Interreg
Danube Transnational Programme
ENERGY BARGE

ENERGY BARGE

Building a Green Energy and Logistics Belt

Project Code: DTP1-175-3.2

Deliverable 3.1.1

Compendium of national market study reports

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I. About the ENERGY BARGE project

The Danube region offers a great potential for green energy in the form of biomass. The main objective of ENERGY BARGE is to exploit this potential in a sustainable way, considering the Renewable Energy Directive 2009/28/EC, thereby increasing energy security and efficiency in the Danube countries. The project brings together key actors along the entire value chain, biomass companies and Danube ports as well as relevant public authorities and policy stakeholders. The project maps value chains and facilitate the market uptake of biomass, support better connected transport systems for green logistics and provide practical solutions and policy guidelines. FNR coordinates the project with its fourteen partners from Austria, Bulgaria, Croatia, Germany, Hungary, Slovakia and Romania.

Project coordinator

Agency for Renewable Resources		
Fachagentur Nachwachsende Rohstoffe e.V.	FNR	Germany

Project partners

BioCampus Straubing GmbH	BCG	Germany
Deggendorf Institute of Technology	DIT	Germany
Austrian Waterway Company	VIA	Austria
Port of Vienna	PoVi	Austria
Bioenergy2020+ GmbH	BE2020	Austria
International Centre of Applied Research and Sustainable Technology	ICARST	Slovakia
Slovak Shipping and Ports JSC	SPaP	Slovakia
National Agricultural Research and Innovation Center	NARIC	Hungary
MAHART-Freeport Co. Ltd.	MAHART	Hungary
International Centre for Sustainable Development of Energy, Water and Environment Systems	SDEWES Centre	Croatia
Public Institution Port Authority Vukovar	PoVu	Croatia
Technology Center Sofia Ltd.	TCS	Bulgaria
Romanian Association of Biomass and Biogas	ARBIO	Romania
Federation of owners of forests and grasslands in Romania	Nostra Silva	Romania

II. About this document

This report corresponds to D 3.1.1 *Compendium of national market study reports* of ENERGY BARGE. It has been prepared by:

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1. Background of the deliverable

ENERGY BARGE aims at exploiting the macroregion's bioenergy potential to increase energy security and diversification of energy sources by establishing secure, efficient and sustainable bioenergy supply chains along the river. To this end, a holistic view on the bioenergy market and underlying value and supply chains is needed. Given national and regional disparities in theoretical, geographical and market potential for bioenergy, deployment, public support, and also cooperation between private and public actors, it is necessary to identify levers for tapping potential and options for market actor cooperation, business development and market uptake.

A theoretical model designed to increase the market uptake of bio-based feedstock for both material and energetic (ideally cascading) use in the Danube region and thus to address the objectives also set out in the EUSDR is a concept called "Green Energy and Chemistry Belt" (see Figure 1). It was developed by the BioCampus Straubing GmbH (PP1) and aims at using the River Danube as a natural biomass corridor and sustainable transport axis for biomass. The underlying principle follows the logic of "local harvesting – decentral processing into more transport-worthy states (e.g. oils, pellets, liquids) – central refinement or enduse", so that added value creation can mainly stay in rural areas along the Danube. This concept forms the basic idea of the ENERGY BARGE project.

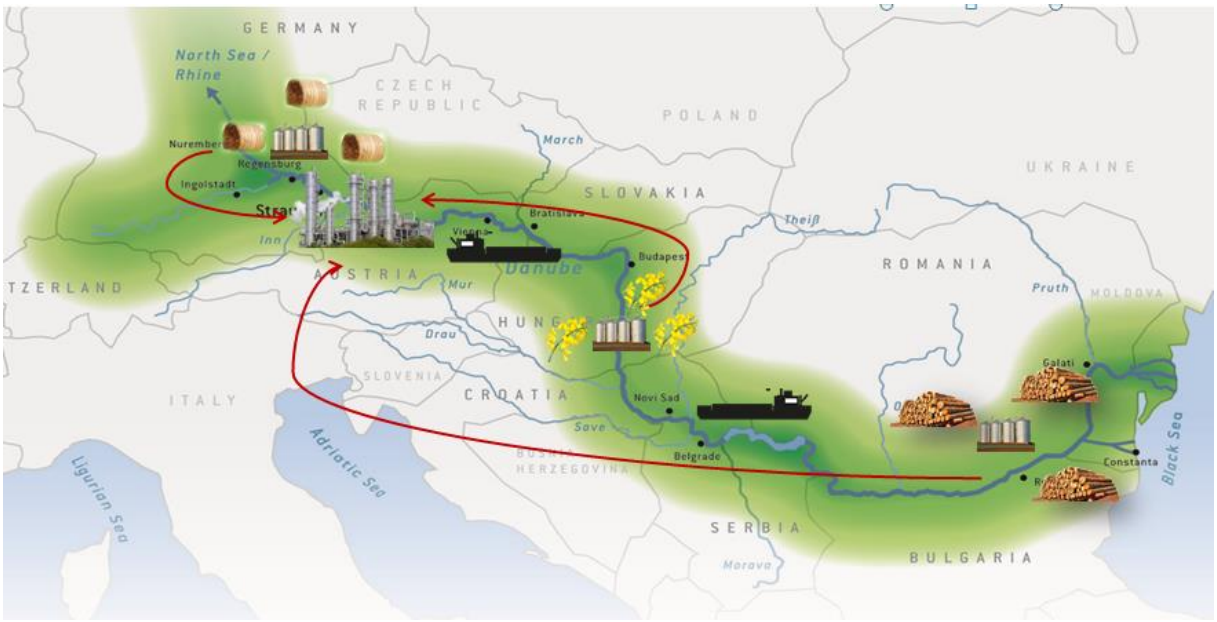

Figure 1: Green Energy and Chemistry Belt (Source: BioCampus Straubing GmbH, own visualization).

In order to reach the targets outlined above, WP3 provides market-oriented mapping of the Danube region's value chains from biomass feedstock production and residues to energy generation from an integrated, transnational perspective, giving regional and transnational guidance for market development along the River (green bioenergy belt) and setting the stage for increased use of Danube logistics in the bioenergy sector. This will be achieved through a transnational market study compendium including biomass flows and sustainability aspects

(macro-perspective), business landscape mapping, case studies and identification of best practice locations for bioenergy value chain integration (micro-perspective).

This deliverable "D 3.1.1 Compendium of national market study reports" is mainly based on the activity as described in the latest approved version of the Application Form of the project ENERGY BARGE (Project Code: DTP1-175-3.2).

- *A3.1-Overview of the bioenergy market and value chains situation (lead: BCG)*

Activity 3.1 analyses the bioenergy market and related value chains' situation in PP countries as well as from a transnational perspective, including sustainability aspects. It aims at identifying regional strengths, weaknesses and potential for improved energy supply and security via increased bioenergy usage in the Danube region. It is focusing on the macro-economic dependencies within the partner countries and aims at drawing conclusions on transnational level for the biomass and bioenergy market in the Danube region. Moreover, it mainly serves as a theoretical basis for the other thematic work packages as well as for the Outputs developed in Workpackage 3. A validation of these outputs, mainly Output 3.1, the biomass and bioenergy atlas, will take place during the workshops organized during the expert delegation programme.

Deliverable 3.1.1 (together with D.3.1.2 and D.3.1.3) forms the first part of theoretic and data-related input for Output 3.1, the biomass and bioenergy ICT Tool. This means that the results gained from D.3.1.1. will be used to fill the ICT tool with content.

An overall visualization of the relation of Work Package 3 and its activities is presented in the figure below:

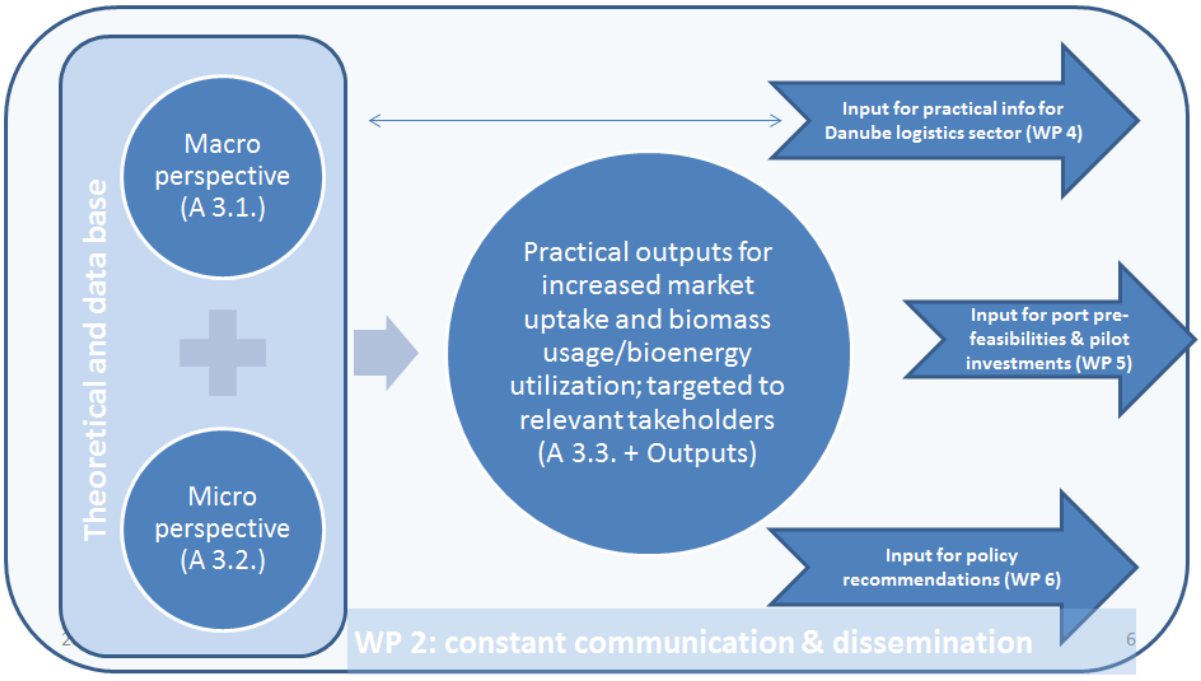

Figure 2: Role of WP 3 in the entire project (own visualization)

2. Introduction to biomass and bioenergy markets in the Danube region

In the EU Strategy for the Danube Region (EUSDR) (European Commission, 2010), bioenergy as energy sourced from biomass is covered under Priority Area (PA) 2, Sustainable Energy. This PA's main objective is to create an integrative and sustainable energy market in a region where the situation regarding energy availability, sustainability and economic viability of energy supply is heterogeneous and poses a number of key challenges (Danube Region Strategy Energy, 2017). One of these challenges in the region is posed by the widespread dependency on fossil-based energy imports from a restricted number of export countries, which results in relatively high prices, compared to other EU-regions and insecurity of supply. With fragmented markets, partly outdated and not well-connected energy infrastructures and a high percentage of high-pollutant fuels such as coal, the overall picture does currently not add to what the EU2020 (RED/28/2009)(European Commission, 2009) goals aim to achieve for energy, climate and resources. Consequently, the EUSDR sets out for a greater diversity of supply, energy security and efficiency, sustainability and market integration as well as a stable investment environment. To achieve this, renewable energy sources (RES), and particularly those based on biomass, provide theoretical, technical and sustainable potentials which remain to be not fully tapped and which depict the central element of the ENERGY BARGE project.

According to the National Renewable Energy Action Plans (NREAP) all EU member states developed specific national targets for the shares of different RES types in the energy mix (sectors electricity, heating/ cooling and transport) are set out, alongside with strategies, support schemes and guidelines how to reach these targets and monitoring mechanisms through progress reports (European Commission, 2017). In 2012, according to the EU's Joint Research Centre (JRC), the bioenergy consumption in all Danube region countries added up to 1,317 PJ (approx. 9 GJ/capita), making up 64% of the entire RES consumption in these countries (see Figure 3).

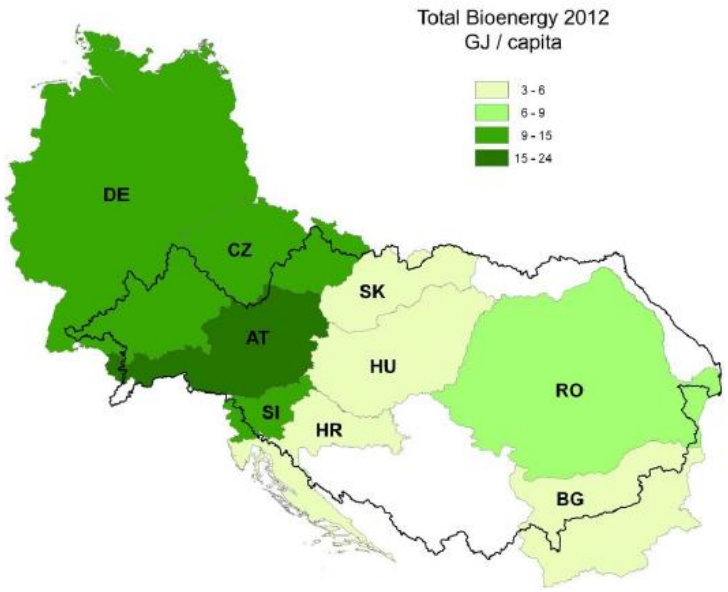

Figure 3: Total bioenergy consumption in the Danube region per Capita, 2012 (JRC, 2014).

However, the biggest contributors to these numbers were Germany and Austria. According to the latest progress report by the EU commission, most EU Danube countries are on a good way to meet their binding NREAP targets (European Commission, 2017). In 2020, the total bioenergy consumption is expected to amount to 1,661 PJ for the entire Danube Region (JRC, 2014).

At current state, for the entire Danube region, the heating sector is the predominating demand sector for bioenergy, followed by an increasingly stronger electricity sector and a slowly

developing transport fuels/liquids sector. Regarding the types of energy carriers used in the sectors, solid biomass is predominating, making up between 80 and 90% of the entire biomass use in the Danube countries, followed by biogas (from agricultural materials and residues) and bio liquids, mostly used for transport fuels (European Commission, 2017; JRC, 2017).

Especially for energy from solid and gaseous biomass, but also for bio liquids, the Danube region offers potential, with significant amounts still unused due to a number of reasons from the regulatory, market-oriented and technological realms. By increasing the sustainable utilization of non-food biomass for energy purposes, positive implications for the climate, economic growth and job creation in rural areas can be reached (4Biomass, 2016). This potential was also recognized by the EUSDR, resulting in the set-up of the Danube Region Biomass Action Plan (Danube Region Strategy Energy, 2017).

Despite the development of NREAPs and considerable increases of shares of energy from biomass in the total energy consumption, national bioenergy markets especially in a number of Danube countries, remain fragmented. Moreover, the non-food biomass that could be sustainably sourced and utilized for both material and energy purposes has a much higher potential in many Central European and Danube regions and countries than is currently being used (4Biomass, 2016), the reasons being diverse. Each country faces similar challenges regarding increased market uptake such as lacking economic viability and competitiveness, logistical barriers, swings in support mechanism, societal acceptance, market actor reluctance and fragmentation, and the like, with factors weighing in to different extent. Moreover, market actors along the value and supply chain often lack sufficient information about the overall market situation, additionally, data availability and reliability is heterogeneous. In such a situation, it is complicated to design targeted recommendations for a better integrated bioenergy market in the Danube region and to exploit the potential which has been identified by a number of research projects, e.g. via improved logistics solutions and biomass and bioenergy hubs as laid out in the Green Energy and Chemistry Belt. Therefore, this deliverable aims at identifying the biomass and bioenergy market status quo on national level in the ENERGY BARGE partner countries.

3. Objectives and structure of the deliverable

In a first step to gain a holistic overview on the status quo of the biomass and bioenergy markets along the Danube and in the involved partner countries, the project partners will compile seven national market study reports based on a common framework including methodology, underlying definitions, scope and references. The framework for the reports will build on, but go beyond the NREAPs by considering several aspects of the domestic and cross-border supply and demand situation, development potential, stakeholders involved, factors influencing market uptake and a specific view on the most promising biomass feedstock, intermediary, and final bioenergy products also suitable for inland waterway navigation and their respective supply chains.

In this delivery document, the reports are a) compiled by the partners and b) systematically merged in a compendium. A summary focusing on the transnational market and supply chain situation considering the national specialization areas, especially regarding feedstock production and theoretical potential, relevant aspects for increased market uptake, also via the integration of Danube waterway navigation (e.g. spatial disparities, synergy potential for

transnational cooperation, etc.) is given. Eventually, transnational conclusions tailored for the respective target groups as well as for the needs of the subsequent ENERGY BARGE work packages and Output generation (Output 3.1., 3.2) are drawn – these include aspects of data availability and reliability as well as content-related aspects. The final analysis of the national market studies is done in Output 3.1., the Danube biomass and bioenergy atlas ICT tool.

3.1 Target groups

The target groups of WP 3 are tailored towards the involvement of both actors from the national and EU wide bioenergy and bio-based industries sectors as well as from the Danube logistics side. Within this twofold realm, WP 3 aims to deliver input for an increased bioenergy uptake in the Danube region for: regional as well as national and transnational public authorities and policy makers, interest groups and associations, as well as SMEs and bigger enterprises. Deliverable 3.1.1 mainly feeds into Output 3.1., the biomass and bioenergy atlas ICT tool. It shall be usable for private business actors from the biomass, bioenergy and Danube logistics sectors, as well as for public regional and national authorities dealing with regional, energy and transport planning.

3.2 Common market study report framework

As seven Danube region countries' biomass and bioenergy markets are under review, a common framework for all reports is laid down to allow drawing conclusions in the summarizing compendium. The aim of the framework and its components as described below is to reach a consistent collection of the market situation in all partner countries by focussing on specific aspects of the market situation and market potential.

3.2.1 Underlying perspectives and scope

The compendium of national market study reports within WP3 aims at delivering a comprehensive overview of the bioenergy market and supply chain situation in all seven partner countries but also the Danube region as a whole. As a result, potentials, hurdles, and levers for market uptake measures involving the contribution of Danube logistics and ports shall be identified. The bioenergy sectors as well as their upstream segments in terms of biomass feedstock per se are complex and heterogeneous. Moreover, the market situation, both in terms of feedstock availability and final deployment differs not only on national, but even on regional and local level and is depending on a multitude of technical and non-technical factors. The same accounts for national policy goals regarding bioenergy deployment (see WP 6, D.6.1.1).

Thus, in order to facilitate the project work and to allow for relevant conclusions, underlying perspectives and scope for this deliverable have to be defined.

Firstly, as the market comprises both supply and demand side, a supply chain perspective shall be applied, as depicted in Figure 4.

Figure 4: Simplified biomass and bioenergy value chain (own visualization)

This perspective also lays down the scope of directly involved market actors or stakeholders to be considered in the national market reports, namely suppliers, processors, traders, end users and the respective logistics players.

In order to gain a holistic overview, this perspective shall in a first step (national fact sheets) be applied to all three bioenergy market segments:

- Electricity
- Heating and cooling
- Transport

The same accounts for the corresponding biomass feedstock types – all potential feedstock types present and utilized in the respective countries shall be assessed in broad strokes. The feedstock sources under review include:

- Biomass from forestry and wood industry (primary & residues)
- Biomass from agriculture (primary & residues)
- Biomass waste, residue and by-products outside forestry & agriculture

As ENERGY BARGE aims at enhancing the deployment of bioenergy in the Danube region by improving feedstock supply and availability through improved transport and logistics conditions for biomass, intermediaries and bioenergy products, the markets assessed have to be at least theoretically suitable for inland waterway transport, both in terms of physical properties (homogeneity/bulk character, density, specific weight, moisture content, etc.) as well as in terms of economic viability. Therefore, due to its regional, decentral character and unsuitable physical conditions, biogas and its upstream feedstock, including manure and sewage sludge are excluded.

Thus, based on the factsheets, in a second step, the most promising bioenergy products and their respective feedstocks shall be identified and be further analysed in the market study reports.

The geographical scope of assessment for the single country reports within this deliverable shall be the national level, in order to ensure comparability and a comprehensive picture of the market situation. This also accounts for Germany, although only two Bundesländer are included in the DTP area. In the country reports, special attention is ideally – depending on data availability – given to regional biomass potential, bearing in mind the proximity to the Danube river basin and port locations in particular.

3.2.2 Market study framework design

The compendium aims at providing a comprehensive overview on the biomass and bioenergy market situation in the Danube region. The base for this is given by seven market study reports all consisting of two elements:

- Country fact sheet (mainly quantitative)
- Country report (mainly qualitative)

The fact sheets (entire fact sheets available in the annex, reports only include parts) provide information on macroeconomic data on a general level, national bioenergy deployment, and biomass potential therein. In order to allow for conclusions regarding development potential,

the fact sheets, for these criteria, aim to assess – wherever data availability allows – both data from the past (reference year: 2010) and the current status, based on the most recent data available.

Moreover, the fact sheets give an overview on the biomass / bioenergy supply and demand situation in the respective country and the most promising deployment sectors. Based on this analysis and a set of selection criteria, the country's most promising biomass feedstock and resulting bioenergy products shall be identified. This way, it becomes possible to identify the respective country's strengths and future potential regarding biomass supply for bioenergy generation and thus possibilities for further specialization and opportunities to trade. Moreover, it becomes possible to identify regions especially qualified for feedstock production and/or bioenergy deployment. The qualitative selection criteria, which have partly been drawn from other relevant EU projects and partly are tailored to suit the needs of ENERGY BARGE's further WPs that build on WP3's results, are:

- Important role or future potential of biomass type in NREAP or other national official document
- Important role or future potential of bioenergy product(s) in NREAP or other official national document
- Important role or future potential of bioenergy deployment sector(s) in NREAP or other national official document
- Sufficient overall and sustainable supply quantities of biomass feedstock type
- Sufficient overall supply quantities of bioenergy product
- Established, economically viable conversion technology
- Feedstock quality / properties suitable for inland waterway transport logistics
- Established, reliable market
- Good availability of data and market information
- Potential for cascading/chemical-material use of the feedstock

The selected types then are reviewed in more detail in the country market report regarding the technical and sustainable potential, supply chain situation, infrastructure and logistics (current situation, properties), market actors involved, economic viability and factors influencing market uptake resulting in market profiles for these bioenergy feedstock and product sectors.

Each market report also includes a brief summary of the country's overall biomass and bioenergy market size and growth, framework conditions (technical and non-technical, incl. brief political context and support schemes), qualitative stakeholder and SWOT analysis as well as a summarizing qualitative assessment of the potential for improved availability through increased inland waterway transport. The political and regulatory framework conditions are analysed at length in WP 6, D.6.1.1.

3.2.3 Methodology

The compilation of the national market reports was executed by the responsible project partners for their respective country and was mainly based on desk research, data and knowledge available in the partners' own institutions and, where needed, on national experts, e.g. chambers of commerce or associations, to be identified by the partners themselves. Moreover, the partners were asked to involve their national networks, the other project

partners, the project's stakeholders list as well as their ASPs, if applicable and relevant. Utilization of information from these sources was duly documented.

A number of EU-funded projects and initiatives focussing on different aspects of sustainable biomass potentials and supply for the bio-based economy in general and bio-based energy in particular have been executed in the recent years. The geographical coverage of these projects differs. Except for the Danube Region Biomass Action Plan (Danube Region Strategy Energy, 2014), which is a document commissioned by the Sustainable Energy Priority Area within the Danube Region Strategy and the Danube Renewable Energy Information Tool as a JRC service (JRC, 2017), none of the projects focus primarily and solely on the macroregion Danube area. ENERGY BARGE thus aims for a stringent capitalization strategy by building on these projects' and initiatives results and to develop them further towards ENERGY BARGE's project-specific aims, creating added value for the Danube region. The projects most relevant for WP 3 include:

- 4Biomass[1]
- Biomass Futures[2]
- Biomass Policies[3]
- BiomassTradeCentreII[4]
- BioPad[5]
- BioRes[6]
- BioTrade2020plus[7]
- Danube Bioenergy Nexus (JRC)[8]
- EU BEE – Biomass Energy Europe[9]
- EuBioNetI-III[10]
- LogistEC [11]
- S2Biom[12]
- SeemLa[13]

The fact that data availability, consistency and reliability, especially in terms of energy-dedicated biomass feedstocks and demand side, has still not significantly improved in general terms and is very heterogeneous between the different countries which has been identified by numerous EU-funded projects (e.g. EU BEE – Biomass Energy Europe, 4Biomass, S2Biom), has also implications on the results of the ENERGY BARGE national market studies. By providing a stringent methodology, a list of potential reliable data sources (JRC; EuroStat, EurObserver,

[1] 4Biomass project, http://www.4biomass.eu/en/project (last access: 15.5.2017)
[2] BiomassFutures project, http://www.biomassfutures.eu/(last access: 15.5.2017)
[3] BiomassPolicies project, http://www.biomasspolicies.eu/ (last access: 15.5.2017)
[4] BiomassTradecentresII project, http://www.biomasstradecentre2.eu/about/ (last access: 15.5.2017)
5 Bioenergy Proliferation and Deployment project, http://www.biopad.eu/biscuit/ (last access: 15.5.2017)
6 BioRes Sustainable Regional Supply Chains for Woody Bioenergy project, http://bioresproject.eu/ (last access: 15.5.2017)
[7] BioTrade2020plus project, http://www.biotrade2020plus.eu/activities/biomass-potentials.html (last access: 15.5.2017)
[8] Danube Bioenergy Nexus, https://ec.europa.eu/jrc/sites/jrcsh/files/jrc-danube-bioenergy-nexus.pdf (last access: 15.5.2017)
[9] Biomass Energy Europe project, http://www.eu-bee.eu/ (last access: 15.5.2017)
[10] EuBioNet3 project, http://eubionet.net/default.asp?SivuID=25343 (last access: 15.5.2017)
[11] Improving Logistics for Energy Crops project, http://www.logistecproject.eu/ (last access: 15.5.2017)
[12] S2Biom project, http://s2biom.alterra.wur.nl/ (last access: 15.5.2017)
[13] SeemLa project, http://www.seemla.eu/en/ (last access: 15.5.2017)

IRENA, IEA, DG Energy, Worldbank, Aebiom), at least a commonly usable basic data groundwork should be achievable. A nuanced analysis of the actual data disparity is given in chapter 6.

4. Compendium of market study reports

The following seven market study reports, comprising of a fact sheet and a report section, give an overview on the market situation on national level in the Danube riparian countries regarding bioenergy and bioenergy feedstock (biomass), as defined in the common framework. Wherever possible and sustainably sensible, a first connection to potentials for port involvement and options for inland waterway transport was drawn. Regarding the fact sheets, selected extracts on the most market-relevant national indicators have been implemented in the text body based on the data availability[14].

4.1. *Austria*

The total primary energy supply of Austria in 2014 amounted to 1,342 Petajoule (PJ) with fossil fuels (oil, gas, coal) still contributing most. Renewable energy sources have a share of 32.8% or 441 PJ. Oil products account for a third of the energy supply (474 PJ), coal products (127 PJ) and natural gas are contributing to another third (267 PJ). Electricity as a source has a share of merely 2.5% or 33 PJ. The total primary energy supply of renewable energy sources comprises energy from biomass with 61%, followed by hydropower with 33.0%, solar and wind energy together with 6% and geothermal power with 0.3% (IEA Bioenergy Countries Report, 2017). According to the NREAP, Austria has committed to a target of 34% share of renewable energy in gross final energy consumption in 2020 (NREAP-AT, 2010). In 2015, the share already reached 32.8% (Statistics Austria, 2016).

The major part (84%) of bioenergy consumed in Austria is composed of solid biofuels. Solid biofuels include firewood, wood chips, bark and sawmill by-products. Firewood is the most important biogenic source of energy in Austria with a share of 25% of total bioenergy consumed. Wood chips, bark and sawmill by-products together contribute a share of 37%. Wood chips and sawmill by-products are primarily used for energy production in forest based industries, as well as in cogeneration and district heating plants. Pellets are mainly used in domestic heating systems. Waste lye, sludge and bark are used for the production of electricity and process heat in the pulp and paper industry. The supply of bioenergy in Austria more than doubled from 1990 to 2014. In 1990 bioenergy almost entirely originated from solid biomass and accounted for 97 PJ. In 2014 solid biomass contributed 209 PJ, liquid biofuels 20 PJ and gaseous 12 PJ. The share in total final energy consumption increased from 1990 (9.3%) to 2014 (17.9%). The sharpest rise in consumption occurred between 2005 and 2010, when the use of solid biomass increased and liquid biofuels were established on the market (IEA Bioenergy Countries Report, 2017). In 2016, the consumption of solid biomass including agricultural biomass amounted to 180.75 PJ in Austria (Biermayr et al., 2017).

4.1.1 Country Fact Sheet Austria

The Austrian country fact sheet on the biomass and bioenergy market gives an overview of available data on macro-economic indicators relevant for the national market and transnational comparison. Its main goal is to identify the most promising feedstock types available in Austria for utilization in the bioeconomy, mainly as bioenergy feedstock.

[14] The full excel file can be found in attachment.

COUNTRY: Austria			
Indicator	**Data 2010**	**Latest data (indicate year)**	**Measure**
Macro Data:			
Inhabitants	8,363	8,629 (2015)	Mio people
GDP per capita	35,240	39,990 (2016)	€
Total land area	83,879		km^2
Share of agriculture+ forestry in gross national value added	3.76	3.94 (2016)	%
Share of energy sector in GDP (incl. waste treatment and water supply)	7.97	7.51 (2016)	%
Energy dependency rate	59.7	62.8 (2016)	%
Danube Indicators:			
Navigable length Danube stretch	250		km
Number of Danube ports	4 public ones		
Land Use, Biomass Feedstock and Energy Indicators:			
Total arable land	6,285,646	6,313,908	ha
Area utilized for agriculture (includes energy crops)	2,879,895	2,720,372 (2015)	ha
Area utilized for forestry	3,405,750	3,427,510 (2015)	ha
Area used for cultivation of energy crops	924	1,149 (2015)	ha
Fallow land	36,683 (excl. Grassland)	166,026 (incl. Grassland)	ha
Theoretical biomass potential	1,220	1,183 (projection for 2020)	PJ
Technical biomass potential	488	451 (projection for 2020)	PJ
Sustainable/Economic potential		295.9	PJ
Unexploited biomass potential	244	244 (projection for 2020)	PJ
Type/Source of biomass feedstock with highest potential for bioenergy purposes	woody biomass		
Type/Source of biomass feedstock with highest current use for bioenergy purposes	wood chips		

Contribution of this feedstock type to domestic biomass supply for bioenergy production	1,770	1,949 (2016)	ktoe
Annual imports of biomass for energy conversion purposes		2.7 Mio. (2014)	m^3
Employment in Biomass sectors	13,302	17,486 (2016)	Direct employment, FTE
Main domestic primary source of energy (e.g. coal, renewables):	Bioenergy	Bioenergy (2015)	
Main domestic sector of bioenergy (e.g. biofuels for transport, heating, electricity)	Heating	Heating	

Biomass feedstock types - national supply situation					
Origin/Sector	**Feedstock**	**Potential for growth: yes/no**	**Quantities / Availability (t, m^3, etc.)**	**Comment**	**Bioenergy Product/Intermediary (solid, liquid)**
Forestry & Wood industry:					
Wood production and primary wood residues	wood chips		9 Mio - 12 Mio atro-t/a		wood chips
	firewood				Firewood
	(wood pellets, sawmill-by-products)				
Secondary residues from wood industry (e.g. saw mills)	wood chips		25,696 – 48,760 atro-t/a		wood chips and pellets
	bark				
	sawdust				
Agriculture:					
Oilseeds (primary production & residues)	none with significance				
Sugar & Starch crops (primary production & residues)	none with significance				
Dedicated energy crops/lignocellulosic biomass on agricultural land	Miscanthus		16,086 atro-t/a		Briquettes, Pellets
Any other type of agricultural bioenergy feedstock, e.g. residues from industries using agricultural products	Straw		100,000 atro-t/a		Pellets
	Corn cobs		50,000 atro-t/a		

Waste & Residue material outside of agricultural and forestry sectors:	none with significance				
Other:	none with significance				

Most promising value chains:	
Feedstock type(s):	Forest residues
	Sawmill by-products
	Waste (sewage sludge)
	Short rotation forestry
Bioenergy product(s):	Wood chips
	Pellets
	Briquettes
Deployment sector(s):	High temperature applications
	Co-firing (torrefication)
	Micro-grids

4.1.2 Country Report Austria

The share of renewable energy in Austria's gross domestic consumption has risen significantly since the nineteen-seventies. In 1970 the share of renewable energy in gross domestic consumption was 15.5%, in 2015 the share increased to 29.2%. However, this corresponds to a decline of 0.9% compared to 2014. The share of bioenergy within the renewable energies has also risen from 38% in 1970 to 58.6% in 2015. This figure has also increased compared to 2014 (56.8%). Bioenergy includes solid biofuels, biogas, landfill gas, biodiesel, sewage sludge, waste, animal flour and fat. However, woody biomass is the main feedstock for bioenergy (Biermayr et al., 2017).

The energetic utilization of solid biomass has a long tradition in Austria and is still a very important factor within the renewable energy sector. The consumption of final energy from solid biofuels increased from 142 PJ in 2007 to 179 PJ in 2013. In 2014 the consumption of solid biofuels decreased to 150 PJ due to relatively high average temperatures. In 2016, the consumption of solid biofuels increased again to 179.7 PJ (Figure 5: Market development of different biomass fuel types from 2007 to 2016 in Austria. (Source: BIOENERGY 2020+ in Biermayr et al. 2017). The consumption of wood chips has been increasing since the beginning of the 1980s. In 2016 the wood chips consumption was 81.6 PJ and thus exceeds the consumption of wood logs with 69.2 PJ. The very well documented wood pellet market developed with an annual growth rate between 30 and 40% until 2006. This development was then stopped 2006 due to a supply shortage which resulted in a substantive price rise. But meanwhile the production capacity of 28 Austria pellet manufacturers has been extended to 1.45 million t/a and this resulted in a market recovery. In 2016 the national pellet consumption increased by 6% compared to the previous year. The Austrian pellet production was around 15.3 PJ (900,000 t) in 2016 (Biermayr et al., 2017).

Fuels from solid biomass contributed to a CO_2 reduction of about 9.8 million t in 2016. The whole sector of solid biofuels made a total turnover of 1,467 billion €, thus creating 17,486 jobs (Biermayr et al., 2017).

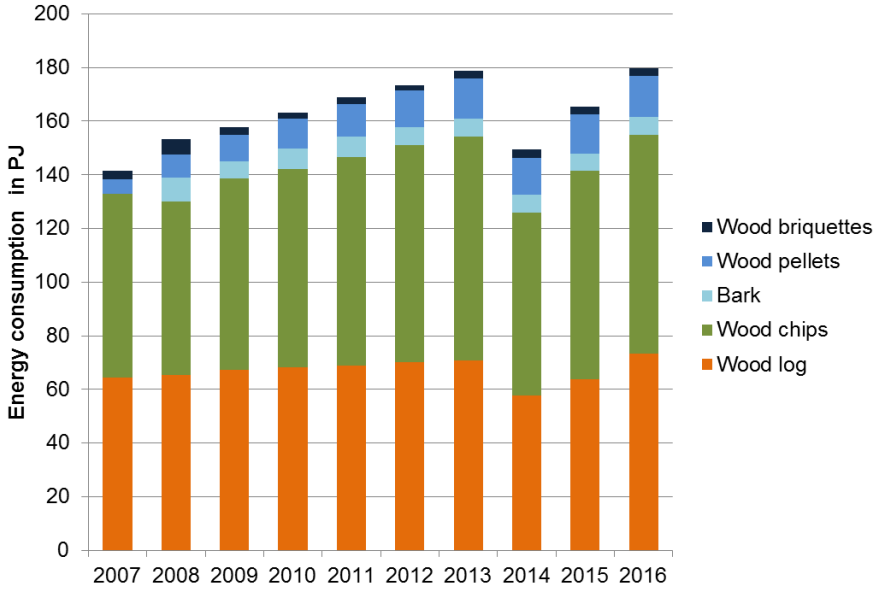

Figure 5: Market development of different biomass fuel types from 2007 to 2016 in Austria. (Source: BIOENERGY 2020+ in Biermayr et al. 2017)

According to the NREAP, Austria has committed to a target of 34% share of renewable energy in gross final energy consumption in 2020 (NREAP-AT, 2010). In 2015, the share already reached 32.8% (Statistics Austria, 2016). Furthermore, in the National Action Plan for Renewable Energy binding figures for the development of solid biomass in Austria can be found: For the year 2020 a share of 3.56 Mtoe (= 150 PJ) is indicated. This represents an increase of 5% compared to 2010. However, in 2016 the biomass consumption already increased to 180.75 PJ (including agricultural biomass) (= 4.317 Mtoe). Thus, the share of solid biomass in the final energy consumption, as defined in the NREAP, was already exceeded in 2016. However, political efforts are still needed to finally achieve a successful transition from a fossil to a renewable energy system (Biermayr et al., 2017). Table 1 and Table 2 show a SWOT analysis for the woody and agricultural biomass as well as the bioenergy market.

