

2. Author contact information	
[Technical: Contact information comes from your community profile. You can edit it by visiting your user dashboard] [Ideally, the owner of the good practice should fill in the form. Indeed, if you submit a good practice, your personal and organisational profile in the Interreg Europe community will be linked to it.]	
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Email	*paavo.lahteenaro@lab.fi*
Telephone	*+358 469 232 738*
Your organisation	
Country	*Finland*
Region	*Päijät-Häme*

3. Detailed description	
Short summary of the practice	

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	Biogas is produced from wastewater sludge and is burned in the pulp mills waste biomass boiler to power the plant. Biogas as support fuel replaces fossil fuels. COD (chemical oxygen demand, mainly carbon) of wastewater can be seen as a resource for biogas production. If anaerobic reactor is installed in front of traditional activated sludge process, up to 80% of the COD can be turned to biomethane. That also generates huge savings when treating the rest 20 % in the aerobic process. Chemicals and aeration energy will be saved.
Detailed information on the practice	*What is the problem addressed and the context which triggered the introduction of the practice?* Wastewater treatment process (WWTP) is very expensive (chemicals and energy), and it also finally generates wet bio sludge that is a new problem. COD (carbon) of the wastewater is lost. Normally, WWTP only generates costs. Also, pulp mills burn their waste biomass, such as bark in bark boilers to produce electricity and heat for the plant's own use. To burn low quality biomass like bark, high-quality support fuel is needed which is usually fossil fuel. Producing biogas from wastewater sludge reduces the need for expensive wastewater processing and the resulting gas can be burned immediately in the bark boiler where it can replace fossil fuels. *Please briefly technically describe the practice. Also state the motivation of the owner for the installation and the decision process.* There is an anaerobic bacterial granular based process that is capable of generating biomethane directly from wastewater. Wastewaters can be characterized to evaluate which streams can be collected to such reactor. The reactor and granules inside can cut up to 80 % COD and turn that to biomethane. Granular bacteria are valuable and have a positive value (compared to wet bio sludge waste from the aerobic process). Idea is to put the anaerobic process in front of regular wastewater treatment, leaving less COD to treat, that means less chemical, energy and sludge treatment cost. *How does the practice reach its objectives and how it is implemented?* The process has worked well and is easy to operate. There are no rotating parts inside the reactor, so the maintenance costs are low. Biogas can be used as biofuel. Chemical and especially energy savings from aerobic activated sludge has been bigger than estimated. *Who are the main stakeholders and beneficiaries of the practice?* Company / City / State responsible for wastewater treatment.
Resources needed	Cost of the reactor, of course, depends the size needed, so the amount of wastewater treated. The total cost of the project consisting

	25 000 kg COD/d capacity reactor was roughly 5 M€. The system is largely maintenance-free requiring some monitoring.
Resources used	*Institutional / Structural EU funds (describe the program used) / Other* Aid from the Ministry of Industry providing 30 % of project costs, totalling 647 550 €. ENERGIATUKI INVESTOINTIHANKKEESEEN Työ- ja elinkeinoministeriö myöntää Teille energiatuen myöntämisen yleisistä ehdoista annetun valtioneuvoston asetuksen (1063/2012) nojalla energiatukea seuraavasti: Tuettava hanke: Biokaasun tuottaminen Investoinnin tarkoituksena on uusiutuvan energian tuotanto. Hanke sisältää uutta teknologiaa, minkä johdosta energiatuki on myönnetty valtioneuvoston asetuksen 1063/2012 7 § 2 mom perusteella (maksimituki 40 %). Tuen piiriin hyväksyttävät kustannukset (ilman arvonlisäveroa): Rakennukset 524 000 € Koneet ja laitteet 3 479 000 € Muut kustannukset 314 000 € Yhteensä 4 317 000 € Myönnetty energiatuki 647 550 €
Policy instrument used	Business Finland energiatuki - energy aid that can be granted to energy efficiency, renewable energy or any other project that reduces carbon emissions.
Total project costs (EUR)	4,5 M€
Net present value of the investment (EUR)	6,2 M€
Internal rate of return on investment (%)	30,5
Payback period (y)	5,8
Lending rate (%)	NA
Timescale (start/end date)	April 2015 – June 2016
Installed capacity (kW)	The capacity of the reactor is 25 000 kg COD/d (that much has not yet been available). Biogas produced: 2017 4387 MWh, 2018, 5289 MWh, 2019 4840 MWh. with typical pulp mill annual run time of 8000 h/a that gives average thermal power of 600 kW.
Fraction of renewable energy consumed (%)	*Solar fraction or amount of renewable energy used within the facility over the total energy consumption before the installation of the renewable energy source during the year in percentage. The denominator consists of actual energy consumption plus amount of renewable energy used.* $FR_{RES} = \frac{E_{RES\,USED}}{E_{CONS} + E_{RES_{USED}}}$ NA
Investment costs per installed kW (EUR/kW)	*Review the total investment costs per installed kW of renewable energy source in euros per kW.* 8333 €/kW (however, the system also grants energy and other savings for wastewater treatment)
RES type used	Biomass energy

