biomass policies

Deliverable 3.2
BENCHMARKING bioenergy policies in Europe

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Executive Summary

The Biomass Policies project, supported by the Intelligent Energy for Europe programme, aims to improve the policy framework for the mobilisation of indigenous bioenergy value chains in contributing to the renewable energy targets and beyond. The focus is on the countries participating to this project–the Netherlands, the United Kingdom, Belgium, Germany, Austria, Finland, Spain, Greece, Slovakia, Poland, and Croatia.

This report provides an analysis and evaluation of the different national policy approaches applied for the bioenergy sector in 11 Member States (MS). Additionally, it focuses on a number of value chains that have been selected within WP2 of the Biomass Policies project. It presents their current use for bioenergy purposes, identifies the barriers to their utilisation and introduces the existing energy policies directed to them.

Bioelectricity

Results confirm that Austria and Finland followed by Germany are relatively at a mature stage for solid bioelectricity generation, whereas Germany, the UK and Austria are doing well for biogas generation. These countries have already utilised their low hanging fruit (except the UK) and the current policy process aims on the one hand to sustain the existing generation levels and on the other hand focus more on resource efficiency aspects. Croatia, Greece, Spain, and the UK are lagging far behind when compared with Austria, Finland and Germany, giving indications that the existing policy frameworks are not sufficient to cover the barriers in the entire bioenergy value chain. This is also the case for Poland and Slovakia even though both countries score very well in policy impact indicator (PII).The NL and Belgium can be categorised as in between the well developed and lagging behind countries with the feature both countries having a limited biomass feedstock potential and high dependence on exports. As such both countries give high priority to a biobased economy and resource efficiency plays an important role.

In terms of policy measures most of the countries apply feed-in tariff (or premium) and investment subsidy combined with the tax incentives. The success of these instruments relates, among other things, to the sufficient levels of financial support provided to the sector. Only Poland, Belgium and the UK apply Green Certificates.

Bioheat

The most common policy instrument applied to the bioheat sector is the investment support. Similar to the bioelectricity sector, Austria and Finland score well in both solid and biogas heat generation. Both countries provide a range of investment support to both centralised heating plants and decentralised heating systems. The critical success factors for biomass heat market development in both countries relate to the long tradition in both district heating (DH) and biomass utilisation, strong and advanced forestry industry (that enabled an effective supply chain of biomass as both producers and users of bioenergy), pubic support to heat entrepreneurship and wood energy advisory services and of course governmental investment support . The MS' heat markets however differ considerably, as a result of the variety of their climate conditions, their heat-producing histories and conventions and existing infrastructures (e.g. gas distribution, district heat, or indeed no infrastructure in warm climates where heat is often produced by electricity). As a result, each market may require different, customised renewable heat policy approaches suited to local conditions (Beerepoot & Marmion, 2012).

Biofuels

Spain and Austria score high in almost all indicators related to the biodiesel sector driven by the mandates imposed since 2009 and the hydrocarbon/mineral oil tax exemptions provided to biodiesel. The results indicate that a quota obligation alone is not sufficient to promote biofuels. In fact, countries with only a quota obligation, such as Poland, Greece, Croatia (just tax exemption to pure biofuels) and the UK in general, score low almost in all indicators. The combination of tax relief and quota obligation seems to function well (i.e. in Spain and Austria). An obligation creates demand for biofuels, while financial incentives facilitate the development of production capacity. Tax relief is considered especially suitable for early stages of development and it is strongly dependent on the initial levels of the excise: it is effective where these levels are significantly high.

Sustainability considerations, mobilisation and resource competition

Sustainability concerns have been an important issue for the bioenergy sector. They have been to some degree captured in the existing policy arena through the sustainability criteria for biofuels and bioliquids for the transport sector within the renewable energy directive (RED). A wider consideration of sustainability that includes all energy sectors is, however, needed. There have been some efforts in this direction in some of the MS. Belgium and the UK, for instance, have adopted sustainability criteria for biomass used in electricity and heating & cooling. Germany has introduced sustainability criteria for liquid biomass that is used for combined heat and power production. More recently, the Netherlands has adopted a comprehensive set of sustainability criteria for wood pellets for co-firing addressing, among others, impacts on forest carbon stocks and on indirect land use change (ILUC). In Austria and Germany subsidies under most programmes are also tied to certain sustainability criteria. Resource efficiency concept and its integration into the bioenergy sector has been so far limited to inclusion of sustainability criteria and promotion of more efficient conversion technologies.

Mobilisation of primary forest residues and the agricultural resources has been recognised as an important barrier to the bioenergy sector. Existing policies clearly play an important role in mobilising the above mentioned resources through dedicated subsidies with special bonuses to feedstocks and through capacity building activities. However, other factors, such as specific traditions, socio-economic character of the farmers & the forest owners and the industry sector set the fertile grounds for the effective implementation of the policies.