Table 1: SWOT Analysis for woody and agricultural biomass in Austria

	Woody biomass and wood residues	**Agricultural biomass**
Strengths	• Sustainable Forestry • Know-how regarding production and harvest • Different types and qualities of solid biofuel like pellets and wood chips are available • Well developed supply chains	• Sustainable production • Residues are not competing with food production • Degree of organization of farmers • Regional supply chains possible
Weaknesses	• Ownership structure of the forest (many owners of small-scale forest areas)	• Legal uncertainties regarding the use as fuel • Missing standardization

	• Linkage between energy wood, pellets, sawmill by-products and the sawmill industry which is related to the economic development • Low contribution margin for firewood and wood chips /energy wood	• Fuel characteristics • Supply chains (regarding harvest and processing)
Opportunities	• Unused potential in the forest of small-scale forest owners • Cascading use • High fossil fuel prices • International pellet market • Climate change	• Additional income for farmers • Fast growing plants/crops • Option for farmers who want to quit the livestock breeding • High fossil fuel prices • Climate change
Threats	• Increasing damages • Discussion about material vs. energetic use • Declining investments • Oversupply of fossil fuels	• Discussion about animal feed versus fuel • Discussion food versus fuel • Sustainability criteria

Table 2: SWOT Analysis for the bioenergy market in Austria

	Technology (Residential and Communal)	**Market**	**Policy**
Strengths	• State-of-art technologies for all sizes are available	• Good developed market. For instance more than 120,000 pellet boilers for residential heating are installed • Incentives are available	• Support from policy for biomass is available • New international regulations for thermal treated biomass are available • New European regulations for combustion are available
Weaknesses	• Higher investment costs systems relative to fossil systems	• Heat demand for modern buildings is low	
Opportunities	• Sophisticated control systems for the whole heating system and not only for the boiler will allow higher seasonal efficiency and lower emissions • Secondary measures especially for	• Jobs can be created from the sale, engineering, installation, operation and maintenance of the technology • Industries with high energy demand on a high temperature level	• The replacement of fossil systems will contribute to the reduction of greenhouse gases • Inspection requirements on a regular basis will improve the performance of biomass heating systems

	systems using non-woody biofuels could significantly reduce emissions		
Threats	• Heat pumps are more and more attractive for houses with low energy demand for heating	• Investment costs are high • Low oil price	• Regulations for efficiency and emissions are becoming more and more stricter, this could lead to a ban of biomass systems • Other renewable energies like PV and wind power seems more attractive

Austria has established a comprehensive legislative and administrative framework regulating and facilitating sustainable development of renewable energies. This framework is supported by various financial, fiscal, research and promotional measures and incentives. A detailed description of all fiscal and non-fiscal supports for bioenergy development is available at: http://www.iea.org/policiesandmeasures/renewableenergy/?country=Austria. Furthermore, the deliverable 3.1 of the IEE "Biomass Policies" project provides an overview of policy Landscapes for the selected biomass value chains in Austria (http://www.biomasspolicies.eu/). The most important policies in the field of bioenergy are also summarized in Deliverable 6.1.1 of this project.

Since the energetic utilization of solid biomass has a long tradition in Austria, many boiler and stove producers are located in Austria (Table 3). Furthermore, there are several Austrian wood shredder and firewood technology companies (Table 4). The Austrian pellet producers are listed in Table 5. In addition, 2,108 heating plants with a total capacity of 1,860 MW produce 4,650 GWh heat per year. The 111 CHPs with a total capacity of 313MWel produce 2,128GWh power per year and 4,457GWh heat per year. Furthermore, there are 300 biogas plants and 22 wood gas CHPs in Austria.

Table 3: Boiler and stove producers in Austria. Source: ÖBMV- Austrian Biomass Association "Bioenergie Atlas Österreich" 2017

Boiler and stove producers	Location	Firewood boilers	Wood chip boilers	Pellet boilers	Stoves	Large-scale plants (>500kW)	Wood gas-CHP plants
Agro Forst & Energietechnik GmbH	9470 St. Pail i. L.				•		
Andritz Energy & Environment GmbH (AE&E)	8074 Raaba				•		
Austroflamm GmbH	4631 Krenglbach			•			
BERTSCHenergy Josef Bertsch GmbH & Co. KG	6700 Bludenz				•		
Billensteiner GmbH	3150 Wilhelmsburg			•			
Binder Energietechnik GmbH	8572 Bärnbach		•	•	•		
Biokompakt Heiztechnik GmbH	4391 Waldhausen	•	•	•			
Biotech Energietechnik GmbH	5300 Hallwang			•			
Bösch KG	6890 Lustenau	•		•			
Buderus Austria Heiztechnik-GesmbH	4600 Wels			•			
calimax Entwickl. u. Vertr. GmbH	6830 Rankweil			•			
Christof Holding AG	8051 Graz					•	
Dumag Brennertechnologie GmbH	1037 Wien				•		
Anton Eder GmbH	5733 Bramberg	•		•	•		
Enickl Friedrich, Ing., „Tropenglut"	4407 Dietach		•		•		
En-Tech Energietechnikproduktion GmbH	9300 St. Veit/Glan			•	•		
ETA Heiztechnik GmbH	4716 Hofkirchen/Trattnach	•	•	•			
Evotherm Heiztechnik Vertriebs GmbH	5121 Tarsdorf		•	•			
Fröling Heizkessel-u. Behälterbau GesmbH	4710 Grieskirchen	•	•	•	•	•	
Gast Herd- und Metallwarenfabrik	4407 Steyr	•			•		
Gebe GmbH	1140 Wien	•	•	•	•		
Gilles Heiz-und Energiesysteme GmbH	4810 Gmunden		•	•	•		
Guntamatic Heiztechnik GmbH	4722 Peuerbach	•	•	•	•		
Haas+Sohn Ofentechnik GmbH	5412 Puch			•	•		
Hallach GmbH	3040 Neulengbach				•		
Hargassner GmbH	4952 Weng	•	•	•		•	
Herz Energietechnik GmbH	7423 Pinkafeld	•	•	•	•		
Hoval Gesellschaft m.b.H.	4614 Marchtrenk	•		•			
Integral Engineering und Umwelttechnik GmbH	2544 Achau				•		
Kesselbau Sutterlüty GmbH	6971 Hard a. Bodensee				•		
KÖB Holzfeuerungen GmbH	6922 Wolfurt	•	•		•		
Kohlbach Energieanlagen GmbH	9400 Wolfsberg				•		
Kurri Ges.m.b.H.	2700 Wiener Neustadt		•	•			
KWB – Kraft und Wärme aus Biomasse GmbH	8321 St. Margarethen/Raab	•	•	•			
Lignotherm Heizsysteme GmbH	9852 Trebesing	•	•	•			
Lohberger HeizEtKochgeräte Technologie GmbH	5231 Schalchen	•			•		
Lohberger Heiztechnik GmbH	5231 Schalchen	•		•	•		
Mawera Holzfeuerungsanlagen GesmbH	6971 Hard a. Bodensee		•				
NTH-Heiztechnik GMBH	3385 Prinzersdorf	•		•	•		
ÖkoFEN Forschungs- u. Entwicklungs GesmbH	4133 Niederkappel			•			
Olymp OEM Werke GmbH	6430 Ötztal-Bahnhof	•		•	•		
Perhofer GmbH	8190 Birkfeld	•	•	•	•		
Pöllinger Heizungstechnik GmbH	3385 Gerersdorf		•	•			
Polytechnik Luft- u. Feuerungstechnik GmbH	2564 Weissenbach		•	•			
RIKA Innovative Ofentechnik GmbH	4563 Micheldorf				•		
Schmid energy solutions GmbH	8501 Lieboch	•	•	•			
Solarfocus GmbH	4451 St. Ulrich/Steyr	•	•	•	•	•	
Sommerauer & Lindner - Technik-GmbH	5120 St. Pantaleon		•	•			
Strebelwerk GmbH	2700 Wiener Neustadt	•	•	•			
SynCraft Engineering GmbH	6130 Schwaz				•		
Thermostrom Energietechnik GesmbH	4407 Steyr-Dietachdorf	•	•	•		•	
Thöni Industriebetriebe GmbH	6410 Telfs				•		
TM Feuerungstechnik GmbH	8271 Bad Waltersdorf		•		•		
Urbas Maschinenfabrik GesmbH	9100 Völkermarkt				•	•	
VAS Energy Systems GmbH	5071 Wals-Siezenheim				•		
Windhager Zentralheizung GmbH	5201 Seekirchen/Wallersee	•		•			
Wolf Klimatechnik Vertriebs GmbH	4034 Linz	•		•			
WTI Wärmetechnische Industrieanlagen GmbH	3380 Pöchlarn				•		

Table 4:Wood shredder and firewood technology companies. Source: ÖBMV- Austrian Biomass Association "Bioenergie Atlas Österreich" 2017

Auer Landmaschinenbau Gesellschaft m.b.H., 4202 Hellmonsödt
Binderberger Maschinenbau GmbH, 5144 St. Georgen a. F.
Eschlböck Maschinenfabrik GmbH, 4731 Prambachkirchen
Heizomat GmbH, 5310 Mondsee
Jenz Österreich GmbH, 3072 Kasten
Komptech GmbH, 8130 Frohnleiten
Lasco Heutechnik GmbH, 5221 Lochen am See
Lindner Wood Shredders GmbH, 9800 Spittal a. d. Drau
MUS-MAX GmbH, 8522 Groß St. Florian
Neuson Ecotec GmbH, 4053 Haid
ÖKO-Recycling Bioabfallbehandlung-Maschinenhandel GmbH, 3434 Tulbing
Posch GmbH, 8430 Leibnitz/Kaindorf
Technisches Büro für Forstwirtschaft Renner, 4723 Natternbach
Vermeer AG – Niederlassung Grein, 4360 Grein
Westtech Maschinenbau GmbH, 4731 Prambachkirchen

Market profile: Analysis of most promising biomass/bioenergy supply chain

For a long time the use of firewood dominated the biomass market. The use of biogenic fuels (e.g. wood chips, sawmill by-products, pellets, biofuels and biogas) has become increasingly important in recent years and has gained in importance due to strong market growth. However, the use of firewood has remained relatively stable.

The forest is and remains the most important raw material source for the biomass sector. Austria currently has historically high timber stocks: Since 1970 the amount of wood in Austria's forests has grown by about 45%. This means, there is still less wood used than growing up (BMLFUW, 2015).

In Austria, forest land has increased for decades. It covers about 4 million hectares, a figure which corresponds to 47.6% of the whole Austrian territory (Figure 6) and exceeds the EU average of 42% (BMLFUW, 2015).

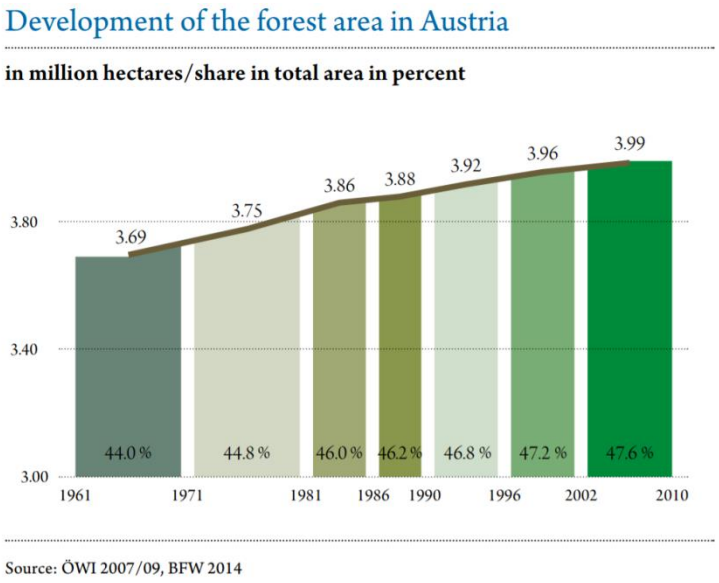

Figure 6: Development of the forest areas in Austria (Source: BMLFUW, 2015)

With 1,135 million m^3, the stocks in wood have reached a record level. With an average 354 m^3/hectare, small private forests have the largest stock of all ownership types. The increase in stocks is not only a consequence of the growth in area, but is also due to a significant increase in forests themselves (BMLFUW, 2015).

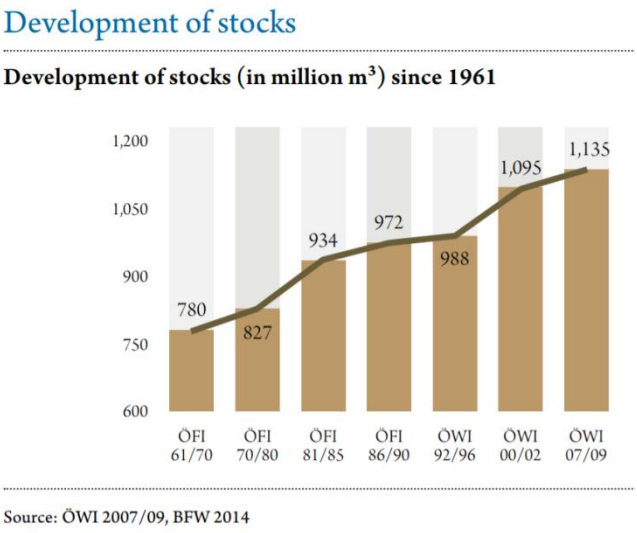

Figure 7: Development of stocks in Austria (Source: BMLFUW, 2015)

Since the first surveys of the nineteen sixties the quantity of wood consumed in Austria has always been below the increment. Presently the annual increment amounts to approximately 30.4 million cubic metres, of which 25.9 million cubic metres are utilized (BMLFUW, 2015).

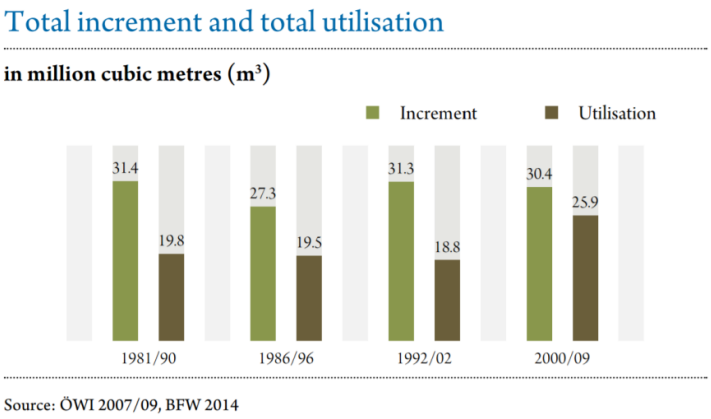

Figure 8: Total wood increment and total utilization in Austria (Source: BMLFUW, 2015)

In 2012, the forestry sector accounted only for about 1.8% of the GDP; in absolute terms the gross value added amounted to 5 billion Euro. However, with a foreign trade surplus of 3.69 billion Euro the value-added chain of forest-timber-paper is one of the most important items of Austria‘s foreign trade. About 300,000 persons draw an income from the forest- and wood-based sector. The significantly increasing mechanization and technical development of timber harvesting which has taken place since the beginning of the nineteen eighties, as well as administrative rationalization measures, have led to declining numbers of employees (BMLFUW, 2015).

Since the 1990s, wood pellets have established themselves as fuel for use in small to medium-sized biomass heating systems. The industry association proPellets Austria, in which all major pellet producers are members, regularly collects the data of the Austrian pellet industry, including industrial production capacity, pellet consumption in Austria and total production of pellets.

In Austria, wood pellets made from sawmill by-products as heating fuel were introduced to the market in the mid-1990s. Since then, the use of wood pellets for residential heating has grown rapidly with an annual growth rate between 30 and 40%. This development was stopped in 2006 due to an EU wide supply shortage arising from limiting domestic pellet production capacities. In Austria, the production capacity of at present 28 pellet manufacturers (Table 5) producing high quality pellets has been expanded from 0.61 million t per year in 2006 to 1.45 million t per year in 2016. A large amount of small to mid-sized production facilities constitute a low market concentration level (Kristöfel et al., 2016). The catchment area for pellet production is usually located within a radius of 100 km around the wood processing plant. Pellets are marketed directly from the factory or via the fuel trade and transported to the end customer via truck or as sacks of 15 kg.

Table 5: Production capacity of Austrian pellet producers in Austria and abroad in 2016. Source: ProPellets Austria in Biermayr et al. 2017

Pellet-producers	**Production capacity in Austria 2016 in t**	**Production capacity abroad 2016 in t**
Andreas Wiessbauer	2,000	
Arlberg Pellets (Holz Falch)	1,700	
Binderholz GmbH	124,000	180,000 (GER)
Cycle Energy	40,000	
FM Pellets GmbH	20,000	
Franz Eigl GmbH	25,000	
Enzlmüller	6,000	
Firestixx-Salzburg GmbH	50,000	
Glechner Ges.m.b.H.	88,000	20,000 (GER)
Hasslacher	110,000	30,000 (RO)
Holz-Bauer KG	8,000	
Johann Pabst Holzindustrie	60,000	
Kärtner Pellets- löwenstark	25,000	
Labek Biopellets	1,000	
Ländle Pellets	18,000	
Mafi Naturholzboden GmbH	7,000	
MAK Holz GmbH	30,000	
Mayr-Melnhof	75,000	80,000 (CZ)
Ökosticks GmbH	18,000	
Pellex Green Power	40,000	
Pfeifer Holz GmbH & CoKG	175,000	255,000 (GER, CZ)
PROöko Energie GmbH	1,300	
RZ Pellets	310,000	
Schmidt-Energie Produktions GmbH	20,000	
Schößwendter Holz GmbH	32,000	
Schweighofer	-	502,000 (RO)
Peter Seppele GmbH	103,000	
Sturmberger	45,000	
Weinsbergpellets	20,000	
Sum	1,455,000	1,067,000
Total	**2,522,000**	

Austrian pellet manufacturers produce mainly high quality pellets for the residential heating sector according to ÖNORM or EN 14961-2 class A1. These norms regulate ash content, sulphur, chlorine and nitrogen content and the mechanical durability such that pellets of high quality must be made of stem wood or untreated sawmill residues like sawdust and wood chips without bark in order to fulfill the requirements. Small to medium scale users obtain the high quality pellets mainly from domestic traders with national or even regional supply chains and usually store the pellet amount required for the average annual use. Public and commercial buildings as well as apartment buildings are typical medium scale users (e.g. schools, administrative buildings and multifamily houses). Typical small scale users are private households using pellets as the primary heating source in pellet boilers or pellet stoves. In contrast, heating plants and combined heat and power plants use usually sawmill by-products of lower quality like wood chips with bark and other industrial wood residues. Large scale users obtain pellets from international traders and have large on-site storage facilities (Kristöfel et al., 2016)

Currently, the Austrian pellet manufactures produce more than domestically demanded. In 2016, Austria produced about 1,070,000 t of pellets, whereas the domestic demand amounted to 900,000 t of pellets. Consequently, a considerable part of the production is exported to Italy and in the last years, larger amounts are imported from Germany, Czech Republic and Romania as well. Figure 9 gives an overview of the pellet production locations in Austria as well as the export and import quantities in the year 2015. In 2015 the total Austrian pellet production amounted to 1,000,000 t. Total export quantities amounted to 555,000 t of which 483,000 t have been exported to Italy. The largest import volume of 187,000 t were received from Romania. The total imports were 369,000 t. In Figure 9 the yellow dots indicate a production capacity of up to 20,000 t/a, the green dots a production capacity of 20,000 - 60,000 t/a and the red ones a production capacity of 60,000 to 150,000 t/a.

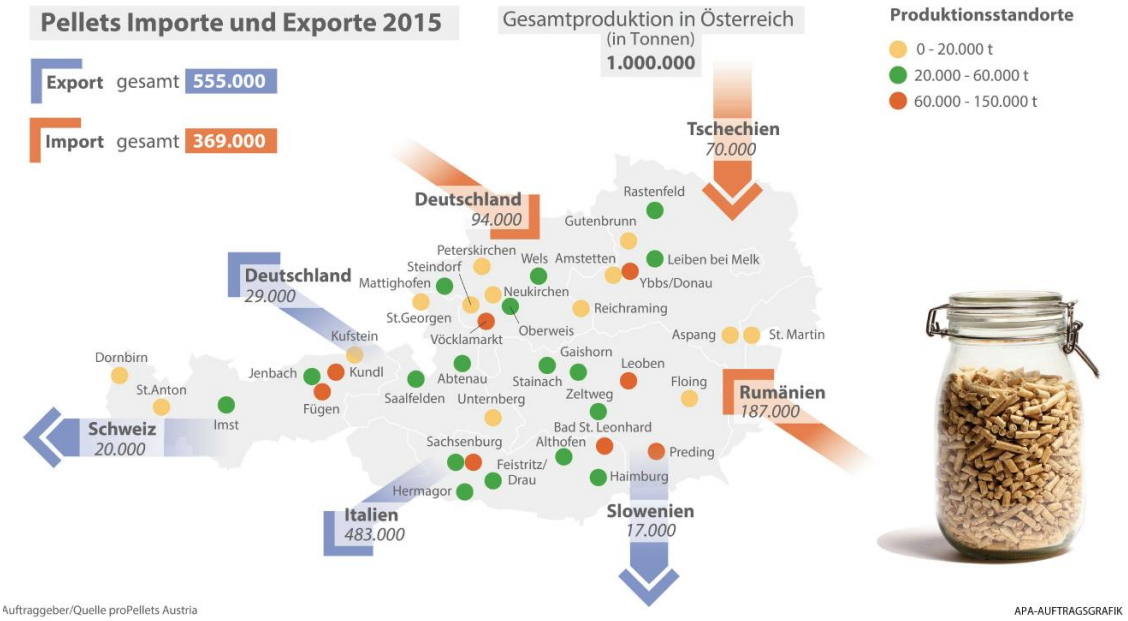

Figure 9: Production locations and trade of wood pellets 2015, (proPellets Austria, 2017)

Large quantities of industrial wood pellets are shipped from North America to Rotterdam for the use in large scale appliances. More than one third of the worldwide pellet trade is distributed via ocean transportation. These ocean vessels and bulk carriers, respectively are either used in

coastal or trans-oceanic transportation. These vessels consist out of two to eleven cargo holds, each containing between 700 to 7,600 t. During the ocean pellets transportation the pellets are protected against seawater by a tight cover and the ventilation is turned off in order to keep the pellets dry.

The Danube represents a good connection to South- and East Europe. The pellets could be transported via Rotterdam – Rhein–Main-Donau to Austrian ports. Furthermore, the way from the Black Sea to Austria grants access to a huge potential. However, transport costs are a relevant share of the pellet price. Hence, the cost-effectiveness using inland waterways has to be checked.

In recent years, wood pellets have been commonly used to substitute heating oil in the residential heating sector in Austria. Wood pellet prices have been significantly lower and incline less sharply than heating oil prices at least since 2010. Pellet prices are less volatile than fossil fuels (Kristöfel et al., 2016).

The energetic use of wood chips in various forms has already a long tradition in Austria. Wood chip boilers were the first automated heating systems for bioenergy carriers, whereby the application always focused on medium to large power ranges. For the residential heating sector there are also wood chip boilers available.

Over the past 13 years, there has been a steady market development in the wood chip sector. In 2013, around 83 PJ wood chips were consumed for energy purposed in Austria, an increase of 2.3% compared to the previous year. In 2014 the consumption of wood chips decreased to 68.3 PJ, since the months of March, April and September to November 2014 were very warm compared to the last two years. In 2015, an increase to 77.7 PJ can be observed. In 2016 wood consumption increased by almost 5% to 81.6 PJ. The production of wood chips takes place in numerous decentralized and mostly mobile systems of different sizes. After an intermediate storage, wood chips are usually transported by agricultural vehicles or trucks to the heating plant, which is often connected to the end customer via a local or district heating network. The typical catchment area of the wood chips for small district heating networks up to 2.5 MW is about 10 km (Biermayr et al., 2017). There is usually a high demand for wood chips in Austria, not only for energetic use but also from the wood processing industry (e.g. panel production).

Logs (firewood) are primarily used in small scale boilers for single-family houses. The market for firewood shows a steady growth until 2009, between 2010 and 2013 it has remained almost constant. In 2013 more than 4.9 million t of firewood were used in Austria. However, in 2014 firewood consumption decreased by about 20% to around 4 million t. In 2016, firewood consumption increased again to more than 5.1 million t. Often, firewood is harvested from private forests and are also processed and used privately. Until 2009, the sales of firewood boilers had moderate growth, but in 2010, a marked decline could be observed. In 2011 and 2012, a slight increase in sales of firewood boiler could be observed (2 and 9% respectively). In contrast, a significant decline in the sales of firewood boilers of 16.5% could be observed again in 2013. This trend continued with a 33.6% and a 9.6% drop in the number of firewood boilers in 2014 and 2015. In 2016, a further decline of 8% compared to the previous year can be observed (Biermayr et al., 2017).

In 2015, 2,336 ha of short rotation forestry and 1,149 ha of Miscanthus were cultivated in Austria. The cultivation and use of agricultural fuels is still at a low level. It has risen strongly

from 2010 to 2011 (from approx. 24,700 to approx. 27,400 t/a) and currently amounts to approx. 40,000 t / a (0.72 PJ) (Statistics Austria 2016).

Straw for energy purposes is only used in small quantities in Austria. In Lower Austria, the use of 20,000 t of straw in eight district heating plants is known for the year 2016. The energetic straw potential of Austria is also assessed as moderate in the future. According to Statistics Austria (2015), 1.9 million t of straw were recorded - but the potential for energy use is considerably lower for several reasons.

The energetic use of corn cobs in Austria is promoted by ÖNORM C 4003 "loose corn cobs - requirements and test provisions - national supplement to ÖNORM EN 14961-1 and ÖNORM EN 15234-1". In 2014, 195.252 hectares of corn cobs were cultivated in Austria (Statistics Austria 2017) - the calculated yield amounted to 2,179,587 t. The realistic potential for corn cobs is assumed to be 50,000 t (Biermayr et al., 2017).

It is assumed that, under optimal conditions, the use of energy wood in Austria could be increased by 12% or by 3 million solid cubic meters to a total of 28 million solid cubic meters by the year 2020. By 2030, the use of energy wood could be increased by 22%, or by around 5.6 million solid cubic meters, to 31 million solid cubic meters. However, this can only be achieved if the use of wood in Austria is significantly increased in terms of material and energy utilization, and rapid comprehensive measures are being taken to mobilize the potential, especially in the rural small-scale forests (Austrian Biomass Association, 2015).

In addition to raw materials from the forestry and timber industries, new resources of domestic agricultural land as well as waste will gain in importance. These raw materials can be used for the production of solid biomass, biogas and biofuels. In 2012, around 47,000 hectares of arable and grassland were used for the production of biomass in Austria. By 2030, the cultivation of energy crops as main crops could be expanded to 125,000 hectares. In addition, 95,000 hectares of energy crops could be produced and 405,000 hectares of arable and grassland residues could be used for energy production. The increased use of manure and biogenic waste also offers additional biomass potential (Austrian Biomass Association, 2015).

Table 6: Additional biomass potential in Austria in PJ until 2020 and 2030 (Source: Austrian Biomass Association, 2015)

	until 2020	from 2020-2030	Total
Woody biomass	21.2	19.8	41
Short rotation forestry	3.3	5.8.	9.2
Lye	1.3	-	1.3
Sewage gas	0.2	-	0.2
Biogas	6.1	15.5	21.7
Liquid biomass	13.1	-	13.1
Other solid biomass	5.7	3.3	9
Sum	**51.1**	**44.4**	**95.4**

4.1.3 Conclusion on Market Study Report Austria

Currently, the largest share of bioenergy is covered by firewood as well as wood chips, sawmill by-products and bark, which are mainly used in relevant wood processing industries, as well as in cogeneration and district heating plants. The importance of pellets, which are mainly used in small-scale furnaces, is, however, small compared to this despite of a continuous increase in recent years. Other solid biofuels, e.g. household waste, sewage sludge, straw or other biogenic fuels cover a small share of bioenergy at present.

The future development of bioenergy depends on the use of potentials. Estimates assume a bioenergy potential of around 95 PJ by 2030, with the supply of wood-based energy (forestry and short-rotation forestry) and other solid biogenic raw materials making up about 59.2 PJ (Austrian Biomass Association, 2015).

The success of bioenergy highly depends on the availability of suitable biomasses in sufficient volumes and at competitive prices. Therefore, measures to mobilize additional energy wood potentials are needed. The upgrading of residues, co-products and waste from agriculture to solid biofuels will be important in the upcoming years since it is seen as high potential for the future extension of the biomass base. The sustainable use of these biomass potentials requires the optimization of processes as well as technologies and the integration of cascading utilization paths as well as regional concepts. Furthermore, ecological boundaries should be considered. The establishment of sustainable supply and value chains and the cooperation of all actors along the value chain is of high importance (Biermayr et al., 2017).

4.2 *Bulgaria*

According to the current National Renewable Energy Action Plan of Bulgaria, the target for electricity from renewable sources in the gross domestic consumption of electricity is 11%. The share of biofuels in the consumption of petrol and diesel fuels in the transport sector is targeted with a share of 5.75% (Ministry of Economy, Energy and Tourism, 2010).

A coherent national policy has been developed to promote the production of energy from renewable sources and biofuels, as well as to encourage their use. Bulgaria has adopted the Energy Efficiency Act with the goal to promote energy efficiency as a key to improve economic competitiveness, security for supply and preservation of the environment.

Due to insufficient experience of energy suppliers and consumers in the field of renewable energy technologies and the relatively high prices the demand for small-scale renewable energy technologies is currently much weaker.

4.2.1 Country Fact Sheet Bulgaria

The Bulgarian country fact sheet on the biomass and bioenergy market gives an overview of available data on macro-economic indicators relevant for the national market and transnational comparison. Its main goal is to identify the most promising feedstock types available in Bulgaria for utilization in the bioeconomy, mainly as bioenergy feedstock.

COUNTRY: Bulgaria			
Indicator	**Data 2010**	**Latest data (indicate year)**	**measure**
Macro Data:			
Inhabitants	7,504,868 (31.12.2010)	7,101,859 (31.12.2016)	people
GDP per capita	5,993.94	6,945.36	€
Total land area		110,371.8 (31.12.2016)	km^2
Share of agriculture in GDP	5.4 (31.12.2010)	5.1 (31.12.2016)	%
Share of forestry in GDP	0.3	0.3 (2015)	%
Share of energy sector in GDP		19.6 (31.12.2015)	%
Energy dependency rate	70% of gross energy consumption is provided through fuel imports.	36.7 (2015)	%
Danube Indicators:			
Navigable length Danube stretch	471.55		km
Number of Danube ports	8		
Land Use, Biomass Feedstock and Energy Indicators:			
Total arable land	5,202,752 (2015)		ha
Area utilized for agriculture	n/a	5,011,494 (2015)	ha
Area utilized for forestry	n/a	3,866,372 (2015)	ha
Area used for cultivation of energy crops	n/a	3,084,067	ha
Fallow land	n/a	191,258 (2015)	ha
Theoretical biomass potential	n/a	1,134	ktoe
Technical biomass potential	n/a	n/a	
Unexploited biomass potential	n/a	159 (in 2020)	ktoe
Type/Source of biomass feedstock with highest potential for bioenergy purposes	Forest residues, oil seeds		
Type/Source of biomass feedstock with highest current use for bioenergy purposes	solid biomass/firewood for households		
Contribution of this feedstock type to domestic biomass supply for bioenergy production	402 (2005)	n/a	ktoe

Annual imports of biomass for energy conversion purposes	n/a	n/a	
Employment in Biomass sectors	n/a	71,733 (31.12.2015)	Direct employment
Main domestic primary source of energy (e.g. coal, renewables):	nuclear 45.6%, coal 39.5 %		
Main domestic sector of bioenergy (e.g. biofuels for transport, heating, electricity)	heating 65%, electricity 35%		

Biomass feedstock types - national supply situation					
Origin/Sector	**Feedstock**	**Potential for growth: yes/no**	**Quantities / Availability (t, m³, etc.)**	**Comment**	**Bioenergy Product/Intermediary (solid, liquid)**
Forestry & Wood industry:					
Wood production and primary wood residues	Roundwood	yes	6,372,000m³(2015) 4,599 (2010)	Solid combustion for heat and electricity, cellulosic biofuel	firewood, pellets
	Primary Forestry residues	yes	409.6 ktoe (2010)	see above	firewood, pellets
Secondary residues from wood industry (e.g. saw mills)	Sawmill byproducts (excl. saw dust)	yes	66.7 ktoe (2010)	see above	Chip fines, Shavings
	Saw dust	yes	36 ktoe (2010)	see above	Saw dust
Agriculture:					
Oilseeds (primary production & residues)	Sunflower seeds	yes	1.7million t		biofuel
	sunflower residues				
	Rapeseeds	yes	422,000 Mt (2015/16)		biofuel
	rapeseeds residues				Food/feed, material use
	Soybeans	yes	40,000 Mt (2015/16)		Biodiesel
Sugar & Starch crops (primary production & residues)	Wheat and spelt		5,798.13 (1,000 t) (2016) 4,094.59 (2010)		Food/feed
	Wheat residues				biofuel, solid combustion for heat and electricity
	Grain maize and corn-cob-mix		2,218.78 (1,000 t) (2016) 2,047.41 (1,000 t) (2010)		Ethanol
	Maize residues				biofuel, solid combustion for heat and electricity

	Barley		712.96 (1,000 t) (2016) 833.27 (2010)		Food/feed
	Barley residues				biofuel, solid combustion for heat and electricity
	Green maize		621,640 (1,000 t) (2016)		Ethanol
	Dry pulses and protein crops		66,830 t (2016)		
	Oats and spring cereal mixtures		31,370 t (2016)		
Dedicated energy crops/lignocellulosic biomass on agricultural land	Miscanthus				
	Paulownia				
Any other type of agricultural bioenergy feedstock, e.g. residues from industries using agricultural products	Grapes		211,080 t (2016)		Food
	Residues from wine production		9.78 t/ha		
	Residues from seed oil industry				Food/feed, material use
Waste & Residue material outside of agricultural and forestry sectors:					
scrap material from landscape management	grass				
	wood				
Post-consumer biomass	food leftovers				biofuel, solid combustion for heat and electricity
	paper				Recycling
Other:					
Organic waste from industry and trade	None with relevance				

Most promising:	
Feedstock type(s):	Forest residues
	Straw
	Oil seeds (rapeseed, soy beans) + residues
Bioenergy product(s):	Wood chips, pellets
	Vegetable oils, biodiesel
	Bioethanol
Deployment sector(s):	Heating
	Transport fuels
	Also chemical-material use

4.2.2 Country Report Bulgaria

According to a Country Summary Report (CSR) provided by Horizon 2020 Coordination and Support Action number 646495: Bioenergy for Business „Uptake of Solid Bioenergy in European Commercial Sectors"(Bioenergy for Business, 2015) for achieving the EU targets regarding the EU strategy in RES (see ENERGY BARGE D.6.1.1/ Bulgaria) Bulgaria mainly used energy from hydro-power, solar power and wind power. Some heat plants and CHP which work with biogas from cattle manure, wood residues or municipal waste were built. These plants are currently working as pilot projects. This underdevelopment of the heat plants in Bulgaria resulted from the fact that the renewable energy targets for 2020 for Bulgaria (16%) were achieved already in 2012. And this was possible only by using solar, wind and water power plants. As a consequence in 2013 the target was exceeded to 19%, which led to an increase of the electricity price in Bulgaria as a result of the feed-in tariffs for RES. This development has had major political consequences in Bulgaria.

