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Investment and Policy Plan for the Latvian Wood Processing Industry

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Abstract

The report aims to provide an evidence base for the design and implementation of policies and investment in the decarbonisation of the wood processing sector of Latvia. This is the largest energy consuming industrial branch of the country, and whereas large industries have been already addressed by the EU emission trading scheme (EU ETS) and other policies, this branch was not due to too many diversified actors. The report analyses energy efficiency benchmarks for the wood processing sector based on literature review and the energy audits of several Latvian wood processing companies. Then, it tracks investment in the branch decarbonisation during the last ten years, identifies public sources to support such investment in the future, and provides lessons learned reviewing the German case study on the design of financial incentives for decarbonisation of the industrial sector.

Briefly about CIC2030 project

According to Regulation (EU) 2018/1999 on the Governance of the Energy Union, each Member State prepared the National Energy and Climate Plan (NECP) for the period of 2021-2030, setting out energy and climate targets. To achieve them, countries must mobilize significant capital, however they have limited experience in doing so and must build the knowledge and capacity. The Climate Investment Capacity 2030 projects aims to address the challenge. In collaboration with policymakers, the partners developed prototypes to track national climate investment flows, assess the investment needs in meeting the targets, and develop capital raising plans to cover the gap. The project team is:

	Partner	Short name	Country	Logo
1	Institute for Climate Protection, Energy, and Mobility	IKEM	Germany	IKEM
2	Climate & Company	C&C	Germany	CLIMATE COMPANY
3	Czech Technical University in Prague	ČVUT	Czechia	CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE
4	Riga Technical University	RTU	Latvia	RIGA TECHNICAL UNIVERSITY

Disclaimer

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For more information and feedback on the report

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Abbreviations

ALTUM	Latvian Development Finance Institution *ALTUM*
BAT	Best Available Technologies
CFLA	Central Finance and Contracting Agency
CCFI	Climate Change Financial Instrument
CIC2030	Project “Climate Investment Capacity 2030”
CSP	Central Statistical Bureau
EC	European Commission
EE	Energy Efficiency
EEA	European Economic Area
EECC	Energy Efficiency Cost Curves
ETS	Emissions Trading Scheme
FM	Ministry of Finance
EM	Ministry of Economics
ETS	EU Emission Trading Scheme
EU	European Union
IT	Information Technologies
GDP	Gross Domestic Product
GHG	Greenhouse Gas Emissions
LVIF	Latvian Environmental Investment Fund Ltd.
KPI	Key Performance Indicators
NECP2030	National Energy and Climate Plan for 2021–2030
PPP	Purchasing Power Parities
RES	Renewable Energy Sources
RTU	Riga Technical University
SEC	Specific Energy Consumption
SEAP	Swedish Energy Audit Program
SME	Small and Medium-sized Enterprises
VARAM	Ministry of Environmental Protection and Regional Development

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Executive summary

The report aims to provide evidence-based grounds that assist the programming of policy and investment support for decarbonisation of the wood processing sector of Latvia. It is the fourth publication in a series of reports for Latvia supported by Climate Investment Capacity 2030 project. The first report assessed the recent investment flows in energy and climate projects of Latvia.[1] The second report assessed investment needs to reach the country's energy and climate targets of 2030.[2] The third report prepared recommendations on mobilizing capital for the projects, which help meet the targets.[3] The primary target group of the reports is the ministries and other stakeholders responsible for the implementation of the Latvian National Energy and Climate Plan (NECP).

The wood processing sector is the largest energy consuming industrial branch of Latvia. While the EU Emission Trading Scheme (EU ETS) and other policies have been adopted to reduce greenhouse gas (GHG) emissions of large industrial companies, the policies did not address sufficiently the emissions of small companies. The wood processing branch is dominated by small and medium enterprises (SMEs) and in order to reduce their energy consumption and emissions, the country needs to introduce further policies.

Benchmarking, i.e. comparing the energy performance of an industrial process of an enterprise with an established reference or the performance of other enterprises, could help identify whether it is possible to improve the energy performance and to which extent. It could also assist policy design, for instance the design of financial incentives. Even though there is no standardized database of benchmarks in energy consumption of the wood processing branch, there have been projects and studies that have defined them.

Typically, these projects and studies identify energy efficiency benchmarks in the wood processing industry as **a range and/or an average specific energy consumption per cubic meter of wood products**. Table ES.1 illustrates the benchmarks that a Swedish study suggests for planning of wood processing companies. According to it, the production of a cubic meter of sawn goods requires 56-82 kWh electricity, with an average of 71 kWh, and 214-282 kWh heat, with an average of 243 kWh.

Table ES.1: Specific energy consumption (SEC) of wood processing companies in Sweden [4]

Process	$SEC_{electricity}$ [kWh/m^3 sawn goods]		$SEC_{fuel/heat}$ [kWh/m^3 sawn goods]	
	Average	Range	Average	Range
Log sorting	5	4-5		
Sawing	10	2-20		
Drying of wood	43	30-57	242	214-282
Regrading	4	2-5		
Other production processes	6	2-8	2	2
Process ventilation	2	2		
Boiler ventilation	6	3-8		
Total	**71**	**56-82**	**243**	**214-282**

[1] Kamenders, A., Rochas, C., Novikova, A., "Investments in Energy Efficiency and Renewable Energy Projects in Latvia in 2018", Riga Technical University (RTU), November 2019.
[2] Kamenders, A., Rochas, C., Juergens, I., Rusnok, D., "Nepieciešamās investīcijas Latvijas enerģētikas un klimata mērķu 2030 izpildei", Rīgas Tehniskā universitāte (RTU), 2020. gada februāris
[3] Kamenders, A., Rochas, C., Rusnok, D., Novikova, A. "Capital Rising Plan for Energy Efficiency and Renewable Energy Projects in Latvia", Riga Technical University (RTU), December 2020.
[4] Simon Johnsson, Elias Andersson, Patrik Thollander, Magnus Karlsson, Energy savings and greenhouse gas mitigation potential in the Swedish wood industry, Energy, Volume 187, 2019, 115919, ISSN 0360-5442

To identify the most promising areas for energy efficiency improvement, we conducted energy audits of **three pilot companies**. They represent typical companies of the wood processing branch of Latvia, including a plywood producing company (pilot 1), a saw wood producing company (pilot 2), and a furniture producing company (pilot 3). The results of this analysis are summarized in Table ES.2. According to it, the **potential for energy savings is 13%** in pilot 1 and pilot 2, and it is **28%** in pilot 3. The potential is **mostly delivered by heat recovery and energy management** measures.

Table ES.2: Energy efficiency potential of the pilots audited

	Pilot 1: a plywood producing company	Pilot 2: a saw wood producing company	Pilot 3: a furniture producing company
Largest energy end-uses (top 3 in the order of declining share)	1. electricity for industrial processes 2. energy consumption for heating 3. propane for loaders	1. thermal energy for industrial processes 2. energy for transport 3. electricity for industrial processes	mostly thermal energy for industrial processes
Measures with the largest potential (top 3 in the order of declining priority)	1. heat recovery for the compressor 2. optimization of boilers control 3. energy management and reduction of air leaks for compressed air	1. heat recovery for the compressor 2. energy management 3. improvement of lighting	1. heat recovery through the reconstruction of aspiration system 2. energy monitoring and management
Potential for energy efficiency	All measures can save 13% of total final energy consumption in an economically feasible way	Heat recovery can save 13% of total final energy consumption	Heat recovery can save 45% of total final energy consumption that is ca. 28.75% % of all possible savings

The report further reviewed available studies calculating energy efficiency **potential in the industrial sector of several countries**, including Latvia, **to compare** it **with the results of the pilots**. The Latvian literature reported that the energy efficiency **potential of Latvian industrial companies is 6,35%** of their final energy consumption. This is not far from the figures reported for other countries: **Sweden – 6%; Germany – 1,7%; and Denmark 5,4%.** A comparison between measures implemented is hard to conduct because of the size, capacity, and maturity levels of the companies. The studies calculated the potentials based on large-scale energy audit programmes and thus they are likely to report representative results. However, the studies do not provide the results of individual branches. This is why, they could be applied to the wood processing branch cautiously.

Finally, the report tracked investment in the decarbonisation of the wood processing branch of Latvia during the last ten years, identified the public sources to support such investment in the future, and provided recommendations on how to leverage additional private investment, based on the review of German experience.

Latvia has a long history of providing the financial support for energy efficiency and renewable energy measures in the industrial sector, with the wood processing branch as a part of it. This includes the incentives sourcing from EU Structural and Investment Funds, the framework of the European Economic Area (EEA) and the Norwegian Financial Instrument, and EU ETS.

We estimate that in total, **EUR 33.7 million have been invested in wood processing industry from 2011 until 2020**. Most investments went to drying equipment and heat recovery systems. From our analysis, we see that in the first projects starting from 2011, most attention was paid to the improvement of energy efficiency of production buildings. However more investments are now being made in production technologies. **The private sector accounted for 72% of all investment** occurred, with the rest 28% stemming from public sources, mostly in form of investment grants. Private investments made without public support were negligible that attests **the important role of public finance** in the sector decarbonisation process. The private sector raised capital mostly at the capital market, in a form of commercial loans.

The NECP intends to continue implementing energy efficiency improvement measures and measures to promote the use of renewable energy sources in industry and other economic operators, mostly **with help of EU funds**. The next operational programme planning the use of the EU Structural and Investment funds in the period 2021-2027 has been negotiated accordingly. **The exact design of the respective financial incentives** sourced from the operational programme **is under the development**.

We further examined the design of financial instruments of Germany, to provide an example of lessons learned and ideas for replication of useful elements. Germany has several federal and subnational programmes, which provide a wide range of investment loans and grants to promote energy efficiency and renewable energy use in the industrial sector. There are no dedicated products for the wood processing industrial branch: the programmes cover enterprises of all commercial and industrial branches, subject to eligibility and funding criteria. **Subsidized loans are disbursed through local branches of all German public and private banks** that makes this support easily accessible for beneficiaries in all localities.

Enterprises in Germany could often choose whether to apply for an investment grant or a subsidized loan. It is often that subsidized loans envision not only a low interest rate but also a partial debt relief (repayment subsidy) upon the proof of the investments made in accordance with their initially stated commitment. For the same project, the debt relief is often as high as the grant funding. **For energy efficiency projects, the debt relief and grant support are up to 30% of eligible costs** and **for renewable energy projects, they are up to 45% of eligible costs**. **Should an applicant be an SME, it will receive +10% to these support** (i.e. 40% and 55% of eligible costs respectively). Subsidized loans offer interest rates starting from 1.03% depending mostly on the applicant's creditworthiness. Furthermore, to promote innovation and complex approaches to decarbonization in the industry, Germany awards **grants for up to 50% of eligible costs on a competitive basis**.

The programmes either provide minimum technical requirements to investment measures applied, or require compliance with energy efficiency benchmarks. The latter is determined by a certified company or an energy consultant. Thus, the **funding may be obtained for the measures, which achieve at least 10% final energy savings**. For retrofitted technologies or installations, these specific final energy savings are measured versus the average final energy consumption of the respective technology or installation over the last 3 years. For new installations, these specific final energy savings are measured against the industry average. In 2020, Germany also introduced a federal programme, which operates a **financial product, aligned with the EU taxonomy on sustainable activities**. Respectively, the technical requirements are determined by the taxonomy technical annex.

The investment subsidies are accompanied by subsidies for energy consulting and audits. There are various types of these products and they accompany investment projects along its lifecycle. Energy consultants providing them are certified to ensure the quality of services. **The programmes cover up to 80% of eligible costs for these services.**

1. Introduction

The European Green Deal, as proposed by the European Commission (EC) at the end of 2019, is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases (GHG) in 2050 and where economic growth is decoupled from resource use.[5]

The industrial sector is the third largest energy consuming sector in Latvia. In 2018, the **increase in final energy consumption in industry was + 13.3%** compared to 2017**.** Despite the high potential for energy efficiency improvement and renewable energy use in the sector, innovations in energy efficiency, renewable energy and information technology solutions for more efficient resource management remain untapped. According to the National Energy and Climate Plan (NECP) 2030, in the medium and long term, the industrial sector will continue growing faster than other sectors of Latvia.

Relatively fast growth rates are also forecasted in the largest manufacturing sector - wood processing. Whereas large industries have been already addressed by the EU emission trading scheme (EU ETS) and other policies, this branch was not due to too many small, diversified actors. Therefore, Latvia needs to accelerate the transformation of its industrial sector, and especially its wood processing branch, by **bridging the investment gap and accelerating deployment of new energy efficiency technologies in the industry**.

Therefore, the report aims to provide an evidence base for the design and implementation of policies and investment for the decarbonisation of the wood processing industrial branch of Latvia and thus contribute to meeting the targets of the NECP. For this, the report analyses energy efficiency benchmarks used in the wood processing branch. It also analyses three pilot wood processing companies, to identify the most promising areas for improvement. It further provides an assessment of the potential to reduce energy consumption and greenhouse gas emission reductions in Latvia and EU member state at branch level. As a result, the report proposes **energy efficiency benchmarks were proposed, to assist an understanding of improvement and optimization strategies and support decision-making processes for sustainable investments in the branch**. Finally, the report tracks investment in the branch decarbonisation during the last ten years, identifies the public sources to support such investment in the future, and provides recommendations how to leverage additional private investment in Latvia, based on the review of German experience.

[5] EC (2020), A European Green Deal website, https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

2. The wood processing industry branch at glance

2.1. The role of the branch

The wood processing industry is one of the most important sectors on economy in Latvia. Out of all the country's registered manufacturers, 26% are linked to the forestry sector, which employs around one-fifth of the manufacturing labour force.[6]

In 2018, 2 755 companies were working in the wood processing sector. As shown in Figure 1, the largest number of companies are of sawing, shading, and impregnating - represented by 816 companies, while the production of carpentry products is carried out by 580 companies. The third largest performer of activity is the manufacture of unspecified furniture, with 504 companies. The least represented sector is the production of parquet panels with five companies only.

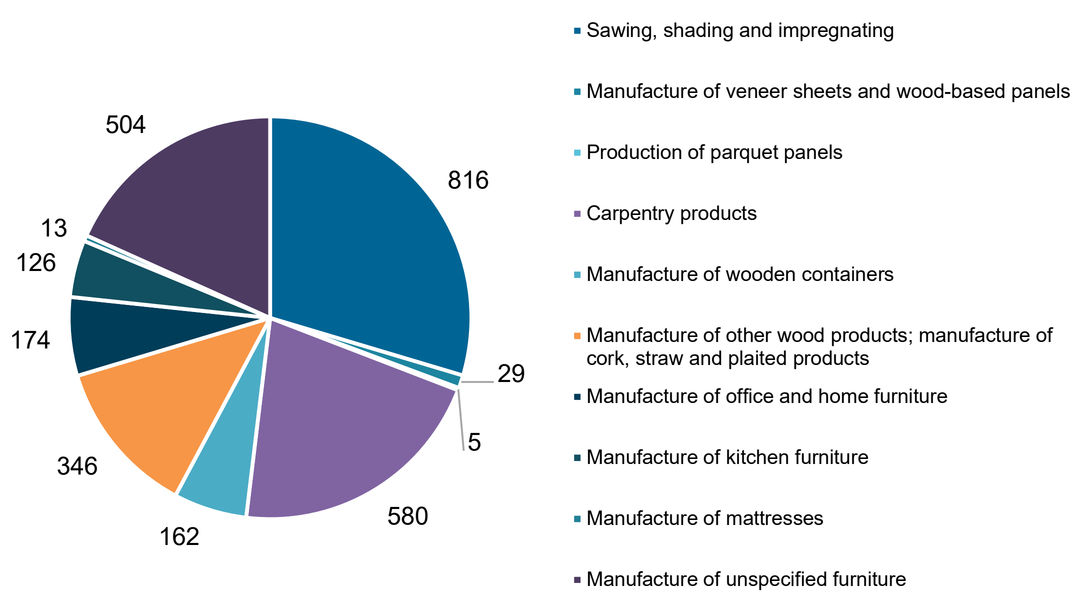

Figure 1. Number of companies operating in the wood processing sector of Latvia by type of operation in 2018[7]

The wood processing sector is characterised by a large number of small and medium enterprises (SMEs) mainly working in the forestry sector, with companies having less than 10

[6] Wood Industry, http://wood-industry-latvia.liaa.gov.lv/jp/en/
[7] Central Statistical Bureau, economically active enterprises, broken down by main types of activity, https://data.csb.gov.lv/pxweb/lv/uzn/uzn__01_skaits/SRG020.px/table/tableViewLayout1/

employees accounting for 96% of the total number. In the wood products sector, the number of companies with a number of employees under 10 represents 76%, while in the furniture sector 87% (see Table 1 for details). To the largest extent, SMEs produce niche products, such as boards, finishing, and packaging etc., while big companies produce higher, value-added products, for instance construction materials, load-bearing products, and impregnated products.

Table 1. Economically active companies in the wood industry by branch in 2018

Type of economic activity / Number of employees	0-9	10-19	20-49	50-249	250+	Total
Forestry and logging	4009	97	49	18	2	**4175**
Manufacture of wood products	1466	185	187	89	11	**1938**
Manufacture of furniture	711	52	34	17	3	**817**

In 2018, the number of the wood industry companies increased by 26.6% compared to 2013. The largest increase was observed in the number of forestry and logging companies, which showed an increase of 43.4% since 2013. This was mainly based on small businesses with a 46% growth (0-9 employees). There has also been an increasing in the number of companies representing manufacture of wood products and manufacture of furniture, as illustrated in Figure 2.

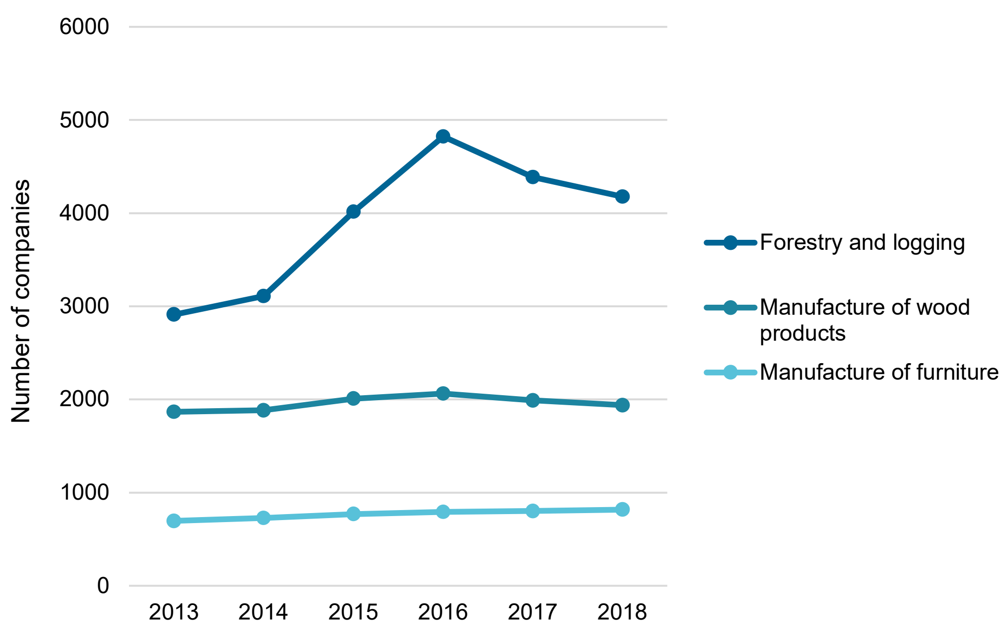

Figure 2. Changes in the number of companies in the wood sector from 2013 to 2018

In 2018, forestry, wood processing and furniture production accounted for 5.1% of Latvia's gross domestic product (GDP), while exports amounted to EUR 2.6 billion – 21% of the country's total exports. In 2018, the forest sector's total net turnover amounted to EUR 4,225 million. This included the production of wood and timber products with EUR 2,609 million net turnover or around 62% of the sector total, forestry and logging with EUR 1,328 million net turnover or 31% of the total, and furniture production with EUR 266 million net turnover or 7% of the total. The forest sector's total profit in 2018 amounted to EUR 428 million, of which 54% was composed of wood and timber products. [8]

In 2018, 39 thousand workers were registered in the forest sector, 23 thousand in the manufacture of wood and wood products, 10 thousand in forestry and logging, as well as 6 thousand in the manufacture of furniture.[9]

2.2. Energy and carbon performance of the branch

Error! Reference source not found.presents the final energy consumption of energy-using sectors of Latvia. The figure illustrates that since 2000, the final energy consumption in the industry had increased by around 37% with a share close to 23% in 2019. Over the past five years, the final energy consumption in the industry has increased by 13% and reached 37.6 PJ in 2018.