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Evidence of success (results achieved)	[500 characters] Why is this practice considered as good? Please provide factual evidence that demonstrates its success or failure (e.g. measurable outputs/results). Biogas produced: 2017 4387 MWh, 2018, 5289 MWh, 2019 4840 MWh Wastewater treatment energy use is reduced by 35 % and the total use of fossil fuels by the plant is reduced by 5 %.
Challenges encountered (optional)	*[300 characters] Please specify any challenges encountered/lessons learned during the implementation of the practice.* *NA*
Potential for learning or transfer	The system can be used in any pulp mill or pulp and paper to increase the use of renewables and replace fossil fuels. The system is considered novel in Finland, so there is much potential to apply the same system to other plants. A similar system has already been implemented in some other Stora Enso's plants in Central Europe. COD from wastewater is a resource we should not forget. It has been seen only as a cost before. Biogas is a renewable fuel. By traditional activated sludge process, a lot of chemicals is needed, also electricity and especially wet wastewater sludge problem are globally getting bad. This can be one part of the solution.
Further information	Reactor suppliers, like Paques, Econvert, Veolia etc. https://www.econvert.nl/econvert-products

Please enter the value scaled from 1 – best, 2 – good, 3 – neutral, 4 – bad, 5 – worst:

Criteria	Description	Value
Energy efficiency	*Please rate the energy efficiency of the practice on the scale of 1 to 5.*	*1*
Financial efficiency	*Please rate the financial efficiency on the scale of 1 to 5.*	*1*
Environmental impact	*Were there any challenges connected to the e.g. visual impact of the practice?*	*1*
Political influence	*Does the project in any way influence the political situation in the surroundings of the installation?*	*3*
Social influence	*Is there any social influence on the industry or the local municipality?*	*2*
Replication possibility	*Please clarify how can this practice be replicated.*	*1*

10. BIOMASS BOILER FOR EFFICIENT DRYING PROCESS

1. General information	
Title of the practice	*Biomass boiler for efficient drying process*
Does this practice come from an Interreg Europe Project	**no**

Please select the project acronym	**RESINDUSTRY**

Specific objective	**Renewable energy sources used for industry**	
Main institution involved	*Technical: The name of the institution and location of the practice are per default those of the practice author. They remain editable.]* LAB University of Applied Sciences	
Geographical scope of the practice	*Local*	
Location of the practice	Country	*Drop-down list Finland*
	Region	*Drop-down list Päijät-Häme*
	City	*Drop-down list Lahti*
Keywords related to your practice	*Select existing keywords or add* *Biomass, food production, renewable energy, climate change*	
Upload image		