Today there are still feed-in tariffs for electricity from biomass, including wood, which were recently decreased by 27-35%. Furthermore, the CSR reveals the current situation in Bulgaria with respect of the use of woody biomass that is firewood, with a share of 60% or more, which is mainly used for heating of household and of small guest houses or family hotels in rural regions on the country, and especially in the mountain regions. The use of firewood for heating in villages and even cities is not supported by any governmental or national programmes in Bulgaria, but it still remains the most economically attractive for a high percentage of the Bulgarian households. There is a social benefit program, which the state is currently running in Bulgaria, where local people from the rural areas, who are eligible to participate in the program, can buy 10 m^3 of logged wood from a local state forest at a special price, which is usually much cheaper than the market price. This price can vary depending on the year and the forest status. This program is not considered as bioenergy support measure, but as a social benefit for local people in rural areas, where the unemployment rate is relatively high. In larger cities, on the other hand, the use of pellets for heating of private households became more popular and has increased in recent years in Bulgaria. The pellet prices are more economical and at the same time, the heating with pellets is more effective than with electricity. Another argument for the increased usage of pellets today is that it is cleaner than firewood and coal. An additional benefit of the pellet use is that it is a more reliable and locally produced energy source than natural gas, which is imported from politically unstable regions.

Bulgaria disposes of a vast forest cover with 4.1 million ha, which is 33% of the national territory. This provides a solid basis for the Bulgarian wood pellet production. Nevertheless and as mentioned above, pellets are mainly used on a small scale (heating of private households and small hotels) and are hardly used in the energy balance of the country (Holzforschung Austria et al., 2009).

In Bulgaria, the biggest issue remains the need for relatively high initial investment costs for the installation of boiler, pipes and heat exchangers. A recent development in this regard in Bulgaria is that several banks already offer support for energy efficiency measures and have added pellet installations as eligible for credit.

Current consumption of energy from biomass

The consumption of energy which is gained from biomass increased from 714 ktoe in 2002 to 937 ktoe in 2011.

Figure 10 shows the gross inland energy consumption divided in fossil and non-fossil energy carriers. In 2013 the total gross inland energy consumption in Bulgaria was 197.2 TWh.

The share of fossil fuels coal, oil, gas and combustible waste made up 138.7 TWh or 70% of total gross energy consumption.

In sum, 30% of the gross inland energy consumption is supplied by renewable energy sources (mainly by bioenergy and hydropower).

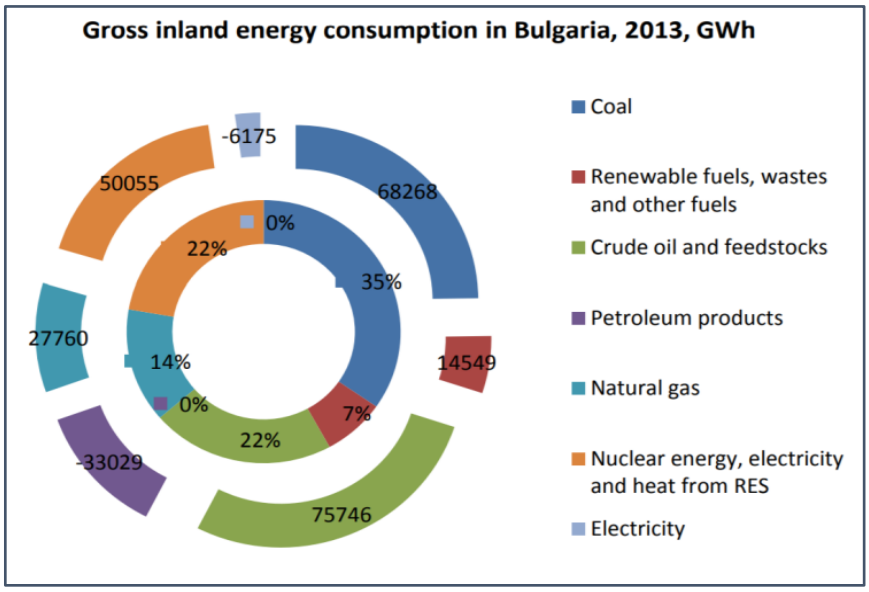

Figure 10: Gross inland energy consumption Bulgaria (Source: National Statistical Institute, Energy Balance Sheet. 2013)

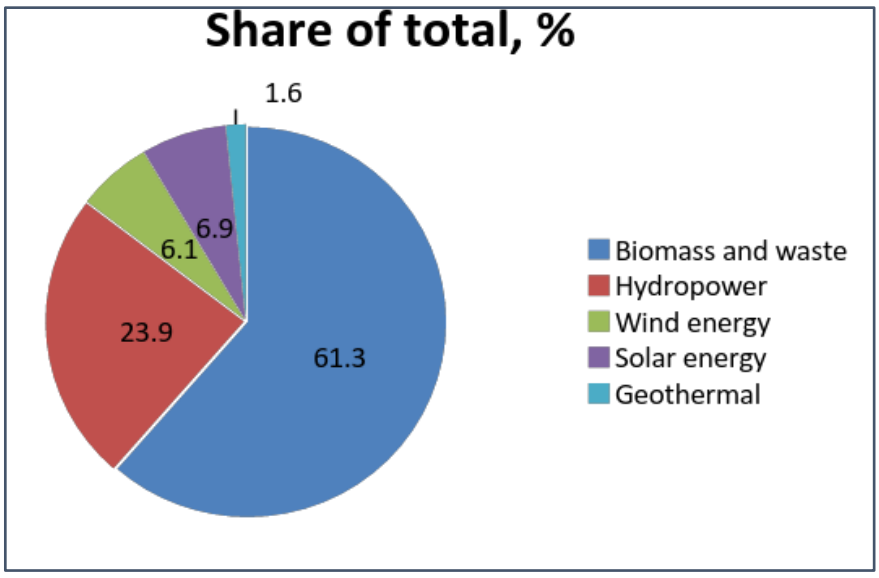

Figure 11: Share of primary production of renewable energy 2015 (Source: Eurostat, 2015)

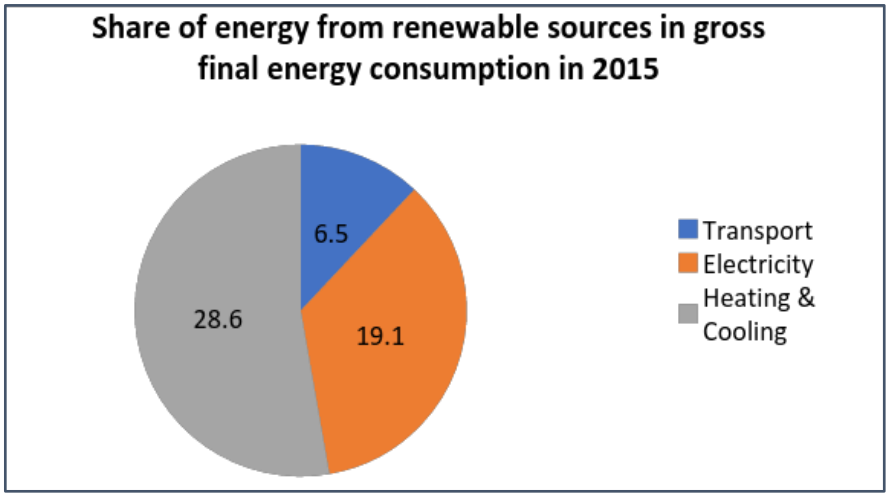

Figure 12: Share of energy from renewable sources in gross final energy consumption 2015 (Eurostat, 2017)

Bioenergy market characteristics

Bulgaria's renewable energy already represents 18.2% in 2015 of the country's total installed capacity, there is still potential to exploit renewable resources, particularly biomass. The regulatory framework on RES is determined by the Energy Act and the Energy from Renewable Sources Act (ERSA). Furthermore, in 2010 mandatory and indicative targets for the share of energy from RES were set in the National Renewable Energy Action Plan 2020. The governmental commission for energy- and water regulation has set the following quotas:

- Wind power plant 2,017 MW
- Photovoltaik power plant 230 MW
- Electricity generating stations which operate with biomass 15 MW
- totally 2,262.1 MW.

Renewable energy generation is supported through a feed-in tariff (FIT), which is now restricted to solar and biomass projects (see ENERGY BARGE D6.1.1.). According to the NREAP the target for electricity from renewable sources in the gross domestic consumption of electricity is 11%. The share of biofuels in the consumption of petrol and diesel fuels in the transport sector is targeted with a share of 5.75% (NREAP Bulgaria, 2010).

The total land area of the Republic of Bulgaria accounts for 110,371 km^2, out of which nearly 60% are arable and agricultural land. 30% of the territory is covered by forests. In 2015 the amount of 3,866,372 ha was used for forestry and 5,011,494 ha for agriculture.

Biomass is a renewable energy source that has enormous potential. According to UNDP in 2012 Bulgaria had an electricity capacity of 6.6 MW from Biomass, with a potential of 3,700 MW. Biomass could cover 8.5% of the final energy consumption in Bulgaria – this was stated in the National Long-term Program to promote the use of biomass for the period of 2008-2020. Shown in the following table is the expected amount of biomass supply in Bulgaria according to the NREAP.

Table 7: Expected biomass supply for Bioenergy production in 2015-2020 (Source: National Renewable Energy Action Plan, Bulgaria) (Units in ktoe)

Bulgaria	**2015**	**2020**
A) Biomass from forestry, of which	860	930
1. direct supply of wood biomass from forests and other wooded land for energy generation	830	892
2. indirect supply of wood biomass for energy production	30	38
B) Biomass from agriculture and fisheries	130	169
1. Agricultural crops and fishery products	100	130
2. By-products and residues	30	39
C) Biomass from waste	144	194
1. Biodegradable fraction of municipal solid waste	80	110
2. Biodegradable fraction of industrial waste (including paper, cardboard, pallets)	60	80
3. Sewage sludge	4	4

According to a study concerning the sustainable potential of biomass, conducted by S2Biom, from primary forestry production up to 3.2m dry t/year and from residues, dedicated perennial crops, bio-wastes and post-consumer wood 11.5m dry t/year will be available in 2030. The following map shows the regional potential in Bulgaria which is quite evenly spread.

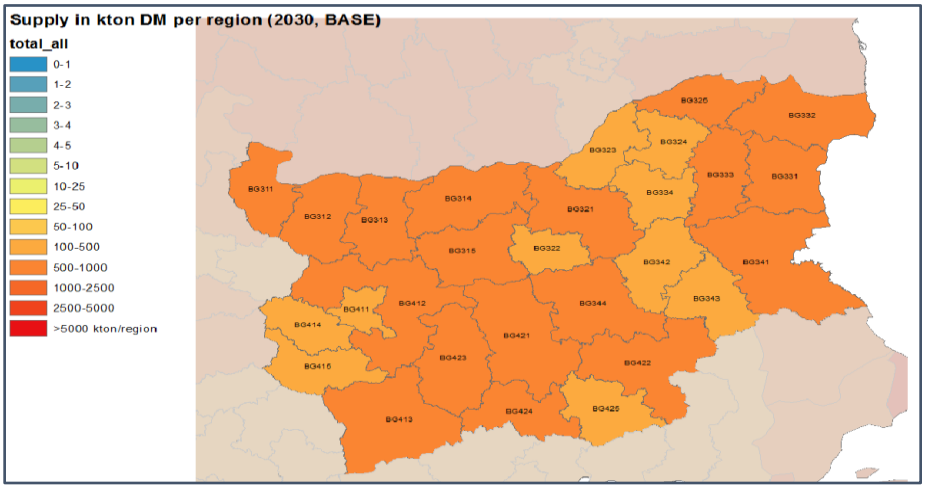

Figure 13: Total lignocellulosic biomass by region (Source: S2Biom, 2016)[15]

Forest wood is one of the main biomass resources in Bulgaria. The entire surface of wood adds up to 3,866,372 ha. The reserves of wood are over 591 mio solid cubic metre and the natural growth is over 14 mio solid cubic metre per year. The exploitation out of pinewood is 325 ktoe and out of hardwood 567 ktoe. With this the annual wood-biomass potential adds up to 892 ktoe.

Agricultural wastes also have a high potential for bioenergy production. The production costs are at the expenses of the agricultural country culture, except the costs for the collection and transport. One part of the wastes is inaccessible due to high costs for the collection, transport and storage. The technology for the usage of corn-silage as solid fuel using direct cremation is not yet mature enough.
The main quantity of agricultural wastes in Bulgaria are the following:
- Straw out of wheat and other grains
- sunflower-silage
- sunflower shell
- branches from fruit trees
- tobacco-silage

The description of the amount of wastes is as following:
Straw 196 ktoe, sunflower-silage 158 ktoe, sunflower shells 39 ktoe.
The full potential for the usage of energy in Bulgaria is 1,134 ktoe, from that is 892 ktoe biomass out of wood and 439 ktoe from agricultural wastes.
The estimated sustainable potential of agriculture residues can reach up to 6.4 m dry t/a in 2030. The regional distribution is shown in the following figure as analysed by the S2Biom Project.

[15] Lignocellulosic biomass includes: Forest biomass from primary forestry productions (fellings), primary field residues and secondary forest industry residues; Agricultural biomass from primary field activities; Biowastes and post consumer wood; Dedicated perennial crops.

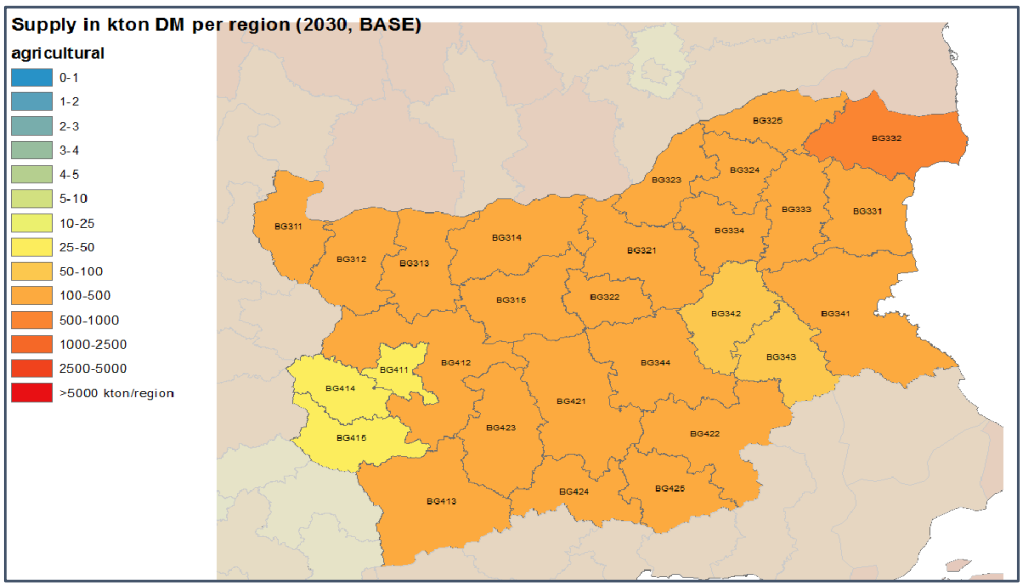

Figure 14: Agriculture (primary field residues and tree pruning's) by 2030 (S2Biom, 2016)

A number of stakeholders are involved in the Bulgarian biomass and bioenergy market and its underlying supply chains. An overview of these stakeholders and their predominant interests, also including the inland waterway transport sector, is listed in the table below.

Table 8: Stakeholder List with interests and needs

Stakeholder	Interests and Needs
Port and Terminal Operators	• High degree of capacity utilization
Shipping Companies and Ship Brokers	• High degree of capacity utilization • Constant order situation • Fast possibilities of transhipments • Good prices
Ministry of Transport	• Higher degree of capacity utilization of the ports • Decompression of road networks
Biomass associations	• Favourable regulations that they can easily participate in the market. • Availability of enough raw material for biomass.
Ministry of agriculture and forestry	• Regulations for controlled decomposition • Bulgaria first supplier for biomass/bioenergy • Possibility to sell unused biomass
Forestry and Agriculture associations	• Safe the environment • Regulations for controlled decomposition
Other Logistics Service Provider	• Get orders as a supplier • Good prices for their service
Media	• Enough information about biomass/bioenergy to inform the population and to write articles about it
Biomass suppliers	• Enough demand for their biomass • Fair prices • Long lasting relationships with their partners
Policy makers	• Compliance of the regulations
Companies in general	• Fair prices for electricity and heat • Constant prices • Constant and secure availability for energy and heat
Private Energy users (Population of Bulgaria)	• Electricity and heating/air-conditioning system with affordable prices and security for the availability.
Other energy-generating companies	• Fair competition • Good prices for their service
Environmental Organisations	• The change from fossil burning to biomass/bioenergy • Regulations that the environment is preserved • Further regulations for fossil burning companies to make it difficult for them to survive • Good regulations for the biomass/bioenergy that it

	is easy for the operating companies to participate in the market • Regulations for controlled decomposition
Financial institutions and investors	• Financial security and high return on investment

Bulgaria, compared to other EU countries, and also to other so-called new member states poses a more complicated situation regarding strengths, weaknesses, opportunities and threats for the biomass and bioenergy market, as it does for most other aspects of the economy.

Table 9: SWOT Analysis Bulgaria (own table acc. To: BMWi, 2013; Ifeu, 2014;Researchgate, 2015)

Strengths	Weaknesses
• National policy for the support of renewable energy sources • Payment obligation for energy out of renewable sources including selling prices for biomass which have a stability and are predictable for investors • Legal regulations adjusted to the European legalisations • High potential of unused biomass waste • Good developed road network • Existing experienced consulting companies, which offer complete project support • Large amount of available feedstock	• Selling prices for feed-in remuneration for energies out of renewable sources is fixed because of the costs for production. This supports the most expensive energies from renewable sources but also inhibits competition in the market • Relatively high import prices for machines and installations due to a lack of local production and a much lower price level in Bulgaria compared to other EU-countries • Lack of information for the population about the possibilities and chances of biomass • Involvement of stakeholders for different market sectors (agriculture, forestry, energy, chemical) over full biomass value chain necessary • Most promising biomass value chains, including current/future market volume/prices not clear • Lack of research and expertise • Poverty as a barrier for investments • Excessive bureaucracy • Lack of qualified work force
Opportunities	**Threats**
• Target-oriented policies to develop a national scheme for financing for EEQ-Projects • Access to funds from EU-programmes • Well-developed financing mechanisms with equity	• Legislative uncertainty with regard to long-term policy development • Participation of a great number of institutions • Limited exploitation of biomass due to high selling prices for the feed-in remuneration of

• Developed district heating system and industrial cogeneration, which may be used for the implementation of economical efficient projects for cogeneration of biomass • Suitable climate conditions and possibilities for the cultivation of energy cultures on set-aside land • Strengthening of the economic position of various market sectors (e.g. agriculture, forestry, chemical and energy) • Strong demand from consumer industry for bio-based chemicals • Consumer awareness • National training programmes for forest entrepreneurs • Forest certification • Fast growing energy demand • Innovation due to R&D in advanced processes for biomass procurement,pre-processing and conversion • Governmental/EU-support: CO_2-taxes, subsidies, feed-in tariffs, research projects • Instability of fossil fuel supply and volatile fossil fuel prices	electrical energy out of cogeneration in natural gas plants • Increase of prices for biomass in a development of bioeconomy • Economic change and volatility in fossil fuel prices • Bio-based products and bioenergy are assessed to a higher standard than traditional products (no level playing field) • Availability and contractibility of raw materials (e.g. climate change, policies, logistics) • (High) investment capital for pilot and demo initiatives • Changing governmental policies • Competition with fossil fuels

The following table shows the key factors influencing the market development of bioenergy in Bulgaria.

Table 10: Key factors for future markets (own table acc. To: Helmholtz Zentrum für Umweltforschung, 2016)

Category	Key factor
Consumers / Society	• Willingness to pay of consumers for bio-based products – if there is a price difference to conventional energy sources • Environmental awareness
Economy and Producers	• Globalisation and global economic development • Supply and demand of feedstock • Policy for technology, innovation and research
Policy	• Energy and climate policy • Support of local value

Technology	• Technology and innovations in the supply chain of biomass
Environment	• Climate change • Availability of biomass/forest structure/ feedstock

In order to exemplify a typical bioenergy supply chain in Bulgaria, the example of the firewood company "Lovela Eood" which is based in Slivo Pole region Ruse shall be used. First, they buy log wood from the forestry sector. The trunks will be felled and prepared. The trunks will be collected at an assembling point and after that they will be transported on trucks. Mostly they load logs with a size of 1-2 metres. After the transportation to the factory in Slivo Pole, the logs get sawed, divided and piled up on pallets. Lovela Eood stores the pallets until they are sold. With 90%, most of the pallets are transported to regional wholesalers. Only 10% are exported to adjoining countries. The wholesalers in Bulgaria store the material again and organize the disposal. The wholesalers sell it to different retailers and the end-consumer buys the wood from these retailers. The end-consumer is responsible for the waste disposal after burning.

4.2.3 Conclusion on Market Study Report Bulgaria

As has been shown, Bulgaria is comparatively self-sufficient concerning energy supply and RES have increased in recent years. The biggest share of renewable energy however has not been generated from biomass, although Bulgaria has a high theoretical agricultural and forestry potential for both energetic and material purposes. Also, there are quite a number of actors in the biomass and bioenergy market, but market performance and subsequent numbers for bioenergy deployment, especially for new technologies, is low. In sum, it can be concluded that the industry of energy out of biomass did not get sufficient support in the last years, leading to a high potential not being exploited and options for value added unused.

4.3 *Croatia*

Croatia, having almost 50% of its land area covered with area used for forestry (largely state-owned), is relying mostly on woody biomass to cover the bioenergy needs. Recently, due to the incentives and co-financing, several CHP biomass powered plants have been built, currently delivering an approximate amount of 24.5 MW of combined heat and power. Biogas used for electricity production has surpassed the electricity production of solid biomass plants with current installed capacity in total of 30.4 MW.

When considering the current bioenergy situation from available data, one needs to bear in mind that there is no reliable statistical data on installed capacities for biomass heating systems. Additionally, heat capacity data of the heating power plants using biomass refer to biomass-fired industrial facilities and do not contain information on small heating furnaces heat capacity and hot water preparation in households.

The Croatian National Energy Strategy has been adopted by the Croatian Parliament in October 16th 2009, as prepared by the former Ministry of Economy, Labour and Entrepreneurship. The Energy Strategy is adopted for the period until 2020 and sets out to harmonize with goals and time framework of strategic documents of the European Union. From 2006 to 2013, it has the

purpose to define the development of Croatian Energy sector by 2020 and the goal to build, under the conditions of uncertainty in the global energy market and scarce local energy resources a sustainable energy system.

The Strategy has three basic objectives: 1) to increase the security of energy supply, 2) to develop a competitive energy system and 3) to ensure development of the sustainable energy sector. The strategy document recognizes the large biomass potential in Croatia, also visible from the projection for the year 2020 where from all renewable energy sources the majority comes from the bioenergy sector:

- Solid biomass at 31.5%
- Biofuels at 10.8%
- Biogas at 1.3%

Biomass potential is here referred to the wood biomass and biomass out of agriculture, as well as the firewood cultivation, with addition of wood biomass from wood harvesting during maintenance of waterways and power facilities. The strategy defines a goal, along with the existing incentive measures and removing the existing administrative barriers, to use around 15 PJ of biomass in energy purposes in 2010, with the aim of almost doubling in 2020, around 26 PJ. Part of this biomass shall be used in many biomass fired power plants of total power of 85 MW in 2020, preferably cogeneration plants. In respect to biofuels for transport, according to the National Energy Strategy, Croatia sets up a goal to use 9 PJ energy out of biofuels in 2020, which amounts 10% of conventional petrol and diesel consumption in transport, and is determined that biofuel sources do not compete to food, finally setting up a goal to produce around 340,000 t of biofuels in 2020.

The Republic of Croatia has chosen to use RES in line with the principles of sustainable development. The Energy Strategy has set the following objectives concerning RES:

- Increasing the share of RES in the gross final consumption of energy to 20% in 2020, while the sectoral objectives are as follows:
    - 35% share of RES in the production of electricity, including large hydroelectric plants;
    - 10% share of RES in transport;
    - 20% share of RES in heating and cooling.

Regarding biomass within the National Action Plan, it is mostly being regarded as a part of the future district heating systems. To 2020, an increase in the use of RES in district heating and cooling systems is expected, from the current 1.1 PJ to 2.9 PJ. District heating based on RES is primarily expected in smaller urban centres with up to 10,000 residents, in areas rich in forest biomass and areas with geothermal sources. In these areas, district heating systems and the infrastructure (network) have not been developed yet, such that development will begin from the very beginning. It can be assumed that new district heating systems will be developed in 10 to 15 cities.

The majority of the target is achieved in households and services, particularly in tourism, e.g. hotels, followed by industry and district heating systems. Furthermore, it is necessary to stress that the National Action Plan for the production of energy from renewable energy sources to 2020 has assumed a target of 19% for heating and cooling, while the Energy Strategy has assumed a share of 21%. The difference in these shares is the result of the strict calculation methods applied as defined by Directive 2009/28/EC.

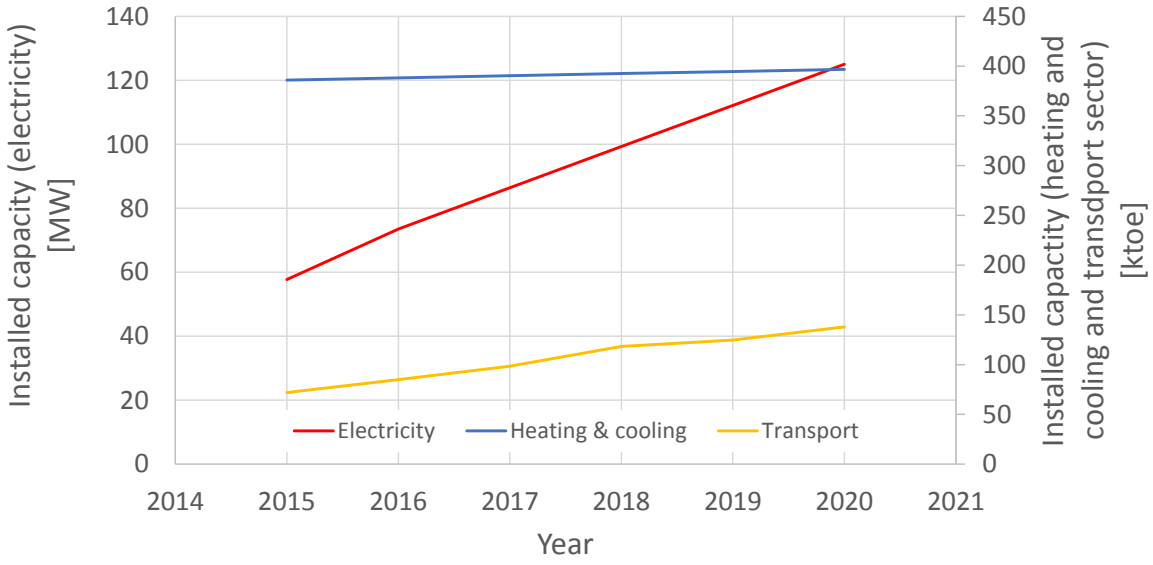

Figure 15: Planned capacity of bioenergy per sector according to NREAP

According to the NREAP, in 2020, the following breakdown of RES is expected in electricity production: 79.6% from large and small hydropower plants, 10.5% from wind plants, 9.3% from biomass plants, 0.9% from geothermal plants and 0.7% from solar plants. The total amount of renewable energy for heating and cooling in 2020 will be about 605 ktoe. The trajectory of annual targets in the transport sector is defined by the National Action Plan on the stimulation of production and use of biofuels in transport for the period 2011–2020.

Solid biomass, with a share of 64.5% in 2020 will play the main role in total energy from RES in the production of thermal energy for heating and cooling. Solid biomass includes wood biomass and biomass from agriculture. Of the total consumption of biomass for heating and cooling, 50.7% is planned for consumption in general consumption (households, services, agriculture, and construction). The total amount of renewable energy in transport to 2020 will be about 162 ktoe. Renewable energy consumed for transport in 2020 will primarily consist of energy from biofuels (8.85%), while the remainder to the 10% share will be electricity (1.15%), which will be used in all types of transport.

4.3.1 Country Fact Sheet Croatia

The Croatian country fact sheet on the biomass and bioenergy market gives an overview of available data on macro-economic indicators relevant for the national market and transnational comparison. Its main goal is to identify the most promising feedstock types available in Croatia for utilization in the bioeconomy, mainly as bioenergy feedstock.

COUNTRY: Croatia			
Indicator	**Data 2010**	**Latest data (2016)**	**measure**
Macro Data:			
Inhabitants	4,203,604	4,190,669	people
GDP per capita	10,500	10,900	€
Total land area	56,594		km^2
Share of agriculture in GDP	4.1	3.5	%
Share of forestry in GDP			%
Share of energy sector in GDP	42,948	42,827	%
Energy dependency rate	60.2	47	%
Danube Indicators:			
Navigable length Danube stretch	137.5		km
Number of Danube ports	1		
Land Use, Biomass Feedstock and Energy Indicators:			
Total arable land	4,291,139		ha
Area utilized for agriculture	1,334,825	1,537,629 (58%)	ha and share of total arable land
Area utilized for forestry	2,233,354	2,753,510	ha
Area used for cultivation of energy crops	n/a	n/a	ha
Fallow land	16,580	33,725	ha
Theoretical biomass potential	n/a	2,200	ktoe
Technical biomass potential	n/a	n/a	
Unexploited biomass potential	n/a	n/a	
Type/Source of biomass feedstock with highest potential for bioenergy purposes	wood		
Type/Source of biomass feedstock with highest current use for bioenergy purposes	wood		
Contribution of this feedstock type to domestic biomass supply for bioenergy production	n/a	n/a	ktoe
Annual imports of biomass for energy conversion purposes	0.2 mio.	1.18 mio.	t
Employment in Biomass sectors	23,771	17,285	Direct employment, FTE
Main domestic primary source of energy (e.g. coal, renewables):	Liquid fossil fuels		
Main domestic sector of bioenergy (e.g. biofuels for transport, heating, electricity)	biomass for heating		

Biomass feedstock types - national supply situation					
Origin/Sector	**Feedstock**	**Potential for growth: yes/no**	**Quantities /Availability (t, m^3, etc.)**	**Bioenergy Product/Intermediary (solid, liquid)**	**Comment**
Forestry & Wood industry:					
Wood production and primary wood residues	Fuel wood	yes	1,769,000 m^3	solid/pellet briquette	
	Industrial roundwood	yes	409,200 m^3	solid/pellet briquette	
Secondary residues from wood industry (e.g. saw mills)	wood chips, particles and residues	yes	639,000 m^3	solid/pellet briquette	
Agriculture:					
Oilseeds (primary production & residues)	rapeseed	yes	66,000 t	liquid/biodiesel	
Sugar & Starch crops (primary production & residues)	Sugar beet	yes	1,144,000 t	liquid/bioethanol	
Dedicated energy crops/lignocellulosic biomass on agricultural land	none of significance				
Any other type of agricultural bioenergy feedstock, e.g. residues from industries using agricultural products	Wheat straw	yes	661,670 t	solid / pellet	technical potential
	Corn stover	yes	410,100 t	solid	technical potential
	Vineyards pruning leftovers	Yes	109,000 t	solid	potential
	Olive groves pruning leftovers	Yes	48,000 t	solid	potential
Waste & Residue material outside of agricultural and forestry sectors:					

scrap material from landscape management	maintenance of parks and gardens etc. (Green, biodegradable waste)	Yes	41,969 t	solid	
Post-consumer biomass					
Other:	none of significance				

Most promising:	
Feedstock type(s):	Fuel wood
	Wheat straw
	Corn stover
Bioenergy product(s):	Pellet/briquette from wood
	Processed straw
	Processed corn stover
Deployment sector(s):	Heating from CHP
	Energy from CHP
	Biofuel

4.3.2 Country Report Croatia

Bioenergy market characteristics

The Croatian Energy Regulatory Agency (HERA), has been founded as an autonomous, independent and non-profit public institution based on the Energy act (OG 177/04 and 99/07), in order to establish and implement regulation of energy activities. It issues licenses for carrying out energy activities, and also temporarily and permanently revokes these licenses and rulings on granting the status of eligible producers, and also temporarily and permanently revokes these rulings. It also decides on invitations to tenders and selecting the most advantageous bidder for construction of production facilities up to 50 MW, in line with the Article 10, Electricity Market Act (OG 120/12) and submits proposals to the Government of the Republic of Croatia on invitation to tenders and selecting the most advantageous bidder for building production facilities of 50 MW and higher (OG 120/12). It also supervises the work of the Croatian Energy Market Operator (HROTE), which performs activities of organizing electricity and gas market as a public service, as well as performing activities in system for incentivizing electricity production from renewable sources and cogeneration and in system for incentivizing production of biofuels for transport.

The land surface of the Republic of Croatia spreads over a total of 56,542 km^2, out of which 42% is under forests, 19% is available for cultivation, 19% is limitedly suitable for cultivation, and 14% is not available for cultivation and can be used for cultivation of energy crops. Republic of

Croatia is divided into counties, primary territorial subdivisions. There are 21 counties in total, counting in the City of Zagreb which has the status equal to a county. Croatia produces more than 2.8 Mt of wheat and corn grain annually and cuts over 4.5 million cubic meters of state owned forest. Planed yearly felling in the period of 2006 - 2015 is around 5.8 million cubic meters of tree and for the period 2016 - 2025 planed yearly felling will be between 5.8 and 6.4 million cubic meters. According to the Tariff system (OG 113/13), for biomass power plants incentive price correction is done for reaching the total annual plant efficiency for ongoing year opposite to total annual efficiency from the year before, and for electricity production from cogeneration power plants incentive payment is done solely in amount of the valid reference price. Electricity must be produced in a cogeneration process in a way determined by the rule which governs procedure of acquiring eligible producer status.

As described in the previous chapter the Croatian NREAP sets out to steadily increase the electric energy production from biomass to 120 MW of installed capacity. One should note that since the document has been prepared in 2013 (latest version) a comparison of the trends (real values and planned) can be made in this half-way stage. HROTE's data on the latest incentives for the electricity production shows that it is currently at around 55 MW (all plants are privately owned, with two from the Croatian National Energy Company (HEP) being developed). As seen in the image above, the action plan suggested 50% higher values. The share of dedicated biomass facilities is still below 30 MW with the majority coming from biogas plants mostly using corn silage (top non-woody biomass used for energy production). Biogas facilities have seen an increase in development since 2009 when the first one was put into operation with 135 kW installed. In 2012 this facility was the first biogas facility that contracted the incentive price for selling the electric energy produced.

Prices of the biomass feedstock (per energy unit) in Croatia have been shown in a study by JRC and are given in the following table:

Table 11: Biomass prices in €/GJ in Croatia

Firewood – log	Wood chips	Forest residue	Agricultural biomass
2,2	4	3	3,1

Even with a complicated bureaucratic and administrative process, which is one of the greatest pitfalls in the development of the new installations, recent increase in (mostly biogas) facilities does show that the problems can be overcome.

