Report

on regional added value of renewable energy in BSR

WP2.3 Fostering regional development through renewable energy in BSR

Tartu Regional Energy Agency

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The project "Baltic Energy Areas – A Planning Perspective" (BEA-APP) 11 partners from eight countries around the Baltic Sea cooperate to support the transition towards low-carbon energy systems. BEA-APP brings together two perspectives: spatial planning as well as regional energy policy. The project aims at increasing the capacity of regional and renewable energy planning actors by:

- Providing adjusted spatial planning instruments targeting renewable energy development,
- Developing innovative stakeholder involvement methods and financing systems to increase social acceptance through local ownership,
- Applying the developed measures to pilot cases, studying the features of suitable renewable energy production sites and, thereby, setting the scene for concrete projects.

BEA-APP is a flagship project under the EU Strategy for the Baltic Sea Region (EUSBSR).

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Abstract

Delivering regional growth and socio-economic benefits by deployment of renewable energy sources in the BSR

The use of renewable energy sources (RES) is seen as a key element in energy policy, reducing the dependence on fuel imported from non-EU countries, reducing emissions from fossil fuel sources, and decoupling energy costs from oil prices. The majority of Baltic Sea region (BSR) countries and regions have reached the 2020 renewable targets.

The link between the expansion of RE and the resulting economic benefits has been discussed in numerous surveys with different geographical focuses, tending to downscale from the national to the regional level, and summarising economic and business outcomes of renewables in the BSR level. This report summarises data mining, analysis and assessment of the regional impact of deployment of RES technologies by key indicators, regional profiles of renewable energy technologies and conceptual modelling of macro-regional tiers and trade. Deployment of renewables contributes to regional growth, creates jobs and increases value added as well as to the climate change mitigation and the environment.

The report elaborates on the drivers for RES and draws conclusions on the emerging innovative and competitive renewable sector in BSR regions, taking into account regional potentials as well uneven patterns of natural, economic and social capital.

BEA-APP Executive Summary: fostering regional development via RES

Key messages, evidences, and policy recommendations on regional benefits of RES

This executive summary presents the key messages, evidence, and policy recommendations for delivering regional growth and socio-economic benefits by deployment of renewable energy sources.

RES status

- There has been a rapid expansion of renewable generation capacity in BSR over the 2000s and 2010s. The growth has been predominantly in bioenergy, wind and solar capacity though hydro energy dominates the Nordic-Baltic electricity market. The participating regions of Sjælland, Mecklenburg-Vorpommern, Southern Estonia, Zemgale, Kaunas County, West Pomerania, Central Finland, Blekinge and Skåne are more renewable than BSR countries.
- RES in heating (H&C, cooling is exceptionally low) is high in BSR countries, led by Sweden (68%), followed by Latvia (53%), Finland (52%), Estonia (47%) and Denmark (40%) (2017).
- Combined heat and power (CHP) is a dominant technology producing more than half of the total energy supply in all listed regions - in some cases up to 80%.
- Renewable energy contributes to the macro-economy in terms of the value added, income and employment that it generates from its production, transformation and distribution as well via manufacturing, R&D and trade of renewable energy technologies.
- The substitution of renewable energy for fossil fuel inputs offers the opportunity to reduce exposure to volatile global energy prices. If the renewable equipment is manufactured within BSR countries (Germany, Sweden, Denmark and Poland as a renewable powerhouses), it also offers the possibility of reducing BSR countries' energy trade deficit, and, potentially through first-mover advantages, establish an industry that can serve European and global markets.
- Bioenergy is the most job-creating renewable energy, while the large hydro is the least. The ratio of jobs in investment&development, operations&maintanence (O&M) and biomass provision of the bioenergy sector is as follows: 3:2:4. Off shore wind is the strongest job creator in the investment and development phase.
- Solar energy demonstrates a new wave of renewable jobs and value added, based on microgeneration and the prosumer model, though installations are getting bigger and faced with deployment barriers.
- Progress in the Baltic states has been faster than in the more mature markets of the Nordic countries. However, the scale of investment required to decarbonise the power generation sector in eastern and southern BSR countries is still large and will require the mobilisation of private finance, incl strong growth in private R&D.

Factors of RES progress

- The regional renewable business model is the most complex in bioenergy (CHP, biogas, small-scale heating).
- Two major factors impact allocation and deployment of renewable facilities: availability of resources and transmission capacities as well the consumer base in heating.
- Generally, stronger focus should be given to making in-depth analysis of emerging sources such as solar and wind to speed up deployment and to avoid administrative burdens. The main problem is lack of data and regionally poorly disaggregated statistics; however, qualitative data can be used as substitute and supplement.

The value chain tends to be longer in bigger countries, and the added value is higher due to manufacturing of renewable technologies. The value chain stage of systems manufacture and site development contribute the largest share (>50%), in case of wind energy up to 85%. Due to the open and more globalised economy the value added increases in trading renewable technologies, specifically in solar, heat pumps and bioenergy.

- The scale of economics, macroeconomic and GDP-level implications, and different modelling methods make transnational comparison highly complex and uncertain. In smaller countries, only a couple of big facilities play a dominant role in the regional economy. Therefore, the role of regulators as well the optimal division of resources and assets is important to avoid oligo-monopolistic domination and concentration (vulnerability).
- Investment-project-based progress is strongly dependent on a business model which relies on support schemes (feed-in tariffs, investment grants, private investment from banks – government guarantees). Both business and technological cycles in RES are implemented much more quickly than they were in the conventional energy. Business indicators such as rate of return focus on short-term profits (annual IRR 7-8%), which might be not beneficial in the long run. Sweden has kept increasing investments in RE as other BSR countries declined in recent years.

Policy recommendations

- A strong political agenda for climate and environmental policy exists, but benchmarking and evidence-based policy-making on a regional scale is poor. For example, despite its growing importance, the energy chapter is missing in the Eurostat regional yearbook (in the regional statistics, only heating and cooling degree days are available by region). Also, the national gap exists as the regional energy statistics is more advanced in the Nordic countries and Germany, but less so in the Baltic states and Poland. Therefore, strategic decision-making is based on political ideology rather than facts, figures and evidence.
- National estimates for jobs in RES tend to be overestimated provided in cross-European surveys, and uncertainty is high as it is difficult to separate "pure" RES jobs from jobs in infrastructure/the grid as well R&D, while co-generation combined fossil fuels has been increased. Business statistics remain loose in the value chain, starting from resource management and harvesting to generation and supply. Public administration and project support is only partially accounted for.
- As macroregional integration and trade plays increasingly stronger role, interdependency between national electricity systems should deepen, with benefits shared by all. A narrow, national perspective on power system security fails to reap the significant cost savings offered by cross-border cooperation, transmission and barrier-free trade.
- Investments in RES are facilitated by a dynamic regulatory framework that attempts to reduce the risk for investors and hence the cost of capital. However, incentives need to be reduced in line with falling technology costs in order to avoid over-compensation, which is the case in many countries and regions, whether related to the lock-ins in the energy market or to the emerging technologies.
- The promotion of RES serves mainly climate objectives in the EU policy framework and less energy security and accessibility in the open and liberalised electricity market and regulatory heating market. The secondary benefits of the development of RES include innovation, reduced air pollution, the creation of jobs and local/regional added value.
- Pronouncing the ethos of the Paris agreement, government ideology is a political factor that impacts the stringency of climate and energy policies. However, the implementation of energy transition and the deployment of renewables in regions depends on integrity of policy model, harmonised measures and shared commitments at national, regional and local level. Currently,

the administrative and financial burden is disproportionate at local authorities in case of the Baltic states.
- Policies promoting the energy transition need to keep in view the wider land-use and environmental impacts (the energy-water-food nexus) which may create opposition of some stakeholders or interest groups.
- Renewables play an important role in public relations for the regional promotion.

1. Introduction

The core objective of task 2.3 "Fostering regional development through renewable energy" of the Baltic Energy Areas – a Planning Perspective (BEA-APP) project is to assess the general regional importance of RES conversion considering RES generation and consumption in the BSR countries and pilot regions. Additionally, the main gross economic impacts of the RES sector are presented, including the total value added by the RES sector as well as gross employment effects due to RES deployment. Indirect regional impact is assessed using case studies and regional approaches.

The work package aims at the following:

1. Assessing and enhancing the renewables in the participating regions. It relates to the **regional development potential of renewable energy** for the structural changes in the energy sector and in the regional economies, in particular in rural areas and in (post)transition countries. Increasing the share of RES in the energy mix is also of strategic importance for regional policy.
2. Structural changes in the energy sector resulting from the increased production and use of renewable energy are **generating new territorial dynamics** and further developing the value chains and business models of the agriculture and forestry sectors in particular.
3. **Renewables should enable local assets, including capital and assets, natural resources and human resources.** The renewable energy sector is characterised by decreased labour intensity and may increase value added. It takes advantage of new markets originating from the demand for renewable energy and energy-efficient solutions.
4. RES technologies having a **value chain with a multiplying effect** contribute to regional economies and enable local natural and human capital. Controversially, a narrow approach in the energy sector could add only a few new jobs or even create labour decreases, though the indirect effect in processing or in energy distribution chains could be increased.
5. **ICT and innovations**. A new phenomenon in the energy sector is incorporating new sectors such as ICT and other service and knowledge-based sectors.

The work package for seeking regional benefits integrates the following tasks:

- **Elaboration and setting a common methodology** for assessing regional RES value chains as well BSR macro-regional tiers,
- **Selecting and compiling headline regional indicators** to explore territorial implication factors (quantitative and qualitative) and to describe the establishment and drivers of RES, focusing on specific needs for regional data on energy supply, demand, intensity and efficiency as well as structural change,
- **Assessing major RES schemes**, models and best practices as regional development and rural diversification cases in the security, economic and environmental dimensions,
- **Conceptual modelling of the BSR macro-regional, regional and local value chains** of RES and the related trade balance, which mainly focuses on bioenergy and biofuels, BSR direct foreign investment and BSR 'multinational' firms.
- **Robust comparative assessment of socioeconomic benefits and regional potentials**, mainly indicated by added value, jobs, and energy trade, RES electricity, heating/cooling and bioenergy.

The report has been contributed to by all partners of the The Baltic Energy Areas – a Planning Perspective (BEA-APP) project. The report has been drafted and edited by Antti Roose (Tartu Regional Energy Agency, Estonia) with the full expert support of Christina Landt and Tyge Kjær (Roskilde University, Denmark), Jennifer Grünes (EM-M-V, Germany), Hannu Koponen and Virpi Heikkinen (RCCF, Finland), Evija Ērkšķe (Zemgale Planning Region Administration), Nerijus Pedisius (Lithuanian Energy Institute), Tomasz Furmańczyk (Regional Office for Spatial Planning of the Westpomeranian Voivodeship), Monika Oredsson and Jenny Rydquist (Region Blekinge, Sweden), and Marcus Larsson (Skåne Energy Agency). The team thanks experts and institutions in data, analysis and support.

2. Methodology for assessing regional potentials and importance of RES

2.1. Framework

Establishing a common methodology and headline regional indicators to describe the establishment and drivers of RET is based on the following three conditions:

- **Realistic considerations on data availability on a regional scale**: receiving responses and feedback from partners/regions, data search and mining, project surveys, data availability and quality;
- **Using qualitative methods for assessment**: elaborating and facilitating the methodological framework to complement the quantitative approach and empirics;
- **Using value chain cases and in-depth (bottom-up) analysis to explore regional potentials and benefits**: the BSR coverage according to the regional specialisation.

The transnational relevance of this group of activities is achieved through joint methodology development and knowledge transfer of regional development models based on RES from the BSR. The project partners involved represent relevant parts of the target group as well as a representative mix of the BSR regions. The national scope and scale should also be considered as the macroeconomics and the scale of economics play a significant role in energy transition. The availability of regional data is assessed in relation to the national datasets and possible disaggregated analysis. The data availability on regional level is poor and the quality control of the regional data on energy production, consumption and RES shares (inconsistencies in methods and annual progress) affected the analysis in great extent.

Table 1. Regional data on RES

RES importance	Impacts and indicators
1. Regional/national energy autonomy and security	Share of regional RES total MWh produced, share, households influenced, District Heating, CHP, Electricity
2.Regional economic development	Jobs; energy price sold to grid energy; consumer energy price
3.Regional contribution to climate policy	CO_2 emissions and reduction of CO_2, Structural changes from fossil to RES; Energy saved

Three dimensions of regional benefits are assessed in relation to the regional economy and the region's contribution to climate policy. In addition, the nation's energy autonomy and security become key as the trade balance, including energy trade in the energy system, has an economic impact on national economy. As the energy transition is supported by an increasingly integrated market and cross-European and macro-regional networks, the concept of energy autonomy has been steadily withdrawn and taken over by 'affordable and clean energy for EU citizens and businesses'. A European Energy Union will ensure secure, affordable and clean energy for EU citizens and businesses by allowing a free flow of energy across national borders within the EU and bring new technologies and renewed infrastructure to cut household bills, create jobs and boost growth. State-of-the-art autonomous and decentralised energy systems are demonstrated within given geographies, settlement structures and emerging technologies. Higher energy costs can be associated with weaker export performance for energy-intensive industries. Such cross-sector links are neglected as it is difficult to identify the impact of energy costs on the output and investment decisions. The share of energy-intensive industries in GDP has also continuously declined in the past decade.

Gross value added and employment: direct and total impact of RES

It is a widespread phenomenon that RET deployment impacts regional economies, sectors and social welfare. The major effect on employment appears in the energy sector. The energy market and final energy consumers are incidentally influenced when converted from conventional energy to renewables. The drop in the cost of renewable technology has gone far beyond all expectations. In this path, the economics, leaving and cutting down steadily support are now decisively tipping in favour of renewable energy.

RET deployment impacts the energy sector, generation technologies and transmission, distribution and marketing. Many stakeholders are involved in this rearranged and distributed value change. The use of RET may impact market prices as the power supply curve and the demand for fuels changes. The shift in supply and demand results in a price change. This is passed on to the final consumers, whether wholesale, industrial or domestic.

The current pricing system includes various policy-induced tariffs which effect consumption at the end-user stage. So far, though to a lesser extent, the RET deployment is promoted through the public investments and grant schemes which accordingly have a substantial impact on penetration of RES and energy transition as well on other public investments and budgeting depending on political decision and public budget strategies. The use of RET has an impact on technological innovation and practices which could lead to changes in production, technology costs, efficiency and trade.

It's a cliché that there is considerable potential for gross job creation in renewable energy. However, the extent of the employment effect is often debated because bottom-up detailed surveys count far more less jobs than macroeconomic modelling and national strategic forecasts which serve the cross-European benchmarking and amplify society's multipliers in line with EU energy and climate policy. Most studies agree renewable deployment is associated with net job creation. The number of jobs depends on a range of factors such as extent of deployment, labour policy, export and the multiplier effects of deployment on the rest of the economy. The system is more sophisticated and comprehensive in bigger countries. RET affects other economic sectors, for example, changing commodity or land prices. These impacts are not explicitly considered here as they are beyond the scope of the model.

According to the Fraunhofer (2016) synthesis the multiple impacts of RET deployment are presented in the figure and the types of impacts are summarised in the table below.

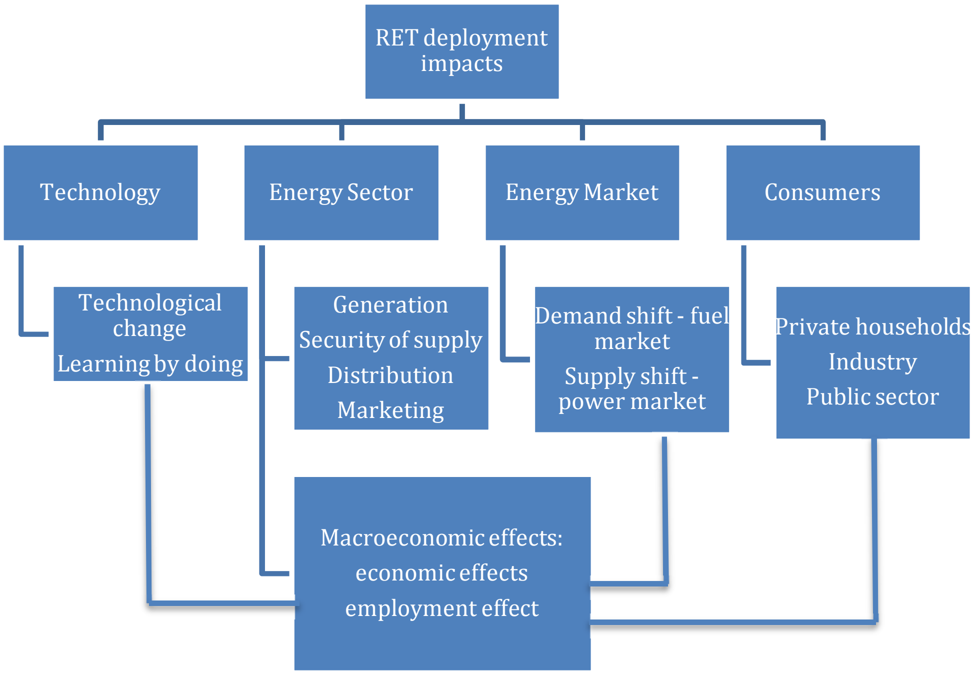


Figure 1. Impacts of RET deployment on technology, the energy sector, the market and consumption (Fraunhofer 2016).

Table 2. Types of regional impacts

Direct impact	Indirect impact: second-round effects	Economic impulses on energy sector
One-time effects of development and deployment	Entire value chain	Induced effects across energy consumers
First-round effects of O&M expanded RET-facilities	Spin-off effects in the rest of economy	Induced effect in energy mix and technologies

Investments in the energy technology and service industry trigger production and hence employment. Direct effects refer to jobs, which are directly and positively related to RET and often negatively to conventional energy technologies if investments in these technologies may be replaced by RET. Indirect effects change demand in sectors also affect economic functions and activities in initial stages of energy sectors.

Let's refer to key figures. The European Parliament declares renewable energy industry has an annual turnover of €129 billion and employs over a million people. Fraunhofer (2014) estimated that there is **44 billion euros direct of value added** produced and **one million directly employed** in the renewable energy sector, which doubles if indirect value added and indirect jobs added are taken into account. The million people employed in RES seems to be a symbolic, easy-going figure, which is confirmed by multiple sources and surveys. The total jobs in the renewable sector account for almost 1% of total employment, though value added remains a bit lower at 0.7%. Gross value added by RES totalled €94 billion in 2011. Employment of 2 million was estimated in 2011, though admittedly, that is an outdated number.

Table 3. Direct and total added value and employment of RES sector in the European Union (Fraunhofer, 2014)

Direct vs total	Direct value added	Direct employment	Total value added	Total employment
Unit	m€	Th employed	m€	Th employed
RES investment	24500	500	59900	1170
RES operation	11400	220	18100	350
RES fuel use	8500	270	16100	440
TOTAL	**44400**	**990**	**94100**	**1960**
% of EU total	**0.3%**	**0.4%**	**0.7%**	**0.9%**

On other hand, investment in European RES has fallen in recent years: from €88 billion in 2011 €47 billion in 2014 and €44 billion in 2015, despite record levels of investment in offshore wind projects (IRENA 2017).

Excluding large hydropower, which is massively capital-based and has a rather small employment effect per installed capacity, IRENA (2017) estimates 334 thousand jobs in Germany, of which 143 thousand are in wind power, 45 thousand in solid biomass and 45 thousand in biogas. The rest of EU contributes 667 renewable jobs, one third in solid biomass.

Investments in renewable energies (with the exception of bioenergy) are characterised by high upfront costs and low operational costs. Once an investment decision has been taken, investors have little room for adapting it to changing regulatory and market conditions.

The total Baltic Sea Region employment in the renewable energy sector counts for 555 thousand jobs (both direct and indirect). The macroregional renewable sector turnover is more than 64 billion euros. Germany dominates the RE market, contributing about half. As shown by another source, EurObserv'ER, with the most recent 2016 data, the employment in Germany, the biggest RE country in Europe and BSR, is given substantially less at 283 thousand with turnover of 35.5 billion euros. The share of renewable jobs is higher in Latvia (3.2%), Estonia (2.4%), Finland (1.7%) and Denmark (1,7%).

Table 4. Turnover and direct and indirect employment of renewable energy sector in 2016 (EurObserv'ER, 2017)

	RE turnover	**RE jobs**	**RE jobs**	**RE jobs**	**RE jobs**
Country / Unit	**billion €**	**th**	**% of total**	**dominant**	**2nd**
Denmark	7.37	43.0	1.67%	wind	biomass
Germany	35.50	283.1	0.72%	wind	biomass
Estonia	0.84	14.6	2.41%	biomass	heat pumps
Latvia	1.00	27.4	3.20%	biomass	biofuels
Lithuania	0.71	18.3	1.40%	biofuels	biomass
Poland	3.69	81.8	0.52%	biofuels	biomass
Finland	6.30	39.2	1.69%	biomass	heat pumps
Sweden	8.74	47.9	1.04%	biomass	heat pumps
BSR TOTAL	**64.15**	**555.3**	**0.83%**	wind	biomass
EU28 TOTAL	**149.25**	**1427.0**	**0.67%**	biomass	wind

As shown in the figure below, the installed capacity and investment bulk of RES differ by types. The Estonian data exemplifies that the investments in wind energy add more capacity than bioenergy, biogas and hydroenergy. The share of renewable energy has increased strongly in Estonia in the past ten years, due mainly to a growth in wind power and biomass, which is used for household heating and for district heating, including combined heat and power (CHP) technologies.

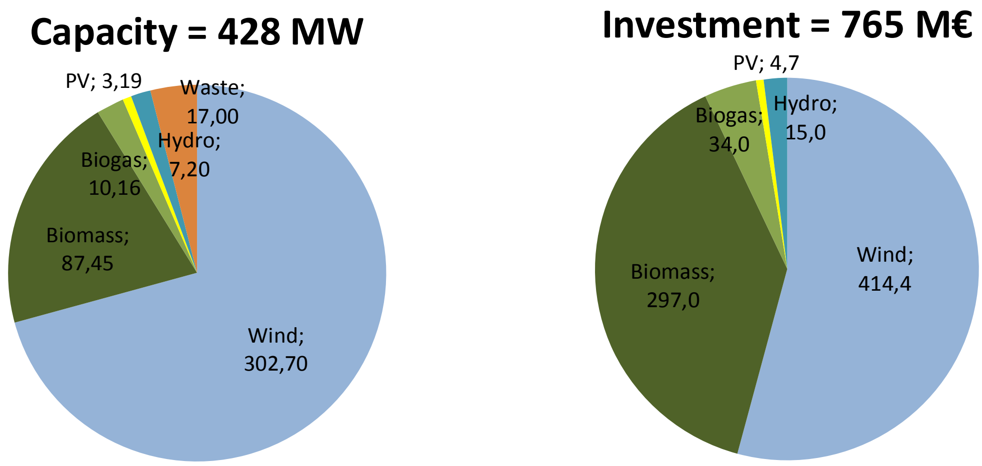


Figure 2. Total capacity vs investment of RES in Estonia (capacity 428 MW, investments 765 M€)

2.2. Pilot regions

The NUTS3 is a basic regional scale, though Sjælland, Mecklenburg-Vorpommern and West Pomerania are NUTS2 regions. Germany and Poland as bigger countries are to be analysed and assessed on a higher territorial scale which can adjust the administrative hierarchies in bigger and smaller countries. Disaggregating Sjælland to NUTS3 units (eastern and western) complicates the renewable energy analysis.

Table 5. The list of BSR focus regions

NUTS2/3	Country	NUTS code	Population th	Area km²	Pop density inh/km²	Final energy consumption M toe	RES % in final cons.	Dominant renewable
Sjælland	Denmark	DK02	833	7 273	114	2.0	29%	Bioenergy
Mecklen.Vorpommern	Germany	D80	1 607	23 174	69	3.3	115%	Wind
Southern Estonia	Estonia	EE008	315	16 698	21	0.6	50%	Bioenergy
Zemgale	Latvia	LV009	235	10 733	23	0.3	63%	Bioenergy
Kaunas county	Lithuania	LT002	570	8 089	74	na	na	Bioenergy
West Pomerania	Poland	PL42	1 715	22 896	74	0.5	na	
Central Finland	Finland	FI193	276	19 950	17	1.5	38%	Bioenergy
Blekinge	Sweden	SE221	158	3 039	53	0.6	64%	Bioenergy
Skåne	Sweden	SE224	1 325	11 302	118	na	na	

The biggest pilot regions by population are West Pomerania, Mecklenburg-Vorpommern and Skåne, the smallest Blekinge, Zemgale and Central Finland. The largest regions by territory are Mecklenburg-Vorpommern and West Pomerania, the smallest Blekinge. The population density is the highest in more urbanised Skåne and Sjælland, while sparsely populated peripheral and rural regions include Central Finland, Southern Estonia and Zemgale.

2.3. Setting headline regional indicators

The headline indicators approach provides a comparative outlook on renewables. The indicator trends are described on the basis of a set of specific quantitative rules. Selecting and compiling headline regional indicators and territorial implication factors (quantitative and qualitative) describes the main characteristics and explores drivers of RES. This workflow of methodology focuses on specific needs for regional data on energy supply, demand, intensity and efficiency as well as structural change. The dynamics of energy transition was evaluated in the 10-year period 2004-2014 to consider the EU accession of eastern countries and the progress in renewable energy. The regional data was delayed and assessed for the period 2008-2014 as a rule.

The EU has facilitated and advanced the energy and climate statistics to a great extent in the last decade and advances in statistics continue to support policy developments. The RES calculation is implemented in Eurostat's SHARES tool, which directly signals trends and progress. National statistics available in Eurostat, collected and summarised in the macro-regional and national context are as follows:

❑ **Europe 2020 indicators on energy and climate** (source: Eurostat)
- Greenhouse gas emissions, base year 1990 (t2020_30)
- Share of renewable energy in gross final energy consumption (t2020_31)
- Primary energy consumption (t2020_33)
- Final energy consumption (t2020_34)

❑ **RES statistics** (source: Eurostat, below code)
- Primary production of renewable energy by type (ten00081)
- Gross inland renewable energy consumption (tsdcc320)
- RES-Electricity: Electricity generated from renewable sources (tsdcc330)
- RES- Transport: Share of renewable energy in fuel consumption of transport (tsdcc340)
- RES-combined: Combined heat and power generation (tsdcc350)
- Greenhouse gas emissions intensity of energy consumption (tsdcc220)

❑ **Socio-economic data:** it requires comprehensive data mining, referencing special surveys (EurObserv'ER) as national statistics are not yet elaborated for the socio-economic assessment of RES.
- Gross value added by RES.
- Employment in RES.
- Fiscal revenue due to RES.
- Qualitative assessment: assessment matrix, which is based on panel estimates, also high-low, other merits and features are given on a comparative basis.

Table 6. RES indicator established on the national and regional scale.

Indicator	Unit	Definition
Final energy consumption	Million TOE (tonnes of oil equivalent)	Final energy consumption is the total energy consumed by end users, such as households, industry and agriculture.
Share of renewable energy in gross final energy consumption	%	Eurostat: the renewable energy shares calculation methodology.
Electricity generated from RES	% of gross electricity consumption	This indicator is the ratio between the electricity produced from renewable energy sources and the gross national electricity consumption.
Gross inland energy consumption of RES	1 000 tonnes of oil equivalent	Renewable energy in gross final energy consumption
Combined heat and power generation	%	Share of combined heat and power (CHP)
Greenhouse gas emissions per capita	Tonnes of CO_2 equivalent per capita	The indicator shows trends in man-made emissions of the 'Kyoto basket' of greenhouse gases.

Contextual, methodological and temporal inconsistencies exist in the regional scope. As a result of data screening the following indicators have been selected: RES in gross final energy consumption (%), RES-E production (toe and %), and CHP (%). The latter is the most representative at the regional level. The company-level data and regional sum provides inputs on bold impacts, though it remains non-systematic due to differences in taxation and indirect flows and multipliers. However, the question remains: can we zoom in on regionally listed indicators to explore social-economic contributions and implications of renewable sources and technologies in regional scale and scope? The 'conventional' RES national dataset required additional enquiries and processing to disaggregate data on a regional basis, to proceed with data mining or to seek project-based surveys the methodology of which is not necessarily fit for purpose. The analysis is elaborated first in absolute figures, though it is supplemented for comparative assessment as in normalised figures per capita and per installed capacity MW.

In addition, OECD, the International Energy Agency, the World Energy Council and other reports of umbrella and think-thank institutions give a synthesis of regional growth related to the energy transition being given as reference, comparative or support data.

2.4. Case study on regional RET value chains

This part of regional analysis is based on the bottom-up approach and provides the outlook according to the regional specialisation or selection of renewables. Regional case studies rely much more on the qualitative approach to generalise renewable progress. The statistics are based on special surveys or contributed to by a renewable company.

The assessment embodies counting job creation and wealth creation, and enumerating 'other' environmental, climate or socio-economic benefits scoping in regions, the major RES companies or landmark/dominant facilities. This part required a review of studies of 1) regional- and national-level benefits, 2) benefits delivered by a RES sector, project, or projects, 3) RES employment/economic stimulation and 4) energy security and environmental benefit valuation.

The four stages of the value chain assessment are subdivided into various value chain steps, depending on the specific technologies involved. Systems manufacture includes the manufacture and production of the various components; O&M covers items such as maintenance and fuel costs; and the system operator stage includes energy generation profits and their associated tax revenues. For each of the value chain steps, the cost structures of investments in the specific technologies and system operations turnover are identified.

The model includes a wide range of renewable energy technology value chains, representing a broad portfolio of distributed power and heat-generating facilities which can be taken as value chain models. The list is regionally representative for CHP and district heating networks fed by renewable energy sources, onshore wind, biogas and emerging solar. Also, premium biofuels are represented by the Estonian case. Thus, essentially all technologies and plant sizes in the areas of renewables that would be applicable to the nine BSR regions are analysed. Renewable energy cases such as hydropower, which is very important in renewable electricity, and deep geothermal, which is an important source to generate heating energy in Sweden, are not included in the study.

The primary basis for assessing value added in the model is an analysis of the specific turnovers relating to installed capacity along the renewable energy technology value chain. The value chains are broken down uniformly into four stages, reflecting the various phases of the life cycle of a renewable energy facility, and thus provide for comparability across all technologies. The systems manufacture and planning and installation stages account for one-time impacts, arising before a facility is placed into operation. The operation and maintenance (O&M) and system operator stages, on the other hand, include annually re-occurring effects that continue throughout the entire operational lifespan of a facility. Research and development and dismantling are further stages, but they are not explicitly analysed here, since their impact at the regional level is minor.

A few model results, namely Mecklenburg-Vorpommern, Sjaelland and Central Finland, correspond to the net value added provided by sectoral or facility accounts. A company's economic data in the RE value chains are estimated, followed by an assessment of taxes paid by enterprises and employees. The template of the regional renewable energy technology lays the basis for assessment of regional benefits in the next subsection.

2.4.1. The model regional RET template

The regional model of renewable energy technology and its value chain
Region: the model of renewable technology
Pls narrow down sector-wise and regionally, or choose 1-2 major units, representative in the county or city

Regional importance

Energy autonomy	Economy	Innovation	Environment & climate

High, medium, low

Trend 2010-15

Production	Investment	Employment	Innovation

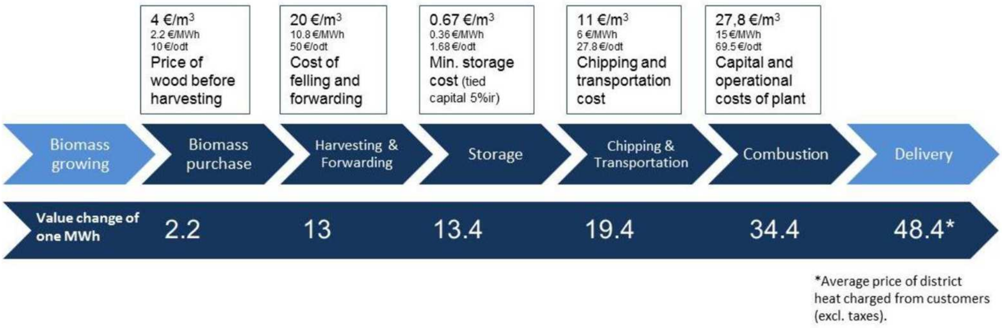
Strong increase, increase, stable, decline, strong decline

Maturity of value chain:

Emerging, growing, transforming, stagnating, declining etc examine the dynamics of changing system.

Regional value creation

Value change of 1 MWh or choose other unit indicator, absolute figures, estimates



Example: District heating value chain in Finland (BioPAD, 2014)

Stages of value chain	Added value regionally
Project development	
Manufacturing	
Installation	
Grid connection	
Operation	
Consulting	
R&D	
Financial services	

Key indicators and landmark developments

What is publicly available and region-wide dis-aggregated, could be downscaled/upscaled to the single plant or summing up just major units. You can use absolute figures instead of normalised. Pls use given indicators if too speculative to fill-in 6 given estimates, expecting at least one monetary/added value and one job-related indicator

Value added in EUR

Impact on employment, new jobs created 60 in pellet mills, up to 100 job in harvesting etc

Reduced CO_2 emissions kg/MWh

Investment cost €/MW

Production cost €/MWh

Employment person y/MWh

Drivers

What are the main drivers and forces behind. RES growth in addition to the EU energy and climate policy. Pls narrow down political drivers, fine-tune default and mainstream macroeconomic statements and avoid rhetoric and greenwashing.

The value chain and core technologies

Visual schematic process (to be redesigned and standardised later). Describe the cascade of RET, how value chain contributes to an efficient transition to low carbon energy system, direct and indirect impact on regional economies. The impact of greater system integration in the region (or nation-wide). List core/main technologies adopted and diffused in the region. Google your regional reports and surveys, insert critical upgrades and elements, we'll reformat the illustrative part, add references at the end.

Weakest link

Describe limiting factors and weakest links in the value chain. Renewable sources/commodities, equipment suppliers; project developers; engineering services; operations and maintenance; consultancy

Resource & technology	Market & socio-economic	Nonmarket & stakeholder

Outlook

Describe the potentials and forecasts in energy transition and RET deployment, considering major policies and support measures, market conditions (supply-and-demand-side), and other circumstances which may be of concern.

Sources

2.5. The survey on BSR tiers, business models and trade

The template 'BSR energy tiers and trade – focus on renewables' is elaborated and structured for fill-in by partners at the national scale. It aims to explore a country's flows in regard of RES transition and energy market liberalisation. As the BSR tiers have been intensifying year by year in terms of capital, trade and engineering/expertise in the RES energy sector, the dimension of pan-European and global trade has an inevitable effect on macro regional tiers. However, the BSR electricity market plays a major role in market liberalisation and energy transition though this report does not intend to provide a synthesis of Nord Pool Spot trading and the trends of the interconnected electricity market. The wholesale electricity price is determined hourly based on the balance of demand and supply in the BSR common market, as an incentive for the most affordable electricity production.

This part of the analysis indicates the developments which may have a dominant, cutting-edge, or critical role in trade and business development across borders in the BSR. The survey is based on national statistics, BSR reports and special case studies. The country reports are delivered in the form of a template presented in the next sub-section.

2.5.1. The template 'BSR energy tiers and trade'

BEA-APP
BALTIC ENERGY AREAS
A PLANNING PERSPECTIVE

EU STRATEGY FOR THE BALTIC SEA REGION
FLAGSHIP

Interreg
Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Tiers, business models and trade in the BSR energy market–renewables' focus

The BSR macro-regional tiers, trade and know-how transfers in regard renewable sources

Summarise your national trends and perspectives of macro regional renewable tiers in relation to electricity market liberalisation, taxation, trade, capital and know-how flows. Compromise national statistics, case studies and business briefs as well other reliable sources. Below, some BSR-scale indicators on electricity market are listed though this overview is not intending to copy Nord Pool reporting and other market analysis.

Country

RES implications of electricity market liberalisation

Use national statistics and briefings to indicate energy transition in BSR trade flows due to exchange and market liberalisation. Describe drivers and major feedbacks and implications of electricity market liberalisation if relevant for RES.

Electricity trade balance (GWh)

	2011	2012	2013	2014	2015
Import					
Export					
Balance					

Countries Transmission capacity MW

Biomass and biofuels trade

Summarize BSR and cross-border biomass trade, the indicate trends in biomass and biofuels market

Capital, know-how and companies

Select and summarize benchmarking investments, capital and know-how flows between BSR countries or cross-border

Sources

3. Headline regional indicators

3.1. Europe 2020 and RES indicators

The nation's and regions' contributions in climate change are indicated by the greenhouse gas emissions.