Resource competition has been recognised by the industries that use the same resources as the bioenergy sector, particularly the pulp & paper and the panel industry. Few countries have introduced regulations aimed at addressing potential competition with existing biomass uses. In Belgium (Flanders region) for example, woody feedstocks suitable for the wood-processing industry are not eligible for Green Power Certificates. Moreover, Poland has adopted a policy increasingly excluding the use of stemwood (with a diameter above a certain size) from being eligible for national financial incentives for renewables. Due to the high utilisation rate of waste wood in Germany, newly erected biomass power plants cannot get feed-in tariffs for waste wood as feedstock. In Finland a reduced feed-in tariff support is given for electricity production for stem wood (large stems). Among the industrial wood residues only forest chips from thinning and loggings residues receive policy support.

Priority value chains

In total 8 feedstock based value chains have been selected by the 11 MS based on their high potential, current underutilisation and future possibilities to use them more efficiently. Among the value chains primary forest residues, organic waste, straw and manure are selected by more than 4 MS as a priority.

- Among the 11 countries Finland appears to be the most successful country in mobilising primary forest residues thanks to its developed forestry sector and the existing biomass supply infrastructure.
- For organic waste Austria, the Netherlands and Germany hold the best management practices. These countries all have comprehensive waste collection systems, landfill generally less than 5% of their waste, well developed recycling systems, sufficient treatment capacity, and they perform well with biodegradable waste.
- Straw use for energy purposes is currently very limited (mainly happening for local heat demand) in the participating countries and the existing policy dedicated to this feedstock (i.e. in the form of feedstock bonus) has not resulted in increased use of straw for energy purposes.
- The political framework surrounding manure based biogas differs from country to country. The introduction of a bonus for feedstock and for manure has pushed the development of manure co-digestion in Germany. The existing measures to promote small-scale manure digestion appear to be non-successful both in Germany and the Netherlands.

Some of the main conclusions and recommendations of this study are listed below.

- **The bioenergy policies should address all barriers in the entire bioenergy value chain and provide incentives to overcome them**. A perfect, one-suit-fits-all package of policy instruments doesn't exist. The appropriate combinations of policy support (the optimal mix) depend on the country specifics and on factors such as the capacity to efficiently produce and harvest biomass feedstocks, the availability of supply infrastructure, the maturity of the technology, the logistics and the end use.

Bioelectricity&heat

- A combination of feed-in tariff and the investment support that targets less mature technologies appear as effective, but only when **the level of support is sufficient**.
- **Dedicated policy support to certain feedstocks**, be it a feedstock bonus or a subsidy for harvesting for energy purposes, can be **successful with the pre-condition that other barriers in the value chain are also sufficiently addressed.**
- Establishment of **strong sustainable forest and agricultural management practices** are key to the success of bioenergy policy support.
- **Environmental benefits of biogas production from organic waste and manure** should be emphasised both at the national and the EU level policy making and reflected in the relevant legislations and regulations
- The right mix of policy incentives for the renewable heat sector depends on the country conditions (climate conditions) and the heat sector (i.e. presence of infrastructure). However, **a combination of investment subsidy and tax incentives is a useful approach**, especially for countries where the market is in its early stages and without District Heating systems.
- It is crucial that any renewable heat policy also considers energy efficiency policies and that the policy framework is designed accordingly.

Biofuels

- Combination of **blending obligation supported by tax exemptions** can be effective with the pre-condition that **the level of tax relief is high enough**.
- Existing support-**double counting advanced biofuels- has not been sufficient** to bring the more advanced technologies into the market. **Additional policy measures** will be needed to reduce investment risk and ramp up the production of advanced biofuels.

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Content

1. Introduction

The Biomass Policies project, supported by the Intelligent Energy for Europe programme, aims to improve the policy framework for the mobilisation of indigenous bioenergy value chains in contributing to the 2020 renewable energy targets and beyond. The project pays particular attention to competition, resource efficiency and sustainability. The focus is on the countries participating in this project; the Netherlands, the United Kingdom, Belgium, Germany, Austria, Finland, Spain, Greece, Slovakia, Poland, and Croatia.

This report presents the recent bioenergy developments and analyses of bioenergy policies by comparing the different national policy approaches applied in 11 Members States (MS). Next to that, it focuses on a number of value chains that have been selected by the national representatives of the Member States in the Biomass Policies project. It presents their current use for bioenergy purposes, introduces the existing energy policies directed to them, identifies the barriers to their further utilisation and introduces the future prospects, also taking into consideration sustainability and resource efficiency aspects. As such, the main objectives of this study are twofold: (i) to determine what and where improvements are needed and based on the lessons learned give recommendations on how to improve bioenergy deployment in the selected countries, (ii) to identify existing barriers to certain value chains that are significant for the Members States (in potential and/or in resource efficiency aspects), learn from each other and share existing (or in some cases planned) good practices related to these value chains.