The current legal framework includes the following conditions for developing an electrical/thermal facility: NO_x/CO emissions, feedstock handling propositions, feedstock storage propositions, sufficient distance from the inhabited area, additional load of the local access roads, local resource handling, using of local energy infrastructure and enforcement of fire protection standards. For the statistical information for the year 2015 for solid biofuels,

pellets were produced in 15 facilities. Total installed capacity for the pellet production is 376,900 t/yr, out of which 56% was utilized in 2015. Around 89% of the total pellets production was exported while little was placed on the domestic market. Wooden briquettes capacity is estimated to 61,400 t/yr while its actual production is usually done periodically depending on the feedstock availability – waste from wood processing industry. Around 66% of the total briquettes production was exported during 2015.

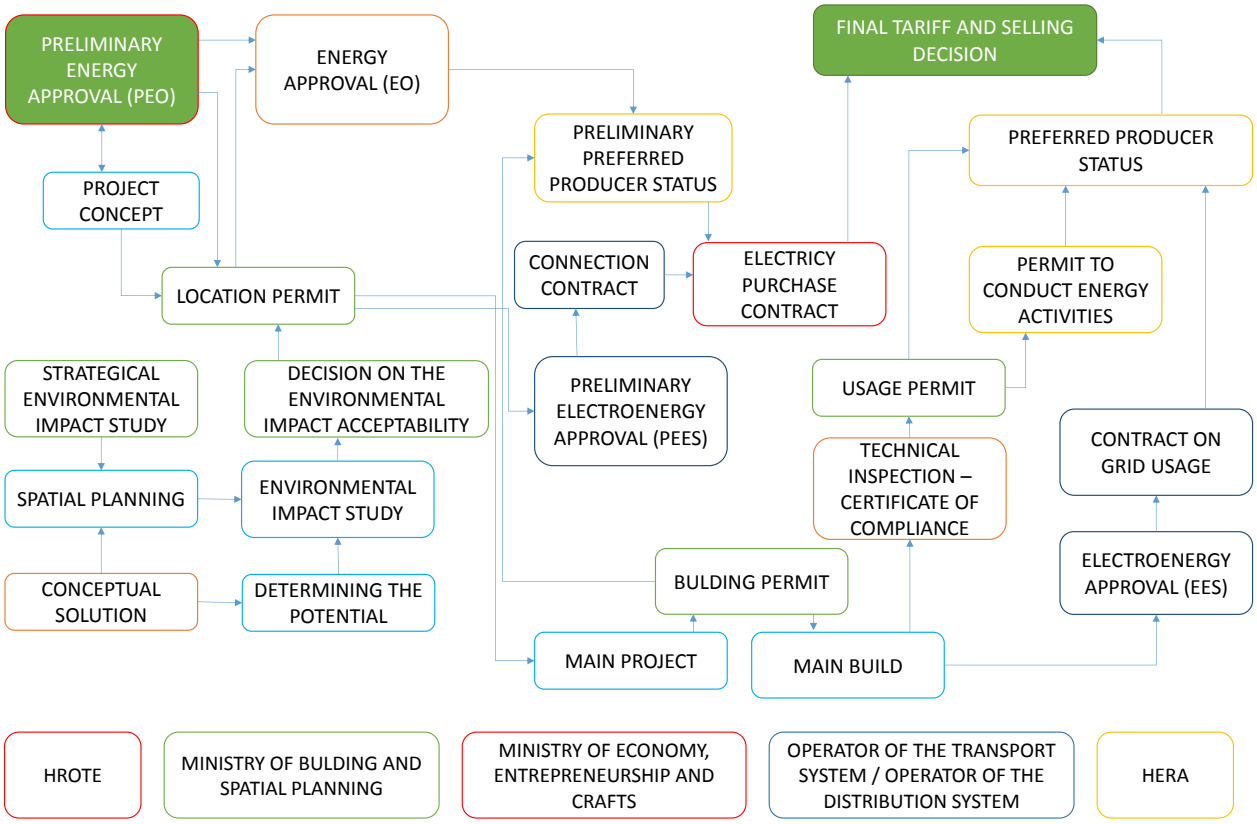

Figure 16: Workflow for obtaining the preferred producer status and selling tariff

On the figure above both the legal framework/workflow to be included as a preferred producer of electric energy from RES (not only biomass) (with final tariff defined) and the main market stakeholders are indicated. From this figure, the complex and inhibiting bureaucratic system in Croatia can be drawn.

The geographic location and shape of Croatia also plays an important role when determining the bioenergy potential in the light of using the river Danube as a transport route. The Danube, located on the far east Croatian border (with Serbia) is placed rather remotely from the Croatian counties holding the biggest forest biomass potential. However, in the work by Cosic et al. (2011), an analysis was performed for the assessment of the biomass cost at the energy plant location in Croatia, indicate that these costs range between 38.5 €/t and 48.7 €/t. The Analysis was performed for different biomass types, sizes and locations of the power plants (forest residues, wheat straw and corn stover). Also, analysis performed for the assessment of the upper-level price of the biomass on the basis of the resulting cost of the electricity, the biomass-

fired plants could even pay up to 100 €/t (10 MW power plants) for the biomass bought from outside suppliers, if the payback tariff of the electricity sold to the grid was equal to the feed-in tariffs.

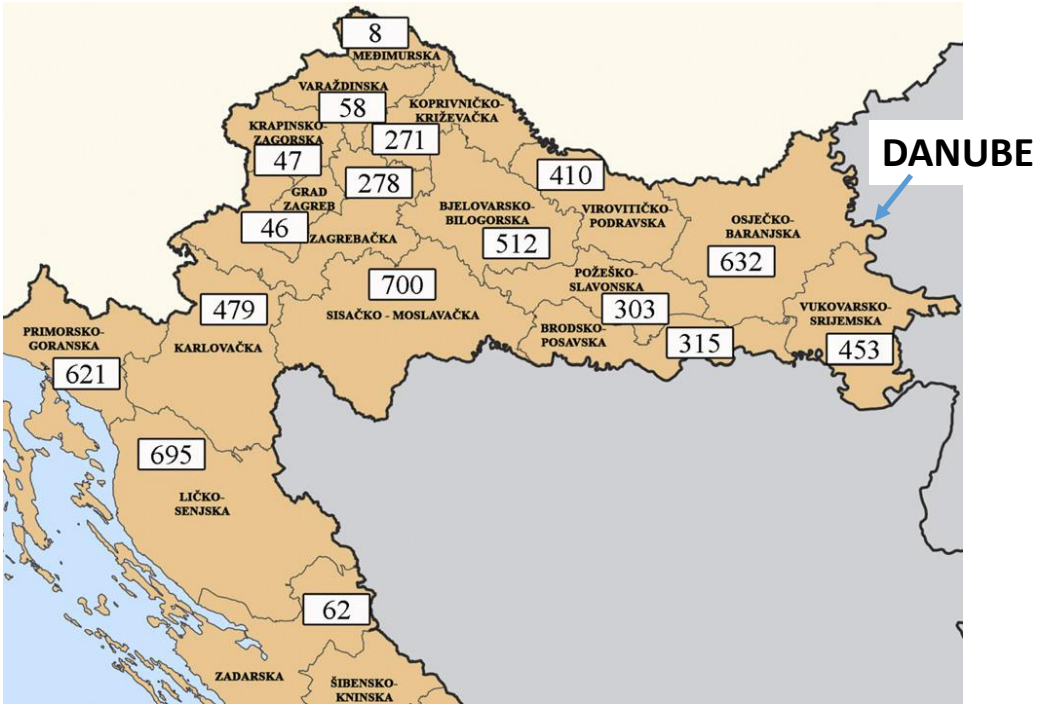

Figure 17: Energy potential of forest residues in Croatian counties [1000 GJ] (Source: Cosic et al., 2011)

If not treated as dangerous goods, biomass is subject to the general regulations on handling and storage that are valid for all other types of cargo, basically no special requirements except those that are related to handling requirements in order to prevent cargo from damaging and provide safe environment for handling personnel, surroundings and nature protection. If the biomass has any characteristic specified in the Dangerous Goods Transport Act, it may be classified as dangerous.

Market profile: Analysis of most promising biomass/bioenergy supply chain

Judging from the current situation in production of energy using biomass in Croatia it is likely that the current trends in using forest residues will continue. Interestingly, Croatia produces much more woody biomass-based energy carriers (pellets, briquettes) than it uses on its domestic energy production market. There are no dedicated electrical production facilities from biomass, and with the current legal framework this is unlikely to change in the upcoming years. The entire current electricity production from biomass is made either from CHP plants or biogas installations.

The current tariff system for delivering electricity from the power plants using renewables can be found in the following table.

Table 12: Tariff prices for the preferred producers of electricity from biomass power plants

Facility type	Tariff (HRK/kWh)
Facilities with installed capacity ≤ 1MW	
Solid biomass power plants with installed capacity over 300 kW (including waste)	1.2
Power plants using biogas from crops and organic residues (plants and animals) with installed capacity over 300 kW	1.2
Facilities with installed capacity > 1MW	
Solid biomass power plants with installed capacity over 2 MW up to 5 MW (excluding waste)	1.15
Solid biomass power plants with installed capacity over 5 MW up to 10 MW (excluding waste)	1.05
Power plants using biogas from crops and organic residues (plants and animals) with installed capacity up to 2 MW	1.2

The prices of three selected feedstocks compared to the size of the installed capacity of a biomass power plant can be seen on the following chart (Cosic et al., 2011).

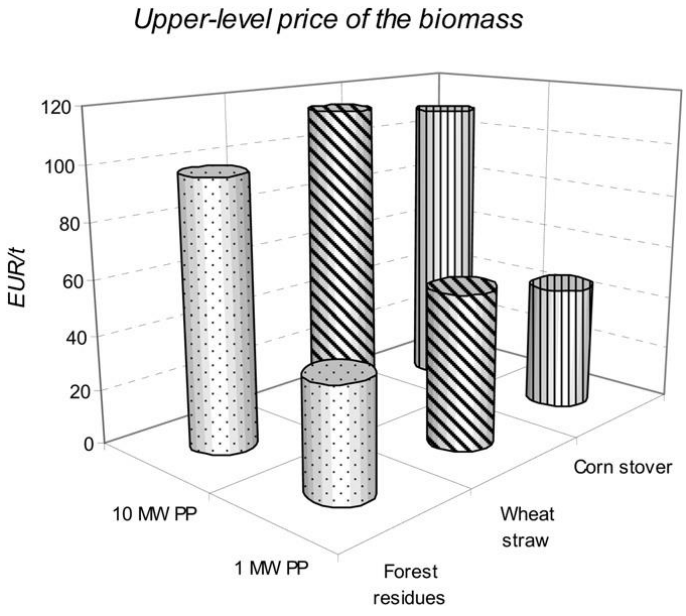

Figure 18: Upper-level price of the biomass for different sizes of the power plants and selected feedstock types in Croatia (Source: Cosic et al., 2011)

According to new Tariff System for the production of Electricity from Renewable Energy Sources and Cogeneration (Official Gazette 133/13 and 155/13), for the power plants connected to transmission or distribution network that are using renewable energy sources for electricity production with installed power > 5 MW, regardless of plant type, the incentive price is set to reference price. The reference price of electricity is a price equal to the amount of the valid tariff

item for active energy based on unique daily tariff for the electricity supply within universal service, Blue tariff model, whose amount is set by article 39. part 2, point 1. of the Methodology for determination of the tariff items amount for electricity supply within universal service (Official gazette, 116/2013), according to which, suppliers are obliged to repurchase electricity from the renewable energy sources and cogeneration from the market operator. According to Tariff system (OG 113/13) condition to reach incentive price and signing a power purchase contract with HROTE is minimal total annual efficiency of the power plant to be 50% in conversion of fuel primary energy conversion into electricity and usable heat produced.

For biomass power plants an incentive price correction is done for reaching total annual plant efficiency for the ongoing year opposite to total annual efficiency from the year before, and for electricity production from cogeneration power plants incentive payment is done solely in amount of the valid reference price. Electricity must be produced in a cogeneration process in a way determined by rule which governs the procedure of acquiring eligible producer status.

Also, for cogeneration power plants which are not using renewable energy sources, the amount of incentive price in HRK/kWh for delivered electricity is set to the reference cost, regardless of the rated power.

For cogeneration power plants tariff items and their levels in HRK/kWh for delivered electricity are determined during higher (HT) and lower (LT) daily tariff item. Duration of the HT & LT is determined by the tariff system for electricity generation.

In terms of agricultural biomass, wheat straw and corn stover are considered the most promising feedstock types for future bioenergy generation. Traditionally agricultural counties in the east part of Croatia, Osijek-Baranja and Vukovar- Srijem, have the highest potential of the agricultural residues with both being reasonably close to the Danube port in Vukovar. To calculate the technical available potential of wheat straw, the number of cattle in counties has been used. These numbers vary from county to county. The technical available potential of wheat straw in Croatia ranges from the maximum 930 kt/year to a minimum 450 kt/year and corn stover ranges from the maximum of 600 kt/year to the minimum of 370 kt/year.

The calculated potential of forestry residues as the third most promising biomass type for energy purposes in Croatia is above 700,000 m^3. Counties with the largest quantities of forestry residues are Sisak-Moslavina and Lika-Senj, with over 80,000 m^3. Both these counties are located in central Croatia with larger distance to the river Danube. Sisak-Moslavina county, however has the first inland port in Sisak located on Sava river, but the availability for inland river transfer of the biomass is questionable since this waterway is not connected to Danube on Croatian territory (Danube-Sava channel is planned).

Since the Croatian solid woody biomass production is mainly limited to the state-owned forestry company (Hrvatske šume), the market actors can be divided into the suppliers of the biomass (Hrvatske šume), processors identified between the various saw-mills and pellet/briquette producers and final end users (biomass power plants, household users). In most cases, suppliers and processors are also traders of the products having all necessary infrastructure and logistics for distribution. Forestry residues and biomass are sold by Hrvatske šume by public

procurement and or public bidding/auction as defined by Croatian law. The rest of the forestry, owned by private businesses, is not available in databases but is most likely to follow the same pattern as the public ones with direct selling of the raw feedstock to retail traders or processors.

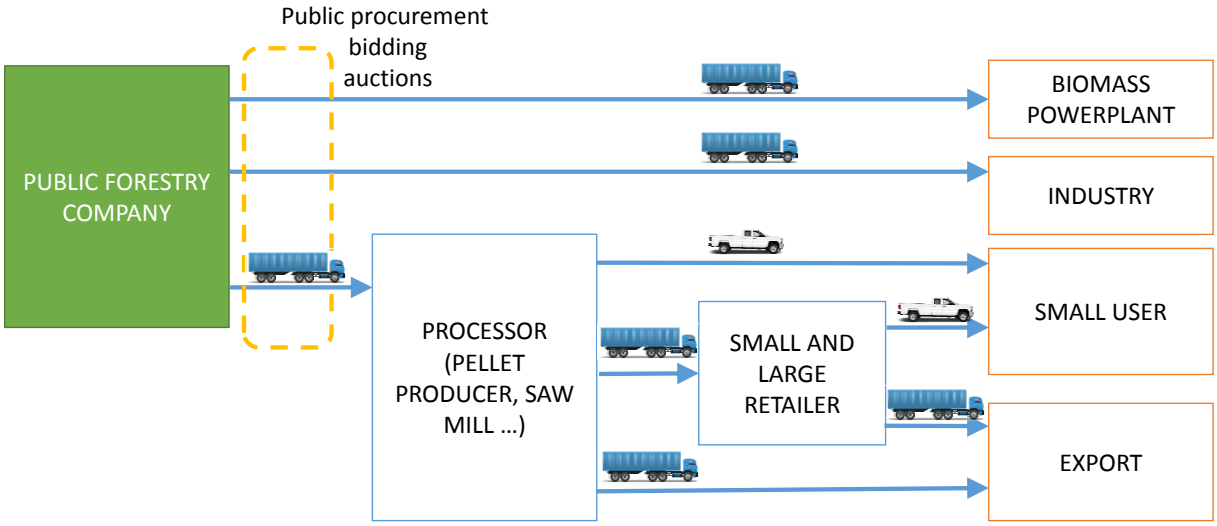

Figure 19: Supply chain example in case of public forestry company distributing woody biomass

All biomass transport (except direct extraction done by special vehicles) is currently done by road traffic, namely trucks. The figure above depicts a standardized supply chain for woody biomass in Croatia.

Agricultural residues are mostly used as an excess feedstock produced by the end-user, which usually means that there are no special logistics needed due to the integration in an existing supply chain, but only a need for temporary storage. Most of the residues (wheat straw, for example) that is finally used for energy production are exported to Hungary and Slovenia. Transportation costs of low-density and high-moisture agricultural residues straw are a major constraint to their use as an energy source. As a rule of thumb, transportation distances beyond a 25–50 km radius (depending on local infrastructure) are uneconomical. For long distances, agricultural residues could be compressed as bales or briquettes in the field, rendering transport to the site of use a viable option.

For three types of feedstock selected (the ones with highest technical potential for energy production), wheat straw, corn stover and forest residues, one can obtain the following properties:

Table 13: Properties of most promising feedstock types

	Forest residues	Wheat straw	Corn stover
Lower heating value of biomass [GJ/t]	8.5	14.7	13.74
Humidity [%]	50	20	20
Specific weight [kg/m^3]	9.08	0.968	0.5
Potential for hazardous behaviour	High	Medium	Low

Since Croatia still needs to catch up with the planned share of bioenergies in (primarily) electricity production, there is a significant space for implementing both new technologies and facilities. Traditionally, wood and forest residues have been largely contributing to the above, and this is not likely to change until the targeted 2020, but mentioned research show high potential of using agricultural biomass for energy production (even higher than in forest residues).

The downside of using agricultural residues (as in this case indicated, wheat straw and corn stover) is that the production is done by decentralized producers, which, in some cases where the producer is actually a large one, can consider building a facility which could utilize the residue and sell the produced electricity. On the other hand, forest residues are mainly produced by a single company (Hrvatske šume) which already has a well-established system of transport and selling the raw material, even with long-term contracts. The same should be done by establishing central markets for agricultural residues, and this would require significant effort in preparing the legislative background coordinated with planned power production facility projects.

4.3.3 Conclusion on Market Study Report Croatia

The current situation of utilizing biomass for energy production in Croatia shows that even though there is a significant potential of using novel approaches to introduce biomass into both heat and power production. Croatia's national action plan on renewable energy sources for including biomass in transport, electricity and heating and cooling for the year 2020 has only been partially fulfilled half way through. Installed capacity of electricity generation has been covered mostly by biogas plants while the woody biomass has largely contributed in the heating sector.

As stated, this trend is not likely to be changed, e.g. by introducing agricultural biomass, already having been proved with higher technical potential for energy production. Alternative crops, used exclusively for bioenergy purposes are currently also being only used in academic/testing environment. Here, additional potential is obvious.

The river Danube, as a major European inland waterway, is situated on the far east of the country making it currently not directly economically viable for using as a mean to improve the availability of bioenergy in Croatia, especially when there's rather large amount of unused potential for biomass feedstock production in the country itself. On the other hand, since the new energy plants largely depend on complicated administration and incentives, the potential of feedstock production can be utilized by exporting raw and processed feedstock (e.g. semi-finished goods) to other users in the Danube region, exploiting the potential that is not being used in Croatia itself. This is particularly true for the woody biomass sections, but also applies to agricultural residues.

4.4 *Germany*

Germany has been and is among the top players worldwide in terms of use of renewable energies, with biomass as an energy feedstock as the most important source. Regarding the production of electricity from biomass, Germany is the leading producer with 49,9 TWh in 2015,

mainly from biogas and solid biomass, making up 25,5 % of all RES sources (FNR, 2016). In its NREAP, Germany sets out a goal of 18% RES in gross final energy consumption for Germany as a whole in 2020 (NREAP Germany). Especially Bavaria as one of the Danube-adjacent Bundesländer is a frontrunner in Germany in terms of support of bioenergy, with biomass being by far the most important renewable energy carrier (StMWi, 2014).

In 2015, Germany covered 8% of its entire primary energy consumption of 13,309 PJ with bioenergy. Overall, bioenergy makes up two thirds of all RES in Germany (FNR, 2015). According to the latest potential analysis by German Agency for Renewable Raw Materials (Fachagentur für Nachwachsende Rohstoffe, FNR), Germany would be able to cover 25% of its primary energy consumption in 2050 (expected to be at round about 7,000 PJ then) with bioenergy, the major part then coming from agricultural biomass from the residue sector, second would be energy from woody biomass (ibid.). With the so-called Erneuerbare-Energien-Gesetz (Renewable Energy Directive) as its legislative backbone, the German bioenergy market has seen significant growth but also U-turns in certain segments and is now with its latest amendment in 2016 aiming for more stability and sustainability, especially in the use of biomass as a source for energy.

4.4.1 Country Fact Sheet Germany

The German country fact sheet on the biomass and bioenergy market gives an overview of available data on macro-economic indicators relevant for the national market and transnational comparison. Its main goal is to identify the most promising feedstock types available in Germany for utilization in the bioeconomy, mainly as bioenergy feedstock.

COUNTRY: Germany			
Indicator	**Data 2010**	**2016**	**Measure**
Macro Data:			
Inhabitants	81,750,000	82,180,000 (2015)	People
GDP per capita	32,137	37,997	€
Total land area	357,022		km^2
Share of agriculture in gross value added		0.6 (together with forestry and fishery)	%
Share of forestry in gross value added		0.6 (together with agriculture and fishery)	%
Share of energy sector in GDP	2.9% (2011)		%
Energy dependency rate	60.3	61.9 (2015)	%
Danube Indicators:			
Navigable length Danube stretch	213		Km
Number of Danube ports	5		

Land Use, Biomass Feedstock and Energy Indicators:			
Area utilized for agriculture	16,704,000	16,658,900; share of the total area: 47%	ha and share of total arable land
Area utilized for forestry	11,409,000	11,419,000 (2015); share of the total area: 32%	ha and share
Area used for cultivation of energy crops	1,834,000	2,421,000	ha
Fallow land	252,400; share of the area utilized for agriculture: 1.5%	303,400 (2015); share of the area utilized for agriculture: 1.8%	ha and share
Theoretical biomass potential		151.1 Mio t DM (dry matter)	
Technical biomass potential		outlook until 2050: 1,819 PJ or 26% of the total German energy demand (thereof: 988 PJ energy from agriculture --> 2/3 currently being unused, 697 PJ energy from wood --> 1/3 currently being unused, 134 PJ energy from waste --> largely used)	PJ
Unexploited biomass potential		outlook until 2050: 988 PJ energy from agriculture --> 2/3 currently being unused, 697 PJ energy from wood --> 1/3 currently being unused, 134 PJ energy from waste --> largely used (all data from 2016)	PJ
Type/Source of biomass feedstock with highest potential for bioenergy purposes	potentials of biomass byproducts: residual forest wood 218 PJ, grain straw 141 PJ (animal excrements 70 PJ --> not part of the biomass that is taken into account for ENERGY BARGE)		
Type/Source of biomass feedstock with highest current use for bioenergy purposes	crops for biogas: 1,450,000 ha (thereof maize 1,000,000 ha); rapeseed oil for biodiesel/vegetable oil: 760,000 ha; crops for bioethanol: 184,000 ha; crops for solid fuels (e.g. farmed wood, miscanthus); 9.4 Mio m^3 fuel wood (18% of the total logging in Germany)		
Contribution of this feedstock type to domestic biomass supply for bioenergy production	n/a	n/a	ktoe

Annual imports of biomass for energy conversion purposes	biodiesel and FAME (583,977 t in 2014), firewood and charcoal (3,888,923 t in 2014)	n/a	
Employment in Biomass sectors	n/a	119,900 (2015)	Direct employment
Main domestic primary source of energy (e.g. coal, renewables):	Petroleum 34%, Natural gas 22.6%, Coal 12.2%, Renewables 12.6%, Lignite 11.4%, Nuclear energy 6.9%		
Main domestic sector of bioenergy (e.g. biofuels for transport, heating, electricity)	Biofuels 4.8% of the total fuel consumption in the transport sector 2015 (--> 2,688,000 t); bioenergy has a share of approx. 13% of the total heat supply (2015); biomass has a share of 8% of the gross electricity generation (2016)		

Origin/Sector	**Feedstock**	**Potential for growth: yes/no**	**Quantities / Availability (t, m³, etc.)**	**Comment**	**Bioenergy Product/Intermediary (solid, liquid)**
Forestry & Wood industry:					
Wood production and primary wood residues	Wood		68.4 Mio solid m^3	use of wood in general for bioenergy in 2012	Solid
	Residual forest wood	yes	11.9 Mio t DM (dry matter)	amount describes the unused potential	solid
	wood pellets	yes	2.2 Mio t	production capacity 3.2 Mio t	solid
	Logs		22.2 Mio solid m^3 (2014)	used in private households (use of energy wood in total in private households 27.6 Mio solid m^3 in 2014)	Solid
Secondary residues from wood industry (e.g. sawmills)	wood shavings	no		already largely used	Solid
	sawmill by-products	no		already largely used	Solid
Agriculture:					

Oilseeds (primary production & residues)	Oilseeds	yes	760,000 ha / 5.4 Mio. T	current area under cultivation	biodiesel/vegetable oil
Sugar & Starch crops (primary production & residues)	Crops for bioethanol	yes	184,000 ha	current area under cultivation	Bioethanol
Dedicated energy crops/lignocellulosic biomass on agricultural land	crops for solid fuels	yes	11,000 ha	current area under cultivation	e.g. farmed wood, Miscanthus
	Grain straw	yes	8.5 Mio t DM	amount describes the unused potential	Solid
Any other type of agricultural bioenergy feedstock, e.g. residues from industries using agricultural products	none of significance				
Waste & Residue material outside of agricultural and forestry sectors:					
scrap material from landscape management	wood from landscape management	yes	1.2 Mio t DM	amount describes the unused potential	Solid
Post-consumer biomass	biogenic waste	no	36.6 TW/h	potential almost fully exploited	Solid
Other:	None				

Most promising:	
Feedstock type(s):	Residual forest wood (218 PJ)
	Grain straw (141 PJ)
	[Animal excrements (70 PJ)]
Bioenergy product(s):	Solid woody biomass (pellets, chips)
	Straw pellets
	Liquid fuels
Deployment sector(s):	119,900 in the field of bioenergy (2015), heating, electricity, transport

4.4.2 Country Report Germany

Bioenergy Market characteristics

Regarding the political and regulatory framework in Germany for biomass and bioenergy utilization, a number of documents shape the current situation of the German bioenergy market.

The main objective of the National Action Plan ((European Commission, 2017b) of 2010 is to advance the development of renewable energies. The overall goals of Germany's energy and climate policy have not been changed in the last seven years and are outlined in detail (European Commission, 2017c). The main coverage of the German political and regulatory landscape regarding biomass and bioenergy within ENERGY BARGE can be found in WP 6, D.6.1.1.

Established in 2009, the National Biomass Action Plan aims to provide a concept to significantly increase the bioenergy share in Germany's energy supply while adhering to sustainability criteria. The Action Plan for the Material Use of Renewable Resources of 2009 (BMELV, 2009) complements the Biomass Action Plan. It aims at a shift from an industry dependent on fossil resources to a bio-based economy geared to raw materials grown in fields and forests.

The Renewable Energy Sources Act – EEG has existed since April 2000 and has been continuously developed since then. It remains to be the central control instrument for the expansion of renewable energies. On 13th October 2016 the new EEG 2017 (renewable energies act) has been adopted.

In the Renewable Energies Heating Act – EEWärmeG (BMJV, 2014b), amended 20th October 2015, the target of meeting 14% of the heat market demand with renewable energy sources by 2020 is defined. The EEWärmeG aims to facilitate a sustainable development of energy supply and further development of technologies generating heat from renewable energy sources. The Market Incentive Programme (BMWi, 2017) is an integral part of the EEWärmeG and has become a central funding instrument for heat supply from renewable energies.

In January 2016 the revised Combined Heat and Power Act (KWKG) entered into force. The aim is to increase electricity generation from CHP plants, to support the launch of the fuel cell sector and funding for construction and expansion of heating and cooling systems.

The Ordinance on the Generation of Electricity from Biomass (BMU, 2012) of 21st June 2001 regulates which substances are classified as biomass, which technical procedures for electricity generation from biomass fall within the scope of application of the Act and which environmental requirements have to be met when generating electricity from biomass.

The requirements of the RED are implemented into German legislation through the Biofuel Sustainability Ordinance and the Biomass Sustainability Regulation.

The purpose of the Biomass Electricity Sustainability Regulation (BMJ, 2009) of 23th July 2009 is to ensure the sustainability of the generation of electricity and heat from liquid biomass.

The Biofuels Sustainability Regulation (BMJ, 2011) of 1st January 2011 is intended to ensure the

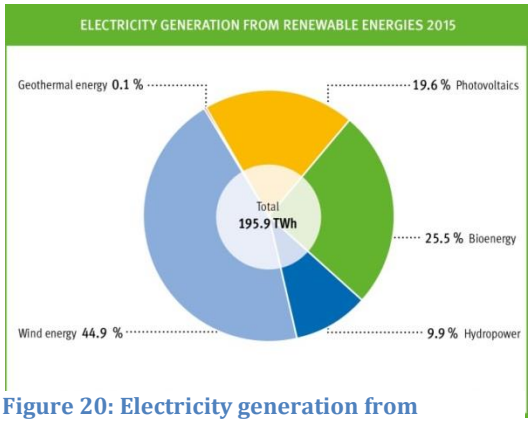

Figure 20: Electricity generation from renewable energies in 2015 (Source: FNR, 2016)

sustainability of biofuel production. For this reason only biofuels are calculated for the biofuel quotas, which meet certain requirements for environmental protection and sustainable agriculture. The Biofuels Quota Act (Bundesanzeiger, 2009) of 1st January 2007 declares to add a certain percentage of biofuels to all petrol and diesel fuels placed on the market.

With over 61%, biomass is the largest contributor to energy from regenerative sources in Germany. It is mainly used for heating. While wind power dominates in power generation, biomass is currently the only regenerative source in the fuel sector.

32.6% of German gross electricity consumption came from renewable sources in 2015. Although the largest share is supplied by wind power plants, the contribution of bioenergy is also important. With a share of 50.0 billion kWh, it generated around 25.5% of renewable electricity in 2015.

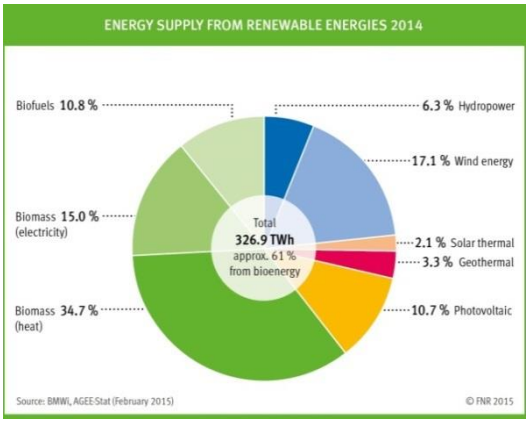

Figure 22: Energy supply from renewable energies in 2014 (Source: FNR, 2016)

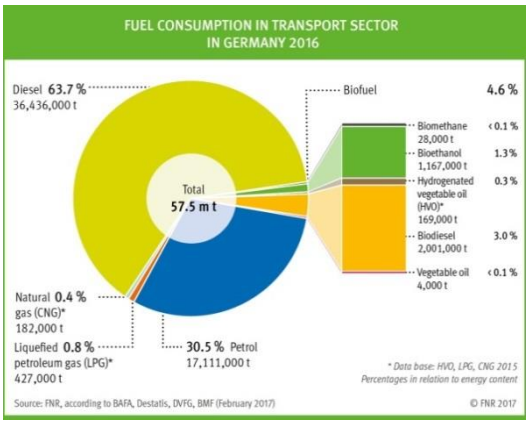

Figure 21: fuel consumption in transport sector in Germany in 2016 (Source: FNR, 2016)

Biomass is the most important renewable energy source for heat generation. The share of biomass for heat from renewable energies accounted for 88% in 2015. It includes the provision of heat from solid fuels (e.g. wood), liquid fuels (e.g. vegetable oil), gaseous fuels (e.g. biogas from manure and energy plants as well as sewage and landfill gas) and the biogenic fraction of waste.

In 2016, 3,369 million t of biofuels were sold in Germany. Biodiesel is the most important biofuel in Germany with 2.0 million t, followed by bioethanol with 1.17 million t and fuel from hydrogenated vegetable oils with 169,000 t.

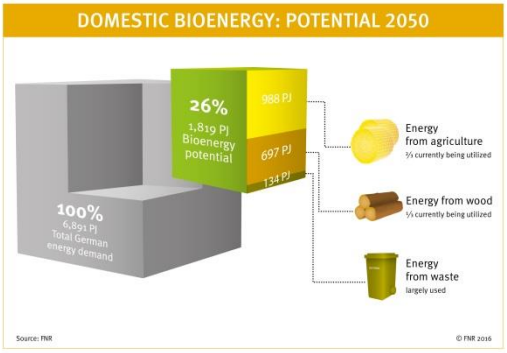

Figure 23: Domestic bioenergy potential in 2050 (Source: FNR, 2016)

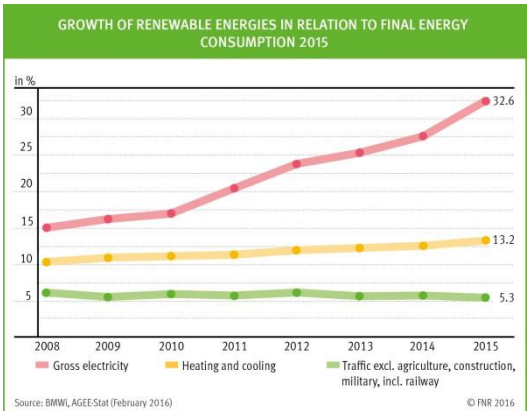

Figure 24: Growth of renewable energies in relation to final energy consumption 2015 (Source: FNR, 2016)

Renewable energies have steadily increased over recent years. Especially electricity generation from renewable sources has grown continuously. The energy scenarios of the Federal Government of Germany and the Agency for Renewable Resources assume that in 2050 the contribution of bioenergy can cover 26% of the energy demand. It is estimated that the primary energy requirement at this time is 7,000 PJ, this is half of the requirement of the year 2008. Prerequisites are also high yields and efficient conversion procedures. The most important contributing biomass types will be energy from agricultural residues, mainly grain straw(1/3 unused, 988 PJ), forest residue materials (2/3 unused, 697 PJ), and animal excrements and waste (not considered in ENERGY BARGE). These are also the most promising biomass types as identified in the country factsheet (FNR, 2016) In the following, the most important stakeholders, both public and private, in the national biomass and bioenergy market are presented and analysed. For each biobased feedstock type, energy carrier and deployment sector, interest groups and associations exist on national, and often even on regional level.

Policy makers – Federal Government

The Federal Government provides the framework for climate policy the overall goal is to cover Germany`s energy supply mainly with renewable resources in 2050. The expansion of bioenergy in all sectors (heat, electricity and fuel) is a building block for achieving this goal (Bundesregierung, 2017).

The potentials of biomass residues will be exhausted in the future. Therefore manure, green cut and organic waste will contribute more to the generation of energy. Furthermore an improvement of the feed-in potentials for bio methane into the natural gas network is contemplated. Nevertheless, it should be noted that bioenergy must not endanger a sustainable agriculture and forestry.

The German Federal Government provides the legal framework for bioenergy. The ambitious goals are supported with special funding programs and laws (see ENERGY BARGE D 6.1.1).

Plant operators

Plant operators e.g. for biomass heat and power plants or biogas plants, need a political framework that concentrates on clear and reliable market perspectives for the sustainable use of bioenergy in the electricity, heat and fuel market.