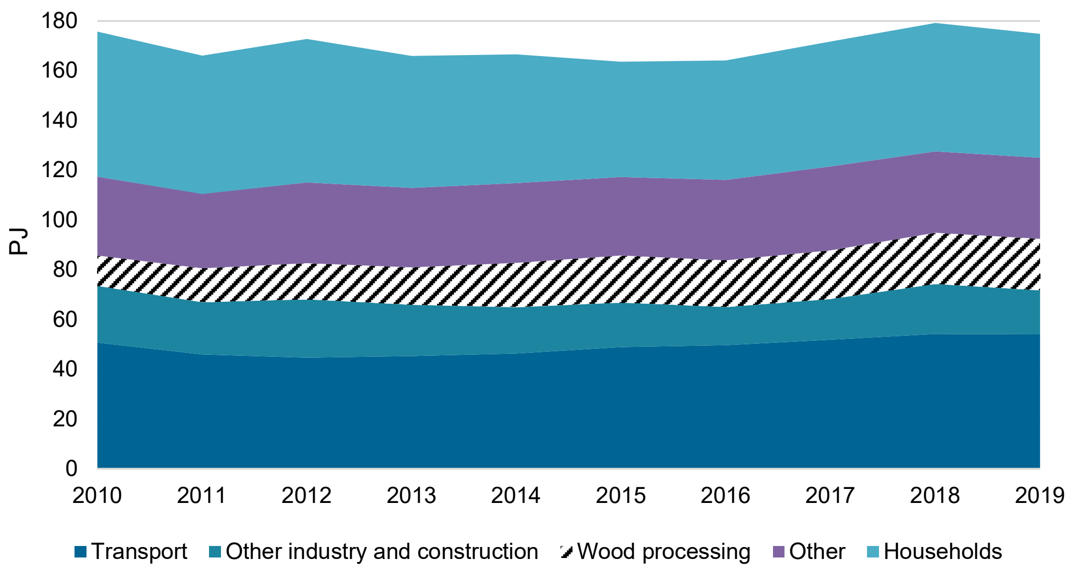

Figure 3. Final energy consumption [PJ]

The largest share of final energy consumption of the industrial sector in 2018 came from the wood processing branch, 20.7 PJ or 50.4% of the final figure (Figure). Compared to 2017, the

[8] Ministry of Agriculture, Forest sector in figures and facts 2020, https://www.zm.gov.lv/public/ck/files/ZM/mezhi/skaitlifakti_LV20.pdf
[9] Ministry of Agriculture, Forest sector in figures and facts 2020, https://www.zm.gov.lv/public/ck/files/ZM/mezhi/skaitlifakti_LV20.pdf

final energy consumption of the wood processing branch increased by 5.5%, driven by an increase in wood pellet consumption.[10]

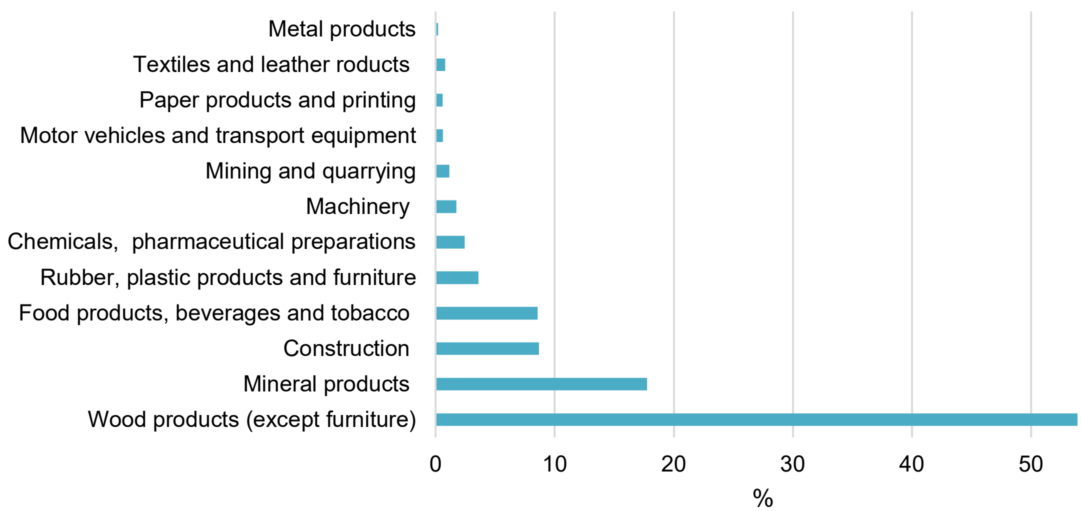

Figure 4. Contribution of industrial branches to the industry sector final energy consumption, 2018

In 2019, the final consumption of electricity from the industrial and construction sectors amounted to 1847 GWh, or 27.8% of the total national electricity figure, whilst heat consumption was 923 GWh, or 13.7% of the total national thermal energy consumption figure. In 2019, the final consumption of electricity from the manufacture of wood and cork products (excluding furniture) amounted to 835 GWh, representing 45.2% of the consumption of the industrial and construction sector or 12.6% of the total national consumption. Thermal energy consumption was 800 GWh from the manufacture of the same products, or 86.7% of the whole industrial and construction sector, contributing 11.8% to the total national consumption. [11]

Together with metal processing, the wood processing branch has the highest energy intensity among all sectors. As the wood processing branch mainly uses production residues for heat production, then wood also accounts for the largest consumption as an energy source. The main energy sources used in 2019 were wood (66%), fossil energy (5%), heat (14%) and electricity (15%), as presented in Figure .

[10] Latvian National Energy and Climate Plan 2030, https://em.gov.lv/lv/nozares_politika/nacionalais_energetikas_un_klimata_plans/
[11] Central Statistical Bureau, Energy balance, in natural units of measure, https://data.csb.gov.lv/pxweb/lv/vide/vide__energetika__ikgad/ENG010.px

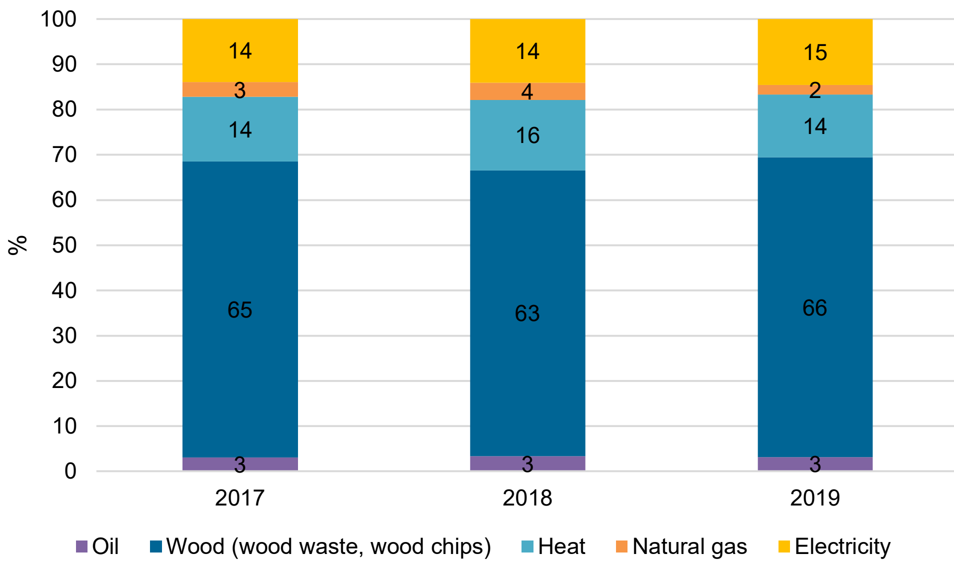

Figure 5. Energy mix (%) of the wood processing industrial branch, 2019

For its thermal energy uses, the wood processing branch uses wood production residues that is considered as relatively cheap. For this reason, energy costs make up only a small share of total company operating costs.

In 2018, the industrial sector of Latvia accounted for 7.3% of the total national GHG emissions or 861 thousand tonnes of CO_2-eqv. However, the wood processing branch does not account for the largest share of its GHG emissions. The largest share of industrial emissions is produced by the mineral industry, including the production of cement, glass, and bricks. It accounted for 65.3% of the total industrial GHG emissions or 4.8% of Latvia's total GHG emissions in 2018. The second largest GHG emission sub-sector is that the use of fluorinated gases in refrigeration and air conditioning, construction foams, fixed fire protection equipment and aerosols. The latter accounts for 27.7% of total industrial GHG emissions or 2% of Latvia's total GHG emissions in 2018.

3. Branch's energy efficiency benchmarks

The aim of this chapter, which includes the literature review and analyses of pilot projects, is to identify possible energy efficiency improvements in the wood processing industrial branch. To assist this process, the chapter relies on the use of energy efficiency indicators or benchmarks that can greatly facilitate the process of improving energy efficiency in the industry.[12]

3.1. Benchmarks as a mean to facilitate energy efficiency

Benchmarking could be implemented at an international, sectoral and company level by analysis of statistical data on energy consumption - or even at process level by applying Pinch analysis.[13] The benchmarking of energy consumption data has been facilitated by the European standard EN 16231:2012. However, the standard provides neither actual data nor a method for how to collect the data. One of the major challenges today related to improved energy efficiency in the industry is thus: the lack of well-structured bottom-up data for various sectors as well as a methodology on how to collect and structure this data.[14]

Despite this, there exists numerous national or international, e.g. pan-European level benchmarking databases that allow for comparison and evaluation of companies' specific energy consumption. For example, the site "SawBenchmark" was developed as part of the Ecoinflow project. The site offers an opportunity for companies to compare their energy consumption to fifty European sawmills. More information can be found at: http://sawbenchmark.com/results/?lang=en.

The other tool for benchmarking the industrial energy performance has been developed by the EU-funded project ODYSSEE-MURE, which administers a database containing energy efficiency indicators of top-down national data. In the United States, the Environmental Protection Agency's voluntary labelling program ENERGY STAR also provides a benchmarking tool for industrial plants, including pulp and paper manufacturing, to track their energy performance.[15] More information can be found at: https://www.energystar.gov/buildings/tools-and-resources/pulp-mill-epi.

One of the typical sources of benchmarking references is the best available technologies. According to the Industrial Emissions Directive (IED, 2010/ 75/EU), information about the best available techniques (BAT) is provided to relevant industries through reference documents. The wood industry lacks specific BAT reference guidelines however.[16] Even if such guidelines would be available; should external factors that affect energy performance, such as climate, raw material quality or product quality be not normalized, it would difficult for a company to

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[12] Tobias Fleiter, Matthias Rehfeldt, Andrea Herbst, Rainer Elsland, Anna-Lena Klingler, Pia Manz, Stefan Eidelloth, A methodology for bottom-up modelling of energy transitions in the industry sector: The FORECAST model, Energy Strategy Reviews, Volume 22, 2018, Pages 237-254, ISSN 2211-467X

[13] Anna Kubule, Kristaps Ločmelis, Dagnija Blumberga, Analysis of the results of national energy audit program in Latvia, Energy, Volume 202, 2020, 117679, ISSN 0360-5442,

[14] Tobias Fleiter, Matthias Rehfeldt, Andrea Herbst, Rainer Elsland, Anna-Lena Klingler, Pia Manz, Stefan Eidelloth, A methodology for bottom-up modelling of energy transitions in the industry sector: The FORECAST model, Energy Strategy Reviews, Volume 22, 2018, Pages 237-254, ISSN 2211-467X

[15] Elias Andersson, Oskar Arfwidsson, Patrik Thollander, Benchmarking energy performance of industrial small and medium-sized enterprises using an energy efficiency index: Results based on an energy audit policy program, Journal of Cleaner Production, Volume 182, 2018, Pages 883-895, ISSN 0959-6526,

[16] Simon Johnsson, Elias Andersson, Patrik Thollander, Magnus Karlsson, Energy savings and greenhouse gas mitigation potential in the Swedish wood industry, Energy, Volume 187, 2019, 115919, ISSN 0360-5442

compare their performance.[17] The other drawback of the references to BAT is that they are more appropriate for industrial countries with larger capacity production plants than for smaller companies.[18] Due to this reason, it is better to rely on the average energy efficiency, as a reference value. Thus, benchmarking to an average value determines whether the benchmarked entity is better or worse than the average.[19]

Indicators used for benchmarking purposes can be either economic or physical. Economic indicators are often referred to as energy intensity, and they are measured in economic terms such as GDP. For analysis of these indicators, data envelopment analysis (DEA), a non-parametric statistical approach, is commonly used. Other methods include the stochastic frontier analysis (SFA) and the Malmquist Productivity Index (MPI). Physical indicators have a physical denominator. One commonly used measure is specific energy consumption (SEC), defined as the amount of energy used per unit of output. The specific energy consumption is a useful measure of energy efficiency for one individual process, but for systems that consist of multiple processes it is better to rely on energy efficiency indices (EEI).[20]

The other source of benchmarking references is energy audit programs. The energy audit report functions as decision support to optimize firms' energy use. The audit report includes energy use, how energy is distributed by a company, and suggestions for energy efficiency measures.[21]

Even though in Latvia there is no standardized vision on how to analyze energy audits, usually, for the calculation of energy end-use and efficiency potentials, a database or a summary table of all the needed information is developed from a series of such audits. They could include such data as the total end-use energy (MWh per year), end-use energy distribution by energy source type (thermal energy, electricity, transport fuels in MWh per year), end-use energy distribution by processes (for example for heating, hot water preparation, ventilation, lighting, cooling, production process equipment (electrical energy consumption) or production processes (thermal energy consumption). Also, data on annual amounts of goods produced or annual turnover is collected if available. Information on all mentioned energy efficiency measures from the energy audits are also gathered. The latter includes information about energy savings (MWh per year), investment costs, potential cost savings and measure lifetimes where they were available. The suggested measures are then divided into categories. There is no standardized way to divide the measures as this also depends on the case study. Usually, measures are divided into the production process and support process-related measures. Both of these categories include more in-depth sub-categories.[22]

One of the widely applied methods for determining the technical and economic energy efficiency potential is Energy Efficiency Cost Curves (EECC). This method can be used to identify the most cost-effective energy efficiency measures for the industrial sector. The two most important tasks for applying the EECC method include characterizing the current situation and defining the potential savings of energy efficiency measures. The country's

[17] Elias Andersson, Oskar Arfwidsson, Patrik Thollander, Benchmarking energy performance of industrial small and medium-sized enterprises using an energy efficiency index: Results based on an energy audit policy program, Journal of Cleaner Production, Volume 182, 2018, Pages 883-895, ISSN 0959-6526
[18] Anna Kubule, Kristaps Ločmelis, Dagnija Blumberga, Analysis of the results of national energy audit program in Latvia, Energy, Volume 202, 2020, 117679, ISSN 0360-5442,
[19] Elias Andersson, Oskar Arfwidsson, Patrik Thollander, Benchmarking energy performance of industrial small and medium-sized enterprises using an energy efficiency index: Results based on an energy audit policy program, Journal of Cleaner Production, Volume 182, 2018, Pages 883-895, ISSN 0959-6526,
[20] Ibid.
[21] Sandra Backlund, Patrik Thollander, Impact after three years of the Swedish energy audit program, Energy, Volume 82, 2015, Pages 54-60, ISSN 0360-5442
[22] Ibid.

energy efficiency potential depends on the current energy consumption, the overall technological opportunities, and previously implemented energy efficiency measures. [23]

3.2. Benchmarks of the wood processing branch

Even though there is no standardized database of benchmarks in energy consumption of the wood processing industry, there have been many projects and studies that have defined them. The previously mentioned tool *SawBenchmark*[24] is a result of one of these projects. The project *Ecoinflow* was led by 12 project partners involving nine countries (Austria, Belgium, England, France, Germany, Italy, Latvia, Norway and Sweden) from 2012 until 2015. SawBenchmark includes such benchmarks as:

- Electricity consumption per m³ of logs received depending on the type of sawmill;
- Electricity consumption per m³ of sawnwood depending on the type of sawmill;
- Electricity consumption per m³ of logs received based on the percentage of drying;
- Total energy consumption (electric + thermal) per m³ of logs received depending on the percentage of drying;
- Electricity consumption per m³ of sawnwood depending on the material yield and percentage of drying;
- Heat consumption per m³ of log received depending on species;
- Total energy consumption per m³ of sawnwood depending on the material yield and percentage of drying;
- Electricity consumption per m³ of sawnwood and group;
- Total energy consumption (electrical + thermal) per m³ of sawnwood and group.

Table 2 shows the average specific electricity consumption values from this tool.

Table 2. Benchmarking for sawmills[25]

		Hardwood	Softwood	Mixed	Average
Electricity consumption per m³ of logs received on the type of sawmill	kWh/m³	94,51	38,71	76,76	52,94
Electricity consumption per m³ of sawnwood depending on the type of sawmill	kWh/m³	362,37	68,97	177,72	131,46

A study on energy savings and GHG mitigation potential in the Swedish wood industry suggested a series of key performance indicators (KPIs) to monitor inhouse energy management of a sawmill for the entire mill and that of two most energy intensive processes, sawing and drying of wood, as follow[12]:

- Sawmill:
  - $SEC_{electricity}$ [$kWh_{electricity}/m^3$ produced goods]

[23] Anna Kubule, Kristaps Ločmelis, Dagnija Blumberga, Analysis of the results of national energy audit program in Latvia, Energy, Volume 202, 2020, 117679, ISSN 0360-5442
[24] SawBenchmark : your statistical comparison tool, http://sawbenchmark.com/results/?lang=en
[25] SawBenchmark : your statistical comparison tool, http://sawbenchmark.com/results/?lang=en

   - SEC_{fuel} [$MJ_{heat/fuel}/m^3$ produced goods]
- Sawing
   - Energy use by the amount of sawn goods [$kWh_{electricity}/m^3$ sawn goods]
   - Energy use per log processed [$kWh_{electricity}$/no. logs]
   - Energy use by sawn area [$kWh_{electricity}/m^2$ timber]
- Drying of wood:
   - Thermal efficiency of drying [$MJ_{heat/fuel}/m^3$ dried wood]
   - Electrical efficiency of drying [$kWh_{electricity}/m^3$ dried wood]
   - Thermal energy use by the amount of water removed [MJ_{heat}/kg water]
   - Electrical efficiency by the amount of water removed [$kWh_{electricity}$/kg water]
   - Energy efficiency of kiln and product [kWh_{kiln}/m^3 product]

Table 3 shows average SEC values for electricity and fuel/heat consumption for specific production processes of Sweden's sawmills.

Table 3. The average and range of SEC for electricity and fuel/heat for Sweden's sawmilling and planning of wood companies[26]

Process	$SEC_{electricity}$ [kWh/m^3 sawn goods]		$SEC_{fuel/heat}$ [kWh/m^3 sawn goods]	
	Average	Range	Average	Range
Log sorting	5	4-5		
Sawing	10	2-20		
Drying of wood	43	30-57	242	214-282
Regrading	4	2-5		
Other production processes	6	2-8	2	2
Process ventilation	2	2		
Boiler ventilation	6	3-8		
Total	**71**	**56-82**	**243**	**214-282**

3.3. Lessons learned from pilot projects

The following sections analyse three pilot wood processing companies of Latvia, to identify the most promising areas for improvement. These companies represent representative examples of the wood processing branch.

3.3.1. Pilot project 1: a plywood producing company

A wood processing company selected as pilot 1 was founded in 1992. The main product groups are sawn plywood, processed plywood, and sawn-coated plywood. The company also produces rocking horses, furniture, roller-skating ramps, and road signs from birch plywood. The main raw material for production is plywood, which is brought to the company by road transport and it is delivered to a warehouse with other raw materials. Figure presents the production facilities of the company.

[26] Simon Johnsson, Elias Andersson, Patrik Thollander, Magnus Karlsson, Energy savings and greenhouse gas mitigation potential in the Swedish wood industry, Energy, Volume 187, 2019, 115919, ISSN 0360-5442

Figure 6. Wood processing and energy production

The total energy consumption of the company is 2,626 MWh per year or 86.7 kWh per product unit. Company's energy consumption for heating was 656 MWh (25%), for hot water preparation 57 MWh (2%), for lighting 147 MWh (5%), for ventilation 142 MWh (6%), electricity for industrial processes 1,279 MWh (49%), electricity for lighting and office appliances 63 MWh per year (2%), and propane for loaders 281 MWh (11%).

Out of the total energy consumption, thermal energy was 713 MWh per year (27%), propane was 281 MWh per year (11%), and electricity was 1,632 MWh per year (62%). The main energy efficiency measures with the largest potential for energy savings have been identified as:

- An exchange of territory lighting - estimated electricity savings approximately 1.7 MWh per year;
- Heat recovery for the compressor - calculated thermal energy savings of 122 MWh per year. Heat recovered could be used to provide both process and sace heating and hot water;
- The implementation of good management principles and reduction of air leaks for compressed air systems: estimated electricity savings 61 MWh per year;
- The optimization of boilers control — calculated primary thermal energy savings of 121 MWh per year;
- Intake of air from boiler room — calculated primary thermal energy savings of 23 MWh per year;

Altogether, we estimated that economically feasible energy **savings are 13% from the total energy consumption at present.**

3.3.2. **Pilot project 2: a saw wood producing company**

This company selected as pilot 2 was established in 1994 with its main focus on the production and sales of sawn wood. The company's main products are the production of dried sawn wood. Sawn boards are delivered to the drying area where they are dried from their original humidity (approx. 45%) until they reach a humidity of 17%. Energy is used for wood processing, wood drying, and for the company's buildings. Figure illustrates the sawmill and wood drying facilities of the company.

Figure 7. The automated sawmill and wood drying

The total energy consumption of the company was 21,959 MWh per year, or 470 kWh per m^3 of dried sawn wood. Final energy consumption for heating was 74 MWh (0.34%), for hot water preparation 22 MWh (0.10%), for lighting 60 MWh (0.27%), thermal energy for industrial processes 16,895 MWh (76.9%), for electricity for industrial processes 2,262 MWh (10.30%), and for transport 2,645 MWh (12.1%).

As the largest share of energy is consumed for the industrial processes, the study focused on possibilities of improving the wood drying process. It has been estimated that heat recovery could reduce energy consumption by 2,967 MWh per year **or 13% of the total energy consumption** observed at present. Other energy efficiency measures included improvement of the lighting system and the implementation of an energy management system.

3.3.3. Pilot project 3: a furniture producing company

For Pilot 3, we selected a wood processing company that produces furniture. Based on experience gained from other case studies, the main focus has been made on the investigation of possibilities to recover heat from the industrial processes. To comply with health and production standards, it is necessary to ensure good indoor air quality and working conditions by the suction of shavings and dust. Large masses of warm air are exhausted from their industrial premises. To improve energy efficiency, we analysed a reconstruction of the aspiration system. Figure presents the factory site and the aspiration system of the company.

Figure 8. Factory site and aspiration systems

The ventilator is deployed in the air recovery part to provide air exchange balancing and remove only the amount of air that will be recycled 100% back indoors. Filters are cleaned continuously during the operation of the equipment with the use of a high-pressure regeneration ventilator, which injects the air from the 'clean air' chamber back through filter bags using nozzle pipes. As a result, filters are not clogged and the air suction, where the air was unable to return to the premises, works effectively. A pressure control adjusts the operation of the engine, thus providing the necessary air exchange. The manufacturer's experience shows that in this way up to 70% of energy savings are achieved.

Since the amount of energy savings depends directly on the production line load, the calculation assumes 45% savings for both heat and electricity consummation in aspiration system. Depending on the amount of suction air required (based on the number of operating pieces of equipment), this system would reduce electrical power, including the amount of air that needs to be sucked. Beside these improvements for the aspiration system, it has been proposed as well to implement an energy efficiency monitoring system. In total energy savings estimated reached 28.75% from total energy consummation.

4. Branch' energy efficiency potential

The chapter provides an assessment of the potential to reduce energy consumption and GHG emission reductions in Latvia and EU member state at branch level. It proposes energy efficiency benchmarks for the measures identified in the previous chapter, to assist the design of improvement and optimization strategies.

4.1. Energy and emission intensity of the Latvian manufacturing industry

Energy intensity describes the amount of energy used to generate a unit of GDP. Figure presents its trend for the manufacturing industry since 1995. In the last 20 years, compared to the value added by the Latvian manufacturing industry in 2010 prices, purchasing power parities (PPP) had increased by 40.08%, but the final energy consumption of Latvian manufacturing industry increased by only 36.66%. As a result, the energy intensity of the Latvian manufacturing industry (at PPP) has not changed significantly and in total, it has decreased by only 2.42%. In 2008, energy intensity had decreased by 13.35% compared to 2000, but due to the global financial crisis of 2008 the value increased by 32.53% in 2010 compared to 2008.