2. Author contact information *[Technical: Contact information comes from your community profile. You can edit it by visiting your user dashboard]* *[Ideally, the owner of the good practice should fill in the form. Indeed, if you submit a good practice, your personal and organisational profile in the Interreg Europe community will be linked to it.]*	
Name	*Paavo Lähteenaro*
Email	*paavo.lahteenaro@lab.fi*
Telephone	*+358 469 232 738*
Your organisation	
Country	*Finland*
Region	*Päijät-Häme*

3. Detailed description	
Short summary of the practice	Biomass boiler provides heat and steam for malt making

Detailed information on the practice	Increasing costs of natural gas lead to a need for replacing the older heating system. The natural gas heating system was replaced with a biomass burning steam boiler capable of burning wood chips and agro biomass. The boiler is fitted with a flue gas scrubber with heat recovery. Recovered heat from flue gas scrubber is used to preheat local district heating systems water. The heating plant was built by Lahti Energia, a local energy company, which provides the plant as a paid service type contract. The boiler provides heating and steam for the malt making process as well as heating the buildings of the factory and can also be used to heat district heating water in times of high heat demand such as very cold winter days.
Resources needed	*[300 characters] Please specify the amount of funding/financial resources used and/or the human resources required to set up and to run the practice.* Running the heating boiler is done remotely and doesn't employ any workers full-time.
Resources used	Business Finland energy aid was given to the project covering 15 % of project costs.
Policy instrument used	Business Finland energiatuki - energy aid that can be granted to energy efficiency, renewable energy or any other project that reduces carbon emissions. Money is granted a percentage of project costs depending on a project type and novelty of the technology.
Total project costs (EUR)	9 000 000
Net present value of the investment (EUR)	NA
Internal rate of return on investment (%)	NA
Payback period (y)	NA
Lending rate (%)	NA
Timescale (start/end date)	11/2014-2/2016
Installed capacity (kW)	12 000
Fraction of renewable energy consumed (%)	Biomass boiler covers 90 – 95 % of the heat demand of the Malt factory with a backup natural gas boiler covering for maintenance and other downtime.
Investment costs per installed kW (EUR/kW)	750
RES type used	biomass energy
Evidence of success (results achieved)	+90% reduction in fossil fuel use.
Challenges encountered (optional)	The technology used is very conventional, so no new challenges were encountered.
Potential for learning or transfer	This technology could be used for process heat in most food industry facilities if a supply of biomass is available. It is a fine example of easily replacing natural gas burning with renewable energy.
Further information	*Link to where further information on the good practice can be found*

Please enter the value scaled from 1 – best, 2 – good, 3 – neutral, 4 – bad, 5 – worst:

Criteria	Description	Value
Energy efficiency	*Please rate the energy efficiency of the practice on the scale of 1 to 5.*	*2*
Financial efficiency	*Please rate the financial efficiency on the scale of 1 to 5.*	*2*
Environmental impact	*Were there any challenges connected to the e.g. visual impact of the practice?*	*1*
Political influence	*Does the project in any way influence the political situation in the surroundings of the installation?*	*3*
Social influence	*Is there any social influence on the industry or the local municipality?*	*3*
Replication possibility	*Please clarify how can this practice be replicated.*	*1*

11. GOOD PRACTICE FROM POLICY LEARNING PLATFORM KUITTILA FARM

Good practice:
Energy self-sufficient Kuittila farm

Print Following

Kuittila farm has been almost energy self-sufficient since 2012 when the farm invested in a small CHP plant that generates electricity and heat from wood.

The farmer was interested in decreasing energy costs and producing own energy for the farm and a repair workshop located on the site. The farm has a dairy herd of 150 cows. The annual electricity consumption of the cow shed, repair shop, grain dryer, main building and wood chip dryer is c. 340,000 kWh and heat consumption c. 700,000 kWh.