The EEG (Renewable Energy Sources Act), as the central control instrument for the expansion of renewable energies, is very important for existing and future plant operators. The amendment of this law in 2017 provided the possibility of continuing to operate existing bioenergy plants by participating in a tender even after expiry of its EEG remuneration period. From the view of plant operators, the tendering procedure has to be designed more detailed to provide a real prospect for the existing plants. In addition, the right conditions have to be set so that the potential of the existing bioenergy plants can be fully exploited. This includes a comprehensive upgrade to a flexible driving system, the expansion of heat consumption and a maximization of greenhouse gas savings. In order to further develop bioenergy technology and to replace decommissioned plants, there should also be a moderate addition of new and innovative plants.

The use of biomass for heat generation should be further developed both in efficient decentralized heaters and in heating systems. The duty to reduce GHG emissions in transport, which has been introduced in Germany since 2015, is an effective instrument for improving climate efficiency. This is why it should be consistently developed further. Therefore it is necessary to gradually increase the GHG quota 4.0% today to 6.0% in 2020 and not in a single step in 2020. Also for beyond 2020, a clear commitment should be given to develop or increase the GHG quota (Bundesverband Bioenergie, 2017).

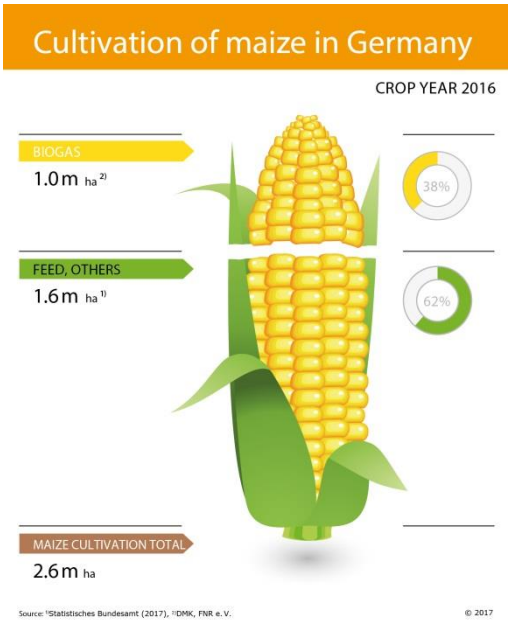

Figure 25: Cultivation of maize in Germany (Source: FNR, 2016)

Society

93% of the German population supports the expansion of renewable energies (Agentur für Erneuerbare Energien, 2017). However, the acceptance is not unrestricted and it must be differentiated. For large biomass and, in particular, large biogas plants the acceptance decreases especially in regions which have a high density of those plants. Reasons are possible odor problems, pollutant and noise emissions which are associated with the transport of the substrates. Moreover the monoculture in the landscape caused by large-scale maize cultivation is a problem for some parts of society (Bioökonomierat, 2012). This is not unfounded as within the last decade corn cultivation has increased to 2.6 million ha in total. The share of maize cultivation in Germany today is 20% of the entire arable land. This means that maize has become the most important arable crop in Germany after wheat. Regulations on the regional limitation of maize cultivation could increase the acceptance of bioenergy and reduce

the negative ecological impacts of maize cultivation (BMELV, 2011). Furthermore the expansion of the energy plants spectrum and the cultivation of plants with higher yields per area could also increase society's acceptance. More specific fertilization and plant protection could also improve the opinion of the German population. If the society is willing to accept modern methods of plant breeding, including transgenic plants, is not clear at this point in time.

Farmers

The expansion of renewable energies has given additional jobs, added value and economic power to rural areas in Germany. The EEG has opened up new income opportunities for farmers and made them important stakeholders in the process of the "Energiewende" (energy transition). The farmers have to find a balance between the task of food production and the production of biomass for bioenergy purposes.

The German Farmers' Association (Deutscher Bauernverband) has formulated its ideas for the future development of the bioenergy sector (Deutscher Bauernverband, 2014). When planning new power lines, the protection of the area and agricultural structures must be taken into account. The possibilities for the development of farms must not be restricted and a dissection of those areas has to be reduced to an absolute minimum. Moreover earth cabling of high-voltage cables is seen critical due to the massive impact on the soil structure and the productivity of the soils. Projects within the framework of grid expansion for renewable energies are particularly suited to environmental and climate protection and therefore have to be exempted from nature conservation. The use of residues and by-products has to be increased.

The following applies to the individual utilization paths:

Biofuels: The EU and Germany must provide a reliable framework. Therefore double and multiple calculations of residues as well as emission factors for indirect land-use effects (iLUC) are rejected.

Electricity: Made investments have to be strictly protected by the EEG. The EEG must remain open for new, decentralized concepts beyond the large electricity suppliers. Particularly important for this, is the exemption of own and local electricity consumption. The planned switch to tendering procedures leads is not accepted as an adequate process. New photovoltaic plants on agricultural land should no longer be promoted.

Heat: Heat from biomass is competitive. In order to support the modernisation of buildings, the political blockade for tax promotion has to be overcome. In the field of industrial use, the industrial users are asked to revert to renewable raw materials to a greater extent than before.

Forest owners

Forestry products, no matter if used conventionally or as energy wood, represent a carbon sink or have a favorable effect on the carbon footprint by replacing fossil fuels. Every piece of wood or other biomass removed from the forest means also a removal of carbon and nutrients from the forest ecosystem. The limit is then exceeded if the nutrient balance is negative. In the long term, depletion always leads to a reduction of soil fertility, unless compensatory measures, for

example fertilization, are taken. Experimental results from Scandinavia, Austria and Scotland show that considerable growth losses are possible after intensive biomass use (Meiwes et al., 2008). This should be avoided if the use of energy wood is supposed to be economical and sustainable. Increased use of wood and biomass has to be carried out in a way where the nutrient balance remains intact (ibid.).

Nature Conservation

From the view of nature conservation the energy potentials should only be exploited by taking into account the natural compatibility, as Germany has committed itself to preserving biodiversity. Therefore the promotion and support of adapted land use methods should be a main concern of climate protection. An expansion of bioenergy which has a negative influence on nature and landscape must not receive any support (Bundesamt für Naturschutz, 2010). The promotion of bioenergy should be reconciled with the needs of nature conservation. This includes the consideration of nature conservation and resource protection needs in the cultivation of energy crops in the field, the maintenance of extensive and species-rich grassland, the establishment of new, diverse crop rotations and short rotation coppices, the use of cutting material from uncultivated land, edge structures (i.e. hedgerows) and nature conservation areas as well as the upgrading of degraded land (ibid.; Deutscher Verband für Landschaftspflege & Naturschutzbund NABU, 2007). The German biomass and bioenergy market, as depicted above, is a "high performer", NREAP goals are in reach – but also, a number of weaknesses and risks are present, that influence the current and future market development. A qualitative SWOT analysis as presented in Table 14 gives insight into the situation.

Table 14: SWOT Analysis for the German bioenergy market

Strengths	Weaknesses
▪Strong political support schemes ▪ Reduction of GHG emissions ▪ Independence of energy supply ▪ Energy supply gets independent from fossil resources ▪ Decentral production of heat & power ▪ Well-established technologies, particularly for heat & power ▪ Well-developed market actor landscape with strong interest groups	▪ Full supply of biomass cultivated in Germany is not possible ▪ Government subsidies create economic costs and dependencies ▪ Lacking economic viability for several sectors ▪ Lack of security for investments
Opportunities	**Threats**
▪Unused potentials of residue materials ▪Economic development of rural areas ▪ New income opportunities for Farmers ▪ Creation of new technologies opens new markets ▪ Steady backup for more fluctuating RES sources e.g. wind and solar ▪ Rising feedstock demand from the material-chemical use sectors (can be both opportunity and threat)	▪ Continuously low levels of fossil fuel prices ▪ Development of monocultures for the cultivation of energy crops ▪ Disturbance of the landscape picture ▪ Worldwide rising prices and competition for arable land ▪ Lacking societal acceptance ▪ Rising feedstock demand from the material-chemical use sectors (can be both opportunity and threat) ▪ Lack of stringent sustainability criteria for all sectors of bioenergy

Market profile: Analysis of most promising biomass/bioenergy supply chains

As can be seen in the country fact sheet and the market characteristics section, the most promising supply chains in terms of future potential, availability, sustainability, and technology for bioenergy in Germany are based on 1) woody biomass, mainly from forest and wood industry residue material, feeding into both the electricity and heating sector and 2) agricultural biomass, mainly residue material such as grain straw and energy crops, feeding into the heating and transport fuels sector (FNR, 2015). Both also have high potential for material use. The technical energy potential for agricultural residues adds up to 988 PJ, that of woody biomass to 700 PJ for 2050 (FNR, 2016). In the woody biomass segment, the most promising feedstock type group stems from the forest residue material (218 PJ), for the agricultural biomass, it is grain straw (141 PJ). In the following, more nuanced profiles of these two feedstock types will focus on market-relevant aspects along the supply chain towards their respective bioenergy utilization segments (solid and liquid biomass, heating, electricity and transport fuels).

The main types of woody biomass with unused potential stem from residue materials from the forestry industry, mainly from prunnings, logging, shavings and thinnings (FNR, 2015; S2Biom, 2016). 31.9 % of Germany's entire area was covered by forest in 2016, which equates to 11.4 mio. ha. Overall, 10.5 mio. m^3 from the around 56 mio. m^3 sustainably harvested wood from German forests was used for energetic purposes (FNR, 2016). Due to the forest residue material's physical properties, the majority of this woody biomass can be used either in the final form of wood chips or wood pellets as a bioenergy product. This means either physical conversion through hacking (wood chips) or pressing (pellets, briquettes) is necessary a final conversion step (FNR, 2014). As such, particularly the heating and power sectors are the main deployment sectors that can benefit from the unused potential, especially CHP plants for distant and district heating purposes as well as household boilers.

Price development for woody biomass products for bioenergy purposes depends on common market rules, namely supply and demand, meaning that for the fuel product as such, no state aid mechanisms are in place (only for the heating appliances themselves) (C.A.R.M.E.N. e.V., 2017). Factors further influencing the price are feedstock costs (thus the forest residue materials or in a conventional case for pellets, saw mill residues), production costs, and logistics costs. Also, the type of packaging (big bags, bulk delivery, smaller bags), distance of delivery to the final customer and volumes bought have an influence on the final price. When using the free potential from forest residue materials, the logistics costs might pose a decisive factor as the material occurs decentralized in forests and needs to be collected transported to places of conversion. In general, independent of the feedstock used for their production, prices for wood chips and pellets develops independent of fluctuations in the conventional fuel sectors (oil and gas) and lie well below the prices for these fossil-based fuels, in relation to their caloric value. This situation is expected to stay the same at least for the medium term (FNR, 2009).

For many years now, German production volumes of pellets and wood chips have surpassed the demand, making Germany an exporting country for these bioenergy products. Moreover, with a high share of woody biomass resources potentially usable for energy purposes unused at current state, it can be assumed that pellets and wood chips can contribute extensively to

security of supply with renewable energy sources and further reducing dependency on fossil fuels (C.A.R.M.E.N. e.V., 2017).

In recent years, prices for both pellets and wood chips have risen moderately. In general, due to the higher need for conversion, pellets are more expensive and cost between 200 – 280 €/t. Wood chips , depending on the water content and the area sold (Northern or Southern Germany), cost between 70 and 130 €/t (ibid.). In the figure below, the price development curve is shown in €/MWh as this is the indication used most commonly for wood chip pricing.

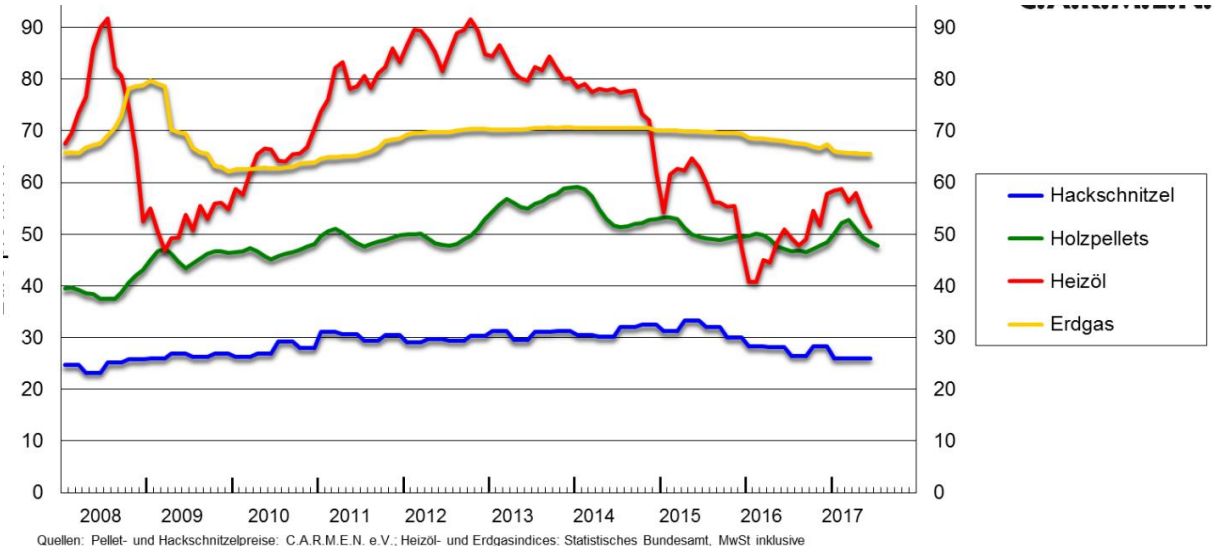

Figure 26: Price development of wood chips and pellets in Germany compared to oil and gas (Source: ibid.)

The main share of unused potential from agricultural residues in Germany currently stems from grain straw from wheat and barley (FNR; 2015b). Regarding deployment sectors in bioenergy, straw can be burned in straw-fired heating systems or can be converted to second generation biofuels for the transport sector, converting the carbohydrates in the cellulose via fermentation into ethanol, as e.g. the company Clariant is doing it in demoplant in Straubing (Clariant, 2017). In comparison to imported fossil-based fuels, straw has the advantage of sustainable and relatively price-stable availability according to FNR's publication on heating with straw (FNR, 2015b). Straw as a feedstock for bioenergy production is not supported by state-regulated support schemes or mechanisms.

Straw however has an important function of improving soil fertility by providing nutrients after harvest. Depending on soil quality and region, straw is left on the fields to decompose there. Another competitive use stems from its use as bedding material for livestock such as horses, coverage material for vegetable farming and also material use, e.g. for insulation purposes. Therefore, availability of straw as a feedstock for energetic use is limited and can vary from region to region depending on soil quality. In this respect, straw from non-cereals such as maize or rape straw have less competitive uses and can also contribute to an increased potential for energy usage (S2Biom, 2017). Consequently, in regions with nutrient demand in soils and large quantities of horses, prices are higher (FNR, 2015b). In Lower Bavaria for example, where the Danube stretch runs, soil requires humus builders such as straw, which is why farmers tend to

leave large quantities of straw on the fields, making them demand high prices on the "straw market", amounting to up to 120 €/t. According to the FNR; the average straw price "from the farm" lies around 75 €/t, however, the span reaches from 40 to above 120 € per t (S2Biom, 2017). Straw can be delivered and packed in different forms, e.g. in big quadrated bales, round bales, or small bales. The cheapest feedstock prices on the straw market can be found in Saxony (50 €/t), the most expensive in Hesse (106.67€/t) (Agrarheute.de, 2017).

The economic viability of a straw-fuelled heating system, especially compared to a fossil-fuelled system, mainly depends on the usage rate of the system. With a caloric value of about 4 kWh/kg for dried straw, the sustainable potential of around 10 Mio. t of straw as indicated by the FNR; this accounts to 4 Mio. t oil equivalents. A straw-fired combustion system of 600 kW has amortized its investment costs in €/MWh in comparison to an oil-fired system based on oil price of 0.65 €/l after 2,000 hours of running time per anno. In general, decentral biomass energy utilization based on straw has effects of municipal added value creation (FNR, 2015b).

Regarding the technical potential of the two selected feedstock types for future energetic use in Germany, the following picture arises. The future energetic, but also material use of forest residue wood and grain straw as most promising type from the agricultural residue materials section depends of both economic and political factors (FNR, 2017). The potential, both technical and sustainable, differs regionally across the country. The German Agency for Renewable Energies has published a potential forecast study in 2012 for 2020 for all 16 German Länder separately (Agentur für Erneuerbare Energien, 2014). The technical potential according to this study for the entirety of Germany is 103,121 TJ for grain straw and 511,439 TJ for forest residue materials (ibid.). According to a projection of the FNR and the German Biomass Research Centre (FNR, 2015), the technical potential for energetic use of currently unused feedstock is even higher, especially for grain straw, as described in the section above and indicated in the country fact sheet. In total, they sum up to 30,9 Mio. t of dry matter, of which around 60 % stem from forest residues (11,884,000 t) and grain straw as agricultural residue (17,577,000 t) as indicated in the figure below (FNR, 2015).

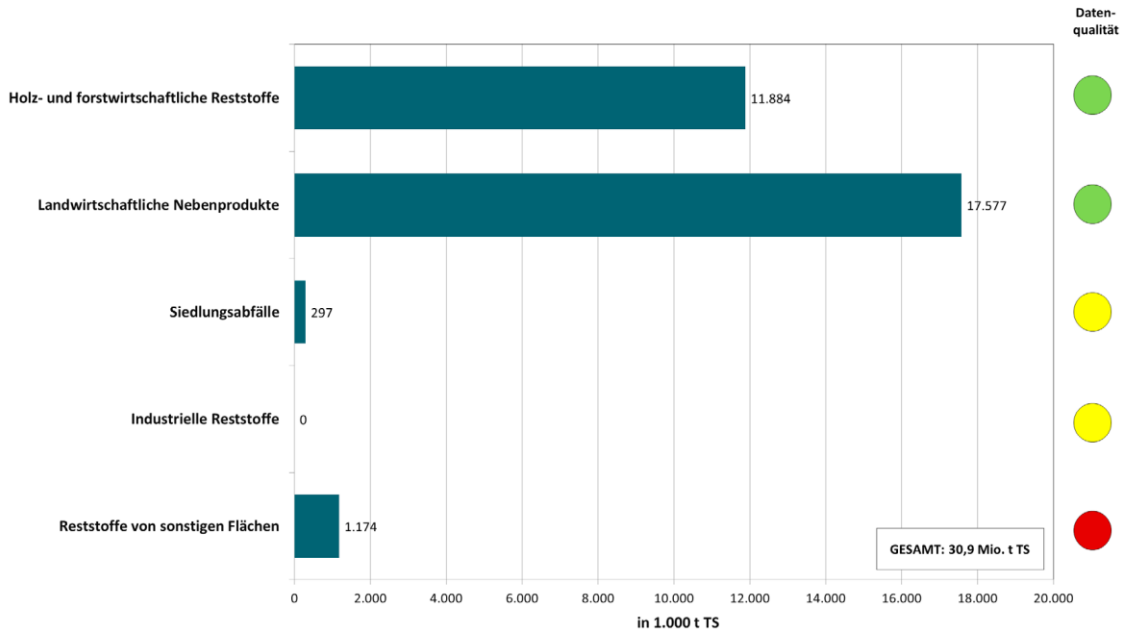

Figure 27: Unused technical biomass potential in tons dry matter (Source: ibid.)

When referring this to energetic use, the current potential of these most promising residue types is as follows:

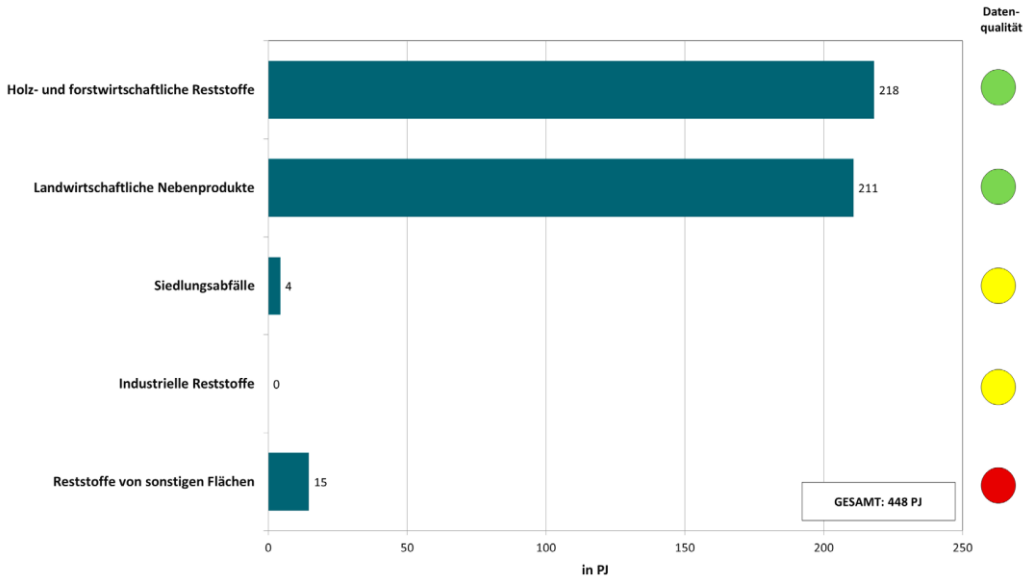

Figure 28: Unused technical potential of biomass for energetic use in PJ (Source: ibid.)

In order to achieve efficient, sustainable and economically viable utilization paths for biomass – both for energetic and material use and for biomass from the agricultural and the forestry sector– it is decisive to establish long value chains, utilizing as many side- and residue product streams as possible. Especially potentials of residue material use which is indicative from a sustainability-related point of view, depend on the value and supply chains of the main agricultural and forestry products (e.g. wheat, log wood) and are influenced by factors such as

optimized crop rotation systems, harvest and logging structures, existing material flows, etc. These again depend on regional and geographical conditions, availability of technologies and equipment, and suitable process chains. Thus, the theoretical, technical and sustainable potentials of all kinds of biomass feedstocks can only be optimized to a limited extend, but clearly need the cooperation between suppliers, research and downstream processing industries. Moreover, data availability especially on lower regional spatial levels (NUTS 2, 3) and for residue feedstock flows is still limited and thus makes potential estimations rather difficult (BERST, 2015; BiomassFutures, 2012; FNR, 2014; 2015).

For both forestry residue materials and agricultural residues, esp. straw, these relatively long, well-established supply chains of the main products already exist in Germany. Therefore, integrating a cascading additional energetic use of these residue materials is less challenging than establishing an entirely new supply and value chain. This factor elevates the technical potential for energetic utilization of these feedstocks in Germany and thus a contribution to sustainable feedstock supply for the bioenergy sector. This of course also simplifies an analysis of suitability for inland waterway transport and whether this system can be integrated in existing value chains, improving economic and environmental sustainability of these chains.

Forestry residue material: pellets & chips

A number of EU-funded projects has specifically focussed on analysis of logistics behind entire biomass supply chains and the value added in every step, creating value chains, for example BioPad and its tool "Biscuit" (wood) (BioPad project, 2014), or BioRes and its Biomass Logistic and Trade Centres (BioRes project, 2016) or Simwood (Simwood project, 2016).

For forestry residue material targeted at energetic use, the established supply chain and underlying logistics is systematically depicted in the figure below in relation to the general underlying ENERGY BARGE logistics chain system.

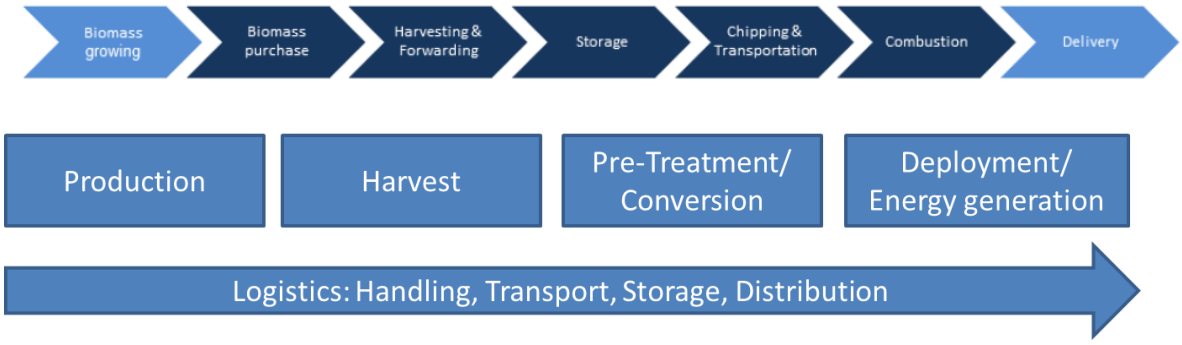

Figure 29: General woody biomass supply chain for energetic utilization (Source: BioPad project, 2014 + own figure)

Market actors directly involved along this chain include:

- Forest owners, private & institutional/public
- Forest workers
- Forest authorities

- Wood-related service providers for forest owners
- Wood trading business
- Logistics providers
- Sawmills
- Pellet- and wood chip-producing industry
- Pellet and wood chip traders
- Pellet- and wood chip boiler industry
- End consumers (individual households, private companies, public authorities)

Especially at the beginning of this chain, actors in general are located rather close to each other (FNR, 2009). As Germany is a net pellet exporter (9 % of total production volume of total production of 1,1 Mio. t from January to June 2017), end consumers can also be located outside of Germany, e.g. Italy is a target market for German pellets (proplanta, 2017). However, especially pellets are mainly characterized as a regional energy carrier (Deutsches Pelletinstitut, 2017). In Germany, there are 37 pellet producers operating at 54 locations out of which over 50 % are located in Baden-Württemberg and Bavaria and thus in the two Bundesländer which are part of the Danube region. In Bavaria, at least six ENplus producers are located close to the river Danube in lower Bavaria. Over 50 % of the over 100 certified traders have their main location also in those two Länder (ENplus-pellets.de, 2017; Deutsches Pelletinstitut, 2017).

Figure 30: certified pellet production sites in Germany (Source: DEPI, 2017b)

In terms of spatial distribution, all elements of this chain are generally decentralized with attempts to cluster and centralize steps such as storage, conversion (e.g. chipping or pelletizing, depending on the final product) and trade in order to improve economic viability and economies of scale (BioRes project, 2016). End consumers can be both bulk consumers (e.g. CHP plants) or private households. In terms of wood pellets and chips from forestry residue materials, the processing from the initial residue feedstock to the final energy carrier happens in pelletizing plants which usually are located close to either sawmills or directly located at wood logistics centres (FNR; 2009). Residue material usage directly from forests however has not yet been fully exploited and logistics options for transport from the location of residue generation (forests) to location of energy carrier production (pelletizing plant) have to be fully developed (FNR, 2017).

With wood pellets and chips being categorized as flowable bulk goods, the logistics chain from production to trade and end consumer is rather simple and economically viable. Pellets and wood chipss are standardized in terms of quality according to the standard DIN EN ISO 17225-2 and thus are easy in handling and can be transported in automated conveying systems at the end user. Certification standard for most pellets produced in Germany is the ENplus standard (C.A.R.M.E.N. e.V., 2017; FNR, 2009). Pellets are often transported in big bags, however, they are

oftentimes delivered in road tank cars (FNR, 2009). Wood pellets have a bulk density of around 650 kg/m^3 and a water content of between 10–15% (Deutsches Pelletinstitut, 2017). In terms of storage and handling, pellets are generally not characterized as dangerous good. However, pellet storage facilities need to be ventilated to avoid development of carbon monoxide. No other hazards are characteristic for wood pellets and chips (C.A.R.M.E.N. e.V., 2017; Deutsches Pelletinstitut, 2017; FNR, 2009). Also, pellets can be prone to mechanical degradation which in turn reduces their calorific value and quality.

Due to this feature and the fact that pellets are mainly designed to be energetically used regionally and in proximity to their feedstock's origin for both economic and environmental reasons, the energy products deriving from forestry residue materials are no obvious cargo for inland waterway transportation from or within Germany. However, an economic assessment of this alternative transport route would be indicative and sensible, especially since round wood is a classical cargo good for inland waterway transport, however mainly for material use. Moreover, inland ports along the Bavarian Danube could be logistically suitable locations for production sites for wood pellets and wood chips from forest residue material which does not system-immanently occur at saw mills but decentral and directly in the forests, making feedstock collection at a central point necessary. With Bavaria being the by far biggest wood producer in Germany (18.6 mio. m^3 in 2015; BMEL, 2016)The geographical situation of the Bavarian Danube which is the navigable stretch of the German Danube that is connected to the Rhine via the Main-Danube channel unfolds in a way that the rich wood resources of the Bavarian Forest are a maximum of 100 km away from at least one of the Danube ports (googlemaps, 2017), making transportation to the ports for further processing a sensible option.

Agricultural residues: grain straw

In terms of grain straw, it has already been pointed out that in a market-related point of view, straw is not waste but a contested resource with a market, that however is regionally varying and an option for the farmer which is usually the sole producer/supplier of straw, to generate additional income (S2Biom, 2017).

The underlying supply and value chains of straw as an energy feedstock differ from those of wood-based products as described above and are not as established with respect to the end of the chain that relates to the actual energy generation and combustion yet. This is due to the fact that the energetic potential of grain straw in Germany is not fully utilized yet and straw in some regions without competing utilization options is just brought back into the soil (FNR 2015, 2015b).

The first elements belong to the classical agricultural supply chain of grain production on farms and thus are highly decentralized in terms of spatial distribution. These chains are well-established and include farmers, agricultural service providers and contractors such as the "Maschinenring", agricultural traders and cooperative associations, processors and end users of the primary (edible) agricultural products with the latter two being both domestic and foreign.

Looking at the energetic utilization of straw, all types of straw are potentially usable as solid biomass for bioenergy purposes. Besides grain straw, also rape straw, corn stover or sunflower

straw – thus the residues of all other crops typically grown in Germany can be converted to energy. However, two different types of conversion and target market can be differentiated. Both are in a stage of early development in Germany and thus have potential for increased market uptake (FNR; 2015). Firstly, straw can be combusted for electricity and heating purposes. Especially district heating has a potential for straw as fuel, allowing a regionally fuelled, stable, reasonable priced and sustainable heating system that additionally contributes to job creation and additional income sources for farmers and other related branches in rural areas (FNR, 2015). Secondly, straw for energetic purposes can also serve as a feedstock for transport fuels, either bioethanol or biomethane for CNG technology – so-called advanced or second-generation biofuels. Both products are based on biotechnological fermentation processes of the lignocellulosic biomass (straw) and can have alternative material-chemical usage (Clariant sunliquid project, 2017; verbio, 2017).

In the first utilization path, straw can be either pelletized or mechanically shredded and be combusted in bulk combustion plants. This however only makes economic and environmental sense on a regional level and in regions that are suited, i.e. with high numbers of crop production and little competition for straw. Both public and private actors can install these combustion systems. In Germany, so-called bioenergy-towns already have straw-combustion for heating purposes (FNR, 2015). In terms of actors for this value chain, companies offering technical equipment such as the combustion systems are important. A number of these producers exists in Germany. Also, farmers and agricultural contractors need to ensure a certain quality for the straw to allow the combustion to run smoothly, this includes water content, avoidance of stones and other impurities in the straw, and low content of chlorine (ibid.). In order to allow this utilization path to further develop, it is important to close the logistics and trading gaps between the early elements of the supply chain (farming) and the latter elements (energy generation), making it able for actors running straw combusting plants to buy feedstock.

The second path of energetic utilization for straw, namely the transport fuel path, in Germany can still be described as an emerging market. Commonly, bioethanol is produced from first generation biomass such as maize, wheat or sugar beets (International Council on Clean Transportation, 2012). Nevertheless, there are companies already producing these advanced biofuels from straw on a market or pre-market scale in Germany and have developed logistics and production strategies that can be both central (large-scale production plants) and decenteral. These companies in a supply chain would take the part of processors and also traders. An additional supply chain actor group in this case is depicted by the fuel traders and fuel station network in Germany. The end consumer would be everybody owning a petrol-fuelled or CNG-fuelled (in the case of biomethane) car. Compared to the straw-combustion, this utilization path generates residues itself in the process of conversion. These products, namely lignin and stillage, can both be used energetically (lignin) or for the feed industry (stillage) and can contribute to circular economy and added value.

Regarding logistical needs, this utilization path is more complex. Straw in higher quantities is needed especially for industrial plants. In an anonymous expert interview with a company producing advanced bioethanol, it was stated that 240.000 t of straw are needed per anno to produce around 50,000 t of ethanol. Around the same amount of residue material that needs to

be transported away from the plant incurs. Also, large storage areas are needed (FNR, 2015). According to this interview, the straw, due to its comparatively low energy density and specific weight, will not be prone to inland waterway transport. This is confirmed by FNR that state that there is nearly no transregional trading and competition for straw at the moment (FNR, 2015). A different picture however arises for the product ethanol and residues lignin (if not used for firing the ethanol plant) and stillage.

With respect to market uptake, clearly the bioenergy produced from the high potentials of woody biomass currently has a higher market penetration in Germany than the advanced biofuels market based as well as heating based on straw. This generally means that although the theoretical, technical and also sustainable potential for energetic use of the two identified most promising feedstock types is high and evident (FNR, 2017), market uptake of the final energy carrier products and energy generation from these sources is comparatively low – due to a number of technical and non-technical reasons. For example, according to the German federal association for bioethanol industries (BDBE), in 2016, only 12,310 t out of 739,000 t of overall bioethanol production was produced from non-food residues. However, this amount is a 56% increase compared to 2015(BDBE, 2017), which indicates that this market in Germany is currently growing.

In the following table, the key technical and non-technical factors influencing future market uptake for the two identified most promising biobased feedstock groups in Germany depending on their manifestation are gathered.

Table 15: Factors influencing market uptake of forest residue material supply chain for energetic purposes

Forestry residue material – pellets/wood chips – CHP/heating/electricity
• Political strategies, goals and mechanisms towards mitigation of climate change and success of the "Energiewende" on several levels
• Political objectives to increase the utilization of biobased residue material potential and incentives for forestry sector to mobilize these potentials
• Political support mechanisms and investment incentives for bioenergy appliances based on woody biomass
• Market prices for fossil fuels
• Complex and heterogeneous structures of forest ownership
• Fluctuation of technological and sustainable potentials by region
• Logistics for collection of residues to storage and conversion sites from forests
• Dependence of availability of residue feedstock on market demand from primary wood industry
• Overproduction and export options
• Efficiency of combustion technologies and suitability for medium- and large-scale appliances beyond household level

Table 16: Factors influencing market uptake of grain straw supply chain for energetic purposes

Grain straw – straw pellets – heating
• Political strategies, goals and mechanisms towards mitigation of climate change and success of the "Energiewende" on several levels
• Political support mechanisms and investment incentives for bioheating appliances to avoid investment disadvantages compared to fossil fuels
• Market prices for fossil fuels
• Regional disparities of feedstock availability
• Competition of usage / alternative utilization
• Regional appliance / demand market
• Seasonal fluctuations in feedstock availability and quality
• Interest of farmers for new market options
• Efficiency of combustion technologies and suitability for medium- and large-scale appliances beyond household level
Grain straw – bioethanol/biogas – transport
• Political strategies, goals and mechanisms towards mitigation of climate change and success of the "Energiewende" on several levels
• Market prices for fossil fuels
• Political support mechanisms for market penetration of biobased transport fuels
• Political support mechanisms for conventional transport fuels
• Regional disparities of feedstock availability
• Competition of usage / alternative utilization
• Seasonal fluctuations in feedstock availability and quality
• Regional supply vs. global demand market
• Interest of farmers for new market options
• Economic viability of conversion technologies and products (technology readiness)

4.4.3 Conclusion on Market Study Report Germany

Germany has been one of the leading EU countries in terms of use of bioenergy from sustainable sources for many years. Still, unused *and* sustainable energetic potential exists that could allow Germany to cover up to 26 % of its primary energy demand by bioenergy in 2050 (FNR, 2017). Exploiting this potential which is for example provided by forest residue material or grain straw can highly contribute to value added generation in rural areas, including job creation, as well as to security of supply with environmentally friendly energy sources.