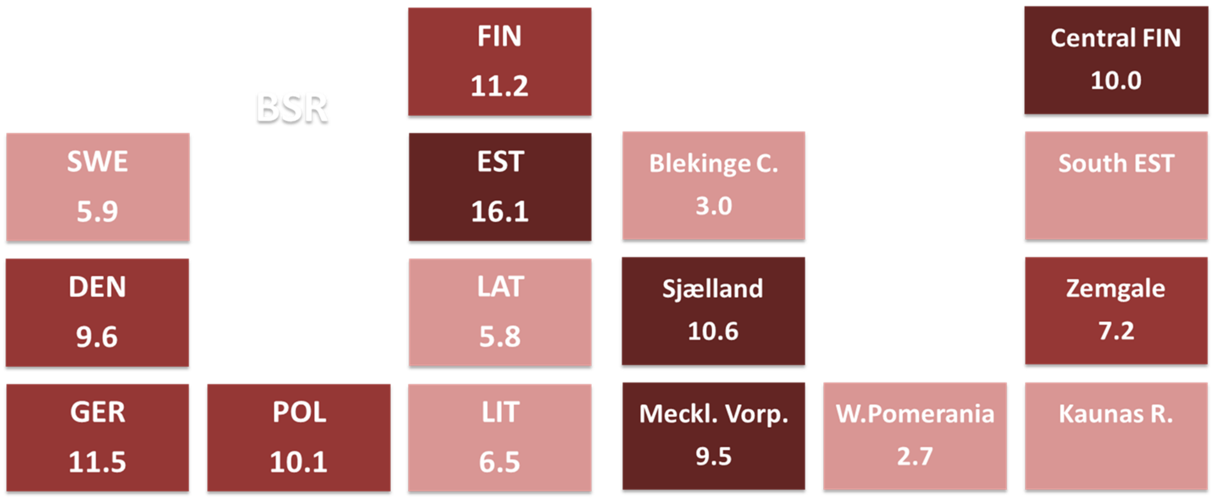


Figure 3. Greenhouse gas emissions per capita 2014, t CO2 eq per capita (Eurostat, authors) (darker colours indicate higher intensity).

Per capita, Estonia is the least climate-friendly country, followed by Germany, Finland, Poland and Denmark. In a regional comparison based on per capita, Sjælland, Central Finland and Mecklenburg-Vorpommern are the biggest GHG emitters. West Pomerania, Southern Estonia, Kaunas County and Blekinge are the regions that emit the most GHG, which is based primarily on deployment of renewables.

As a direct indicator, the question arises about what kind energy we consume and what the share of renewables is. This indicator may be considered an estimate of the RES generating and energy gross consumption indicator. The BSR average indicates 21% RES in consumed energy. Sweden has the most renewable energy, followed Finland and Latvia. The shares and trends vary by project regions.

The figure below illustrates the share of renewables in final energy consumption and the progress made in 2004–2014 (2016 if available). The latter shows the increase of RES in all BSR countries. The same pattern of moderate increase of RES consumption is on the regional level in 2008–2014. Exceptionally, Mecklenburg-Vorpommern produces more RES than it consumes. In Blekinge, Zemgale and Southern Estonia more than half of the energy consumed is renewable, due to the high share of heating in the energy balance.

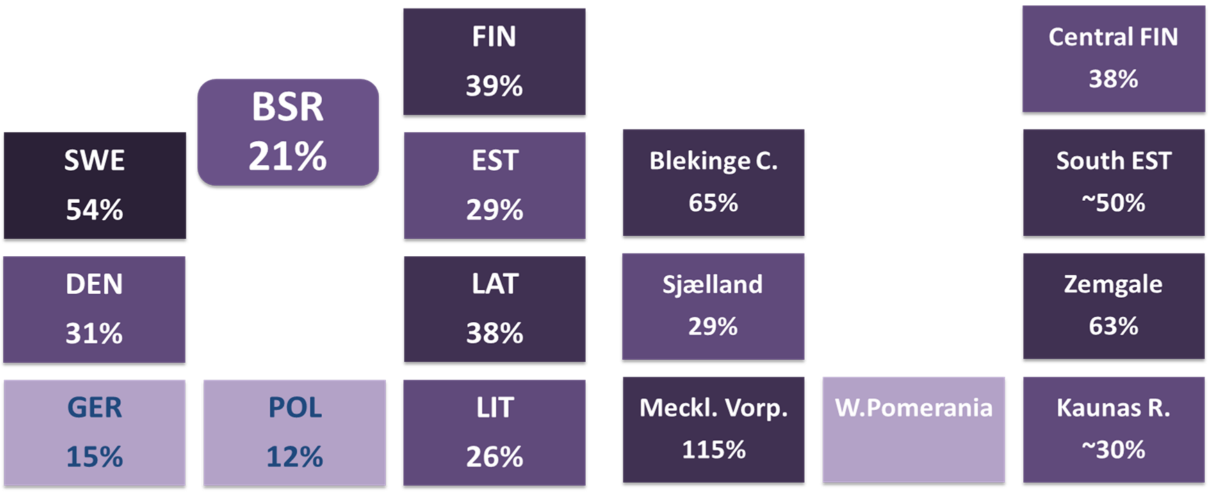


Figure4. Share of energy from RES 2014, % (Eurostat, authors) (darker colours indicate higher intensity).

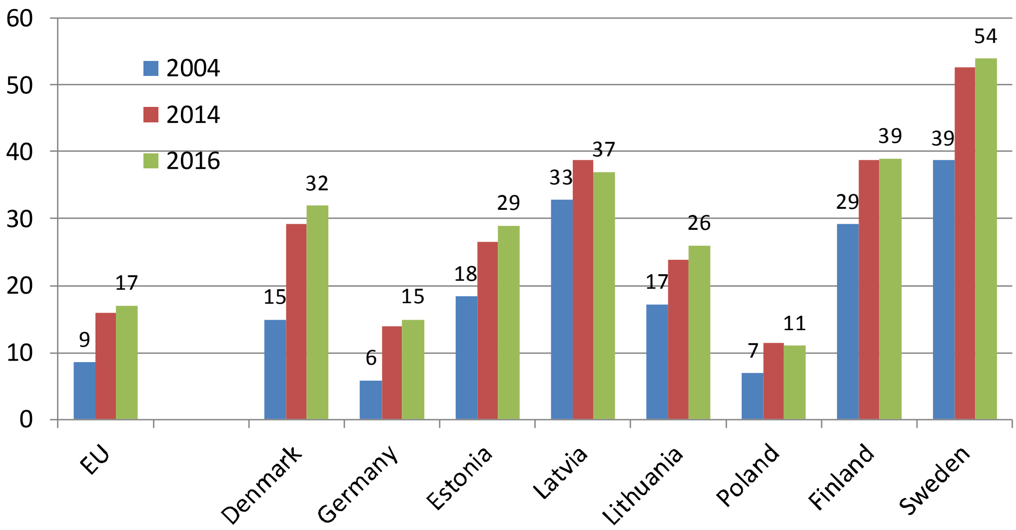


Figure 5. RES % in gross final energy consumption by BSR countries in 2004, 2014, 2016 (Eurostat).

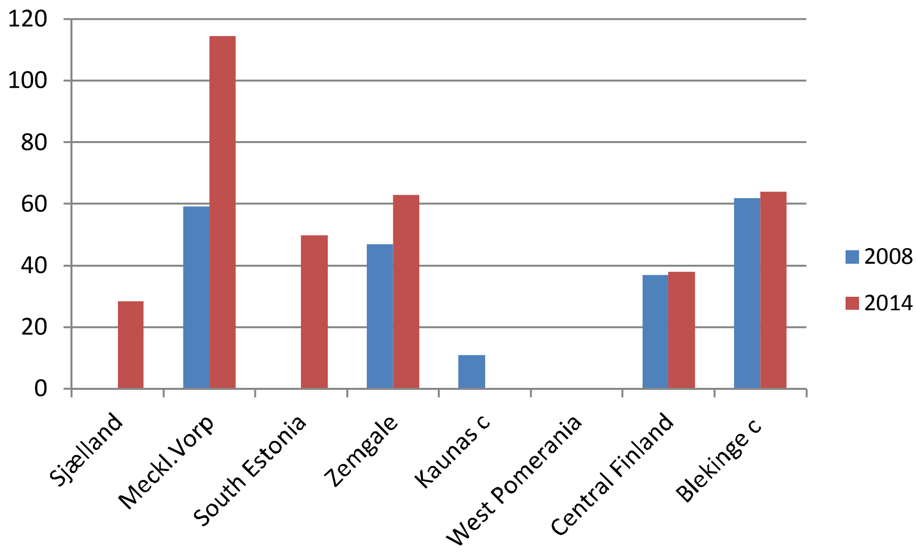


Figure 6. RES % in gross final energy consumption in the project regions in 2008–14 (Authors).

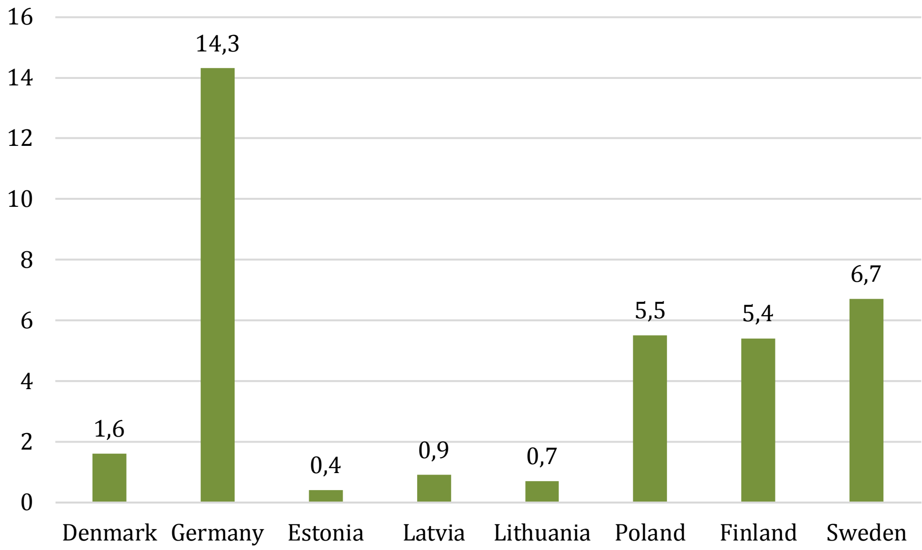


Figure 7. RES in gross final energy consumption by BSR countries, M toe, 2016 (Eurostat).

In absolute figures, the gross inland consumption of RES is by far the highest in Germany, followed by Sweden, Finland and Poland. The share of renewable electricity is the highest in Sweden (66%) followed by Latvia (52%) and Denmark (51%). The electricity mix is the least renewable in Poland (13%), Estonia (15%) and Lithuania (16%). The share of RES in regional mixes is higher, reaching more than two thirds in Southern Estonia, Blekinge, Mecklenburg-Vorpommern and Zemgale. Almost all countries and regions have been improving their RES share in the energy mix during last decade, which is a direct outcome of EU energy policy and support schemes. Obviously, the growth rates of RES were higher in the Baltic states because the reference level was much lower compared to the Nordic countries.

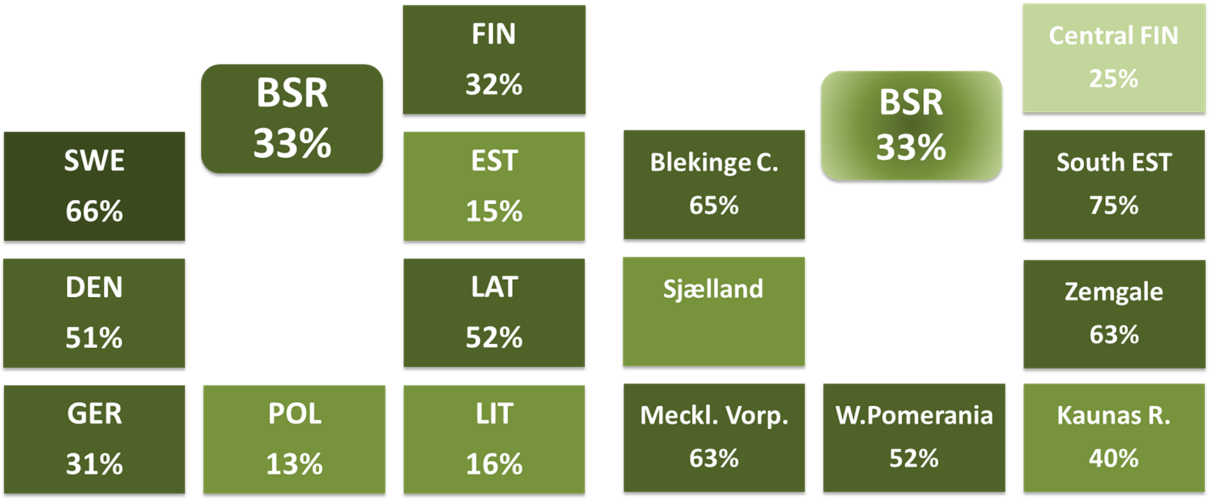


Figure 8. Share of renewable electricity 2015 (Eurostat, authors) (darker colours indicate higher intensity).

In five BSR countries, wind power produced half or more than half of final renewable electricity. The installed capacity for bioenergy accounted for more than half of renewable energy installed capacity in four BSR States. As the share of wind electricity has grown in Sweden (Blekinge) and Germany (Meckl.-Vorpommern) as well in some other countries, it has cut CHP share in the gross electricity generation

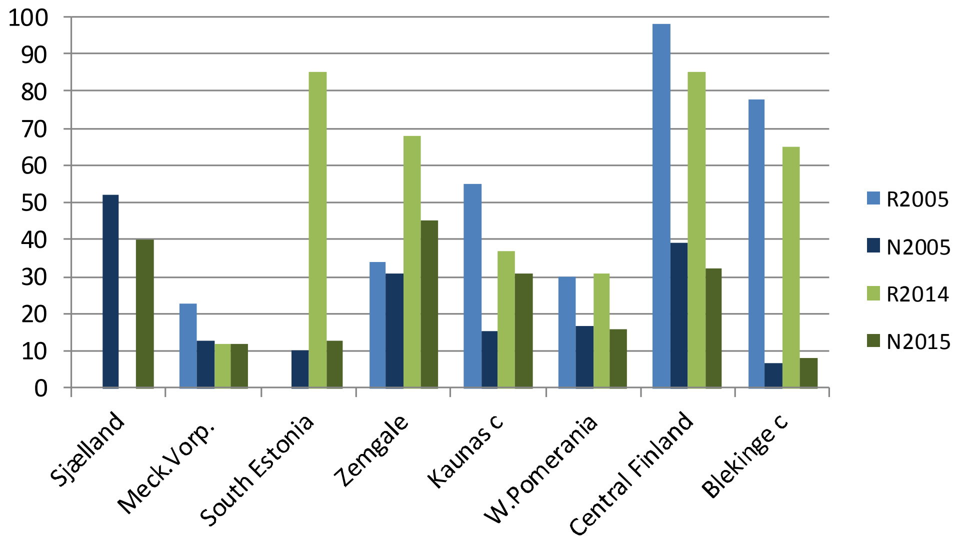


Figure 9. Share of CHP % of gross electricity generation, national N, regional R, 2005–14 (Eurostat, authors).

There are multiple keys to exploring a nation's energy independence or autonomy in a path to Europe's Energy Union and to contextualise energy in the macroeconomic framework. Energy dependency shows the extent to which an economy relies upon imports in order to meet its energy needs. The indicator is calculated as net imports divided by the sum of gross inland energy consumption (plus bunkers). The least energy dependent countries are Estonia and Denmark, while the most dependent are Lithuania and Germany. Estonian energy independence is controversial due to path dependency of oil shale energy having a massive climate impact. On the flip side, the Danish energy balance is highly independent due to wind and bioenergy.

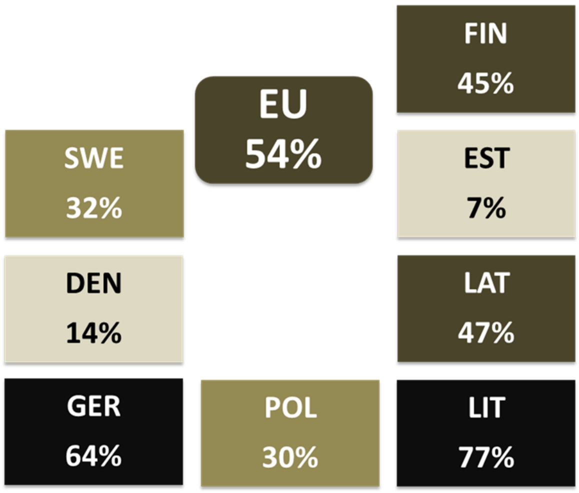


Figure 10. Energy dependency 2016 (Eurostat) (darker colours indicate higher intensity).

Based on a nation's economy on one side and on energy consumption on another side, the indicator of the productivity of energy results from the division of the gross domestic product (GDP) by the gross inland consumption of energy. The least productive and wasteful country in the economy-energy ratio is Estonia where the productivity is almost two times lower than in neighbouring Latvia, Lithuania and Finland, and three times lower than in Sweden and Germany.

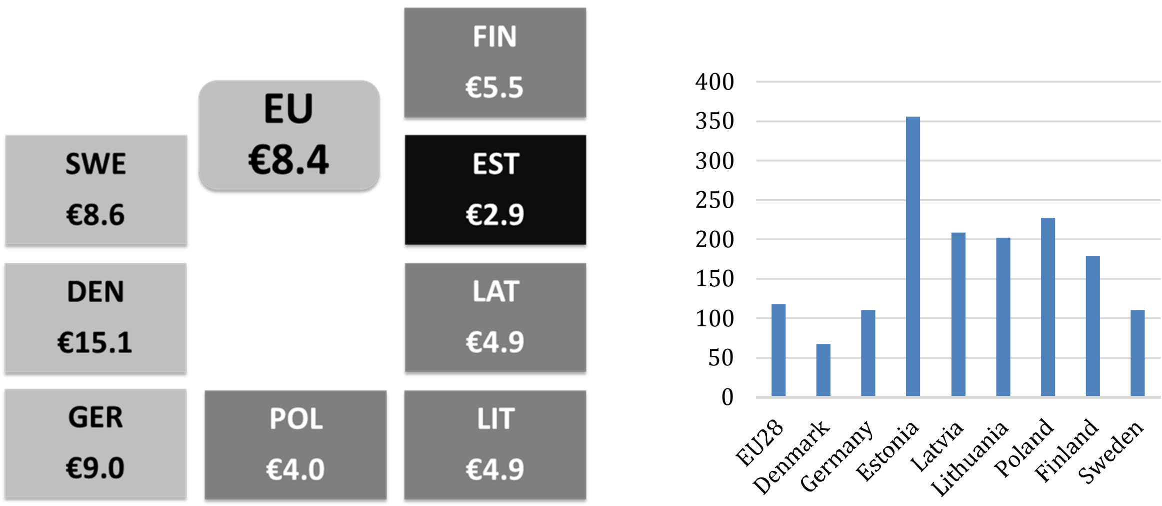


Figure 11. The energy productivity 2016 (€ per kilogram of oil equivalent) and energy intensity (kg oil equivalent per €1000) (Eurostat). (opposite scale: darker colours indicate low energy productivity).

Using the same approach with the opposite ratio, exceptionally high energy intensity is seen in the Estonian national economy and the lowest energy intensity in Denmark. Latvia, Lithuania and Poland need to lower their energy intensity, achieving the EU average as reflected by Sweden and Germany.

3.2. Sjælland

3.2.1. RES profile of Denmark

Like in other Nordic countries, the energy intensity of the Danish economy continues its downward trend to 65 toe/Million Eur in 2015. Denmark has a very low import dependency: 13% in 2015, though the import dependence for solid fuels remains very high at 85%. Greenhouse gas emissions reached 54 Mt CO_2 eq in 2014, being 26% below the emissions in 1990. Energy remained the main source of emissions with a share of 46% (25 Mt CO_2 eq). Specifically, in relation to the dominant wind energy, the role of renewable energy in the reduction of GHG emissions realized a net savings of 18 Mt CO_2 eq (JRC 2017).

The renewable energy in Denmark reached 4621.6 ktoe in 2015, almost double in ten years. More than 61% of renewable energy in Denmark is consumed in the heating/cooling sector and the rest in the electricity sector (33%). The renewable energy consumed in Denmark is expected to increase substantially to 5090 ktoe (213 PJ) until 2020.

In regard to the renewable energy share, the overall renewable energy contribution in gross final energy consumption in Denmark reached 31% in 2015, which is the 2020 target. The renewable energy share in the electricity sector in Denmark reached more than half, 51% in 2015 and the share of renewable energy in the heating/cooling sector reached 40% in 2015. In addition to the historically strong biomass and wind energy, faster development of solar PV is providing an electricity share greater than planned.

Biomass is the main renewable energy source in Denmark with a 66% contribution in final renewable energy in 2015, followed by wind with 25%, biofuels with 5%, heat pumps with 4% and solar with 2%. Wind represented 73% of renewable energy installed capacity in Denmark followed by biomass with 16% and solar with 11%.

According to EurObserv'ER, in 2016, the turnover of the renewable energy industry was estimated at around EUR 7.37 billion, the vast majority being attributed to the wind industry (2017). Total RES employment was 43,000, of which 26,600 was in the wind sector.

3.3. Mecklenburg-Vorpommern

3.3.1. RES profile for Germany

Germany is the main EU renewable market, having an installed capacity of 45 GW wind turbines and 40 GW PV systems in 2015. Hydropower and geothermal energy play a subordinate role in energy production. In total, 15 billion euros were invested in the construction of RES plants in 2015.

According to the German Renewable Energy Act an annual expansion of onshore wind energy is expected to be between 2,800 MW and 2,900 MW in the coming years. Offshore wind energy becomes increasingly important. An increase in installed capacity of offshore wind turbines up to 6.5 GW in 2020 and up to 15 GW in 2030 is envisaged. In the field of solar energy, annual expansion rates of 2,500 MW are expected.

In Germany the renewable energy generation reached 381 TWh in 2015, with a production of 49% in the electricity sector, 41% in the heating/cooling sector and 8% for biofuels in the transport sector.

The overall renewable energy contribution in the gross final energy consumption in Germany amounted to 14.9% in 2015 – more than double compared to 2005. In the heating and cooling sector the renewable energy share in the final energy consumption reached 13.2% and in the transport sector 5.2%. In line with the objectives of the Federal Government, the renewable energy share of the gross final energy consumption must be increased to 30% by 2030 and to 60% by 2050.

Despite to the comparatively low RES contribution in the gross final energy consumption in Germany, the share of RES in the total gross electricity consumption reached 31.6% – more than tripling in the period from 2005 to 2015. The goal is to increase the RES contribution in the gross electricity consumption to 40–45% by 2025.

Across sectors, biomass is the most important renewable energy source in Germany, which accounts for 62% of the energy supply. Especially in the heating/cooling and transport sector, biomass reaches 88% and 89% of the final energy consumption from renewable energies. In the electricity sector wind energy dominates with 42.3%, followed by biomass (26.8%) and solar energy (20.7%).

In 2015, emissions of 156 million tonnes of CO_2 equivalents were avoided, whereof 75% were in the electricity sector, 22% in the heating/cooling sector and 3% in the transport sector with biofuel use. The savings of fossil fuels by the use of renewable energies in the fields of electricity, heating/cooling and transport have continuously increased in recent years. While the total savings amounted to 309 billion kWh of primary energy in 2007, it increased to 539 billion kWh in 2015.

The share of renewable energy-related employment in total employment was at about 0.72% in Germany (283,100 jobs). Employment is particularly high in the wind (121,700), biomass (42,500) and biogas industries (35,700). The turnover of the renewable energy industry was estimated at around EUR 35.5 billion (EurObserv'ER 2017). About 40% is attributed to the wind industry, 15% to the biomass industry and 10% to the photovoltaic industry.

3.3.2. Mecklenburg-Vorpommern

Mecklenburg-Vorpommern covers a large share of its energy consumption in the electricity sector and an increasing share in the heating sector from renewable energies. In particular, the electricity consumed is already completely renewable and climate neutral in purely arithmetical terms. While in 2005 the share of RES in the gross final energy consumption in Mecklenburg-Vorpommern amounted to 34%, currently more energy is being generated from RES than is consumed.

The electricity generation in Mecklenburg-Vorpommern has been increasing in recent years. In 2015, a total of 9,776 million kWh of electricity could be generated from renewable sources. In 2005 the electricity generation from renewable energies amounted 2,226 million kWh, so this number more than quadrupled over a decade.

In the renewable energy sector, wind energy and photovoltaics in particular contributed to the growth and increasing electricity exports of the state. In 2015, 70% of the electricity could be generated from renewable energy (44% from wind energy, 17% from biomass, 9% from PV). Thus, the renewable energy share more than doubled between 2005 and 2015.

As a result of the expansion of renewable energy, Mecklenburg-Vorpommern, formerly dependent on electricity imports, was able to develop into a major electricity exporter, which will be continued in the future. In accordance with the energy policy concept from 2015, the state wants to contribute 6.5% to German electricity generation by 2025 according to the land area share from Germany as a whole. In particular, wind energy is expected to continue to grow strongly (12 TWh onshore and 8.25 TWh offshore).

3.4. Southern Estonia

3.4.1. RES profile of Estonia

Over the past 10 years, due largely to EU and national policies, the use of renewable energy has increased dramatically in Estonia. The share of renewables reached almost 15% as gross inland energy consumption reached 6.2 Mtoe. The energy intensity of the economy has grown to 358 toe/Million Eur in 2015. Hence, Estonia import dependence is very low, at 7% in 2015. Final renewable energy reached 878 ktoe in 2015 (Eurostat).

The overall renewable energy contribution in gross final energy consumption in Estonia reached 29% in 2015. The development of the heating sector was determinant in the fast penetration of overall renewable energy in Estonia. Renewable electricity consumption in Estonia reached 1,435 GWh (123.4 ktoe) as biomass was the main source of renewable electricity (53%) followed by wind with 45%. Biomass contribution in the heating sector was 93%, while the rest was covered by heat pumps (7%).

Final renewable energy in Estonia is as follows: biomass (87%), wind (6%), heat pumps (6%). In 2020, the share of biomass in final renewable energy is expected to decrease up to three quarters. Renewable electricity installed capacity in Estonia reached 482 MW, covered by wind with 62% or 300 MW of total renewable electricity capacity, leaving the rest to biomass with 37% or 176 MW.

According to EurObserv'ER, in 2016, the turnover of the renewable energy industry was estimated at around EUR 0.84 billion, the vast majority (EUR 0.56 bill) being attributed to the heating sector related biomass (2017). Total RES employment was 14,600, with 10,000 employees in the biomass sector.

3.4.2. Southern Estonia

Statistically, 1,522 GWh of electric energy (16% of the total Estonia) and 1,952 GWh of heating energy (23%) was consumed in Southern Estonia in 2016. From Estonian totals, Tartu consumed 5% of both electric and heating energy. Assessing the trends in Southern Estonia, the electric energy consumption has been increased by 12% and heating energy by a fifth over the 5-year period between 2012 and 2016.

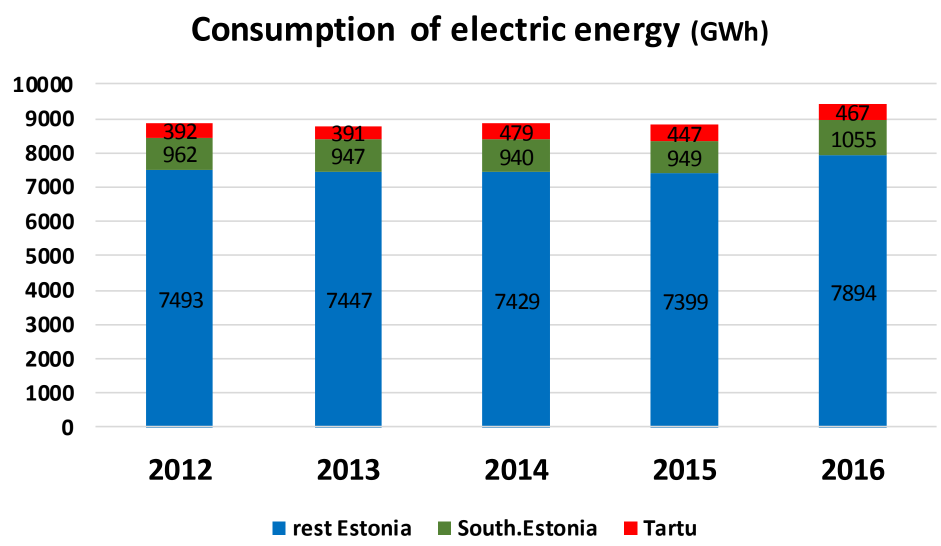


Figure 12. The electricity consumption in Southern Estonia and Tartu compared to the rest of Estonia (Statistics Estonia, 2017).

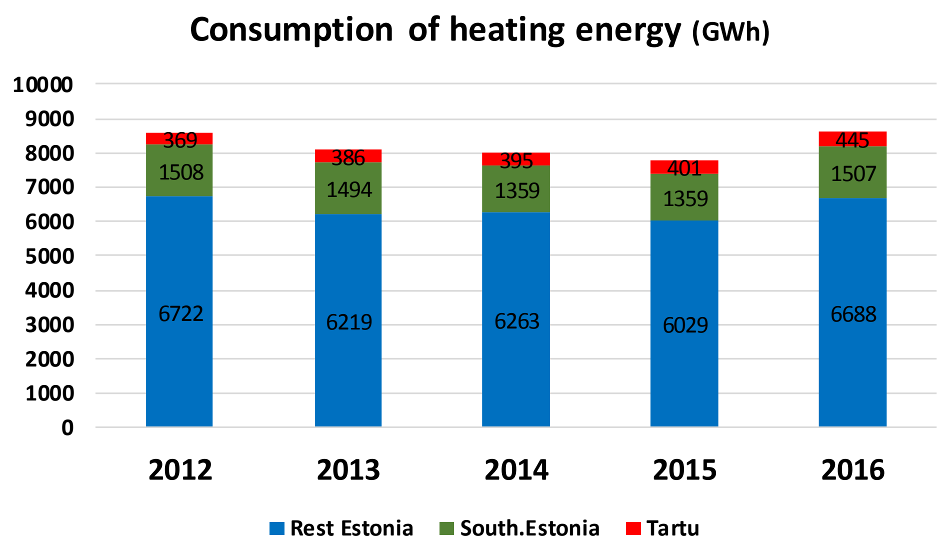


Figure 13. The heating consumption in Southern Estonia and Tartu compared to the rest of Estonia (Statistics Estonia, 2017).

In terms of energy production, biomass from wood is the dominant, near 100% renewable source of electricity as well in heating. Over the last ten years, mid-size CHPs were developed in Tartu, Osula, and Helme. Current CHP development focused mainly on the supply of heat to district heating systems or industrial CHPs integrated within premium pellet processing. CHPs contributed substantially to the national primary energy saving targets and aimed to achieve 20% cogeneration electricity production in the gross domestic consumption and in this way a further decrease in GHG emissions. The strong growth in the pellet industry is based on the emerging export market beyond the neighbouring BSR into the USA. The share of wood chips and biogas is growing in CHPs. Unfavourable energy market conditions with low electricity prices and a declining population, increasingly fewer heat corporate consumers are the key barrier for faster CHP development in Southern Estonia.

3.5. Zemgale

3.5.1. RES profile of Latvia

Renewables had the highest share at 35% in Latvia's energy mix in 2015. The gross inland consumption of energy in Latvia totalled 4.4 Mtoe. Energy intensity of the economy stood flat at 207 toe/Million Eur, marginally lower than in 2014. Latvia's import dependence ratio in 2015 was a high 51%.

Final renewable energy reached 1,491.5 ktoe in 2015, up more than 100 ktoe since 2005. The overall renewable energy contribution in gross final energy consumption reached 38% in 2015 having the third highest share in the EU. Renewable energy share in the heating/cooling sector reached 52% in 2015. Final renewable electricity grew to 3,842 GWh (330.3 ktoe) in 2015.

Latvia is actively developing renewable energy sources (RES) from biomass and wind to increase its level of self-sufficiency in energy generation. In 2014 the share of RES in overall energy supplies amounted to 38.6%.

Table 7. Share of RES in energy supplies in Latvia (%)

	2013	2014
RES in heating and cooling	49.7	52.2
RES in electricity production	48.7	51.1
RES in transport	3.1	3.2
Overall share of RES	37.1	38.6

Biofuels Market Outlook in Latvia, 2016

Biomass contribution in the final renewable energy reached 81%, while the rest is dominated by hydropower at 17%. Renewable electricity installed capacity amounted to 1,784 MW in 2015 as almost 90% of installed capacity was hydropower and the rest biomass at 7% and wind at 4%.

Centralized heat energy was produced by 638 boiler houses and 166 combined heat and power plants (CHP) in 2013 in Latvia. For sale were produced 7.29 TWh of centralized heat energy. In 2013, 69.1% of heat energy was produced in CHP and 30.9% in boiler houses. The consumer structure of centralized heating has not changed over the past few years. The main heat energy consumers in 2013 were households – 71.1% of the total heat energy consumption.

The share of direct and indirect renewable energy related to employment (excluding large hydro-power plants owned by the incumbent Latvenergo) in the total employment of the economy in Latvia was at about 3.2% with 27,400 jobs. The turnover of the renewable energy industry (excluding large hydro-power plants owned by the incumbent Latvenergo) was estimated at around EUR 1 billion (EurObserv'ER 2017). The biomass industry related to CHP and heating dominates with a turnover of 720 million euros and employment of 21,800 workers.

3.5.2. Zemgale

District heating is a dominant energy generator in Zemgale. The most significant part of total energy consumption has been produced in decentralized (local, individual) heat supply systems. In 2013 in total 44.6% of the total energy final consumption was consumed in decentralized systems. At the same time the centralized heat supply system is an effective solution from the perspective of usage of resources and environmental protection.

Zemgale is crossed by five roads of national importance and important international transport corridors and their intersections, the main highway and railway lines, long-distance natural gas and petroleum pipelines and fibre optic cables.

609 GWh or 8.4% of Latvia's total heat amount production was produced in the Zemgale region (2013). Comparatively, the Riga region consumes more than half (56%) of the total produced heat energy of Latvia. Whereas in final heat energy consumption the Zemgale region reaches 7.4% or 449 GWh of the state's total heat energy.

Bioenergy and CHP are elaborated in depth in the RET model case section.

3.6. Kaunas County

3.6.1. RES profile of Lithuania

Renewables covered one fifth in Lithuania's energy mix in 2015. The gross inland consumption of energy totalled 6.9 Mtoe. The energy intensity of the economy had in 2014 the lowest level at 203 toe/Million Eur since 2005, which then increased slightly in 2015 to 205 toe/Million Eur. Final renewable energy consumed in Lithuania reached 1,309 ktoe (54.8 PJ). Almost 83% of final renewable energy in Lithuania was used for heating/cooling purposes and the rest in electricity at 12%. The overall renewable energy share in gross final energy consumption reached 26% in 2015. In the heating/cooling sector the share of renewable energy reached 46% in 2015. The renewable energy share in the electricity sector reached 16% in 2015 as renewable electricity consumption in Lithuania increased to 1,783 GWh (153.3 ktoe).

Of final renewable energy, 86% was biomass. Renewable electricity consumption originated from wind technology multiplied between 2005 and 2015, reaching 836 GWh (72 ktoe). Renewable electricity installed capacity in Lithuania reached 688 MW in 2015. Wind installed capacity in Lithuania covered 63% of renewables, leaving the rest for hydropower with 17% and both solar photovoltaic and biomass energy with 10%.

Lithuania has undertaken, according to the Directive of the European Parliament and of the Council No. 2009/28/EC on the promotion of the use of energy from renewable sources, to increase the RES share in final national energy consumption up to 23% by 2020 and to increase the share of RES in all modes of transport up to at least 10% of the final consumption in the transport sector.

The Law on Energy from Renewable Sources of Republic of Lithuania contains sectoral objectives: to increase the share of electricity produced from RES up to at least 20% of the final national consumption, to increase the share of centrally supplied heat energy, produced from RES, up to at least 60%, of the heat energy balance, and to increase the share of RES used in households up to at least 80% of the total energy consumption balance.

According to the Lithuanian Department of Statistics, Lithuania has already reached the 23% target: in 2014, the share of RES in the total energy balance of the country exceeded one fifth, accounting for 23.66%.

In 2015, the share of RES in the total energy balance of the country reached 25.86%, the electricity sector 15.55%, the heating and cooling sector 46.17% and the transport sector 4.56%.

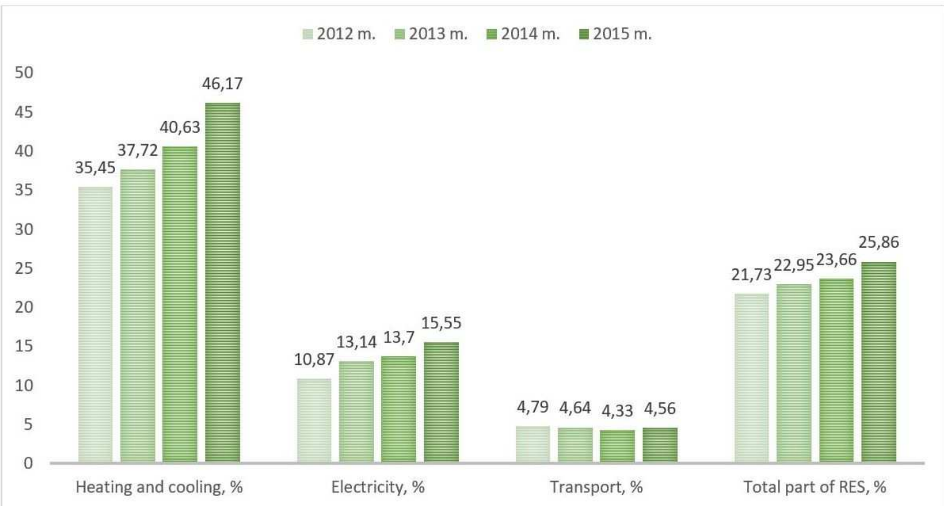


Figure 14. Part of RES in the energy sector (National Commission for Energy Control and Prices)

As of 18 January 2017, Lithuania has 2,566 power plants installed and holding permits to generate electricity from RES. Total installed capacity of these plants is 799.355 MW:

- (2,263) solar plants – 72.54 MW;
- (153) wind plants (farms) – 498.906 MW;
- (12) solid biomass plants – 64.95 MW;
- (39) biogas plants – 35.05 MW;
- (99) hydroelectric plants – 127.909 MW.