Since then, energy intensity for the Latvian manufacturing industry has decreased by 15% and in 2017, it was 0.197 koe/EUR2010p. In 2017, the energy intensity value for Latvia was 1.46 times higher than the average value for the European Union. The value for the EU in 2017 has decreased by 34.27% compared to 2000 and in 2017 it was 0.135 koe/EUR2010p. Compared to the rest of the EU countries Latvia, has the sixth highest energy intensity, as illustrated in Figure .[27]

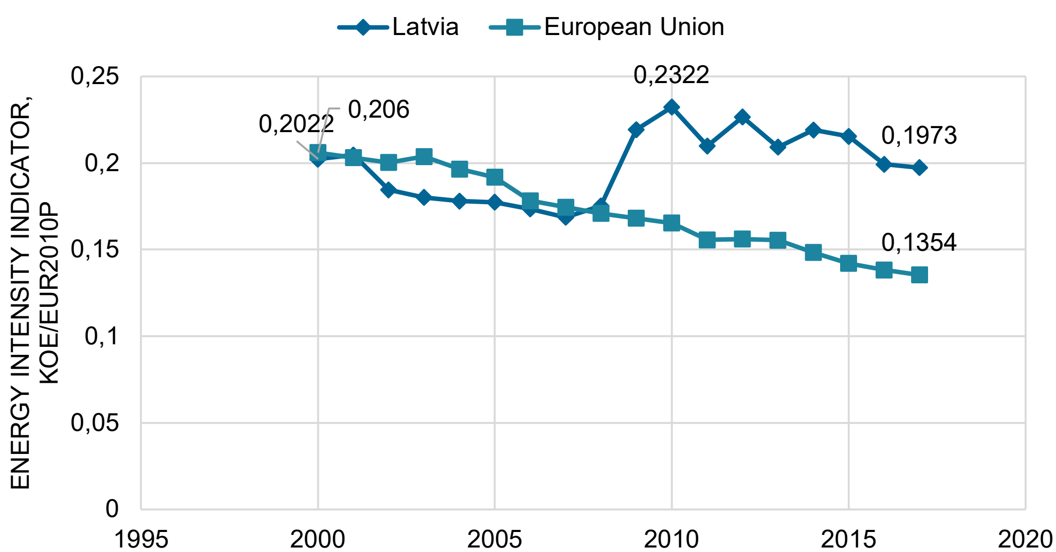

Figure 9. Energy intensity values (at purchasing power parities) for Latvian and EU manufacturing industry from 2000 until 2017, koe/EUR2010p

[27] Odyssee - Mure project, https://www.odyssee-mure.eu/

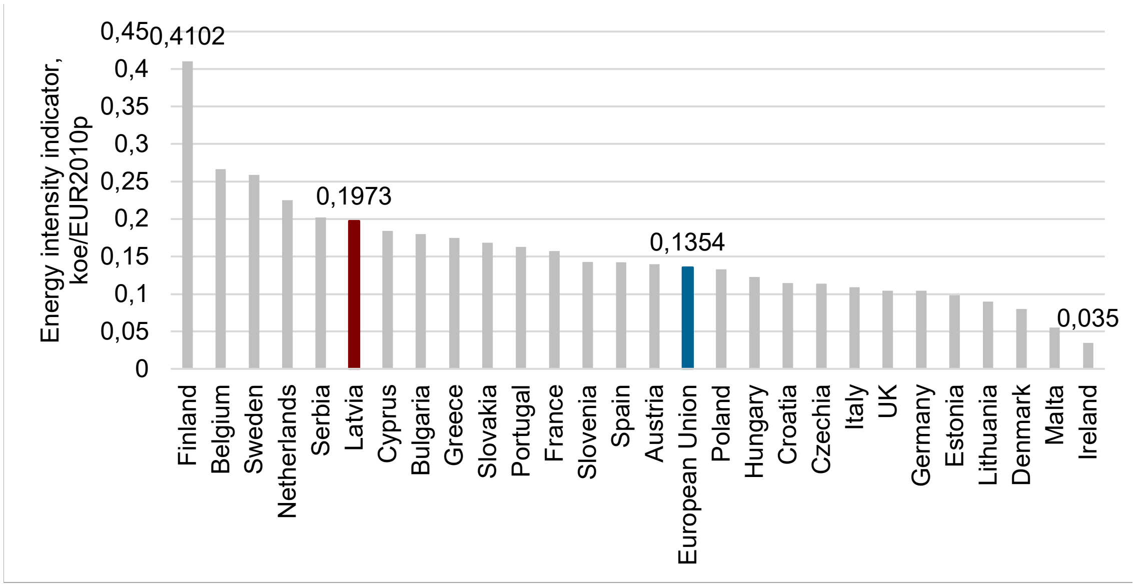

Figure 10. Energy intensity values (at purchasing power parities) for manufacturing industries of EU countries for 2017

Even though the energy intensity of a country's economy is often used as an indicator of energy efficiency, low energy intensity does not necessarily mean that the country has high energy efficiency. The energy efficiency index called "ODEX" is used to measure the energy efficiency progress by the main sector and for the whole economy. For each sector, the index is calculated as a weighted average of sub-sectoral indices of energy efficiency progress. The sub-sectoral indices are calculated from variations of specific energy consumption indicators, measured in physical units and selected to provide the best "proxy" of energy efficiency progress, from a policy evaluation viewpoint. [28] Figure 3 shows the technical energy efficiency indexes for Latvia and EU overall for the years 2000 until 2018, with 2000 being the base year.

In ODYSSEE, the technical efficiency and the apparent energy efficiency are separated. The apparent energy efficiency is measured by the gross ODEX, i.e. by the direct application of the formula. To separate the influence of behavioural factors, a technical ODEX is calculated and used to measure the energy efficiency progress that is the difference between energy efficiency and energy index.

The technical energy efficiency index for the Latvian manufacturing industry has been gradually decreasing since 2000. In 2017, the technical energy efficiency index for the Latvian manufacturing industry was 53.717, meaning, the technical energy efficiency of the manufacturing industry has improved by 46% compared to 2000. The technical energy efficiency of the Latvian manufacturing industry has improved by 1.5 times more than the average value for the EU overall. The Latvian manufacturing industry experienced the sixth largest increase in energy efficiency among EU countries.

[28] Definition of energy efficiency index ODEX in ODYSSEE data base, https://www.indicators.odyssee-mure.eu/odex-indicators-database-definition.pdf

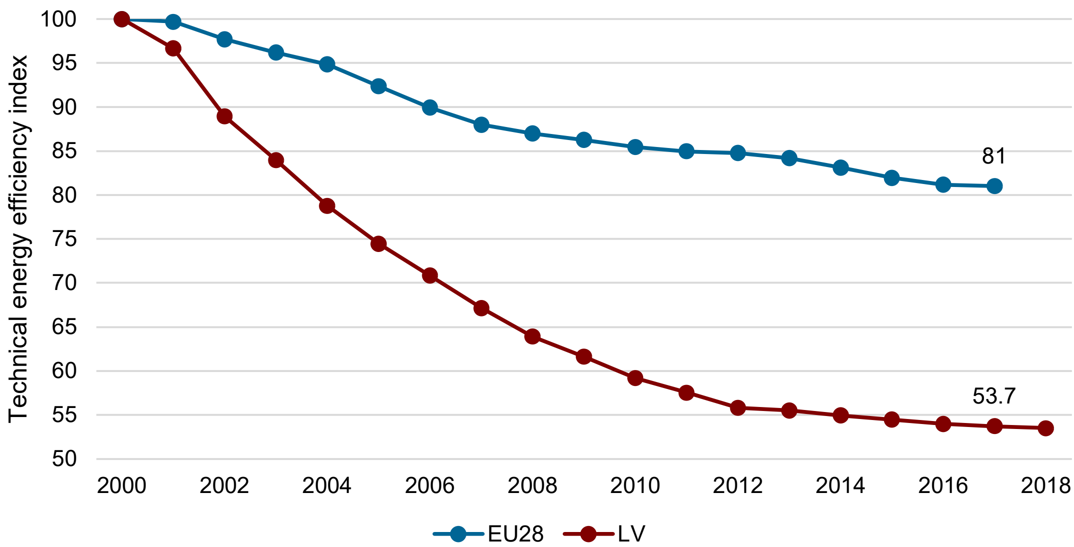

Figure 3. Technical energy efficiency index of Latvian and EU manufacturing industry (2010-2017), the base year is 2000

As can be seen in the lasts 20 years, the energy intensity of the Latvian industrial sector has decreased mainly due structural economic changes. Technical energy efficiency index for manufacturing industries is 54%. Figure 4 compares the technical energy efficiency index across all EU Member States, illustrating the level of performance of the Latvian industry.

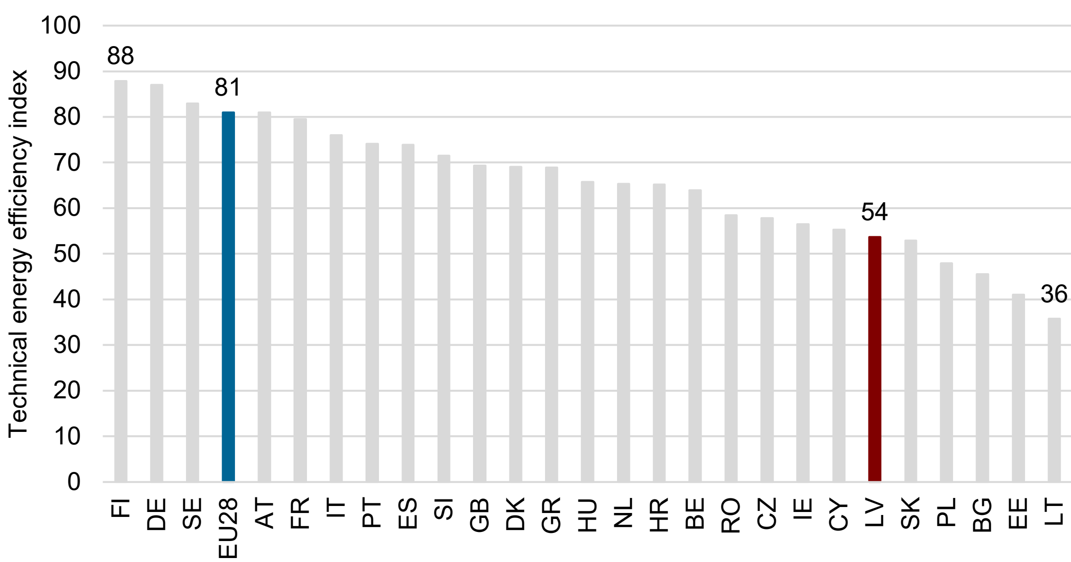

Figure 4. Technical energy efficiency index for manufacturing industries of EU countries for 2017

The CO_2 emission intensity is the emission rate of a given pollutant relative to the intensity of a specific activity, or an industrial production process. In 2018, CO_2 emission intensity of the Latvian industry sector has decreased by 52% compared to 2000, and it was close to the level of the EU average, as presented in Figure 5. Data on the manufacturing industry alone was not available.

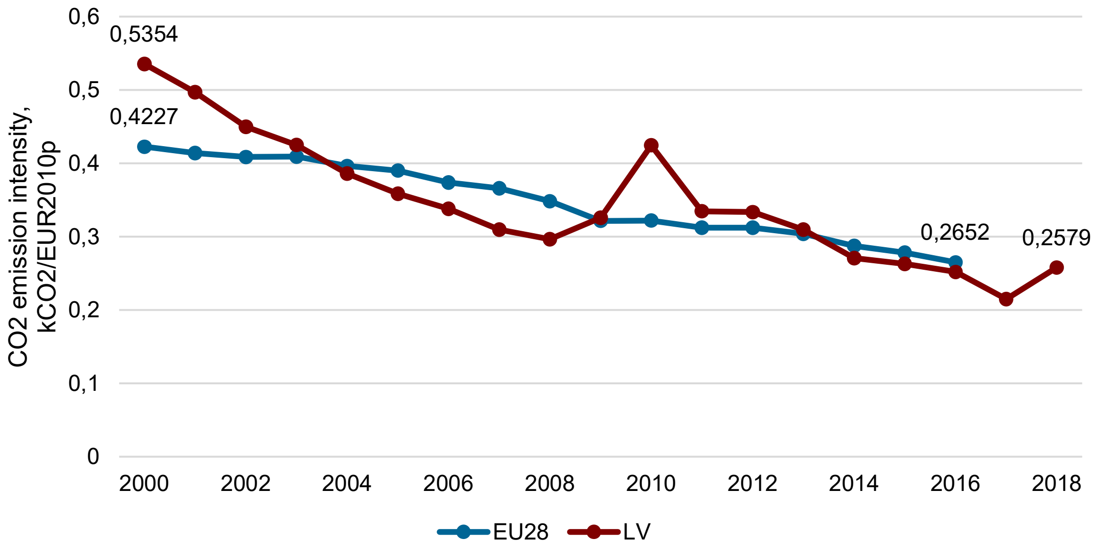

Figure 5. Total CO_2 intensity of Latvian and EU overall industry (including electricity) from 2010 until 2017

Figure 13 shows the total CO_2 emissions of pulp and paper per ton for Latvia and the EU overall. The value for Latvia decreased from 2000 until 2012 by 77%, where it reached its lowest point 0.257 kCO_2/EUR2010p. Since then, it has increased and in 2018, CO_2 emissions of pulp and paper per tonne reached 0.794 tCO_2/t.

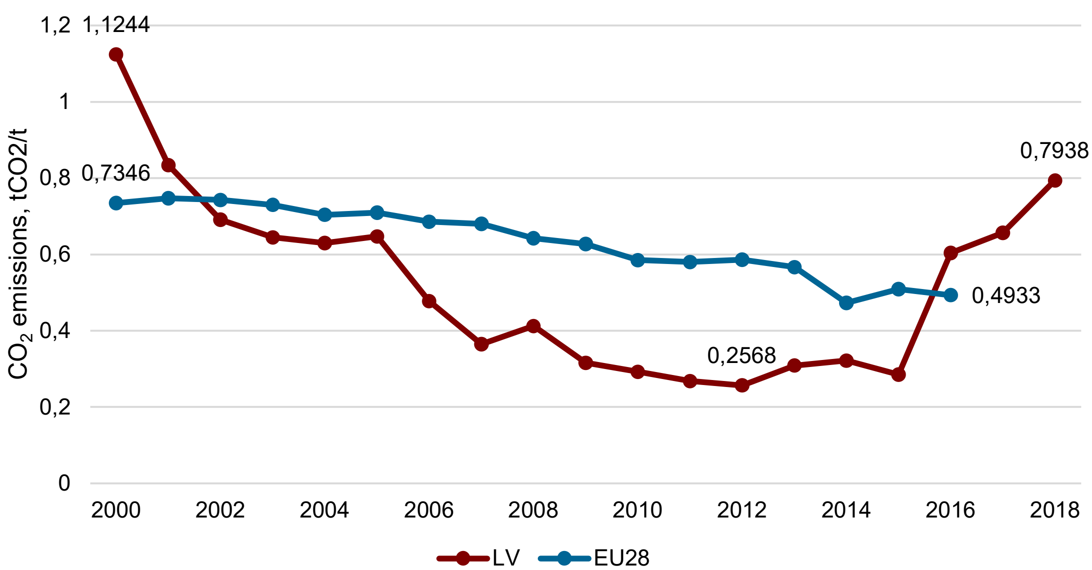

Figure 6. Total CO_2 emissions of pulp and paper per tonne of output (included electricity)

If this indicator is compared to other countries, then the Latvian wood processing industry is slightly above EU28 average. Figure 7 compares the carbon intensity of the pulp and paper industry across EU Member States.

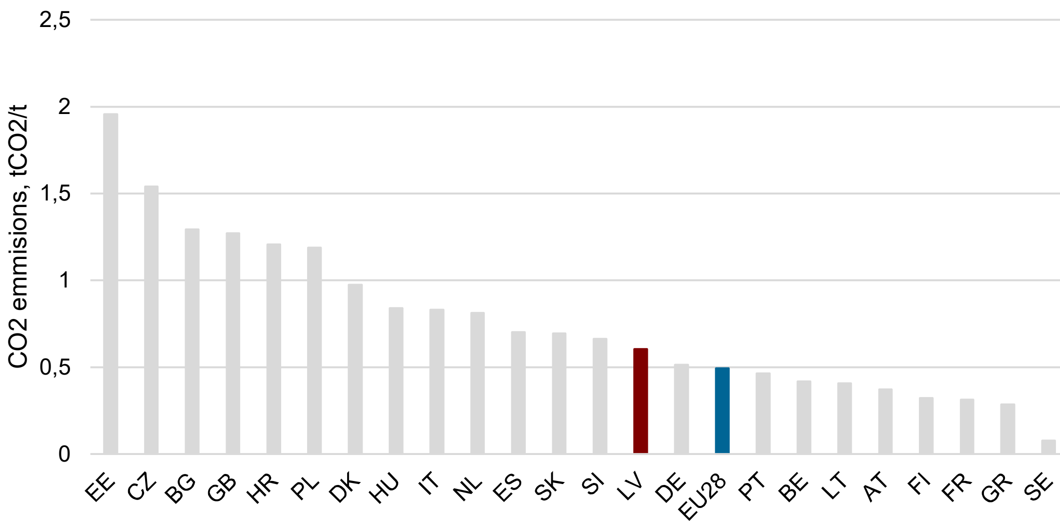

Figure 7. Total CO_2 emissions of pulp and paper per tonne of output (included electricity) for EU countries (2016)

4.2. Energy and emission intensity of Latvian wood processing companies

The energy and CO_2 emission intensity of Latvian wood manufacturing companies were calculated using the data from the Latvian Central Statistical Bureau. The energy and CO_2 emission intensity index were calculated by dividing respectively, yearly energy consumption (Ktoe) [29] and CO_2 emissions (thousand tonnes) data of wood and paper product manufacturing [30] - by total added value for manufacture of wood and paper products represented in 2015 reference prices[31]. Collected data is shown in Table 4.

[29] Latvian Central Statistical Bureau, Energy balance, TJ, thousand toe, (16-18) Manufacture of wood and paper products, https://data.csb.gov.lv/pxweb/lv/vide/vide__energetika__ikgad/ENG020.px/table/tableViewLayout1/
[30] Latvian Central Statistical Bureau, Air emission accounts, (16-18) Manufacture of wood and paper products, https://data.csb.gov.lv/pxweb/lv/vide/vide__vide__ikgad/VIG070.px
[31] Latvian Central Statistical Bureau, Breakdown of total added value by type of action, (16-18) Manufacture of wood and paper products, https://data.csb.gov.lv/pxweb/lv/ekfin/ekfin__ikp__IKP__ikgad/IKG10_060.px/

Table 4. Collected data from the Central Statistical Bureau

Manufacture of wood and paper products	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Energy consumption, Mtoe	0.181	0.250	0.299	0.332	0.355	0.369	0.429	0.456	0.454	0.473	0.181
CO_2 emissions, tonnes	170.5	129.6	177.8	170.2	133.9	104.6	108.9	107.2	118.8	121.6	138.8
Added value, MEUR2015p	498.1	458.6	615.1	642.0	695.6	636.2	667.0	678.7	685.2	741.2	498.1

Calculated values for the years 2008 until 2018 are presented in Figure 8. In this period, final energy consumption for the wood and cork product manufacturing has increased by almost three times. Produced CO_2 emission amount has decreased by 29%. Total added value for the manufacture of wood and paper products has increased by 1.5 times.

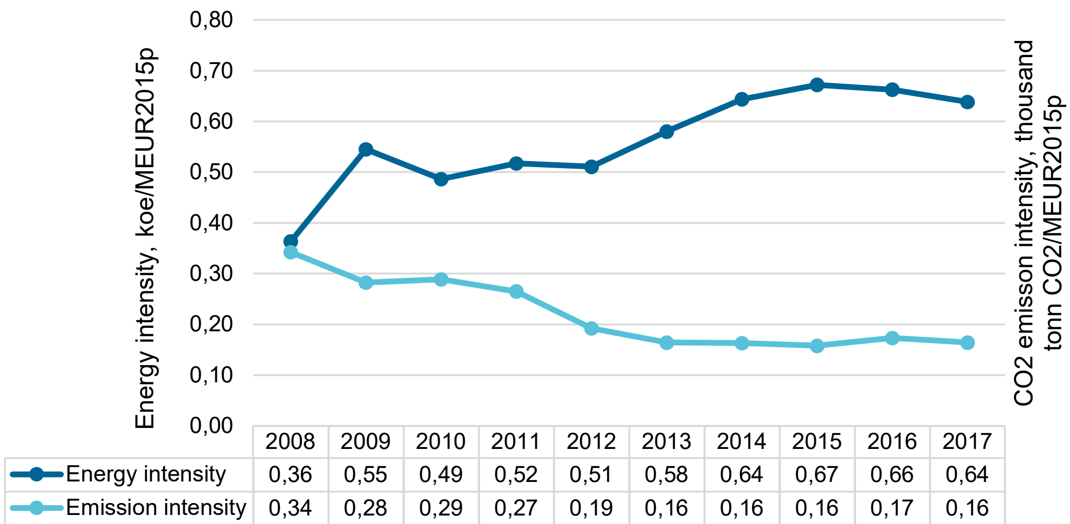

Figure 8. Latvian wood manufacturing company energy and CO_2 emission intensity 2008-2017

Because energy consumption is increasing more than the added value of products, the energy intensity of these products is also increasing. In 2018, the energy intensity of wood and paper product manufacturing was 0.6381 Ktoe/MEUR2015p. Even though energy consumption is increasing, CO_2 emission production is decreasing. Therefore, CO_2 emission intensity is decreasing as well, and in 2018 it was 0.16 thousand tonnes CO_2/MEUR2015p.