In 2012, the farmer invested in a CHP (combined heat and power) system manufactured by Finnish Volter Ltd. The solution is unique because it produces electricity and heat by gasification of wood. The 140 kW CHP plant generates c.150 MWh of electricity and 375 MWh of heat a year. It consumes 700 m3 (loose volume) of wood chips per year. The farm has a 1,000 m3 storage facility and the wood chips are mechanically dried by using the waste heat of the plant. Wood chips with a moisture content of less than 18% are burned to process gas and converted into electricity and heat in an internal combustion engine. Wood chips are preheated before gasification in pyrolysis area.

Gasification temperature is 900-1,200 C. Gas is cooled from 550 to 200 C filter temperature. Fine soot is filtered, after which gas is cooled to 50 C, and ready for combustion. Combustion engine runs the generator, producing high-quality electricity for the farm. Excess electricity is sold to the national grid. Th e heat from the gas and engine cooling is utilised in the farm's micro-scale heating network.

Project	AgroRES
Main institution	Kuittila farm
Location	Pohjois- ja Itä-Suomi, Finland (Suomi)
Start Date	October 2012
End Date	Ongoing

Further information

Contact

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+358 50 441 6731
More contact details

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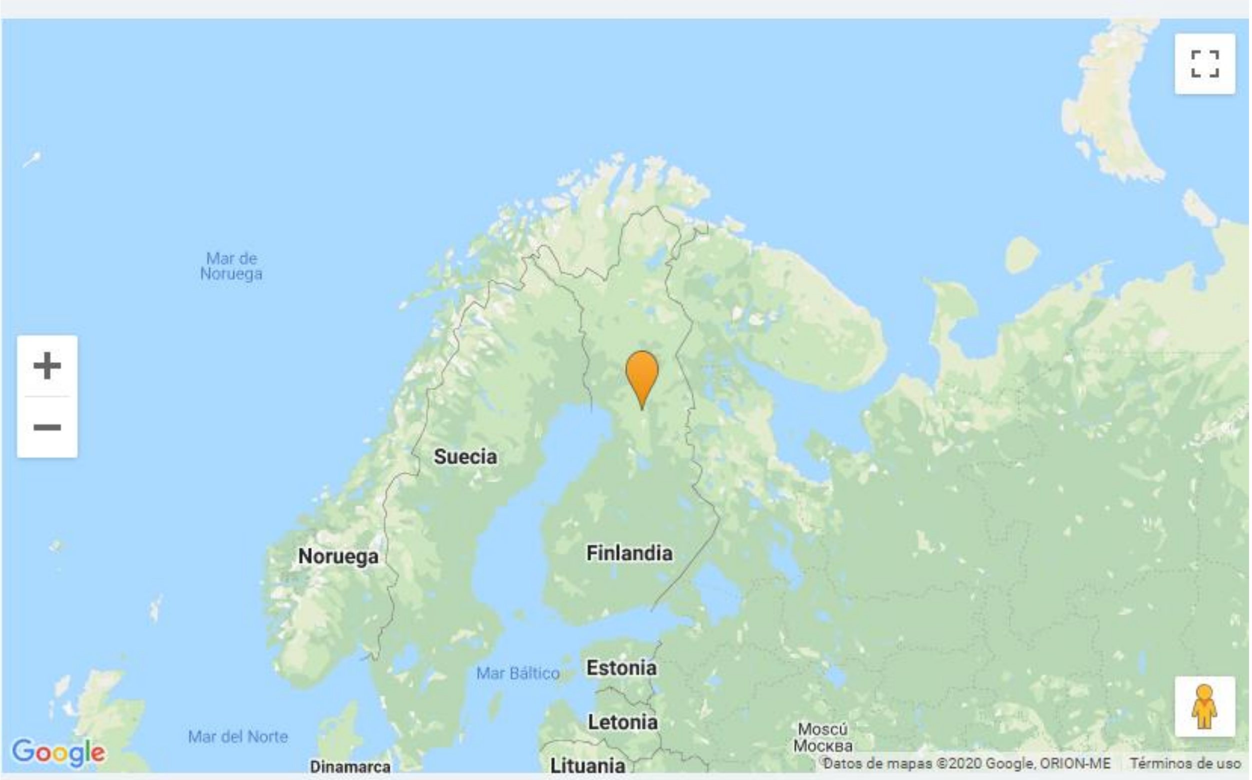
RESINDUSTRY Interreg Europe

European Union European Regional Development Fund



Resources needed

The total cost of the plant was c. 350,000 €: CHP unit and buildings cost around 220,000 €. The estimated payback period is 10 years. The farm received support for planning and implementation of the investment from an EAFRD project and 35% of investment support from ELY centre.