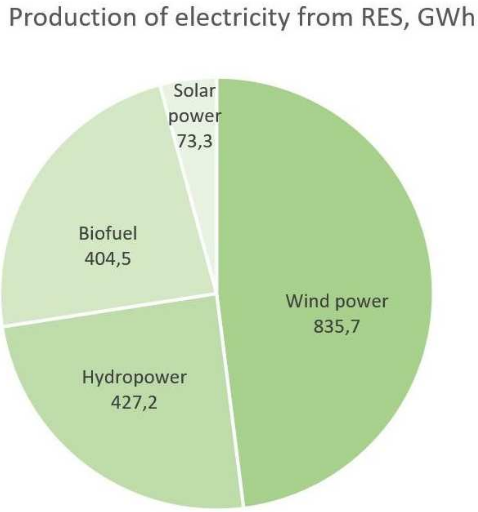


Figure 15. RES in the electricity energy sector, 2015 (Lithuanian Department of Statistics)

According to the Lithuanian Department of Statistics, in 2015 the share of RES in the electricity sector was 1.740 GWh. Energy was mainly generated in the wind plants, which accounted for 48%, and hydropower plants, which accounted for 24.6%. The rest of energy was generated in biofuel plants (23.2%) and solar power plants (4.2%).

An interactive map of all power plants in the territory of the Republic of Lithuania that use RES (in which a search can be conducted by locality, type of RES used and/or installed capacity) is published at http://www.avei.lt/lt/component/energy/?task=map.

The share of direct and indirect renewable energy-related employment in total employment of the economy in Lithuania was about 1.4% with 18,300 jobs, and half of those were in the biofuels sector, followed by biomass with 4,700 jobs. The turnover of the renewable energy industry in the same year was estimated at around EUR 0.71 billion, about more than one third being attributed to biofuels industries (41%) followed by biomass (36%) (EurObserv'ER 2017).

3.6.2. Kaunas County

The progress of RES in the Kaunas County is dominated by bioenergy via heat-only boilers (HOB) and heat/electricity in CHP. The first Kaunas City Renewable Energy Development Action Plan was adopted by the Kaunas city council in 2010. In 2016 it was revised. The achieved result during period of 2010–2016 discloses the shift in biomass share in fuel balance from 4% (biogas) to 85% (biomass and biogas) by the end of 2017. Replacement with biomass boilers in the boiler houses of Kaunas DH company amounted to 106.7 MW and for independent energy producers 190 MW of heat capacity. The total installed biomass capacity was 296.7 MW with long-term January monthly average demand of integrated network being 290 MW. The achieved economic result is reduction of heat tariffs from 8.84 ct/kWh in October 2013 to 4.15 ct/kWh in October 2016 (excl. VAT). The share of biomass in the fuel balance is 85% during peak heating demand in January/February.

The construction of the new CHP Fortum Heat Lietuva (a waste/biomass incineration plant) – 50 MWth, 20 MWel was initiated in 2017. This would create the ability to achieve a 100% RES share in the integrated district heating network of the Kaunas DH company. Here we should also indicate other small-scale RES possibilities, which could improve the share of RES in the heating sector. These are solar collectors with heat storage installations, which could be used for production of hot tap water during the summer season, thus reducing heat losses in the transmission network. These installations can be and already are installed on both the supply and demand sides. Another opportunity is geothermal heating (heat pumps). Such examples already exist in some other towns in Lithuania.

Involving independent producers (IP) has advantages (competitive tariffs for consumers, use of renewables, additional jobs) and drawbacks (limited technical conditions for the use of RES in DH systems, complicated adjustment of a DH system for operation with several independent producers, constant debates between heat suppliers and independent producers due to imperfect legislation). Publicity and information is of key interest in solving planning conflicts. If the planner or developer implements only the formal requirements for information, this may cause conflicts with residents who live in the vicinity of the object.

3.7. West Pomerania

3.7.1. RES profile of Poland

The share of renewables was just 9% in the Polish energy mix in 2015. Gross final energy consumption amounted to 65 Mtoe. Energy intensity of the economy continued to decrease, reaching 227 toe/Million Eur. Although in an increasing trend, Poland has a low import dependence rate at 29% due to domestic coal. Greenhouse gas emissions continued to decline at 382 Mt CO_2 eq in 2014.

Final renewable energy consumption in Poland reached 7,749 ktoe (324.4 PJ) in 2015, renewable energy in heating/cooling sector had a contribution two third whereas electricity and transport followed with 24% and 11%. The overall renewable energy contribution in gross final energy consumption in Poland reached 12% in 2015. Renewable electricity consumption in Poland amounted to 22,030 GWh (1894 ktoe) in 2015, increasing by one fifth in period between 2005 and 2015.

Biomass was the main renewable energy source in Poland with a contribution of three quarters, followed by wind with 11% and biofuels with 10%. In 2020, the contribution of biomass in final renewable energy is expected to decrease up to 60%. Wind technology contribution reached 9,687 GWh (833 ktoe) in 2015, increasing by almost 50% since 2005. Biomass contribution reached 9,933 GWh (854 ktoe), increasing by one fifth since 2005. The renewable electricity installed capacity reached 6,538 MW in 2015 as wind technology capacity reached 4,886 MW.

The share of renewable energy-related employment in total employment of the economy in Poland was at about 81,800 workers for the renewable energy sector. Most of these jobs are in biofuels (34,800), biomass (26,100) and wind industries (11,400) (2016 data, EurObserv'ER 2017). The turnover of the renewable energy industry was estimated at around EUR 3.7 billion, about one third being attributed to the biofuel industry, 27% to the biomass industry and 21% to wind industries (EurObserv'ER 2017).

3.7.2. West Pomerania

The regional RES is based on onshore wind power and bioenergy. There are strong prospects in the field of offshore wind. In 2016 in West Pomerania there was 1,477 MW capacity installed in onshore wind farms, which is 25% of total power capacity installed in wind farms in Poland. The share of energy produced from RES in the total electricity consumption in the West Pomerania in 2015 was over 60%, which gives this region the leading position in the country.

3.8. Central Finland

3.8.1. RES profile of Finland

Renewables had the highest share in Finland's energy mix in 2015. Gross inland consumption of energy in Finland totalled 33.1 Mtoe. Energy intensity of the economy stood at 177.2 toe/Million Eur and greenhouse gas emissions continued to decline at 61 Mt CO_2 eq in 2014.

Final renewable energy consumed in Finland amounted to 9,955 ktoe (416.8 PJ) as 71% of final renewable energy in Finland originated from the heating/cooling sector. The overall renewable energy contribution in gross final energy consumption in Finland reached 40% in 2015. Development of renewable energy share in the heating/cooling sector in Finland was fast approaching 53% in 2015. Renewable electricity consumed in Finland amounted to 27.6 TWh (2287.5 ktoe), not much higher than in 2005.

Biomass was the main renewable energy source in Finland with a contribution of three quarters followed by hydropower with 12% and biofuels with 5.0%. Renewable electricity installed capacity in Finland reached 6,053 MW in 2015, from which hydropower installed capacity covered more than half, leaving 30% for biomass and 17% for wind. Biomass capacity in Finland remained at the level of 1,794 MW since 2013.

According to EurObserv'ER (2017), the share of direct and indirect renewable energy-related employment in total employment of the economy in Finland was about 1.69%, which represents about 39,200 jobs. The turnover of the renewable energy industry in the same year was estimated at around EUR 6.3 billion, the largest part being attributed to the biomass (EUR 4.32 billion) followed by heat pumps (EUR 700 million), wind (EUR 520 million), and biofuels (EUR 300 million) industries.

3.8.2. Central Finland

Central Finland’s total energy consumption is 17.6 TWh (Figure 16). This value includes the use of oil (transport, 16% of total consumption). On a regional level, 69% of locally produced electricity is from CHP (Finnish Energy, 2015) This corresponds to 1.15 TWh. Of this, 600 GWh is from industry and 550 from district heating. Of regional energy production, almost all district heat is from CHP, which corresponds to 2.3 TWh. The energy balance of Central Finland reveals electricity import dependency. Of the total energy, 24% was imported electricity. The use of locally produced renewable energy is relatively high, in total 38% of the energy consumed. New investments in forest industry will increase regional renewable production to more than 60% of consumption by 2020. (Energy Balance of Central Finland 2014).

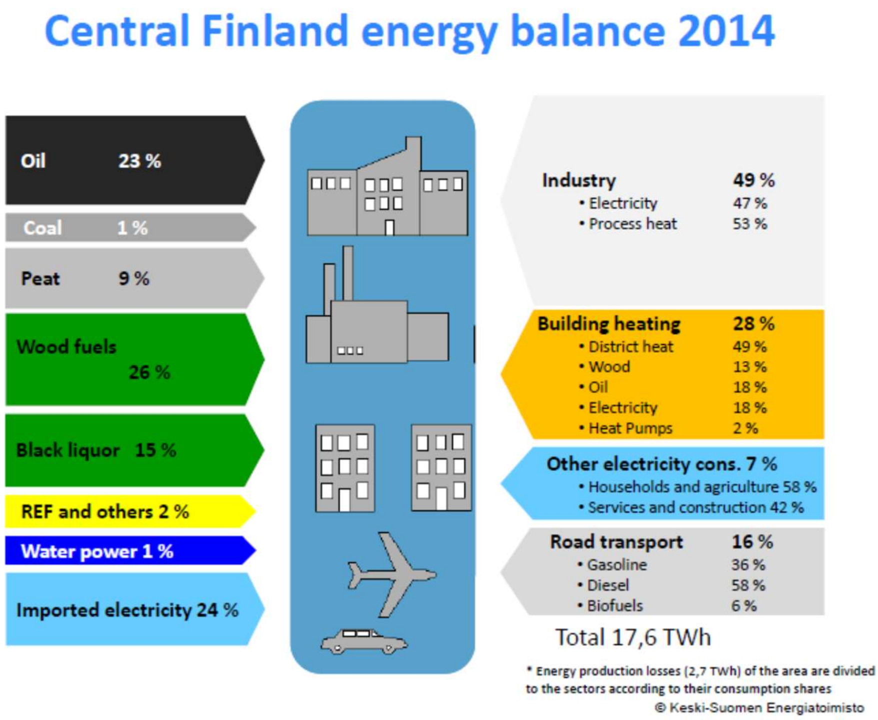


Figure 16. The energy balance of Central Finland (2014, Keski-Suomen Energiatoimisto)

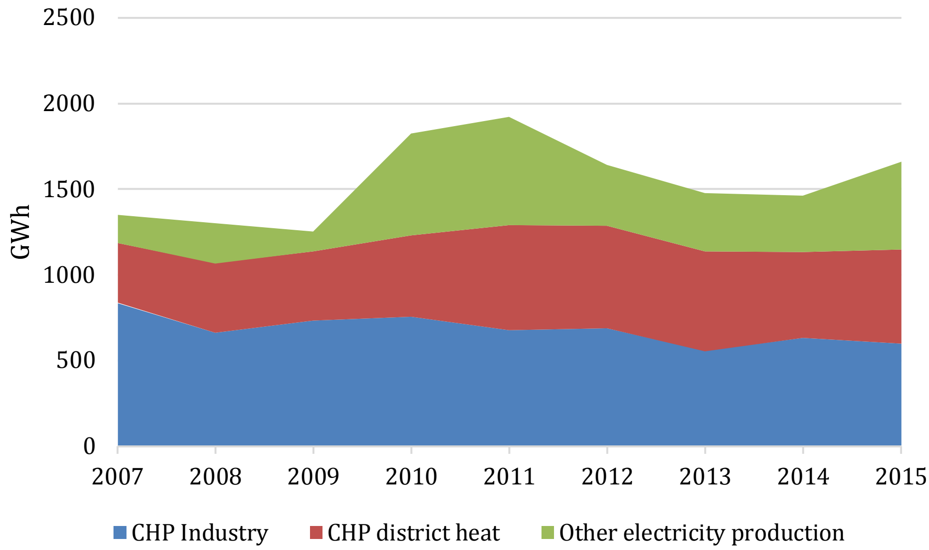


Figure 17. CHP derived electricity production in Central Finland (2007–2015).

The majority of imported electricity is for industry use. Central Finland has two forest industry sites. The presence of the forest industry also creates unique situation with CHP:, in Äänekoski the waste material from the pulp industry (black liqueur) is used for CHP to generate electricity and heat for processes and for the city of Äänekoski. This accounts for 15% of the total regional energy consumption (Energy Balance of Central Finland 2015). Another unique feature is the presence of big production units: five CHP power plants with a capacity from 100 – 500 MW. CHP capacity in Central Finland is approximately 1,540 MW thermal capacity, corresponding the electricity output of one nuclear power reactor. This capacity will increase in 2017, when the Äänekoski bioproduct mill (Metsä Fibre) will commission a new CHP plant, with 1,800 GWh bioelectricity per annum (750 will be used in the mill) and 7,000 GWh district heating and process heat. This plant will contribute to Finnish renewable energy use by + 2%. This new unit is 100% wood-based biomass.

Wood residue from forestry has been another major source for CHP in the region. In 2010 the use of wood residue was 1.73 TWH, of which the CHP plant used a total of 1.61 TWh. Use of forest chips has increased in Central Finland after the Keljonlahti power plant (240 MW heat/200 MW electricity) in Jyväskylä started production in 2010. The forest chip users in Central Finland are mainly (almost 90%) in four CHP plants in Jämsä, Jyväskylä and Äänekoski. All CHP plants in Central Finland us wood-based materials as their main fuel; there is co-combustion with peat and coal. Agrobiomass does not have significant importance for CHP production in Central Finland; agrobiomass is seen more as a potential for biogas production (BIOCLUS project 2012).

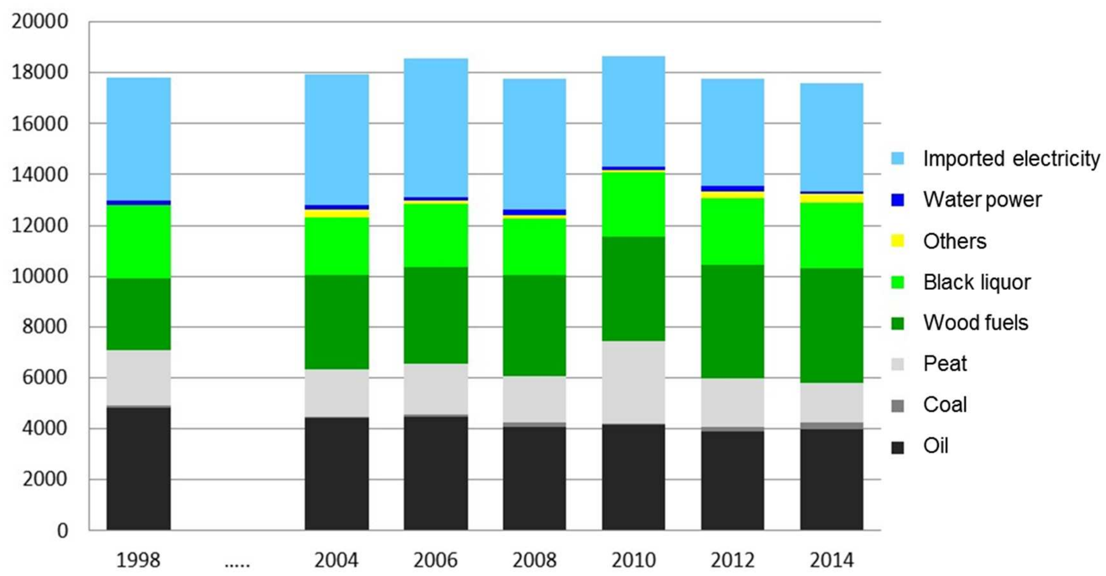


Figure 18. The energy sources of Central Finland 1998, 2004–2014 (Keski-Suomen Energiatoimisto).

3.9. Southern Sweden

3.9.1. RES profile of Sweden

Renewables had the highest share with 42% in Sweden's energy mix in 2015 together with nuclear. The gross inland consumption of energy in Sweden totalled to 45.5 Mtoe. Energy intensity of the economy has decreased to 111 toe/Million Eur. Sweden had an import dependence ratio at 30% in 2015. Greenhouse gas emissions continued to decline at 56.7 Mt CO_2 eq in 2014.

Final renewable energy reached 1,8774 ktoe (786 PJ), 54% of its gross final energy consumption in 2015. Renewable electricity consumption in Sweden amounted to 91.6 TWh (7878 ktoe) in 2015 as the hydropower share reached at 73% followed by wind at 15% and biomass at 12%.

Biomass was providing half of final renewable energy in Sweden followed by hydropower at 31%, wind at 7% and heat pumps at 6%. The renewable electricity installed capacity reached 26,452 MW in 2015, just 3% more than in 2005. The hydropower presented 61% of renewable electricity installed capacity followed by wind at 22% and biomass at 16%.

The share of direct and indirect renewable energy-related employment in total employment of the economy in Sweden was at about 1.04%, above the BSR average of 0.83%. The turnover of the renewable energy industry in the same year was estimated at around EUR 8.7 billion, the biggest part being attributed to the biomass sector (EUR 4.09 billion), followed by heat pumps (EUR 2.11 billion) and wind (EUR 1.01 billion) industries (EurObserv'ER 2017).

3.9.2. Skåne

Based on 2013 data the electricity use in Skåne amounts to 13.2 TWh, power (electricity) production is 3.1 TWh and import of electricity is 10.1 TWh (both from parts of Sweden north of Skåne and foreign countries). A self-sufficiency of around 23% is realized. The renewable power produced amounts to 1.9 TWh, which makes up 14.5% of electricity use and 62% of power production. The power production from PV consists of 0.01 TWh and of 1.1 TWh of wind power. The rest consists of small-scale hydropower and bio-CHP. PV makes up only a fraction of the power production today but may result in an amount of 3−5% within 10−15 years. An investment boom will increase and speed up the rate of growth.

Due to statistics privacy the regional energy statistics in Skåne county are not complete and are not having satisfactory quality in order to be able to present the headline indicators on a regional level.

3.9.3. Blekinge

Blekinge have a high level of bioenergy compared to the national level. However, the development of new CHPs has been rare in recent years due to the low electricity price. Developments in wind power has had a decline after a refusal from the Swedish government to issue a special permission to the off-shore wind power. It remains unclear what subsidies off-shore wind power can get, and that has a negative impact on sector and investors. The expansion of solar power (PV) has been impressive during last years in Blekinge.

4. Regional models of renewable energy technology

4.1. Comparative analysis of regional models

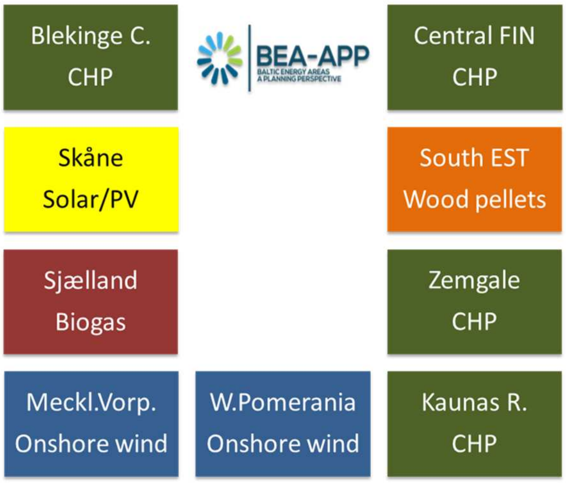


Figure 19. Regional models of renewable energy technology (RET).

CHP, combined heat and power, usually with district heating upgrades, is chosen as a model in four regions: Blekinge, Central Finland, Zemgale and Kaunas. Heating energy plays an important role in carbon-free urban energy and renewal and relates to household welfare via heat bills as a required expense. Onshore wind, energy generation based on effective use of the coastal wind resources, is exemplified by Mecklenburg-Vorpommern and West Pomerania, which demonstrate the high added value. Some pilots focus on a few new generation RET facilities. The Sjaelland explores two biogas facilities, the pellet industry has grown quickly in Southern Estonia, and solar energy is quickly emerging in Skåne.

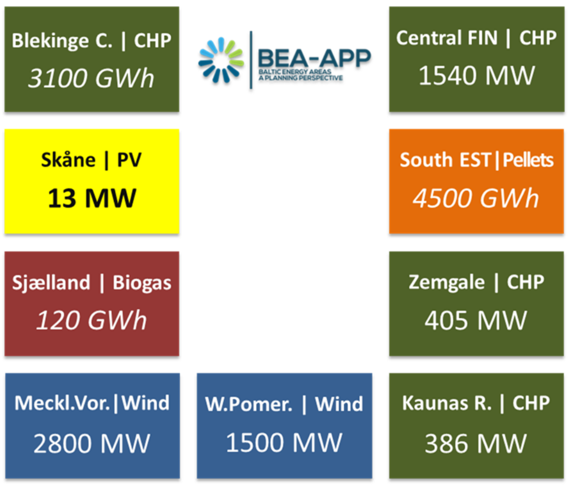


Figure 20. Installed power capacity and production of regional pilot cases of RET (authors' estimates).

The figure scales the BSR model cases by installed capacity or energy production (or equivalent). The wind energy sector in Mecklenburg-Vorpommern (2,815 MW) and West Pomerania (1,500 MW) as well bioenergy in Central Finland (1,540 MW) provide the largest renewable capacities. The Baltic regional capacities are represented by bioenergy installations and CHP in Zemgale (405 MW) and in Kaunas district (386 MW), which have progressed over the last ten years. The smallest though fastest-growing sector is solar PV in Skåne.

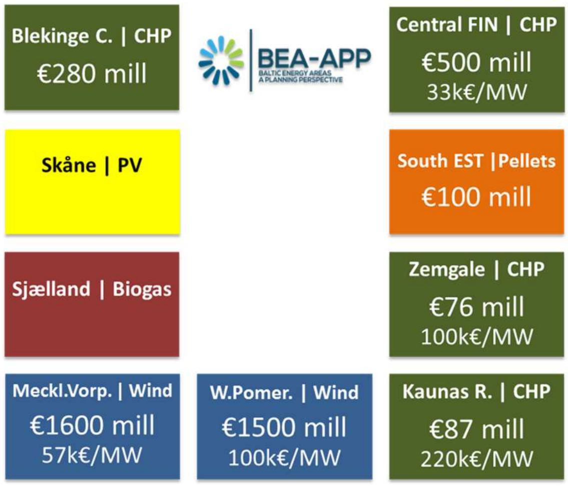


Figure 21. Capital investments 2010–15 in absolute figures and per installed MW in the regional RET (authors' estimates).

At large, the investment totals mirror installed power capacities, though the investment sum normalised for installed capacity differs greatly. For wind power, the capital cost is almost half of that in West Pomerania. Similarly, comparing CHPs, the more advanced the sector like in Central Finland is, the lower the capital cost per installed capacity (€33k/MW). In Kaunas, the 220 thous. euros is invested per megawatt, which is more than double compared to Zemgale CHP, namely €100k/MW. It should be kept in mind that even if cases qualify as CHP, the technologies differ and may include distant heating and other related facilities and networks.

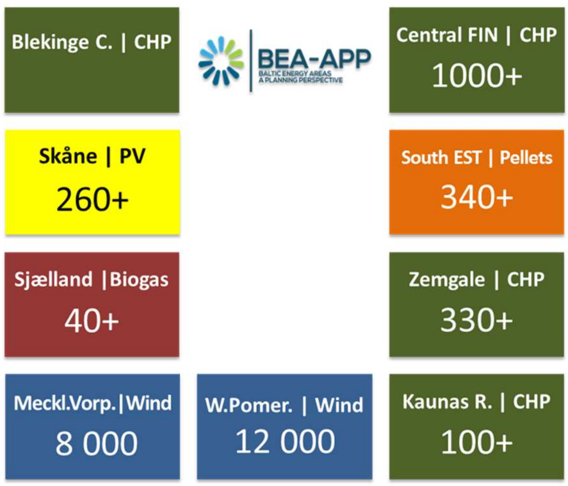


Figure 22. Employment in regional RET (authors estimates).

The employment data is robust covering the RET operations, though in some renewables such as wind power and solar PV also development and technology supply is attributed. The wind power in Mecklenburg-Vorpommern is more productive in terms of labour and requires fewer employees (3 jobs/MW) than in West Pomerania (8 jobs/MW, all production, support, R&D). The CHP sector in Zemgale employs 4 persons per MW, which is substantially higher than in Central Finland (0.6 persons/MW) and in Kaunas (0.3 persons/MW).

Table 8. Main characteristics of model RET cases

Country	Denmark	Germany	Estonia	Latvia	Lithuania	Poland	Finland	Sweden	Sweden
Region	Sjælland	Meckl.Vorp.	South.Estonia	Zemgale	Kaunas c.	W-Pomerania	Centr.Finland	Blekinge c.	Skåne
Renewable Energy Technology	Biogas	Onshore wind energy	Wood pellet industry	CHP + district heating	CHP + district heating	Onshore wind energy	CHP	CHP + district heating	Solar energy
Importance: energy autonomy	Low	High	Low	Low	High	High	High	High	High
Importance on economy	High	High	High	High	High	Medium	Medium	High	Medium
Importance on innovation	High	High	Medium	Medium	Medium	Medium	High	High	High
Importance on E&Climate	High	High	High	High	High	High	High	High	High
Trend 2015: production	Increase	Strong increase	Strong increase	Increase	Strong increase	Strong increase	Strong increase	Stable	Strong increase
investment	Increase	Strong increase	Strong increase	Low	Strong increase	Strong increase	Strong increase	Stable	Strong increase
employment	Increase	Strong increase	Strong increase	Light increase	Moderate	Increase	Stable	Stable	Moderate
innovation	Increase	Increase	Increase	Increase	Moderate	Increase	Transforming	Increase	Increase
Maturity	Growing	Growing	Growing	Growing	Growing	Stagnating	Transforming	Growing	Growing
Value creation	Medium	High €380/kW	High	Medium	Medium	Medium	Medium	High	Medium

No doubt, the regional importance of renewable facilities is high for the climate and environment. Also, the economic importance is stated high, except solar PV in Skåne and wind energy in West Pomerania. Contributing to energy autonomy differs being high in all other regions except low for biogas in wind power-supplied Sjælland, for the pellet industry in bioenergy-heated Estonia and in hydropower-supplied Zemgale.

Generally rated as high, the economic importance of the surveyed regional RES is stated medium in West Pomerania, Central Finland and Skåne. The innovation of RES is assessed as medium in the Baltic countries and Poland, as the Nordic countries and Germany have been pioneering the RES innovation. Almost all regional cases experienced strong increase in production and investment during the period 2010−2015, with a stable status in Blekinge and moderate increase in Sjælland.

The innovation is rated as growing though not at a pace as high as economic progress may predict. The maturity of RET is still growing, but CHP has been transforming in Central Finland and onshore wind power has been stagnating in West Pomerania.

The RET cases demonstrate the reduction of CO_2 emissions, up to 2 million tons annually. The CO_2 cuts range between 90 to 1,200 kg per MWh in generated renewables (the national energy mix applies in this approximation). The CO_2 indicator of CO_2 reduction is country- and technology-specific. The energy generated annually is between 3,100−5,300 GWh in large cases and less than 400 GWh in smaller regional cases. The figures of turnover fluctuate significantly depending on the size, scale and complexity of the sector or facilities. As seen from the table, several figures are not available. Also, the basis and methods may differ, which makes comparisons robust or speculative.

Table 9. Key figures of model RET cases.

Country	Denmark	Germany	Estonia	Latvia	Lithuania	Poland	Finland	Sweden	Sweden
Region	Sjælland	Meckl.Vorp.	South.Estonia	Zemgale	Kaunas c.	W-Pomerania	Centr.Finland	Blekinge c.	Skåne
Renewable Energy Technology	Biogas	Onshore wind energy	Wood pellet industry	CHP + district heating	CHP + district heating	Onshore wind energy	CHP	CHP + district heating	Solar energy
Reduced CO2 kt	73 kt	1.5 Mt	4.1Mt	13kt	26 kt	2 Mt		175 kt	
Reduced CO2 kg/MWh	610	280		1232	90	510		270	
Installed RES capacity MW		2815	85	78	386	1500	1540		13
RES production GWh	120	5300	4500	340	400	3900		3100	
Investment total million €		1600	100	76	87	1500	500		
Investment per MW		1 300 €		97 000 €	220 000 €	143 000 €	32 468 €	€90/MWh	
RES Turnover M€	9,4	900 + 220		13				32	8
Employment, total	40	8000	340	330	100	12000	1000		260
Employment per MW		3,0		4,0	0,3	8,0	0,6	300/TWh	20,0

Table 10. Drivers and barriers of model RET cases.

Country	Denmark	Germany	Estonia	Latvia	Lithuania	Poland	Finland	Sweden	Sweden
Region	Sjælland	Meckl.Vorp.	South.Estonia	Zemgale	Kaunas c.	W-Pomerania	Centr.Finland	Blekinge c.	Skåne
Renewable Energy Technology	Biogas	Onshore wind energy	Wood pellet industry	CHP + district heating	CHP + district heating	Onshore wind energy	CHP	CHP + district heating	Solar energy
Drivers	GHG, RES, employ	Available areas (LEP, RREP), wind conditions, RE Act (EEG)	Low production cost, raw material, big ports	Raw material, GHG, investing in biomass, employment	Market liberalisation, investing in biomass	Wind conditions, land availability, grid	Raw material, RET, small scale CHP, cold winter peaks	Raw material, low cost	Cost decline, positive PR, prosumer approach
Weakest Link: Technology	Gas quality, residues availability	Storage, grid	Sawdust limitations, too fast growth	Low investments	Independent producers, waste inceneration	Nature protection, grid	Stagnating	Sawdust limitations, deploying high temperatures	Price stabilisation
Weakest Link: Socio-economy	cost of develop.	E prices, decrease EEG	Weak domestic market	Low economy, low purchase power, missing assets	Tariffs cut	support services, legal	Uncertainty, price risks	Weak domestic heating, labour shortage	Low e prices, permitting
Weakest Link: Non-market factors	length of planning	Nature conservation, acceptance	Engineering capacity	State support, technologies vs quality of biomass, the value chain cooparation	Acceptance	Acceptance	Forest practices in climate policy	Grid, heat pump techno	Varying policies
Outlook	Positive	Highly positive	Highly positive	Developing	Compiting	Light positive	Transforming	Price dependent	Subsidy-dependent

The primary driving forces behind RES progress are resource availability, measures of the climate and energy policy, market liberalisation, and grid and transport networks.

The weakest link in terms of technology is availability of resources (specifically biomass) and grid and storage conditions. The barrier in the socio-economy is related to low and declining energy prices or need for price stabilisation. Also, high capital cost remains one of the major barriers for further progress of RET. The dominant non-market barrier is public acceptance or direct opposition to RES projects. Smaller countries argue about administrative and engineering capacity and missing expertise. Despite the shortlisted issues and barriers, the outlook is positive in a majority of cases, even highly positive in Mecklenburg-Vorpommern and Southern Estonia. In mature RES markets, the outlook of Swedish cases is marked with keyword price- and subsidy-dependent. The CHP sector is transforming in Central Finland. The competition is increasing, heating up or freezing the CHP sector in Kaunas district. Wind power progress moves from onshore to offshore in West Pomerania.

4.2. Region of Zealand: Biogas production & utilization

Regional importance

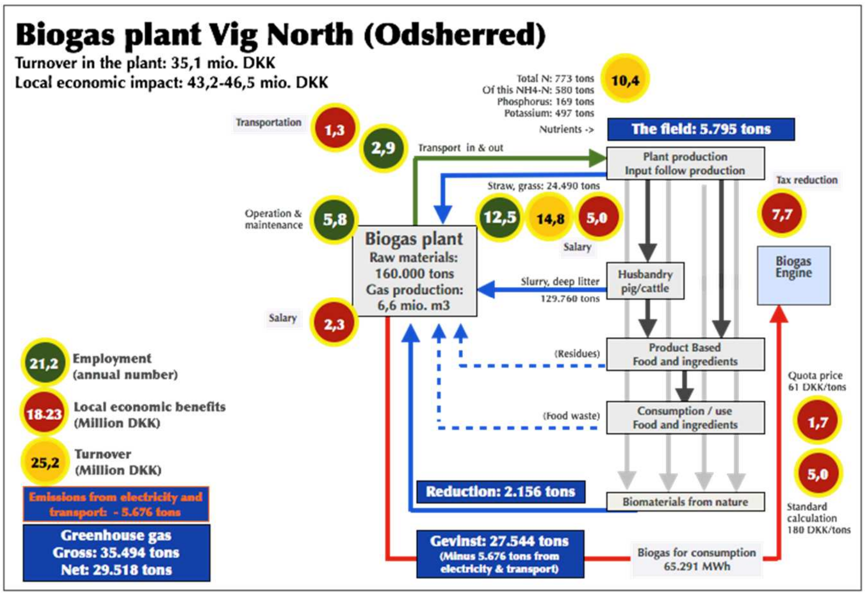
Energy autonomy	Economy	Innovation	Environment & climate
Low	High	High	High

Trend 2010–15

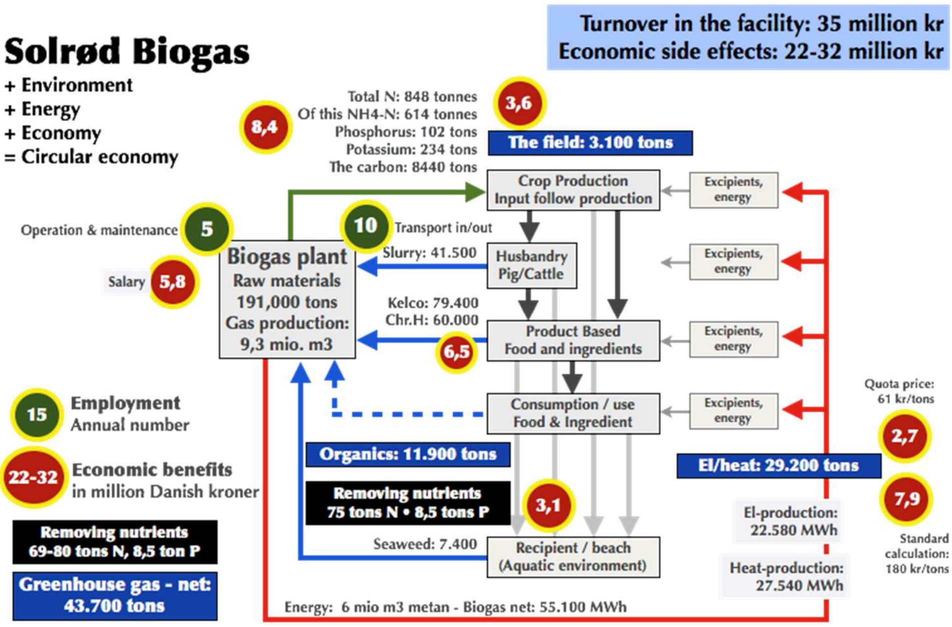
Production	Investment	Employment	Innovation
Increase	Increase	Increase	Increase

Maturity of value chain: Growing

Regional value creation: Biogas plant Vig North (Odsherred municipality)



Regional value creation: Biogas plant in Solrød



Key indicators and landmark developments

Value added: The total turnover from the Solrød facility is 35 million DKK, and the expected turnover from the Odsherred facility is approximately the same. This is approximately 4.55 million EUR.

Impact on employment: The annual employment (number of total employed people on an annual basis in Solrød is 15, and in Odsherred the number is expected to be 21.

Reduced CO_2 emissions: The Solrød plant has a net reduction of 43,700 tons of CO_2-eq, and the Odsherred plant is expected to mitigate 29,500 tons.

Drivers

Regional goals on greenhouse gas mitigation and renewable energy production, as well as goals on increasing local employment.

The value chain and core technologies

Please see the visualisation of biogas plant processes above

The biogas plants take in a range of residues and by-products, thereby creating or increasing the value of these biomass fractions. This includes, among others, slurry, deep litter, residues, food waste and seaweed.

These residues are transported to the plant and utilized in the production of biogas.

This process supplies biogas for the gas engine, producing electricity for the grid and heat for local district heating systems.

The residue from the biogas plant is returned to local farmers and used as high-quality fertilizer.

Weakest link

Resource and technology	Market and socio-economic	Nonmarket and stakeholder
The quality of gas production from the available residues within a reasonable driving distance.	Cost of plant development, especially in the early stages.	The number of hearings in and the length of the public planning process.

Outlook

There is still a significant untapped potential for expanding biogas production in the region in a number of areas. This is, however, subject to limitations on the availability of local resources for biogas production, especially quality residues with a high degree of dry matter. The availability of these residues will limit the expansion of biogas production in the region. For the time being, however, there is still potential for expanding biogas production and replacing current CHP plants based on oil, natural gas or wood pellets.

4.3. Mecklenburg-Vorpommern: onshore wind energy

Regional importance

Energy autonomy	Economy	Innovation	Environment and climate
High	High	High	High

Onshore wind energy is the driving force of the energy transition. It is the leading and most cost-effective technology in the field of renewable energies. With 71 inhabitants per square kilometre, Mecklenburg-Vorpommern is the most sparsely populated federal state in Germany, but with about 2,000 km of coastline and a richly structured inland, it has excellent wind conditions for on- and offshore programs. The share of wind energy of gross electricity generation amounted to approximately 44% in 2015. This is higher than the combined gross electricity generation from coal and natural gas.