4.3. The potential of Latvia compared to that of other countries

4.3.1. Latvia

In Latvia, a national level benchmarking database that allows for comparison and evaluation of companies' specific energy consumption does not exist. Nor have there been many studies analyzing the energy efficiency potential for the Latvian manufacturing sector or for energy efficiency measures that could be implemented. In 2019, researchers from the Riga Technical Universities (RTU) and the Institute of Energy Systems and Environment analyzed the results of the first Latvian mandatory energy audit program, to evaluate the breakdown of energy end-use by different sectors and develop energy efficiency cost curves (EECC) for seven energy efficiency measure (EEM) categories. The audit reports from 111 industrial companies were analyzed. The analysis identified over 650 energy efficiency measures (EEM) that in total account for 1.89% energy savings if attributed to the total energy consumption of the whole industrial sector. The average technical energy efficiency potential for the companies which have reported an energy audit implementation is 6.35%.[32]

In the study, it was concluded that energy management measures presented a relatively high energy efficiency potential at low costs: up to 1200 MWh/year savings can be achieved with costs less than 50 EUR/MWh_{saved}. However, another 350 MWh/ year identified savings already require higher investments of up to 357 EUR/MWh_{saved}. Heating measures have a significantly high potential at no-cost or low-cost - up to almost 4000 MWh/year might be saved by measures costing less than 20 EUR/MWh_{saved}. Various more significant heating related EEMs might require larger specific investments up to 340 EUR/ MWh_{saved}. Building renovation measures have higher investment costs, but when compared to the specific-costs per saved MWh, the analysis identified measures that could provide 500 or 1000 MWh/year savings for costs less than 25 EUR/MWh_{saved}. As for process equipment, related numerous low-cost measures (up to 20 EUR/MWh_{saved}) account for up to 5000 MWh/year energy efficiency potential. The ventilation measures achieve only 1000 MWh/year savings with specific costs of less than 20 EUR/MWh_{saved}. The specific costs of the transport related measures range from 4 to 130 EUR/MWh_{saved} for such transport related EEMs as use of engine performance increasing greases and use of fuel-efficient tires. The most expensive EEM is vehicle exchange (210 EUR/MWh_{saved}).[33]

Such analysis specifically for the wood processing companies has not been done. However, the RTU study concluded that 87,5% of the total wood processing sector energy use comes from thermal and electrical energy use for technological processes. Furthermore, the share of support processes (heating, hot water, cooling, ventilation, lighting and others) to overall energy end use consumption amounts to 12.5%. It should also be taken into consideration that the heat tariff is generally lower per MWh than electricity tariff, thus when comparing EEMs with the same specific costs, electricity saving measures lead to lower payback times.[34]

4.3.2. Sweden

In Sweden, the industrial sector account for 35%-40% of total energy use. Approximately 70% of industrial energy use comes from energy-intensive large companies and 30% from non-

[32] Anna Kubule, Kristaps Ločmelis, Dagnija Blumberga, Analysis of the results of national energy audit program in Latvia, Energy, Volume 202, 2020, 117679, ISSN 0360-5442,
[33] Anna Kubule, Kristaps Ločmelis, Dagnija Blumberga, Analysis of the results of national energy audit program in Latvia, Energy, Volume 202, 2020, 117679, ISSN 0360-5442
[34] Ibid.

energy-intensive SMEs. As a consequence of the European energy savings targets, the SEAP (Swedish energy audit program) was introduced in 2010, and it lasted until 2014.[35]

An ex-post evaluation based on data for the whole running time of SEAP was performed, showing that the program resulted in net energy efficiency improvements equivalent to 340 GWh/year. This corresponds to 6% of the EEU of the analyzed companies (713 companies) with a 53% implementation rate. The largest energy saving potential was found in the support processes space heating (26%), ventilation (26%) and lighting (8%), and the average energy efficiency potential per firm was found to be 440 MWh/year. Total investment cost per firm was EUR 214,060 or EUR 520/MWh, and cost-effectiveness of the SEAP was EUR 700/measure or EUR 7/MWh.[36]

In a study by Sandra Backlund and Patrik Thollander (2014) energy efficiency measures were more specifically analyzed. It was concluded that the implementation rate is higher in manufacturing firms than in firms of non-manufacturing sectors. The highest energy savings share came from space heating and ventilation measures, which accounted for 50% of the total suggested EEMs. The average investment cost for such measures was between 125 EUR and 1833 EUR/MWh. The cost for the implemented measures in companies lied between 87 EUR/MWh and 1423 EUR/MWh.[37]

Even though the wood industry accounts for only 5% of Sweden's' industrial sectors' final energy use, the forest industry is the largest net exporting industry in Sweden, with a net export value of SEK 96 billion.[38] In 2018, a study based on SEAP was done that analyzed three manufacturing industries, including wood and cork, separately. The wood industry was represented by 30 SMEs.[39] The study concluded that the Swedish wood industry's average energy use per company and year accounts for 12,200 MWh. In the wood industry, approximately 74% of the energy used is for production processes, the rest is from support processes, for which the average energy use per year and company is 3200 MWh. The highest energy use in wood industry production processes comes from drying (almost 70%).[40] In the other study, this share came up to 80%.[41] As for the support processes, space heating has the biggest share and it is followed by transport.[42] More than half of the electricity end-use is allocated to the production processes, with the drying of wood accounting for about 25% of all the electricity use. District heating and fossil fuels are mainly used in the support processes - in particular, space heating (for district heating) and internal transport (for fossil fuels). [43]

Altogether 41 measures were implemented, and 16 measures were not implemented in wood industry companies participating in the SEAP, which added up to a 72% implementation rate

[35] Sandra Backlund, Patrik Thollander, Impact after three years of the Swedish energy audit program, Energy, Volume 82, 2015, Pages 54-60, ISSN 0360-5442

[36] Svetlana Paramonova, Patrik Thollander, Ex-post impact and process evaluation of the Swedish energy audit policy programme for small and medium-sized enterprises, Journal of Cleaner Production, Volume 135, 2016, Pages 932-949, ISSN 0959-6526,

[37] Sandra Backlund, Patrik Thollander, Impact after three years of the Swedish energy audit program, Energy, Volume 82, 2015, Pages 54-60, ISSN 0360-5442

[38] Anna Kubule, Kristaps Ločmelis, Dagnija Blumberga, Analysis of the results of national energy audit program in Latvia, Energy, Volume 202, 2020, 117679, ISSN 0360-5442

[39] Elias Andersson, Magnus Karlsson, Patrik Thollander, Svetlana Paramonova, Energy end-use and efficiency potentials among Swedish industrial small and medium-sized enterprises – A dataset analysis from the national energy audit program, Renewable and Sustainable Energy Reviews, Volume 93, 2018, Pages 165-177, ISSN 1364-0321

[40] Latvian Central Statistical Bureau, Air emission accounts, (16-18) Manufacture of wood and paper products, https://data.csb.gov.lv/pxweb/lv/vide/vide__vide__ikgad/VIG070.px

[41] Anna Kubule, Kristaps Ločmelis, Dagnija Blumberga, Analysis of the results of national energy audit program in Latvia, Energy, Volume 202, 2020, 117679, ISSN 0360-5442,

[42] Latvian Central Statistical Bureau, Air emission accounts, (16-18) Manufacture of wood and paper products, https://data.csb.gov.lv/pxweb/lv/vide/vide__vide__ikgad/VIG070.px

[43] Anna Kubule, Kristaps Ločmelis, Dagnija Blumberga, Analysis of the results of national energy audit program in Latvia, Energy, Volume 202, 2020, 117679, ISSN 0360-5442,

of the EEMs for production processes. Total energy savings for wood industries production processes accounted for 30435 MWh, from which 86% were fuel savings. The largest amount of fuel savings stems from the increased efficiency of the process in the wood industry, more than 24,000 MWh/year. These EEMs relate to a large degree to the wood-drying process, where a majority of the heat is used, as well as a large share of the total energy used in the wood industry. All of the suggested EEMs for the wood industry that concerns the conservation of fuel have a cost of conserved energy (CCE) of less than 350 SEK/MWh. For the implemented measures, the four with the largest energy savings are all concerned with the increased efficiency of the drying process. All of the implemented measures for the drying process in the industrial SMEs studied corresponded to a total of 14,431 MWh or 95% of all the energy from the implemented measures for conservation of fuel.[44]

4.3.3. Germany

In Germany, manufacture of wood and of products of wood and cork consumed 95.8 million GJ of energy in 2016 (1,17% of the total energy consumption of the industry sector). That year the total turnover was EUR 20.4 billion, translating to 4.7 GJ per thousand EUR turnover.[45]

A program offering partial subsidies for energy audits was launched by the German Ministry of Economics in 2008. Audits covered SMEs of all sizes and sectors.[46] In 2011, a study was done that assessed this energy audit program. The study revealed that on average, each company implemented 2.8 out of 5.3 recommended measures as a direct result of the energy audit. The measures implemented resulted in 1.4 TWh energy savings per year, 470,000 tonnes CO_2 reduction, investments of EUR 480 million, and energy cost savings of EUR 80 million. Program costs amount to 0.5–0.7 EUR/MWh energy saved.[47]

The study concluded that average energy savings per measure were 70 MWh. Of these, 75% were related to fuels and 25 % for electricity. The absolute savings translate to relative savings of 1.7% of the companies' energy consumption per measure (weighted average). The average measure resulted in a reduction of 27 tonnes of CO_2 per year. Nearly 45% of the measures analyzed showed CO_2 savings of below 5 tonnes per year, while 6 % achieved reductions of more than 100 tonnes of CO_2.

Regarding specific emission index, a study was conducted in 2015 analyzing the monitoring of energy efficiency and environmental impacts of the wood processing industry in Germany. The study shows that from 2003 until 2012 the sawmill industry increased its average GHG emissions from 35 to 43 kg CO_2-eq./m^3 and the wood-based panels industry decreased the emissions from 353 to 325 kg CO_2-eq./m^3.[48]

[44] Latvian Central Statistical Bureau, Air emission accounts, (16-18) Manufacture of wood and paper products, https://data.csb.gov.lv/pxweb/lv/vide/vide__vide__ikgad/VIG070.px
[45] The Federal Statistical Office, Germany, Energy consumption of manufacturing by selected economic branches, https://www.destatis.de/EN/Themes/Economic-Sectors-Enterprises/Energy/Use/Tables/energy-consumption-branches.html
[46] Edelgard Grube, Tobias Fleiter, Michael Mai, Birgit-Jo Frahm, Efficiency of an energy audit programme for SMEs in Germany – results of an evaluation study, ECEEE 2011 SUMMER STUDY, Energy efficiency first: The foundation of a low-carbon society 2011.
[47] Svetlana Paramonova, Patrik Thollander, Ex-post impact and process evaluation of the Swedish energy audit policy programme for small and medium-sized enterprises, Journal of Cleaner Production, Volume 135, 2016, Pages 932-949, ISSN 0959-6526,
[48] Stefan Klaus Diederichs, Monitoring energy efficiency and environmental impact of the wood processing industry in Germany, European Journal of Wood and Wood Products, 2015, DOI: 10.1007/s00107-015-0934-9

4.3.4. Finland

In 2017, the industry and construction sector took up 47% of all Finland's electricity consumption, of which the forest industry took up 23%. In 2017, the forest industry's electricity consumption was about 19 TWh.[49] The most electricity was consumed in the manufacture of mechanical pulp. The manufacture of wood products consumed the least energy of all forest industry products. Wood product manufacture likewise consumed a remarkably small amount of natural resources. Building with wood eventually yields more energy than it was consumed in its manufacture.[50] Paper and pulp mills require a steady supply of electricity all year round because they operate around the clock, seven days a week. Therefore, many production facilities have their power plants, which supply about 40% of overall electricity consumption – and the majority of this is bioenergy.[51]

According to the National Energy Efficiency Action Plan of Finland (28th of April 2017), industrial sector energy efficiency measures associated with the energy efficiency agreement for businesses and supported energy audits are monitored separately at industrial sites governed by the Energy Services Directive (ESD) and those participating in emissions trading. As a result of agreements, energy saving of 10.1 TWh was calculated for the year 2010. Relative to the total energy consumption attributable to the Finnish industry, which amounted to 140 TWh in 2010, the energy saving effect of all of the implemented measures came to more than 7 % of the sector's total final energy consumption.[52]

The energy audit program has been implemented in Finland since 1994. Energy audits for the medium-sized industry have been subsidized since 1992. During the 1992–2010 period, 1,246 medium-sized industrial production facilities have been audited. Energy audits were supported and analyzed by the Ministry of Employment and Economy of Finland. When analyzing, the sites were categorized depending on their energy consumption. Results from this analysis for audits from 1992 until 2016 are shown in Table 5.

Table 5. Results from the analysis of Finish energy audits[53]

Energy consumption	<10 GWh[54]	10-70 GWh	70-200 GWh
Sites inspected Sites inspected	628 SME	273 SME	51 SMW
Total annual total energy consumption	2120 GWh	7,190 GWh	
Thermal energy and fuel savings potential	approx. 273 GWh/a (25%)	approx. 807 GWh/a (20%)	approx. 870 GWh/a (16%)
Electric energy savings potential	approx. 85 GWh/a (8%)	approx. 200 GWh/a (6%)	approx. 50 GWh/a (3%)
Water savings potential	approx. 0.64 million m^3 (11%)	approx. 2.7 million m^3 (7%)	approx. 1.8 million m^3 (7%)

According to the National Energy Efficiency Action Plan of Finland, it was estimated that half of the savings effect of technical measures implemented each year materializes during the

49 Finnish Forest Industries, Energy and Logistics, https://www.forestindustries.fi/statistics/energy-and-logistics/
50 Finnish Forest Industries, The forest industry and energy, https://www.metsateollisuus.fi/uploads/2017/03/30041743/886.pdf
51 Motiva, https://www.motiva.fi/files/13562/Pk-teollisuus_saastopotentiaalit_2011-2016_taulukot.pdf
52 Finland's National Energy Efficiency Action Plan, 28 April 2017, https://ec.europa.eu/energy/sites/ener/files/documents/fi_neeap_2017_en.pdf
53 Finnish Forest Industries, The forest industry and energy, https://www.metsateollisuus.fi/uploads/2017/03/30041743/886.pdf
54 Motiva, Energy audititing activities, Statistics on review, Saving potentials, https://www.motiva.fi/ratkaisut/energiakatselmustoiminta/tem_n_tukemat_energiakatselmukset/tilastotietoa_katselmuksista/saastopotentiaalit

first year. According to the plan, the coefficient measures implemented in 2014 was 6.5 and for 2020 it was predicted to be 0.5.[55]

4.3.5. Denmark

In 2017, Denmark's final energy consumption by industry and services was 34% of the total final energy consumption and this is expected to rise to 38% in 2030. Total electricity consumption by industry and services is expected to increase too, from 76PJ in 2017 to 108PJ in 2030. 80% of this increase depends on increasing electricity demand for large data centers. From 2017 to 2030, the final consumption of fossil fuels by industry and services is expected to fall from 83PJ to 75PJ.[56]

Since 1996, the Danish Energy Agency has entered into energy efficiency agreements with large, energy-intensive enterprises in Denmark. Up to 2010, there were about 230 companies with voluntary agreements covering about two thirds of the total fuel consumption and between a third and a fourth of the electricity consumption in the Danish industry and manufacturing sectors, corresponding to about 8-9 % of the national gross energy consumption. In 2013 an evaluation showed that the agreement companies in the period 2006-2011 saved 5.4 % of their energy consumption on average.[57]

The Danish government has also set requirements for energy audits of large enterprises, which entail an obligation for large enterprises to carry out a mandatory energy audit every four years. In 2014, the EU's Environment Agency believed that 500-700 enterprises in Denmark would be covered by the energy audit. [58]

The Danish Energy Agency regularly analyzes its audit programmes. In the analysis of winter 2016/2017 approx. 250 energy audits were covered. The total potential yearly energy savings were 807.4 GWh, or approx. 15.8% of the total consumption of the audited companies. The total investments were EUR 336.3 million and yearly economical savings EUR 64.8 million. Not considering the subsidies, the average simple payback period of the measures was 5.2 years (considering subsidies 4.9 years). Approx. 70% of the responding companies have implemented and/or plan to implement some measures as a result of the energy audit. Most implementations have been in lighting and ventilation. The biggest barrier for the companies is the costs of implementation compared to possible savings.[59]

4.3.6. Cross-country comparison

The industry sector plays an important part in the total energy consumption in all countries. Energy efficiency potential in all of the covered countries was calculated from the energy audit programs. The studies do not analyze every sub-sector of the industry sector separately, therefore there are no studies on the wood processing industry specifically.

In Latvia, a study was done to assess audit reports from 111 industrial companies. The analysis identified over 650 EEM, that in total accounted for 1.89% energy savings if attributed

[55] Finnish Forest Industries, The forest industry and energy, https://www.metsateollisuus.fi/uploads/2017/03/30041743/886.pdf
[56] Danish Energy Agency, Denmark's Energy and Climate Outlook, 2019, https://ens.dk/sites/ens.dk/files/Analyser/deco19.pdf
[57] Danish Energy Agency, Energy Policy Toolkit on Energy Efficiency in Industries, https://ens.dk/sites/ens.dk/files/Globalcooperation/ee_in_industries_toolkit.pdf
[58] Denmark's National Energy Efficiency Action Plan, April 2017, https://ec.europa.eu/energy/sites/ener/files/dk_neeap_2017_en.pdf
[59] Danish Energy Agency, Analysis of Danish Energy Audits, Winter 2016/17, https://www.ca-eed.eu/content/download/3942/file/Analysis%20of%20Danish%20Energy%20Audits.pdf/attachment

to the total energy consumption of the whole industrial sector. The average technical energy efficiency potential for the companies which have reported an energy audit implementation is 6.35%. The Latvian study concluded that due to weaknesses in the study, the results might not represent the real situation and that the actual energy efficiency potential in Latvian companies is much higher.

The study in Sweden that covered the whole running time of the Swedish energy audit program resulted in net energy efficiency improvements equivalent to 340GWh/year. In 2017, Sweden's industrial sector accounted for 143 TWh final energy use.[60] Based on this we can say that the program's savings attributed to 0.238% of the total energy consumption of the whole industrial sector. But it also corresponds to 6% of the EEU of the analyzed companies (713 companies) with a 53% implementation rate. The average investment cost for the suggested measures in the SEAP is between EUR 125 and EUR 1,833/MWh. The cost for the implemented measures in firms in the SEAP lies between EUR 87/MWh and EUR 1,423/MWh.

The German study of its energy audit program concluded that the measures implemented resulted in 1.4 TWh energy savings per year, 470,000 tons CO_2 reduction, investments of EUR 480 million and energy cost savings of EUR 80 million. The programme costs amounted to 0.5–0.7 EUR/MWh energy saved. The absolute savings translate to relative savings of 1.7% of the companies' energy consumption per measure (weighted average).

In Finland, the energy audit program has been existed since 1992. In the period from 1992 until 2016, 752 energy audits were performed overall. Sites covered are grouped based on their energy consumption. The saving potential of thermal energy and fuels has averaged 25% (approx. 273 GWh/a) for companies with energy consumption <10GWh, 20% for companies with energy consumption 10-70 GWh and 16% for companies with energy consumption 70-200 GWh. As for electricity, consumption saving potential has averaged 8% for companies with energy consumption <10GWh, 6% for companies with energy consumption 10-70 GWh and 3% for companies with energy consumption 70-200 GWh.

In Denmark, the Danish Energy Agency has entered into energy efficiency agreements with large, energy-intensive enterprises since 1996. Up to 2010, there were about 230 companies with voluntary agreements covering about two-thirds of the total fuel consumption, and between a third and a fourth of the electricity consumption in the Danish industry and manufacturing sectors, corresponding to about 8-9 % of the national gross energy consumption. In 2013 an evaluation showed that companies in the agreement in the period 2006-2011 saved 5.4 % of their energy consumption on average.

Based on the analysis of countries' energy audit programs, Latvian energy efficiency potential for a company (6,35%) is not far off the potential in other countries (Sweden – 6%; Germany – 1,7%; Denmark 5,4%). A comparison between measures implemented is hard to conduct because of the size, capacity, and maturity levels of the companies covered.

[60] Swedish Energy Agency, Energy in Sweden 2019, https://energimyndigheten.a-w2m.se/FolderContents.mvc/Download?ResourceId=133464#:~:text=In%202017%20the%20total%20energy%20supply%20in%20Sweden%20amounted%20to%20565%20TWh.&text=143%20TWh%20The%20industrial%20sector,and%20electricity%20to%20run%20processes.&text=The%20transport%20sector%20uses%20mainly,a%20growing%20share%20of%20biofuels

5. Financing energy efficiency in the branch

The 2030 target of the Latvia's NECP is to reduce the total country's GHG emissions by 65% compared to 1990. The NECP also sets the target to achieve cumulative national energy end-use savings of 20 472 GWh.[61] There are no specific national targets for GHG reduction in the industrial sector. However, given that the wood-processing industrial branch accounts for around 12% of Latvia's total energy consumption with an upward trend in it, the promotion of energy efficiency measures in this branch is an essential part of achieving the national targets.

In this chapter, we track investment in the branch decarbonisation during the last ten years and we identify the public sources to support such investment in the future. Then, we assess the design of financial incentives to improve the industrial energy efficiency in Germany, as a case study of the country with one of the longest and successful track records in this field. Based on the review of this experience, we provide lessons learned which are useful for the design of financial instruments in Latvia to leverage additional private investment and accelerate the decarbonisation of the branch.

5.1. Recent investment

Latvia has a long history of providing the financial support for energy efficiency and renewable energy measures in the industrial sector, with the wood processing branch as a part of it. This includes the incentives sourcing from EU Structural and Investment Funds, the framework of the European Economic Area (EEA) and the Norwegian Financial Instrument, and EU ETS.

The financial incentives from EU funds have been available since the 2007-2013 programming period. This included above all the incentives promoted from the European Structural and Investment Funds (ESIF), delivering the Cohesion policy of the EU. Further support was also available from several European Territorial Co-operation projects implemented to promote the use of renewable energy and improve energy efficiency measures.

The financial incentives 2009-2014 were further available within the framework of the European Economic Area (EEA) and the Norwegian Financial Instrument. Thus, Latvia had access to the 2009-2014 programme of the Norwegian financial instrument "Innovation in the field of green production", with a total available funding of EUR 12.6 million. It further had access to the EEA financial instrument programme "Development of sustainable buildings, renewable energy technologies and innovative emission reducing technologies", with a total available funding of EUR 5 million.

During the 2014-2020 programming period, the funding for decarbonisation of the industrial sector was programmed under the operational programme of the European Regional development Fund and the Cohesion Fund in the specific support program 4.1.1 "To promote efficient use of energy sources, reduction of energy consumption, and transition to renewable energy in the manufacturing industry". The funding was disbursed by the Ministry of Finance, with an intermediary assistance of the Central Finance and Contracting Agency (CFLA).

Further financing for energy efficiency and renewable energy use in the industrial sector was also available within the framework of the climate financial instrument (CCFI), financed from

[61] Latvian National Energy and Climate Plan 2030, https://em.gov.lv/lv/nozares_politika/nacionalais_energetikas_un_klimata_plans/

the revenues of EU ETS. The instrument was managed by the Ministry of Environmental Protection and Regional Development, but an intermediary assistance of the Environmental Investment Fund. The funding was available within the framework of two CCFI calls. One of these was the activity “Complex solutions for GHG emission reduction in manufacturing buildings”.