Evidence of success

The plant has been operating for several years and it has attained significant status as a small-scale CHP demonstration site in the region, both nationally and internationally. The small-scale CHP technology is innovative as it uses wood chips to generate heat and electricity.

Thanks to the investment, the farm is now almost energy self-sufficient. They need to buy fuels for machines.

Difficulties encountered

Fuel quality was a challenge at the beginning, but it was improved and controlled with the supplier of the CHP system.

Cost efficiency of the system depends much on the heat demand, and thus on the weather conditions.

Potential for learning or transfer

The energy system improves security of energy supply in farms and reduces the risks associated with climatic and weather conditions. In addition, the investment leads to significant carbon emission reductions and creates a positive image for the entrepreneur.

The practice would be potentially interesting for regions that have good forest resources. The Kuittila farm harvests its biomass mainly from local forests (thinning). The harvesting of small-sized wood improves the forest growth and provides high-quality fuel. The high quality pre-dried fuel, together with advanced combustion technology ensure low emissions and reduces harmful environmental and health impacts. The resulting ash can be used as forest fertiliser.

The CHP plant has opened additional business opportunities for the farm. The excess heat can be utilised in drying of forest fuel, in other farming activities or, for example, in hydronic underfloor heating, preheating of air-conditioning or domestic water.

Expert opinion

Simon Hunkin

Bioenergy is a truly local energy resource, with technologies able to make use of locally available resources, including wastes. This practice is especially promising because of its use of a CHP plant, where many single farms instead install heat only systems – especially those of small scale – as boilers are cheaper than CHP plants, and as there is also a need to find a use for the electricity which brings some additional complexity and costs. Transferability will depend on regional factors (biomass availability, regulatory framework, availability of financial support), but should certainly be encouraged. An excellent example of decentralised energy production.

Tags: Agriculture, Energy, Forest, Renewables

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Low-carbon economy

12. GOOD PRACTICE FROM POLICY LEARNING PLATFORM ALAVA FARM

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Alava dairy farm is among the first farms in North Karelia, Finland, to generate electricity for the farm's needs by photovoltaic solar panels. Alava farm in the municipality of Kitee, North Karelia, Finland, is a dairy farm that was established in 1675. The farm milks around 60 cows and requires a lot of electricity for its daily activities. The annual electricity consumption of the farm is about 120,000 kWh. The largest share of electricity is needed for ventilation fans, milk machines and cooling of milk.

To decrease electricity bills, the owner invested in a solar photovoltaic (PV) system that covers one fourth of the farm's electricity needs (30,000 kWh). The investment was made in 2014 and the farm opted for a 33 kW photovoltaic system that, at the time, was the largest photovoltaic power plant in North Karelia. Photovoltaic panels were installed on a roof of a south-facing cowshed. The building was ideal for this purpose as it is surrounded by open fields and there are no trees around it to shade the PV panels.

The farm received renewable energy investment aid (EAFRD) for the investment through the Rural Development Programme for Mainland Finland 2014-2020.

The farm has also installed a geothermal heating system to replace oil heating and LED lighting solutions to further decrease its energy bills. The profitability of the farm has increased due to these investments. Moreover, the PV system and other measures have reduced the CO_2 emissions produced by the farm.

Project	AgroRES
Main institution	Alava dairy farm
Location	Pohjois- ja Itä-Suomi, Finland (Suomi)
Start Date	January 2014
End Date	Ongoing

Further information

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Resources needed

The solar panel investment cost around 45,000 €. The farm received investment support from the Rural Development Programme for Mainland Finland 2014-2020. The support rate was 30 %.