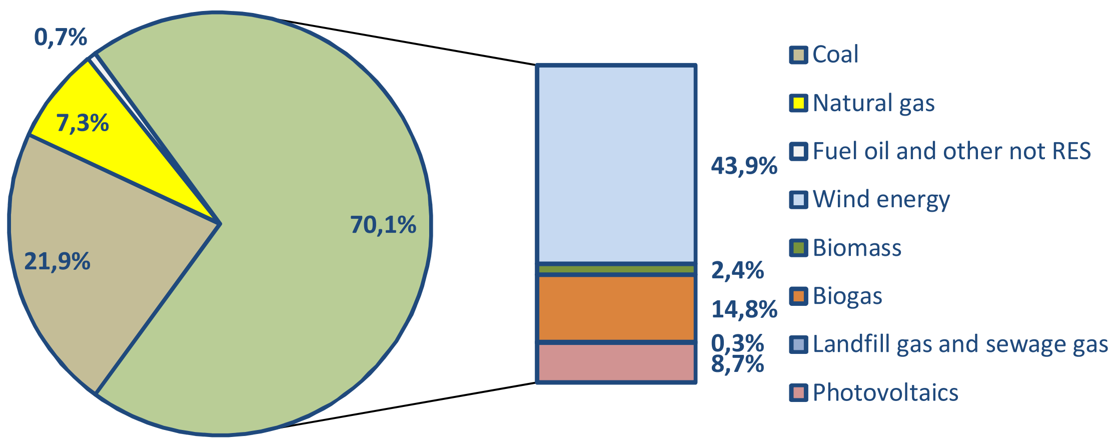


Figure 23. Gross electricity generation per energy source in 2015

In Mecklenburg-Vorpommern 1,703 wind turbines with a capacity of approx. 2,800 MW were installed onshore in 2015. As a result, more than 60% of the gross electricity consumption was covered by wind energy. Therefore, Mecklenburg-Vorpommern takes a leading position in the use of wind energy in Germany. The use of these plants will save more than 600,000 t/a of natural gas and 1.5 million t/a of CO_2. In 2015, the operation and maintenance of the wind energy plants cost approx. 130 Mio €.

The region already has excellent expertise with the companies and scientific institutions in the wind energy sector located in the state. The wind energy industry in Mecklenburg-Vorpommern is and remains on the upswing. The linkages with diverse industrial, service and craft sectors are various. In the region more than wind turbines and their components are manufactured. Numerous metal working and processing companies, foundries and companies in the construction industry and electronic industry, service sector companies such as those dealing with logistics, reviewers, planners and financial service providers as well as companies for service and maintenance receive orders from the wind energy sector.

This development also has positive effects on the labour market. In the summer of 2008 in Mecklenburg-Vorpommern approx. 40 companies with about 2,000 employees worked in the wind energy sector. Today, their number has increased to more than 8,000 employees in only about 200 companies. Manufacturers of wind energy plants and plant components (incl. export) generated a turnover of 900 Mio € in the year 2015.

In cooperation with scientists, a continuous development of wind energy technologies is taking place. Thereby turbines for less windy locations, increasing the megawatt capacity as well as improving the aerodynamics of the rotor blades represent a part of the innovation. In addition, the production of hydrogen from wind energy is tested through the use of electrolysis in Mecklenburg-Vorpommern. The wind-hydrogen system, which is the largest in Germany, makes it possible to store wind energy in the form of hydrogen and to make it available in a timely manner as required.

Trend 2010–15

Production	**Investment**	**Employment**	**Innovation**
Strong increase (2-fold growth)	**Strong increase**	**Strong increase**	**Increase**
● gross electricity generation: 2.5 TWh (2010) 5.3 TWh (2015) ● number of plants: 1,345 plants 1,546 MW installed capacity (2010) 1,703 plants 2,815 MW installed capacity (2015)	● 2010–15: ca. 1.6 Mrd. € ● 2005–10: ca. 0.6 Mrd. €	● 2008: 40 companies with 2,000 employees ● 2014: 200 companies with 8,000 employees	● R&D energy storage systems

Maturity of value chain: growing

Regional value creation, key indicators and landmark development
To illustrate the complete steps along the life cycle as well as the complete value added of wind energy plants (onshore), the following 4 stages of added value are distinguished:

1. Investment (production of plants and plant components)
2. Planning, installation, (partially) property purchase, etc. (incidental investment costs)
3. Operational management (service, maintenance, partially rent, etc.)
4. Operating company (financial management, profit determination)

Total added value of wind turbines in €/kW

Within the framework of the study from HIRSCHL, ET AL. (2010) the investment costs, operating costs, profits, income effects and taxes were determined in €/kW for onshore wind turbines in order to be able to estimate the total value added of this RES technology. The specific investment costs for wind turbines were calculated as the quotient of the total investment in wind energy plants in one year and the total installed capacity of the same year in Germany. The result has been divided into investment costs for wind energy plants (WEA), incidental investment costs and partial operating costs.

The investment costs for the wind turbines are indicated with 1,000 €/kW and the incidental investment costs with 247 €/kW. The installation costs include costs for the foundation, opening, grid connection, services and material costs. Profits occur in all value-added stages. The following table shows the pre-tax profits and gross income effects of onshore wind turbines.

Table 11. Investment costs and pre-tax profits of wind energy plants (WEA)

Cost item	Share of total costs %	Generated revenues €/kW	Pre-tax profits €/kW	Gross income effects €/kW
Investment costs WEA	**100**	**1,000**	**87**	**292**
Hub and main shaft	6	55	5	14
Gondola (rotor house)	7	74	7	18
Generator	9	92	8	23
Tower	22	221	20	54
Blades	22	221	20	54
Gear box	17	166	15	41
Azimuth system	2	18	2	5
Hydraulic system	2	18	2	5
Cables and sensor system	3	28	2	7
Installation	6	65	5	45
Logistic	4	43	1	28
Incidental investment costs	**100**	**247**	**13**	**95**
Planning	19	48	4	34
Installation	56	138	6	44
Compensatory measures	25	61	3	17
Total investment costs	**100**	**1,247**		**386**

The operating costs are calculated as annual costs in the study and are estimated as 14% of the WEA investment costs.

Table 12. Operating costs of onshore wind energy plants

Cost item	% of investment costs	€/kW annual
Service and maintenance	1	12
Electricity costs	0.2	2
Insurance	0.6	6
Other costs	0.8	8
Rental payments (land costs)	0.9	9
Dismantling	0.2	3
Management	0.9	9
ɛmuneration	0.03	0.3
Interest on borrowed capital	3	31
Depreciation	6	62
Total	**14**	**144**

The results of the one-time as well as the annual value effects of the "Onshore Wind Energy" value chain are summarized in the table above. This shows that in a municipality in which theoretically all stages of the value chain for onshore wind energy – from production to operation – are based, approx. 317 €/kW by the investment in the plant and its construction and approx. 55 € kW by the operation and the operator can be generated as maximum added value per year. If the production shares are neglected, which is rarely found in an "average" municipality, the added value is reduced significantly, but it remains approx. 70 €/kW per year by plant planning and installation as well as 55 €/kW by the operation.

The largest share is attributed to the net employment, in other words the income generated in the municipality and possibly spent there in significant parts. Looking at the municipal income from trade taxes and income taxes alone, this amounts to about 11 €/kW. In addition, a municipality can increase the added value by leasing municipal areas.

Table 13. Added value effects of onshore wind energy in €/kW

Stage of value chain	**After tax profit €/kW**	**Net employment €/kW**	**Trade tax (net) €/kW**	**Municipal share of income tax €/kW**	**Total added value €/kW**
One-off effects					
WEA	**61**	**168**	**10**	**9**	**248**
Hub and main shaft	5	8	1	0.5	12
Gondola (rotor house)	5	10	1	1	16
Generator	6	13	1	1	20
Tower	14	31	2	2	49
Blades	14	31	2	2	49
Gear box	11	23	2	1	37
Azimuth system	1	3	0.2	0.2	4
Hydraulic system	1	3	0.2	0.2	4
Cables and sensor system	2	4	0.3	0.2	6
Installation	3	26	1	1	31
Logistic	1	18	0.2	1	19
Incidental investment	**8**	**57**	**1**	**3**	**69**
Planning	3	19	0.4	1	23
Installation	4	27	1	1	32
Compensatory measures	2	11	0.3	0.4	13
Total investment costs	**69**	**225**	**11**	**12**	**317**
					Annual effects
Operation	**12**	**7**	**1**	**1**	**19**
Service and maintenance	1	2	0.1	0.1	3
Electricity costs	0.1	0.3	0	0	0.4
Insurance	0.2	0.3	0	0	0.5
Rental payments (land	8	0	0	0.2	8
Dismantling	0.1	1	0.02	0.1	2
Debt financing (banks)	3	3	0.5	0.2	6
Operating company	**26**	**4**	**4**	**1**	**36**
Management (partner with unlimited liability)	-	4	-	0.3	4
Liability remuneration (partner with unlimited liability)	0.2	-	-	-	0.2
Operator limited partnership (KG)	26	-	4	0.8	31

In 2010, an added value of approx. €105 million was gained by the onshore wind energy sector in Mecklenburg-Vorpommern. The majority of the total added value is currently generated by onshore wind energy, while offshore wind energy accounts a minor share (Table 13). However, this will shift in the coming decades.

Table 14. Added value and direct employment by wind energy in Mecklenburg-Vorpommern in 2010

RET	After tax profit in 1,000 €	Net employment in 1,000 €	Taxes to municipality in 1,000 €	Added value municipalities M-V in 1,000 €	Taxes to state M-V in 1,000 €	Total added value M-V in 1,000 €
Wind energy (onshore/ repowering)	63,674	25,172	7,780	96,625	8,444	105,069
Wind energy (offshore)	2,170	6,854	563	9,587	856	10,442
Total wind energy	**65,843**	**31,951**	**8,343**	**106,212**	**9,300**	**115,511**

Drivers

- Available areas: designation of suitable areas for wind energy by the State Spatial Development Programme (LEP) and the Regional Spatial Development Programmes (RREPs);
- Meteorological conditions, especially wind conditions;
- Available work forces (utilization of potentials, skills and staff from the former shipyards): Mecklenburg-Vorpommern is a federal state characterized by agriculture with an additional need for industry (connection of wind and maritime industries);
- Electricity grid infrastructure;
- Energy policy objectives of the state government;
- Renewable Energy Law (EEG): regulates the supply of electricity from renewable sources into the electricity grid and guarantees the producers compensation for electricity fed into the grid (fixed price);
- Citizen and Municipalities Participation Law MV (Bürger- und Gemeindenbeteiligungsgesetz MV - BüGembeteilG): Obligation of an offer for economic participation to affected citizens and municipalities;
- Production location of wind turbines and plant components: worldwide demand, export;
- Promotion of academic training by the state government: Endowed Chair for Wind Energy Engineering at the University of Rostock, academic training for wind energy engineers.

The value chain and core technologies

In Mecklenburg-Vorpommern almost 50% of the wind turbines are more than ten years old with an installed capacity of 640 kW on average. From individual plant sites to large wind parks with more than 100 MW of installed capacity, everything is available in the region. The largest wind farm, RH2-Werder/Kessin/Altentreptow (RH2-WKA), consists of 53 plants with a total capacity of 197 MW and has integrated hydrogen storage.

An important factor which generates a high value added is the production of plants and plant components directly in Mecklenburg-Vorpommern. The product portfolio of the various companies ranges from the construction of foundations over production of steel towers, plastic rotor houses, blades and rotor hubs as well as complete control cabinets, attachments such as brakes and special containers to point-of-corrosion protection and surface technology. Larger companies in the region include Nordex Energy GmbH, eno energy GmbH, Iron Foundry

Torgelow GmbH, Nordic Yards Holding GmbH, EEW Special Pipe Constructions GmbH and EnBW Ostsee Offshore GmbH. Not insignificant are the operating companies and companies for service and maintenance, since they are usually located nearby and thus ensure long-term employment.

Weakest link

Resource and technology	**Market and socio-economic**	**Nonmarket and stakeholder**
Energy storage systems Grid extension	Rising electricity prices Acceptance Decrease promotion by EEG	Nature conservation Species protection Acceptance

Outlook

Due to the good wind conditions on the Baltic Sea coast, wind energy plays a major role in the electricity generation mix of Mecklenburg-Vorpommern today and will do so in the future as well. The expansion of wind energy utilization is further promoted by the designation of new and expansion of existing suitable areas for wind farms. According to the current status, approx. 100 suitable areas with an area of approx. 13,000 ha are determined. In the scope of the revision of the Regional Spatial Development Programmes in Mecklenburg-Vorpommern, new areas for wind energy installations will be available in quantities that are yet not quantifiable.

The potential for repowering is increasing. Almost half of the plants in Mecklenburg-Vorpommern are more than ten years old. These plants are characterized by an installed capacity of 640 kW on average. Replacing a great number of these small wind turbines with a small number of new and more efficient plants could enable the region to grow and give new impetus to the construction industry and many municipalities in the structurally weak state. In 2015, 68 new wind energy plants with a capacity of 182.7 MW were installed in Mecklenburg-Vorpommern. As part of the repowering, smaller plants were dismantled and 10 taller wind turbines (hub heights of 131 m on average) and larger installed capacities (2.8 MW in average) were built in the same year.

Furthermore, 101 offshore wind turbines with a capacity of approx. 350 MW were operating in 2015. The energy yield of wind turbines on the high seas is estimated to be 40 percent higher than onshore due to strong and constantly blowing winds. For this reason, offshore wind parks will make a steadily growing contribution to energy supply in the coming years. According to the study by Hirschl et al. (2011), the added value effects of onshore wind energy will rise by at least 25% up to 50% (131–161 Mio. €) in the timeframe between 2010 and 2030. In addition, through offshore wind energy an added value is expected in 2030, which is, at minimum, the same or higher than the generated effects by onshore wind energy.

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4.4. Southern Estonia: the wood pellet industry

Regional importance

Energy autonomy	Economy	Innovation	Environment and climate
Low	High	Medium	High

Trend 2010–15

Production	Investment	Employment	Innovation
Strong increase 3-fold growth	Strong increase Directly 100 m€	Strong increase Directly 100+ jobs, in harvesting 240+	Increase Deployment of BAT

Maturity of value chain: growing

Regional value creation

Stages of value chain	Added value regionally
Project development	Low
Manufacturing	Low
Installation	Medium
Grid connection	Medium
Operation	High
Consulting	Medium
R&D	Low
Financial services	Low

Key indicators and landmark developments

Impact on employment, new jobs created: 100 in pellet mills, up to 240 jobs in harvesting, etc.

Total energy volume 4500 GWh (2015)

97% of pellets exported, 10% of EU28 pellet exports

Nationally 1,3 million tons, domestic use 60 000 t (2017)

2011 Helme pellet mill upgrade and CHP by Graanul Invest, 24 m€, production cap. of pellets 230,000 t and CHP installed capacity 15 MW heat and 6,4 MWe

2012 Varese pellet mill by Graanul Invest, 24 m€, 20 jobs, production cap. 300,000 t

2015 Varese CHP installed capacity of 10 MWe and 28 MW heat

2014 Järvere pellet mill by Warmeston, 20 m€, 20 jobs, production cap. 100,000 t

2016 Imavere CHP installed capacity of 10 MWe and 27 MW heat

2017 Osula CHP installed capacity of 10 MWe and 27 MW heat

Other minor pellet mills in southern Estonia: Kavastu 60,000 t, Tila 30,000 t, Karksi 10,000 t.

Drivers

- Relatively low costs of production concerning raw material, salaries and energy;
- Availability of raw material: wood resources available and cheap labour and energy costs can make the price competitive;
- Big ports for pellet exports (Riga, Tallinn, Pärnu)

The value chain and core technologies

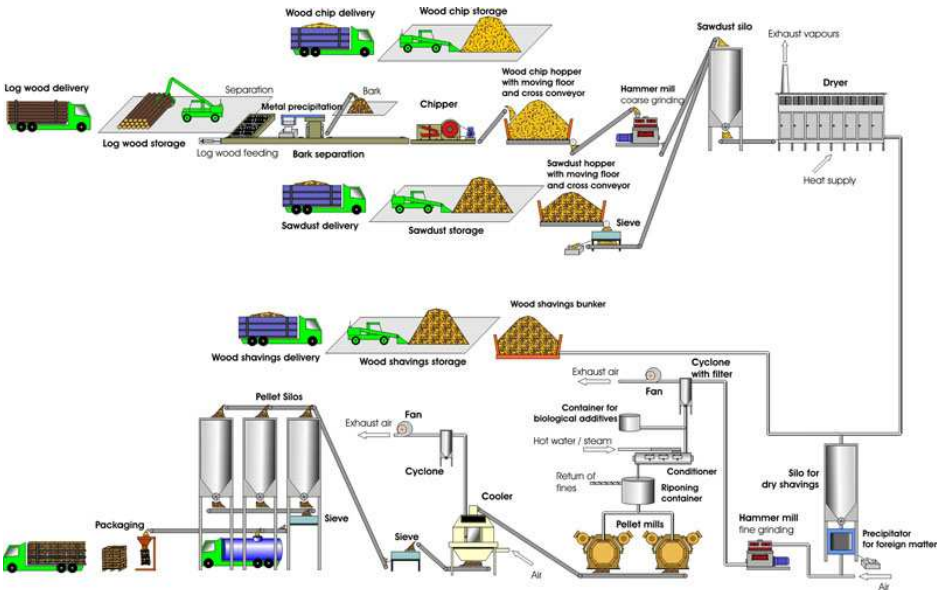


Figure 24. An illustration of value chain in premium pellet industry (Graanul Invest).

Mills use wood, chips, sawdust and shavings. In large mills, half of feedstock residue is provided by the sawmill industry and another half from low-quality roundwood. The main export markets are Sweden, Denmark, Italy and the U.K. Estimates are that 30% of the pellets produced are premium and 70% industrial.

Medium-sized CHP plants have been developed near major pellet mills (prod. capacity 300 thous. t). The CHP in Osula has an installed capacity of 10 MWe and 28 MW heat. The CHPs is based on a grate-type biomass boiler and enables the efficient burning of a significant proportion of forest wood wastes. Forest chips are used as fuel and generate heat and electricity for pellet plants.

Environmental and social benefits created by introducing additional renewable energy generation capacity and pellet production processes. On the other hand, the pellet boom is not without controversy. Harvesting mass quantities of forest and shipping them across the Baltic and to Western Europe has drawn scepticism.

Weakest link

Resource and technology	Market and socio-economic	Nonmarket and stakeholder
Sawdust limitations due to fast growth of the sector	Weak domestic market for pellets and qualifies, also labour shortage.	Engineering capacity

Outlook

There are very high potentials for the region to activate and develop the domestic biomass pellet fuel market as well to continue growth in export markets, considering that the global demand for wood pellets is set to double over the next decade. In Estonia, the domestic wood pellet market remains very small and is mostly serviced by local secondary producers, though there is a forecast for domestic use up to 2 million tons of pellets annually. The district heating still uses largely inexpensive wood chips (expected growth to 5 million tons). The sector's potentials include establishment of a comprehensive system of domestic equipment producers, setup of a more stratified and stable certified supply chain and stimulation of big domestic consumers and energy producers. New mills in a more competitive market consider roundwood for raw material as using wood by-products that would otherwise go to waste is limited.

The public debate continues on sustainable harvesting levels. As a large share of Estonian forests will reach maturity in coming years, Estonia has the capacity to extract greater levels of biomass. However, this would need to be balanced by sustainable forest management, as bio-refinery development has begun to be conducted near Tartu. The prices for the commodity will rise due to substantial expansion of biofuel and processing.

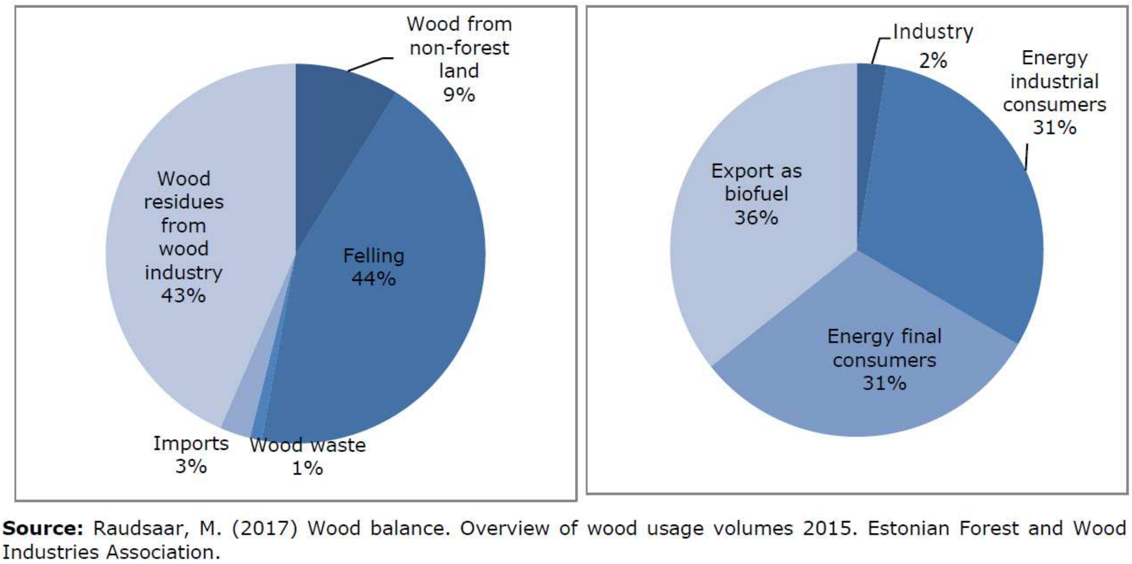


Figure 25. Sources of wood for energy (left) and main consumers (right) (Raudsaar 2017)

Sources

Estonian Statistical Office, Foundation Private Forest Centre; Pellet Mill Magazine, Graanul Invest; Raudsaar 2017.

4.5. Zemgale: CHP and district heating

In Latvia's climatic conditions district heating has a significant role in the energy industry. District heating is ensured by the centralized heat supply system, local heat supply and individual heat supply. The most significant part of total energy consumption has been produced in decentralized (local, individual) heat supply systems. In 2013 44.6% of the total energy final consumption was consumed in decentralized systems. At the same time the centralized heat supply system is an effective solution from the perspective of usage of resources and environmental protection.

In 2013 in Latvia centralized heat energy was produced by 638 boiler houses and 166 combined heat and power plants (CHP). For sale were produced 7.29 TWh centralized heat energy. In 2013 69.1% of heat energy was produced in CHP and 30.9% in the boiler houses. The consumer structure of centralized heating has not changed over the past few years. The main heat energy consumers in 2013 were households – 71.1% of the total heat energy consumption.

Regional importance

Energy autonomy	Economy	Innovation	Environment & climate
Low	High	Medium	High

Zemgale is crossed by five nationally importat roads and important international transport corridors and their intersections, the main highway and railway lines, long-distance natural gas and petroleum pipelines and fibre optic cables.

In 2013 the Zemgale region produced 8.4% of Latvia's heat amount production – 609 GWh. Comparatively, the Riga region consumed more than half (56%) of the total produced heat energy of Latvia, whereas in the final heat energy consumption the Zemgale region reached 7.4% or 449 GWh of the state's total heat energy.

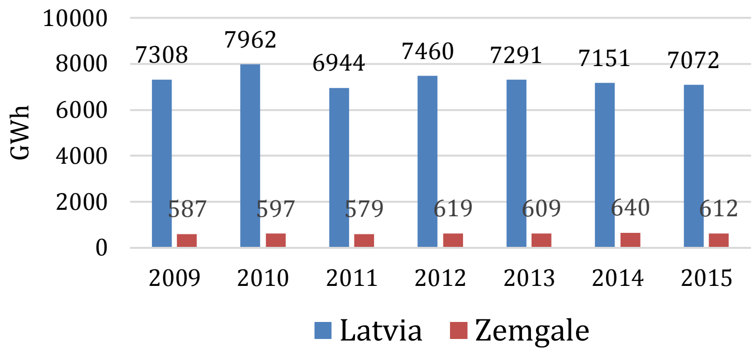


Figure 26. Produced heat energy *(Central Statistical Bureau of Latvia).*

A substantial part of the input for heat production must be imported. In 2013, 73.2% of produced energy for the heat supply was created from imported fossil fuels, mainly natural gas.

Trend

Each year Zemgale faces the trend of a decreasing number of boiler houses; the installed heat power is fluctuating but with the tendency to decrease.

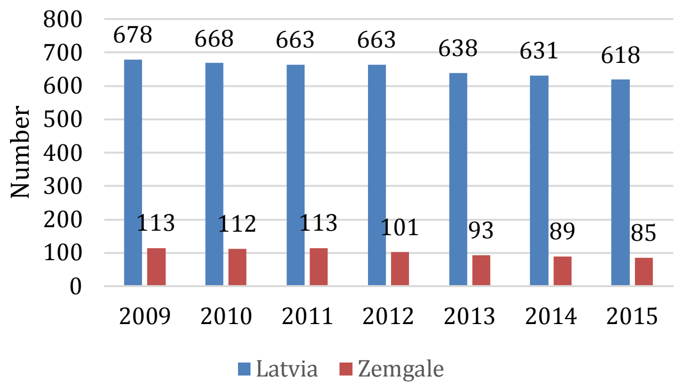


Figure 27. Number of boiler houses in Latvia and Zemgale 2009–2015 (Central Statistical Bureau of Latvia).

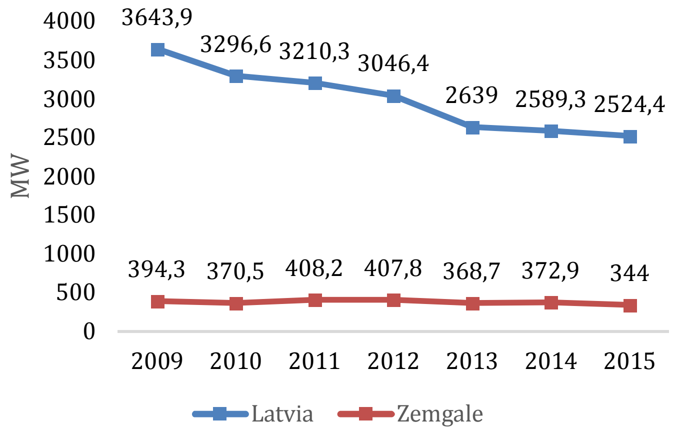


Figure 28. Installed heating power of boiler houses in Latvia and Zemgale 2009–2015 (Central Statistical Bureau of Latvia)

There is a tendency to increase the amount of boiler houses that use RES in heat production. In 2013 the share of RES in the heat supply was 26.8% with a slight share increase from year to year. In the period from 2007 to 2013 this was achieved by the redirection of EU budget assets as well as Climate Change Financial Instrument sources. However, the number of CHP plants is growing and the installed electricity power is showing a gradual increase.

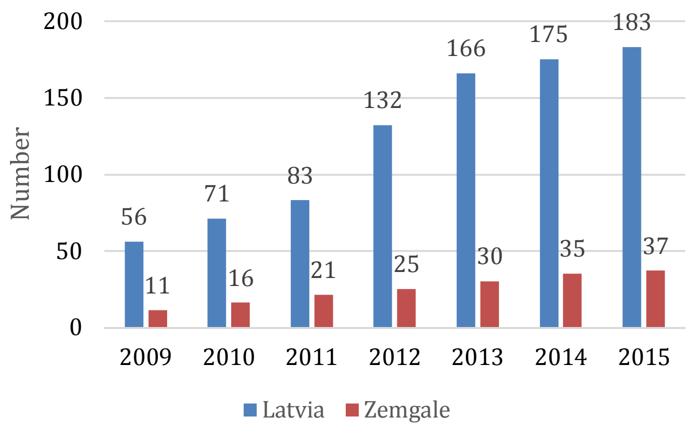


Figure 29. CHP in Latvia and Zemgale 2009–2015 (Central Statistical Bureau of Latvia).

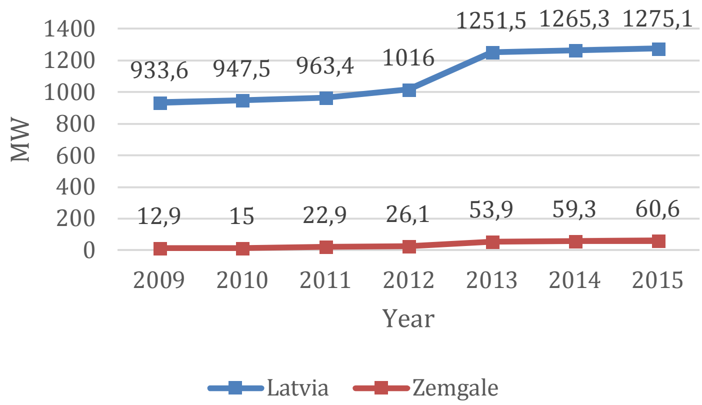


Figure 30. Installed electric capacity in CHP in Latvia and Zemgale 2009–2015 (*Central Statistical Bureau of Latvia)*

This shows the overall trend to optimize the heat supply systems and to switch to combined heat and power generation. The reason for reduction in the number of boiler houses is due to the centralization, optimisation and increase in energy efficiency of the plant and grid.

Production	**Investment**	**Employment**	**Innovation**
Increase	Low	Light increase	Increase
Each year there is an increase in the amount of biomass used in heat production.	The overall amount of investments in the Zemgale region has been decreasing in the past few years. Also, the overall trend in Latvia is to decrease the amount of investments in industry of electricity, gas supply, heat supply and conditioning systems.	The tendency to decrease the number of boiler houses and the increase of CHP plants shows that there is a need in the area of employment for specialized employees as the work in CHP industry demands more specific knowledge.	The large companies entering the local market also introduce new technologies in the region.

The data of financial and non-financial investments in Zemgale and Latvia have shown fluctuation but in 2012 and 2013 it shows a tendency of reduction as can be seen in the graphs below.

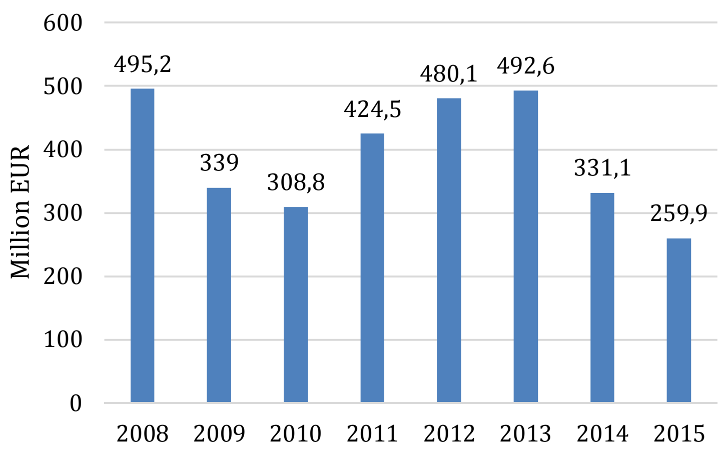


Figure 31. Non-financial investments in Zemgale 2008–2015 (Central Statistical Bureau of Latvia)

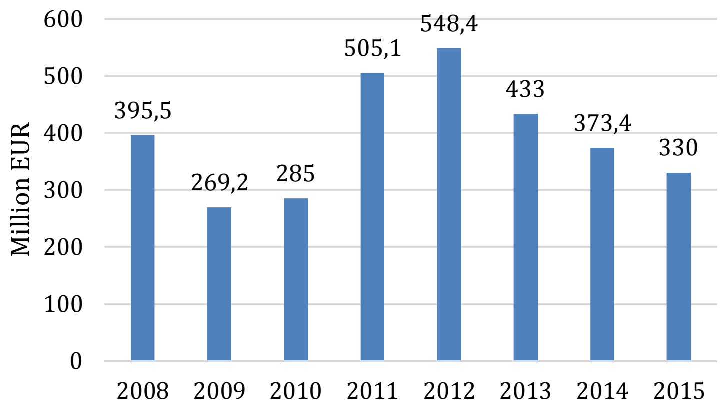


Figure 32. Investments in energy sector in Latvia 2008–2015 (*Central Statistical Bureau of Latvia).*

Maturity of value chain: growing

The trend of biomass usage in heat and electricity production has been growing over the years. The structure of produced district heat in boiler houses in 2011 showed 63% for natural gas and 33% for fuelwood, straw and other biomass. But the structure of produced heat in CHP in the same year was 93% for natural gas, 2.8% of fuelwood and 1.5% of coal.

Since 2011 in Latvia there can be seen the trend to limit the usage of fossil fuels and to replace them with biomass. The most popular biomass type is fuel chips, which shows the substantial increase of consumption both in boiler houses and CHP plants.

A steady reduction in the consumption of natural gas in the heat production in Latvia can be seen. However, at the same time, the usage of RES increases from year to year. Taking as example chips which are produced locally as fuel, there can be seen steady increase in the number of these boiler houses using only chips as fuel: from 46 in 2007 to 128 in 2016 in Latvia.

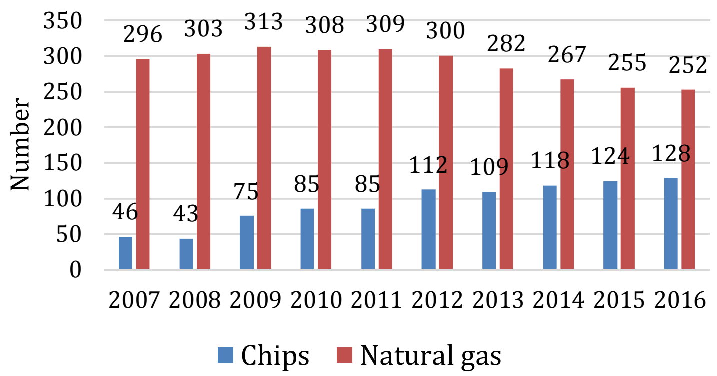


Figure 33. Boiler houses by fuel type in Latvia (*Central Statistical Bureau of Latvia).*

The number of CHP plants in Latvia showed a steady increase from 8 in 2011 to 44 in 2015.

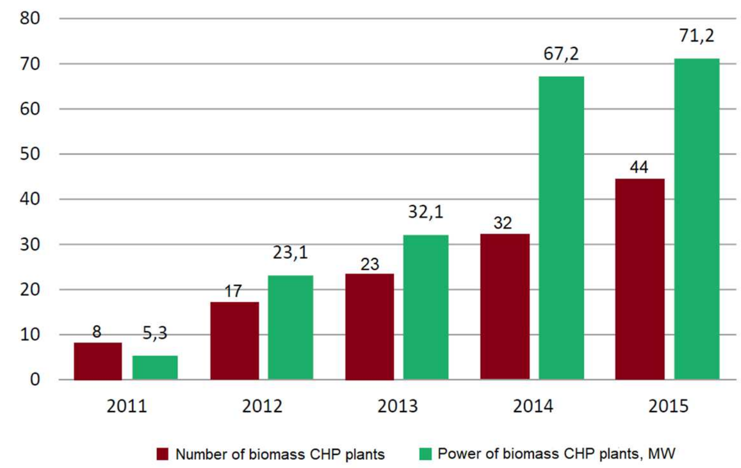


Figure 34. Biomass CHP plants in Latvia (*Latvian RES Federation, Renewable Energy and Climate Change).*

The high soil fertility and relatively unpolluted agricultural and natural areas are significant advantages of Zemgale, which defines the potential for agricultural development and specialisation. Forests cover about 40% of the territory in Zemgale.

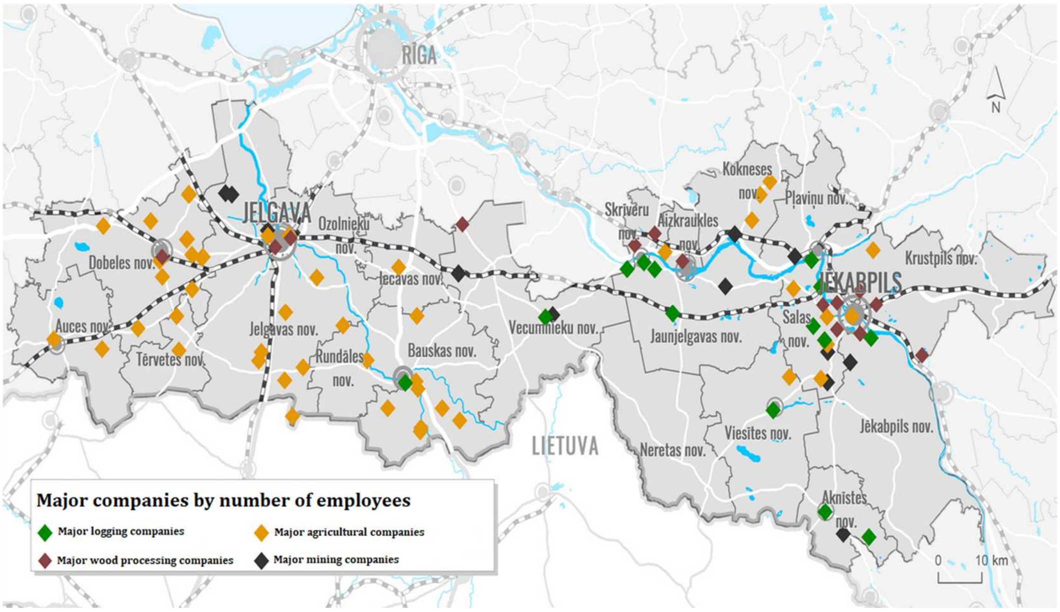


Figure 35. Map of the major bioeconomy companies by number of employees in Zemgale region *(Data of Zemgale Planning Region administration).*

There is also a trend to combine various fuel types to lessen the energy dependence on fossil fuels.

Regional value creation: medium

The main local beneficiaries are farmers and forest owners who have the opportunity to gain from the heat production. Of core importance is the price which they are willing to receive for the materials.