Benchmarking is defined as 'the formal and structured process of searching, observing and exchanging good practices'. While there is no single benchmarking process that has been universally adopted benchmarking follows a number of common stages that are:

- Identify the problem
- Identify organisations (in our case countries) that are leaders in the area
- Detail the policy measures and practices
- Compare them among each other and
- Identify good practices

In the next section the methodology applied in this study is presented. The boundaries of this study and the main limitations to the methodology are also discussed. Chapter 3 introduces the existing bioenergy policies for the electricity, heating and cooling and transport fuels sectors. Chapter 4 'benchmarking bioenergy policies' compares a number of indicators to assess the impacts of bioenergy policies in the period 2009-2012. It also looks into the sustainability and resource efficiency considerations of each Member State. Next to that, this chapter introduces the existing barriers and presents some of the good (policy) practices identified in some of the MS. Chapter 5 is dedicated to the value chains that are prioritised by the national partners. This chapter introduces the value chains, presents the current utilisation rates and introduces existing policies that are dedicated to these value chains (if available). Chapter 6 includes a discussion section, conclusions and lessons learned. Finally, this chapter concludes with the policy recommendations.

2. Methodology

As a first step, country reports have been drafted that present the current status of bioenergy deployment and the policy process. These reports have been structured in a way to enable a thorough and comparative analysis. Existing studies such as BAP Driver (BAP Driver, 2009) and Cross-Border Bioenergy[1] have helped us to identify the structure as:

- Relevant strategy documents dedicated to bioenergy
- Existing policy measures for biomass derived electricity, heating and cooling, and biofuels
- Deployment of bioenergy between 2009 and 2012
- Potential barriers and existing good practices
- Information on selected value chains
- Framework related to sustainability and resource efficiency.

Annex I presents the 11 detailed country reports that have been drafted with great help from national representatives from Austria, Belgium, Croatia, Finland, Germany, Greece, the Netherlands, Poland, Slovakia, Spain and the UK.

As a next step, existing indicators developed for the European Commission (OPTRES project, Reshaping project) have been reviewed. In total 4 bioenergy policy performance indicators have been established to enable a comparative policy analysis. These indicators are introduced in the following sections.

The bioenergy sector is presented as electricity or heating & cooling from biomass and biofuels for transport. For each sector the type of biomass in the form of solid, liquid and gaseous biomass is further detailed.

As a third step, we focus on the value chains selected by the national representatives within WP2 of the Biomass Policies project (Pelkmans, et al., 2015). The selected feedstocks are: *primary forest residues, industrial wood residues and wood waste, straw, landscape care wood*[2]*, perennial energy crops, organic waste, manure and sugar beet.* Their current use to produce energy has been analysed and in the absence of available statistics the utilisation rates derived from the ECN RESolve-Biomass model (see below) are introduced. Existing policies targeting these value chains and existing barriers and good practices are also included.

RESolve-Biomass Model

RESolve-biomass determines the least-cost configuration of the entire bioenergy production chain through minimal additional generation cost allocation, given demand projections for biofuels, bioelectricity and bioheat, biomass potentials and technological progress. By doing so it mimics the competition among the three sectors for the same resources. The RESolve-biomass model includes raw feedstock production, processing, transport and distribution. One of the most important features of the RESolve-biomass model is the ability to link the national production chains allowing for international trade. By allowing trade, the future cost of bioenergy can be approached in a much more realistic way than when each country is evaluated separately.

The reference scenario

The reference scenario focuses on the current policy measures and the 2020 set NREAP targets. As such it uses the most up to date PRIMES reference scenario used by DG-ENER.

[1] Http://www.crossborderbioenergy.eu/

[2] According to EN ISO 17225-1 it is landscape management wood.

2.1 Indicators

Effectiveness has been defined as *'To what extent has the measure achieved its intended objectives, in relation either to outcomes (i.e. changes in the behaviour of socio-economic actors) and/or impacts (on the state of the bio-physical environment)?'*[3]. Conducting a comprehensive policy effectiveness analysis requires a thorough examination of all the objectives set in each country. Such an analysis is, however, very complex and also not intended in this study. Instead we look at the effects of the policies between 2009-2012 and measured them through indicators grouped as policy effects and market maturity.

Sustainability and the resource efficiency focus of the MS is also included into this assessment to present the state of the play when it comes to policy frameworks related to bioenergy sustainability and resource efficiency.

2.1.1 Policy effects

- **Policy impact indicator**

The 28 EU MS set their renewable energy related policy ambitions in their National Renewable Energy Action Plans (NREAPs) including bioenergy targets. These targets are interpreted as the intended policy ambitions of each Member State and used as the comparable reference quantities. One may question the 2020 targets set by the MS as some being under or overestimated when the country's bioenergy potential is considered. This study does not assess whether the set targets are reasonable or not. Instead, we accept them as reported and use them in this analysis as the bioenergy policy targets. Besides, target setting not solely depends on the existing potentials. Other factors such as environmental, industrial and rural development policies in each country clearly play an important role in setting the targets.