For the most common bioenergy value chains, stable structures and markets exist, mainly shaped by political frameworks which also create a certain dependence of the markets on political stability. A widespread network of interest groups and associations lobbying for the different kinds of biobased feedstocks and bioenergy market segments has developed. Most bioenergy value chains in Germany have functioning, often regionalized systems. Mobilization of the currently most unused feedstock types will however require further political support and innovation along the value and supply chains, e.g. regarding provision of security of feedstock supply/availability and logistics options. Clearly, biobased lignocellulosic residue materials such as straw and wood can also be used for chemical-material purposes, opening up additional future markets for these feedstocks in utilization cascades. This also has an indication for logistics needs as the new demand market is located more centralized than the classical bioenergy demand, opening up options for environmentally friendly transport modes such as

inland waterway transport and inland ports as bio-hubs. As the regions along the Danube are among the most fertile agricultural and forest regions in Germany with consequently high amounts of residue material, new transport and logistics options can also be offered to bioenergy supply chains built on these feedstock types (both primary and residue feedstock) from the inland waterway transport sector.

Overall, ongoing support for the sustainable market uptake of unused biomass potentials politically and technically will be of special importance as the residue material potential from agriculture and forestry can contribute to reaching Germany's energy- and climate goals to a great extent (FNR; 2015b). In general, with the support of increased research and also innovation along the value and supply chains, efficiency and competitiveness of already established and new paths of utilization for biobased feedstocks can be improved in Germany (FNR; 2015), provided that political frameworks ensure stability and reliability for investments.

4.5 *Hungary*

As a Member State of the European Union, the adopted common legislation and long-term strategic objectives set out several tasks for Hungary in the field of bioenergy. The Renewable Energy Directive (RED) of the European Parliament and of the Council specified a legally binding obligation for Hungary to ensure a 13% minimum share of renewable energy in gross final energy consumption by 2020. As part of the Europe 2020 Strategy aimed at energy and climate policy, Hungary is committed to increasing its rate of renewable energy sources consumed to 14.65%, and a maximum 10% increase in greenhouse gas emissions (compared to the 2005 level) by 2020 in the sector outside the scope of the EU Emissions Trading Scheme, and aimed at a 92 PJ primary energy savings target value, which, taking the year 1990 as a basis, is a 16.2% saving.

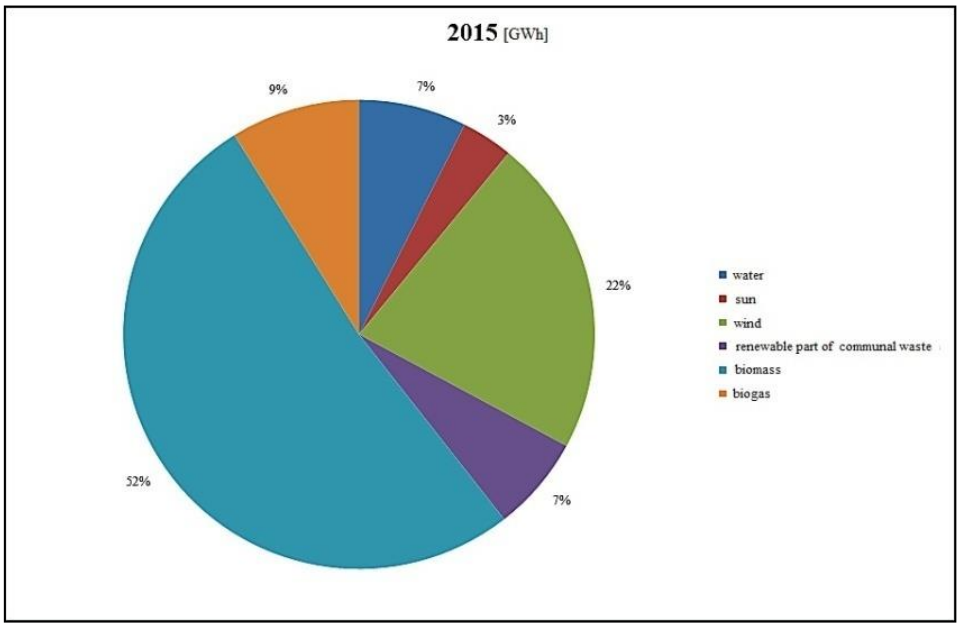

Figure 31: Gross electricity generation from renewable energy sources in 2015 (Source: Hungarian Energy and Public Utility Regulatory Authority, 2017)

Figure 31 demonstrates the gross electricity generation from renewable energy sources in 2015. Roughly 52% of the electricity was generated from biomass, 22% from wind power, 9% from biogas, 7% from recycled waste and 3% from solar power.

The share of RES in the energy mix rose from 2.2% in 2004 to 10.5% in 2015, the main contributor being biomass based power generation. Based on the last available data electricity generated using renewable resources edged up by 0.7% (compared to 2014) to 3,159 GWh in 2015. According to the National Renewable Energy Action Plan, Hungary has excellent agro-ecological conditions for a competitive production of biomass that is sustainable in the long term. In rural regions biomass is one of the most readily available cheap energy sources, and its use for energy purposes thus goes beyond energy policy objectives, representing an important means of agricultural and rural development as well. Accordingly, in terms of volume, it will be the use of solid biomass for energy purposes that will show the greatest growth by 2020 (with an increment of nearly 19 PJ). Besides the encouragement of improving the efficiency of high-capacity power plants, the targets set are best served by utilization for local heat generation purposes and, in the case of electricity, the establishment of low to medium-capacity local power plants with regional development potential. Ratios of biomass raw materials are expected to shift in favour of energy crops specifically grown for this purpose (ligneous and herbaceous energy crops), but even more so towards by-products and wastes. The share of the latter in the biomass mix may reach as much as 50% by 2020. During the production of biomass for energy purposes, particular attention must be paid to environmental protection and nature conservation aspects.

Hungary has a large potential in biofuel production, supported by agricultural products. On the basis of an estimate by experts, more than 10% of the estimated consumption for 2020 can be fulfilled just from first generation biofuels, while at the same time ensuring the fulfilment of food and feed provision objectives. With the emergence of second generation biofuels, through the expansion of the scope of raw materials, this volume can be increased even further depending on the seasonal variations in the amounts of agricultural produce.

There is also a significant biogas production potential. Electricity generation was 293 GWh (installed capacity 69 GWh) in connection with biogas plants (agricultural, landfill and waste water) in 2015.

4.5.1 Country Fact Sheet Hungary

The Hungarian country fact sheet on the biomass and bioenergy market gives an overview of available data on macro-economic indicators relevant for the national market and transnational comparison. Its main goal is to identify the most promising feedstock types available in Hungary for utilization in the bioeconomy, mainly as bioenergy feedstock.

COUNTRY: Hungary			
Indicator	**Data 2010**	**Latest data (indicate year)**	**measure**
Macro Data:			
Inhabitants	10,014,324	9,830,485 (2016)	people
GDP per capita	9,800	11,200 (2016)	€
Total land area	93,030		km^2
Share of agriculture in GDP	2.9	3 (2015)	%
Share of forestry in GDP	n/a	n/a	%
Share of energy sector in GDP	n/a	n/a	%
Energy dependency rate	56.4	53.4 (2015)	%
Danube Indicators:			
Navigable length Danube stretch	417		km
Number of Danube ports	8		piece
Land Use, Biomass Feedstock and Energy Indicators:			
Total arable land	4,332,000 (2015)		ha
Area utilized for agriculture	5,300,000; 72% ; (of the crop land)	5,346,00 (2015) of the crop land 72% (2015) of the crop land	ha and share of total arable land
Area utilized for forestry	1,900,000; 26% (of the crop land)	1,940,000(2015); of the crop land 26% (2015) of the crop land	ha and share of total arable land
Area used for cultivation of energy crops	2,523 (2006)	n/a	ha
Fallow land	1,947,000; 21%	1,916,000; 20.6% (2015)	ha and share
Theoretical biomass potential	n/a	4,850 – 7,830 ktoe also includes the biogas potential (2006)	ktoe
Technical biomass potential	n/a	167.89 PJ (excl. biogas)	PJ
Unexploited biomass potential	n/a	n/a	
Type/Source of biomass feedstock with highest potential for bioenergy purposes	Agricultural by-product waste		
Type/Source of biomass feedstock with highest current use for bioenergy purposes	Solid biomass - firewood (combustion technology)		
Contribution of this feedstock type to domestic biomass supply for bioenergy production	22.5 (2006)	23.74 (2015)	PJ

Annual imports of biomass for energy conversion purposes	Only direct supply of wood biomass from forests and other wooded land for energy generation = 200,000	n/a	m^3
Employment in Biomass sectors	n/a	n/a	Direct employment
Main domestic primary source of energy (e.g. coal, renewables):	natural gas		
Main domestic sector of bioenergy (e.g. biofuels for transport, heating, electricity)	heating		

Biomass feedstock types - national supply situation						
Origin/Sector	**Feedstock**	**Potential for growth: yes/no**	**Quantities / Availability (t, m^3, etc.)**	**Comment**	**Bioenergy Product/Intermediary (solid, liquid)**	**Comment**
Forestry & Wood industry:						
Wood production and primary wood residues	wood chips	yes	151,000 m^3 (2009)	Availability shows only dedicated to energy sector.	power plant energy production	-
	thick firewood	yes	3,012,000 m^3 (2009)			-
	thin firewood	Yes	363,000 m^3 (2009)			-
Secondary residues from wood industry (e.g. saw mills)	sawdust	Yes	98,710 t (2008)		pellets and briquette production	-
	sawmills waste	Yes	10,030 t (2008)			The furniture industry produces fewer by-products.
	energy forest wood chips	Yes	90,000 t (2008)			-
	by products of wood	Yes	31,520 t (2008)			-
	other by products of wood	yes	109,650 t			The rate of recycling in the paper industry is expected to

						increase further, so increasing the amount available for energy recovery.
Agriculture:						
Oilseeds (primary production & residues)	Rape	yes	590,000 t (2015)	total amount harvested in Hungary.	liquid fuels	-
	Sunflower seeds	no	1,557,000 t (2015)			-
						-
Sugar & Starch crops (primary production & residues)	Maize	no	6,633,000 t (2015)			The goal is domestic supply and mixing.
	Wheat	yes	5,331,000 t (2015)			
Dedicated energy crops/lignocellulosic biomass on agricultural land	Chinese reed	yes	-	-	renewable fuels and raw materials production	priority in Hungary
	energy grass	yes	-	-		priority in Hungary
Any other type of agricultural bioenergy feedstock, e.g. residues from industries using agricultural products	straw	yes	-	-	power plant energy production	Annual by-product and waste volume over 20 million t per year. A significant part of it could be used for energy purposes.
	corn stalk	no	-	-		
	sunflower stalk	yes	-	-		
Waste & Residue material outside of agricultural and forestry sectors:						
scrap material from landscape management	by product of animal husbandry	no	-	-	nutrient replenishment and soil regeneration	-
	animal husbandry waste	no	190.000 t (2008)	Quantities /availability shows only dedicated to energy sector.	energy recovery	Waste generated in 2008 in Hungary about 30% of the volume was utilized, of which 3.4% was

						used for energy recovery, while most of the remaining waste was deposited on a landfill.
Other:	communal waste	no	-	-	direct incineration	
	selected waste	no	-	-		
	recycled waste	no	-	-		

Most promising:	
Feedstock type(s):	agricultural by-products
	energy crops (ligneous and herbaceous energy crops)
	organic wastes
Bioenergy product(s):	liquid fuel (biodiesel, bio-ethanol)
	solid biomass
	Biogas
Deployment sector(s):	local heat generation
	low to medium-capacity local power plants
	Biogas plants

4.5.2 Country Report Hungary

Bioenergy Market characteristics

The biggest part of the area of Hungary (total of 9,303,000 ha) is a plain, and the climate conditions are suitable for agricultural production. The total cultivated land was 7,400,000 ha in 2015. Within this agricultural area was 5,300,000 ha and forest area was 1,900,000 ha. Hungarian agriculture is capable of sustainably producing biomass in excess of food and feed demands and at the same time, there is a significant biogas production potential. Agriculture and food industry are important pillars of the local economy, particularly in rural areas. Based on data from 2014 the average farm size in Hungary is 8.1 ha - much below the EU average; 87% of the farms have less than 5 ha. The average age of farmers in Hungary is 56 years; therefore there is an urgent need for generational renewal. Hungary has a limited and outdated irrigation system and only 2.4% of the agricultural area is irrigated. The main environmental challenges to be tackled concern the protection of biodiversity, the quality of surface and ground water and soil erosion.

Based on the Hungarian Central Statistical Office in 2015 Hungary produced 2% of the total agricultural output of the EU. The proportion of agriculture in the production of Hungarian GDP

is of 3%. According to the NREAP the total use of renewable energy in Hungary, nearly 80% is derived from biomass and 50% thereof is derived from firewood. The biomass produced, as a dominant component of renewable energy sources, can be a basic pillar for growth. There are various ways for using biomass – depending on the form it takes and the purpose for which it is used –, such as combustion, biogas or biofuels. Wood harvest is steadily around 7 million cubic metres and shows no increasing tendency. Of the gross volume of 7 million m^3 of wood extracted a year, approximately 1.4 to 1.5 million m^3 of wood takes the form of logging waste and forest residue material (branches, twigs, bark, chippings from cutting, trunks, etc.) and is left unused. A smaller portion of the logging waste is collected by the population for firewood but the majority is currently left in the forest. The additional demand for wood for energy generation may encourage forest managers to collect logging waste more efficiently, but there are technical and economic limits to this as well.

Apart from forest biomass, the greatest potential lies in by-products and waste. It is estimated that approximately 700,000 m^3 of wood industry waste (refuse, wood chips, waste from furniture manufacturing, etc.) is produced annually. Some of this waste is currently used for other applications (e.g. chipwood, plywood, etc.) or locally for energy recovery or otherwise (e.g. as bedding for small animals, poultry, etc.), which makes the potential of this segment limited. Wood industry waste is also optimal for pellet and briquette production and is highly sought after in this segment. It is estimated that approximately 250 000 t of wood industry by-products are available annually for energy recovery. A significant portion is used to heat wood industry plants; about 50–60% appear in the energy market. In the case of biomass collection, a maximum collection radius of 20 km could be justified. This would result in an increase in local employment and a significant reduction of transport distances (and consequently, the reduction of emissions). Besides the encouragement of improving the efficiency of high-capacity power plants, the targets set are best served by utilization for local heat generation purposes and, in the case of electricity, the establishment of low to medium-capacity local power plants with regional development potential. Ratios of biomass raw materials are expected to shift in favour of energy crops specifically grown for this purpose (ligneous and herbaceous energy crops), but even more so towards by-products and wastes. The share of the latter in the biomass mix may reach as much as 50% by 2020.

In summary, Hungarian 2020 renewable energy targets are the following:

- Overall target: 14.65% of share of energy generated from renewable sources in gross final energy consumption;
- Heating and cooling: 18.9% of heat consumption met by renewable sources;
- Electricity: 10.9% of electricity demand met by electricity generated from renewable energy sources;
- Transport: 10% of energy demand met by renewable energy sources;

Currently the below regulatory frameworks are existing in the field of bioenergy:

- Hungary's Renewable Energy Utilization Action Plan (time frame: 2020);

- New Széchenyi Plan (time frame: 2020);
- National Energy Strategy (time frame: 2030, with an outlook to 2050);
- EU 2020 objectives in Hungary's National Reform Programme (time frame: 2020);
- Energy Efficiency Plan I, II, III (time frame: 2020);
- METÁR (Renewable Support Scheme)

The aim of the National Action Plan is to provide the greatest possible benefit to the entire society by drawing on Hungary's natural, economic, social, cultural and geopolitical assets. The main objective of the utilization of renewable and alternative energy is to reduce dependency on gas and crude oil imports. The key areas of Hungarian renewable energy policy are the following in the NREAP: Security of supply, environmental sustainability and climate protection, agriculture and rural development, development of a green economy, contribution to Community Goals.

The most important strategic aspects of the New Széchenyi Plan are: the dynamic expansion of employment, the maintenance of financial stability, the establishment of conditions for economic growth, and the improvement of competitiveness. One of the plan's programs is called Renewal of Hungary – Development of green economy.

The main goal of the Nation Energy Strategy (European Commission, 2017) is the decrease of energy dependency by energy efficiency, high ratio of renewable energy sources, nuclear energy and joining to the European energy infrastructure. Within the framework of the Europe 2020 Strategy, in the National Reform Programme Hungary contributes to the achievement of the five quantified headline targets set out at a European Union level by fulfilling national commitments that also reflect Hungary's own characteristics and priorities. The main goal of the Energy Strategy is the decrease of energy dependency by energy efficiency, high ratio of renewable energy sources, nuclear energy and joining to the European energy infrastructure.

On 13 June, 2016, the Parliament of Hungary enacted the Renewable Energy Support System (METÁR) the new regulatory and support scheme for electricity generation from renewable energy sources, which may help to achieve the above ambitious aims**.** The most important measures foreseen include: supporting the plantation, processing and use of ligneous energy plantations grown for this purpose, installing biomass fuelled district heating centres to replace the heating of individual gas-heated homes and community buildings, establishing a system of biomass-fuelled small-scale power plants for the generation of electricity and the simultaneous use of waste heat produced, implementation of small-capacity biomass-fuelled (agricultural and forestry byproducts, biomass production) power plant and heating plant projects along with related agricultural (e.g. horticultural) projects.

Considering the natural endowments of Hungary, biomass could play a decisive role within renewable energy sources. The potential range of feedstocks is very wide and may be broken down into the following categories:

- biomass from forestry;

- energy crops specifically grown for this purpose (herbaceous and ligneous energy plantations);
- agricultural by-products and waste;
- other by-products and waste.

The following table presents the potential volume of biomass which can realistically be produced or collected in the individual categories in the medium term (7–15 years), as well as the amount of energy which can be generated.

Table 17: Quantities of biomass which can potentially be secured for energy generation in the medium term

Description	Realistically produced/collected (million t/year)	Energy content (PJ/year)	Electricity (GWh/year)
From forestry	3.25	45.5	2,275
Produced for this purpose	5.6	74.16	6,180
Agric. by-product, waste	5.4	62	5,100
Other by-product, waste	0.55	6.6	550
Total	**14.8**	**188.26**	**14,105**

It is estimated that 7.8 to 8 million t/year of biomass will be required to satisfy the growing renewable energy demand up to 2020. Being a country with seven neighbours, regional cooperation is a vital element of Hungary's energy market and security policy, aiming at which Hungary is actively developing the regional electricity market, including new interconnectors and market coupling. The declared aim of Hungary is –as presented in the National Energy Strategy- to proceed towards a sustainable, low-carbon, energetically efficient economy.

Looking at the domestic energy situation it can be stated that it has not changed significantly in the last 18-20 years. Generally, the total energy consumption is 1,100-1,150 PJ. There is a decrease in the utilization of coal and oil consumption. The emissions of the large power plants have dropped significantly. There are about 50 biomass power plants in Hungary. In the NREAP, the government continues to account for firewood from traditional forestry, agricultural by-products as well as energy crops from energy plantations.

Domestic agricultural biomasses are estimated between 100 -170 PJ/year. According to the Agriforvalor.eu project (Agriforvalor project, 2016) 54 million t of dry matter of primary biomass is produced per year (46 million t from agriculture and 8 million t from forestry). Roughly 13 million m^3 of wood is produced every year from the two million hectares of forests in Hungary. Of this, 10.5 million m^3 (about 7.5 million t) can be lumbered in a sustainable way. Every year about 700,000 m^3 (525,000 t) of wood sidestream (waste wood, wood chips) are generated in the wood processing plants. Because these are often contaminated with chemical substances, only about 50% of the resulting quantity, mostly sawdust and bark, can be used for energy production. Shifting to the issue of agricultural sidestream every year 4-4.5 million t of straw originates from the production of grain cereals and of this about 2.4-2.8 million t could

be used for energy production in a sustainable way. In addition, 8-10 million t of corn stover is produced. About 2.5-3 million t of maize stover could be utilized as biomass for energy production. A significant amount of sunflower stems and oilseed rape straw is produced annually, as is about 150-200 thousand t of biomass from vineyards and a further 400-500 thousand t of biomass from orchards.

85% of agricultural and food industry waste and biomass comes from plant residues from agricultural plantations and forestry and manure from animal breeding. The remaining 15% mostly come from food industry and is organic waste that needs to be tackled with traditional waste handling methods.

Hungary has a large potential in biofuel production, supported by agricultural products. On the basis of an estimate by experts, more than 10% of the estimated consumption for 2020 can be fulfilled just from first generation biofuels, while at the same time ensuring the fulfilment of food and feed provision objectives. With the emergence of second generation biofuels, through the expansion of the scope of raw materials, this volume can be increased even further depending on the seasonal variations in the amounts of agricultural produce.

Table 18: Electricity generation from renewable energies in Hungary at the end of 2015 (Source: MAVIR, KAT)

Renewable Energy	Situation at the end of 2015*		
	GWh/year	PJ/year	%
Biogas	138.1	0.5	5.66
Biomass	1,319.87	4.75	54.13
Landfill gas	57.3	0.21	2.35
Waste	25.22	0.09	1.03
Sun	10.52	0.04	0.43
Wind	663.61	2.39	27.22
Water	223.62	0.81	9.17
Total	2,438.24	8.78	100

The following Table 19 includes the most important responsible administrative facilities and their competences in the field of bioenergy.

Table 19: Most important administrative facilities in Hungary

Abbreviation (in Hungarian)	Name	Responsibility
NFM	Ministry of National Development	Energy policy and regulations, tender schemes, development policy and transportation issues, Issues relating to financial regulation and allocation of support, the supervision of support programmes
BM	Ministry of Interior	Spatial planning, construction regulations;
NGM	Ministry of National Economy	Issues relating to construction economy, home creation, industry, consumer protection and training Issues relating to financial regulation and allocation of support, the supervision of support programmes
FM	Ministry of Agricultural	Environmental protection, nature conservation, agriculture;
MEKH	Hungarian Energy and Public Utility Regulatory Authority	Energy authorisation (competence: national);
MKEH	Hungarian Trade Licensing Office	Technical permits
MAVIR	Hungarian Independent Transmission Operator Company Ltd.	Provides for the reliable, efficient and secure operation of the Hungarian electricity system

In the energy sector, the Hungarian Renewable Energy Utilization Action Plan 2010-2020 is based on the EU Renewable Energy Directive 2009, and aims to exceed legal requirements of renewable energy production. In addition, the National Energy Strategy 2030 suggests measures for biomass based solutions, including the gradual conversion of uncultivated land to energy crops and the recognition of biomass and waste as potential feedstocks for biotechnology-based economy. The strategy identifies that development requires training, and a stronger industrial and innovation knowledge base. For renewable energy and waste-to-energy production, feed-in tariffs are in place, under the framework of the Electricity Act 2007. For biofuels the obligations of the EU Renewables Directive are implemented. The National Environmental Technology Innovation Strategy 2011 is a framework for eco-innovation within the Hungarian National Reform Programme. The vision of the framework is to facilitate environmental industries and technology, to focus on environmental innovation, reduce primary material use, encourage reuse and recycling, and prevent environmental problems. The Government also approved the following strategies to improve sustainable development, innovation R&D, the economy and

employment in various sectors: National Rural Development Strategy, New Széchenyi Development Plan, National Research and Development and Innovation Strategy 2020. The multiple aspects of bioeconomy are split between the Ministry of Agriculture, the Ministry for National Economy and the Ministry of National Development.

Table 20: National biomass and bioenergy market SWOT analysis Hungary

STRENGTHS	WEAKNESSES
• Job creation • Reduction of import energy • Domestic innovation, Strong knowledge and skills in valorization technics in the research sector • High volumes of biomass side streams • Resources from the EU • Awakening local government bodies and regions • Superior utilization of the wood • Possibility to sell in any period of the year • Sufficient wood quantity • A new secure market for farmers • In case of energy plantations: Extension of the working season for farmers and extended utilization of the equipment	• Farmers and foresters know little of the existing biomass valorization technologies and how to use them • Lack of scale and fragmented supply chain • Continuity/Security of biomass • Low qualification of forest entrepreneurs • Excessive bureaucracy • Low profitability due to high procurement resp. investment costs • Information deficits and lack of coordination resp. transparency in the supply chain • Lack of qualified work force • Complicated legal background; Adaptation of existing network; Significant support for the use of fossil fuels
OPPORTUNITIES	**THREATS**
• Small amounts of domestic fossil energy • Instability of fossil fuel supply and volatile fossil fuel prices • National and EU support for a growing Forestry and Agro sector as well as CO_2-taxes, subsidies, feed in tariffs, research projects • Favorable agro- and forest ecological conditions • High demand of valorized biomass • Strong networks can help to optimize the supply chain • Options to reduce financial risks for the business sector by providing funding and	• Financial risks and access to finance • Uncertainty regarding the availability of biomass exists and leads to uncertainty for the industry • Low level of education/Lack of skilled people working in the sector • Lack of awareness • Strong fossil lobby • Price rise for standing timber • Raw material competition with forest based/wood processing industry • Unpredictable periodical undersupply

risk management • Centralized large-scale valorization sector should be extended with a local small-scale biomass industry • Powerful development of renewable and efficiency technologies • Increasing wood land area resp. growing stock • Innovation due to R&D in advanced processes for biomass procurement pre-processing and conversion • Stricter climate policy and emission mitigation targets	• Natural conservation (e.g. Natura 2000) restricting harvesting • Lack of adequate funding sources and forms, Restrictive capital market • New pathogens, the appearance of pests; Loss of resistance

Market profile: Analysis of most promising biomass/bioenergy supply chain

From among the factors affecting the security of energy supply in the winter, the responsible behaviour of market players, the continuous availability of natural gas supply and, to a lesser degree, that of the alternative fuels (biomass) are the most important. Therefore, a harmonised cooperation of natural gas and electricity markets ensuring adequate flexibility is of special importance.

The major part of renewable electricity is currently generated by the burning, at a low rate of efficiency, of biomass (primarily firewood) in antiquated coal power plants. With regard to the above, the local utilization of certified firewood purchased from forest farmers engaging in sustainable forestry, biomass from energy plantations and agricultural by-products should primarily be utilized, preferably in CHP plants. More than half of the total green electricity and over 60% of bioenergy used for district heating are generated by Hungarian forest wood.

For biomass, individual supply being quality and logistics-intensive, the boosting of the domestic pellet manufacturing capacities may offer a solution. In order to satisfy the increasing demand for renewable energy, an estimated 7.8 to 8 million t of biomass a year will be required by 2020. Nearly 50% of that amount is available in public and private forests in Hungary. While the geographical location of wood suitable for energy uses allows it being used at short transportation distances, it requires significant technological and logistic improvements. The most efficient utilization of firewood and other potential energy products from Hungarian forests and afforestation could therefore be achieved by a system of decentralized heating plants. It is not appropriate to use biomass for electricity generation independently. Much more advantageous is the so-called cogeneration (CHP) production, when all the heat is used in addition to the produced electricity. Biomass is transported from large distances by rail or road, considerably impacting the energy balance and sustainability of the activity in a negative way. The high raw material demand of power plants takes up the majority of sustainably logged timber capacities in Hungarian forests. Firewood from traditional forestry, agricultural by-

products and energy crops from energy plantations have the most diverse potential. The Hungarian pellet market is expected to grow exponentially in the near future. There is experience in general boiler development, and in special boiler development suitable for green by-product burning. Theoretically, 7% of Hungary's total decentralized heat demand could now be covered by pellets, supplying heat and hot water to 234,000 households. A similar number of pellet-devices (boilers) would also be required.

The greatest uncertainty is the possible use of so-called biological by-products, since e.g. cereal straw, corn stalk, grape vine harvesting is highly weather-dependent. The potential proportion (e.g. area) of herbaceous energy crops and energetic wood plantations due to the significant production investment are determined by market conditions (marketability).

In the cultivation of biomass for energy purposes, with particular regard to the production of first-generation fuels, it should always be kept in mind that is should not compete with the cultivation of crops for food and fodder. The utilization for such purposes of marginal or degraded areas, not representing a nature conservation value (including for example areas exposed to inland water, located in floodplains or being of low productive value) should have priority. Areas withdrawn from farming and not used for other purposes but suitable for conversion to arable land through recultivation can be added to the areas suitable for green energy crops (fallow land). Rather than the planted varieties, bioenergy production should therefore be assessed on the basis of the nature of the area concerned (the type of former activity being replaced by it, assessment of alternative uses, job creation), the available biomass yield and the place and nature of the utilization of the biomass produced (decentralized and sustainable model).

Table 21: Estimated biomass mix 2020

Biomass type	Volume (thousand t/year)	Share (%)
Forestry products	2,114	27.17
Wood processing byproducts used for energy generation	231	2.97
Energy crops	1,914	24.60
Agricultural by-products and Waste	3,522	45.26
Total	7,781	100

A special category includes biomass (maize, wheat, rape, sunflower, etc.) suitable for the production of transport fuels. A market for biofuels is emerging in Hungary, as evidenced by recent investments, but there is still huge potential for growth in biofuel production supported by agricultural products. Experts agree that more than 10% of the estimated consumption by 2020 can be fulfilled from first generation biofuels, whilst ensuring food and feed provision objectives. With the emergence of second generation biofuels, via expansion of the raw material range, this volume can be increased further, depending on seasonal changes in agricultural production.

Significant development is expected for biogas, agricultural waste and the residual materials of municipal sewage treatment plants. Feasible potential is 24-48 PJ. The total real potential of biogas in Hungary is estimated at 300-400 MW.

Table 22: Estimation of the total contribution expected from biogas in Hungary

	2010	2012	2015	2020
Installed Capacity (MW)	14	21	43	100
Gross Electricity generation (GWh)	85	125	262	635

In accordance with and in compliance with the criteria of sustainability and energy efficiency, the local energy utilization of the by-products of agriculture (e.g. straw and maize stalk) and sewage water and sludge in biomass power and biogas plants, among other options, are treated as a priority.

Table 23: Estimated biomass domestic supply in 2015 and 2020

Sector of origin		2015		2020	
		Expected domestic sources	Primary energy pro-duction PJ/year	Expected domestic sources	Primary energy production PJ/year
(A) Biomass from forestry:	1. Direct supply of wood biomass from forests and other wooded land for energy generation	3,100,000 m^3 (estimate)	22.32	3,300,000 m^3 (estimate)	23.74
	2. Indirect supply of wood biomass for energy generation	400,000 m^3	2.14	500,000 m^3	2.9
(B) Biomass from agriculture and fisheries (1):	1. Agricultural produce and fishery products directly provided for energy generation	1,500,000 m^3	15.1	3,000,000 t	30.14
	2. Agricultural by-products/processed	2,100,000 m^3	12.14	2,850,000 t	17.17

	residues and fishery by-products for energy generation				
(C) Biomass from waste:	1. Biodegradable fraction of municipal solid waste (biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants) and landfill gas	2,100,000 t	N/A	2,100,000 t	N/A
	2. Biodegradable fraction of industrial waste (including paper, cardboard, pallets)	1,500,000 t	N/A	N/A	N/A
	3. Sewage sludge	499,000 t	N/A	N/A	N/A

According to the above table the most promising feedstocks are the wood biomass from forests and other wooded lands as well as agricultural and fishery products. The following figures demonstrate maps of estimated sustainable potential lignocellulosic biomass by region within Hungary, namely: forest (primary forestry production, field residues and secondary forest residues) and agriculture (primary field residues and tree prunnings). Estimated sustainable potential can reach up to 6.3 million dry t/year regarding the forest category. In the case of agriculture, the sustainable potential number can reach up to 9.7 million dry t/year.

The size of the forest area by region in Hungary is presented in the following table.

Table 12: Forest area distribution by regional counties (in 2012)

County name	**Administrative area** [km²]	**Forest area** [km²]	**Forest area ratio from the total area** [%]	**Forestry purpose** [km²]
Central Hungary	6,918	1,699	24.6	1,796
Central Transdanubia	11,116	2,508	22.6	2,811
Western Transdanubia	11,328	2,944	26	3,144
Southern Transdanubia	14,169	3,562	25.1	3,783
Northern Hungary	13,433	3,943	29.4	4,098

Northern Great Plain	17,729	2,239	12.6	2,349
Southern Great Plain	18,337	2,382	13	2,526
Total	93,030	19,277	20.7	20,507

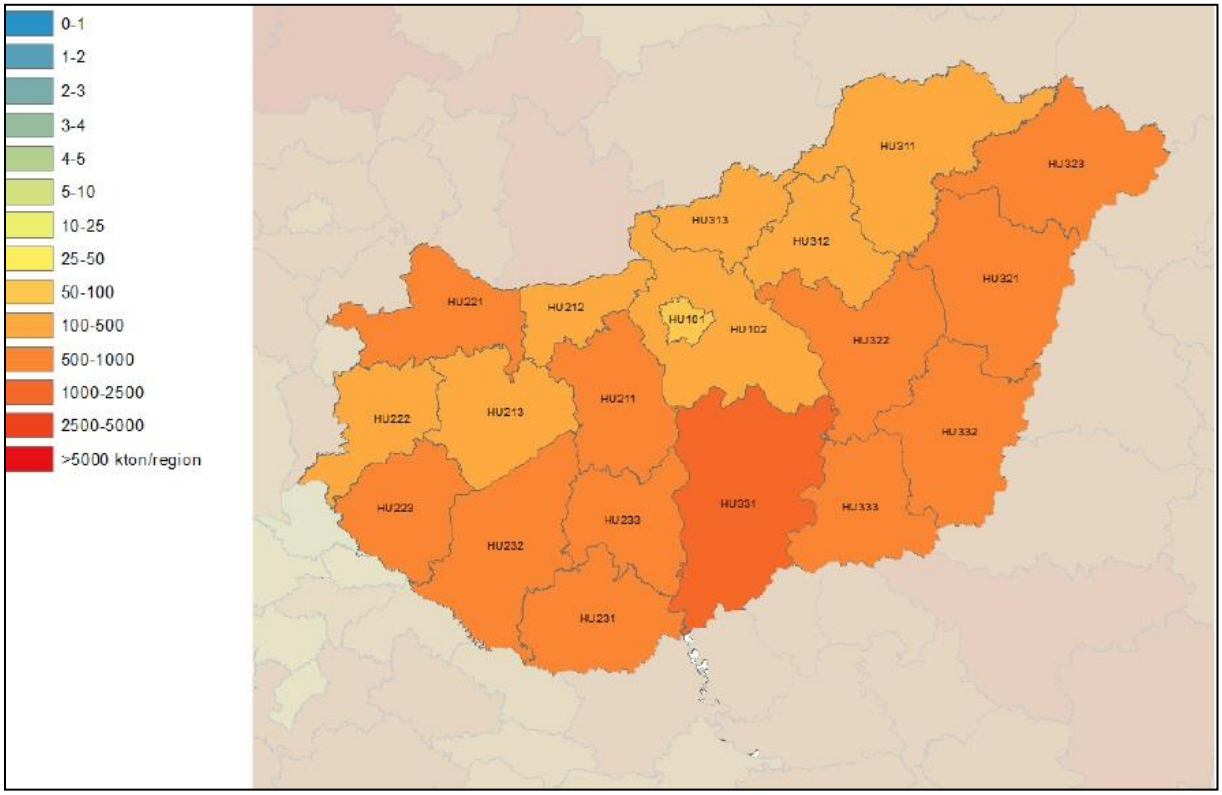

Figure 32: Agriculture situation (supply in kt DM per region) (Source: S2Biom, 2016)

Modern energetic use of biomass has long traditions in Hungary, as well. Since 2003 several power plants have shifted from coal to biomass firing to produce electricity. Available biomass is increasingly used for all three purposes (food, energetic, material) inducing enhanced competition in the future. A lion's share of the biomass is used in large scale power stations by the co-burning of firewood and coal with low-efficiency, requiring deliveries from large distances; biomass should mostly be used for energy purposes in local scale units within decentralized energy systems, where electricity is generated by many small energy producers, close to where it is used. Instead of at large power plants located far from the consumers. The energetic efficiency of using biomass this way is only 20-25% as waste heat is not utilized in most of the cases. Rather than large power plant capacities, Hungary wishes to support biomass use for the local generation of thermal energy. To satisfy this biomass demand Hungary needs to rely on the current forests, new plantations the firewood and logging waste derived from these as well as on agricultural by-products, herbaceous and ligneous energy crops, by-products and waste. The local energy utilization of the by-products of agriculture (e.g. straw and maize stalk) and sewage water and sludge in biomass power and biogas plants, among other options, are

treated as a priority. Figure 33 is trying to show a solution for a new forest policy which contains all relevant factors from biomass supply to end use.