There are differences in technologies the CHP plants use to produce heat and electricity. There are plants with technologies that can produce energy from any quality of biomass as well as plants that need only good-quality fuel. The biomass does not always come from the regional forestry or agriculture industry.

Stages of value chain	Beneficiary	Added value regionally
Growth of wood, agriculture cultures	Farmer, forest owner	Medium
Raw material harvesting, selling	Farmer, forest owner	High
Transportation to heat company	Logistic companies	Medium
Heating company receives the materials and produces heat, electricity	Heating company	Medium
Consumer of produced heat and electricity	Consumers	Medium

The average cost for logging in Latvia has been fluctuating over the recent years. In 2016 the preparation of wood in the main cutting paid 5.54 EUR/m^3 without VAT.

Key indicators and landmark developments.

CPH plant in Jelgava

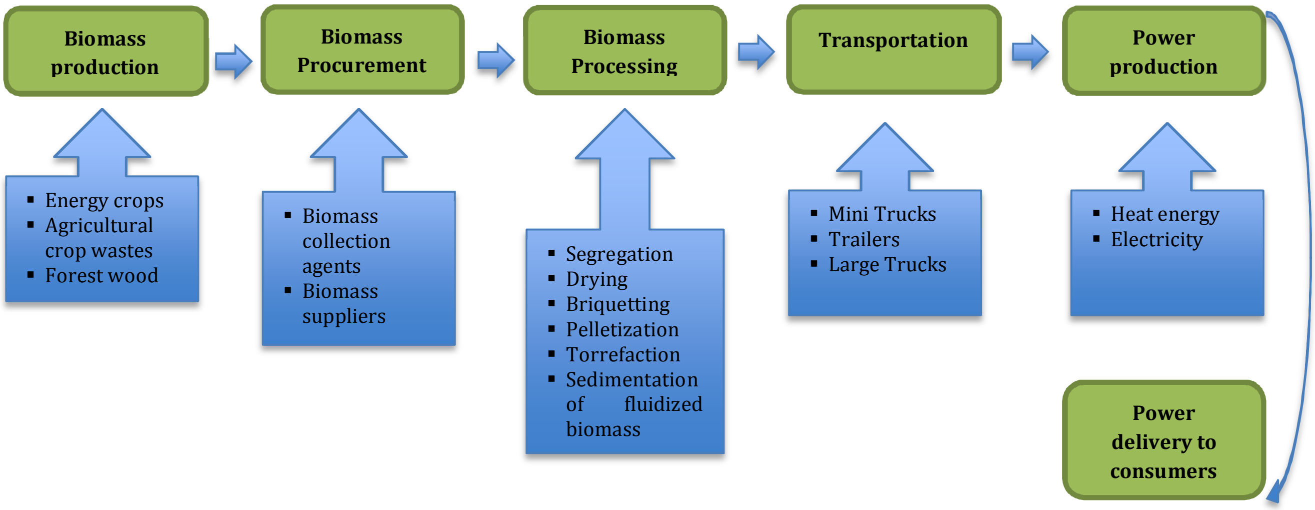
2015 data:
First high-power biomass CHP plant in Latvia;
First heat supply system interconnection under the riverbed;
Ensures 85% of the load of the Jelgava district heat system;
Switch from imported fossil fuel to local RE – chips;
Installed capacity: thermal heat – 45 MW, electricity – 23 MW;
Investment of Fortum together with infrastructure – 70 million EUR; 6 million EUR – from EU funds;
31 new jobs for highly qualified specialists;
Approximately 300 indirect jobs for fuel producers and in logistics;
Yearly fuel consumption – 400,000 MWh chips;
Fuel supply – approx. 6,000 trucks/year: in summer 10–15 trucks/day, in winter 25–30 trucks/day;
7 suppliers with contracts of 1 year;
The origin of chips – Latvia with a radius of 150 km around Jelgava;
The type of chips – wood chips, shrub chips;
Main quality criteria – ashiness, humidity, heat capacity.
Latvian RES Federation, brochure "Renewable Energy and Climate Change"

Drivers

- The use of income from emission allowances trading for implementation of new and innovative RES technologies in heat supply;
- Great options to use local energy sources as geothermal energy and peat for energy production concerning environmental and especially air quality requirements;
- The need to expand the district heating consumers network by connecting new consumers that are currently using heat produced by fossil fuels;
- The extended usage of heat pumps technology for heat production.

The value chain and core technologies

The value chain is basically similar to other BSR countries. But there is still a need to develop the advanced system of biomass exchange and delivery.



Regarding the core technologies, a recently discovered innovative process which has not been used so far in the industry can be mentioned. It involves the pre-processing of biomass chips in the field of microwaves and further modification with natural oils. This process allows substantial increase in the heat combustion of pelleted biomass and also has a positive influence on other characteristics. For example, the processing of commercial wood pellets after the usage of previously mentioned technology ensures an increase in heat capacity from 18 MJ/kg to 24 MJ/kg and energy density from 12 to 16.5 MJ/m3 compared to unprocessed pellets. In the combustion process, there is increased heat energy amount and decreased harmful emissions.

Weakest link

Resource and technology	Market and socio-economic	Nonmarket and stakeholder
Lack of investments in technologies to use the biomass in energy production	The low-economy of remote regions, the low payability of inhabitants which creates a cycle – the low capacity of current assets of energy producers and providers	Lack of state support politics, the discrepancy of technologies versus quality of biomass, the cooperation among biomass producers, intermediaries and suppliers

The main problems that should be currently dealt with according to the Latvian Energy Sector Development Guidelines for 2016–2020 (2016).

- ❑ Heat generation and supply:
- Insufficient development and efficiency of existing district heating infrastructure;
- High consumer debts for heat supply, which creates substantial risk for the existence of heat producers;
- An overall district heating and CPH system evaluation and potential determination has not been done;
- The increase of heat energy tariffs (due to the increased prices of energy sources, end of support for high-efficiency cogeneration plants) is why consumers refuse centralized heat supply systems.

- ❑ Electricity generation and supply:
- Insufficient capacity of power transmission interconnections, which creates differences in prices in price area of Latvia/Lithuania;
- Administrative obstacles in the building of networks;
  Insufficient financial sources for network maintenance;
- The state support mechanisms create additional burdens for the end consumers;

- Current regulatory mechanism doesn't ensure a balanced support policy of highly effective cogeneration and biomass;
- Insufficient knowledge by the general society about energy market principles, price mechanisms, advantages of the market or effective usage of electricity.

Outlook: developing

Latvia is in third place in Europe behind Iceland and Lithuania regarding the amount of inhabitants (%) with a centralized heat supply. The future challenge is related to maintaining this position. The next step after the evaluation of the system as a whole is the review and arranging of industry's regulations. A common legal framework should be created with a target of adapting the current heat supply model to future challenges, including a potential switch from a third-generation to fourth-generation heat supply model. This model involves open transmission networks, thermal energy surplus collection and accumulation, increased usage of RES and other innovative energy sources, which can strengthen the consumer role in the energy market.

Most of the district heating systems were built more than 25 years ago. They are old and experience substantial losses. The total length of the network is 2000 km. According to national statistical data, in 2014 the losses in heat transmission and distribution networks in Latvia were 13% and in the Zemgale region13.2%. In the bigger cities the losses were 9% but in the smaller cities 16%. Still there are some places with heat losses reaching 35−38%.

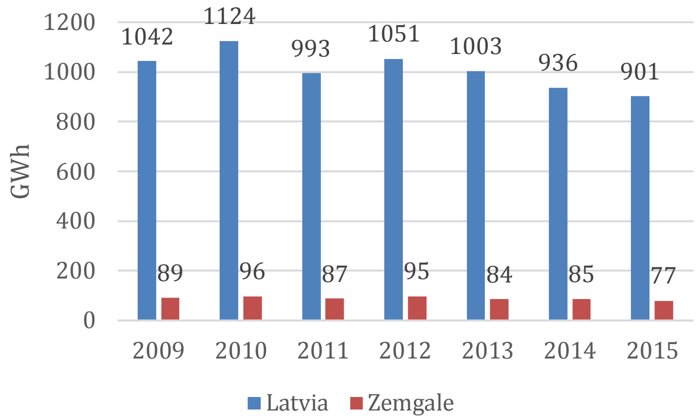


Figure 36. Heat losses in transmission *(Central Statistical Bureau of Latvia).*

The increase in the energy efficiency of centralized heating is prevented by lack of necessary investment amount, the limited options for municipalities to take a loan as well as slow capital turnover rate. Due to the abovementioned reasons, in municipalities ineffective equipment continues to operate that creates increased fuels consumption and cannot provide the heat supply of the required quality. Only through a complex renovation of the system is it possible to optimize the energy production process and decrease the heat losses in the transmission systems.

To enhance the market conditions for biomass technologies it is essential to also promote centralized heat energy consumption in summer. This would increase the cogeneration potential. A relevant solution would be connection to the heat supply for new industrial consumers.

Taking into consideration the RES technology cost dynamics presumption, the development strategy of the industry as well as system safety, it is preferable to integrate a variety of RES technologies in the centralized heat supply system. Their uniform distribution would make the heat supply system more stable in general. Thereby also in the next planning period EU financial sources investment in the switch from fossil fuels to RES in the heat supply system is foreseen.

4.6. Kaunas Region: CHP and district heating

Regional importance

Energy autonomy	Economy	Innovation	Environment and climate
High	High	Medium	High

High, medium, low

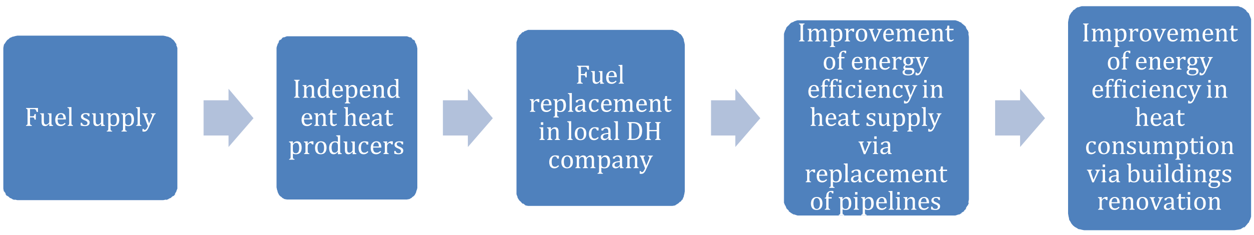
Trend 2010–2015

Production	**Investment**	**Employment**	**Innovation**
Strong increase	Strong increase in building biomass boiler house capacities.	Medium increase	Moderate increase
From nearly 0% to 50% biomass in fuel balance	Directly at least 70 mill € (where info available); Strong increase into pipelines replacement. Directly at least 7 mill € Moderate increase in renovation of public and residential buildings. Directly at least 10 mill € in public buildings	Total number N/A	

Maturity of value chain: growing

Heat production from biomass fuel is still growing RET. Processes of energy efficiency improvement in heat supply and final consumption by replacement of pipelines and renovation of buildings is also developing.

Regional value creation



Stages of value chain	Added value regionally
Project development	Low
Manufacturing	Medium
Installation	High
Operation	High
Consulting	Medium
R&D	Low
Financial services	Medium

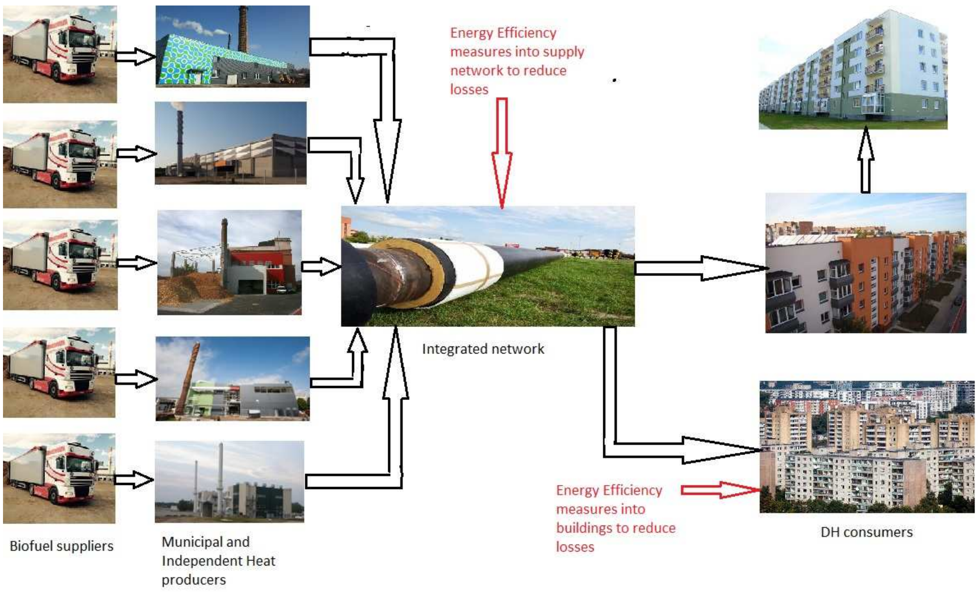
Key indicators and landmark developments

Impact on employment, new jobs created – at least 100
Reduced CO_2 emissions 25,951.8 t CO_2 or 90.2 kg/MWh (during 2010–2015)
Investment cost 240,000€/MW
Production cost approximately 49.4 €/MWh (as of March, 2017)
Total biomass energy capacities installed 300 MW boilers plus 86 MW condensing economizers (by 2015)
Solid Biomass fuel consumption 34,252.2 toe (2015)
Biogas fuel consumption 228.4 toe (2015)
Reduction of total non-CO_2 emissions (during 2010–2015) 35.4 t

Drivers

- Introduction of independent energy producers;
- Investment into company biomass capacities as well as reduction of supply losses via investment into energy efficiency;
- Using services of National Biomass Exchange thus reducing biomass purchasing costs;
- Reduction of heat tariffs, which provides support from population.

The value chain and core technologies



Biomass producers supply biomass fuel to municipal district heating companies as well as to independent heat producers for heat generation. Biomass supply takes place via the National Biomass Exchange. Biomass used in the district heating sector is mainly wood chips produced from wood cutting residue and forest management (thinning and cleaning activities). During the farming season it also includes some farming waste, energy plants, grass, as well as some residues from urban parklands. It is considered that more than half of biomass is produced locally, while the other half is imported from Latvia, Belarus and other countries.

Generated heat is supplied to the integrated district heating network. Parts of obsolete pipelines are replaced every year with the aim to improve the energy efficiency of supply by reducing heat losses. Current average heat losses are 15%. Renovation of buildings also adds to energy efficiency on the heat consumption side.

Environmental and social benefits are created by introducing new heat generation capacities from biomass and biofuel production. However, the latter is not on a regional but on a national scale. Social benefit is mainly expressed by reduction of heat tariffs due to lower biomass prices compared to natural gas.

Weakest link

Resource and technology	Market and socio-economic	Nonmarket and stakeholder
Unclear situation with waste incineration plant; Technological conflicts between independent producers and DH company.	Not as efficient tariff reduction as was expected	Conflicts with residential stakeholders in the vicinity of new boiler houses

Outlook

Three main driving forces initiated the process of introducing biomass into district heating in Lithuania: the fast growth of natural gas prices in 2008–2010; introduction of independent heat producers in the three largest cities in Lithuania; and the establishment of the National Biomass Exchange, which introduced competition and led to reduction in biomass prices.

Solid biomass has become the leading renewable in Lithuania and further development is envisaged, especially in the heating sector. Currently (2015) the share is 65% and should reach 80% by year 2020. The existing biomass stock should also involve the use of municipal waste. Kaunas currently uses the largest biomass share of 80% and plans to improve this share to nearly 100%. However, the use of biomass in electricity generation should still be supported due to low market tariffs and significantly high investment into bio-cogeneration technologies.

Sources

Kaunas District Heating Company, Lithuanian Business Support Agency; Public Company Housing Advisory Agency

4.7. West Pomeranian Voivodship: onshore wind energy sector

Regional importance

Energy autonomy	Economy	Innovation	Environment and climate
High	Medium	Medium	High

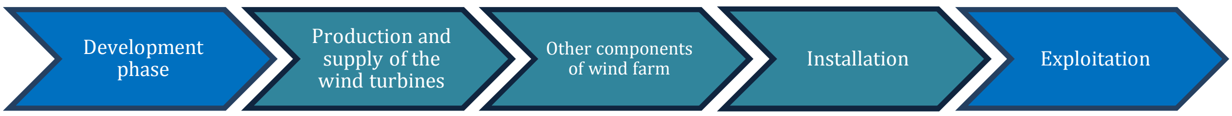
Trend 2010–15

Production	**Investment**	**Employment**	**Innovation**
Strong increase –	Strong increase	2010–2012 strong increase 2012–2014 decrease	Increase
more than 3 times	6 m PLN/MW*, Worth of investments for West Pomerania 6,4 bn PLN	In 2012 about 12,000 jobs in country. According to new regulations (2016) further decrease in employment is forecasted	Szczecin and its science centres (West Pomeranian University of Technology, University of Szczecin and Maritime University of Szczecin) are one of the leaders in the field of R&D in this sector.

* The average investment outlay for 1MW of power for onshore power plant (Own elaboration of RBGPWZ based on "Report: wind energy in Poland 2013" TPA Horwath, "Influence of wind energy on economy "presentation Ernst & Young oraz Tundra Advisory, 2012 r.)

Maturity of value chain: stagnating

Regional process of value creation



Structure of investment costs for onshore power plants

Source: Own elaboration of RBGPWZ based on "Influence of wind energy on polish job market" Warsaw Institute of Economic Studies, 2015.

Value chain for onshore wind energy power plant in West Pomeranian Region

Stages of value chain	Regional added value
Designing and planning	Low
Turbine production	Medium
Production of connection infrastructure and foundations	High
Installation	Medium
Exploitation and maintenance	Low

Key indicators and milestones of development

Overall quantity of installed power in this sector, status 2000: 2 wind installations – 5.2 MW;
Overall quantity of installed power in this sector, status 2016: 100 wind installations – 1,500 MW;
Estimated number of workplaces in West Pomerania in this sector, status 2014 – 1,500
Estimated number of workplaces (Poland) in this sector, status 2014 – 8,400;
Installed power of wind power plants in West Pomerania are 93% of all RES and more than 25% of wind power plants in the country;
The total volume of RES energy: 3,900 GWh (2015);
Share of RES electricity in energy consumption is 63.8 % (in Poland 14.7 %).

Companies in the West Pomeranian Region:

LM Wind Power Blades Poland in Goleniów
Activity: blade production for the wind energy sector;
Employment: 600 people;
KK Wind Solutions Polska in Szczecin
Activity: production and maintenance of electronics for wind turbines – control and steering systems;
Employment: 400 people.

Drivers
The region has very good wind conditions, and it is a national leader of wind energy development.
A large amount of possible land to allocate to the new wind power plants (26,132 ha / 2,600 MW estimated by the Regional Office for Spatial Planning of West Pomeranian Voivodship in 2014)
Wind Energy has a strong impact on the landscape – negative attitude of the local communities.
Possible connection to the existing power grid and receiving energy from new wind farms.
Polish Wind Energy Society main headquarter is located in Szczecin.

Comment: Current national policy, strongly stopped development of onshore wind farms and had bad influence on financial liquidity of this sector. There is no possibility to locate new or recreate used wind farms due to new localization distance (10 times high of wind turbine installation distance between wind turbine and households or protection area). This has crucial influence also on employment etc.

The value chain and core technologies
Wind power station – the construction with the necessary technical equipment and accompanying infrastructure, which is a productive unit using wind energy for generation of electricity.
Wind farm – a set of wind turbines connected to the grid at one point of attachment. Placing the plants together reduces construction and maintenance costs and simplifies the power grid.

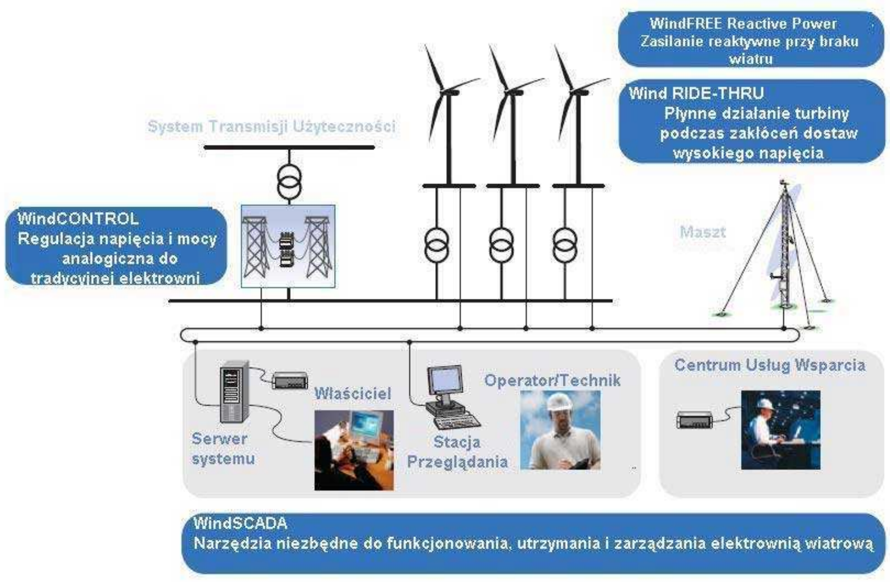


Figure 37. Scheme of connection of wind farm to the power grid (www.ekoenergia.pl)

Wind turbines are divided into types due to their usage (household or industrial), power (micro, small and large) and location (onshore and offshore). For domestic purpose (for the user's own) microgeneration is used. Large industrial plants are adapted to the sale of energy.

A micro wind plant is a wind plant with a power capacity of less than 40 kW, connected to the power grid with a voltage rated less than 110 kV.

A power system of 21. century is a network of cooperation of different sources of energy, consumers, services and users (prosumers). A prosumer is a customer who not only receives energy from the network but will become an additional supplier. This is individual client that meets their energy demand on their own, sometimes with the network and sometimes transmitting the surplus energy to the network. This new energy system requires qualitative changes in management and technology under applicable law in order to remove existing financial and construction barriers hindering the development of this segment of the energy market.

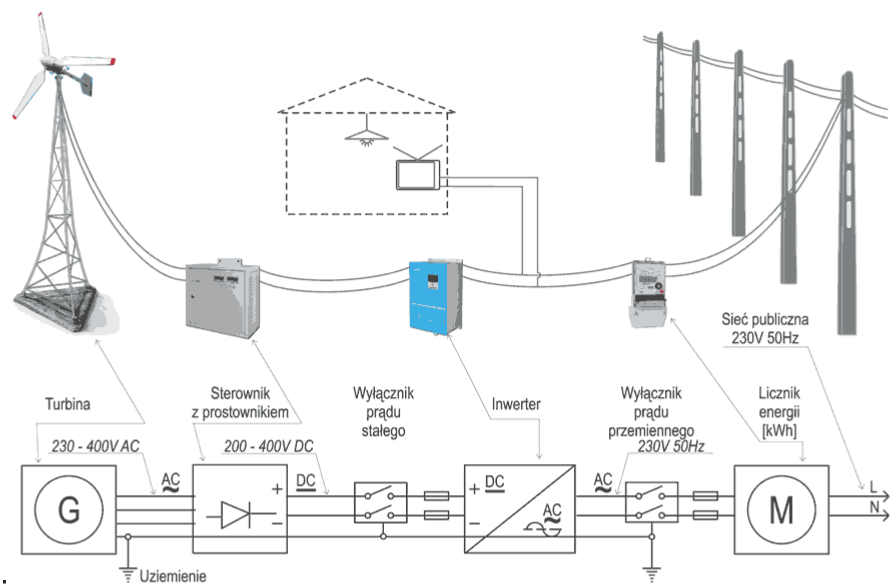


Figure 38. Scheme of connection of micro wind plant in prosumer system (www.ekoenergia.pl)

The development of wind energy stimulates the development of the region. The new companies start up, and existing companies connected with the sector are developing. New job places are created and the power grid is being developed. Municipalities in the area where the wind farms are located receive additional tax revenues, and local staff is being employed. Investors often take action for the local communities, for example, they construct new roads and sports facilities, fund culture for youth, etc.

The weakest link

Resources and technology	**Market and socio-economic**	**Nonmarket and stakeholder**
The region is covered by different types of natural protection areas. The power grid has limited possibilities of receiving energy.	Support – financial systems for wind power development. The formal and legal procedures are complicated and require a long- term commitment	Social and landscape conflicts related to the location of wind turbine.

Outlook

In 2014 the Regional Office for Spatial Planning of the West Pomeranian Voivodship in Szczecin developed the study "Predisposition of area of West Pomerania for potential localisation of wind farms". As a result of the analyses, including the conditions affecting areas of potential location of wind power facilities (space, nature and landscape, infrastructure), a map of potential localisation of wind energy development in the region has been developed. The potential has been defined based on the assumption that all non-restricted areas have been included. For the adopted protective zone of residential buildings of 1,000 m, the estimated potential of allocations reached more than 2,600 MW of new power capacity.

In July 2016 the new law on investments in wind power plants was adopted. Currently, the distance between a wind plant and residential buildings and natural protection areas should be larger than ten times the total height of the wind turbine (measured from the ground level to the highest point of the construction, including the rotor blades). Assuming that average height of a wind turbine 150 m, the new law establishes the required distance of 1,500 m. Taking into account the new requirements, development was summed up at about 300 MW, which represent 14% of the previous potential possibilities location of wind turbines in the region. It should be emphasized that this defined potential does not take into account the infrastructure conditions and economic justification for the location of distributed devices. Dispersal of areas where location of wind turbines meets the requirements of the law decrease potential localization to zero. The new law does not apply to investments in marine areas of Poland and micro-wind turbines (less than 40kW). Location of wind farms is possible only by the local spatial development plan. On-shore wind power is not a part of the Polish government national energy policy, which is based on coal.

Sources:

Legal act from the 20 may 2016 r. about investments in wind plants
Report *State of wind Energy in Poland in 2015*, Polish Wind Energy Society, 2016 r.
Report: wind energy in Poland 2013" TPA Horwath TPA Horwath, 2013 r.
The impact of wind power on the economy, Ernst & Young and Tundra Advisory presentation, 2012 r.
The impact of wind power on the Polish labour market, Warsaw Institute of Economic Studies, *2015.*
www.ekoenergia.pl

4.8. West Pomeranian Voivodship: offshore wind energy sector

Regional importance

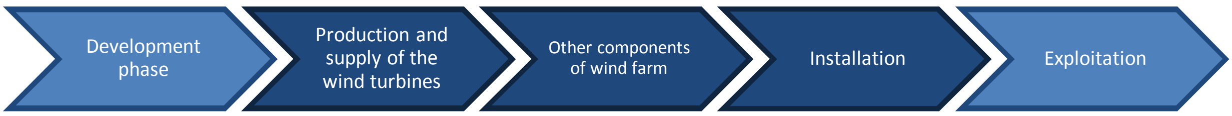
Energy autonomy	Economy	Innovation	Environment and climate
Missing	Medium	Medium	Missing

Trend 2010–15

Production	**Investment**	**Employment**	**Innovation**
Increase stable	Increase stable	Increase stable	Increase stable
Currently there is a lack of production of energy in the offshore wind energy sector. In West Pomerania there is production of fundaments for Denmark offshore wind farms (ST3 Offshore Factory).	Currently there are only investments in the development phase.	200 people in the larger, local wind farm factory in the West Pomeranian Region (data from owner's website). There is no available data including data about employment in other small enterprises.	The offshore wind energy is a new technology in our country. Szczecin and its science centres (West Pomeranian University of Technology, University of Szczecin and Maritime University of Szczecin) are leaders in R&D in this sector.

Maturity of value chain: emerging

Regional value creation



Average percent of toal investments' expenditures on wind power plants with a 500 MW capacity.

(Example: Value chain for wind power plant in Great Britain. Source: own elaboration of RBGPWZ based on: Development of off-shore wind energy in Poland. Perspectives and evaluation of the influence on local economy, McKinsey & Company, 2016)

Stages of value chain	Regional added value
Designing and planning	Low
Turbine production	Low*
Production of connection infrastructure and foundations	High**
Installation	Medium (predicted)
Exploitation and maintenance	Medium (predicted)

* There are no further plans of turbines' production in the region
** Foundations' production in region already exists, so the increase of the production in next years can be assumed

Key indicators and landmark developments

ST3 Offshore Factory in Szczecin:

Activity: production of foundations for offshore wind power plants

Employment/ year: 200 people (target: 500 people)

Currently due to lack of functioning wind farms there are no other indicators.

Drivers

- Good wind conditions in SW part of the Baltic Sea;
- Direct access to the Baltic Sea, including access to sea ports in Darłowo and Kołobrzeg, which could be Polish operational ports for offshore wind power plants;
- Existing shipyard infrastructure in Szczecin could be used for the production of structural elements of offshore wind power plants;
- Gradually developing sector of production of elements for offshore wind power plants;
- Big part of Polish exclusive economic zone and Polish sea area (estimated potential: possibility of location of installations up to 20 GW capacity/ after excluding the NATURE 2000 areas the potential amounts to 7.5 GW).

The value chain and core technologies

The offshore wind power plant is a group of turbines located on the sea which are connected to the electrical grid with underwater cables. The main elements of the wind power plant are:
Foundation;
Off-shore turbines;
Interior cables;
Sea transformer station (one or more);
Export cables.

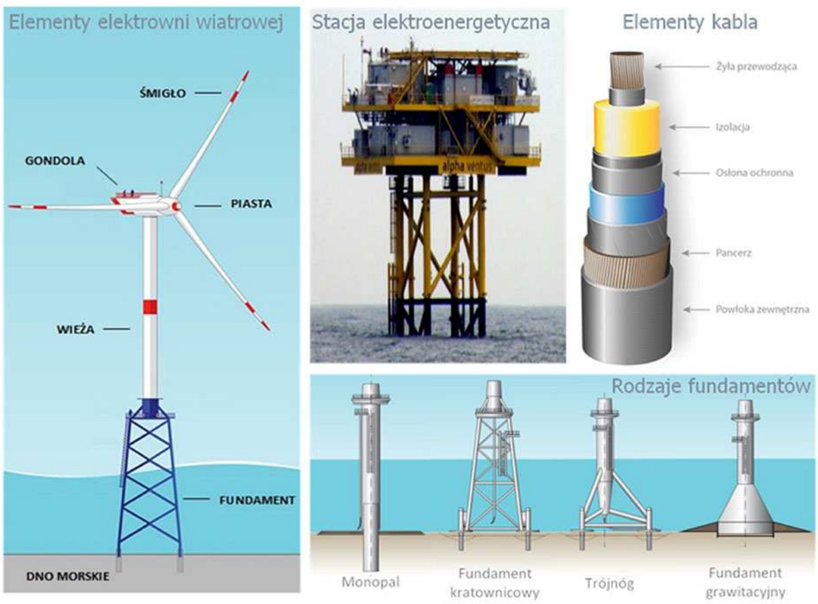


Figure 39. Technology of offshore wind farm Source www.baltyk2.pl .

The foundation of the offshore wind power plant attaches the power plant to the sea bottom. Different technologies are used, depending on the depth and the kind of seabed. The turbine is the main and most expensive element of the offshore power plant. It changes the kinetic energy from wind into a three-phase current. The turbine consists of three main parts: the nacelle, the rotor (its main elements are the blades) and the tower. The nacelle is located on top of the tower and has an energy generator inside. Its mass is between 150 and 300 tonnes. The rotor in offshore wind energy usually consists of three blades, made of composites, which contain glass fibre, polyester, epoxy resin, and sometimes carbon fibres. The main material for the production of a tower is steel sheets. The weight depends on the capacity of the turbine, which influences its height and mass. Underwater cables connect the power plant with sea electrical stations. Currently, electrical cables and optical fibre cables are being used. The last element of the power plant is sea transformer stations which prepare the energy for transmission in order to lessen the energy loss. The transformers which raise energy voltage or voltage converter transformations are used very often – they help to convert the alternating current into direct current.[1]

Weakest link

Resource and technology	**Market and socio-economic**	**Nonmarket and stakeholder**
Technological problems with connecting the offshore power plants and national transmission network.	Lack of correlation of the terms of permits. During the procedure for obtaining environmental decision, a decision on establishing a location could lose its validity. Lack of knowledge about future energy auctions. In the current law system, the Prime Minister announces with a regulation a date of the auction before the end of the year preceding the auction. Necessity to compete with other RES within the energy mix; the offshore wind energy is not separated. In order to obtain support for an energy mix it is necessary to possess a set of valid, legitimate permits, which is very difficult to achieve. Also, taking part in the auction doesn't necessarily secure finances, so an investor will bear costs without certainty of gain.	Integration of offshore wind power plants with a landscape Conflict of interest with fishing sector

Legal and formal issues

The first permit which is obligatory for an investor planning an offshore wind power plant is a decision on the location, which is the permission to build artificial islands, constructions and devices within the Polish sea area. Such permit allows the use of this particular area of water. (PSZW).

A separate decision on location is needed for transmission cables, which transmit the power produced in the offshore wind power plant to the power grid onshore.

In order to connect the offshore power plant with the national power grid it is necessary to obtain so-called connection conditions, where the operator of the power grid describes the point of connection and the amount of energy which could be delivered into the power grid and the capacity of the power plant. After obtaining these conditions, the investor signs a connection agreement with the operator.

According to Polish law, an offshore power plant is an investment which requires an environmental impact forecast and EIA decision. An EIA decision is issued by the Regional Directorate for Environmental Protection, competent based on the location of the power plant.

The last necessary permit is a construction permit, which is needed for starting construction of the power plant and (requiring a separate construction permit) the exterior connection infrastructure (cables outside the power plant area). The permission is issued by the voivode and is based on decisions and permits obtained in earlier stages and on the technical plan for investment provided by the investor.

[1] Development of off-shore wind energy in Poland. Perspectives and evaluation of the influence on the local economy (Rozwój morskiej energetyki wiatrowej w Polsce Perspektywy i ocena wpływu na lokalną gospodarkę), McKinsey & Company, 2016

Outlook
The surface of the Polish sea area amounts to 8,682 km^2, and the surface of the Polish exclusive economic zone amounts to 22,500 km^2. Within this area, 2,747 km^2 are protected by NATURE 2000. The Maritime Institute in Gdańsk estimates that the whole potential of the Polish sea area and Polish exclusive economic zone is about 20 GW. This value has to be reduced by the excluded areas (NATURE 2000protected areas), which decreases the potential to 7.5 GW. According to the analysis made in 2016 by the McKinsey & Company legal office, the feasible capacity till the year 2030 amounts 6GW. This scenario is possible provided that a good support and regulation system are developed, which would allow investing in this sector. In the National Action Plan for RES it is assumed that in the year 2020 offshore wind power plants will have the capacity of 500 MW (0.5 GW).

Polenergia is the first company in Poland which obtained from the EIA a decision for the Bałtyk Środkowy II and Bałtyk Środkowy III offshore wind power plants (connection pint next to Słupsk in Pomeranian Region) from the Regional Directorate for Environmental Protection in Gdańsk. The planned capacity of these two power plants amounts 1,200 MW (goal: 2,400 MW). The construction of the Bałtyk Środkowy III wind power plant will begin in 2020 and will last 5 years. The Bałtyk Środkowy II Wind plant will be constructed in 2023–2026.
All planned investments in Poland are summarized in Table 15.

Table 15. Summary of the planned investments in offshore wind energy sector

Name of the project	**Investor**	**Capacity**	**Progress of the investment**	**Additional information**
AEGIR 4	ENERGA S.A	No data	Received decision on setting the location in sea part	Potential network connection point: Dunowo in the West Pomeranian Region
Baltex 2	Baltex-Power	800 MW	Received decision on setting the location in land part	-
Baltex 5	Baltex-Power	1200 MW	Received decision on setting the location in land part	-
Baltica 1	PGE-Polska Grupa Energetyczna S.A.	900 MW	Received decision on setting the location in sea part	-
Baltica 2	PGE-Polska Grupa Energetyczna S.A.	1500 MW	Received decision on setting the location in sea part	-
Baltica 3	PGE-Polska Grupa Energetyczna S.A.	1050 MW	Obtained connection conditions [2]	Network connection point: Żarnowiec A consortium responsible for preparation of the environmental decision has been chosen
Bałtyk Północny	Polenergia	1500 MW	Obtained connection conditions	-

[2] http://www.pse.pl/index.php?dzid=14&did=1223

Name of the project	Investor	Capacity	Progress of the investment	Additional information
Bałtyk Środkowy II	Polenergia	1200 MW	Obtained decision on environmental conditions	Network connection point: Słupsk – Wierzbięcino, Point of bringing cable ashore: Ustka
Bałtyk Środkowy III	Polenergia	1200 MW	Obtained decision on environmental conditions[3]	Network connection point: Słupsk – Wierzbięcino, Point of bringing cable ashore: Ustka
A-Wind	DEME Group	450 MW	Received decision on setting the location in sea part	-
C-Wind	DEME Group	200 MW	Received decision on setting the location in sea part	-
B-Wind	DEME Group	200 MW	Received decision on setting the location in sea part	-
Baltic Power	ORLEN	1200 MW	Received decision on setting the location in sea part	-
Estimated capacity:		**10370 MW**		

Source: own elaboration of RBGP WZ based on project materials from SOUTHBALTIC-OFFSHORE

Predicted trend 2020–2030

Production	Investment	Employment	Innovation
According to the analysis made in 2016 by the McKinsey & Company legal office, the feasible capacity till the year 2030 amounts 6GW. The presented power has been calculated for the whole Polish exclusive economic zone.	The accumulated value of the investments at a national scale will amount till year 2030, according to the forecasts, to 70 bn PLN.	Strong increase of employment in this branch is expected. The increase will amount to approx. 77 thousand direct and indirect jobs at a national scale.	The offshore wind energy is a relatively new technology, which is focused on innovation. Szczecin and its science centres can become one of the leaders in of R&D in this sector in the Baltic Sea Region.