In this study the policy impact indicator shows to what extent the remaining gap to a future target for renewable energy sources is covered per year and reads as:

$$E = \frac{B - A}{C}$$

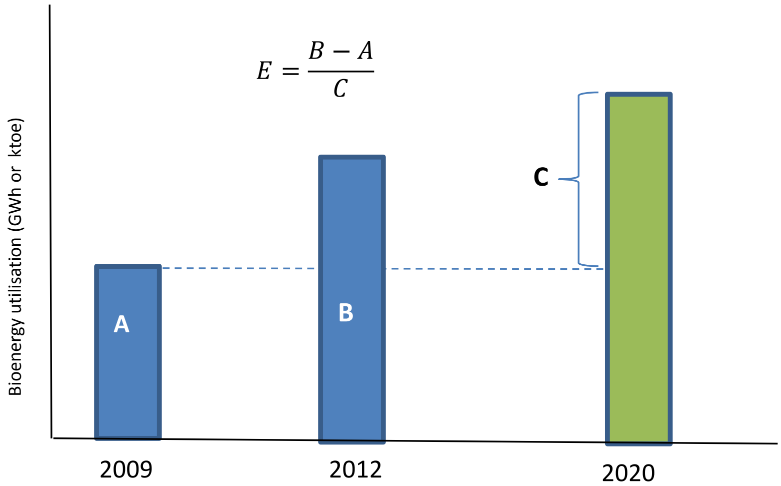
Where:

E	=	*Effects of policy indicator*
B	=	*Bioenergy consumption in 2012*
A	=	*Bioenergy consumption in 2009*
C	=	*NREAP set bioenergy target in 2020-Bioenergy consumption in 2009*

[3] See 'Towards a new EU framework for reporting on environmental policies and measures (Reporting on environmental measures - 'REM')' at www.eea.europa.eu/publications/rem/defining.pdf

An illustration of the calculation of the *indicator* is presented in Figure 1 as an exemplary case.

Figure 1 Illustrative calculation of policy effects



This indicator doesn't represent the actual deployment rates as such, it doesn't take into account that a country may have invested in deployment and already reached a high scale of deployment. Instead, it reflects the relative increase between 2009 and 2012 in comparison to the 2020 NREAP target. To reflect the scale of deployment the following indicator is used (bioenergy deployment per capita). Another weakness of the indicator is that if the ambition of a country was rather low in 2020 targets may score higher. In the assessment such effects are introduced through presentation of 'distance to target'.

- **Bioenergy deployment in 2012 per capita**

As introduced above the policy impact indicator doesn't reflect the actual bioenergy deployment. The bioenergy increase in a certain country may be low between 2009-2014 and this can be due to the fact that the country has already reached a high scale of deployment and the sector has slowed down. On the other hand the high PII may relate to deployment of low hanging fruits as the country may be just taking off. This indicator will present the absolute bioenergy utilisation in a country to capture such effects.

- **Distance to target**

The first indicator, the policy impact indicator is very sensitive to the 2020 set of NREAP targets for bioenergy. Therefore, it is important to present how far the bioenergy deployment in each country is from the 2020 set bioenergy target. Besides, this indicator can also reflect the required policy effort in the coming years to achieve the set targets in a comparative manner.

2.1.2 Bioenergy market maturity

A single policy effects indicator alone will not suffice to analyse the renewable energy policies. The effects of policies, particularly the ones targeting the bioenergy sector, are influenced by many other aspects. For instance, depending on the maturity of a bioenergy market, the policy support framework needs to overcome different types of barriers (e.g. market entry or high-end-system barriers[4]). The way risk is shared between market players and public may be adjusted to the maturity of the respective bioenergy market, assuming that more mature markets can more effectively cope with risks (Held et al., 2010).

The bioenergy market maturity assessment is composed of a few sub-indicators, representing different aspects of the bioenergy sector. The sub indicators are as follows:

- ***Consumption of bioenergy as share in total sector consumption***

This indicator reflects the relevance of bioenergy for its energy sector (i.e. electricity, heating and cooling or transport) and to what extent it is visible for policy makers. For instance a high share of solid biomass derived electricity in the total electricity sector can indicate that there has been significant support for this sector and typical market entry barriers have most probably been overcome.

The comparison and the scoring is based on the average of the 11 MS[5].

- ***Bioenergy Installed Capacity***

This indicator serves as a minimum threshold and reflects whether a minimum capacity of bioenergy has been realized. In that case project developers, investors and banks are assumed to have gained trust and experience in the national bioenergy market. Even if most of the bioenergy technologies are well developed: only domestic projects are a proof whether barriers in permitting grid integration, support scheme and energy market access have been overcome (Held et al, 2010).