The State Development Finance Institution ALTUM provides complementary measures, including technical support for project preparation and loans for project financing[62]. ALTUM provides loans to merchants unable to receive financing from commercial banks, leasing companies, or other funders in the financial market. Thus, ALTUM provides loans to small and medium-sized merchants, which as discussed are typical companies of the wood processing industrial branch.

Based on the sources described above, we estimated that in total, EUR 33.7 million have been invested in wood processing industry from 2011 until 2021. As Figure 9 illustrates, Figure 1the majority of investments went to drying equipment and heat recovery systems. From our analysis, we see that in the first projects starting from 2011, most attention was paid to the improvement of energy efficiency of production buildings. However more investments are now being made in production technologies.

Figure 10 illustrates the assessment of investment flows in energy efficiency and renewable energy projects occurred in the wood processing industrial branch of Latvia in 2011-2020. In additional to public sources described above, the figure provides an overview of private investment volumes which were supported by these public programmes. According to expert opinions, private investments made without public support are negligible that attests the role of public finance in the sector decarbonisation process. The private sector accounted for 72% of all investment occurred, with the rest 28% stemming from public sources, mostly in form of investment grants. The private sector raised capital mostly at the capital market, in a form of commercial loans.

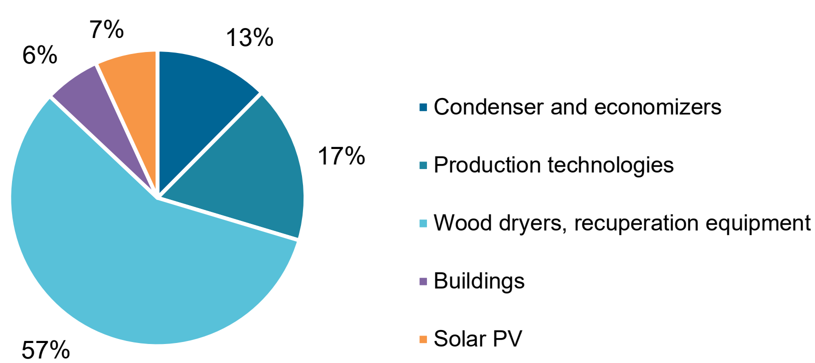

Figure 9. Breakdown by type of project in terms of investments, 2011- 2020

[62] Loans for Energy Efficiency of Businesses and ESCO (“*Aizdevums uzņēmumu energoefektivitātei un ESKO”*), https://www.altum.lv/lv/pakalpojumi/uznemumiem/aizdevumi-uznemumu-energoefektivitatei/aizdevumi-uznemumu-energoefektivitate/

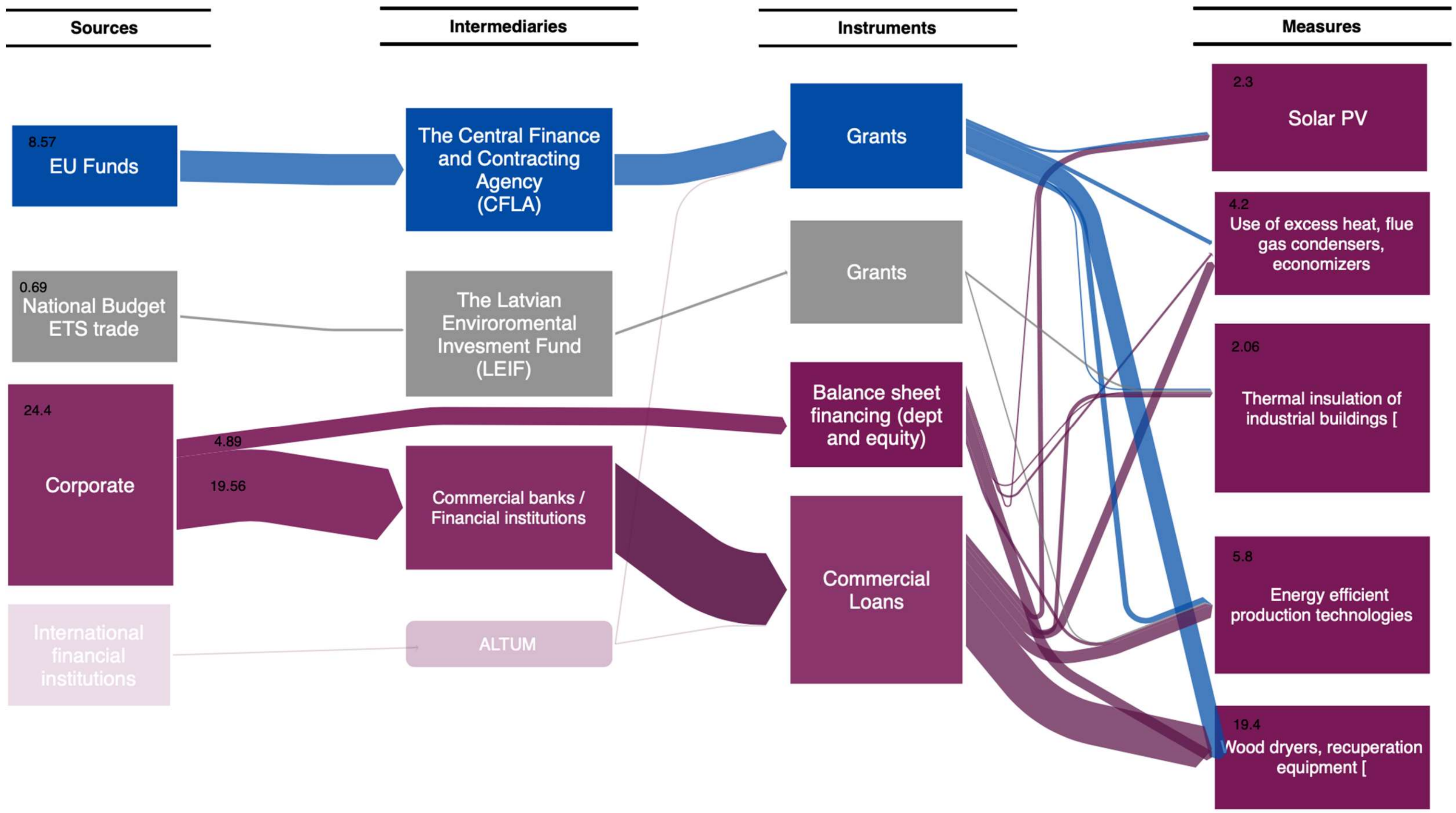

Figure 10. Investment in energy efficiency and renewable energy projects in the wood processing industrial branch of Latvia, 2011-2020 (in million EUR)

5.2. Planned resources for financial incentives in 2021-2030

The NECP intends to continue implementing energy efficiency improvement measures and measures to promote the use of renewable energy sources in industry and other economic operators, mostly with help of EU funds. The next operational programme programming the use of the EU Structural and Investment funds in the programming period 2021-2027 has been negotiated accordingly.

Under it, the industrial sector is covered by Policy Objective No. 2 "Greener, low-carbon Europe, by promoting clean and fair energy transition, green and blue investment, the circular economy, climate adaptation and risk prevention and management". Or more specifically, it will be programmed under Priority 2.1 "Climate change mitigation and adaptation to climate change", within which Specific Objective "Promoting energy efficiency and reducing greenhouse gas emissions" is programmed. The respective Objective 2.1.1 will support the upgrading of existing industrial production capacity by installing more energy efficient production and production adjacent plants, improving the energy efficiency of production buildings and sites, replacing internal and external engineering networks and engineering systems in the area of production buildings against energy efficiency.[63]

The exact design of the respective financial incentives sourced from the operational programme is under the development. The next section presents the design of financial instruments of Germany, to provide an example of lessons learned and ideas for replication of useful elements.

5.3. Financial incentives: a case study of Germany

The section presents financial incentives to promote energy efficiency and renewable heat in the commercial and industrial sector of Germany, as of February 2021.[64] The financial incentives to overcome the financial barrier of high upfront technological costs are offered by several programmes.

The federal programme package "Federal funding for energy efficiency in the economy" („Bundesförderung für Energieeffizienz in der Wirtschaft“) provides financial incentives for energy efficiency in industrial and commercial sectors of the German economy. The package consists of two programmes, "Energy efficiency and process heat from renewable energies in industry - loan and grant" („Energieeffizienz und Prozesswärme aus erneuerbaren Energien in der Wirtschaft – Kredit und Zuschuss“) and "Energy efficiency and process heat from renewable energies in the economy - competition" („Energieeffizienz und Prozesswärme aus erneuerbaren Energien in der Wirtschaft – Wettbewerb“).

The programme "Climate action campaign for SMEs" ("Klimaschutzoffensive für den Mittelstand") provides financial incentives to SMEs for investment in climate-friendly products,

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[63] Operational programme for Latvia 2021-2027 *("Darbības programma Latvijai 2021.–2027.gadam")*, http://www.esfondi.lv/upload/2021-2027/darbibas-programma_29.10.2020.docx
[64] German Federal Ministry of Ecoomics and Energy (Bundesministerium für Wirtschaft und Energie - BMWi). Energieeffizienz in Unternehmen. Das rechnet sich: Mehr aus Energie machen und Kosten senke. January 2021. https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/energieeffizienz-in-unternehmen.pdf?__blob=publicationFile&v=42

technologies and processes in line with the EU Taxonomy of Sustainable Activities[65]. The programme "Energy efficiency programme – Production plants and processes" ("Energieeffizienzprogramm – Produktions-anlagen/-prozesse") provides financial incentives for energy efficiency investments in production processes. The decarbonisation of non-residential buildings is covered by dedicated programmes and they are not discussed in this chapter.[66]

The federal programmes or parts of the federal programmes disbursing subsidized loans mentioned are operated by the German national development bank KfW[67]. The programmes or parts of the programmes disbursing grants are often operated by the Federal Office of Economics and Export Control (BAFA)[68], but sometimes also by other intermediaries. Section 5.3.1 will present the financial incentives disbursed in a form of subsidized loans and section 5.3.2 will describe financial incentives disbursed in a form of grants.

Besides the financial incentives at national level, there are also further support programmes at regional level. They are typically operated by state promotional banks, often in cooperation with the KfW. Both national and subnational programmes are typically open for application from any branches, and therefore, they are not tailored to the wood processing branch specifically.

Germany also provides financial incentives for energy-related audits and consulting, which may help identify energy efficiency and renewable heat measures. Section 5.3.3 will describe financial incentives for these measures.

5.3.1. Subsidized investment loans

As mentioned, the disbursement of subsidized loans of the federal programmes mentioned is managed by the KfW bank. The KfW bank does not work directly with beneficiaries: it disburses its products through local branches of other public and private banks. There is hardly any bank in Germany, which does not work with the KfW that makes its support easily accessible for beneficiaries in all sectors and localities.

The programme "Energy efficiency and process heat from renewable energies in industry - loan and grant" provides incentives for technologies, with a choice between a grant and a low-interest loan with partial debt relief (repayment subsidy). The list of supported technologies includes cross-sectional technologies, technologies delivering renewable heat for processes, measurement and control technologies, as well as energy management software. The geographical focus of the programme is Germany only. The part of the programme providing subsidized loans is operated by the KfW, under the product number #295[69] (the grant part is operated by BAFA).

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[65] European Union. 2021. „EU taxonomy for sustainable activities. Available at: <https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en>. Accessed on 31 March 2021

[66] For details, please see https://www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/F%C3%B6rderprodukte/F%C3%B6rderprodukte-(S3).html (in German).

[67] KfW (Kreditanstalt für Wiederaufbau) – the Credit Institute for Reconstruction.

[68] The programme webpage at Bafa: https://www.bafa.de/DE/Energie/Energieeffizienz/Energieeffizienz_und_Prozesswaerme/energieeffizienz_und_prozesswaerme_node.html

[69] The programme webpage at KfW: https://www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/F%C3%B6rderprodukte/Energieeffizienz-und-Prozessw%C3%A4rme-aus-Erneuerbaren-Energien-(295)/

The programme “Energy efficiency programme – Production plants and processes” provides financial incentives in a form of low-interest loan for energy efficiency investments. It aims to support energy efficiency in production plants and processes. The programme provides funding not only for projects in Germany, but also for elsewhere in the world. The programme is operated by the KfW, under the product number #292.[70]

Some promotional banks of federal states of Germany also provide financial incentives for energy efficiency improvements in enterprises of their geographical jurisdictions. Several such banks cooperate with KfW on the above mentioned programme and further enhance its conditions. For instance, one of the largest German promotional banks, the L-Bank of the state Baden-Württemberg, operates programme “Resource efficiency financing” (“Ressourcen-effizienz-finanzierung”) together with the KfW Bank. The programme part "Energy-efficient production" is dedicated to measures that lead to energy savings in operational processes, and it provides even more favorable conditions than those of the KfW parent programme[71].

The programme “Climate action campaign for SMEs” (“Klimaschutzoffensive für den Mittelstand”) provides financial incentives to SMEs in a form of low-interest loans in combination with grants for investment in climate-friendly products, technologies and processes. These include a wide range of mitigation measures in industry, transport, electricity and heat generation, waste and wastewater management, and green information technologies (IT). To be eligible, the measures must comply with the technical requirements of the EU taxonomy of sustainable activities. The programme is operated by the KfW, under the product number #293.[72]

Table 6 presents the programming features of the subsidized loans of these programmes.

[70] The programme webpage at KfW with a list of cooperation programmes of promotional banks: https://www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/F%C3%B6rderprodukte/EE-Produktion-292/
[71] The programme webpage at L-Bank: https://www.l-bank.de/produkte/wirtschaftsfoerderung/ressourceneffizienzfinanzierung.html#
[72] The programme webpage at KfW: https://www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/F%C3%B6rderprodukte/Klimaschutzoffensive-f%C3%BCr-den-Mittelstand-(293)/

Table 6. Loans programmes for energy efficiency improvement in the commercial and industrial sector of Germany, as of 02.2021

Funding Programme	**EE programme - production plants and processes, EE in companies**	**Federal funding for EE in the economy, EE and process heat from RE energies**	**Climate action campaign for SMEs, Climate protection in companies**
Financial Product	**KfW financial product 292:** Financing of EE measures of commercial enterprises	**KfW financial product 295:** Financing of projects to EE and use RE heat - technologies in the economy.	**KfW financial product 293:** Financing of climate protection measures of commercial SMEs based on the criteria of the EU-taxonomy of sustainable business.
Funding target	The product supports EE measures in production facilities/processes of commercial enterprises with **low-interest loans**. Projects in DE as well as abroad can be funded.	The product supports measures to save energy and reduce CO_2 through **low-interest loans** provided from KfW**, in combination with repayment subsidies** from funds of the BMWi (Alternatively, the BMWi provides investment grants for the same measures via BAFA, as mentioned). Only projects in DE can be funded.	The product supports SMEs in implementing investments aligned with the criteria of the EU's Taxonomy on Sustainable Activities through **low-interest loans** provided from KfW, **in combination with climate grants** from funds of the BMWi. Projects in other EU countries can also be funded.
	Note: If a company seeks energy advice before applying for a loan: for SMEs, the programme "Bundesförderung für Energieberatung im Mittelstand" of BAFA provides financial support to cover the costs of qualified EE consultations.		
Eligible applicant	For projects in DE: - Com. companies, registered in DE or abroad, - Sole proprietor or freelancer in DE and abroad, - Eligible companies that provide energy services to a third party under a contracting agreement (ESCOs). For projects abroad: - Comm. companies, sole proprietors, freelancers in DE, and subsidiaries of the above DE companies domiciled abroad, - Joint ventures with significant DE participation abroad.	Applicants with a permanent establishment/ branch in DE: - Com. domestic and foreign companies, - Municipal enterprises, - Freelancers, - Contractors who carry out measures for an eligible company, - Farmers: eligible only in Module 2, - Non-profit applicants, provided they are engaged in economic activity.	For projects in DE, domestic and foreign applicants with sales of up to EUR 500 million/yr.: - Com. companies, - Municipal companies, - Sole proprietor or freelancer. For projects in the EU, applicants with a max. turnover of EUR 500 million/yr.: - Comm. companies, sole proprietors or freelancers in DE, - Subsidiaries of the above DE companies in the EU, - Joint ventures with significant DE participation in the EU.
Eligible measures: investments	All investment measures that achieve min 10% energy savings measured as: - Modernization: specific final energy savings vs the average consumption of the last 3 years. - New installations: specific final energy savings vs the industry average determined by a company or an energy consultant. Examples of supported measures: - Machinery/plant/process technology; compressed air/vacuum/extraction technology; electric drives/pumps; process heat; process refrigeration, cold stores, cold rooms; heat recovery/waste heat utilization for production processes; measurement and control technology;	Measures under either of 4 modules. The measures must be carried in DE and operated for at least 3 years. For technical requirements for all modules please see the Annex. Module 1 “Cross-sectional technologies” provides funding new or replacement of individual technologies for industrial and commercial use, such as electric motors and drives; pumps; fans; compressed air generators and their control system; heat exchangers for waste heat utilization or heat recovery from waste water; insulation of plants or their parts; frequency converters. Module 2 – “Process heat supply from RE” provides funding for measures ensuring process heat supply from solar collector systems; biomass plants; heat pumps using RE heat source; integrating them into the existing process, and for the measurement & data acquisition equipment.	Investments are the construction and acquisition of eligible plants as well as modernizations of existing plants: - Production of climate-friendly technologies, products and key components that have a high climate-protecting effect in downstream sectors (including private households), such as RE energy plants, low-emission vehicles, energy-efficient building technologies; - Climate-friendly production processes, incl. new plants such as production of cement, aluminum, iron and steel. - Generation of electricity, heating, cooling from RE energies;

<table>
<tr><td></td><td>information and communication technology; combined heat and power plants.

Projects abroad could also be funded, given the legally applicable environmental and social standards of the investment country must be met (non-EU, non-OECD countries are reviewed case-by-case).</td><td>Module 3 “Measurement and control technology, sensors and energy management software” provides funding for the purchase and installation of measurement and control technology; sensors for monitoring and control of energy flows for their integration into an energy or environmental management system (for SMEs into an alternative system); energy management software and respective trainings; the cabling of the technologies; the preparation of a measurement concept by an external third party. [73,]
Module 4 / Energy-related optimization of plants and processes / provides funding to optimize the EE of industrial and commercial facilities and processes. This can also include the measures under modules 1 - 3. The application requires a savings concept prepared by an external or in-house energy consultant. The savings concept can be prepared in-house, if the applicant has an environmental or EMS certified in acc. with DIN EN ISO 50001 or Eco -Management and Audit Scheme for the specified location. The external energy consultant must be approved by BAFA for the "Energy Consulting for SMEs" funding programme (see the next section for details). The costs of drawing up a savings concept and the implementation support by external energy consultants are eligible for funding. The payback period (calculated by dividing the eligible costs by the sum of the product of final energy savings and energy price) must be more than 2 years.</td><td>- Electricity distribution networks and generation of electricity, heating, cooling from waste heat and gas;
- Distribution networks, incl. district heating, local heating and cooling networks, and measures for waste heat recovery and utilization;
- Energy storage;
- Production of biomass, biogas and biofuels;
- Water, wastewater, waste management;
- CO_2 transport/ storage;
- Sustainable mobility, i.e. investing in public transport, low-carbon infrastucture, climate-friendly passenger cars and commercial vehicles
- Green IT, i.e. data processing, hosting and related activities; and data-driven solutions to reduce greenhouse gas emissions.
The technical requirements are specified in the EU taxonomy and detailed in the programme description as mentioned.
For projects in other EU countries, the legally applicable environmental and social standards of the country of investment must be met.</td></tr>
<tr><td>Eligible measures: other costs</td><td>Expenses for planning and implementation support as well as for EMS can be funded in connection with an eligible corporate energy-saving investment.</td><td>Eligible costs in all modules also include the costs for planning and installation directly related to the measure. In Module 1, these costs are limited to a max. of 30% of the investment costs. In the other modules, there is no limit on these costs. Investment costs assigned to the system periphery that do not belong to the eligible costs can be co-financed via the loan funds from this programme, but they will not be included in the repayment subsidy.</td><td>Furthermore, in connection with an eligible investment measure, expenses for the planning and implementation support as well as the preparation of expert opinions and evidence for the compliance with the minimum technical requirements are supported.</td></tr>
<tr><td rowspan="2">Combination with other funding programs</td><td colspan="3">The combination of a loan from the KfW EE Program with other subsidies (loans or grants) is generally possible within the relevant EU aid limits. [74]
For power generation plants (for example, photovoltaics, wind power plants, combined heat and power plants), it is not possible to claim KfW funding and funding under the RE Energy Sources Act or the Combined Heat and Power Act for the same eligible costs at the same time.</td></tr>
<tr><td></td><td>Simultaneous claiming of an investment grant from BAFA for one and the same measure is excluded. Funds for energy consulting in accordance with the guideline on the promotion of energy consulting in SMEs can, however, be claimed.</td><td>There are further combination possibilities for electric vehicles.</td></tr>
<tr><td>Credit amount</td><td colspan="3">Maximum of 25 million EUR per project. Funding is available for up to 100% of eligible costs. VAT can be co-financed, provided that the right to deduct input tax does not exist. This credit limit may be exceeded if the project has special eligibility.</td></tr>
<tr><td></td><td colspan="3">The following term variants are available:</td></tr>
</table>

[73] The applicant company must have a certified energy or EMS according to DIN EN ISO 50001 or Eco -Management and Audit Scheme or be in the process of certification. If the applicant is an SME, proof of an alternative system in accordance with the Peak Efficiency System Ordinance (Spitzenausgleich -Effizienzsystemverordnung) is sufficient.