Source: Development of off-shore wind energy in Poland - Perspectives and evaluation of the influence on local economy, McKinsey & Company, 2016)

Predicted key indicators and milestones of development:
Overall quantity of installed capacity; forecast for 2030: 6 GW

2020–2025 Bałtyk Środkowy III Offshore Wind Farm
Status of the investment: Awaiting an environmental approval
Estimated lifecycle: 25 years
Cost: 10 bn PLN

[3] http://gdansk.rdos.gov.pl

Total capacity: up to 1,200 MW (during the first stage 600 MW)
Investment cost: 1,666,667 €/MWh,
Production cost: 96 €/MWh
CO_2 reduction/year: 858,830 t
SO_2 reduction/year: 19,973 t
Estimated lifecycle: 25 years

2020–2025 Baltica 3Offshore Wind Farm

Status of the investment: obtained connection conditions
Estimated lifecycle: 25 years
Cost: n. a.
Total capacity: up to 1,050 MW
Investment cost: n. a.
Production cost: 96 €/MWh
CO_2 reduction/year: 1,496,512 t
SO_2 reduction/year: 34,803 t
Estimated lifecycle: n. a.

Sources:

Development of off-shore wind energy in Poland - Perspectives and evaluation of the influence on local economy, McKinsey & Company, 2016; Materials of SOUTHBALTIC-OFFSHORE project ;Materials of WINDENERGY IN THE BSR project; www.baltyk2.pl; www.ptmew.pl; www.gdansk.rdos.gov.pl; www.thewindpower.net; www.4coffshore.com

4.9. Central Finland: Combined heat and power

Regional importance

Energy autonomy	Economy	Innovation	Environment & climate
High	medium	High	High

Combined heat and power production (CHP) is one example of an existing system creating the possibility to respond to challenges associated with the transition into an energy system based on 100% renewable energy sources. In Finland, CHP production has been a centralised and efficient way of producing electricity and heat, and in recent years, also cooling. The low price of electricity and the reduced need for heating in new buildings have undermined the profitability of CHP production. Few new investments have been made in recent years. Using CHP production from biofuels as a regulating power is being studied in Finland and elsewhere in
Europe. (Government report on the National Energy and Climate Strategy for 2030).

Trend 2010–15

Production	Investment	Employment	Innovation
Stable	Decrease	Stable	Transforming
Strong increase until 2010. After that, stable in energy production. Increase in the use of forest biomass. Increase in 2017 due to new CHP plant.	Strong increase in 2000–2010, also in bioenergy development projects (1 – 3 M€ annually) Now decrease due to low price of electricity.	Renewable energy has significant role in employment in energy sector, and CHP has significant role in this. Employment in especially logistics and harvesting. Total in the region: Approximately 600 person years in forest biomass. Approximately 400 person years in peat harvesting and logistics. (2014)	From bioenergy development to new innovations from biomass (fibres). In bioenergy, the innovations are related to logistics and to ICT-solutions, quality control of the raw material.

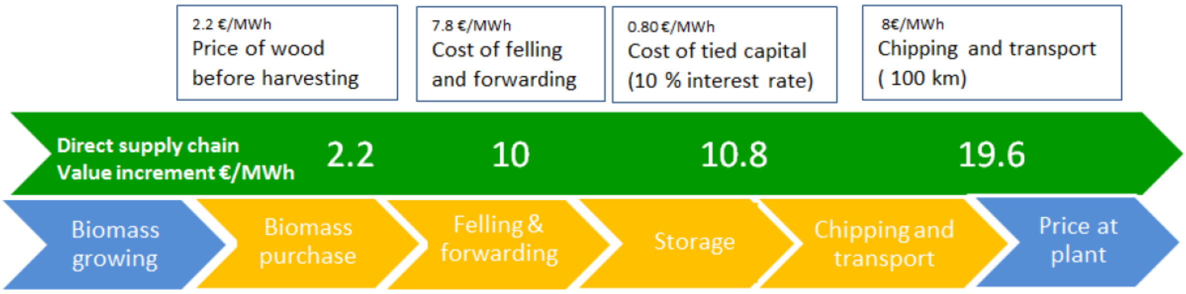
Bioenergy and efficiency in CHP has been one of the focus areas in innovation, and the bioenergy innovation cluster was very active in 1998–2010. This innovation cluster brought together the public authorities, R&D present in the region (University of Jyväskylä, JAMK University of Applied Sciences and VTT) and more than 50 companies in the region. In that time, the infrastructure for CHP development was built and investment in the CHP power plants was active. The investments over the 10-year period amounted to more than 500 M€.

Maturity of value chain: transforming

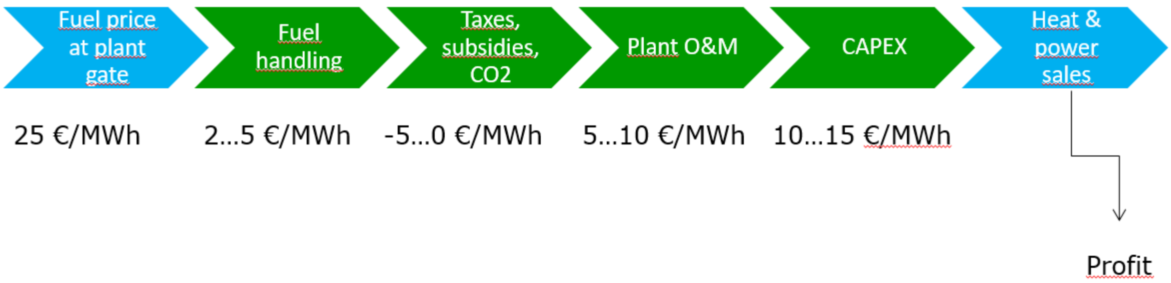
In recent years bioenergy and thus CHP production has seen some major difficulties. This is due to many reasons: cheap electricity does not favour power generation in CHP. Relatively warm winters decrease the need for heat and simultaneously storage for biomass is full. The bioenergy raw material markets are not working, and this has stopped investments in harvesting machines, etc. Due to the low price of the ETS units fossil fuel (peat and coal) is prefered. Wood chip imports create instability in domestic production. Effects are now seen especially on energy wood harvesting.

These instabilities in the bioenergy sector may cause a loss of knowledge and capacity in the sector and thus create difficulties to increase capacities again at rising markets. Also this may create difficulties for R&D&I in the future.

Regional value creation



Value chain in the 'forest energy' business: Fuel supply (€/MWh_{fuel}) (Virkkunen et al. 2015)



Stages of value chain		Added value regionally
Forest owner, wood selling	Selling biomass	High
Machinery company	Harvesting machinery production	Medium
Wood harvesting	Wood harvesting and collection	Medium
Logistics	Logistic companies	Medium
Heating company		Medium
End user		Medium

Key indicators and landmark developments

Table 16. CHP production in Central Finland 2014 (GWh)

Co-production electricity	Electricity	Process heat	District heat	Total
1,086	191	3,037	1,411	5,761

Table 17. Use of energy sources for CHP in Central Finland 2014 (7,686 GWh)

Fossil		Renewable				
Oli and coal	Peat	Waste from pulp industry	Wood chips	Wood from side streams	Biogas	RE
567	1,511	2,607	1,801	1,480	13	7
2078 (26%)		**5908 (74%)**				

Table 18. Use of solid woody biomass in CHP and heat plants in 2015 in Central Finland (source: Luke statistic database)

Wood type	GWh	Raw material of forest chips	1,000m^3
Forest chips	1819	Small-sized tree	494
		Logging residues	330
		Stumps	81
		Large logs	6
		Total	**911**
Bark	1,039		
Industrial wood residue chips	340		
Recycled wood	11		
Pellets	43		
Total	**3 732**		

Landmark developments

In late 2017 Metsä Fibre bioproduct started to produce a total of 9.6 Twh bioenergy from forest biomass. This will help Finland achieve its goals in terms of renewable energy. The mill will produce 2.4 times as much energy as it needs. The mill will increase the share of renewable energy in Finland by more than two percentage points.

Drivers

- Availability of raw material; wood consumption in the region will increase due to investments in the forest industry. This increase will be approximately 4 Mm^3 annually. This will increase the availability of forest chips, especially logging residue.
- National policy favouring the use of renewable energy, for example, in favouring renewables in CHP production. Also in terms of increasing self-sufficiency in energy production. Mechanisms here include energy taxation and an aid scheme for forest chips in CHP production especially on energy production (Government report on the National Energy and Climate Strategy for 2030).
- Potential for small scale CHP is large. District heating, farms, gardens, and recreation areas (swimming halls, ice hockey rings, etc). (Karjalainen 2012)
- Consumption peaks during the cold period also requires local energy production.

The value chain and core technologies

In Finland, most of the combined heat and power (CHP) plants are based on fluidized bed combustion and co-combust different types of woody biomass with peat. This is the case in Central Finland as well. Due to the CO_2 emission reduction targets and subsequent renewable energy support mechanisms, the share of biomass has been increasing. Biomass utilization can increase a plant's operational costs through higher fuel costs and negative effects on efficiency and availability of the boiler and increased maintenance work. The economic feasibility of biomass utilization is then dependent on whether the policy support measures make up for the additional costs. (Hurskainen et al., 2016).

As forest fuel demand increases, new logistical solutions are needed. Most of the increase in use is expected to take place in large heat and power (CHP) production units, which set special requirements for the supply as both procurement volumes and transport distances increase. Terminals do not create direct cost benefits per se: direct supply chains are more economical compared to supply through terminals. However, there are several indirect benefits that can be reached via fuel supply through terminals: regional fuel procurement can be widened to a national scale, security of supply increases (easily available storages), large supply volumes can be delivered by an individual operator, prices remain more stable and a more even quality of delivered fuel can be achieved. (Virkkunen et al., 2015).

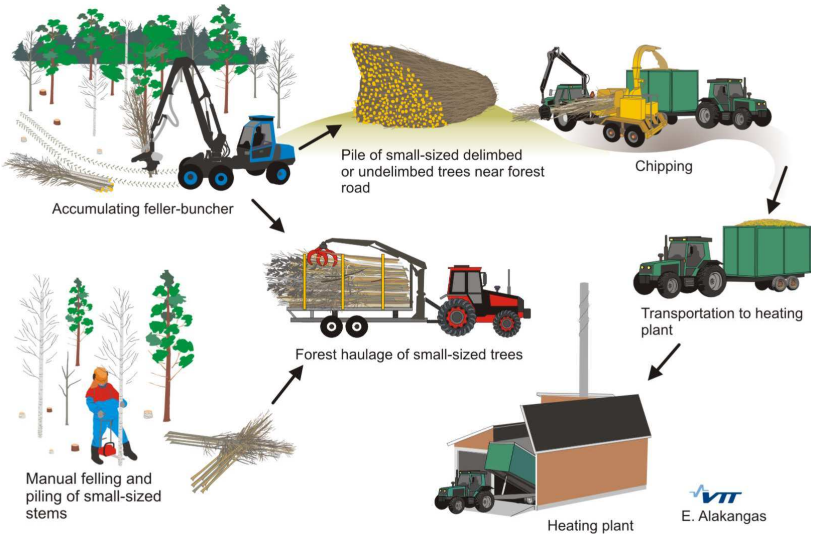


Figure 40. An illustration of value chain in forest biomass for CHP (VTT, Alakangas).

Weakest link

Resource and technology	**Market and socio-economic**	**Nonmarket and stakeholder**
Due to low economic profitability in bio-CHP and forest energy in general, the technology development is not very active at the moment.	If the economic growth is slower than expected and the electricity prices remain low, uncertainty in electricity production investments increases and CHP replacement investments will probably be replaced with heat-only investments.	The role of the forest biomass in the EU energy policy.

Outlook

Combined heat and power production is seen as the most energy-efficient option and having the most potential. Optimizing the use of CHP heat in building and district heat and cooling is important in order to find energy- and cost-efficient solutions. For example, district cooling with an absorption chiller driven by biomass CHP heat is a potential way to achieve CHP heat use in countries with low heating load.

On a small scale, CHP is not presently profitable in Finland. However, there is strong political will to support small-scale CHP production. In the national strategy for energy and climate change, a subsidy for small-scale CHP is suggested. This is seen as an opportunity to increase production in smaller district heating units. This would also increase the domestic power production.

In the near future, the wood raw material markets will undergo a transformation in Finland. The pulp industry is increasing the production volumes, and a higher volume of side streams (bark) is available for the energy markets. This may have effects on wood energy supply chains, especially the demand for raw material from thinning. A debate on sustainability and the sustainable amount of wood harvested from Finnish forests will continue. Simultaneously, the new boom in the forest industry will have effects on wood biomass logistics on the national level, and possible new bioproduct mills in Eastern Finland and Northern Finland will need raw material.

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4.10. Blekinge: CHP and district heating

Regional importance

Energy autonomy	Economy	Innovation	Environment & climate
High	High	High	High

High, medium, low

Trend 2010–15

Production	**Investment**	**Employment**	**Innovation**
Stable	Stable	Stable	Increase

Maturity of value chain: growing

Regional value creation

Strong value creation linked to regional development, independently of to having the entire value chain.

Value change of 1 MWh or choose other unit indicator, absolute figures, estimates

District heating value chain in Blekinge

1MWh = 1.25 m3s 1 m3s = 0.8 MWh Euro 1 = 9.4 SEK 1 SEK = Euro 0.106 1 kr/m3s = 0.106 Euro/m3s = 0.133 Euro/MWh

Stages of value chain	Added value regionally
Project development	High
Manufacturing	High
Installation	High
Grid connection	High
Operation	High
Consulting	High
R&D	High
Financial services	Low

Key indicators and landmark developments

The total amount of used energy in the county of Blekinge is around 7,500 GWh/y. Forty-one percent (3,100 GWh) of this energy originates from bioenergy. A big pulp mill is located in the region and is owned by the forest owner organisation, which is the main user. The mill produces 1,900 GWh of black liquor yearly. This liquor originates, of course, from biomass. Most of the energy produced by this liquor is used internally for the process, but around 180 GWh heat is transported to the district heating grid in the nearby Karlshamn municipality. Besides this grid, based on heat losses, there are other grids in the county. The used district heating is in total around 600 GWh, hence 420 GWh from heat plants and one CHP, the one described in Figure 42, located in Karlskrona. The total production is around 650 GWh. Around 90% of the supplied fuels is bioenergy and 10% fossil fuels. If the heat which originates from bioenergy, 90% or 585 GWh, had been produced by heating oil instead of bioenergy, the emissions of carbon dioxide would have been 175,000 tons (270 kg/MWh).[4] The emissions of carbon dioxide are 3kg/MWh fossil CO2 from the big pulp mill, including production of pulp, electricity and district heating.

The added value for the heat production based on the heat produced in the county, excl. heat deliveries (650 GWh – 180 GWh = 470 GWh) from the pulp mill is €32 million (€68/MWh). Production cost for 470 GWh heat: €20 million (43 Euro/MWh).[5]
The production of district heating is a total of €/MWh: 400 SEK / MWh (= 43 Euro / MWh), while the investment cost €/MWh is 750 million Swedish crowns (CHP Karlskrona) * 0.94 (705,000). In the CHP in Karlskrona they have 20 employed right now. The impact on employment provides 300 new jobs / 1TWh in bioenergy[6]; while the number of employees / annual jobs / 1000 MWh, we have no access to.

Drivers
Relatively low costs of production concerning raw material and energy;
Availability of raw material: energy resources available and existing nearby housing area

The value chain and core technologies

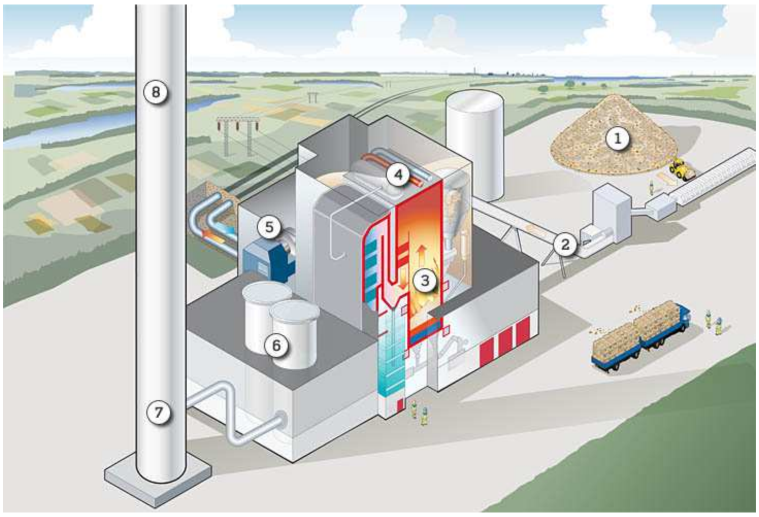

Figure 41[7], Affärsverken.se
The CHP in Karlskrona is one of the municipalities in the county of Blekinge which uses biomass (wood chips with a small addition of peat) for its combustion. The chips are transported with a wheel loader and piled up over the screw, which then transports the chips for fuel preparation where the magnetic material is removed and the large materials are crushed.
The processed fuel is then fed up to two silos. When these are full of chips, it can be kept up and run for two hours. Fuel consumption is about 300,000 cubic meters of wood/year.

[4] Bioenergiportalen, uppdaterad 2013 *Källa: http://www.bioenergiportalen.se/?p=6862&m=1775*
[5] Bioenergiportalen, uppdaterad 2013 *Källa: http://www.bioenergiportalen.se/?p=6862&m=1775*
[6] *Källa: svebio*
[7] Affärsverkens hemsida; http://www.affarsverken.se/Privat/Fjarrvarme/Sa-fungerar-fjarrvarme/Kraftvarmeverk-Karlskrona/

The boiler has an effect of 42 MW and is a bubbling fluidized bed. The boiler produces steam for the steam turbine. Ash is removed as bottom ash and fly ash. The bottom ash is used to cover the landfill via two containers for the ash.
On the very top of the boiler, you will find the steam dome, running by the help of self-circulation created by the density difference between water and steam.
The turbine and generator are located in the turbine hall. The steam produced in the boiler is led into the turbine, which enables the turbine and the generator to operate and produce electricity. The generator can deliver 12 MW of electricity at full load.
The flue gases head through a sleeve filter. The gas needs to be purified before it enters the fans, which will bring the gas to the flue gas condenser. The flue gas condenser uses the heat in the flue gas to preheat the district heating water before it enters the boiler. The heat exchange in this process is up to 7 MW.
The measurement of environmental values is done at the chimney to make sure you have a good combustion process in the boiler and that you have low emissions of unnecessary or toxic substances in the air.
The chimney extends 80 meters into the air and is prepared in order to be able to plug into another plant in the future.

Weakest link

Resource and technology	**Market and socio-economic**	**Nonmarket and stakeholder**
Sawdust limitations due to fast growth of the sector Limitations on how high temperatures can be used	Weak domestic heating and also qualified labour shortage	Capacity restrictions of the electricity network Heat pumps and isolated buildings

Outlook

There is great potential for the region to initiate and develop district heating from both industry and the energy companies, and to connect it with the market. In cases when the interest is high from the industry or the DH company it is also possible to connect turbines to the business and obtain CHP. There are many small suppliers who are able to invest in such a development in Blekinge now.

The trend is influenced by the price of electricity in relation to the price of district heating, as well as various laws. The development is also affected by the decisions that the state and municipalities make, or if the company belongs to a private contractor. The large pulp mill named in this case has a different core business, and if it expands, downsizes or focuses on something else, it will also affect the production of district heating.

Sources

SCB, energibalansen, länsstyrelsen, affärsverken, swebio, The big pulp mill, bioenergiportalen etc

4.11. Skåne: solar power

Regional importance

Energy autonomy	Economy	Innovation	Environment and climate
High	Medium	High	High

Trend 2010–15

Production	**Investment**	**Employment**	**Innovation**
Strong increase in relative terms (from a low level)	Strong increase in relative terms (from a low level)	Increase but moderate in terms of number of employees	Increase R&D

Maturity of value chain: growing

The growing maturity of the value chain follows the high level of increase in the market. The increase is high in relative terms but it will take a few years in order to reckon on in absolute terms (in a comparison with, for example, wind power). A transformation is expected in some sense in terms of new actors entering the market. A very positive opinion among the public exists and a boom in PV investment is likely in the near future. Different activities along the value chain meant to strengthen competence are important in order to get a well-functioning market.

Data and surveys for 2016 are not yet finalized but in progress. The positive PV market development in Sweden continued in 2015 as the annual market grew with 31% to a yearly installed power of 47.4 MW, and Sweden passed the milestone of 100 MW as the cumulative installed capacity at the end of 2015 was 126.8 MW. The PV system prices continued to go down for larger systems, both ground- and roof-mounted, but stabilized for small residential systems in 2015.

The major policy change in 2015 was the introduction of the tax credit for the excess electricity of micro-producers. This improves the profitability for investors and makes it more attractive for private persons and small companies to invest in PVs.
The Swedish industry lost its last module producer when SweModule filed for bankruptcy. Several Swedish companies focusing on new PV technologies or balance of system components continued to develop in a healthy way. The Swedish PV industry is becoming broader as increasingly more actors with other core businesses, such as utilities and real estate owners, are taking an increasing interest in the PV technology/industry.

Table 19. The development of installed PV effect in Skåne 2012–2015

Year	**2012**	**2013**	**2014**	**2015**
Total installed effect PV, (kW)	2 843	4 646	8 532	13 437

The annual growth of PV installed effect shows a quite strong development in relative terms but at the moment a low absolute level. Recent years show an annual growth pace between 60-90% annually. Statistics for 2016 are being compiled as we speak and can be added as soon as they are finished.

The project Sol i Syd just met its indicative targets for solar energy in Skåne. These will be communicated about in 2017/2018 in order to get support from crucial actors and organisations (including municipalities).

For the year 2025, 500 MW installed PV is a target (3.4% of the electricity of Skåne) and for the year 2030 740 MW (5% of the electricity of Skåne, 2013 data). A supportive action plan has been worked out in order to promote and support the development.

In the long term, the Swedish PV market is in a good position to grow. There is a growing interest for PV in Sweden and the general public is very positive about the technology. In a survey from 2014, almost 20% of Swedish house owners said that they are considering investing in the production of their own electricity in the next five years in the form of PV or a small wind turbine. In 2015, around 60% of farming landowners said that they plan to invest in PVs the following year. Other positive indications exist for the moment as well. For example, members of private households say that they are more interested in investing in PV than in renovating their kitchen.

On 17 October 2016 the Swedish Energy Agency published a national strategy for electricity use from solar power. They suggest a number of PV–promoting activities, and they set a goal for Sweden of 5–10% of the electricity use in 2040, which means around 8–16 TWh per year of solar power electricity (energy efficiency not included). They also suggest changes to policies: investment grants and green certificates will be replaced by a Sol ROT, a reduction of taxes on labour for private household investments and renovating activities. This will promote PVs further. Five of the major parties in the parliament in Sweden reached an agreement that stresses a goal of Sweden having 100% renewable power by the year 2040. This promotes the further development of PV in Sweden. The green certificate system that was supposed to end in 2020 will be prolonged until the year 2030, which means an additional of 18 TWh of renewable electricity will be built within the system between 2020 and 2030. A grant for batteries was introduced as 60% of the investment, although it is still an expensive solution with a limited number of hours used annually. Recently a policy change was made regarding a tax reduction for self-consumed electricity for lager installations and will be in effect 1 July 2017. For smaller installations, there are tax reductions up to a limit as a net consumer of electricity. The investment grants for solar PV have been declining from 60% down to a level of 30/20% today. Extended administrative handling time for the investment grants created uncertainty for investors, but the funds added to the governmental budget will strengthen the grant scheme from 2016 onwards.

Regional value creation

Stages of value chain	Added value regionally
Project development	Medium
Manufacturing	Low
Installation	Medium
Grid connection	Medium
Operation	Low
Consulting	Medium
R&D	Medium
Financial services	Low

Key indicators and landmark developments

The number of employees in Sweden has decreased from 2011 to 2015 as a result of production sites closing. In total the number of full-time employees in Sweden was estimated to be 830 (with 352 installers and retailers making up the majority). 139 actors are charted so far in Skåne (architects excluded) for 2016. Skåne (13.4 MW) has one third of Swedish PV capacity. This share used as an estimate for the number of employees makes around 260 full-time employees in Skåne (0.313 x 830 = 260). In the same way the share is used to estimate the PV business in Skåne. 0.313 x 621 million SEK = 81.7 million SEK in Skåne or 8.56 million EUR.

Rough business estimations exist on a national level for 2015 (VAT excluded). The total value of the Swedish PV market is around 621 million SEK (SEK/EUR = 9.54), which equals around 65 million EUR. In the case of Skåne no corresponding study exists.

The below estimates may be added after further calculations:

- Value added in EUR: 8.56 million
- Value added per full-time employee: 8.56 million / 260 = 32,923 EUR

Drivers

- Costs of solar PV going down and starting to level out a bit, expected to decrease but at a slower pace
- Seeking of solutions within the EU in order to abandon the punitive tariffs put on the import of Chinese solar PV to the EU
- Different EU/national/regional goals for renewable energy and greenhouse gas emissions; 100% renewable electricity in Sweden by 2040.
- Development of fossil fuel prices; today, they are low, which creates an obstacle for renewables
- Electricity prices are low and expected to be so in the near future, higher electricity prices are a driver for development
- Very positive attitude among the public as well as increasing awareness among companies and organisations about sustainability issues and renewable energy
- We believe development of batteries and/or electric vehicles has a positive correlation with development of solar PV in houses
- Landowners and farmers constitute a very interesting target group for PV investments
- Building permits must be developed further to promote development in cities
- The Swedish Energy Agency published a proposal for a national strategy for increased solar electricity use, which is under political negotiation. It suggests a number of activities and a solar power goal for 2040 that is 5−10% of the annual Swedish electricity use
- Promoters that act on a local and regional level, such as Solar Region Skåne, are important for influencing investments.

Weakest link

Resource and technology	Market and socio-economic	Nonmarket and stakeholder
Prices stabilizing for small PV, decreasing for larger PV, punitive tariffs on Chinese imports	Low electricity prices and green certificates, building permits not supported properly, boom might create a shortage of installers.	Varying policies and taxes but stabilizing, spread of PV knowledge

Outlook

The Swedish PV market still significantly depends on different subsidies. There exists a great potential for substantial growth over the coming years. Policy changes support development, and there is a very positive opinion among the public. In a comparison with wind power there are fewer spatial planning conflicts, and the setting up of PV is quite fast. If PV is able to contribute to an appreciable part of the Swedish electricity mix the PV system prices must continue to go down or the electricity prices go up. Other factors other than strict economic factors might tend to lead to further investments of PV in Sweden. It contributes to the positive regional image and declares climate responsibility. The household sector is an important part of the future development in Skåne. A number of municipalities published solar charts and tools for planning and calculating the PV system.

In a comparison with other countries such as Denmark, Spain, Germany, Belgium and others, Sweden might have an advantage as a latecomer, meaning lower PV module prices and knowledge, but on the other hand, less strong policy support and lower electricity prices.

Sources

National Survey Report of PV Power Applications in Sweden 2015; IEA/PVPS, Johan Lindahl

5. BSR renewable business tiers and trade

5.1. Germany

5.1.1. RES implications of electricity market liberalisation

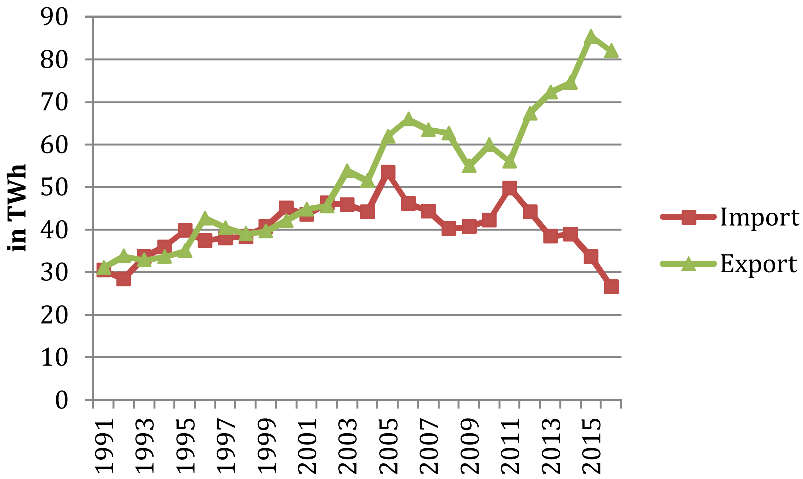

Figure 42. Import and export of electricity in Germany 1991–2016 *(Statista, 2017a)*

The long-term view (Figure above) shows that the import flows have only increased slightly until 2015 compared to the 1990s, while the export flows have reached a much higher level since 2005.

In 2015, the net electricity consumption in Germany decreased 3% by 17 TWh compared to 2010 (Statista, 2017b). At the same time, the net electricity generation increase by 16 TWh (Statista, 2017c). In 2015, Germany exported about 51.8 TWh more electricity to European countries than it imported. Overall, the electricity trade balance increase by 16.2 TWh in 2015 compared to the previous year (Statista, 2017d). This means that the rise in the balance is not only the result of the increased electricity generation but is also indirectly related to the decline in electricity consumption in Germany.

Germany is mainly in an export situation, but the electricity flow abroad is significantly higher in winter than in summer. This is partly due to the fact that the annual revisions of conventional power stations are usually carried out in the summer half year, so that the maximum production capacity is available in the winter half year with higher electricity demand due to weather conditions. But since there are load-weak hours even in the winter months, during these hours free capacities are available for the market. In the Baltic Sea Region, Germany exports most of the surplus to Poland and Denmark.

In 2008, the European Market Coupling Company (EMMC) was founded to couple Central West Europe (the Netherlands, Germany, France, Belgium and Luxembourg) and the Nordic regions. The first interconnection was established between Denmark and Germany in 2009. The Baltic Cable between Sweden and Germany/Austria was integrated in May 2010.

Table 20. Electricity trade balance in TWh

	2011	2012	2013	2014	2015
GER - POL	5.1	5.5	5.5	9.2	10.7
POL - GER	0.43	0.17	0.54	0.05	0.02
GER - DK	2.9	2.5	11.5	8	5.7
DK - GER	5.1	7.3	3.2	4.5	5.1
GER - SWE	0.63	0.29	1	0.77	0.17
SWE - GER	2	2.5	1.1	1.8	1.9
Balance	1.1	−1.68	13.16	11.62	9.55

Source: Fraunhofer ISE, 2016.

The German electricity network consists of two interconnections to Denmark, one interconnection to Sweden and two interconnections to Poland.

The interconnection Kontek from Bentwisch to the Danish Island Sjælland was established in 1995 and is a 400 kV connection with a transmission capacity of 600 MW. The interconnection from Kassø to Germany consists of four connections (two 400 kV connections since 1978 and two 220 kV since 1965 and 1961). One 220 kV connection from Kassø to Audorf will be replaced by a 400 kV connection (720−1,000 MW capacity) which will be finished in 2020. In addition, there is a 150 kV connection between Flensburg and Ensted Power Station. An additional interconnector is planned from Brunsbüttel to Niebüll (Danish border). This 380 kV connection with a transmission capacity of 3,000 MVA will be established in 2021. Furthermore, an interconnector between the Baltic 2 and Kriegers Flak offshore wind parks with a 380 kV connection and a transmission capacity of 400 MW will be finished in 2018 (combined grid solution, Bentwisch-Tolstrup).

The Baltic Cable between Germany and Sweden is a 450 kV connection with a transmission capacity of 600 MW and was established in 1994.

The southern link between the German and the Polish electricity grid is in Hagenwerder-Mikulowa (380 kV connection). The northern interconnector Vierraden-Krajnik has been in operation since 2013 with 220 kV. The conversion to 380 kV will take place in 2018. Then the planned Uckermark link can be connected to this route. The third interconnector between Germany and Poland, between Eisenhüttenstadt and Plewiska (capacity: 3,750 MVA), is currently in the regional planning procedure and will not be realized before 2030.

5.1.2. Biomass and biofuels trade

In the field of the biomass and biofuels trade, Germany imports more than it exports in the Baltic Sea Region.

Germany imported approx. 240,000 t wood briquettes in 2015. Imports from countries in the Baltic Sea Region amounted to approx. 50% of the total import. The main imports of wood briquettes to Germany come from Poland, Latvia and Lithuania. In 2015, the import quantities decrease by almost 20% compared to 2014. The same applies to the small quantity of exports (decline of approx. 50%).

Table 21. Import and export of wood briquettes to and from Germany (quantities in tons and sales M€)

Country	Import in t			Export in t		
	2013	**2014**	**2015**	**2013**	**2014**	**2015**
Sweden	0	0	0	69	8	46
Denmark	243	129	78	248	268	85
Estonia	510	1,362	457	0	0	0
Latvia	15,888	25,171	23,481	1	1	4
Lithuania	27,501	20,857	12,148	19	24	0
Poland	78,300	92,109	77,095	19	211	113
Finland	0	0	0	0	0	5
Total	**122,442**	**139,628**	**113,259**	**356**	**512**	**253**

Source: DEPV, 2017

Country	Import in M€			Export in M€		
	2013	**2014**	**2015**	**2013**	**2014**	**2015**
Sweden	0	0	0	0.01	0	0.01
Denmark	0.04	0.01	0.01	0.08	0	0.04
Estonia	0.1	0.2	0.1	0	0	0
Latvia	2.0	3.2	2.6	0	0	0
Lithuania	3.1	2.9	1.4	0	0	0
Poland	9.9	12.2	9.5	0.01	0.04	0.02
Finland	0	0	0	0	0	0.01
Total	**15.14**	**18.51**	**13.61**	**0.1**	**0.04**	**0.08**

Source: DEPV, 2017

The production of wood pellets has been constant at 1.4 mt in recent years. Almost a half of the produced wood pellets were exported. The export to BSR countries accounted for 23% of the total export in 2015. The majority of the wood pellets exported in the Baltic Sea Region are exported to Denmark and Sweden. The import of wood pellets from BSR countries grew in 2015 by 27%, while the export of wood pellets is characterized by a constant decline in the last years.

Table 22. Import and export of pellets to/from Germany (quantities t and sales €)

Country	Import in t			Export in t		
	2013	**2014**	**2015**	**2013**	**2014**	**2015**
Sweden	7,823	9,155	20,502	49,218	40,912	36,002
Denmark	107,580	50,343	61,567	121,539	54,119	14,846
Estonia	17,143	13,038	3,214	173	156	268
Latvia	5,087	3,702	3,444	107	117	76
Lithuania	32,964	8,603	1,250	541	655	685
Poland	37,184	41,709	70,978	15,559	3,208	3,250
Finland	526	14	0	232	309	379
Total	**208,307**	**126,564**	**160,955**	**187,369**	**99,476**	**55,506**

Source: DEPV, 2017

Country	Import in M€			Export in M€		
	2013	2014	2015	2013	2014	2015
Sweden	1.1	1.0	2.0	10.6	6.3	5.5
Denmark	18.0	8.8	11.4	30.2	9.5	2.7
Estonia	2.9	2.2	0.5	0.1	0.1	0.1
Latvia	0.7	0.6	0.5	0.1	0.1	0.04
Lithuania	5.5	1.6	0.3	0.3	0.4	0.4
Poland	6.3	7.3	12.0	3.7	2.0	2.1
Finland	0.1	0	0	0.2	0.3	0.4
Total	**34.6**	**21.5**	**26.7**	**45.2**	**18.7**	**11.24**

Source: DEPV, 2017

Germany also imports significant amounts of firewood, wood chips and charcoal, especially from Poland. The import of firewood from BSR counties amounted to approx. 30% of the total import in 2014. In the same year 12% of the total import of wood chips came from the Baltic Sea Region and 40% of the charcoal import. The export of firewood and wood chips was less than 1% of the total export, while a third of the total charcoal export went to BSR countries. Surpluses of wood chips are mainly exported in the Baltic Sea Region to Denmark (2.7 M€) and to Poland (1.5 M€).

Table 23. Export and import of firewood, wood chips and charcoal from/to Germany 2014 (quantities and sales)

2014		Poland	Denmark	Latvia	Estonia	Finland	Lithuania	Sweden
Firewood								
Export	t	52	75	0	0	1	43	200
Import		99,834	2,878	21,306	1,032	0	19,250	0
Export	M€	0	0.02	0	0	0	0	0.05
Import		9.8	0.07	2.9	0.2	0	3.1	0
Wood chips								
Export	t	11,510	35,430	32	33	129	151	290
Import		184,330	6,517	23,668	14,971	0	0	2,379
Export	M€	1.5	2.7	0.01	0.01	0.05	0.05	0.1
Import		11.8	0.4	0.9	0.5	0	0	0.3
Charcoal								
Export	t	2,524	996	7	7	1	24	310
Import		64,823	159	1,392	0	0	19,169	164
Export	M€	1	0.7	0.02	0.02	0	0.01	0.2
Import		31.2	0.06	0.1	0	0	3.5	0

Source: DEPV, 2017

5.1.3. Capital, expertise and companies

Enercon GmbH: Enercon GmbH is the largest German manufacturer of wind power plants (14,000 employees; generated sales in 2013: approx. 5 billion €). With more than 26,360 installed wind turbines with an installed capacity of over 43.1 GW in over 30 countries, the company was among the world's leading companies in the wind energy industry. The Enercon Group operates, inter alia, a production site in Malmo/Sweden. Enercon is involved in the development and realization of the wind power project in Markbygden / Sweden (450 km²; 1,101 wind turbines; 12 TWh electricity per year; completion expected in 2020) and was involved in the realization of the a wind park in Narva/Estonia (in operation since 2012; 17 wind turbines, capacity of 39 MW, costs 60 M€).