The minimum capacity is based on the average installed capacity among the 11 countries. If a country has a larger cumulative installed capacity than the average that country is considered to have a more mature sector than the rest. Unfortunately technologies are not grouped into large, medium or small scale to better represent the capacity thresholds (for instance non-grid connected technologies will require different threshold than the grid-connected ones or whether the electricity production is derived from co-firing, combined heat and power (CHP) or gasification would ideally be categorised based on different thresholds) due to time limitations and data unavailability. This indicator has also included the per capita installed capacities to reflect the size of a country.

This indicator is applied to the electricity and biofuels sector.

- ***Existence of District Heating (DH) systems and the share of RE***

To further analyse the heat sector availability of DH systems the current share of RE is included into the analyses. The MS have reported the renewable energy share of DH systems in their progress reports to the Commission.

[4] Typical high-end barriers for bioenergy can be defined as competition for scarce resources as the most cost-effective bioenergy potential is increasingly exploited; possible oppositions due to sustainability concerns, resource efficiency concerns, etc.

[5] If the share in country A is higher than the average share of the 11 MS that country is considered as mature and is indicated in green.

2.1.3 Sustainability and resource efficiency

Bioenergy policies and their effects are and will be influenced by sustainability and resource efficiency concerns.

A qualitative assessment is conducted based on the information provided by the national representatives. Each country representative has provided us with the current status of sustainability criteria applications and resource efficiency considerations in their country. Next to these, the IEA Bioenergy Task 42 study '*National BioEconomy Strategies-IEA Bioenergy Implementing countries'* (IEA task 42, 2014) has been visited.

2.2 Boundaries and limitations of the methodology

Analysing and defining the success of policy measures in the bioenergy sector is very complex. Effects of any policy depend on a variety of factors, such as the availability of feedstocks, economic conditions of the country, maturity of the sector, the cost-competitiveness of bioenergy systems and the structure of the energy market (BAP Driver, 2010; Cross-borders, 2012). Effects of policies also depend on the existing regulatory framework in each country. Unless a sufficiently favourable regulatory framework exists the success of a policy will be hindered. There are no easy ways to isolate the policy effects and address the question *'how far the bioenergy markets would have evolved if there were no policies in the Member States?'.* The bioenergy sector is closely linked with other sectors, most importantly the forestry sector, the agriculture sector and the waste sector, and other policy areas such as environmental policies, agricultural and forestry policies, industrial policies, etc. The developments in these sectors and the policies behind have had and will have implications to the bioenergy sector. Next to these, the historical developments, gained experiences, the socio-economic character of agriculture, forest and waste sectors will impact the effectiveness of existing policies.

Unfortunately this study cannot cover all these aspects and conduct an integrated cross-sectoral analysis. Instead a more simplified approach is followed that could still produce valuable recommendations and lessons learned to the participating countries and to other MS.

An important aspect; 'economic assessment of the bioenergy policies' is not included in this study while such an assessment is crucial and should be the scope of follow-up projects.

In this study the bioenergy development data is limited to the period 2009-2012, while ideally it could have covered a longer time span and also the most recent data. Statistical data on 2013 or 2014 (national energy balance) are not yet available in all of the Member States. The data for 2009-2012 are extracted from the official renewable energy progress reports and the last progress report was published in 2013. When we compared the data sets with other existing databases such as Eurostat or EurObserv'ER Barometers we realised that there were inconsistencies between energy statistics, renewable energy progress reports data and other sources. Therefore, we decided to limit this assessment to progress reports data, thus, to the 2009-2012 time frame to avoid inconsistencies.

Assessments are conducted per sector (electricity, heating & cooling and biofuels for the transport sector). For each sector a further differentiation is made between solid and liquid on the one side and biogas on the other side. However, no further differentiation is made in terms of different scales and technologies. As such, central versus decentralised technology developments are not captured. Such a detailed assessment was not possible due to time and budget considerations.

3. Bioenergy policy support in Europe

Bioenergy is at the intersection of many policy fields, including energy, environment, agricultural and forestry policies. Deliverable 3.1 of the biomass Policies project has already mapped the existing policies that are relevant to the mobilisation and use of biomass resources. In this section we summarise the renewable energy policy support dedicated to biomass resources of the 11 MS.

Renewable electricity has been supported through direct feed-in tariff (or premium in the case of the Netherlands, Finland, in some cases in Spain and for small scale installations in Germany) in almost all countries. Only Poland, Belgium and the United Kingdome apply a Green Certificate (GC) Scheme. Plants between 50 kW and 5 MW located in Great Britain are also entitled to choose between the feed-in tariff or GC scheme. These subsidies are in general combined with tax exemptions, low interest loans and investment subsidies.

For renewable heat investment subsidy and tax reductions have been the common policy support instruments. In the Netherlands, however, renewable heat has been included in the SDE+[6] since 2012 and a premium tariff (bonus on top of the wholesale price) is granted. Among the 11 countries Croatia is the only State with no subsidy to the heat sector.