[74] EU state aid overview could be found at https://www.kfw.de/PDF/Download-Center/Förderprogramme-(Inlandsförderung)/PDF-Dokumente/6000000065_M_Beihilfen.pdf (in German)

<table>
<tr><td rowspan="2">Term and fixed interest rate</td><td colspan="3">- up to 5 years with a maximum of 1 grace year and a fixed interest rate for the entire term of the loan,
- up to 10 years with a maximum of 2 grace years and a fixed interest rate for the entire term of the loan,
- up to 20 years with a maximum of 3 grace years and a fixed interest rate for the first 10 years.</td></tr>
<tr><td colspan="2">-</td><td>When applying for the climate grant, the minimum term of the loan is 5 years.</td></tr>
<tr><td>Interest rate</td><td colspan="3">- The interest rate is based on the development of the capital market and is fixed on the date of the commitment.
- If the term is longer than the fixed-interest period, KfW submits a prolongation offer before the end of the fixed-interest period.
- The interest rate is determined by the borrower’s creditworthiness and the value of the collateral provided for the loan financing partner. The loan is assigned to one of the creditworthiness and collateralization classes specified by KfW. The financing partner assigns the promotional loan to one of the price classes specified by KfW by combining the credit rating and collateralization class. The applicable borrowing rates and effective interest rates per price class are available at www.kfw.de/konditionen (in German).</td></tr>
<tr><td>Provision</td><td colspan="3">- Payment is made at 100% of the committed amount. The call period is 12 months after commitment. This can be extended by a maximum of 24 months for amounts not yet disbursed (products 292 and 295) and this can be extended in individual cases (products 293).</td></tr>
<tr><td rowspan="2">Repayment</td><td colspan="3">During the grace years, the borrower pays only the interest on the loan amounts disbursed. After that, the loan is repaid quarterly in equal installments.</td></tr>
<tr><td colspan="2">Unscheduled repayments can only be made against payment of an early repayment penalty.</td><td>For the climate subsidy: unscheduled repayment is excluded in the first 5 years after full disbursement of the loan. After this period, unscheduled repayment is possible against an early repayment penalty.</td></tr>
<tr><td>Collateral</td><td colspan="3">Customary bank collateral must be provided for the loans. The applicants agree on the form and scope of the collateral with their financing partners during the loan negotiations.</td></tr>
<tr><td>Repayment grant</td><td></td><td>Applicants will receive a repayment subsidy upon the proof of the investments made in accordance with the commitment. The repayment subsidy is a % of the eligible costs and amounts to:
- Module 1: 30% (+10% for SMEs), additionally, ancillary costs are only eligible up to a share of 30% of the investment costs.
- Module 2: 45% (+10% for SMEs).
- Module 3: 30% (+10% for SMEs).
- Module 4: 30% (+10% for SMEs). The repayment subsidy is max 500 EUR/tCO2-yr. saved (max 700 EUR/tCO2-yr. saved for SMEs)
Modules 2-4: a max. repayment grant is EUR 10 million EUR/ project. Module 1: a max. repayment grant is 200,000 EUR/project.</td><td></td></tr>
<tr><td>Proof of the use of funds</td><td>After the measures have been carried out, proof must be provided to the funding partner that the funds have been used in accordance with the programme.

KfW reserves the right to review the calculation documents and to conduct an on-site inspection of the subsidized measures.</td><td>After implementation of the measures, the use of the funds must be proven to the financing partners who document these to KfW:
- Module 2: the specialist planner or specialist contractor confirms that the funded project is being carried out according to plan,
- Module 4: the energy consultant or the applying company, if it has an energy or environmental management system certified in accordance with DIN EN ISO 50001 or Eco - Management and Audit Scheme, confirms the implementation of the project in accordance with the savings concept.</td><td>After the measures have been carried out, proof must be provided to the funding partner that the funds have been used in accordance with the programme.

KfW reserves the right to review the calculation documents and to conduct an on-site inspection of the subsidized measures.</td></tr>
</table>

Notes: DE – Germany, EE – energy efficiency, EMS - energy management systems, RE -renewable, BMWi - Federal Ministry for Economic Affairs and Energy, BAFA - the Federal Office of Economics and Export Control.

5.3.2. Investment grants

As of February 2021, there were two federal programmes disbursing grants for decarbonization of the commercial and industrial sectors.

Under the programme "Energy efficiency and process heat from renewable energies in industry - loan and grant"[75], BAFA provides investment grants for the same technologies as were listed under the loan part of the programme (Table 6). They includes cross-sectional technologies, technologies delivering renewable heat for processes, measurement and control technologies, as well as energy management software. Depending on its financial situation, project size and planned measures, an applicant may decide itself whether it is more profitable to apply for a loan or a grant part of the programme.

The programme "Energy efficiency and process heat from renewable energies in the economy - competition" („Energieeffizienz und Prozesswärme aus erneuerbaren Energien in der Wirtschaft – Wettbewerb")[76] also offers investment grants, but it aims to support even the most complex and ambitious measures. The incentives are awarded to applicants on a competitive basis, i.e. to those who managed to achieve the highest funding efficiency (tCO_2-yr. avoided per EUR funding awarded by the programme). The programme is operared via VDI/VDE Innovation + Technology GmbH. The programme conducts several competition rounds each year.

The comparison of the programmes is provided in Table 7.

Table 7. Grant programmes for decarbonization of the commercial and industrial sector of Germany, as of 02.2021

Funding Programme	The programme "Energy efficiency and process heat from renewable energies in industry - loan and grant"	The programme "Energy efficiency and process heat from renewable energies in the economy – competition"
Eligible applicants	- Private enterprises, - Municipal enterprises, - Contractors carrying out the measures specified as eligible on behalf of enterprises (ESCOs), - Freelance professionals, if the business premises are predominantly used for freelance activities.	
Eligible measures	The same technologies and eligible criteria as listed in Modules 1-4 in Table 6.	Projects for energy-related optimization of production plants and processes, including waste heat recovery, process heat supply from renewable energies, with a payback period (without funding) of at least 4 years.[77]
Performance requirements	As listed in Modules 1-4 in Table 6 and detailed in the annex.	The central criterion for the funding decision is the funding efficiency, i.e. tCO2-yr. avoided per EUR funding.
Funding rates	Grants cover the following share of eligible investment costs: Module 1: 30% (+10% for SMEs) Module 2: 45% (+10% for SMEs)	Grants cover up to 50% of eligible investment costs.

[75] The programme webpage at Bafa: https://www.bafa.de/DE/Energie/Energieeffizienz/Energieeffizienz_und_Prozesswaerme/energieeffizienz_und_prozesswaerme_node.html
[76] The programme webpage at BMWi: https://www.wettbewerb-energieeffizienz.de/WENEFF/Navigation/DE/Home/home.html
[77] The list of technologies is provided here https://www.wettbewerb-energieeffizienz.de/WENEFF/Redaktion/DE/PDF-Anlagen/richtlinie-bmwi-wettbewerb-energieeffizienz-banz-at-15-02-2020.pdf?__blob=publicationFile&v=3

	Module 3: 30% (+10% for SMEs) Module 4: 30% (+10% for SMEs)	
Maximum subsidy	- Module 1: the maximum subsidy is EUR 200,000 per investment project (the net minimum investment volume must be at least EUR 2,000), - Modules 2 - 4: the maximum subsidy is EUR 10 million per investment project	The maximum subsidy is EUR 5 million per investment project.
Combination with other types of funding	- No application may be made simultaneously for the same project to obtain the funding from these parallel programmes, - Other limitations are in Table 6.	

5.3.3. Energy consulting in facilities and systems

There are several programmers offering financial support for energy-related audits and consulting, which may help identify and implement energy efficiency and renewable energy measures. The energy consulting services subsidized within the programme "Energy consulting for non-residential buildings, facilities and systems"[78] includes several products, which details are provided below (we do not discuss the parts of the programme covering energy consulting for buildings). To be supported, consulting services and audits have to be provided by BAFA approved experts.[79]

First, the programme supports energy consulting in a form of energy audits. Since 2015, there have been mandatory energy audits for all large companies that do not have a certified energy management system according to ISO 50001 or environmental management system according to EMAS. An energy audit must be carried out at least every four years. The programme subsidizes these audits with qualified energy consultants according to (DIN) EN 16247 “Energy audit”. The energy audit includes a systematic inspection and analysis of the energy use and energy consumption of a system, of a building, a system or an organization. It aims to examine energy flows, analyse the current status, identify potential for energy efficiency improvements, and report on results in an energy audit report. If annual energy costs exceed EUR 10,000 (net), the programme provides a grant for 80% of eligible consulting fees, with a maximum subsidy of EUR 6,000. If annual energy costs do not exceed EUR 10,000 (net), the programme provides a grant for 80% of the eligible consulting fee, with a maximum subsidy of EUR 1,200.

Second, the programme supports orientation consulting related to energy performance contracting for SMEs and non-SMEs with a total energy consumption of up to 500,000 kWh. During the orientation consultation, a certified project developer analyzes with a company, whether energy performance contracting, or another type of contracting is worthwhile in its case. As part of the general energy consulting program for SMEs, up to 80% of the net fee for an orientation consultation on energy-saving contracting can be subsidized.[80] If annual energy costs do not exceed EUR 300,000 (net), the subsidy amounts to 80% of eligible consulting fees, with a maximum of EUR 7,000. If annual energy costs of the project under consideration exceed EUR 300,000 euros, the subsidy covers up to 80 % of eligible consulting fees, with a maximum of EUR 10,000.

[78] Please see more details here www.machts-effizient.de/energieberatung-mittelstandoder (in German).
[79] Please see details here www.machts-effizient.de/expertenliste
[80] More information is provided at www.machts-effizient.de/Contracting (in German).

Finally as mentioned in the previous section, support is provided for the promotion of energy management systems. As part of the investment programme "Federal funding for energy efficiency in the economy (Module 3)", funding is provided for the purchase, installation and commissioning of measurement and control technology and sensors, the purchase and installation of energy management software, and the training of personnel by third parties in the use of the software. In addition, advice on the introduction and maintenance of an energy management system in SMEs is funded as part of the energy consulting program for SMEs.[81]

5.4. Lessons learned for Latvia

Germany has several federal and subnational programmes, which provide a wide range of investment loans and grants to promote energy efficiency and renewable energy use in the industrial sector. There are no dedicated products for the wood processing industrial branch: the programmes cover enterprises of all commercial and industrial branches, subject to eligibility and funding criteria. Subsidized loans are disbursed through local branches of all public and private banks in Germany that makes this support easily accessible for beneficiaries in all localities.

Enterprises in Germany could often choose themselves whether to apply for an investment grant or a subsidized loan. It is often that subsidized loans envision not only a low interest rate but also a partial debt relief (repayment subsidy) upon the proof of the investments made in accordance with their initially stated commitment. For the same project, the debt relief is as high as the grant funding. For energy efficiency projects, the debt relief and grant support are up to 30% of eligible costs and for renewable energy projects, they are up to 45% of eligible costs. Should an applicant be an SME, it will receive +10% to these support (i.e. 40% and 55% of eligible costs respectively). Subsidized loans offer interest rates starting from 1.03% depending mostly on the applicant's creditworthiness. Furthermore, to promote innovation and complex approaches to decarbonization in the industry, Germany awards grants for up to 50% of eligible costs on a competitive basis.

The programmes either provide minimum technical requirements to investment measures applied, or require compliance with energy efficiency benchmarks. The latter is determined by a certified company or an energy consultant. Thus, the funding may be obtained for the measures, which achieve at least 10% final energy savings. For retrofitted technologies or installations, these specific final energy savings are measured versus the average final energy consumption of the respective technology or installation over the last 3 years. For new installations, these specific final energy savings are measured against the industry average. In 2020, Germany also introduced a federal programme, which disburses a financial product, aligned with the EU taxonomy on sustainable activities. Respectively, the technical requirements are determined by the taxonomy technical annex.

The investment subsidies are accompanied by subsidies for energy consulting and audits. There are various types of these products and they accompany investment projects along its lifecycle. Energy consultants providing them are certified to ensure the quality of services. The programmes cover up to 80% of eligible costs for these services.

[81] More information is provided at www.machts-effizient.de/enms (in German).

6. Conclusions

The wood processing industry is one the most important sectors of economy in Latvia, and in total it accounts for more than half of the total energy consumption of the industrial sector - or approx. 12% of the country's final energy consumption. While the EU ETS and other policies have been adopted to reduce GHG emissions of large industrial companies, they did not address sufficiently the emissions of small companies. The wood processing branch is dominated by SMEs and therefore, in order to reduce their energy consumption and emissions, the country needs to introduce further policies.

The report conducted various types of analyses that could be helpful for the design and implementation of decarbonisation policies and investment in the wood processing sector of Latvia. The report analysed energy efficiency benchmarks used in the wood processing branch, and it also analysed several Latvian wood processing companies, to identify the most promising areas for improvement.

Based on analysis of the pilot projects, the technological processes use the most of energy in the studied industries, accounting for more than 70% of their total energy use. Of course, the available data from pilot projects used in this report does not fully represent the Latvian wood processing industry in its entirety, as data from only three companies have been used for detailed analysis. A three–year period was considered as an acceptable payback timeframe during the analysis of all the pilot projects, thus an analysis was performed with the aim to identify energy efficiency improvement measures with less than three years payback period. Although the wood processing sector is characterised by great diversity in terms of the size and specialization of companies, based on pilot projects analysis, we have identified the most promising areas of improvements as follow:

- Recovery of heat from industrial process - heat recovery from wood drying systems and aspirations systems;
- Improvement of boiler energy efficiency (control and optimization);
- Electricity savings in compressed air systems and lighting; and
- Energy and production data monitoring.

The report further tracked investment in the branch decarbonisation during the last ten years and identified the public sources to support such investment in the future. Finally, it provided lessons learned from a case study, on how Germany designed its financial incentives to promote the decarbonisation of the industrial sector. We calculated that in total, EUR 33.7 million have been invested in wood processing industry from 2011 until 2020. To the largest extent, this investment was supported from the EU funds. In 2021-2027, the NECP intends to continue implementing the decarbonisation measures in the energy sector with help of the EU funds. The exact design of the respective financial incentives sourced from the operational programme is under the development.

As the German case study showed, enterprises in Germany could often choose whether to apply for an investment grant or a subsidized loan to obtain financial support for energy efficiency or renewable energy use in their installations. It is often that subsidized loans envision not only a low interest rate but also a partial debt relief. For the same project, the debt relief of subsidized loans is often as high as the grant funding. For energy efficiency projects, the debt relief and grant support are up to 30% of eligible costs and for renewable energy projects, they are up to 45% of eligible costs. Should an applicant be an SME, it will receive extra 10% to this support. Subsidized loans offer interest rates starting from 1.03% depending mostly on the applicant's creditworthiness. Furthermore, to promote innovation and complex approaches, Germany awards grants for up to 50% of eligible costs on a competitive basis. Subsidized loans are disbursed through local branches of all German public and private banks that makes this support easily accessible for beneficiaries in all localities. The programmes either provide minimum technical requirements to investment measures applied, or require compliance with energy efficiency benchmarks. Thus, the funding may be obtained for the measures, which achieve at least 10% final energy savings. In 2020, Germany also introduced a federal programme, which disburses a financial product, aligned with the EU taxonomy on sustainable activities. The investment subsidies are accompanied by subsidies for energy consulting and audits, which cover up to 80% of eligible costs for these services.

In regard to the future research needs, still further emphasis is needed for bottom-up, industry-specific data to be collected and to be used for the development of energy efficiency benchmarks. To help companies to improve energy efficiency, the benchmarks provided in this report can be used to test project ideas based on the real-world data. Especially, it is important to establish benchmarking for cross-cutting technology such as compressed air, wood drying technologies, and aspiration equipment. In addition, more research is needed to understand better the decarbonisation potential of the industrial sector and how financiers and the government can better support its its realization by private companies.

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Annex 1: Investment breakdown by support programmes

Investment breakdown by sources, intermediaries, financial instruments, and technologies during the last ten years, EUR

Technologies / Sources, intermediaries, and financial instruments	Energy efficient production technologies	Solar PV	Thermal insulation of industrial buildings	Use of excess heat, flue gas condenser and economizers	Wood dryers, recuperation equipment	Grand Total
Private	**20673111**	**1637796**	**96273869**	**3031897**	**14341631**	**135958304**
Corporate	**20673111**	**1637796**	**96273869**	**3031897**	**14341631**	**135958304**
Commercial banks	20673111	1637796	96273869	3031897	14341631	135958304
Commercial loan	16538488,8	1310236,8	77019095,2	2425517,6	11473304,8	108766643,2
Balance sheet equity	4134622,2	327559,2	19254773,8	606379,4	2868326,2	27191660,8
Public	**15990220**	**673159**	**54905261**	**1158813**	**5023412**	**77750865**
EU Budget	**1557848**	**673159**	**166530**	**1158813**	**5023412**	**8579762**
The Central Finance and Contracting Agency (CFLA)	1557848	673159	166530	1158813	5023412	8579762
Grant	1557848	673159	166530	1158813	5023412	8579762
Public budget from ETS	**14432372**		**54738731**			**69171103**
The Latvian Environmental Investment Fund (LEIF)	14432372		54738731			69171103
Grant	14432372		54738731			69171103
Grand Total	**36663331**	**2310955**	**151179130**	**4190710**	**19365043**	**213709169**

Annex 2: Technical requirements to applications for German financial incentives

The present Annex provides minimum technical requirements for applications under the programme “Energy efficiency and process heat from renewable energies in industry - loan and grant”. The requirements are the same for applications to obtains grants from BAFA and low-interest loans with repayment subsidy from KfW[82].

Module 1: Cross-cutting technologies (effective date 01.12.2020)

Definitions

Funding is available under Module 1 for high-efficiency gensets for industrial and commercial on-site use as replacements or new purchases in the following cross-cutting technologies:

- Electric motors and drives,
- Pumps for industrial and commercial use,
- Fans,
- Compressed air generator,
- Heat exchanger for waste heat utilization or heat recovery,
- Insulation of plants or parts of plants,
- Frequency converter.

The eligibility of the systems or units applied for is checked in each case on the basis of the criteria listed below, based on evidence in the form of a manufacturer's declaration or a product or material data sheet (insulation).

Requirements

Electric motors and drivers

Funded are:

- Highly efficient brand-new electric motors as well as electric drives consisting of an efficient electric motor and a control system (speed-controlled drives) as a standard product offered on the market for stationary use.
- Frequency inverter for demand-based control of the speed of electric motors and electric drives.

What are the requirements?

[82] The information is prepared based on the following leaflets: “Minimum technical requirements for cross-sectional technologies" № 600 000 4386, "Minimum technical requirements for process heat from renewable energies" 600 000 4390 "Minimum technical requirements for measurement and control technology, sensor technology and energy management software" 600 000 4391, "Energy-related optimization of plants and processes" 600 000 4471 (all available at www.kfw.de/295).

- High-efficiency electric motors and drives
    - Electric motors with a rated output power below 0.75 kW must have a rated minimum efficiency of at least 82.4% calculated according to the procedure in Regulation (EC) No. 640/2009 of July 22, 2009.
    - Electric motors with a rated output power between 0.75 kW and 375 kW must be assigned at least to efficiency class IE4 according to Regulation (EC) No. 640/2009 in conjunction with IEC 60034-30.
    - Electric motors with a rated output power greater than 375 kW must have a rated minimum efficiency greater than 96.0% calculated in accordance with the procedure in Regulation (EC) No. 640/2009 of July 22, 2009.
- Speed control for electric motors and drives
    - The frequency inverter must be designed for the rated current of the motor (nameplate electric motor and FI manufacturer's specification).

Electrically driven pumps

Funded are:

- High efficiency centrifugal pumps and glanded pumps.
- High-efficiency glandless circulators.
- Frequency converter for pumps with variable flow.

What are the requirements?

- Centrifugal and glanded pumps
    - The electrical input power of the pump motor must not exceed 1 MW.
    - The impeller (paddle wheel) located in the volute casing must be driven via a shaft by a high-efficiency electric motor in accordance with the criteria set out in this data sheet.
    - Alternatively, the pump must have a minimum efficiency index (MEI) of 0.70 according to Regulation (EC) No. 547/2012 and be driven by a motor with efficiency class IE3 according to Regulation (EC) No. 640/2009.
    - Positive displacement pumps must also be driven by a high-efficiency electric motor in accordance with the criteria of this bulletin.
- Glandless circulators
    - The pumps must have a minimum hydraulic power of 1 W and a maximum of 2,500 W.
    - The pumps must have an energy efficiency index (EEI) 0.20 calculated according to the procedure in Regulation (EU) No. 622/2012.
- Frequency converter (speed control) for pumps:
    - The frequency converter must be designed for the rated current of the pump motor (nameplate electric motor and drive manufacturer's specification).

- The pump motor to be equipped must be designed for continuous operation in the respective frequency range.

Fans

Funded are:

- High-efficiency fans that use an electric motor to drive a rotating blade to maintain a continuous flow of gas through the unit, whose work per unit mass does not exceed 25 kJ/kg. Specification:
    - The drive of the rotary blade must be the main function of the electric motor.
    - The fan must consist at least of electric motor, rotary blade and housing.
- Frequency converter for demand-dependent control of the fan speed.
- Heat exchanger for heat recovery in ventilation and air-conditioning systems.

What are the requirements?

- High efficiency fans

    - The electrical input power of the fan must not be less than 0.125 kW and must not exceed 500 kW.
    - The fan must meet the minimum efficiency values listed in Table 1, calculated in accordance with the procedure set out in Regulation (EC) No. 327/2011

Table 1: Minimum values for the efficiency level (N)

Fan type	**Measurement category (A-D)**	**Efficiency category (static or total efficiency)**	**Minimum efficiency value (N)**
Axial fan	A, C	static	50
	B, D	total	64
Centrifugal fan with forward curved blades and centrifugal fan with radial blades	A, C	static	62
	B, D	total	65
Centrifugal fan with backward curved blades without housing	A, C	static	62
Centrifugal fan with backward curved blades with housing	A, C	static	62
	B, D	total	65
Diagonal fan	A, C	static	62
	B, D	total	65
Tangential fan	-	-	Not eligible

- Speed control for fans

    - The frequency converter must be designed for the rated current of the fan (nameplate electric motor and FI manufacturer's specification).

- Heat recovery

    - Heat recovery devices in ventilation and air-conditioning systems must at least meet the requirements of DIN EN 13053 - Class H1.

- The heat recovery figures shall be reported in accordance with DIN EN 308 (Heat exchanger test methods for determining the performance criteria of air/air and air/flue gas heat recovery systems).
- The volume flow through the heat recovery unit must be at least 2,000 m³/h.

Compressed air generators

Funded are:

- High-efficiency compressed air generators (compressors)
    - with speed control.
    - without speed control, if the compressor is operated with low switching frequency and low no-load percentage.
- Retrofitting of a higher-level control system on multiple compressors for demand-driven optimization of the overall efficiency of the compressed air station.
- Heat exchanger for heat recovery in compressed air generation systems.
- In connection with the application for a high-efficiency compressed air generator or a higher-level control system, the initial investment in an ultrasonic measuring device for detecting leaks (leakage measuring device).
- In combination with a high-efficiency compressor, moreover, the associated refrigeration dryer.

What are the requirements?