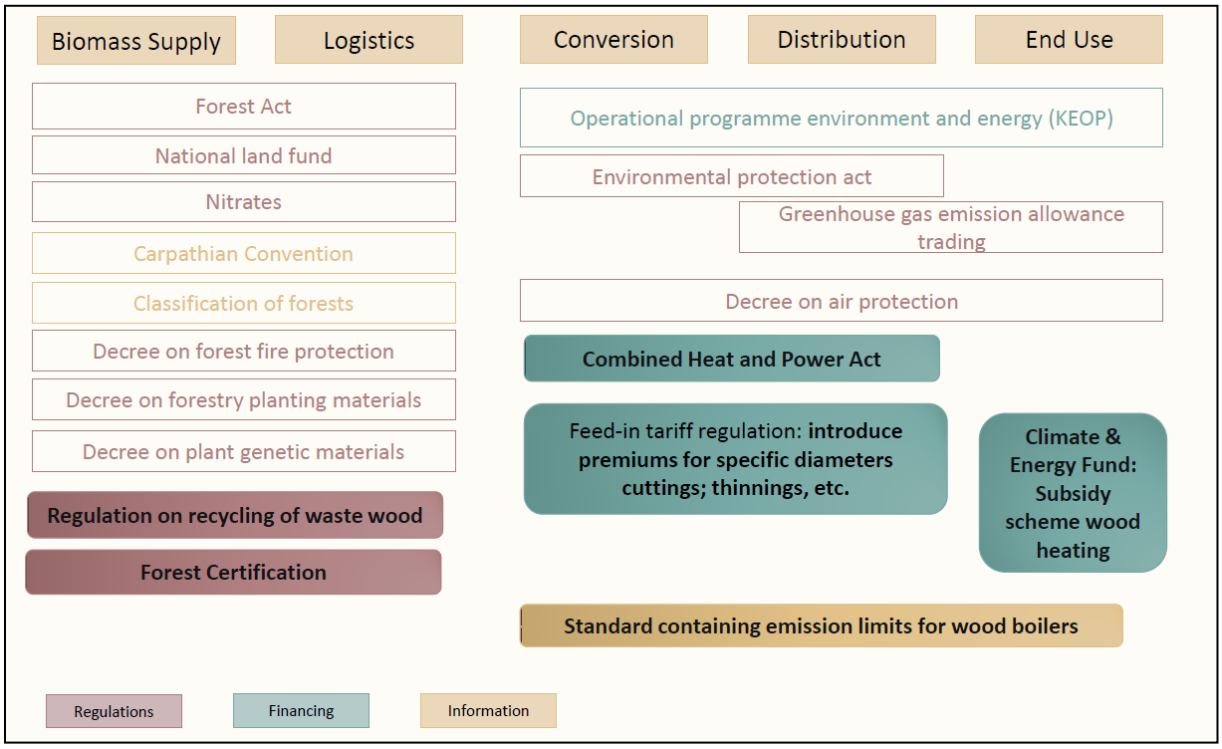

Figure 33: Recommended new policy concerning forest sector (Source: S2Biom project, 2016)

In the last years a cross-border trade of biomass has been increasingly developing in Central Europe. The biggest importer in the region is Italy, followed by Austria and Germany. In Austria, 90% of the imports of firewood come from the Czech Republic, Slovakia and Hungary. Most of the international trade focuses on wood and wood products. The importance of liquid biofuels trade has been decreasing during the last couple of years. Regarding transportation compared with coal, biomass is characterized by lower calorific value (about 50%) and lower bulk density (20-50%). Thus, the amount of energy contained in a given volume of biomass is only about 25% of the corresponding energy contained in the same volume of coal. This obviously translates into the consumption of liquid fossil fuels and corresponding emissions, as well as other environmental and economic costs related to the life cycle of vehicles, attrition of roads, etc. This effect can obviously be minimized, if the biomass were used locally, i.e. possibly close to the place where it is produced. Moreover, the location of a coal power station is based on the easiest access to the fossil fuels. Therefore, its location is not suited to the biomass resources in its vicinity. According to the literature, the maximum economically justified transport distance with trucks is 15 km and 50 km for straw and wood, respectively. In Hungary, the international trade is also significant. As much as 7.9% of the produced firewood was exported in 2008, mainly to Italy, Austria and Slovakia, while 4% was imported from Ukraine, Romania and Slovakia. The phytosanitary risk is another problem which recently attracts more and more attention. Namely, with the transported biomass there is a risk of transmitting plant diseases, pest species, as well as seeds of invasive plants. According to the Hungarian Central Statistical Office, in 2015 the

freight transport was developed as follows: road transport ratio was 70% (in domestic terms this ratio is 84%) rail transport was 18% and the remaining percentage is divided between the waterway and pipeline transport solutions.

4.5.3 Conclusion on Market Study Report Hungary

Due to the described lack of functioning support mechanisms, biomass in Hungary is currently used mostly in co-firing with coal in big-scale power stations in a centralized energy system which leads to huge technological problems on top of costs and emissions of biomass transportation at large distances as well as huge amounts of heat which remains unused in thermal power plants. Since the energy density of biomass is low, its energy utilization is transport intensive. Therefore, utilization of biomass is most efficient if used locally, in small scale units, in frame of a decentralized energy system. From economic point of view the co-firing made sense, because building new installations from scratch could be avoided and the reporting effect could be achieved relatively quickly. This approach was stimulated by a system of the so-called green certificates (which is still in place), in which additional gratification is paid to "green" electricity producers in form of tradable certificates. There are three main problems in co-firing biomass with coal: 1. transportation of large volumes of biomass, 2. technological problems on the generation side and, last but not least, 3. cost of the "green" electricity. The main barriers are a lack of proper support for CHP high gas prices combined with low wholesale electricity prices. Energetic utilization of biomass as a very useful supplementary source can only be considered, which can have a number of positive effects through rural development to the development of people's attitude to their environment. For future energy systems, agricultural and forestry by-products and wastes should be preferred with materials which are not essential to the supply of soil fertility. In addition, compromises should be found on the use of energy crops. The goal to be achieved a decentralized, smaller capacity solution which can service the local energy demand from local raw materials with small transport demand. In livestock farms this can mean practically the implementation of biogas power plants which is great for handling organic wastes and at the same time generating renewable energy.

4.6 *Romania*

According to the Romanian Energy Strategy 2016-2030 (Ministry of Environment, 2017), Romania has rich and various renewable energy resources: biomass, hydropower, geothermal, wind power, solar and photovoltaic energy. They are distributed throughout the country and can be exploited more widely to the extent that the performance and price of technologies will be improved by maturing new generations of technological equipment and related facilities.

Biomass is a key renewable energy source and occupies a central place in combining electricity, especially through the use of firewood in rural areas, but the development potential remains high, in particular by streamlining and introducing new technologies such as bio-refineries and biogas production capacities.

Romania benefits of a diversified energetic mix (ibid.) (data of 2015): 111 TWh natural gas, 101 TWh crude-oil. 65 TWh from coal, 46 TWh biomass, 35 TWh nuclear, 26 TWh RES (hydro, wind & solar).

The optimal scenario for 2030 shows a decrease of natural gas at 106 TWh (27%), maintenance of crude oil consumption (26%) and reduction of the contribution of coal. Instead, the contribution is doubled for nuclear power, energy growth from biomass (including biogas) to 51 TWh and the remaining RES in electricity production grow to 37 TWh.

Currently, the latest data available shows the share of the entire energy from renewable sources (Eurostat, 2017) as 24.8% in 2015 over the NREAP (NREAP Romania, 2010) goals for 2020 (24%). The technical potential remained unexploited is of approximately 8,000 ktoe, where biomass and biogas represents 47%, solar energy represents 19%, wind energy represents 19%, hydropower energy represents 14% and geothermal energy represents 2%.

The fact that the development of solar and wind energy exceeded the targets of NREAP has led to the assumption that the focus from the next period will be on bioenergy, where the targets have not been met.

In 2015, ANRE (ANRE, 2016) has accredited the renewable energy generation capacities with a total installed capacity of 4,662 MW. Of the total, 2,932 MW are wind turbines, 1,296 MW - photovoltaic panels and 106 MW - biomass, biogas and landfill. At the same time, 328 MW are small hydro plants below 10 MW each. In total, there are 70 accredited economic operators for wind energy production, 514 for solar energy, 89 for hydro power and 25 for biomass and biogas (ANRE, 2016).

Table 24: RES authorisations granted in 2015 (Source: ANRE, 2016)

Authorizations granted in 2015 are presented in the table below:

No. crt.	Authorized power plants (by type of energy source)	No. of authorizations granted	Installed electrical power of newly authorized capacities [MW]
1	Solar	27	208.48
2	Wind	3	42.05
3	Hydrocarbons	9	82.57
4	Hydro	5	31.76
5	Biomass	3	22.00
		Total 47	**Total 386.86**

4.6.1 Country Fact Sheet Romania

The Romanian country fact sheet on the biomass and bioenergy market gives an overview of available data on macro-economic indicators relevant for the national market and transnational comparison. Its main goal is to identify the most promising feedstock types available in Romania for utilization in the bioeconomy, mainly as bioenergy feedstock.

COUNTRY: ROMANIA			
Indicator	**Data 2010**	**Latest data (indicate year)**	**measure**
Macro Data:			
Inhabitants	20,294,683	19,760,314 (2016)	
GDP per capita	6,260	7,220 (2016)	€
Total land area	238,391		km^2
Share of agriculture in GDP	6.27	4.76 (2015)	%
Share of forestry in GDP	3.5	3.5	%
Share of energy sector in GDP	n/a	5	%
Energy dependency rate	21.9	17.1 (2015)	%
Danube Indicators:			
Navigable length Danube stretch	1,779 km, of which 1,075 km international waterway, 524 km waterways of the Danube and 91 km artificial waterways (Danube - Black Sea and White Gate - Navodari Canal)		km
Number of Danube ports	35 ports are integrated into the inland waterway network and the Black Sea, including 3 seaports, 6 river-sea ports and 26 river ports		
Land Use, Biomass Feedstock and Energy Indicators:			
Total arable land	14,611,900 (2013) / 61.8%		ha
Area utilized for agriculture	13,306,130	13,055,850 (2013) 63.9%	ha and share of total arable land
Area utilized for forestry	n/a	6,900,000	ha
Area used for cultivation of energy crops	n/a	3,205 (2013)	ha
Fallow land	n/	1,400,000	ha
Theoretical biomass potential	n/a	7,600	Ktoe
Technical biomass potential	n/a	n/a	PJ
Unexploited biomass potential	n/a	3,350	Ktoe
Type/Source of biomass feedstock with highest potential for bioenergy purposes	wood-based industries, forest woodchips, pellets, straw		
Type/Source of biomass feedstock with highest current use for bioenergy purposes	wood-based industry		
Contribution of this feedstock type to domestic biomass supply for bioenergy production	6,600	n/a	Ktoe
Annual imports of biomass for energy conversion purposes	n/a	n/a	
Employment in Biomass sectors	n/a	n/a	Direct employment

Main domestic primary source of energy (e.g. coal, renewables):	Crude Oil 27.50%, Natural Gas 28.10%, Coal 18.40%, Nuclear Energy 8%, Renewables 17.70% (2015)
Main domestic sector of bioenergy (e.g. biofuels for transport, heating, electricity)	biomass for electricity, heating and cooling, transport sector

Supply Side - Biomass / Feedstock						
Origin/Sector	**Feedstock**	**Poten-tial for growth : yes/no**	**Quantities / Availability (t, m³, etc.)**	**Comment**	**Bioenergy Product/Intermediary (solid, liquid)**	**Comment**
Forestry & Wood industry:		Yes	10 million m^3	It is used mostly as fire wood	Solid biomass	
Wood production and primary wood residues			8 million m^3		Solid biomass	
				Out of the 18 million m^3 of legal wood exploitation, about 10 million go to the primary wood processing industry, 6.5 million m^3 are used as firewood directly by the population and 1.5 million m^3 by the panel-technical panels industry (PAL, PFL, MDF).		
Secondary residues from wood industry (e.g. saw mills)			2 million m^3		Solid biomass, pellets	
				From primary processing there is an important volume of waste, of the order of 4 million t, half of which is sawdust and half-hardwood (pots from primary processing).		
Agriculture:						

Oilseeds (primary production & residues)		Rape seed	656,000 t (2011)		Liquid, oils	
		Sun-flower seeds	1,625,000 t (2011)		Liquid, oils, solid (husks)	
		Soy beans	625,000 t		Liquid, oils	

Most promising:	
Feedstock type(s):	Pellets
	Firewood waste
	Oil seeds
	Agricultural waste and residues
Bioenergy product(s):	Pellets
	Biofuels
Deployment sector(s):	Heating, CHP
	Transport
	Electricity

4.6.2 Country Report Romania

Bioenergy market characteristics

Currently, the only support scheme for renewable energy sources in Romania is the law 220 which has expired by 31st December 2016.

The National Action Plan for Renewable Energy Sources (NREAP 2010) and the National Energy Efficiency Action Plan (NREAP 2014) work as an indicator for the potential of the RES in Romania, even though the targets have not been achieved according to the projections (European Commission, 2017).

A National Energy Strategy 2016-2030 was launched for public debate in November 2016. In April 2017, the Romanian Government approved a State aid scheme (Theiss, 2017) which is aimed at stimulating investments in an area which both government officials and market players' view as insufficiently developed the production of energy (power and/or heat) from biomass, biogas, and geothermal sources. Currently, a New Bioenergy Law is proposed to the Romanian Parliament for debate following the approval from the Senate (Number of Decision: 853/27-12-2016). The proposed Bioenergy Law aims to support the creation of 300 MW of projects in Romania.

The target of energy from RES in gross final energy consumption for 2020 is 24%, whereas the target for the RES share to the gross final consumption of heating and cooling is 22.05%. The target for the share of solid biomass to the gross final consumption of heating and cooling is 20.99% in 2020. The estimation of the total contribution of district heating in RES heating and

cooling is 1,300 ktoe which corresponds to a share to the total consumption of heating and cooling of 7.1% in 2020. According to the 2nd progress report of Romania (2014), the actual contribution of solid biomass for the RES share in heating and cooling in 2011 and 2012 exceeds the estimated targets according to the NREAP. However, the target on district heating has not been achieved. The shares established for biomass heating are on track because of Romania's particularity that a large part of rural population burns fire wood for household purposes. However, one of the impediments for the investors in biomass technologies is given by the fact that ANRE establishes the level of the subventions (the Green Certificates granted to producers) each year, while the licensing and construction process for a biomass plant exceeds the 1 year period by far.

Table 25: Comparison of NREAP target values (estimation) with results of the 2nd progress report in solid biomass and District heating (actual) in the heating and cooling sector (ktoe) in Romania

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Solid biomass										
Actual (ktoe)	3,469.9	3,657.8								
Estimation (ktoe)	2,801	2,957	2,914	2,856	2,919	2,960	3,11	3,255	3,546	3,845
District heating										
Actual (ktoe)	17.8	16.0								
Estimation (ktoe)	121	188	246	304	362	471	579	736	993	1,300

Primary energy resources include:

- production of primary energy carriers (net coal, crude oil, usable natural gas, fire wood, hydro-electric and nuclear-electric energy and energy from non-conventional sources)
- imports of primary and transformed energy
- stocks of primary energy carriers at producer, consumer and distributor units on January 1st

The actual situation shows that 74% of Romania's gross energy consumption is covered by the usage of fossil fuels – coal, oil, natural gas and combustible waste, while the renewables cover only 17% (mainly wind and photovoltaic) (Bioenergy4Business, 2015).

In terms of solid biomass usage, in 2015 8 operational cogeneration, biomass based plants are operated in Romania, with a total installed capacity of 134.28 MW, while the primary energy product of Romania estimated for the period 2015-2020 targets 8,373 GWh forest wood per year, 9,762.2 GWh by products of wood-based industry per year and 18,445.18 GWh agriculture and fisheries by-products per year.

Table 26: Romanian electricity production based on biomass 2016 (Source: World Energy Council, 2017)

Romania	
Gross electricity generation from biomass in 2014, TOE	39037
Gross electricity generation from biogas in 2013, TOE	4300
Biomass production in 2014, TOE	3645696
Biogas production in 2014, TOE	19299
Liquid biofuels production in 2013, kt	178

Romania occupies an important position in the whole of the European Union in the field of agriculture, ranked 6th in the EU from the perspective of the agricultural area used (PWC, 2017). Although the share of agriculture in the Romanian GDP is decreasing, the value gross added to the GDP in agriculture in Romania is the highest in the EU. Romania has the largest share of the population employed in agriculture in the EU. Romania is on top ten world's largest producers of rape seed has become the top producer for this crop in the Black Sea region with a high potential for exporting of raw material feedstock (seeds), semi-finished goods (vegetable oils) and final products (biodiesel) (Blackseagrain.net; 2017).

The waterway network is entirely in the south and south-east of Romania, with a density of 6.5 km / 1,000 km^2; the length of the network is 1,779 km, of which 1,075 km international waterway, 524 km waterways of the Danube and 91 km artificial waterways (Danube - Black Sea and White Gate - Navodari Canal); 35 ports are integrated into the inland waterway network and the Black Sea, including 3 seaports, 6 river-sea ports and 26 river ports (Portaleromania, 2017).

The following table gives an overview of the strengths, weaknesses, opportunities and threats the Romanian biomass and bioenergy market is influenced by at the moment.

Table 27: SWOT Analysis Biomass and Bioenergy Market Romania

Strengths	Weaknesses
• Significant potential of RES in Romania • Increased independency of society from fossil resources • Extensive areas of agricultural land • Good regional forestry resources • Unused potentials of straw and wood biomass (easy to store) • Number of ports and an increasing traffic transportation on waterway network • Urban areas located relatively	• Low level of utilization of renewable energy resources • Not enough support from the Banking Sector for the RES projects • Problems of the implementation of law 220 and the problems with the Green Certificates market has stopped the investments in RES • Long time to develop a RES project in the field of bioenergy due to administrative barriers • Over-regulation of the forestry sector

close to rural areas, what reduces Logistical problems for domestic and small scale biomass supply • Universities in the region involved in bioenergy research and larger projects • Infrastructure and technologies for harvest are well established for both straw and wood	
Opportunities	**Threats**
• Higher energy and resource security for EU as a goal • Higher exploitation of the potential of biomass, geothermal resources and household and agricultural waste • Attractive investment climate for foreign and local investors • Environmental advantages of energy crop plantations compared to other use options • Potential for export of electricity	• Competitiveness of the prices of biofuels compared to fossils fuels • Governmental under-financing in research, innovation and technology • The banking system hesitant about the investments in the field • High price for wood resources and crisis in supplying wood industry and fire wood for population

Market profile: Analysis of most promising biomass/bioenergy supply chain

For Romania, biomass represents an important RES, as raw materials used in the production of biofuels and bioliquids are widely cultivated (sunflower, rape, soy, corn, sugar cane or sorghum, energetic willow, cynara cardunculus, miscanthus). The most promising biomass potentials comprise mainly wood waste, agricultural residues, domestic waste and energy crops. Production of biomass is not only a renewable energy resource but also a significant opportunity for sustainable rural development (Flanders Investment & Trade, 2013).

According to the Ministry of Agriculture, the country's biomass energy potential is of approximately 7.6 million t of oil equivalent per year, out of which: biogas (7.7%), lumber and firewood waste (15.5%), wood waste (6.4%), agricultural residues from cereals, corn stalk, vineyards (63.2%) and urban household waste (7.2%) (Forbio project, 2017).

The Ministry of Agriculture and Rural Development mentions in its strategy for developing the agri-food sector in the medium and long-term 2020-2030, that agriculture will only contribute to a small extent to the production of renewable energy. The contribution of agriculture to total energy production was 1.7% in 2010, well below the EU-15 average and the new member states (NMS). The share of forestry in the production of renewable energy was much higher, 69% in 2010, but also below the NMS average. Agriculture, through its opportunities, has a great potential to increase its contribution to the production of renewable energy. The biomass available from agriculture is significant, of the order of 4,800 ktoe, with the advantage that it ensures the continuity of the supply of raw material for obtaining energy from the other types of

energy (wind, solar). The development of investments in the field of biomass utilization through the transformation into electric and thermal energy does not meet the potential and the market requirements due to the high costs of these investments (Ministry of Agriculture and Rural Development MADR, 2015).

Romania has approximately 6.9 million hectares of forest, 51% of which are privately owned, show the latest data published by the National Forestry Inventory (NFI). Apart from the forested surface area, there are approximately 14 million hectares of agricultural land. Likewise, there are approximately 830,000 forest owners and approximately 4 million owners of agricultural land.

The share of forested areas available for exploitation out of the total forested area was of 67% in 2015 (compared to 88% in 1990). Coupled with the poor transport infrastructure and lack of forest roads, the decrease of the areas available for exploitation led to the overexposure of those areas that are easier reached by road (PWC, 2017).

The Biomass Trade Centre (CE Delft, 2017) report shows that the prices of wood pellets for domestic purposes (excluding VAT) range from 12 €/GJ in Romania.

Out of the 18 million m^3 of legal exploitation, about 10 million m^3 go to the primary wood processing industry, 6.5 million are used as firewood directly by the population and 1.5 million m^3 by the wood panel industry (PAL, PFL, MDF). The estimated biomass consumption for the heating population is 19 million m^3, according to the NIS study (National Institute of Statistics, 2014).

The large deficit of firewood to supply the population needs makes very little resources available for the use as primary forest biomass in industrial projects. Firewood prices of 50-60 €/t on the forest road are very high and discourage investment in industrial biomass projects. Moreover, current legislation discourages the mobilization of forest biomass from shredders and branches because there is no possibility of storing for subsequent drying and chopping and is not even part of the assessment of the wood biomass.

From primary processing there is an important volume of waste (sawdust and wood processing waste) which qualifies as secondary forest industry biomass, of the order of 4 million t, half of which is sawdust and half hardwood. These are used for

- Firing in own facilities of the companies, for timber drying
- In the Pannel Industry - as a resource.
- The largest proportion is sold to the population as firewood, due to the very good prices in this market segment.
- Part of sawdust is used for pellet production.

Constraints on the use of forest biomass as an energy resource:

- competition with the technical pannels industry.

- Targeting as a substitute for firewood for the population, due to the high prices on this market segment.

Romania's pellet production reached a maximum of 400,000 t in 2013 and has fallen steadily to around 250,000 t. For this production is used primarily as a sawdust resource from primary processing and in relatively small proportions the primary wood resource.

In 2016, Romania imported about 2 million m^3 of softwood logs, used mainly in the primary processing industry, but also in the technical plate industry. In the autumn of 2016, imports of firewood, especially from Belarus, occurred.

Romanian wood chips exports are practically nil because of the high prices on the Romanian firewood market. From the counties of the west of the country there is export of firewood to Hungary - estimated volume of 0.3 million m^3.

Romania's forest biomass exports as an energy resource - firewood, logging, pellets were worth 55 million € in 2016 compared to 84 million € in 2015 (34% decrease), mainly consisting of pellets and firewood on the Hungary relationship. The only forestry area that can supply biomass for transport on the Danube is Caras Severin - the ports of Moldova Noua, Orsova and Dr. Tr Severin. In this area, a volume of 700,000 m^3 of wood is exploited, with the potential for biomass of up to 250,000 m^3.

4.6.3 Conclusion on Market Study Report Romania

Romania has a good potential for sustainable biomass production both for energetic and material use besides the supply of the food and feed markets due to its geographic location and natural resources. The most promising types of biomass are biogenic waste, dedicated energy crops and agricultural biomass, mainly from the oil seeds section. Forestry residue material and residue material from the wood industry do have a theoretical and sustainable potential, but are currently not exploited.

Inland waterway transport offers opportunities for the future to send and receive agro-pellets, to use the inland waterway routes to import and export biofuels, and to prepare a terminal to be able to export liquefied bio methane. Also wood and woody products can be a cargo with potential. In order to ensure quantities that suit inland waterway transport and economies of scale, agricultural and forestry trading companies that provide long-standing delivery contracts will play a decisive role.

4.7 *Slovakia*

Two facts are important to consider for the vision of the energy market development in Slovakia. Slovakia is an open economy, depending on exports. First, due to very high level of openness of its economy, a key economical concern of Slovakia is its dependence on export, and so on the economic demand from countries to which the export is focused. Second, Slovakia is taking advantage of significant foreign direct investments and it will depend on it in the future as well. Thus the main objectives of Slovak economy shall be:

- Strengthen knowledge economy in order to increase the added value of the goods and services.
- Diversify economy structure, currently focused on engineering, metallurgical and chemical industry. From this point of view, biobased economy belongs to key prospective future markets
- Establish an economy based on environmentally and economically effective and sustainable utilization of domestic resources
- Focus on further development of appropriate infrastructure to support financial flow and economic activities (agriculture, forestry, including biomass production)

In all these objectives, biobased economy, biomass as a renewable, ideally sustainable resource and also bioenergy will play a key role. Therefore, the mission for Slovakian biobased economy includes the production and use of biomass, which could have following positive effects:

1) *biomass feedstock production:*
- Increase competitiveness of agriculture by alternative land management,
- Development of innovative activities in rural areas, utilization of unused agriculture and other fallow lands by production of fuel wood biomass,
- Increasing wood biomass production in a form of fuel chips, but with focus on strengthening the state of forest ecosystems (stability, production potential, hygiene),
- Spreading and supporting activities related to biomass production, such as technology development and production, support services, etc.

2) *energy production:*
- Substitution of fossil fuel with biomass and increasing of overall energy self-sufficiency
- Increasing energy security, stabilisation of production costs and increasing the production
- Reaching more efficient trade balance and reduce dependence on imports of energy and fuel
- Focus on elimination of emissions, especially those, caused during production of energy from fossil fuels and their transportation

In order to guarantee a sustainable sourcing and use of biomass feedstock two principles need to be ensured: Firstly, to improve importance and attractiveness of agriculture in a process of sustainable utilization of landscape agricultural potential, including contribution of agriculture to the development of rural economy and its viability. Secondly, to ensure long-term sustainable management of forests, utilizing economic, environmental and social functions for society development, and mainly in rural areas.

The objectives listed above are the main rational underlying the Slovakian NREAP.

4.7.1 Country Fact Sheet Slovakia

The Slovakian country fact sheet on the biomass and bioenergy market gives an overview of available data on macro-economic indicators relevant for the national market and transnational

comparison. Its main goal is to identify the most promising feedstock types available in Slovakia for utilization in the bioeconomy, mainly as bioenergy feedstock.

COUNTRY: SLOVAKIA			
Indicator	**Data 2010**	**Latest data (indicate year)**	**measure**
Macro Data:			
Inhabitants	n/a	5,102,844 (2016)	
GDP per capita	n/a	15,962	$/2015
Total land area	49,035		Km^2
Share of agriculture in GDP	n/a	3.66 (2015)	%
Share of forestry in GDP	0.265	0.256 (2015)	%
Share of energy sector in GDP	n/a	n/a	%
Energy dependency rate	63.1	58.7 (2015)	%
Danube Indicators:			
Navigable length Danube stretch	171		km
Number of Danube ports	3		
Land Use, Biomass Feedstock and Energy Indicators:			
Total arable land	1,430,594 ha		ha
Area utilized for agriculture	2,434,749 ha 40.32%;	40.34% (2015)	ha and share of total arable land
Area utilized for forestry	2,004,927 ha 40.44%	40.02% (2015)	ha and share
Area used for cultivation of energy crops	n/a	n/a	ha
Fallow land	n/a	17,400 (2014)	ha
Theoretical biomass potential	n/a	89.9 PJ	PJ
Technical biomass potential	n/a	Agriculture 46.5 PJ; Forestry 16.9 PJ; Byproducts wood processes and paper industry 26.5 PJ	PJ
Unexploited biomass potential	n/a	n/a	PJ
Type/Source of biomass feedstock with highest potential for bioenergy purposes	Woody biomass, straw		
Type/Source of biomass feedstock with highest current use for bioenergy purposes	Woody biomass		
Contribution of this feedstock type to domestic biomass supply for bioenergy production	n/a	n/a	ktoe

Annual imports of biomass for energy conversion purposes	n/a	n/a	
Employment in Biomass sectors	n/a	n/a	Direct employment
Main domestic primary source of energy (e.g. coal, renewables):	Nuclear energy		
Main domestic sector of bioenergy (e.g. biofuels for transport, heating, electricity)	heating		

Supply Side - Biomass / Feedstock:					
Origin/Sector	**Feedstock**	**Potential for growth: yes/no**	**Quantities / Availability (t, m^3, etc.)**	**Comment**	**Bioenergy Product/Intermediary (solid, liquid)**
Forestry & Wood industry:					
Wood production and primary wood residues	Forest wood		1,060,000 t	Fire wood	
	Pellets (2014)	18 facilities	80,000 t	85 % export	pellets, solid
	Wood chips		1,470,000 t/year (2012)	Production of wood chips in forestry was 550,000 t. State forest enterprises produced 160,000 t, non-state producers produced 390,000 t. Production of wood chips on non-state forest land was 580,000 t.	wood chips, solid
Secondary residues from wood industry (e.g. saw mills)	Black liquor	paper industry		paper industry	
Agriculture:					
Oilseeds (primary production & residues)					
Sugar & Starch crops (primary production & residues)					
Dedicated energy crops/lignocellulosic biomass on agricultural land	Straw			2,874,000 t	solid

4.7.2 Country report Slovakia

Bioenergy market characteristics

Slovakia, lacking significant amounts of natural resources, is among the highly energy depending countries with external dependence rate at 60.9% (Energetike, 2016).

The Energy Policy of Slovakia (SIEA, 2015) determines clear prioritization of renewable energy sources for heat, in particular through biomass and geothermal energy as well as hydropower. It anticipates the increase of share of renewable energy sources in overall electricity production up to as much as 24% in 2020 and 27% in 2030, respectively. Biomass is anticipated as energy source for heat and electricity with the highest potential. On the other hand, biofuels are analysed as the best and most prospective alternative for traditional fossil fuels, especially for transport industry. Currently, Slovakia produces biodiesel. Original targets for biofuels related to the EU directive 2003/30/EC, were 2% at the end of 2005 and 5.75 % at the end of 2010. This is currently increased up to 10% by 2020.

Energy policy implementation will support and strengthen a well-functioning energy market with a competitive environment. The energy policy focuses on creating a stable framework for a safely operating energy market that supports investments into energy. It responds to the interests of customers and end users in order to maximise the exploitation of the advantages offered by a liberalised and secure energy market.

In order to reach these goals, the Slovakian government has set in place a number of legal acts and ordinances which are in line with the EU RES policy. Some of the most important ones and the responsible ministries are listed below (detailed documentation in Deliverable 6.1.1. of ENERGY BARGE).

- Act No. 309/2009 on Support of Renewable Energy Sources and High Efficiency CHP (Energy Sector, Distribution/Storage, Energy Sector, CHP, Energy Sector, Electricity Generation, Energy Sector, Electricity Generation, Renewable, Energy Sector, Electricity Generation, Renewable, Bioenergy); Ministry of Finance of the Slovak Republic
- The Act on Support of Renewable Energy Sources and High Efficiency Combined Heat and Power (CHP) Generation aims to increase the share of electricity generated by renewable energy sources (RES), as well as high-efficiency CHP plants.
  It implements Directives 2004/8/EC and partially 2001/77/EC.
  The Act defines the conditions for supporting of RES and high efficiency CHP production (mostly electricity and biomethane production), rights and duties of electricity producers, distribution network operators and producers of biomethane, the rules for issuing certificates of origin for electricity produced by RES and high efficiency CHP and biomethane, pricing rules and obligations for state administration bodies.
  The Act targets all scale of RES electricity and CHP generation (up to 200 MW).
  Under the Act, RES and high efficiency CHP electricity producers would be entitled to preferential transmission, distribution and delivery of their electricity. System operators would also be required to buy RES and high efficient CHP electricity at a preferential fixed purchase price and for investment period of 15 years.

As a result of demands from Slovak non-governmental organisations, new Operational Programme Quality Environment has been extended by clear set of sustainability criteria, including definition of sustainable usage of biomass (bankwatch.org, 2016). By this achievement Slovakia reached implementation level well beyond existing legal requirements as the European Union itself has not succeeded to create any binding conditions to ensure the sustainability of energy generation from solid biomass (more on this issue in Deliverable 3.1.3 of ENERGY BARGE).

Table 28 shows a summary of the Slovakian measures as promoted under the NREAP (European Commission, 2017) and was compiled in the FP 7 project "BioClus".

Table 28: Slovakian policy measures regarding the use of renewable raw materials according to NREAP 2010

Summary of all policies and measures

No	Title and reference of measure	Type of measure	Estimated result	Target group and/or activity	Existing (E) or planned (P)	Beginning and the end of measure
1.	Obligatory addition of bio-components into motor fuels	financial, regulative,	Increased use of renewable energy resources in transport	Producers of engine fuels	E	2006 →
2.	Promotion of use of renewable energy resources in business sector	financial	Production of electricity and heat from renewable energy resources	Investors	E	2007-2013
3.	Promotion of use of renewable energy resources in households	financial	1. Installation of boilers for biomass 2. Installation of solar panels	Households	E	2009-2015
4.	Access of bio-methane into gas network	regulative	Production of bio-methane	Utilization of agricultural biomass	E	2009→
5.	Guarantee of obligatory purchase of bio-methane	legislative, regulative	Production of bio-methane of 60 ktoe	Utilization of agricultural biomass	P	2011→
6.	Promotion of production of fast-growing wood species	legislative, regulative	Increase of biomass offer	Agricultural enterprises	P	2011→
7.	Production growth of wood raw material	legislative, regulative	Increase of biomass offer	Forest enterprises	P	2011→
8.	Obligatory use of renewable energy resources in restored buildings	regulative	Heat production	Project engineers	P	2012→
9.	Promotion of renewable energy resources for heating and cooling in public buildings	financial	Production of heat and cold in public buildings	Public administration	P	2014-2020

Further on, the current market situation and potential for growth is analysed along the biomass value and supply chain in Slovakia.

The Slovakian Vision for Renewable Energy 2050 by the International Network of Renewable Energies (INFORSE, 2017) is counting on growth of demand for energy services (such as heated floorspace etc.). Comparable development of efficiencies is expected, while the study forecasts a decrease in energy consumption, in comparison with other EU countries. It is envisaged that

Slovakia could reach a self-sufficient level of energy supply with renewable energy in 2050. As it is seen from the graphs below, the renewable energy potential, driven mainly by biomass heat and fuel, is larger than the possible demand in 2050. Biomass heat and fuel, sourced from energy crops play a decisive role in these forecast scenarios.

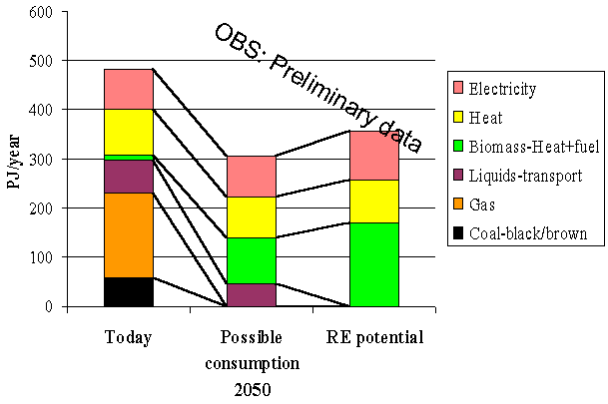

Figure 34: Slovakian renewable energy from biomass potential forecast for 2050 (Source: ibid.)