In the UK a Renewable Heat Initiative (RHI) is designed to bridge the gap between the cost of fossil fuel heat installations and renewable heat alternatives through financial support for owners. At present it is open to non-domestic installations but it is expected to cover also the domestic installations in the future. For a biomass boiler (including CHP) installation to be eligible to RHI it will need to comply with the particular matter (PM) and NO_x emission limitations.

In Germany the Renewable Energies Heat Act (EEWarmeG) regulates the obligation to use renewable energy in new buildings. Owners of new buildings must cover part of their heat supply with renewable energies (15% for solar energy, 30% for heat from biomethane or biogas fired CHP and 50% for other resources). Among these other sources, biomass fuels (firewood, chips, pellets, etc.) can only be used in high-yield boilers that comply with air quality regulations. Through the Market Incentive Programme (MAP) investment support is provided for the installation of highly efficient renewable heat technologies. Next to that KfW provides low-interest loans for the development and expansion of heat installations.

In Austria, heating and cooling from renewable energy sources is supported through a support scheme at federal level as well as by the individual federal states (Länder). The most relevant schemes at federal level are investment subsidies provided under the ‘Environmental Assistance in Austria’ (UFI) programme and the Climate & Energy Fund.

In Flanders region in Belgium, every new building, office or school needs to obtain part of its energy from renewable sources from January 2014. In Wallonia, the heat installations (biomass, shallow geothermal, heat pumps) and solar thermal energy are eligible for the energy premium, including CHP plants using biogas or biomass.

Biofuels for transport are supported through quota obligations in all of the MS. Quota obligation is supported in most Members States with tax exemption (Austria, Germany, Belgium, the Netherlands, Finland, Slovakia).

[6] SDE+ Stimulation of Sustainable Energy Production is the Dutch renewable energy support measure.

Table 1 Summary of the existing support measures for biomass energy in the 11 MS within the period 2009-2012

	Electricity	Heat	Biofuels for transport
AT	Feed-in tariff, investment subsidies (waste liquor), additional premium for efficient CHP	Investment subsidy for biomass heating systems and the connection to local and DH networks Bonus for efficient CHP	Quota obligation; tax reduction/exemption
BE	Regional level (Flanders, Wallonia, Brussels): Green Certificates with guaranteed minimum prices	Flanders: energy premium (auction system for green heat support); CHP certificate system (including bio-CHP); RE heat obligation in new buildings, offices and schools in Flanders (from 2014); Wallonia & Brussels: CHP included in Green Certificate system; investment subsidy to heat plants; subsidies for RE in buildings	Quota obligation; tax exemption (reduced excise tax) – this was phased out mid 2014
Croatia	Feed-in tariff and a loan scheme	No support	Quota obligation[7]
Finland	Feed-in tariff for forest residues[8]. In CHP production heat by fossil fuel has CO_2 tax. Investment support., Excise tax return	CO_2 tax for fossil fuels, investment aid priority given for new innovations and small-scale heating installations excluding domestic appliances; CHP heat bonus	Quota obligation, investment aid priorities for 2G biofuels
Germany	Feed-in tariff. Flexibility premium for additional installed capacity for biogas and biomethane powered plants put into operation before 01.08.2015; Investment subsidy. Loan scheme	Investment support and low interest loans for highly efficient renewable energy technologies; obligation to use RE in new buildings (min 50% for solid biomass, min 30% for biogas and biomethane CHP); low interest loans for biogas purification and construction of local heating networks	Quota obligation
Greece	Feed-in tariff. Subsidy combined with tax exemption	Interest free subsidies and loans; tax relief	Quota obligation
NL	Feed-in premium. Tax reduction	Feed-in premium; tax reduction	Quota obligation; tax credits
Poland	Green certificates; tax relief; loan and subsidy scheme	Investment grant	Quota obligation
Slovakia	Feed-in tariff; tax relief	Investment grant	Quota obligation; tax credits
Spain[9]	Feed-in tariff or premium (optional); investment subsidies	Investment subsidy	Quota obligation; tax exemption
UK	Green certificates; feed-in tariff(for small scale RES); Contracts for Difference Scheme (cfd); climate protection tax	Renewable Heat Incentives(RHI)	Quota obligation

7 Since the beginning of 2015 no operational incentives are available for biofuels in Croatia.

8 The aid scheme 'Operating aid for forest chips fired power plants' has been recently modified in order to address potential distortion of competition in the future. The modification has not yet entered into force, and this is subject to Commission's state aid approval. According to the modification the aid level for electricity produced with forest chips would be reduced by 40% (i.e. the reduced feed-in premium would be 60% of the full feed-in premium), if the forest chips are produced from industrial roundwood (i.e. logs or pulpwood) originating from a felling site of large-sized trees and not for industrial wood residues.

9 Recently in Spain the remuneration scheme for renewable electricity has changed and feed-in tariff is not currently in place.