Evidence of success

The solar PV system has decreased the farm's electricity bills by one-fourth. This has affected the farm's profitability. At the same time, the investment has reduced the farm's CO2 emissions by approximately 4,750 kg per year.

The farm owner has been very pleased with the solar panel system. It is easy to maintain and use, it did not require building permits, the investment cost was fairly low and the estimated payback period is around 9 years.

Difficulties encountered

If the system momentarily produces more electricity than is needed on the farm, the surplus can be fed into the national electricity grid. However, the compensation paid for the surplus electricity is very low.

Potential for learning or transfer

PV systems are suitable for farms due to their long lifespan. In addition, they do not cause emissions or noise, they are easy to use and the need for maintenance is very low.

Solar electricity systems can be applied to a wide range of applications on farms, such as irrigation, cooling, air conditioning, water heating or generating electricity for farm buildings. And as this example shows, the technology is suitable even for farms located in the northern part of Europe.

The costs of PV systems have declined over time, making them even more attractive and accessible options for farms that have high energy needs.

Expert opinion

Simon Hunkin

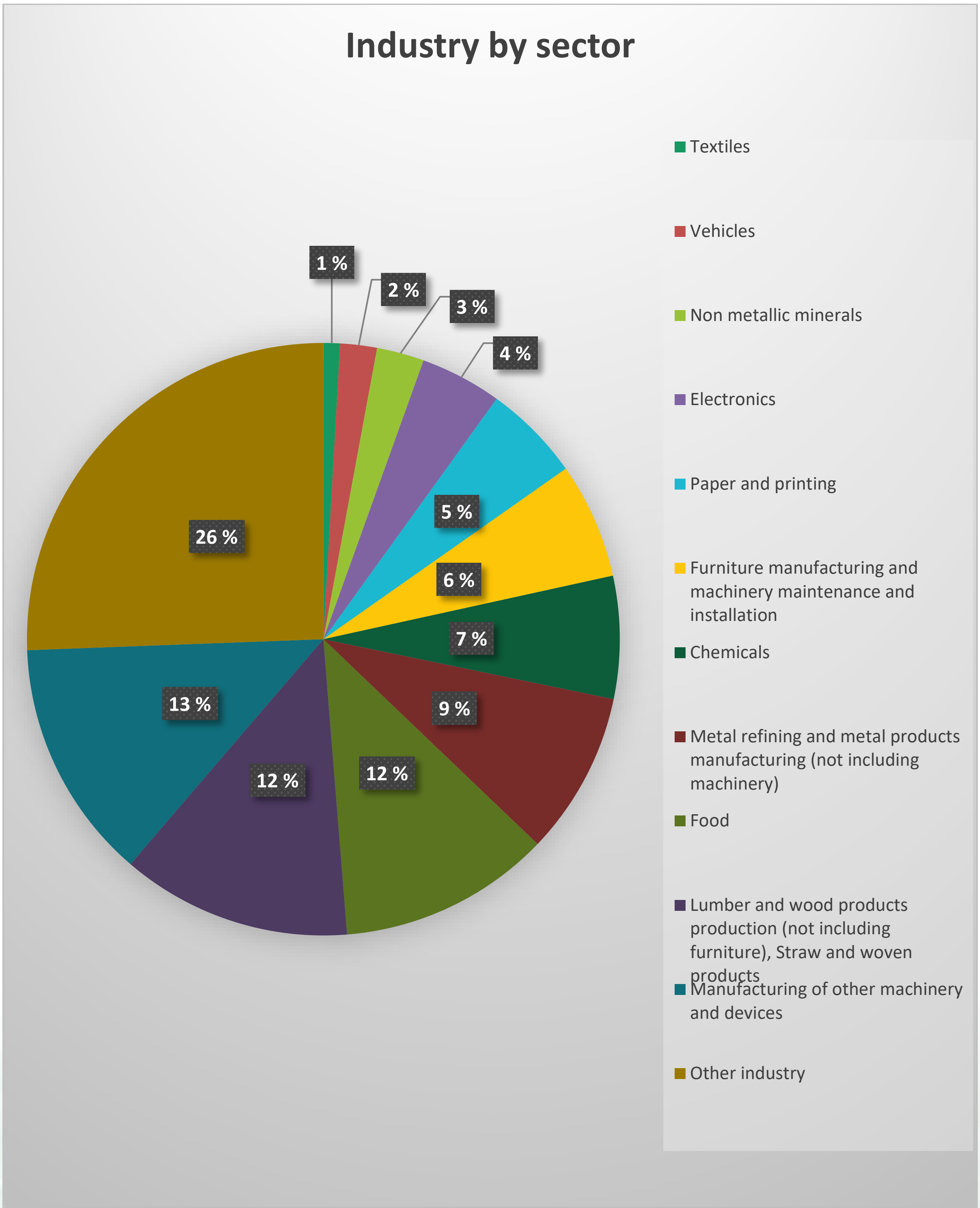
More and more farms are recognising that they can make use of their lands and buildings for renewable energy generation, bringing down farm operational costs. This is a good example of using European Funds to support uptake of decentralised energy generation, in this case, the European Agricultural Fund for Rural Development (EAFRD) which can fund farm diversification activities and uptake of renewables. Even a relatively low rate of 30% coverage can trigger significant uptake.