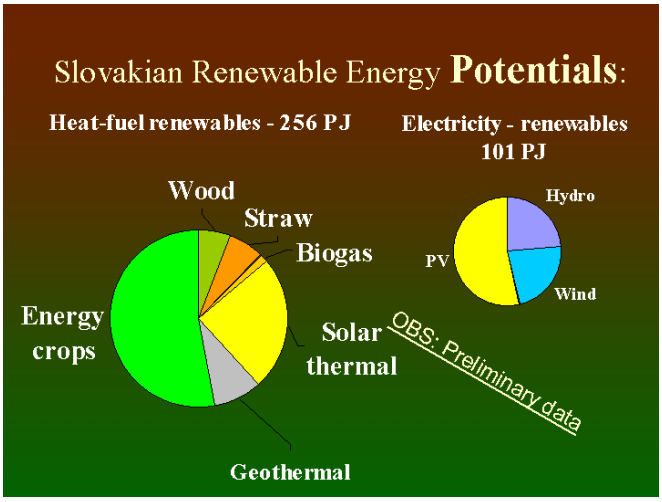

Figure 35: Slovakian Renewable Energy potential (Source: ibid.)

Currently, the demand side for biobased energy mainly focusses on wood as a feedstock for heating. The biggest consumers are district heating plants, the wood processing industry and households, as shown below. Over 3 mio. t of wood-based biomass for energy purposes was consumed in 2012.

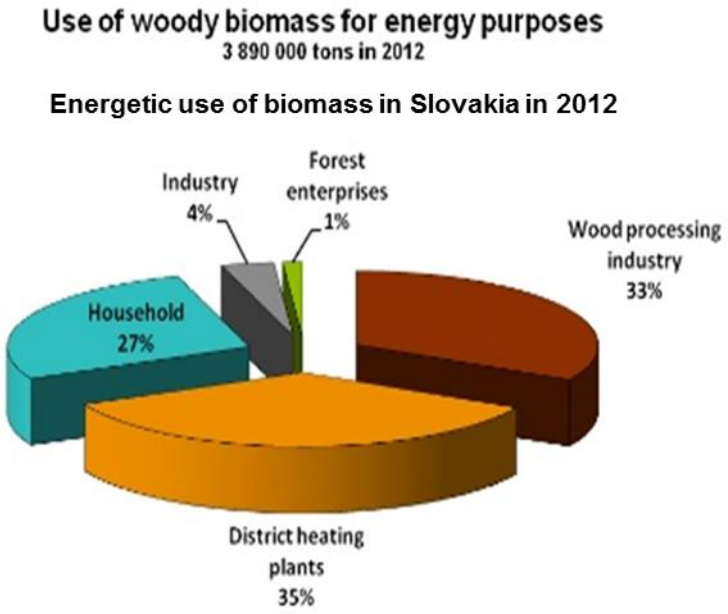

Figure 36: Use of woody biomass for energy purposes in Slovakia, 2012 (demand side) (Source: ibid.)

The Slovak Innovation and Energy Agency (SIEA, 2017) has published the mix of biomass energy used in Slovakia in 2012, indicating the bioenergy use according to sectors and bioenergy carriers as presented in Figure 37. The by far biggest share was made up by heat from solid biomass, contributing 20.6 PJ.

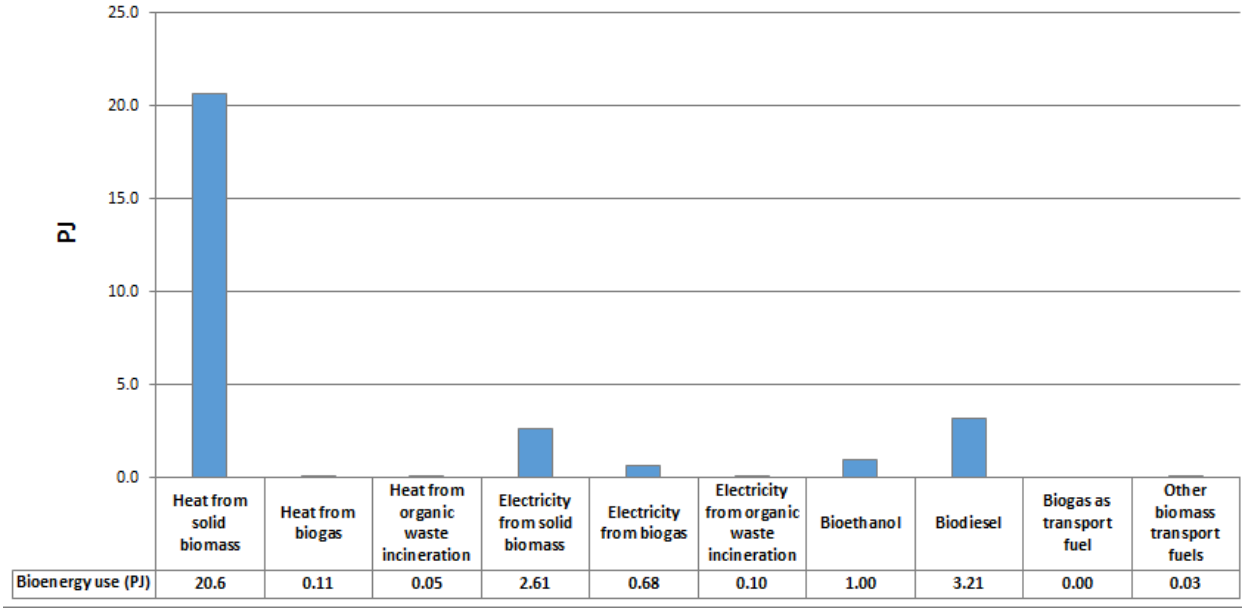

Figure 37: Overview of Slovakia's energy use from biomass in 2012 (Source: Slovak Innovation and Energy Agency (SIEA))

When comparing the shares of biomass in production of electricity, heat and transport fuels to other EU countries and the EU average, an underperforming role can be identified, as shown in figure 38.

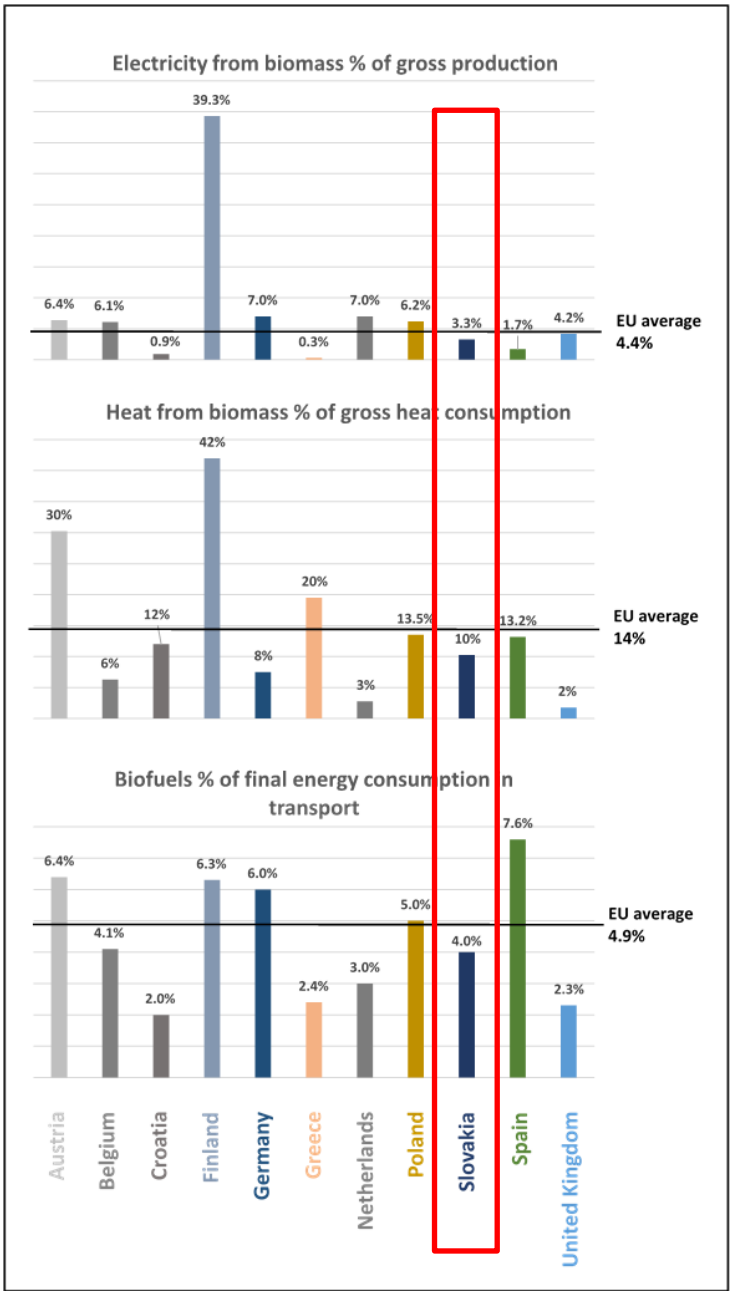

Figure 38: Comparing the role of biomass in Slovakia with consumption in other EU countries (Source: Biomass Policies, 2015)

As was analysed above, woody biomass is the main currently used biomass source for energy purposes, mainly heating. Current annual wood processing is 8 million m^3. Side-products of the wood industry production are used as a raw material for energy production in wood working factories. Production lines are usually designed with the aim to cover whole internal energy needs and thus make them self-sufficient. Some of wood industry residues and byproducts are

used and supplied to the general market. Main products include wood chips, sawdust, firewood and wood pellets. Even though available wood remnants for energy usage are already utilized in very high extent in Slovakia, further potential is seen in development of highly cost and energy efficient products, that can even more diversify and optimize biomass supply chain.

Globalization has also an impact on the forest industry, where increased centralization and concentration of wood processing seems to be a growing tendency over the last years. The main drawing force consists in the wood processing industry run and owned by multinational companies. From sector point of view, biomass players are active mainly in pulp and paper, aglomerate wood based panels and bioenergy raw material providers. All of them are, on the other hand, representing main demand for wood-based feedstock and are competing between each other on the purchase market.

The most dominating and hence important actors in the biomass and bioenergy market in Slovakia come from both the public and private sector and are listed and described below.

The **Slovak Innovation and Energy Agency** provides information service for the **Ministry of Economy of the Slovak Republic**, with special focus on innovations and energy sector. It collects and distributes information related to the topics such as increase of energy efficiency, renewable energy sources, combined heat and power and the development of innovation activities, related to the mentioned topics.

Ministry of Agriculture and Rural Development of the Slovak Republic is supervising complex activities concerning structural, financial and legislative basis for agricultural and rural development.

ZCPP, Pulp and Paper Industry Federation of Slovak Republic, is the business and employment representation of the Slovak industry for production and processing of pulp, paper, board, cardboxes, tissue and sanitary products and print.

International Centre for Applied Research and Sustainable Technology (ICARST), ICARST is an international non-profit research organization based in Bratislava Slovakia that was established in the spring of 2011 with a mandate to foster research and development as well as national and international cooperation in the areas of applied research and sustainable technology. Its members are the frontrunning research institutes, faculties and universities in Slovakia dealing with aspects of sustainable chemistry, biotechnology, material sciences and bioenergy from Bratislava and Trnava.

BIOMASA, Slovak Biomass Association, informs and promotes the rational use of renewable energy sources, the energy savings, the high potential of biomass in Slovakia and the concrete actions regarding the reducing the environment pollution.

Centre for Sustainable Alternatives (CEPTA), is a civil society association located at the Technical University Zvolen. CEPTA was founded in 2005 as an association of people who engage in different activities such as environmental protection, nature protection, and support of civil participation, healthy lifestyle and sustainable alternatives to present consumer lifestyle.

Strategic research in the public research institutions of Slovakia concentrates amongst other on:

- An increase of wood-based biomass production via application of fast-growing wood species,
- An application of economically acceptable and environmentally friendly technologies of complete processing chain of wood biomass,
- Optimization of biomass transport logistics,
- Impact of intensive demand for biomass on balance of soil nutrients and fertilization options,
- Storage of biomass in order to improve its energy features,
- To stress routes to alternative production of various types of energy based on a broad variety of industrial crops depending on the natural conditions,
- Development of economically efficient technology of establishment of forest stands and collection of energy industrial crops, their processing and storage,
- Improvement of logistics of agricultural biomass,
- Improved modes of the intensive production of new types of plants applying the optimization of soil nutrients and the possibilities of fertilization,
- Development of new innovative products from agricultural biomass,

Key bioenergy, biofuels industry and research stakeholders in Slovakia include:

Biorafineria SK is a technology and engineering provider for biodiesel, vegetable oil and second generation (2G) biofuels plants. They are located in Sucany, in the North of the country.

Energochemica SE is a Czech chemical company with mayor production sites located in Slovakia. Although being a classical fossil-based chemical company, they are Slovakia's number one investor in a biomass-based biorefinery in which they are planning to produce and process biomass combined with high-efficiency electricity, heat, ethanol, ethylene and ethylene oxide production. The refinery is not only going to be self-sustaining in terms of energy. It will be able to provide its surplus green energy to other consumers in the public network.

Slovnaft VURUP, belongs to the MOL group and runs the biggest Slovak crude oil refinery. Also, they produce lubricants. They are pushing for an increased use of bio-additives such as ETBE in their petrol mixes. Moreover, they are increasing their production in biodiesel.

The most important actors and stakeholders revolving in the woody biomass sector are more closely analysed in the market profile below.

Overall, when qualitatively analysing the current Slovak market situation in terms of biomass and bioenergy, it can be summarized as in the SWOT table below. All these factors are influencing the current and future market uptake of biomass for bioenergy and material use in Slovakia and comprise technical, economic, societal and legal/organizational aspects.

Table 29: SWOT Analysis Slovak Biomass and Bioenergy Market

Strengths	Weaknesses
• In general high potential for RES utilization • Bioenergy to be one of the most prospective RES • Still relatively high forest coverage, strengthen by utilization of agriculture land for highspeed growing biomass materials • High quality of harvested timber • Existing forest and non-forest land can potentially cover estimated 8% of energy consumption and 30% of regional heat consumption • Well-established infrastructure of road and railways network • Long-term tradition in wood processing and agriculture sectors • High level of centralized heat production in urban areas (estimated coverage 50 % of the total production), suitable for utilization of biomass energy	• Limited financial resources for usage of advanced felling technologies. • Lack of forest density networks, particularly in mountainous areas of the region • Limited cooperation and information exchange between forestry sector and wood processors and lack of influence of the responsible national and regional institutions (Ministry of Agriculture and regional governments) in this area. • Funding available for investments into wood biomass technology • Missing more intensive support for biomass material producers • Relatively high areas of protected forest sites limiting sustainable exploitation of local timber resource. • Legislative obstructions limiting timber and other wood material production on non-forest land.
Opportunities	**Threats**
• Limited local and regional resources of traditional fossil fuels and high dependence on imports • Fuel wood biomass seen as the most prospective renewable energy source with a potential to cover a significant portion of energy consumption • Innovative forest management to increase efficiency of forest land production • Production of fuel wood biomass (other suitable wooden materials) on uncultivated agricultural and other land with the positive economic, environmental and social impacts effects. • More targeted support of R&D activities and systematic utilization of their results in this area • Development of a viable strategy for production and use of fuel wood biomass, including a complex system of support measures to facilitate the optimizing and sustainability of the development and related activities within the region	• Strong position and influence of traditional fossil fuels producers • Historical popularity of nuclear energy in Slovakia • Limited interest of responsible politicians in development of viable strategy of production development and usage of biomass energy, or other renewable energy sources implemented in the individual regions. • Persisting or aggravating situation in the field of biomass promotion and production. • Continual limited support of R&D and implementation / incorporation of such results • Strong dominance of foreign industrial investors, limiting real impact of local targets and needs

Market profile: Analysis of most promising biomass/bioenergy supply chain

As shown above as well as in the country factsheet, woody biomass is considered as the biomass material with highest potential for bioenergy generation in Slovakia. Consequently this source of potential energy is taken as the most promising bioenergy supply chain in the country.

According to Parobek and Paulus (2016), the total domestic roundwood production of primary wood resources consists of 8.06 mil. m^3. The wood consumption is influenced mainly by general economic situation, changing demographic statistics, industry composition, affecting altering demands of sources and current global and consumption trends. Available wood supply is also changing substantially, depending on changes in accidental felling, previous remnants, ownership structure, price of wood itself and of production factors, valid legislation, etc. Natural felling volume is generally stable, but its share is quite high (up to 70%). Demand is partially saturated by the import, especially of round wood (0.922 mil. m^3), mainly coniferous pulpwood used for pulp production. The share of round wood exports is relatively high (35%) and significantly reduces the domestic availability of certain round wood assortments.

In 2015 total resources were 8,984 mil. m^3 round wood equivalents. The use side of the balance is represented by the round wood export, which was 3,122 mil. m^3 . The difference between these two data indicate the estimated volume of domestic consumption (5,862 mil. m^3). The resource side of the round wood volume is healed by wood processing residues consisting mainly of sawmill residues and black liquor. These sources represent 16% of the total resources, the majority (1.3 mil. m^3 round wood equivalents) having been produced by the sawmill industry.

Concerning total biomass resources available in Slovakia (Oravek, Slamka, 2013), 83% of all estimated resources consist of forest biomass while 17% were from industry waste. Distribution of consumption shows that 84% of resources were used industrially, while share of 16% were consumed for energy creation. Sawmill industry is the main consumer, followed by the producers of pulp and wood-based panels.

The estimated amount of consumption of energy wood is around 3 mil. m^3 , consumed mainly of households (relatively high frequency of usage of energy wood mainly for heating due to historical reasons), and the wood processing industry (energy recycling). Wood fuel industry is a very specific sector, with the production of 31,000 m^3 round wood equivalents (most of the production exported). Production sawmill industry which is the main consumer of round wood (coniferous) as well as the main producer of wood products in Slovakia, represents of 1.43 mil. m^3. The pulp and paper industry is important consumer of non-coniferous pulpwood. However, because of the intensive material input/output ratio, the final production was only 0.7 mil. t. The input/output ratio is the highest (4.5) for the production of chemical pulp.

Cost structure (excl. VAT):
Costs for feedstock procurement and storage[€/solid m^3 incl. bark]
Feedstock Conifers (mainly spruce: Picea abies)
Feedstock costs at forest road: 30 – 33 €

Transport forest road to BTC*:9 – 10 €
Costs at factory gate (BTC): 39 – 43 €
Storage: 1.5 – 3 €
Manipulation: 2 €
*Mode/s of transport: almost exclusively round wood truck with trailer are in use, load capacity is approx. 25 solid m^3

Costs for chip production [€/bulk m^3]*
Chipping: 2 – 3 €
Manipulation: 0.5 – 1 €
Administration: 1 €
*Pls. note €/bulk m^3 as unit for the chip production
Conversion factor/s in use
Base unit: 1 solid m^3 incl. bark
Converted Unit: Bulk m^3
Conversion rate: 2.5

State Forest Enterprise is the body for the wood processing and pulp and paper industry, managing over 900,000 ha of forests, with overall timber felling volume of 3,800,000 – 4,500,000 m^3. The overall number amounts to 3,600 employees and additional 6,000 positions in services, mainly felling and timber transportation. The first production of wood chips in Slovakia started in 2011 and at present the production rose up to 150,000 – 220,000 tonnes/year.

Ministry of Agriculture and Rural Development of the Slovak Republic is responsible for creating complex strategies and legislation related to forestry (besides agriculture and related industries). The ministry acts as a national authority concerning biomass production by application of financial and legislative tools. In 2008, the ministry prepared the Action Plan of Biomass Utilization.

National Forest Centre cooperates closely with the Ministry of Agriculture and Rural Development (and in some cases other involved government ministries as well) regarding the strategies and related politics related to wood biomass production. Besides activities focused on research, innovation and knowledge transfer, the NFC cooperates with a number of companies especially in area of technology transfer and innovations.

Regional heating plants owned by the state include Zvolen and Martin (located in Central and Northern Slovakia). The enterprises are using a substantial portion of wood biomass, and the overall annual consumption is up to 150,000 tonnes of chip woods.

A number of private companies such as international companies DALKIA and DTEFE and INTECH SLOVAKIA (national level company) supply heating energy for cities, their total consumption of is estimated at 100,000 tonnes of wood biomass per year.

Mondi SCP Ružomberok must be mentioned here as the biggest pulp and paper producer and the biggest wood contractor in Slovakia consuming annually around 2,500,000 t of wood. The company is heading to become among the most important suppliers of wood biomass for heating also in other regions.

LESY SR (Forests of Slovak republic) is the state-owned enterprise which is responsible for supervising of forests owned by Slovak republic. The company was based in 1999 by a fusion of six independent forest companies active in different parts of Slovakia. In 2009 they possessed 943,272 ha of forests, which is 46.95 % of overall area od forests in Slovakia. The extensive investment in new technologies made LESY SR most important enterprise and resulted in the establishment of new markets and new power plants located next to country's biomass resources. The pilot programme established new opportunities for wood chips, supplying 25 – 30 new heating plants in the region (Banská Bystrica, 2017).

4.7.3 Conclusion on Market Study Report Slovakia

Renewable sources of energy turn out an increasingly important role in Slovakia. The country is a member of the European Union and has joined the EU-wide activity to increase the union's share of renewable energy sources to 20 percent by 2020 of all primary sources of energy. Slovakia seems to be on a progressive way to meet this goal, with the aim to set the expenses for electric power generated from renewable energy sources to the lowest possible impact on final electricity prices.

Slovakia's total annual capacity in the production of forest biomass suitable for energy production reached around 1,080 thousand tons at 2010 (16.9 PJ) (Medved, 2014). A further increase of the amount of forest biomass will be reached through more intensive forest exploitation. The area for energy crops production is expected to grow up to 45,400 ha in near future. Energy crops are considered to be a feasible source of biomass-based fuel, if the biomass is growing in areas unsuitable for standard agricultural and forestry production, or abandoned from other reasons (land temporarily unused for agricultural production, contaminated land not allowed only for food production, or land in industrial glomerations).

Recently the wood for energy production seems to be more and more important. Wood-based fuel is used for energy production in various technical set ups so that an optimal technology can be chosen depending on capacity needed primary in investment availability and environmental requirements. Either internal or external facilities can be involved. At the same time, it represents a significant source for heat energy in households. Wood, traditionally utilised as material for the production of wood products, is increasingly applied for energy production. The growing demand for energy wood leads to a rise of prices of energy wood, influencing the interest of private sector to invest in both production of the energy wood as well as to invest in building new energetic plants for biomass as raw material.

Agricultural biomass of various origin and consistence is frequently converted to fuel mainly in biogas stations and for liquid fuels production since 2020, a binding objective was set up concerning the biofuels to add 10% of biomass-based components into the conventional fuels transport. This goal should be achieved by the cost-efficient way. A binding nature of this target

must fulfil the requirements of production being sustainable. From this point of view second-generation biofuels are under advanced stage of development, and meant to meet the modified directive on biofuels quality, which will be amended to requirement of a higher share of bio-component in the fossil fuels. It was proposed to adopt procedures to promote the use of agricultural biomass for energy purposes. One of the partial goals consists in building biogas plants each year with an installed power of 7.5 MW (Ministry of Economy proposes a construction of 30 plants with an average capacity of 250 kW). According to the lower competitiveness of agriculture in the area of food production, one of the possible solutions consists in an improvement of the economic situation in the sector by a growth of efficient productions of energy crops as the significant factor of rural development. Growth of this production depends on optimal management of agricultural land, while maintaining the national food security, and of abandoned or unused agricultural land for use to produce fuel wood biomass in Slovakia.

5. Comparison of national market study reports

On the basis of the compendium of national market study reports presented here, it is possible to derive information on macro-economic aspects of the biomass and bioenergy markets in the partner countries and the Danube region as a whole which eventually will be covered in the Output O.3.1. These can be summarized as:

- Disparities between countries regarding market uptake, market share and utilization of sustainable biomass potentials
- Most promising national biomass feedstock and bioenergy types and subsequent specialization areas
- Most promising feedstock and bioenergy types for the Danube region and an integrated bioenergy market in the Danube region
- Feedstock types and bioenergy (semi-)products with volume-related, geographical and physical potential for transport via inland waterways

For example, the table below shows the data comparison of all PPs' input on the most promising national biomass types, bioenergy products and deployment sectors and thus the supply and value chains relevant for the future development of bioenergy markets in these countries and the Danube region as a whole. From this, transnational conclusions can be drawn on the overall biomass and bioenergy situation in the Danube region. The quantitative comparison of all indicators analysed in D.3.1.1. (fact sheets and country reports) with relevance will be included in Output 3.1.

Table 30 gives clear evidence, that woody biomass is and will be the predominant national and transnational biomass segment both in terms of potential and in terms of actual current use. Especially the residue material from forestry and wood industry has a major unexploited potential in several countries, e.g. Germany, Austria, Hungary, Romania and Croatia. Moreover, agricultural residue materials, although reported as challenging regarding collection and transportation at times, show future potential that might also be economically viable given the

right political and technological framework. Overall, in line with the principle of sustainable potential, the clear prioritization of food and feed production, aspects such as land use change, monocultures and societal acceptance (S2Biom, 2016), the ENERGY BARGE country reports have clearly shown that in all covered countries, biobased residue material is the feedstock group most promising for energetic purposes in the Danube region. In addition, some countries also indicate significant potential for advanced technologies, especially second-generation, lignocellulosic and oil-based biofuels, e.g. Croatia, Germany, Hungary, Romania, Bulgaria and Slovakia. Here, potential for inland waterways to offer necessary logistical service is of significance due to the high volumes and the rather centralized production infrastructure. This accounts especially for the entire oil seed supply chain and the latter parts of the lignocellulosic biofuels supply chain (transport of products and residues).

For the woody biomass, ports can play a two-fold role, firstly, as logistics hubs and secondly as processing and trade centres[16]. The CHP and transport fuels sectors can be those profiting most from the technical biomass potentials identified, given the measures for increased market-uptake analysed in the national market reports can be formulated as target group oriented recommendations and can subsequently be realized.

Table 30: Comparative exemplary overview of qualitative analysis on the most promising national biomass and bioenergy sector types

Country	Feedstock Types	Bioenergy products	Sector(s)
Austria	Residual forest wood, sawmill-by products, short rotation forestry,	Wood chips, pellets, briquettes	High-temperature heating applications, co-firing (torrefication), micro-grids
Bulgaria	Residual forest wood, round wood, rapeseed, soy beans, grain straw, miscanthus	Wood chips, pellets, vegetable oil/biodiesel, bioethanol	Heating, transport biofuels (1. & 2. G), [chemical use]
Croatia	Fuel wood, forest residues, wheat straw, corn stover	Pellets/briquettes from wood, processed straw, processed corn stover	CHP heating, CHP power, second generation transport biofuels
Germany	Residual forest wood, grain straw, animal excrements	Solid woody biomass, transport fuels such as bioethanol	Heating, transport biofuels, CHP
Hungary	Agricultural by-products, energy crops, organic wastes	Liquid fuels (bioethanol and biodiesel), solid biomass, bio gas	Local heat generation, low to medium capacity local power plants, biofuels & biogas
Romania	Residual forest wood, firewood waste, agricultural residue materials	Pellets, biofuels (biodiesel, bioethanol)	Heating, transport biofuels (1. & 2. G), electricity
Slovakia	Woody biomass, Residual forest wood, grain straw	Pellets, wood chips, lignocellulose-based biofuels (2. G bioethanol)	Heating, advanced (2G) transport biofuels

[16] Analyses of biomass trade centres have been conducted e.g. in the BiomassTradeCentresII or the BioRes projects.

Challenges for the bioenergy market: potential vs. constraints

As the country fact sheets show and as it has been validated by the European Commission (2017), all EU Danube region countries are well underway to reach their NREAP goals. In almost all countries, biomass is the most important contributor out of all RES types. However, especially in Hungary, Slovakia, Romania, Croatia and Bulgaria, this fact results from an extremely high share of household heating based on fire wood, which is not considered an innovative source of bioenergy.

All countries have reported additional potential for certain, nationally and regionally specific types of biomass feedstock and their subsequent bioenergy applications on top of what they are currently deploying and in a sustainable manner. Two conclusions can be drawn from this situation:

1) The Danube region has a substantial and diversified potential to increase its share of bioenergy in all sectors of the transnational energy market based on the available biomass supply
2) A set of factors present in all countries currently inhibits the exploitation of this potential on the demand side

In theory, point 2 is restricting the socio-economic effects a strong biobased energy market and its complimentary biomass feedstock supply could have on the national economies of all Danube countries and the region as a whole, mainly the effects of job creation and added value in rural areas, technological advances, energy independence and contribution to climate goals – potential effects that have been reported for all countries of the Danube river basin.

Looking at the demand side and comparing the country reports and fact sheets, the CHP and transport fuels sectors on a transnational level can be those profiting most from the additional biomass potential identified. However, despite the potential on the feedstock supply side, the demand side for bioenergy in the power, large-scale heating/cooling and transport sectors is not well-established, especially in all Danube countries south of Austria, leading to a mismatch of possible supply from the agricultural and forestry sectors (including infrastructure in place for most promising feedstock types) and demand from the energy sector (energy producers and end-users). This situation is particularly evident in the biofuels sector, where almost all countries report potential for both first and second generation biofuel production but the market shares in all countries have been stagnating or even shrinking.

Looking at the SWOT analyses conducted within the country reports, a major reason for this in all countries is the lacking competitiveness against the currently cheap fossil fuel prices in addition to insufficient or swiftly changing political frameworks both on national and EU level. There is an indication that liquid biofuels, both diesel and ethanol, will probably not be growing much more within the EU and also not in the Danube region. An alternative use of the oilseed and lignocellulosic waste feedstock available in the Danube region could be the chemical-material sector, using side streams of the production for bioenergy generation (e.g. protein biorefineries, 2G sugars for the chemical and industrial biotech industry, biobased plastics, etc.). The electricity sector that will potentially see increased demand from the e-mobility branch

could be backed up by the biomass potential for CHP plants. Overall, the Danube region thus clearly has a comparative advantage from the supply-side in becoming a bioeconomy macro-region in Europe.

Drawing from the SWOT-tables, it is evident that in order to achieve this, a more concerted approach to political framework conditions along the entire value chains, including research and innovation is needed. Before approaching the transnational level, however, it seems to be much more important to engage the actors along the national value and supply chains with each other and to inform them about the options biomass and bioenergy have. The complexity of the value and supply chains even on national or regional level and lacking information and knowledge of each other, potentials, technologies and market support options is an inhibiting market uptake factor in all countries reported.

Options for the Danube inland waterway transport system and inland ports

The country reports have revealed that especially the residue material feedstock types are not the most obvious cargo group for a bulk transport type such as inland waterway transport, especially due to economic and physical property reasons (low energy density rendering long transport too expensive in comparison to their cost, proneness to breaking) and due to their occurrence (e.g. forestry residue material and straw: very local and decentralized). However, the entire value and supply chain has to be considered, also looking at intermediary goods and final products, material use of biomass in the sense of a bioeconomy (cascading use), as well as options for production sites in ports.

Most countries have analysed a significant potential and an already existing market for liquid biofuel based on oilseeds and lignocellulosic waste materials. Here, options for inland waterways to offer necessary logistical services are of significance due to the high volumes and the rather centralized production infrastructure. This accounts especially for the entire oil seed supply chain and the latter parts of the lignocellulosic biofuels supply chain (transport of products and residues). Moreover, for this supply chain, the chemical-material market seems to be developing in a number of countries (Germany, Slovakia, Hungary), opening up future options for high-volume cargo freights from regions with high sustainable harvest potential to decentral first and second conversion and central refining locations such as suggested in the Green Energy and Chemistry Belt concept.

For the woody biomass, ports can play a two-fold role, firstly, as logistics hubs and secondly as processing and trade centres[17]. Generally, inland waterway transport is well-suited for the transport of timber for sawmills, furniture and paper industry as has been identified in some country reports. From these industries, a high secondary potential for the production of bioenergy products such as pellets and wood chips arises, often used to power the industrial plants themselves. Here, most of the potential in the Danube countries is already being used. As many of these production plants are located directly at the Danube (e.g. Austria, Germany) and close to ports, utilizing these biomass potentials to power port infrastructure and companies settling in those ports through CHP plants should be a priority in developing these ports. An

[17] Analyses of biomass trade centres have been conducted e.g. in the BiomassTradeCentresII or the BioRes projects.

example of such a circular integration was demonstrated to the ENERGY BARGE consortium at the port of Aschaffenburg, Germany (Main-Danube channel) in WP 4. This measure could contribute to a transnational Danube region network of ports powered by green sustainable energy.

Forest residue material which was most frequently indicated as the woody biomass feedstock type with the highest potential does not have a direct suitability for inland waterway transport due to logistical and economic constraints caused by its decentral occurrence (as shown e.g. in the German country report). However, for ports located in a vicinity of around 100 km to forestry areas, an option would be to settle pellet and wood chip production facilities in the ports (could also be using residue materials from the industry sectors mentioned above). In general, wood pellets and wood chips are currently not a primary cargo good on inland waterway vessels due to economic and physical property reasons. However, wood pellets are imported to Europe from Northern America via oversea vessels, which shows that a more thorough assessment of viability of transport for pellets and wood chips on inland waterways, especially from the industrial side, could be indicative. Moreover, logistics actors should consider transport options that guarantee that no physical damage is inflicted to the pellets and chips. This could be especially sensible as a number of countries, mainly Croatia, Germany, and Austria have reported that they have high export capacities for wood pellets.

Overall, most countries have reported options for export for a number of bioenergy feedstock types and products, due to overproduction and lack of domestic demand, mostly on the road, which indicates a promising theoretical market for export logistics on the Danube.

Both the factsheets and the country reports will form the basis for further inquiries during the set-up of WP 3's and WP 4's outputs.

6. Project-related outlook and challenges

The task of this deliverable was to lay the data-related and theoretical groundwork for a number of following activities, deliverables and particularly outputs in the thematic Work Packages of ENERGY BARGE. To do so, the aim was to file a compendium of national market study reports considering national biomass and bioenergy situation and relevant value chains. The basis for this was a two-fold framework for qualitative data collection and report assembly which was compiled with input from previous EU research projects in order to facilitate capitalization. By analysing the current market and value chain situation in the respective partner countries' markets, it was aimed towards a comparative compendium, showing strengths and weaknesses of national but also of transnational relevance for the increased market uptake of bioenergy in the Danube region. The information gathered in the market study compendium will be a main input into the design of Output 3.1.

A number of challenges have occurred during the data collection and compilation phase of this document. These include:

- Heterogeneous data availability on national level, especially regarding biomass availability and potential for bioenergy deployment – *solution: slight change of fact sheet*

indicators, intended: communication of pressing need for data availability via recommendations in WP 6 and via other dissemination activities within the project

- Very limited data availability on regional level; consequently very limited information on regions with high biomass potential and port proximity analysis – *envisaged solution: spatial modelling of hinterland potential in GIS models for port cases in D3.2.3, WP 5 and Outputs 3.1, 3.2, 4.1.*
- Delays in some PP's response to task demands – *Lead Partner-measure taken: introduction of interim reports per work package monitoring progress of tasks, delays, and solutions on a regular, 2months basis; envisaged Workpackage-internal solutions: improved WP leader communication and stricter deadline follow-ups, less complex task descriptions and tasks, clear communication from the side of PPs given tasks, simple and clear templates*

The deliverable at hand has been prepared and communicated during the project's kick-off meeting in Linz both at the SCOM to all project partners, and at the first WP 3 coordination meeting on day 2 of the kick-off (28th February and 1st March 2017). An analysis and critical review was being done by the WP leader at the second project meeting in Ruse, Bulgaria, during the 2nd Coordination meeting on June 27th 2017.

This deliverable is the first deliverable for Work Package 3, Activity 3.1. This activity will be finalized in period 2 of the project .

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