4. Benchmarking bioenergy policies

4.1 Biomass electricity

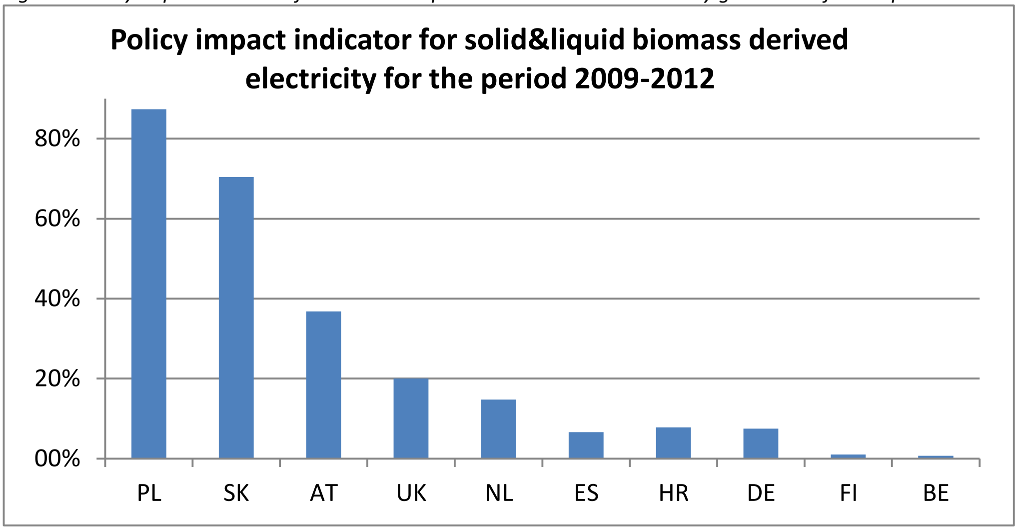
4.1.1 Policy impacts

Solid & liquid biomass electricity

- ***Policy impact indicator(PII)***

Figure 2 illustrates the policy impact indicator between 2009-2012. Biomass based electricity generation comprises biomass incineration, in pure electricity generation plants and cogeneration plants. In addition support for biomass co-firing in coal-fired power plants are covered for countries like Belgium, Finland, the UK, the Netherlands and Poland.

Figure 2 Policy impact indicator for solid and liquid biomass derived electricity generation for the period 2009-2012



*Greece is not included in this graph as there has been no solid biomass electricity generation in the country.

Poland, followed by Slovakia and Austria, has the highest PII between 2009 and 2012 when compared with the other countries. The main policy measures driving these relatively higher growth rates have been the GC scheme applied in Poland and the feed-in tariffs in Austria and Slovakia.

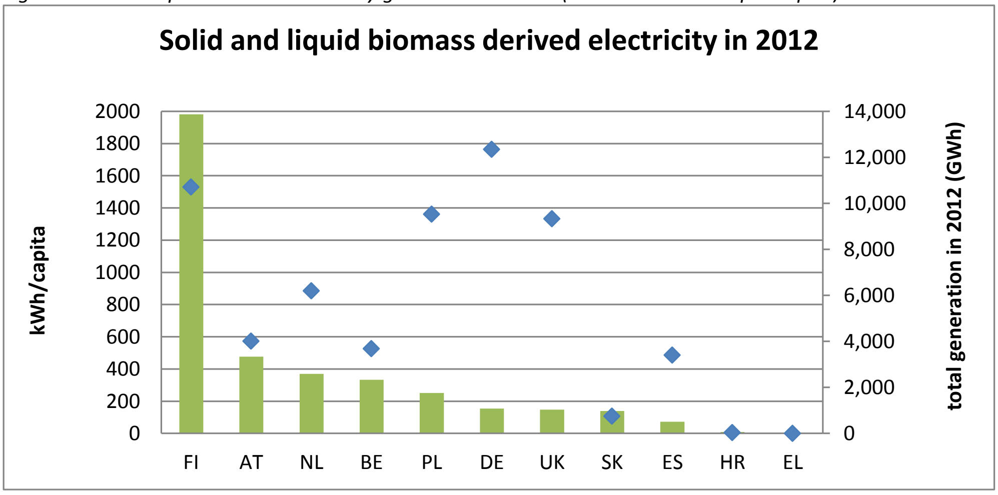
Poland has been experiencing a steady growth rate in this period with an average annual increase of 25% and the biomass co-firing for electricity generation has been largely responsible for the sharp increase in solid biomass consumption in Poland. Such a sharp growth, however, has been criticised, augmenting that the cost to public finances of subsidizing co-firing to produce electricity was too high and contributed to unsustainable utilisation of biomass since the majority of the biomass was imported. Next to that, cheap electricity generation from co-firing has led to systematic production growth that exceeded quotas imposed by the government.