- Highly efficient compressed air generators:
    - The pressure level must be in the range between 4 and 15 bar gauge.
    - Depending on the pressure level, oil-injected compressors must have an efficiency in compressed air generation measured in accordance with ISO 1217 Annex C and the tolerances specified therein, an average specific power value[83] in accordance with Table 2.
    - Depending on the pressure level, oil-free compressors must have an efficiency in compressed air generation measured in accordance with ISO 1217 Annex C and the tolerances specified therein, an average specific power value in accordance with Table 3.
    - Refrigeration dryers are not to be considered when determining the specific power.
    - For speed-controlled compressors, the specific power consumption must be determined in each case in relation to the best point.

[83] The following is a note for manufacturers of compressed air generators: the specific power value is to be measured according to the specifications of ISO 1217:2009 (Displacement compressors - Acceptance tests). Annex C for electrically driven compressors and Annex E for variable speed electrically driven compressors are authoritative. Chapter 5 of ISO 1217:2009 regulates the design of measuring devices/instruments. The setups/procedures described there are to be followed.

Table 2: Specific power consumption of high-efficiency oil-injected compressors as a function of the nominal pressure in bar gauge (interpolation for intermediate values)

Motor rated power in kW	**Specific power value according to ISO 1217:2009 Annex C/E - Nominal pressure in bar gauge**											
	4 bar	**5 bar**	**6 bar**	**7 bar**	**8 bar**	**9 bar**	**10 bar**	**11 bar**	**12 bar**	**13 bar**	**14 bar**	**15 bar**
2,2	7,02	7,08	7,26	7,85	8,29	9,17	9,86	10,50	11,68	12,63	13,92	14,76
3	6,48	6,68	6,88	7,39	7,80	8,54	9,17	9,73	10,67	11,50	12,59	13,32
4	6,19	6,45	6,67	7,13	7,52	8,20	8,79	9,31	10,12	10,89	11,87	12,54
5,5	5,99	6,30	6,52	6,95	7,34	7,96	8,52	9,03	9,74	10,48	11,39	12,02
7,5	5,83	6,18	6,41	6,82	7,19	7,78	8,33	8,81	9,46	10,17	11,03	11,63
9	5,71	6,08	6,32	6,71	7,08	7,64	8,17	8,64	9,24	9,92	10,74	11,32
11	5,56	5,94	6,19	6,55	6,92	7,44	7,96	8,41	8,97	9,62	10,40	10,96
15	5,47	5,88	6,12	6,48	6,84	7,34	7,85	8,29	8,81	9,45	10,20	10,74
18,5	5,40	5,82	6,07	6,41	6,77	7,26	7,75	8,18	8,68	9,30	10,03	10,56
22	5,34	5,77	6,02	6,35	6,70	7,18	7,67	8,09	8,56	9,17	9,88	10,39
25	5,17	5,61	5,86	6,18	6,52	6,97	7,44	7,85	8,29	8,88	9,55	10,05
30	5,12	5,57	5,82	6,13	6,47	6,91	7,38	7,78	8,19	8,77	9,43	9,92
37	5,08	5,53	5,78	6,09	6,42	6,85	7,31	7,71	8,11	8,68	9,32	9,80
45	4,98	5,50	5,75	6,05	6,38	6,80	7,26	7,65	8,03	8,59	9,22	9,70
55	4,94	5,41	5,66	5,95	6,28	6,69	7,13	7,51	7,88	8,43	9,04	9,50
75	4,91	5,38	5,64	5,92	6,24	6,64	7,09	7,46	7,81	8,35	8,96	9,41
90	4,87	5,35	5,61	5,89	6,21	6,60	7,04	7,41	7,75	8,29	8,88	9,33
110	4,84	5,33	5,58	5,86	6,18	6,56	7,00	7,37	7,69	8,22	8,81	9,25
132	4,81	5,30	5,56	5,83	6,15	6,53	6,96	7,32	7,64	8,16	8,74	9,18
160	4,78	5,28	5,54	5,80	6,12	6,49	6,92	7,28	7,59	8,11	8,67	9,11
200	4,76	5,26	5,52	5,78	6,10	6,46	6,89	7,24	7,54	8,05	8,61	9,04
250	4,73	5,24	5,50	5,75	6,07	6,43	6,85	7,21	7,49	8,00	8,55	8,98
275	4,71	5,22	5,54	5,79	6,11	6,47	6,89	7,24	7,52	8,03	8,58	9,01
315	4,68	5,20	5,52	5,77	6,09	6,44	6,86	7,21	7,48	7,99	8,53	8,95
355	4,66	5,18	5,50	5,75	6,06	6,41	6,83	7,18	7,44	7,94	8,48	8,90
360	4,64	5,16	5,48	5,73	6,04	6,39	6,80	7,15	7,40	7,90	8,43	8,85
400	4,62	5,15	5,47	5,71	6,02	6,36	6,77	7,12	7,37	7,86	8,39	8,80
450	4,60	5,13	5,45	5,69	6,00	6,34	6,75	7,09	7,33	7,82	8,34	8,75
500	4,58	5,11	5,44	5,67	5,98	6,31	6,72	7,06	7,30	7,79	8,30	8,71

Table 3: Specific power consumption of high-efficiency oil-free compressors as a function of the nominal pressure in bar gauge (interpolation for intermediate values)

Motor rated power in kW	**Specific power value according to ISO 1217:2009 Annex C/E - Nominal pressure in bar gauge**											
	4 bar	**5 bar**	**6 bar**	**7 bar**	**8 bar**	**9 bar**	**10 bar**	**11 bar**	**12 bar**	**13 bar**	**14 bar**	**15 bar**
2,2	7,20	7,43	7,66	7,89	8,18	9,03	9,70	10,32	11,45	12,37	13,61	14,51
3	6,91	7,25	7,48	7,62	7,96	8,67	9,23	9,72	10,60	11,79	12,79	13,54
4	6,74	7,15	7,38	7,47	7,84	8,46	8,96	9,40	10,14	11,46	12,33	13,00
5,5	6,63	7,08	7,31	7,36	7,75	8,31	8,78	9,17	9,82	11,24	12,01	12,63
7,5	6,54	7,02	7,25	7,28	7,68	8,20	8,64	9,00	9,58	11,07	11,77	12,35
9	6,47	6,98	7,21	7,21	7,63	8,11	8,53	8,86	9,39	10,93	11,58	12,13
11	6,41	6,94	7,17	7,16	7,58	8,04	8,43	8,74	9,23	10,81	11,42	11,94
15	6,36	6,91	7,14	7,11	7,54	7,97	8,35	8,64	9,09	10,71	11,29	11,79
18,5	6,31	6,88	7,11	7,07	7,51	7,92	8,28	8,56	8,97	10,63	11,17	11,65
22	6,27	6,85	7,08	7,03	7,48	7,87	8,22	8,48	8,87	10,55	11,06	11,53

25	6,24	6,83	7,06	7,00	7,45	7,82	8,16	8,41	8,78	10,48	10,97	11,42
30	6,20	6,81	7,04	6,97	7,42	7,78	8,11	8,35	8,69	10,42	10,88	11,32
37	6,17	6,79	7,02	6,94	7,40	7,75	8,07	8,29	8,61	10,36	10,80	11,23
45	6,15	6,77	7,00	6,91	7,38	7,71	8,02	8,24	8,54	10,31	10,73	11,14
55	6,12	6,76	6,99	6,89	7,36	7,68	7,98	8,19	8,48	10,26	10,67	11,07
75	6,10	6,74	6,97	6,87	7,34	7,65	7,95	8,15	8,42	10,21	10,60	11,00
90	6,07	6,73	6,96	6,85	7,32	7,62	7,91	8,11	8,36	10,17	10,55	10,93
110	6,05	6,72	6,94	6,83	7,31	7,60	7,88	8,07	8,31	10,13	10,49	10,87
132	6,03	6,70	6,93	6,81	7,29	7,57	7,85	8,03	8,26	10,09	10,44	10,81
160	6,02	6,69	6,92	6,79	7,28	7,55	7,82	8,00	8,21	10,06	10,39	10,75
200	6,00	6,68	6,91	6,78	7,26	7,53	7,79	7,96	8,17	10,02	10,35	10,70
250	5,98	6,67	6,90	6,76	7,25	7,51	7,77	7,93	8,13	9,99	10,30	10,65
275	5,97	6,66	6,89	6,75	7,24	7,49	7,74	7,90	8,09	9,96	10,26	10,60
315	5,95	6,65	6,88	6,73	7,23	7,47	7,72	7,87	8,05	9,93	10,22	10,56
355	5,94	6,64	6,87	6,72	7,21	7,45	7,69	7,85	8,01	9,90	10,19	10,52
360	5,92	6,63	6,86	6,70	7,20	7,43	7,67	7,82	7,98	9,88	10,15	10,48
400	5,91	6,62	6,85	6,69	7,19	7,41	7,65	7,79	7,94	9,85	10,12	10,44
450	5,90	6,61	6,84	6,68	7,18	7,40	7,63	7,77	7,91	9,83	10,08	10,40
500	5,88	6,60	6,83	6,67	7,17	7,38	7,61	7,75	7,88	9,80	10,05	10,36

- Superordinate control for multiple compressors
    - In the case of several individual compressors conveying in parallel into the same consumer network, a higher-level control system must take over the operating mode of the individual compressors for energy-optimized coverage of the compressed air demand (e.g. operation in common pressure band).
- Heat recovery
    - The thermal recovery capacity must correspond to at least 70% of the electrically absorbed power of the compressor in nominal operation.
- Ultrasonic measuring device
    - Funding is provided exclusively in combination with another funded measure. A maximum of one leakage measuring device with net investment costs of a maximum of EUR 500 is funded per applicant.

What special evidence has to be provided?

- The verification of the best point for speed-controlled compressors is carried out by the manufacturer
- Proof of heat recovery must be provided by means of a calculation based on the product data sheets of the heat exchanger and compressor.

Heat exchanger for waste heat utilization or heat recovery

Funded are:

- Heat exchanger for waste heat utilization or heat recovery from a heat-carrying wastewater or process water stream

What are the requirements?

- With a heat transfer coefficient (k-value) of the heat exchanger of 600 W/(m^{2}K), the mean logarithmic temperature difference must not exceed 12 K.
- With a heat transfer coefficient (k-value) of the heat exchanger between 600 W/(m^{2}K) and 800 W/(m^{2}K), the average logarithmic temperature difference must not exceed 10 K.
- With a heat transfer coefficient (k-value) of the heat exchanger between 800 W/(m^{2}K) and 1000 W/(m^{2}K), the average logarithmic temperature difference must not exceed 8 K.
- With a heat transfer coefficient (k-value) of the heat exchanger between 1000 W/(m^{2}K) and 1200 W/(m^{2}K), the average logarithmic temperature difference must not exceed 6 K.
- If the heat transfer coefficient (k-value) of the heat exchanger exceeds 1200 W/(m^{2}K), the average logarithmic temperature difference must not exceed 4 K.

The temperature of the source circuit must not exceed 100 °C. The mean logarithmic temperature difference (∆Tm) is calculated according to the following formula:

$$\Delta T_m = (\Delta T_{max} - \Delta T_{min}) / ln\left(\frac{\Delta T_{max}}{\Delta T_{min}}\right)$$

$\Delta Tmax$: inlet temperature of the stream to be cooled - outlet temperature of the stream to be heated.

$\Delta Tmin$: outlet temperature of the stream to be cooled - inlet temperature of the stream to be heated

Insulation of plants or plant components

Funded are:

- Insulation of previously uninsulated plant components (e.g. pipelines, tanks, flanges, valves, fittings).
- Replacement and upgrading of existing insulation systems.
- Insulation in new construction of facilities

What are the requirements?

- The execution of the insulation must be in accordance with DIN 4140.
- Eligibility Variant A: Insulation layer thickness and thermal conductivity of the insulation material.

If the reference insulation thickness calculated according to Table 4 is reached or exceeded and at the same time the thermal conductivity of the insulation material used reaches or falls below the values listed in Table 6 or Table 7 (at the present mean temperature).

- Eligibility Variant B: Heat flux density (q)

When the heat flux density reaches or falls below the value calculated according to the formulas in Table 4.

Table 4: Formulas for the calculation of the eligibility of the insulation

Mean temperature [°C]	$\vartheta_m = \frac{\vartheta_M + 15}{2}$
Reference thermal conductivity (λ_R) for thermal insulation [W/(m*K)].	$\lambda_R = 0.0377 + 9.548 * 10^{-5} * \vartheta_m + 1.516 * 10^{-7} * \vartheta_m^2 + 3.723 * 10^{-10} * \vartheta_m^3 + 0.01$
Reference thermal conductivity (λ_R) for cold insulation [W/(m*K)].	$\lambda_R = 0.0355 + 1.17 * 10^{-4} * \vartheta_m + 4.85 * 10^{-8} * \vartheta_m^2 + 5.58 * 10^{-10} * \vartheta_m^3$
Reference insulation thickness (S_R) [mm].	Heat range greater than 15 °C: $K_1 = \frac{0.14 * \lambda_R * (\vartheta_M - 15)}{d_i^2}$, $K_1 = \frac{0.19}{d_i}$ Cold range from 15 to -30 °C: $K_1 = \frac{0.06 * \lambda_R * (15 - \vartheta_M)}{d_i^2}$, $K_2 = \frac{0.1}{d_i}$ $\omega = 0.96 + 0.6052 * e^{-0.1362K^2} * K_1^{0.3429+0.02102K_2}$ Reference insulation thickness: $S_R = \frac{d}{2} * (\omega - 1)$
Permissible heat flux density	Tube $q = \frac{2 * \pi * \lambda_R * (\vartheta_M - 15)}{ln\left(1 + \frac{2s_R}{d}\right)}$ in W/m Wall: $q = \frac{\lambda_R * (\vartheta_M - 15)}{s_R}$ in W/m

Table 5: Formula symbols

Size	Unit	Description
ϑ_M	°C	Medium temperature
ϑ_m	°C	Mean temperature for determining the thermal conductivity
d	mm	Inner diameter of the insulation / outer diameter of the insulated round part of the plant
d_i	m	di = d for round components with a diameter ≤ 1,220 mm di = 1,220 mm for round components with diameter

		> 1,220 mm and for flat surfaces
K_1, K_2	-	Dimensionless key figures of the ecological insulation thickness
λ_R	W/(m-K)	Reference thermal conductivity
ω	-	Ratio of outer and inner diameter of insulation
s_R	m	Reference insulation thickness
q	W/m	Length-related heat flux density of a pipe
q	W/m²	Heat flux density of a wall

Note: A concrete calculation example for determining the reference insulation layer thickness, the thermal conductivity as well as the heat flux density can be found in the glossary, which is provided for download on the web pages of our funding program.

Table 6: Thermal conductivity for thermal insulations

Mean temperature in °C	**Thermal conductivity in W/(m-K):** λ_R**-0.01*2**
50	0,043
100	0,049
150	0,057
200	0,066
250	0,077
300	0,090
350	0,106
400	0,124

Table 7: Thermal conductivity (λ_R) for cold insulation

Mean temperature in °C	**Thermal conductivity in W/(m-K):** λ_R
-30	0,032
-20	0,033
-10	0,034
0	0,036
10	0,037

Special feature with regard to eligible costs for the insulation of systems or system components:

- In contrast to the other subsidy categories, the installation and assembly costs are considered part of the investment costs for the insulation of systems or system components.

Module 2: Process heat from renewable energies (effective date 01.12.2020)

Definitions

Under the measure “process heat from renewable energies“ is promoted the replacement or new acquisition of systems for the provision of heat from solar collector systems, heat pumps or biomass systems, more than 50% of the heat of which is used for processes, i.e. for the manufacture, further processing or refinement of products or for the provision of services (e.g. laundries, swimming pools, etc.).

The following heat sinks do not constitute processes within the meaning of the document[84]:

- District heating (sale of heat);
- Domestic hot water supply (for example, in hotels);
- all installations that fall within the scope of the Building Energy Act (GEG).

In addition to heat generators, eligible investment costs include in particular:

- Heat storage for heat generators applied for,
- Connection of the heat generators applied for to the heat sink(s) relevant to the process heat, in the case of a heat pump also the connection to one or more renewable heat sources,
- Elevation and substructure for solar collectors,
- necessary construction measures for the installation or setup of the biomass plant or heat pump (e.g. foundation or enclosure),
- the measurement and data acquisition equipment installed for yield monitoring and fault detection.

In addition, expenses eligible as incidental expenses include costs for:

- Feasibility assessments and planning in connection with the implementation of a requested measure, as well as
- Installation and assembly costs.

Not eligible are:

- Investments in supplementary heat generators based on fossil fuels,
- Costs for insurance, necessary tests, expert opinions and permits,
- Measures for required improvements to the structural system on and in the building.

Requirements

The Company shall comply with all legal requirements in connection with the investment and shall duly obtain all necessary permits, expert opinions, inspections, and the like. Furthermore, the following applies:

- The system periphery must be adapted or designed to suit the system applied for. Over- or undersized components are to be avoided.
- In the course of the implementation of the measure, hydraulic balancing must also be carried out.
- In connection with the requested investment, effective precautions must be taken to prevent unwanted convection currents (e.g., storage tank connections can be siphoned) and confirmed by the implementing company.
- To ensure that deposits can be removed periodically, shut-off valves and connections for flushing must be provided on the secondary side (fresh water side) of the plate heat exchanger if the system applied for serves to heat fresh water. This must be confirmed by the company carrying out the work.

[84] The list is not exhaustive.

- For documentation purposes, the amount of heat generated by a plant must be continuously measured in each case and the data recorded on a monthly basis for at least 3 years. The following applies:
    - For systems below 100 kWth, it is sufficient to measure the amount of heat introduced by the system into the storage tank by means of a heat meter.
    - For systems from 100 kWth, the useful heat yield must be measured, i.e. the heat quantity fed into the heat sink after line and storage losses. Depending on the system hydraulics and the integration of fossil reheating, several heat meters may be required for this purpose.
    - Regardless of the system output, the process heat component must be verified by measurement for systems that have both a process and a building heat component.

Solar collector systems

Funded are:

- Solar collectors tested according to Solar Keymark and achieving a collector yield (Qkol) of at least 525 kWh/m^2 according to the following calculation formula.

$$Q_{kol} = 0.38\left(\frac{W_{25}}{A_{ap}} - C_{eff}\right) + 0.71\left(\frac{W_{50}}{A_{ap}} - C_{eff}\right)$$

In each case data according to Solar Keymark data sheet:

W_{25} = Annual collector output in KWh/collector module for the location Würzburg at an average collector fluid temperature of 25°C.

C_{eff} = effective thermal capacity per unit area in kJ/m^{2}K

A_{ap} = collector aperture area in m^2

W_{50} = Annual collector output in kWh/collector module for the location Würzburg at an average collector fluid temperature of 25°C

The performance of solar collectors without a Solar Keymark certificate must be proven by an accredited testing body by means of measured performance parameters per expert opinion. The eligibility for funding is decided on the basis of this proof.

Eligible solar collectors are listed under: www.bafa.de/qw595m. For systems that are not listed but meet the technical requirements of this data sheet, the entry "Other & special design" must be selected in the course of the application when selecting the manufacturer. The proof of eligibility must be attached to the application.

What are the requirements?

- Planning, installation and commissioning must be carried out in accordance with the instructions and specifications of VDI 3988.

"Solar thermal process heat" must be carried out. This must be confirmed by the company carrying out the work.

- The useful heat yield of the solar process heating system must be determined by an annual simulation.
- The installation must be planned and executed frost and stagnation-proof. This must be confirmed by the company carrying out the work.

Heat pumps

Funded are:

- Heat pumps certified according to one of the established European series regulations (EHPA, MCS, Keymark, NF- PAC, Eurovent, etc.) and operated in the temperature range of the test conditions in the intended application. The heat source and heat sink temperatures must not deviate by more than 5K above or below the test conditions.

Certified electrically driven heat pumps whose intended operating point exceeds the test conditions by more than 5 K up or down, as well as non-certified electrically driven heat pumps, are eligible if they:

  - achieve an effective coefficient of performance (COPeff) of at least 2.0 at the temperatures specified by the application according to the manufacturer's specifications. For this purpose, a manufacturer's verification (e.g. in the form of a performance curve or table) for the corresponding heat pump and the given application must be submitted with the application, and
  - additionally achieve a quality grade of at least 0.4 at the intended operating point according to the following formula based on VDMA Standard Sheet 24248:

Calculation grade:

$$n_{WP} = \frac{COP_{eff}}{COP_{max}} = \frac{COP_{eff}}{\left(\frac{T_{VL,WS} + 273{,}15}{T_{VL,WS} - T_{VL,WQ}}\right)}$$

n_{WP} = grade

COP_{eff} = effective coefficient of performance according to proven manufacturer's specification for application COPmax = maximum achievable coefficient of performance based on Carnot efficiency

$T_{VL,WS}$ = flow temperature of the heat sink supplied by the heat pump in °C

$T_{VL,WQ}$ = flow temperature of the heat source used by the heat pump in °C

  - For outdoor air as heat source, the COPeff and the quality grade at 0 °C of the source are decisive.

- Gas heat pumps are eligible if they achieve a PEReff of 1.2 for the intended application. As with electrically driven heat pumps, proof of this for the corresponding heat pump and the given application must be submitted with the application.
- Note: Only heat pumps that use renewable aerothermal, geothermal, hydrothermal or solar heat sources are eligible for funding in this module. Heat pumps that use another heat source (e.g. waste heat) may be eligible for funding in Module 4.

What are the requirements?

- For all heat pumps, the required drive energy must be continuously measured with an electricity or gas meter and recorded for at least 3 years.

Eligible heat pumps are listed under: www.bafa.de/qw595m . For systems that are not listed but meet the technical requirements of this information sheet, the entry "Other & special design" must be selected in the course of the application when selecting the manufacturer. The proof of eligibility according to section 1.2 must be attached to the application.

Biomass plants

Funded:

- Combustion plants including boilers that use biomass-based fuels in accordance with § 3 Paragraph 1 Number 4, 5, 5a, 6, 7, 8 or 13 of the 1st BImSchV[85] and which are not single room combustion plants[86].
    - Biomass facilities that have been determined eligible according to the list.
    - Biomass systems for which the manufacturer of the system confirms that the efficiency of the boiler (including economizer, if applicable) exceeds the minimum temperature-dependent efficiency for the intended application based on the lower heating value to be calculated according to the following formula:

$$\eta_{min} = 94 - 0.065 * (T_{Abgas} - 55)$$

η_{min} = minimum efficiency for eligibility in %.

T_{Abgas}= Exhaust gas temperature of the biomass plant for the intended application in °C.

- Associated fuel storage with conveyor systems.