Danpower GmbH: The Danpower Group is a heat supply and contracting company which operates in Germany and the Baltic states. With 84.9%, it is mainly part of the Stadtwerke Hannover AG (enercity). The Danpower Group currently has more than 400 employees and generated sales of around 165 M€ in 2015. To the company group belongs, inter alia, Danpower Eesti AS and Danpower Baltic UAB.

Danpower Eesti AS is a local heat supply company of the city of Võru (approx. 30 employees, sales about 3 M€) and operates 3 biomass heating plants (Võrusoo approx. 35 MW, Laane approx. 2.2 MW, Võrukivi approx. 3.1 MW). Danpower invested approx. 2.5 M€ in the renewal of the district heating pipelines and the modernization of heat production plants.

Danpower Baltic UAB is a joint venture of Danpower GmbH and Geco Investicijos and was founded on 26 May 2014. Danpower Baltic operates 6 biomass projects in Lithuania with an installed capacity of 169 MWth and 5 MWel, i.a. in: biomass CHP in Kaunas (5 MWel; 20 MWth; in operation since 2016), biomass heating plant Vilnius (25 MW, in operation since 2015) and biomass heating plant Joniškis (4 MWth, purchase 2015).

Nordex SE: The Nordex Group has installed more than 18 GW of wind energy capacity in more than 25 markets. It generated turnover of 3.4 billion € in 2015 and currently employs more than 4,800 people. Nordex is active worldwide. Finland is one of the most important markets in the Baltic Sea Region, alongside Lithuania, with more than 100 wind turbines and a capacity of more than 280 MW. Nordex has concluded a framework agreement with the Finnish asset management company Taaleritehdas. In 2016 and 2017, Nordex will supply a total of 72 turbines with 216 MW for of this customer's projects. Other current projects in Finland are: expansion of the Muntila wind farm (3 plants, 9 MW additional) and of the wind farm Kivivaara (6 plants, expansion from 39 MW to 57 MW). In 2007, Nordex achieved its re-entry in Sweden with two major orders (2 wind parks, 35 MW and 15 MW, order volume 47 M€). In 2014, Nordex entered into the market in Lithuania with the order to erect the Jurbarkas wind farm (8 plants, 24 MW). The Mazeikiai wind project (19 plants, 45 MW) is another project of the company group in Lithuania. Nordex is also operating in Poland (i.a. the Tychowo Windpark : 20 wind turbines, 50 MW, contract volume 51 M€; the Opalenica Windpark: 7 wind turbines, 17 MW) and Estonia (the Pakri wind farm , 8 plants, 18.4 MW, contract volume 20 M€).

EnviTec Biogas AG: EnviTec Biogas AG is a German company that plans, builds and operates biogas plants. In addition to Germany, the company is represented in 15 countries worldwide, among others, in Denmark (2 biogas plants in Søndersø and in Hammel) and in Latvia (7 biogas plants). In 2015, EnviTec biogas plants with a capacity of 372 MW were in operation. In total, the EnviTec Group employs 363 people and generated sales of 174.9 million euros (foreign sales: 47.1 million euros) in 2015.

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5.2. Estonia

5.2.1. RES implications of electricity market liberalisation

Table 24. Electricity trade balance (GWh)

	2011	2012	2013	2014	2015
Import	**1,690**	**2,710**	**2,712**	**3,730**	**5,452**
Latvia	1,189	1,099	335	108	175
Finland	501	1,611	2,377	3,622	5,277
Export	**5,252**	**4,950**	**6,300**	**6,484**	**6,377**
Latvia	3,566	4,522	5,739	6,390	6,079
Finland	1,686	428	561	94	298
Balance	3,562	2,240	3,588	2,754	925

Statistics Estonia, 2016

5.2.2. Biomass and biofuels trade

Exports of premium biofuels, wood residue and firewood have been growing in Estonia in recent years. For the last five years, wood pellets have been an emerging fuel on the energy market. In that period, the production of pellets has increased 323%, and compared to 2014 – 44%. Wood pellets account for 7% of wood-product exports (M€128). In 2015, about 80% of the wood pellets produced were exported: 57% of this amount to Denmark (M€67), 27% to the United Kingdom, 10% to Sweden (M€11, high growth) and 4% to Latvia (M€3,6, high growth) of the total exports.

Export of woodchips (M€28) grew 32% in 2016. The major export countries are Finland (M€17) and Sweden (M€8.6). Export of firewood (M€18) grew 14% in 2016, lead by exports to Norway

(M€4.8 at 27%), Sweden (M€4.5 at a high growth of 25%) and Germany (M€3.6 at 20%). Wood briquettes are also exported to Sweden and Denmark.

The production of peat fuels has been in decline for the last five years. In 2015, compared to 2014, the volume of production decreased by half. The majority of peat is exported to the Nordic countries.

5.2.3. Capital, expertise and companies

NEFCO, the Nordic Environment Finance Corporation, enabled exports and sales of Nordic green technology to the Baltic countries, including Estonia, providing loans and equity investments for wind farms in Estonia and Lithuania. NEFCO has invested over EUR 10 million over the years in wind farms in the Baltic countries, plus biogas in Latvia.

Fortum, among the most traded shares on the Nasdaq Helsinki stock exchange with 51% owned by the Finnish State, has been growing steadily in the Baltic countries, reaching power generation of 0.7 TWh and heat sales of 1.3 TWh in the Baltic countries. As divestment of a non-strategic heat business, CHP capacity in Tartu and Pärnu reaches 49MW (26 in Latvia and 18 in Lithuania, Kaunas, waste-CHP 2019).

Nelja Energia, the Nordic-Estonian wind company (60% owned by Vardar Eurus, 11% owned by Norway`s Buskerud County, NEFCO and EBRD, and 29% owned by Estonian investors) successfully entered the Lithuanian renewable energy market operating 14 MW at the Buciai, 14 MW at the Sudenai and 12 MW at the Mockiai wind farms as well as 39.1 MW at Ciuteliai farm in the Silute region. The group`s investments in the Baltic states amount to over MEUR 270.

Sources

Estonian Statistical Office, Fortum Annual Reports http://annualreport2016.fortum.com/en/, Nelja Energia; JRC report 2016: The Baltic Power System between East and West Interconnections.

5.3. Latvia

5.3.1. RES implications of electricity market liberalisation

Most of the electricity in Latvia is generated in the Daugava River HPP cascade – Kegums HPP, Plavinas HPP and Riga HPP. In 2013 all of these HPP generated electricity in the amount of 2,852 GWh, which created 46% of the gross electricity generation of Latvia. The full capacity of HPPs is only able to be realized in the spring full-water period, which lasts approximately 2 months with its peak in April.

About one fifth of the gross electricity consumption creates the net import (17.9% in 2013). Import mainly occurs when there is an insufficient water level for hydro-energy generation or when there is no need to run the CHP in cogeneration mode, usually in summer.

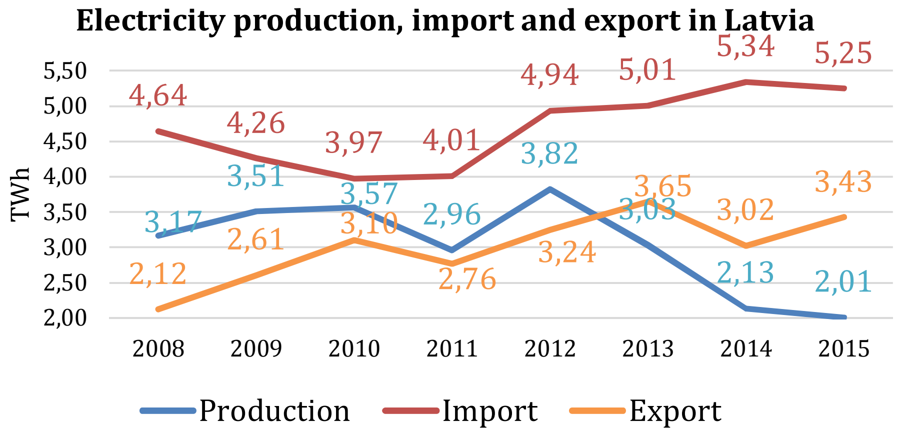

Figure 44. Electricity production, import and export in Latvia (Central Statistical Bureau of Latvia).

The Latvian bidding area of the Nord Pool Spot AS Scandinavian electricity exchange was successfully opened on 3 June 2013, which has also served as a turning point for integration of the Baltic networks with the rest of the European networks. Moreover, it furthers establishment of a common market based on the principles of the Scandinavian electricity market.

In line with the laws of the Republic of Latvia, the electricity market in Latvia is run in cooperation with the Latvian Augstsprieguma tīkls AS transmission operator and the Nord Pool Spot AS electricity exchange, which is an electricity bidding site in Latvia. Trade of electricity also includes the physical transmission of electricity.

Augstsprieguma tīkls AS is in charge of a transmission network receiving electricity from hydroelectric and thermal power stations of Latvia, as well as Lithuania, Estonia and Russia and transferring it further to the companies of distribution networks. Augstsprieguma tīkls AS manages 330 kV and 110 kV transmission lines, substations and distribution points located in the territory of Latvia.

Table 25. Electricity trade balance (GWh) (*Latvian Energy in Figures, 2013*)

	2008	**2009**	**2010**	**2011**
Import	***4,643***	***4,259***	***3,973***	***4,009***
Belarus	-	*1*	-	-
Estonia	*1,688*	*1,138*	*2,694*	*2,632*
Russia	*244*	*54*	*1044*	*934*
Lithuania	*2,711*	*3,066*	*235*	*443*
Export	***2,123***	***2,605***	***3,100***	***2,764***
Belarus	-	*1*	-	-
Estonia	*138*	*497*	*38*	*28*
Russia	*551*	*612*	*9*	*1*
Lithuania	*1,434*	*1,495*	*3,053*	*2,735*
Balance	***-2,520***	***-1,654***	***-873***	***-1,245***

The new interconnections of Lithuania-Poland (LitPol Link) and Lithuania-Sweden (NordBalt) in the year 2016 allowed the electricity price to be reduced for Latvian consumers and promoted price equalization in the region. In 2016 the average electricity price in the Nord Pool Spot AS electricity exchange Latvian bidding site, compared to 2015, has decreased by 13% and in

February 2016, when both interconnections began to work, the decrease compared to the previous month was 40% (*Public Report of the Ministry of Economics, 2016).*

5.3.2. Biomass and biofuels trade

Imported energy sources are mainly used in the Latvian energy sector. In 2013 local energy sources ensured 34.9% of total consumption of primary energy sources. The majority of them were renewable energy sources including wood biomass, hydro resources, wind energy, biogas, biofuels and local energy sources including peat and waste. Actual RES share in the total consumption of energy sources is growing gradually. It is foreseen that by the year 2020 it will reach the target of 40%.

Biomass

The most important RES in Latvia is wood biomass and hydro energy resources as well as wind energy and energy from waste. Wood biomass (roundwood, chips, shavings, pellets and wood residue) is the most significant local fuel that is used in centralized and local heating as well as cogeneration. Wood fuel total consumption has been growing steadily in the past decade. Its proportion in primary energy source balance amounted to 30% of the total consumption of the primary energy sources (7,668 m^3) in 2014 (*Latvian Energy Sector Development Guidelines for 2016–2020, 2016).*

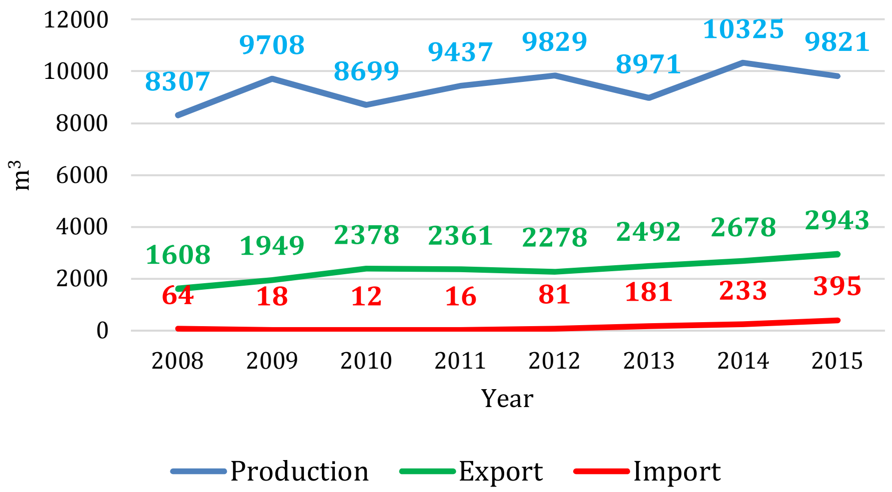

Figure 46. Wood fuel trade *(Central Statistical Bureau of Latvia).*

The main trade markets for wood products are the United Kingdom (19.6% of total wood export, except furniture), Germany (10.6%), Sweden (9.4%) and Estonia (6.3%). In 2015 the market share has been increased in Denmark, Estonia, Lithuania and Poland. The increase in market share mainly ensures export of lumber, slabs, granules, briquettes and various wood products (*Analytical Economic website of the Bank of Latvia www.makroekonomika.lv).*

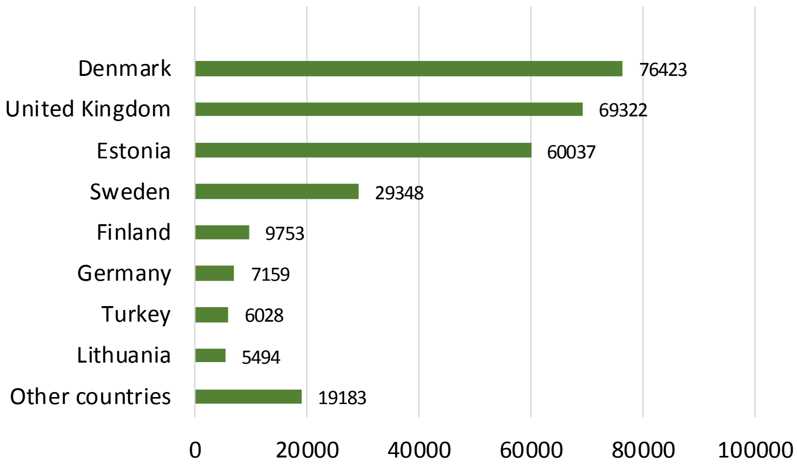

Figure 47. Export markets of firewood in 2015 (mill. EUR) **(**Ministry of Agriculture).

Compared to the year 2015, in 2016 the most of the imported wood production came from Lithuania – 18.5% of the total wood material import, Estonia (14%) and Russia (12%) (*http://financenet.tvnet.lv).*

Bio-fuels

Rapeseed oil is the basic feedstock for biodiesel production in Latvia. In Latvia biodiesel is used only from May to September (5 months) because of climate limitations. In Latvia there is one big biodiesel plant and a few smaller plants. According to the European Biodiesel Board data, the capacity of biodiesel production is 156,000 t while actual use in 2015 is estimated at 70,000 t.

The produced biodiesel and its by-products (glycerine, potassium sulphate) have been traded in Latvia as well as exported to EU countries, including the Scandinavia countries, and Russia and Belarus.

In 2011 in Latvia the total produced amount of rapeseed was 260,000 t. The produced amount of rapeseed is sufficient to ensure the existing biodiesel consumption of Latvia (10%), which is 70,000 t per year.

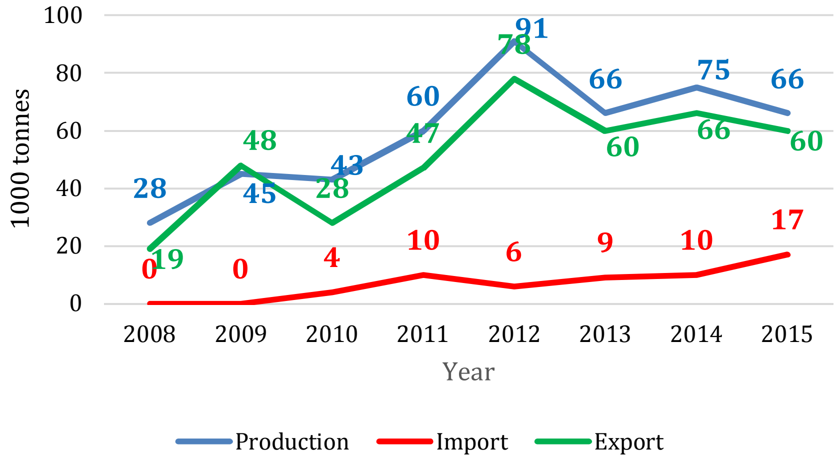

Figure 48. Biodiesel balance (*Central Statistical Bureau of Latvia)*

The amount of export of biofuels over the years has fluctuated, reaching the highest amount of biodiesel export in 2012 at 2,891 TJ, while in 2015 it was 2,223 TJ. The export of bioethanol faces a decrease and in 2015 it was only 54 TJ. However, in 2014 it was even smaller – only 11 TJ. The total consumption of biofuels is also fluctuating. It reached the highest point in 2010 with biodiesel consumption at 808 TJ and bioethanol consumption at 350 TJ. The import of biodiesel reached its highest point in 2015 at 632 TJ; however, the import of bioethanol was 306 TJ in the same period of time.

Use of bioethanol in Latvia is very low, even less than in Lithuania due to the smaller population. In Latvia the number of biogas plants is greater than in Lithuania but here biogas is produced solely for production of electricity.
A reduction of prices for regular fuels made biofuels less competitive. In addition, there are still only a small number of biofuel-using vehicles in the country. The harsh winter condition and very low temperatures in Latvia makes use of high ethanol blends dangerous to car engines.
A third reason is market limitations. Lithuanian blending companies can purchase bio-components from other EU producers who offer more competitive prices. Therefore, local producers are finding it a challenge to sell their higher-cost biofuels.

5.3.3. Capital, expertise and companies

Fortum, among the most traded shares on the Nasdaq Helsinki stock exchange and 51% owned by the Finnish State, has been growing steadily in the Baltic countries, reaching power generation of 0.7 TWh and heat sales of 1.3 TWh in the Baltic countries. As a divestment of the non-strategic heat business, CHP capacity in Tartu and Pärnu reaches 49MW (26 in Latvia and 18 in Lithuania, Kaunas, waste-CHP 2019).

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Nelja Energia, the Nordic-Estonian wind company (60 % owned by Vardar Eurus, 11% owned by Norway`s Buskerud County, NEFCO and EBRD, and 29% owned by Estonian investors), the leading producer of wind power in the Baltic states, opened its first cogeneration plant and pellet factory on 15 June 2017 in Broceni, Latvia. The total cost of the investment is around 30 million euros. The cogeneration plant and pellet factory created 35 jobs. The planned annual production of the modern pellet factory is at least 120,000 tonnes of pellets. The plant is supplied with energy by the cogeneration plant working with biofuel, which has thermal power of 19.4 MW and electrical power of 3.98 MW. The annual estimated electricity production of the cogeneration plant is 30,000 MWh.

Sources

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5.4. Lithuania

5.4.1. Electricity production, import and export

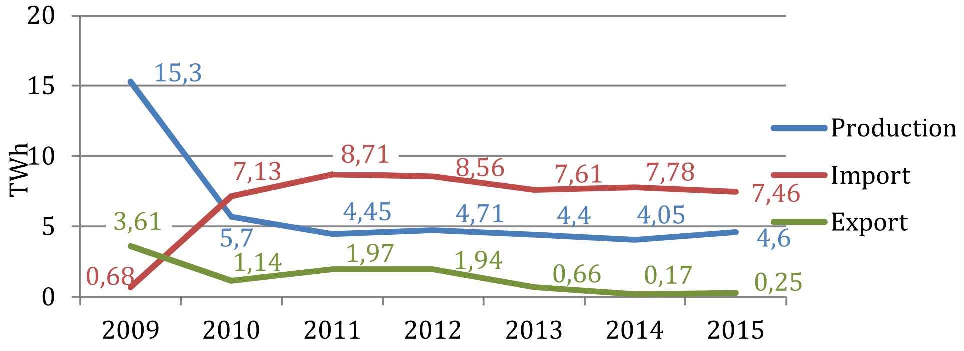

Figure 49. Electricity production, import and export in Lithuania, TWh, 2009–2015. (Source: Report of National Commission for Energy Control and Prices, 2015, Vilnius.)

The Lithuanian state electricity network has 4 links with Latvia, 5 links with Belarus and 3 links with the Russian Kaliningrad district. All abovementioned links are 330 kV voltages. In addition, Lithuania has a 300 kV direct current link with Sweden (700 kW capacity) and a 400 kV link with Poland (500 kW capacity). These new links with Sweden and Poland create new possibilities for more intense electricity trade with Nord Pool power market partners. Electricity import and export to neighbouring countries is presented in the table below (Source: National Commission for Energy Control and Prices).

Table 26. Electricity trade of Lithuania

Country	Electricity import (GWh)				Electricity export (GWh)			
	2016	2015	2014	2013	2016	2015	2014	2013
Latvia	3,620.83	4,179.31	4,054.70	2,540.00	271.77	97.80	192.39	372.70
Russia	3,019.91	2,994.71	3,227.93	3,496.00	115.20	114.58	100.61	0.00
Belorussia	152.22	190.34	498.57	154.00	0.00	0.00	0.00	115.00
Estonia	60.67	28.17	0,00	1,350.00	35.13	24.51	0.00	294.00
Sweden	2,754.75	0.00	0,00	0.00	323.12	0.00	0.00	0.00
Poland	487.83	65.53	0,00	0.00	1,081.48	15.67	0.00	0.00

5.4.2. Biomass and biofuels trade

The annual consumption of roundwood in Lithuania was 6.2 million m^3 in 2014. The increase of consumption was determined by the growth of fellings and the drop in exports. The export of roundwood decreased by 5% to 1.9 million m^3. A higher amount of roundwood remained in the domestic market, which allowed the wood products and green energy production to increase.

The sales of wood fuel decreased by 17% to 0.53 million m^3 (in 2014 compared to 2013).
The mean price of fuelwood was 27 EUR/m^3, which is higher by one fifth compared to 2013.

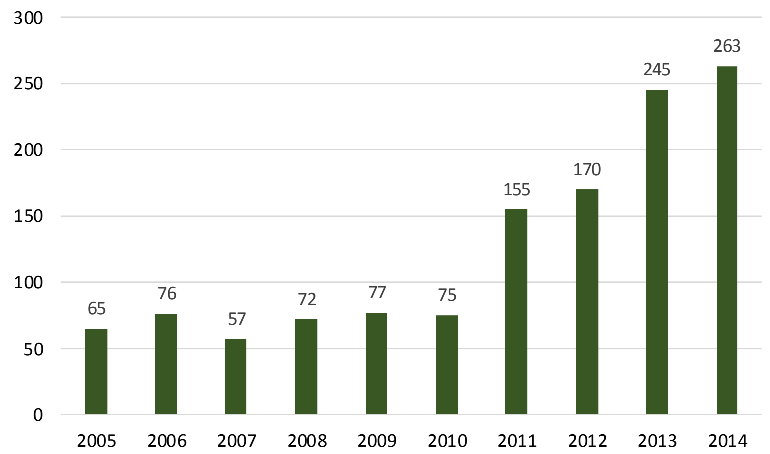

Figure 50. Sales of forest felling residue in state forests, 2005–2014, volume 1,000 m³ (Source: Directorate General of State Forests)

Table 27. Biomass trade balance, ktoe

	2009	2010	2011	2012	2013	2014	2015
Firewood and wood waste							
Import	47.1	48.0	110.0	110.5	118.3	123.9	134.5
Export	113.8	121.9	129.8	116.4	129.7	137.7	136.8

There is a lack of official information on the countries of biomass fuel import/export.

Regarding wood designated for wood chips the main countries for wood import are Belarus, Latvia and Poland. Regarding wood export, these are mainly countries consuming wood pellets, which are Italy, France, Germany, Austria and also the Nordic countries.

5.4.3. Capital, expertise and companies

Danpower Baltic is operated by the municipal services company of Hannover municipality Stadtwerke Hannover AG, which works under the trademark Enercity. Stadtwerke Hannover AG, which is based in Hannover, has 2,700 employees and has sales amounting to EUR 2.5 billion. The company, whose strategy is based on growth, develops renewable energy infrastructure not only in Germany but also in the Baltic states. Kaunas projects:

GECO Kaunas, UAB - The boiler house of Danpower Baltic in Kaunas is the first biofuel boiler house in Kaunas that has been producing heat from renewable energy sources, part of which has been supplied to Kaunas city residents since 2012. The Kaunas biofuel boiler house has two 8 MW capacity boilers, and the total capacity of the boiler house amounts to 20 MW. The biofuel boiler house also has an advanced smoke condensing economiser, with a capacity of 4 MW, which helps increase the effectiveness of the use of fuel and reduce relative pollution to obtain the same amount of energy.

SSPC-Taika, UAB is the first co-generation power plant in Kaunas which produces and supplies heat and electricity obtained from renewable energy sources to Kaunas city residents as an independent heat producer. The power plant of 20 MW capacity of heat and 5 MW capacity of electricity production has a Danish Danstoker boiler and a German M+M Turbinen-Technik steam turbine as well as a 5 MW capacity smoke condensing economiser.

Fortum, among the most traded shares on the Nasdaq Helsinki stock exchange and 51% owned by the Finnish State, has been growing steadily in the Baltic countries, reaching power generation of 0.7 TWh and heat sales of 1.3 TWh in the Baltic countries. As a divestment of the non-strategic heat business, CHP capacity in Tartu and Pärnu reaches 49MW (26 in Latvia and 18 in Lithuania, Kaunas, waste-CHP 2019).

Sources

Directorate General of State Forests
Lithuanian Statistical Yearbook of Forestry 2015
Energy Balance, years 2010–2015, Statistics Lithuania.
LITBIOMA – Lithuanian Biomass Energy Association (http://www.veidas.lt/biomases-energetikos-technologijos-sparciai-pleciasi-uz-lietuvos-ribu)
http://www.danpowerbaltic.lt/

5.5. Poland

5.5.1. RES implications of electricity market liberalisation

Table 28. Electricity trade balance of Poland (GWh)

	2011*	2012*	2013	2014	2015
Import	**1,984**	**3,838**	**2,336**	**4,360**	**3,591**
Czech Republic			111	405	155
Lithuania	0	0	0	0	3
Germany			199	191	171
Slovakia			41	9	1
Sweden	1,467	1,686	956	3,069	3,196
Ukraine			1,029	686	65
Export	**7,234**	**6,675**	**6,855**	**1,716**	**2,374**
Czech Republic	*	*	2,381	874	1,017
Lithuania	0	0	0	0	63
Germany	*	*	2,211	504	873
Slovakia	*	*	1, 456	233	402
Sweden	303	181	807	105	19
Ukraine	0	0	0	0	0
Balance	**5,250**	**2,837**	**4,517**	**-2,167**	**244**

PSE S.A., 2017; Energy Regulatory Office (URE), 2017.

*Country by country data not published

The Polish electricity market is generally separated from its neighbours' markets in that there is no single price zone. The market coupling process has not been implemented comprehensively either, and electricity exchange with Poland's neighbours is limited, most notably by the constraints of the internal grid. From the BSR perspective, however, it is notable that market coupling is indeed in place, through an agreement reached with Nord Pool AS, with respect to links with Sweden and Lithuania. The following trends can be observed:

Poland has turned from a net exporter to net importer of electricity (gross consumption again exceeding production by around 2,800 GWh in 2016), and this trend may persist.

Trade with Germany shrank in 2014–2015, and import was not boosted despite abundant solar electricity in Germany and the brownouts in Poland in August 2015, due to the growing problem of cross-country redispatching. Electricity dispatched from Germany to Austria could not be routed through (insufficient) direct cross-border links between the two countries, so it entered the Polish system, and then the Czech Republic and Slovakia, only to end up in Austria, having taken the "long route". This locked transmission capacity in Poland's trade with Germany and the southern neighbours.

The above led to growing dominance of Sweden in cross-border trade, along with the fact that wholesale electricity prices are lower in Sweden (and have since become lower in the Baltic states as well). But Sweden's role was diminished in 2016, after the opening of the 500 MW LitPolLink with Lithuania and the Sweden-Lithuania NordBalt link in December 2015, the latter absorbing much of Sweden's former exports to Poland.

Table 29. BSR electricity trade shares of Poland (GWh)

Share in import	**2011**	**2012**	**2013**	**2014**	**2015**	**2016***
Lithuania	0%	0%	0%	0%	0%	20%
Sweden	74%	44%	41%	70%	89%	53%
TOTAL BSR	**74%**	**44%**	**41%**	**70%**	**89%**	**73%**
Share in export	**2011**	**2012**	**2013**	**2014**	**2015**	**2016***
Lithuania	0%	0%	0%	0%	3%	20%
Sweden	4%	3%	12%	6%	1%	3%
TOTAL BSR	**4%**	**3%**	**12%**	**6%**	**3%**	**23%**

*Estimated

Poland remains a net exporter to the south-west as the redispatching issue, though now limited, persists. Otherwise, the net imports of 2,812 GWh in 2016, helped by the 3% growth in gross demand in both 2015 and 2016, are a sign that the country may look to its northern partners for future cooperation. A doubling of the 500 MW LitPolLink is planned for 2020.

The development of renewables subsidised from retail electricity prices has been causing wholesale prices to drop, especially in Western and Northern Europe. This puts pressure on prices in adjacent countries – the greater they are, the more coupled the markets become.

At the same time, cross-border transmission capacity still only accounts for 3.5% of domestic production capacity – the figure being among the lowest in the EU and certainly dwarfed by Sweden's 25%. However, energy security concerns (more than any drive towards liberalization) and foreign policy considerations have driven significant investments in cross-border transmission capacity in the recent years. As a side effect, wholesale electricity prices should fall, making it less likely that investments in conventional generation will be viable and delaying the achievement of grid parity by RES sources, keeping them dependent on continuing subsidies.

5.5.2. Biomass and biofuels trade

Foreign biomass trade has been summarised in the below tables.

Table 30. Polish biomass trade by volume (k€)

	2011	2012	2013	2014	2015	2016
Import	**2,061,090**	**3,516,745**	**2,874,157**	**3,664 196**	**3,077,921**	**2,603,961**
Agri	1,416,112	2,300,785	1,866,720	2,377,209	1,838,775	1,177,510
Forest	644,978	1,215,960	1,007,437	1,286,987	1,239,146	1,426,452
Export	**504,202**	**438,621**	**914,110**	**1,094,935**	**1,130,263**	**1,124,465**
Agri	14,316	38,202	65,214	66,366	60,068	47,272
Forest	489,887	400,419	848,896	1,028,569	1,070,196	1,077,193
Balance	**-1,556,888**	**-3,078,125**	**-1,960,047**	**-2,569,261**	**-1,947,658**	**-1,479,496**

Foreign Trade Database (HZ) of the Polish Statistical Office, retrieved in August 2017

Table 31. Polish biomass trade by value (k€)

	2011	2012	2013	2014	2015	2016
Import	**199,735**	**351,209**	**270,424**	**304,389**	**253,370**	**150,953**
Agri	152,564	272,202	215,160	244,460	202,995	103,796
Forest	47,171	79,006	55,264	59,929	50,375	47,157
Export	**69,979**	**60,735**	**114,724**	**134,262**	**138,566**	**130,717**
Agri	2,125	6,123	10,036	11,356	9,563	8,247
Forest	67,854	54,612	104,688	122,906	129,003	122,470
Balance	**-129,756**	**-290,474**	**-155,701**	**-170,127**	**-114,804**	**-20,236**

Foreign Trade Database (HZ) of the Polish Statistical Office, retrieved in August 2017

The biomass market boomed in 2010–2012 due to demand from industrial-scale power plants, particularly coal-fired facilities where biomass was used as an auxiliary fuel. In 2013 the support system of renewable energy started having problems as the prices of certificates of origin fell, and electricity from co-firing furnaces (whose demand for biomass is very flexible) declined from the all-time-high of 7.2 TWh to 3.9 TWh. The impact was partly softened by new dedicated biomass power plants, accounting for an increase from 2.3 TWh to 4 TWh. Demand rebounded again in 2014, each of the two sectors producing 0.6 TWh more. Later in 2016, co-firing dropped by half as the certificate price crisis deepened. All these changes had a decisive impact on imports of biomass; domestic production was insufficient to meet the needs of the energy industry.

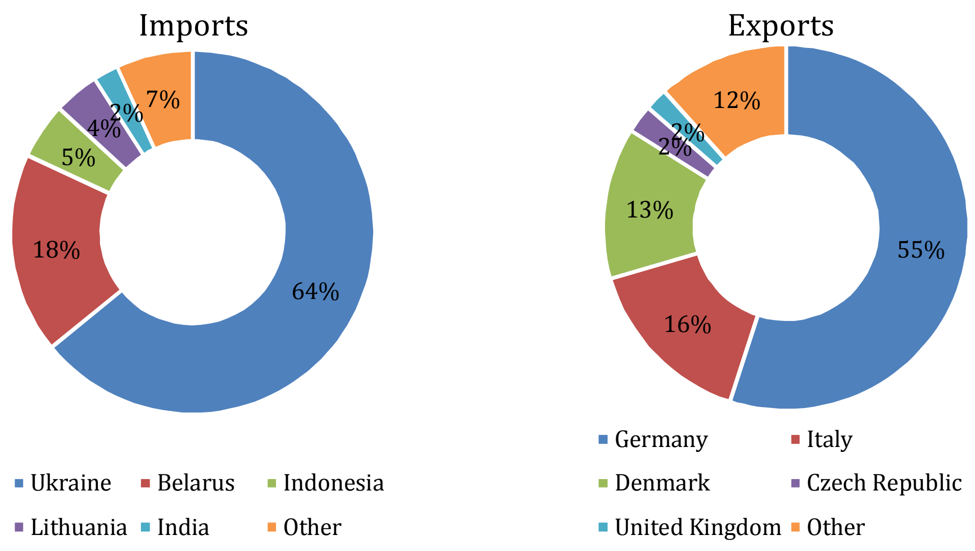

Figure 51. Biomass imports and exports in 2016 by value. (Source: Foreign Trade Database (HZ) of the Polish Statistical Office, retrieved in 2017)

Lithuania is the only BSR country with a noticeable share in the production of biomass fired in Poland. Ukraine and Belarus have traditionally been the main suppliers of forest and agricultural biomass respectively, due to relatively low production costs.

As regards exports, cost differences again being the main driver, Poland sells biomass in Western Europe – most notably nearby Germany and Denmark, but also Italy.

5.5.1. Capital, expertise and companies

PGE, the government-controlled Warsaw Stock Exchange-listed utility, which accounts for 40% of electricity produced in Poland, agreed to acquire all of **EDF**'s conventional assets in the country with an enterprise value of over EUR 1 billion in May 2017. Ostensibly due to pressures to abandon fossil fuels, EDF disposed of its combined-cycle plants with 4.4 GW in heating capacity and 3.3 GW in electrical capacity, as well as two heating grids in medium-sized cities. These mostly dated coal-fired facilities also include the state-of-the-art gas-fired plant in Toruń commissioned in 2017.

Also, a number of secondary investments in renewable energy production assets took place, continuing a trend of foreign investors in the renewables sector leaving Poland. Following the departure of Danish-based DONG Energy from the Polish wind market in early 2013, a number of transactions took place. Among others, the French **Engie** sold its Połaniec power plant of 1.6 GW, including 7 coal-fired units and a 205 MW biomass-fired unit commissioned in 2012 (believed to be the world's the largest at the time), to another Polish utility – **ENEA**. Big sellers in the wind sector included **GEO Renewables**, one of whose wind parks was sold to **IKEA**, as well as the German developer **Vortex**.

Sources

Polish Statistical Office (*GUS*), annual Country Reports of the President of the Energy Regulation Office (*URE*), annual Reports on the Activities of the President of the Energy Regulation Office, European Union Integration Options for the Polish Energy Market (*Opcje integracji polskiego rynku energii w ramach Unii Europejskiej*), WISE and REKK, March 2017, press and internet media.

5.6. Sweden

5.6.1. RES implications of electricity market liberalisation

The Swedish electricity generation is based on hydropower (45%), nuclear power (35%) ang CHP power (8%) (including industrial back pressure power production) in2015. Since 2010 the wind power has been emerging reaching already 10% of market share. To a large extent the Swedish power generation consists of around 97 % fossil free production without CO_2-emissions (nuclear included). In 2040 Sweden shall have 100% renewable power generation due to a parliamentary agreement in 2016. Solar power is building up rapidly in relative terms but from a low level in absolute terms. Intermittent power production increases in the energy system, such as wind power and solar power, the hydro power gets more and more important as acting as balance power in the Swedish system. The hydro power is important in this sense for all Nordic countries. Norway, Sweden and Finland all three have hydro power, but in falling order. The hydro power balance and stored energy together with building of interconnectors, smart grid solutions and even energy storage (batteries etc) will all be important in order to balance the Nordic system in the future. The Nordic countries are connected since a long time and the Nord Pool Spot Market has been the trading market for electricity since 1996 as the market was liberalized. As more and more interconnectors are planned and build it is getting more and more connected and therefore a more flexible system going towards a common electricity market in the Nordics, and in the first stage and in a following stage a common European electricity market. From Sweden interconnectors exists to Finland, Norway, Denmark, Germany, Poland but also to Lithuania since 2016. Norway plan to build interconnectors to both Great Britain and Germany and there is also one to the Netherlands to mention some. More interconnectors are planned in the future and some in order to connect wind power parks at sea. Trade via the interconnectors tend to have the effect to even out price differences and also to stable and balance the electricity system.