Tags: Agriculture, Energy, Farming, Good practice, Renewables

I. REGIONAL ANALYSIS SUMMARY

I.I. INDUSTRY IN PÄIJÄT-HÄME

Size of industrial sectors was estimated based on data from Tilastokeskus. Sectors can be seen in graph below:



Predominant industries were determined to be in order from larger to smaller:

- Machinery and metal products
- Forestry
- Food
- Chemicals

Because national level data was on the level of forest industry in general, we didn't consider lumber, pulp and paper to be separate industries but all part of the forest industry, as that was the level, we had data on.

Constant issue with analysis was the lack of data, including lack of regional level data and sometimes total lack of data at all.

Type and share of energy sources used by industry was determined using national data. This skews the results as for example natural gas use is expected to be greater portion in Päijät-Häme than it is nationally as large parts of northern Finland do not have access to the natural gas grid limiting its use by industry there.

National data was following:

coal	10 %
natural gas	9 %
petroleum	11,2 %
RES	65 %
other, what kind? Peat...................5%	

Attempts were made at trying to determine regional statistics for share of different fuels used in industry but were frustrated by government statistics only existing for certain fuels and statistics mixing energy production and industrial use of fuels. Industry in Finland often is not only an energy consumer but a net energy producer. Specifically, this is common in pulp production but also many factories sell excess heat for district heating purposes. Therefore, it is hard to separate consumption and production of energy in Finnish industry specifically.

In total according to statistics Finland industry in the region uses 2230 GWh of energy annually, of which 670 GWh are electricity, rest being heat.

I.II. CURRENT STATE OF RENEWABLES PRODUCTION IN THE REGION

- **Wind power**
  In Päijät-Häme there is no current wind power production. However, there are two current wind power projects. One in Hartola totalling 7 MW peak production and another in Sysmä totalling 26 MW peak production. As of writing these are in planning stages.
- **Hydropower**
  There are numerous small dams, some of them already decommissioned in the region. However, all of them are very small, none of them larger than 1 MW. All added together they don't produce more than estimated 2 MW power production making them quite insignificant.
- **Solar power**
  In Finland in 2019 total solar power production is estimated 200 MW. Of this approximately 10 MW are in Päijät-Häme. Counting all solar power is difficult and data is not readily available, yet we know of few larger installations, as well as information from grid company Elenia, which publishes that its grid, which covers the northern half of the region, has total of 2.6 MW of grid connected solar energy production. Outside this production we know that various companies including S-Group, K-Group and Tokmanni have invested in roof top solar for their properties. From these we estimate the roughly 10 MWs.
- **Biomass**