Not funded:

[85] Systems for the use of fuels from palm and eucalyptus cultivation and from tropical woods are not eligible.
[86] Furnaces that do not have a heat distribution device and whose generated process heat does not directly affect a process.

- Installations for the use of biomass for which the Ordinance on the Incineration and Co-incineration of Waste (17th "Ordinance on the Implementation of the Federal Immission Control Act"), as amended, applies.

What are the requirements?

- The possibility of using the calorific value must be checked. The test must be confirmed by the company performing the test.
- Biomass plants of 100 kW or more must be equipped and operated with a waste gas heat exchanger[87].
- To extend the maintenance intervals, the use of a particle separator upstream of the exhaust gas heat exchanger should be considered.
- The quantity of fuel used (t) must be documented with its origin, any environmentally relevant markings and the calorific value (MWh/t) for three years from the commissioning of the plant and kept available for possible inspections.

Eligible biomass plants up to 100 kW are listed under: www.bafa.de/qw595m . For systems which are not listed but which meet the technical requirements of this data sheet, the entry "Other & special design" must be selected in the course of the application when selecting the manufacturer. The proof of eligibility must be attached to the application.

Module 3: I&C, sensors and energy management software

Definitions

Funding is provided under Module 3 for, among other things, software and hardware related to the establishment or application of an energy or environmental management system, in particular the acquisition, installation and commissioning of:

- of software solutions to support an energy management system or environmental management system (energy management software);
- sensors and analog-to-digital converters for recording energy flows and other variables relevant to energy consumption for the purpose of integration into the energy or environmental management system, and
- of control and regulation technology for influencing systems and processes, provided that the primary purpose of their use is to reduce energy consumption.

Eligible investment costs include, but are not limited to:

- Acquisition of an initial license to use energy management software and its relevant software components.
- Acquisition of
  - Sensors for integration into an energy or environmental management system or alternative system, o Analog-to-digital converters,
  - Actuators for efficient control or regulation of energy flows,
  - Data loggers as well as gateways for the transmission of sensor data to the software solution, the use of which should lead to a quantifiable reduction in energy consumption.

[87] Requirements of the respective state building code must be checked. Any necessary approvals must be available.

- Instruction or training of personnel by third parties in the use of the funded software solution.
- If the energy management software is a cloud service, the full external costs for use incurred within the grant period.

In addition to installation and commissioning, ancillary costs also include cabling or other technologies and the preparation of a system concept by an external third party.

Not eligible:

- Purchase, install and commission computers/servers to run energy management software and view consumption data/reports.
- Software updates as well as license renewals.
- Monitors, printers, uninterruptible power supplies, and other peripherals.
- Acquisition, installation and commissioning of a building/process control system, as well as control and regulation technology that does not serve the purpose of reducing energy consumption or increasing energy efficiency.
- Purchase, installation and commissioning of industrial PCs or programmable logic controllers to operate a building/process control system that is not for the purpose of reducing energy consumption or increasing energy efficiency.

Requirements

A prerequisite for funding in module 3 is that the respective funded operating facility has a DIN EN ISO 50001 certified energy management system or a registered environmental management system in accordance with the EMAS Regulation. SMEs can also apply for funding in module 3 if the respective subsidized operating facility has a certified, alternative system in accordance with the Peak Compensation Efficiency System Ordinance Annex 2 (to Section 3 No. 2 SpaEfV). An application is already possible if the operating facility is in a certification, registration or testing process (proof based on the order confirmation of the certification company). However, the certification, registration or testing must be carried out at the latest by the time the proof of use is submitted and must be valid for at least the duration of the intended use (3 years from commissioning). For evaluation purposes, the energy indicators recorded in the management system must be stored for at least 3 years from the commissioning of the investment applied for.

Energy management software

An energy management software is an electronic data processing technology that evaluates metrological data for the energetic evaluation and energetic baseline of the organization based on the applicable DIN EN ISO 50001. It must be structured according to the PDCA cycle (Plan-Do-Check-Act cycle) and, in particular, offer the possibility of tracking the set energy targets (controlling and monitoring). All eligible software solutions can be found in the list at the following link: www.bafa.de/qw595m

To be included in the list of eligible solutions, the software must be compliant with DIN EN ISO 50001. This requires the following functionalities:

Function	Description
	Output of sums, mean values, extreme values

Data evaluation	Formation of key figures on energy consumption, specific energy consumption, energy consumption per reference value, fuel consumption per reference value
	Resolution of the data in predefined time intervals, freely definable
	Cost calculation: energy tariff input function, assignment of cost centers
Visualization	Display by line chart (hydrograph), bar chart
	Possibility of individual diagram adjustment, free choice of temporal resolution, recording of several curves in one diagram, display of limit values
Reporting	Output of time-controlled energy reports (e.g. monthly report), presentation of long- and short-term consumption development
	Electronic dispatch of reports, output in common format (e.g. PDF/Word)
Alarms	Early warning mechanism, individual setting of thresholds, automatic Alerting when threshold values are exceeded
	Electronic transmission of the alarm
Integration in existing Systems	Data import for integration of any measurement data, data export in common formats (e.g. csv, xlsx)
	Generation of data point lists
	Control technology: Building management system (BMS), process control system (PCS)
Support	Support in case of problems for at least three years from purchase, employee training, set-up of the software, update service

Cloud-based solutions that meet the above requirements can also be included in the list of eligible solutions.

Measurement and sensor technology

Stationary measurement and sensor technology is eligible for funding if it records the relevant variables for determining and evaluating energy consumption. These include, in particular, current, voltage, electrical power, temperature, amount of heat and/or cold, volume flow (liquid, gaseous), lighting intensity and compressed air volume.

The measurement or sensor technology must be directly related to an energy management system or environmental management system. A direct reference to the energy or environmental management system exists if the measurement results flow into the management process via a listed software solution. The integration can take place directly or via a control system from which the data is read out. The integration must be demonstrated by means of a system concept.

Control and regulation technology

The primary purpose of the control and regulation technology must be to reduce energy consumption. The control or regulation technology must be directly related to an energy management system or environmental management system. A direct reference to the energy or environmental management system exists if the effect of the control or regulation can be quantified by a listed software solution. The direct reference to the energy or environmental management system must be demonstrated by means of a system concept.

Technical documentation for the application

In addition to the documents required in principle for the application, a system concept must be submitted when applying for funding, which clearly shows that the hardware applied for is integrated into the energy or environmental management of the operating site.

System concept

The system concept as defined in this funding module must represent the integration of the hardware into an energy management software and must include

- for the application of measurement technology and sensor technology, a data acquisition plan as defined in 5.9 of DIN ISO 50015:2018-04 and
- for the application of control technology, an action plan in the sense of DIN IEC 60050-351:2014-09 supplemented by a parts list of the sensors and actuators to be used.

Data acquisition plan

Table 1 presents a minimal proposal for a data collection sheet. The data collection plan described in DIN ISO 50015:2018-04 serves as a template.

Table 1. Example data collection sheet

Variable name	Physical Size	Location of the Measuring point	Conveyor-object	Device-designation	Responsibility	Capture-frequency
Energy supplier	Electric Energy in kWh	Transformer station Depot	No	EVU meter	EM Software XYZ	Quarterly
Plant 2_operating transformer1	Voltage in V	NSHV Plant 2, Location Cologne	Yes	Sensor Amp + DatLog Poly	EM Software XYZ	Quarterly
Plant 1_Compressor 3	Compressed air quantity in m³/s	Plant 1, Compressor room	Yes	ABC123 V1L + DatLog Poly	EM Software XYZ	Quasi-continuous

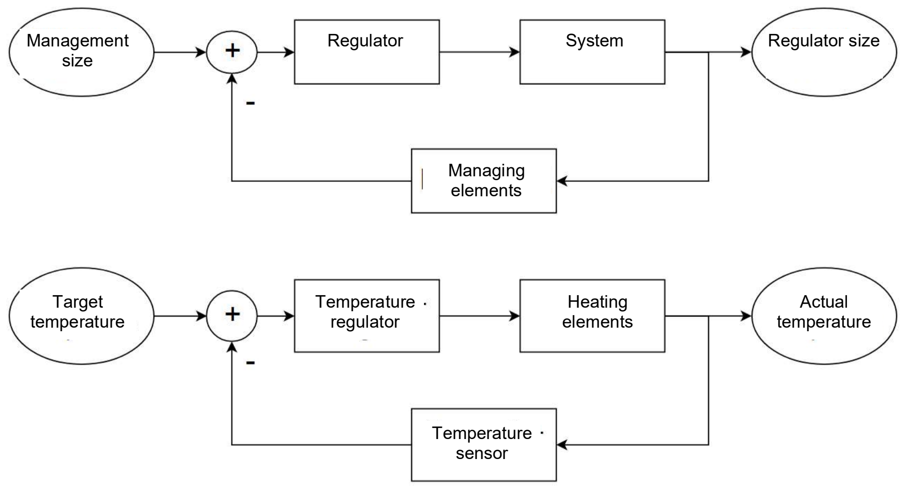
In the event that a data collection plan with a different structure is to be submitted, care must be taken to ensure that at least the above information is included.

If the application includes more than one company location, this must be indicated in the data collection plan.

Impact plan

Figure 1 shows in a simplified form how the impact plan of a control system might look like in general and as an example for a heating control system. When creating impact plans, it is important to ensure that at least the function blocks shown in the figure are specified.

Figure 1 Example of action plan (general and heating control)



Notes: explanation of the subject of funding

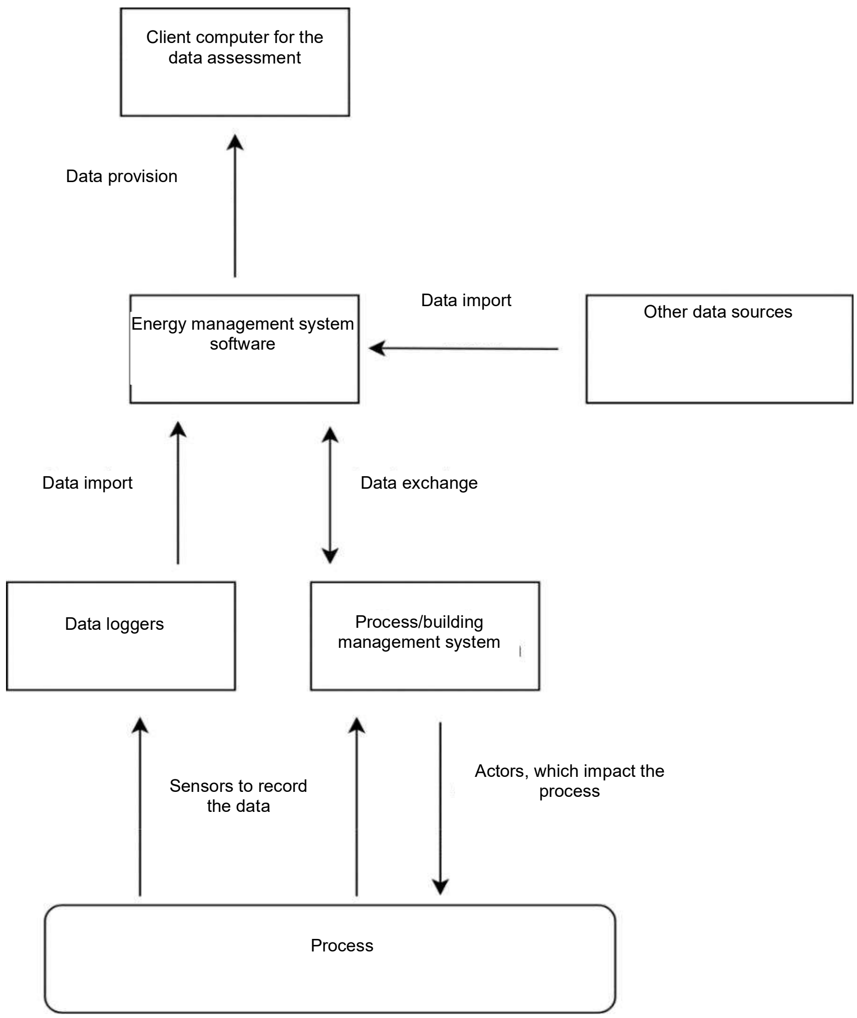
Various sensors collect a variety of measured variables (e.g. temperatures or power consumption) relating to the corresponding process (see Figure 2). The data is aggregated by a data logger and made available to the energy management software. Furthermore, the energy management software can import data for the evaluation of energy consumption from further sources, for example the POS system or weather services. Finally, a separate client computer is used to evaluate the data provided.

The energy management software can continue to transmit data, for example on the optimal operation of the process, to the control system.

The sensors can also transmit the data directly to a process or building control system (hereinafter referred to only as "control system"), which then exports the relevant data to the energy management software.

The control system acts on the process with the aid of actuators to ensure that it runs as desired (for example, with regard to the target variables of product quality, operational safety or energy consumption).

Figure 2: Interaction of the various components



Definitions

Actuator: Technical component for influencing a system or process in a targeted manner, for example a control valve for influencing the flow through a pipe.

Energy management software: An electronic data processing technology that evaluates metrological data for the organization's energy assessment and energy baseline based on the applicable DIN EN ISO 50001, EMAS or the alternative system according to the Peak Efficiency System Ordinance (SpaEfV).

Energy management system: Is a certified system that meets the requirements of DIN EN ISO 50001.

Control: Targeted influencing of a system on the basis of a setpoint/actual comparison. For example, influencing a radiator valve to influence the room temperature, whereby the room temperature is measured and used to set the valve.

Sensor: Technical component for recording chemical or physical properties of a process or a system. For example, thermocouples for temperature measurement or pressure gauges for pressure measurement.

Control: Targeted influencing of a system without a comparison between setpoint and actual value. For example, influencing a radiator valve to influence the room temperature, although this is not measured.

Environmental Management System: is a registered Eco-Management and Audit Scheme based on Regulation (EC) No. 1221/2009 (EMAS).

Modude 4: Energy-related optimization of plants and processes

Definitions

Funding is available for investment measures to optimize the energy efficiency of industrial and commercial facilities and processes in order to increase energy efficiency or reduce fossil energy consumption in companies. The funding is open to all technologies and can also include the measures listed under modules 1 and 3. Eligible measures include in particular:

- Process and process conversions to efficient technologies and energy optimization of production processes, such as the use of energy-efficient systems and machines or replacement of individual components, energy-efficient modification of process control or the process, optimization of measurement and control technology including energy management software.
- Measures for waste heat utilization, e.g. integration of waste heat for the provision of heat including all measures required for this at the plant or building technology, feeding into heat networks including the connecting lines, measures for the conversion of waste heat into electricity (e.g. ORC technology).
- Measures at plants for heat supply, cooling and ventilation, provided that these are clearly and predominantly used for processes for the production, further processing or refinement of products.
- Measures for the energy-efficient provision of process heat or cold, such as energy-efficient heat and cold generators, optimization of heat or cold storage.
- Measures to prevent energy losses in the production process, such as insulation of equipment and distribution lines, hydraulic optimization, renewal of compressed air lines.

In addition, expenses for the preparation of a savings concept and implementation support for the subsidized investment measure by external energy consultants are eligible for funding. Success or performance bonuses of any kind are not eligible for funding and can therefore not be taken into account when determining the amount of funding.

Facilities and structural measures that cannot be clearly and predominantly assigned to a process or that fall within the scope of the Building Energy Act (GEG) are not eligible for funding.

Requirements

Eligible projects are those that demonstrably lead to final energy savings or to a reduction in fossil energy consumption and the associated reduction in CO_2 emissions. The payback period (PA) of the entire project in module 4 must also be more than 2 years in total without claiming a subsidy.

Eligible investment costs (€) of all measures applied for under module 4 [AZ = ∑(final energy savings per energy source [MWha] x energy price per energy source[MWh€])]

Technical documentation for the application

When submitting an application, a savings concept prepared by an energy consultant must be submitted. The energy consultant must be approved by BAFA in the program "Energy Consulting in Small and Medium-Sized Businesses".[88] For the company being advised, the consulting must be manufacturer-, supplier-, product- and sales-neutral as well as technology-neutral.

Note: If the applying company has an energy or environmental management system certified in accordance with DIN EN ISO 50001 or EMAS for the specified location, the savings concept can be prepared in-house. In this case, proof of valid ISO 50001 or EMAS certification must be submitted with the application. If the savings concept is drawn up internally, the costs incurred cannot be taken into account when determining the amount of the subsidy.

Requirements for the savings concept

The savings concept forms an essential basis for assessing whether and to what extent the measure(s) applied for can be funded. The energy consultant must therefore describe the planned measure(s) in sufficient detail and in a comprehensible manner in the savings concept. In particular, the following information must be provided:

1. Description / representation of the site
2. Description of the actual state of the system to be optimized
3. Qualitative description of the optimization measure (target state)
4. Representation of the energy consumption and the system utilization (in each case in the actual and in the target state)
5. Investment costs

The basis for the survey and evaluation of energy consumption and savings potential is a comprehensive, systematic inventory of the affected system and the main influencing factors. The target status is defined as all - i.e. also possible negative - effects of the measures applied for on the Energy demand of the company/ or on the company location to be taken into account.

[88] BAFA provides the list of certified experts: www.energie-effizienz-experten.de.

The calculation methods applied to determine the energy demand and CO2 emissions in the target and in the actual state must be suitable, must comply with the state of the art, and must be plausible, transparent, and comprehensible.

Both the individual calculation parameters and the (manufacturer's) specifications of the equipment concerned, such as for example nominal power, running time, number, manufacturer, type, etc. must be listed and to substantiate suitable (technical) documents.

Note: A consulting report prepared as part of energy consulting for SMEs funded by BAFA is not understood as an application-compliant savings concept. However, the findings and calculations obtained from the energy consulting can be transferred to the savings concept by adding descriptions and explanations and structuring the respective measures.

Determination of the energy and CO_2 saving potential when changing the system use

If the implementation of the measures applied for leads to a change in the system benefit, e.g. to an increase in output, the energy or CO_2 saving is basically calculated from the difference between the specific energy demand of the actual and target state and the multiplication of the result with the system benefit (number of units, output units or similar) in the actual state.

Example:

The existing plant (actual state) has a final energy consumption of 1,000 kWh and an output of 100 units.

The new plant (target state) has a final energy consumption of 1,500 kWh and an output of 200 units.

Specific final energy consumption (actual state) =10 kWh/unit

Specific final energy consumption (target state) = 7.5 kWh/unit

Specific final energy savings = 2.5 kWh/unit

Total final energy saving = 2.5 kWh/unit * 100 units = 250 kWh

Note: Alternatively, the energy demand in the target state can also be compared with the energy demand of a reference investment, provided that the reference plant represents a feasible and economical alternative. Irrespective of this, it should be noted that a reference investment which has a significantly different operating process compared to the target state (e.g. changes in operating/shift times, increase in personnel requirements, etc.) cannot be used as a reference for calculating the energy consumption in the actual state. In this case, however, the same procedure/scenario must be used to determine the additional investment costs for applications under the GBER.

Determination of the energy and CO_2 savings potential for the first-time acquisition of a plant / system

If the measure applied for is a first-time new acquisition[89] or addition[90] to the system under consideration and not a replacement investment, funding is only possible if it is accompanied by a final energy saving and thus a reduction in "future" CO2 emissions compared to a reference plant. Only a technologically comparable but less energy-efficient new plant that is also freely available on the market is eligible as a reference plant. In addition, it must meet the statutory minimum energy efficiency requirements (if the technology is listed in the Ecodesign Directive 2009/125/European Community, the corresponding minimum requirements apply). Furthermore, both installations must have identical/comparable system benefits. Both the reference system and the comparability must be presented in the savings concept.

Promotion efficiency / specific CO_2 emission factors

The subsidy for measures according to module 4 is limited to a maximum amount of 500 € (for small and medium-sized enterprises to 700 €) per ton of CO2 saved per year. The CO2 factors (available below) are binding for the calculation of CO2 emissions per energy source. The factors are stored in the savings concept and the CO2 emissions are calculated automatically. If energy carriers are not listed, "Other" can be selected in the savings concept and a separate factor can be entered. A sound and reliable proof of the calculation method must be enclosed.

Parallel application of measures according to module 4 and module 2 (process heat from renewable energies)

CO_2 savings from measures applied for in parallel under Module 2 can be taken into account for the calculation of the funding efficiency in Module 4. The measures applied for under module 2 must also be presented in the savings concept in a comprehensible manner. The investment costs of the measures applied for under module 2, on the other hand, do not play any role in determining the (maximum) grant amount in module 4.

Proof of implementation / proof of use procedure

The grant/repayment bonus is paid out after the audit of the proof of use has been positively concluded. In the case of subsidies under Module 4, this also requires the confirmation from the energy consultant/expert on the proper implementation of the measure(s) outlined in the savings concept. The confirmation is made by submitting the corresponding form with the proof of use. If changes have occurred during implementation that are decisive for the approval, these must be presented in detail in an updated savings concept. This does not apply to cases where only the eligible costs have changed.

Specific CO_2 factors

The factors shown in the table below are binding for the calculation of CO2 emissions per energy source. The factors are stored in the savings concept for all energy sources; CO2 emissions are calculated automatically.

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[89] For example, the initial installation of a compressed air station.
[90] For example, adding another air compressor to an existing compressed air station without decommissioning/replacing an existing compressor.

Note: It should be noted that the factors refer to the calorific value of the energy sources. If the energy consumption is based on the calorific value, this must first be converted.

Energy source	Unit	CO2 factor
Domestic electricity	tCO_2/MWh	0,427
Local/district heating	tCO_2/MWh	0,280*
Heating oil light	tCO_2/MWh	0,266
Heating oil heavy	tCO_2/MWh	0,288
Liquid gas	tCO_2/MWh	0,239
Natural gas	tCO_2/MWh	0,201
Hard coal	tCO_2/MWh	0,335
Lignite	tCO_2/MWh	0,383
Raw gasoline	tCO_2/MWh	0,264
Diesel	tCO_2/MWh	0,266
Biomass wood	tCO_2/MWh	0,027
Pellets	tCO_2/MWh	0,036
Biodiesel	tCO_2/MWh	0,070
Biogas	tCO_2/MWh	0,152
Sewage sludge	tCO_2/MWh	0,010

In reality, the emissions in the local and district heating sector can deviate significantly upwards and downwards depending on the generator park. When entering the savings concept, it is therefore possible to enter a different value. Proof of the calculation method must be enclosed.

If energy sources used are not listed, "Other" can be selected in the savings concept and a separate factor entered. Proof of the calculation method must be enclosed.

If renewable energies are already used to provide heat or electricity, it is permissible to use the factor for "natural gas" or "domestic electricity".