Installed power generation capacity has been increasing in recent years and at the same time the use of electricity has been levelling out, and in some cases decreased. The new intermittent renewable power capacity together with low electricity prices has put a harder competition for conventional power production facing tougher economic conditions. Energy efficiency and at the same time there are ongoing substitution to electricity from other fuel and energy carriers which makes the use of electricity increase. All together and differences in electricity prices in Sweden and close by markets, the electricity exports have been growing turning Sweden into a net exporter of electricity.

Sweden has been a net exporter of electricity since 2010 and onwards.

Table 32. Exports, imports and net exports of electricity of Sweden

Year	Imports	Exports	Net Export
2010	17,6	15,6	-2,0
2011	14,5	21,5	7,0
2012	13,0	32,3	19,3
2013	14,9	24,7	9,8
2014	16,7	32,5	15,8
2015	12,5	35,1	22,6
2016	17,4	28,9	11,5

Source: Sweden Energy Agency and calculation of Skåne Energy Agency

Figure 52. Electricity trade of Sweden (TWh). Source: Sweden Energy Agency and calculation of Skåne Energy Agency. (Source: Sweden Energy Agency and calculation of Skåne Energy Agency)

Both level of imports and exports is a function of a number of parameters such as temperature and climate, level of stored water in the large waterbeds, demand and supply of electricity, the electricity price and so on. Variations in these parameters makes the electricity prices vary in both Sweden and connected neighbouring countries and market creating trade flows of both imports and exports. The increase in supply, meaning increased installed power capacity, has created an excess supply in Sweden turning Sweden into a net exporter the last six to seven years.

Table 33. Trade balance of electricity in Sweden by countries in 2010–2016 Denmark (TWh)

Year	Denmark	Finland	Norway	Germany	Poland	Lithuania
2010	-2,2	-2,7	3,9	-1,3	0,3	-
2011	2,1	2,2	-0,1	1,5	1,2	-
2012	7,5	14,2	-7,6	2,7	2,5	-
2013	-0,8	11,8	-1,4	0,1	0,2	-
2014	1,0	18,0	-7,3	1,1	3,0	-
2015	3,7	17,2	-3,6	1,8	3,5	-
2016	-2,1	15,1	-7,2	0,7	2,6	2,3

Source: Sweden Energy Agency and calculation of Skåne Energy Agency

Finland is the most important country in terms of net exports for Sweden and Norway is the most important in terms of net imports over the last seven years. Lithuania started up as the interconnector was opened in 2016 and together with other connectors in the Baltics and further to Finland the balance and security of supply are more stable and less dependent on eastern electricity imports.

Building more connectors and interconnectors is an important step towards a more integrated common electricity market in the Nordics and in Europe. It also creates better flexibility in terms of balancing excess demand and excess supply situations in neighbouring countries. This flexibility is important to handle the increasing share of intermittent power generation of both wind power and solar power in the electricity systems in the area.

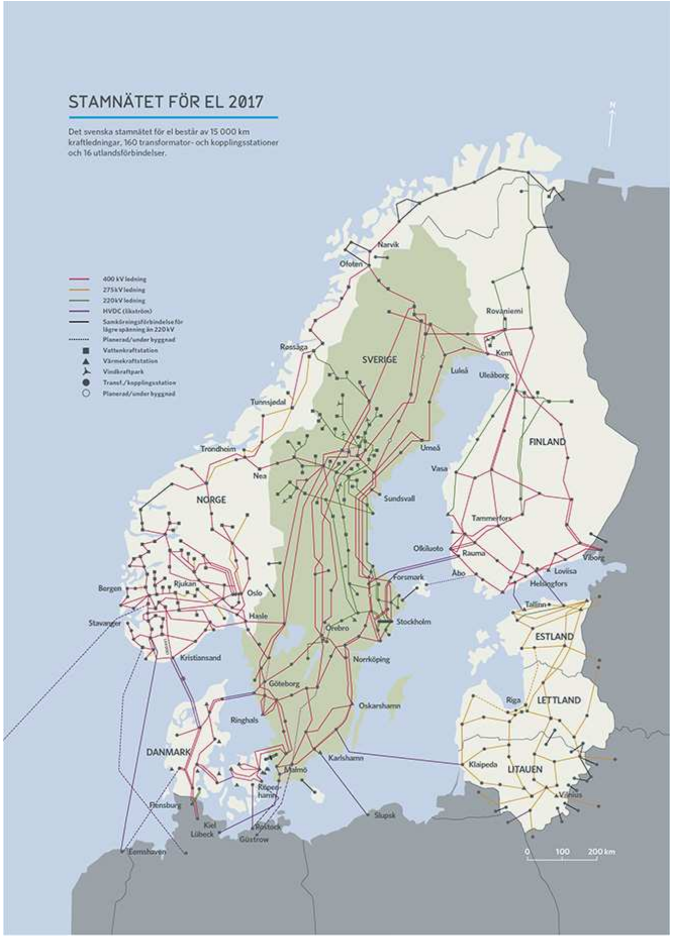

Figure 53. The grid, connectors and interconnectors in the Nordic area (existing and planned). Source: Svenska Kraftnät; Stamätet 2017; https://www.svk.se/drift-av-stamnatet/stamnatskarta/

5.6.2. Biomass and biofuels trade

Bioenergy from the forest is the main part of bioenergy used in Sweden. Sweden has a large wood industry and pulp and paper industry and long traditions and competence to process wood material in different ways. Sweden has well developed district heating systems in the country firing bioenergy and a pretty cold climate creating a heat demand from October to March. Saw mills and pulp and paper has been important big industries in Sweden for a long time. Various fractions for energy use are often different kind of wood residues falling when treating the round wood in different wood industries in Sweden. Energy generated from wood and wood residues was around 51 024 GWh, of which 55 GWh from fast growing energy crops such as Salix etc in 2015. Imports of energy wood (223 GWh) were higher than exports (133 GWh) in 2015.

Sweden has been one of the largest producers and one of the largest users of wood pellets in the world. At the same time, Sweden is also one of the largest importer of wood pellets making it one of the largest users of wood pellets in the world. Wood briquets are not so common in Sweden as wood pellets. Large amounts of imported wood pellets are traded to CHP plants where the ship loads can doc and unload at plant site. Exports are levelled around 240 000 tonnes since 2013, simultaneously the imports have decreased during 2013–2016. The decline of imports is related mainly to Russia and Latvia, but at the same time import has been increasing from Estonia. Sweden exports pellets mainly to Denmark. The trade with Norway, Italy and Germany is quite balanced. In general, the Swedish pellet trade has been becoming more balanced. Certification ("ENplus-certification") of the products among the companies are preparing for an increase in exports.

The figure below shows trade balance of wood pellets in Sweden 2012–2016. As one of the largest markets for wood pellets in the world, Sweden produces large quantities but needs imports to meet the demand. The large users in Sweden are CHP-plants firing wood pellets as their main fuel. Few of them are built during in 2010s though some older coal fired plants have been converted to pellets and bioenergy.

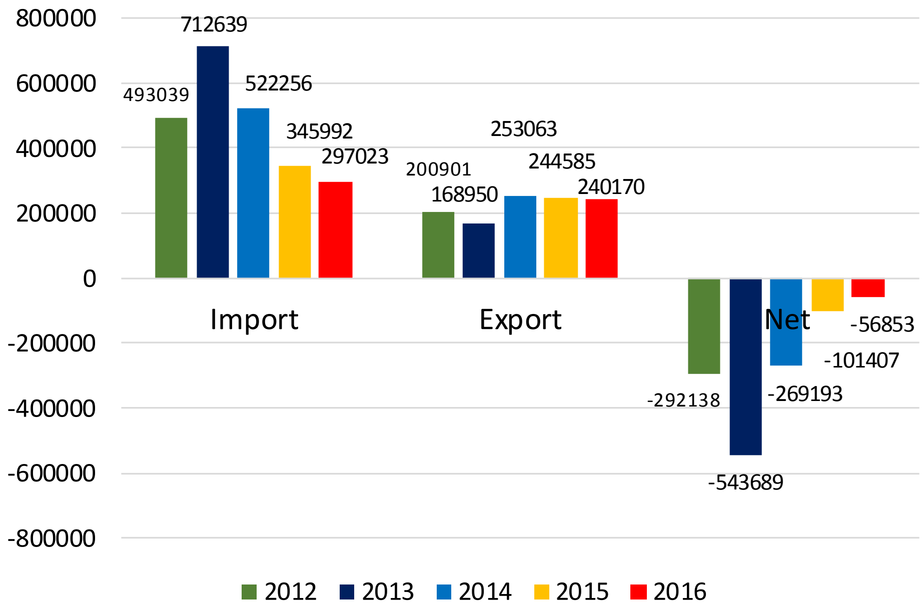

Figure 54. The trade balance of wood pellets in Sweden (tons)
Source: Pelletsförbundet, import och exportstatistik 2017; http://pelletsforbundet.se/statistik/ and SCB, KN 440131 Träpellets.

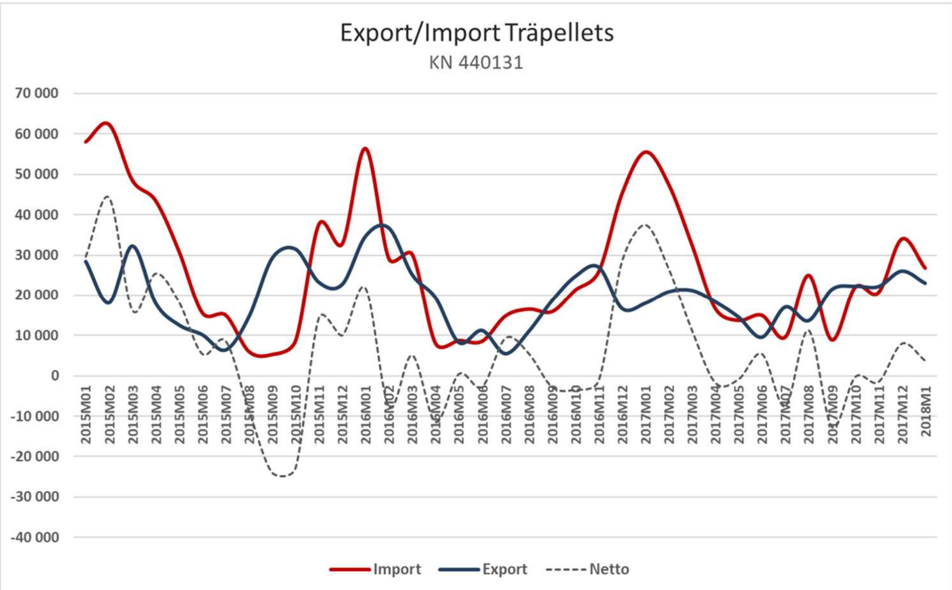

Figure 55. Imports and exports of wood pellets of Sweden
Source: Pelletsförbundet, import och exportstatistik 2017; http://pelletsforbundet.se/statistik/ and SCB, KN 440131 Träpellets

Since 2005 the Swedish production of wood pellets amounted to around 1 100 000 tonnes to 1 500 000 tonnes in annual statistics. Export since 2005 to 2016 has been around 300 000 tonnes and peaked in in 2013 of 712 000 tonnes. Imports since 2005 to 2016 and varied between 50 000 to 340 000 tonnes.

Sources

Swedenenergy (Svensk Energi); Elåret – Verksamheten 2015;
https://www.energiforetagen.se/globalassets/energiforetagen/statistik/el/elaret/svenska-pdf/elaret2015_160429_web2.pdf?v=nonce-b6365222-4815-400d-b7c4-239dfe73f7c5
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http://www.energimyndigheten.se/statistik/energilaget/?currentTab=1#mainheading
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5.7. BSR electricity trade

Renewables play a transforming role in integrating and liberalisation of the BSR electricity market. Nord Pool AS runs the largest market for electrical energy in Europe, measured in volume traded (505 TWh, 2016) and in market share. It operates in Norway, Denmark, Sweden, Finland, Estonia, Latvia, Lithuania, Germany and the UK. Energy commodity shares are divided as follows by major network operators in the Nordic and Baltic countries: Statnett (28.2%), Svenska kraftnät (28.2%), Fingrid (18.8%), Energinet.dk (18.8%), Elering (2%), Litgrid (2%) and AST (2%).

The electricity trade balance is strongly positive in Sweden, positive in Estonia and recently positive in Poland. Due to leaving nuclear power Lithuania became one of the most importing countries.

Current transmission capacity from the Nordic area is over 6,000 MW. Germany – Nord Pool coupling started in 11/2009. The Nord Pool price area extended to Estonia in 2010, Lithuania in 2012 and Latvia in 2013. Poland has been coupled with Nord Pool since 2010.

Jointly with the neighbouring electrical networks of Russia and Belarus, the electrical networks of Estonia, Latvia and Lithuania form the "Baltic Ring", consisting of 330 and 750 kV lines. In terms of exports, Latvia is a net exporter to Lithuania, while it still has considerable dependence on imports from Estonia and Russia.

The implementation of a joint wholesale electricity market for the entire Baltic states has boosted energy market development in the Baltic states. Investing in Estlink (Estonia-Finland interconnectors) enabled imports of renewable electricity and completing with oil-shale-generated electricity. Electricity generation decreased in Estonia in 2015 and 2016, which was caused by less costly inflows of electricity from the Nordic countries, as this reduced the share of Estonian producers on the market. Imports from Finland grew 1.5 times year over year and accounted for the majority of total imports. Increasingly imports can be labelled as renewable as they are generated by hydropower. In 2016, Nordic water reservoirs were clearly above the long-term average, creating pressure on electricity prices. The Estonian network may occasionally experience lower voltages compared with the Latvian and Lithuanian power systems, especially when the Estlinks are under heavy load conditions.

Table 34. Transmission capacity of Nordpool (2016).

Countries transmission capacity MW		
	From	To
Denmark - Germany	2,225	2,100
Sweden - Germany	615	615
Sweden - Poland	600	600
Sweden - Lithuania	700	700
Norway - Netherlands	723	723
Finland - Estonia	1,016	1,016
Finland - Russia	320	1,300
Total	**6,199**	**7,054**

Restrictions especially remain between DK & DE. Net export from the Nordic area to Continental Europe and the Baltics in 2016 was 10 TWh. In 2015 the net export was 18 TWh. Approximately 25 TWh of net export has been feasible since 2016. New interconnections will double the export capacity to over 12,000 MW by 2023. The Swedish electricity exports peak in neighbouring Finland and Denmark.

Market share of the largest generator in the electricity market is historically highest in Estonia (80%), followed by Latvia (57%). Other electricity markets are oligopolies, the most in Lithuania and Finland where the biggest generator is less than a quarter of the total.

Table 35. Market share of the largest generator in the electricity market in 2015 (% of total generation) (Eurostat)

Country	%
Estonia	80%
Latvia	57%
Sweden	41%
Denmark	33%
Germany	32%
Finland	26%
Lithuania	23%

For the consumer, end-user cost of electricity differs across BSR countries depending on national legislation and taxation as the energy price itself is given by the Nordpool commodity exchange. The higher network fees raise the end-user prices in Sweden, Denmark and Poland. The low price electricity countries are Estonia, Latvia and Finland.

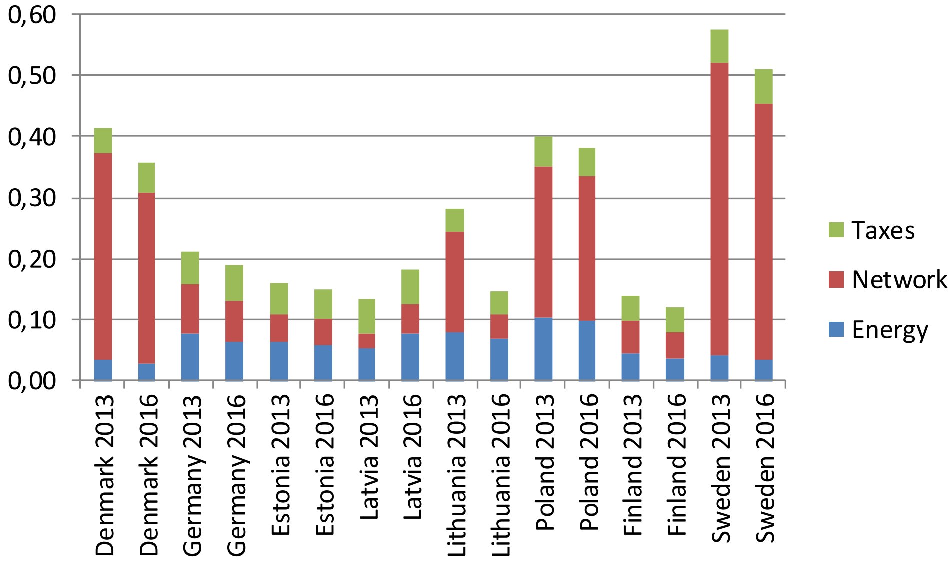

Figure 56. Electricity prices € for domestic users 2013 and 2016, purchasing power standard, Band DD: 5 000 kWh < Consumption < 15 000 kWh. Breakdown: Energy and supply, Network cost, Taxes and Levies. (Eurostat).

5.8. BSR biomass trade

The BSR biomass market is booming, and it is more and more integrated. It has also become highly dynamic and diverse over the last 5 years due to large investments and price fluctuations. The BSR countries are highly forested and forest energy has a central role in renewable energy. The share of RES is highly dependent on by-products from the forest industry in Finland and Sweden. Estonia and Latvia export biomass in various forms and qualities in large extent. The pattern of biomass trade is from east to west, and the flows have become more intense between BSR countries, though some major exports comprise United Kingdom, USA, Italy, etc. The main imports of wood briquettes to Germany come from Poland, Latvia and Lithuania. As a market indication, the pellet exports in Germany declined and were replaced with imports from the Baltic states.

6. Synthesis of regional progress and benefits of renewables

Highlights of the key findings of the report include the following statements. Those apply to the Baltic Sea Region as a whole or specified and narrowed if valid.

Energy transition

1. There has been a rapid expansion of renewable generation capacity in BSR over the 2000s and 2010s. The growth has been predominantly in bioenergy, wind and solar capacity though hydro energy dominates the Nordic-Baltic electricity market.
2. Denmark, Estonia, Finland, Latvia, Lithuania and Sweden have already surpassed their 2020 renewable energy target (6 among EU total 11). At regional scale, project regions of Sjælland, Mecklenburg-Vorpommern, Southern Estonia, Zemgale, Kaunas county, West Pomerania, Central Finland, Blekinge and Skåne have a higher share of RE production than national level average.
3. Progress in the regions in the Baltic states has been faster since 2004 than in the more mature markets in Nordic countries due to the lower starting point in the energy transition.
4. The shares of renewables have increased in the past decade, and heating sector renewables are dominant. Heating and cooling (H&C) remains the largest sector in terms of absolute renewable energy deployment. RES in heating is high in BSR countries, led by Sweden (68%), followed by Latvia (53%), Finland (52%), Estonia (47%) and Denmark (40%) (2017). Combined heat and power (CHP) is a dominant technology producing more than half of total energy supply in all listed regions - in some cases up to 80%.
5. Renewable energy contributes to the macro-economy in terms of the value added, income and employment that it generates from its production, transformation and distribution as well via manufacturing, R&D and trade of renewable energy technologies.
6. Solar energy demonstrates a new wave of renewable jobs and value added though it's share in energy mix remains still very small. While the growth for solar power has been exponential, it has been declining in Mecklenburg-Vorpommern.
7. Current drivers of the energy transition include the price of energy, regulation and policy, financing conditions, incentives for R&D, and the availability of knowledge and technology spill-overs. Macroregional integration and trade plays increasingly stronger role.
8. The promotion of RES serves mainly climate objectives and energy security less in the open and liberalised electricity market and regulatory heating market. The secondary benefits of the development of RES include innovation, reduced air pollution, the creation of jobs (with new skills) and local/regional added value.
9. Finland and Sweden as well the Baltic states have consistently had a higher energy intensity than the EU average, due to their processing industries (mining, steelworks, pulp and paper etc) as well reflecting colder climates and greater energy requirements for space heating in these countries. It is exceptionally high in Estonia due to the oil shale energy and processing.
10. When comparing the carbon intensity of the BSR states, the importance of the energy mix becomes apparent. In Sweden and Finland, a large share of electricity is generated by hydropower. The use of low-carbon and renewable energy for power generation in BSR countries means that the carbon intensity of primary energy consumption is 30−50% lower than the EU average. By contrast, in Poland (3.2 CO_2 eq/toe) and Estonia (2.8 CO_2 eq/toe), the power sector's dependence on carbon-intensive fuels such as coal and oil shale means that the greenhouse gas intensity of the energy supply in these countries is half times higher than the EU average.

11. Interdependency between national electricity systems and biofuel markets has deepened, with benefits shared by all. A narrow, national perspective on power system security fails to reap the significant cost savings offered by cross-border cooperation, transmission and free trade in the progressing energy union.
12. As the net losers and winners of energy transition are unfavourably geographically concentrated, in particular in Poland and Estonia, policy support will be needed to facilitate the transition to renewables and prevent the deterioration of regional economies and social capital associated with the loss of major employers providing targeted skill reorientation in the energy sector.
13. Policies promoting the energy transition need to keep in view the wider land-use and environmental impacts (the energy-water-food nexus) which may create opposition of some stakeholders or interest groups.
14. Pronouncing the ethos of the Paris agreement, government ideology is a political factor that impacts the stringency of climate and energy policies. However, the implementation of energy transition and the deployment of renewables in regions depends on integrity of policy model, harmonised measures and shared commitments at national, regional and local level. Currently, the administrative and financial burden is disproportionate at local authorities in case of the Baltic states.

Capital, investment and value added

15. The cost of renewable energy is plunging — it is shaking up the power sector making renewables more competitive and requiring less subsidies and grants.
16. The substitution of renewable energy for fossil fuel inputs offers the opportunity to reduce exposure to volatile global energy prices. If the renewable equipment is manufactured within BSR countries (Germany, Sweden, Denmark and Poland as renewable powerhouses), it also offers the possibility of reducing BSR countries' energy trade deficit, and, potentially through first-mover advantages, establish an industry that can serve European and global markets.
17. Investments in RES are facilitated by a dynamic regulatory framework that attempts to reduce the risk for investors and hence the cost of capital. However, incentives need to be reduced in line with falling technology costs in order to avoid over-compensation, which is a case in BSR countries and regions, whether related to the lock-ins in the energy market or to the emerging technologies.
18. On the microeconomic and corporate level, the RES business model continues to rely on support schemes (feed-in tariffs, investment grants, private investment from banks – government guarantees). Both business and technological cycles of renewable energy are much quicker than in the conventional energy.
19. The RES has strong positive multipliers to the regional economics. In the Baltic states, complexities of the regional renewable business model are mainly driven by heating and renewable electricity in transmission capacities.
20. The scale of investment required to decarbonise the power generation sector in eastern and southern BSR countries is still large and will require the mobilisation of private finance.
21. The value chain tends to be longer in bigger countries due to manufacturing and specialised services. In smaller countries, only a few facilities and companies have a dominant role.
22. A larger share of value added, reflecting higher labour productivity in the sector, is apparent in the Nordic countries compared to the Baltic states.
23. The value chain stage of systems manufacture and site development contribute the largest share, in case of wind energy up to 85%. The continuous effects, the effects generated by

operation and maintenance (O&M) and in the system operator stage, appear greater in bioenergy though it depends in a certain extent on fuel pricing and its volatility.

24. The potentials differ in regions with and without manufacturing industries of renewable technologies. In practice, the Baltic states need to focus on domestic O&M and supporting services in the development stages.
25. Due to the open and more globalised economy the value added increases in trading renewable technologies, specifically in solar, heat pumps and heating bioenergy.
26. The scale of public R&D budgets in energy technologies has been high in recent years. This effort needs to be sustained and accelerated to maintain the 'upstream' flow of new technologies by adding substantially private R&D, in the Baltic states in particular.
27. The price of energy faced by the end user could be expected to affect energy demand. In the short term, increases in price encourage users to be more efficient by reducing 'wasteful' energy consumption (behaviour component). In the longer term, higher prices can stimulate investment in new, more energy-efficient technologies and processes. Currently, in some BSR countries (Sweden, Estonia, Finland) the energy prices are too low to attract investments.
28. Sweden has kept increasing investments in renewable energy sector as others declined in recent years. There are few major investors which dominate in the Baltic renewables market. NEFCO has funded projects in the Baltic states. Fortum is active in non-strategic heating energy. German Danpower GmbH operates the municipal heating in Lithuania and Estonia.
29. In regard electricity transmissions, Denmark is well interconnected to Sweden, Norway and Germany as the Baltic countries have been suffering greatly from the fragmentation of EU energy markets due to limited interconnections.
30. If energy and capital are complements, they will respond to price changes moving in the same direction. In this case, for example, the promotion of innovation in, and the diffusion of, energy-efficient technologies will be effective in reducing energy consumption. If energy and capital are substitutes, a carbon tax could be preferred, bringing about a change in relative prices and a shift in the relative shares of energy and capital.
31. In large, the economic rationale is a key incentive for regions and local communities to advance renewable energy. In the Nordic countries, the climate and environmental considerations substantially assist the primary economic arguments while the progress in the Baltic states is based on strong public support schemes and economic efficiency and is less environmentally motivated.

Employment

32. As the energy transition accelerates in the majority of RES types, employment in the renewable sector remains strong. The jobs are local, especially in the supply chain, and thus RE is highly important for regional economies, bioenergy in particular. However, while growth has been slowed down with maturing bioenergy and rising labour productivity and automatization, emerging PV and wind energy jobs continue growing.
33. Bioenergy, CHP and heating sector, is a key local employer, providing 4-6 jobs per megawatt (MW), with two jobs inside the plant and two working on the collection, handling, and transportation of the biomass fuels used by the plants.
34. Five or more jobs related to the capital investment create just one job in operating renewable facilities based on onshore wind, PV, solar thermal and ground heat pumps. The strongest job provider in the development phase is offshore wind sector, up to 11-13 jobs in investment per 1 job in operations.

Monitoring and benchmarking

35. Data gaps exist on disaggregated regional analysis. A big political agenda for climate and environmental policy exists, but benchmarking and evidence-based policy-making on a regional scale is poor. For example, despite its growing importance, the energy chapter is missing in the Eurostat regional yearbook (only heating and cooling degree days are available by region). Also, the national gap exists as the regional energy statistics is more advanced in the Nordic countries and Germany, but less so in the Baltic states and Poland. Therefore, strategic decision-making on a regional level is based on political ideology rather than facts, figures and evidence.
36. National estimates for jobs in RES tend to be overestimated provided in cross-european surveys, and uncertainty is high as it is difficult to separate "pure" RES jobs from jobs in infrastructure/the grid as well R&D, while co-generation combined fossil fuels has been increased. Business statistics remain loose in the value chain, starting from resource management and harvesting to generation and supply. Public administration and project support is only partially accounted for.
37. The installed capacity-based proxy on jobs and value added varies in great extent between countries due to the scale of investments and multiple specificities of technology, engineering and support schemes (the employment cost varies).
38. Generally, the stronger focus should be on emerging sources such as solar and wind to have an in-depth analysis to speed deployment to avoid administrative burdens. The main problem is lack of data. However, qualitative data can be used instead.
39. Addressing the institutional and corporate statistics of conventional and renewable energy on socioeconomic figures will be a key step for the benchmarking and assessment of regional benefits. So far, cross-European progress figures on RES jobs and added value are valid for political rhetoric, not for progress reporting and action planning in countries and regions.

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Annex 1. Tables of headline indicators.

Tables of headline indicators GoA 2.3_Fostering regional development through renewable energy.

Final energy consumption

Million TOE (tonnes of oil equivalent)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	2015	2016
EU (28 countries)	**1188,9**	1191,8	1193	1172,9	1180	1114,7	1163,3	1105	1104,5	1106,2	**1061,2**	1086,2	1107,7
BSR countries													
Denmark	**15,4**	15,5	15,7	15,7	15,5	14,8	15,5	14,8	14,2	14,1	**13,5**	14,0	14,4
Germany	**221,6**	218,5	223,4	210,2	217,6	205,8	219,7	208,8	212,1	217,7	**208,9**	212,1	216,4
Estonia	**2,8**	2,9	2,9	3,1	3,1	2,8	2,9	2,8	2,9	2,9	**2,8**	2,8	2,8
Latvia	**3,9**	4,0	4,2	4,4	4,2	4,0	4,1	3,9	4,0	3,9	**3,9**	3,8	3,8
Lithuania	**4,4**	4,6	4,9	5,2	5,1	4,6	4,8	4,7	4,8	4,7	**4,8**	4,9	5,1
Poland	**58,6**	59,0	61,6	61,6	62,5	61,6	66,4	64,8	64,4	63,3	**61,6**	62,3	66,7
Finland	**26,1**	25,2	26,5	26,5	25,7	23,8	26,2	25,0	25,2	24,7	**24,4**	24,2	25,2
Sweden	**34,0**	33,7	33,2	33,3	32,4	31,4	34,1	32,4	32,4	31,6	**31,2**	31,7	32,6
BSR energy regions													
Sjælland									2,0	2,0	**2,0**		
Meckl.-Vorpommern	**3,3**	3,3	3,4	3,1	3,3	3,3	3,5	3,2	3,3	3,4	**3,3**		
Southern Estonia											**0,6**		
Zemgale	**0,3**	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	**0,3**		
Kaunas county													
West Pomerania	**0,4**	0,4	0,4	0,4	0,5	0,4	0,5	0,5	0,5	0,5	**0,5**		
Central Finland	**1,5**		1,6		1,5		1,6		1,5		**1,5**		
Blekinge county		0,6	0,7	0,6	0,6	0,6	0,6	N/A	0,6	0,7	**0,6**		

Source of Data: European environment agency (EEA), Authors

Date of extraction: 30.apr.18

Hyperlink to the table http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=t2020_31

Code: t2020_31

BEA-APP BALTIC ENERGY AREAS A PLANNING PERSPECTIVE

Share of renewable energy in gross final energy consumption

%

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	2015	2016	**TARGET**
EU (28 countries)	**9**	9	10	10	11	12	13	13	14	15	**16**	17	17	**20**
BSR countries														
Denmark	**15**	16	16	18	19	20	22	24	26	27	**29**	31	32	**30**
Germany	**6**	7	8	9	9	10	11	11	12	12	**14**	15	15	**18**
Estonia	**18**	18	16	17	19	23	25	26	26	26	**27**	29	29	**25**
Latvia	**33**	32	31	30	30	34	30	34	36	37	**39**	387	37	**40**
Lithuania	**17**	17	17	17	18	20	20	20	22	23	**24**	26	26	**23**
Poland	**7**	7	7	7	8	9	9	10	11	11	**11**	12	11	**15**
Finland	**29**	29	30	30	31	31	32	33	34	37	**39**	39	39	**38**
Sweden	**39**	41	43	44	45	48	47	49	51	52	**53**	54	54	**49**
BSR energy regions														
Sjælland									25	26	**29**			
Meckl.-Vorpommerı	**31**	34	35	53	59	59	64	82	94	100	**115**			
Southern Estonia								37			**50**			
Zemgale	**26**	52	50	48	47	56	48	53	58	60	**63**			
Kaunas county					11									**30**
West Pomerania														
Central Finland	**36**		35		37		37		37		**38**			**60**
Blekinge county		58	61	62	62	61	62			64	**64**			**100**

Source of Data: European environment agency (EEA), Authors
Date of extraction: 30.apr.18
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Code: t2020_31

Gross inland energy consumption of RES

1 000 tonnes of oil equivalent

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	2015	2016
EU28		121 014	128 335	138 351	148 696	156 808	173 748	170 920	187 272	197 884	**201 273**	188 179	195 906
BSR countries													
Denmark	**2 667**	2 840	2 889	3 206	3 248	3 300	3 920	4 002	4 183	4 329	**4 435**	4 678	5 025
Germany	**14 614**	17 210	20 581	23 728	23 352	24 481	27 571	29 301	32 252	33 397	**35 406**	32 084	33 195
Estonia	**599**	589	531	602	646	718	847	835	862	851	**859**	878	914
Latvia	**1 453**	1 476	1 430	1 407	1 378	1 567	1 435	1 417	1 651	1 611	**1 613**	1 491	1 493
Lithuania	**843**	881	931	964	1 021	1 052	1 065	1 057	1 161	1 212	**1 277**	1 307	1 361
Poland	**4 321**	4 487	4 695	4 824	5 560	6 244	7 267	7 934	8 608	8 559	**8 591**	7 664	7 858
Finland	**8 669**	8 086	8 691	8 657	9 141	8 052	9 352	9 144	9 991	9 912	**10 155**	9 936	10 244
Sweden	**13 147**	14 826	14 388	15 294	15 620	15 819	16 997	16 546	18 524	17 083	**17 301**	18 636	19 359
BSR energy regions													
Sjælland									504	510	**573**		
Mecklenburg-Vorp	**175**	190	199	296	300	327	354	456	529	586	**670**		
Southern Estonia													
Zemgale	**200**	396	399	391	369	420	373	390	439	446	**472**		
Kaunas county					**652**								
West Pomerania													
Central Finland	**546**		559		559		593		636		**645**		
Blekinge county		336	378	397	366	390	403			**416**			

Source of Data: Eurostat, Authors
Date of extraction: 30.04.2018
Hyperlink to the ta http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdcc330

Electricity generated from renewable sources

% of gross electricity consumption

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	2015	2016
EU (28 countries)	14,4	14,9	15,4	16,1	17,0	19,0	19,7	21,7	23,5	25,4	**27,5**	28,8	29,6
BSR countries													
Denmark	23,8	24,6	24,0	25,0	25,9	28,3	32,7	35,9	38,7	43,1	**48,5**	51,3	53,7
Germany	9,4	10,5	11,8	13,6	15,1	17,4	18,1	20,9	23,6	25,3	**28,2**	30,8	32,2
Estonia	0,6	1,1	1,5	1,5	2,1	6,1	10,4	12,3	15,8	13,0	**14,6**	15,1	15,5
Latvia	46,0	43,0	40,4	38,6	38,7	41,9	42,1	44,7	44,9	48,8	**51,1**	52,2	51,3
Lithuania	3,6	3,8	4,0	4,7	4,9	5,9	7,4	9,0	10,9	13,1	**13,7**	15,6	16,8
Poland	2,1	2,7	3,0	3,5	4,4	5,8	6,6	8,2	10,7	10,7	**12,4**	13,4	13,4
Finland	26,7	26,9	26,4	25,5	27,3	27,3	27,7	29,4	29,5	30,9	**31,4**	32,5	32,9
Sweden	51,2	50,9	51,8	53,2	53,6	58,3	56,0	59,9	60,0	61,8	**63,3**	65,8	64,9
BSR energy regions													
Sjælland													
Mecklenburg-Vorp	30,9	32,4	32,3	44,7	44,0	50,0	46,0	51,8	54,3	61,1	**63,3**		
Southern Estonia													
Zemgale	60,8	61,8	53,1	48,9	56,5	68,9	81,8	73,2	74,5	80,6	**63,0**		
Kaunas county					35,0						**40,0**		
West Pomerania		6,2	8,2	10,7	12,4	16,0	12,9	24,6	39,8	44,9	**51,7**		
Central Finland	20,9		19,6		20,6		29,7		27,2		**24,9**		
Blekinge county							100,0			**96**			

Source of Data: Eurostat, Authors
Date of extraction: 30.04.2018
Hyperlink to the tal http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdcc330

Greenhouse gas emissions per capita

Tonnes of CO_2 equivalent per capita

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	2015
EU (28 countries)	**10,92**	10,81	10,76	10,61	10,35	9,57	9,77	9,43	9,28	9,08	**8,72**	8,70
BSR countries												
Denmark	**13,64**	12,80	14,20	13,30	12,57	11,89	11,93	10,95	10,03	10,34	**9,50**	9,00
Germany	**12,56**	12,28	12,39	12,09	12,13	11,33	11,78	11,54	11,60	11,81	**11,50**	11,30
Estonia	**14,01**	13,57	13,17	15,62	14,54	12,19	15,02	15,48	14,74	16,49	**16,10**	13,80
Latvia	**4,99**	5,15	5,43	5,70	5,56	5,29	5,95	5,71	5,76	5,78	**5,80**	5,90
Lithuania	**6,26**	6,68	6,91	7,64	7,44	6,08	6,44	6,79	6,87	6,51	**6,90**	7,00
Poland	**10,42**	10,42	10,80	10,81	10,61	10,14	10,72	10,63	10,47	10,38	**10,10**	10,20
Finland	**15,85**	13,53	15,64	15,33	13,80	13,00	14,50	13,03	11,91	12,02	**11,20**	10,50
Sweden	**7,95**	7,65	7,62	7,42	7,14	6,61	7,19	6,72	6,30	6,09	**5,80**	5,70
BSR energy regions												
Sjælland					11,71					10,56		
Meckl.-Vorpommern		9,50					9,60	9,30	9,60	9,50		
Southern Estonia												
Zemgale	**6,16**	6,28	6,72	7,07	6,83	6,73	7,21	6,99	7,19	7,21	**7,44**	
Kaunas county	**0,03**	0,03	0,02	0,02	0,02							
West Pomerania								0,92	0,94	2,68	**4,29**	
Central Finland	**11,00**		10,90		10,20							
Blekinge county		4,47	5,26	4,43	4,07	4,21	4,44	3,48	3,27	2,98	**2,72**	

Source of Data: European environment agency (EEA), Authors
Date of extraction: 1 Oct 2017
Hyperlink to the table http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=t2020_rd300
Code: t2020_rd300