Biomass makes up vast majority of the region's renewable energy production. From the national powerplants registry we have made a list of the region's biomass burning plants:

Plant	Fuel	Power
Kymijärvi III	Forestry waste	190 MW
Stora Enso Heinola Fluting	Black liquor and bark	19 MW
Fazer	Oat hulls	8 MW
Viking Malt	Wood chips	12 MW
Adven Heinola	Biomass	3 MW
Kymijärvi II	Co-firing waste	160 MW

Some other small biomass heating plants exist for industry but are not large enough for the registry and thus unaccounted for.

In total the electricity production in Finland is approximately 85 % carbon neutral as of 2020. RES makes up around 51 % with 34 % nuclear power of total production. Separating Päijät-Häme from national statistics in carbon neutrality of electricity is impossible as the whole country is part of one national grid. Calculations are further complicated by imported electricity, which makes up on average approximately 20 % of the national demand, and the carbon neutrality of which varies wildly depending on the country it is imported from, with Norwegian and Swedish electricity production being large carbon neutral due to hydropower and nuclear power but Russian electricity being still heavily dependent on coal and only estimated 36 % carbon neutral.

- **Biogas**
  The region has 4 active biogas production plants totalling approximately 60 GWh of annual production. Research done as part of RESINDUSTRY indicates wastewater, municipal biowaste and industrial biowaste is already highly utilized in biogas production with not much more room for growth in production and ever shortages of material, but lots of untapped materiel potential in agricultural biowaste, limited only by the economics of harvesting and transportation to production sites.

I.III. CONSUMPTION STATISTICS

For renewable fuel use there is readily available government statistics for wood biomass fuels. Our findings for the region were that approximately half of the biofuel in use was forestry residue (branches, stumps and tree tops and other material unsuited for further processing into products), one third was bark, 7 % sawdust and 8 % was chipped industrial wood waste (broken or rejected low quality lumber, waste bits from wood products manufacturing etc.) 5 % recycled wood products and the remaining 4 % unclassified industry sidestreams. From this we can conclude that wood biomass in Päijät-Häme is on a very sustainable basis, with only wood unsuited for industry being used for energy purposes and a very high utilization of biomass waste for energy use.

I.IV. INDUSTRY ANALYSIS

The two most prominent industries in Päijät-Häme are machinery and forestry. Analysis performed on these industries included estimates on annual investments, as well as annual reduction of CO_2 emissions.

Other figures planned for the analysis we were not able to present, such as energy costs reductions and industry wide energy efficiency figures as such figures companies prefer to keep secret for reasons of competition. Figures we did gather are presented below in a table.

Type	Machinery	Forestry
Annual investment costs in EURO	*36 M€*	*29,5 M€*
Reduction of CO2 Emissions tons/year	567	464

We also looked into the past and future financing of renewable energy and energy efficiency measures in the region, with information provided by Business Finland, which is tasked with the distribution of energy aid to suitable renewable energy and energy efficiency projects in Finland. The periods examined were 2014-2020 and 2021-2027.

The amounts were estimated as follows: 14 million € for renewable energy and 9,6 million € for energy efficiency in the past 7 years. in the next 7 estimated 4,4 million € will be given to renewable energy projects and 3 million € for energy efficiency projects.

I.V. SWOT ANALYSIS

A SWOT analysis was also performed as part of the greater regional analysis. This analysis is presented below.

	Helpful (to achieving the objective)	**Harmful** (to achieving the objective)
Internal origin (atributes of the RES usage in industry)	**S** STRENGTHS • Availability of biomass	**W** WEAKNESSES • Very little hydropower • Weak sun • Limited aid to biogas
External origin (atributes of the environment)	**O** OPPORTUNITIES • Biogas • Windpower	**T** THREATS • Forestry restrictions • Difficulty of permits for RES (wind and biogas)