The PII is the second highest in Slovakia even though the total consumption of electricity from solid and liquid biomass is one of the lowest among the 11 MS (see below). In 2012, the electricity consumption from solid and liquid biomass was only around 751 GWh. Biomass receives significant governmental support (feed-in tariff) only in case of cogeneration (i.e., generation of electricity alongside with thermal energy) performed in facilities with total installed capacity of up to 10 MW in Slovakia. Although the support scheme in Slovakia claims to be available for all types of RES, in fact it applies a restrictive approach, meaning energy sources with a high fluctuation of electricity generation (solar and wind) receive very little support and it favours bioenergy.

Austria's success lies in the high solid biomass deployment rates and is already achieving more than 85% of the 2020 set target. In the meantime the Austrian government has shifted its focus more to other RES technologies considering the biomass sector as saturated. The resource competition (especially with the paper industry) and biomass price developments have also affected this decision.

- ***Solid and liquid biomass electricity consumption in 2012***

Figure 3 Solid & liquid biomass electricity generation in 2012 (both absolute and per capita)



*Greece is not included into this graph as there has been no solid biomass electricity generation in the country.

As illustrated in Figure 3 Finland has the highest per capita bioelectricity consumption when compared with the other countries. The relatively low PII for this country between 2009 and 2012 (see *Figure 2*) can be explained by the fact that the sector in Finland is very matured and therefore the increase in solid biomass electricity production is lower when compared with the other countries like Poland or Slovakia. Next to that, the country has set a very ambitious 2020 target for electricity derived from liquid biomass resulting in lower PII calculations.

The majority of the feedstocks in Finland are forest residues, wood chips and log wood. Approximately 75% of forest chips are used on CHP-plants. The feed-in-tariff in the country is applicable to forest residues (thinning wood, logging residues and stumps) for electricity production and dependent on the price of competing fossil fuel, peat and the CO_2 emission trade price. For CHP the share of fuels are divided into heat and electricity production, because the fossil fuel replaced by bioenergy in heat production has to pay CO_2 tax. In addition to this, the production is

Finland (IEA, 2008 & 2013)

- The long-term sustainability of forest management has been actively promoted in Finland.
- State subsidies are available for safeguarding sustainable wood production, maintenance of forest biodiversity and improvement of the health of forests.
- The forest management associations assist the private forest owners to promote the profitability of forest management, safeguard the production of high-quality roundwood and the biodiversity of forests.

already indirectly subsidized through differences in taxation of energy production depending on fuels use, and also through the carbon emissions trade to favour the use of wood based energy to fossil fuels. Forest owners may also apply for finance for forest management based on the 'Act on the Financing of Sustainable Forestry' which in return contributes to the success of the policy support.

Germany has been the largest solid and liquid biomass electricity producer in Europe (more than 39 thousand GWh in 2012) in absolute terms. The Renewable Energy Sources Act (EEG)[10] offers fixed payments (feed-in tariffs) for renewable electricity supplied to the national grid. Next to that, there are additional bonus payments for using wood and other renewable resources that have been specifically cultivated for energy production (the 'biomass bonus'), for CHP plants ('cogeneration bonus') and for the use of innovative technologies ('innovation bonus').

[10] (EEG) was first enacted in April 2000, and was revised in July 2004, June 2008, and 2009, with the latest amendment in 2011 (coming into force on 1 January 2012).

Biogas electricity

- **Policy impact indicator**

Figure 4 PII for biogas derived electricity generation for the period 2009-2012

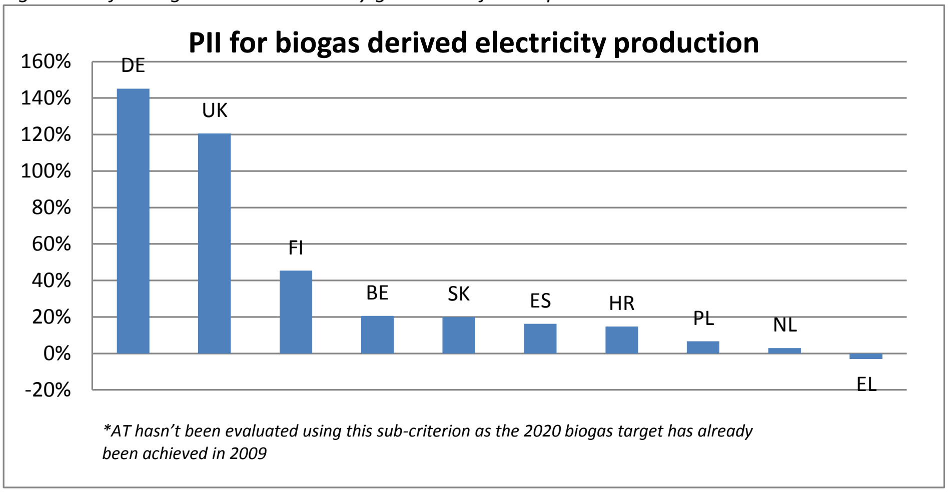


Figure 4 presents the policy impact indicator for biogas derived electricity. Biogas can be split into landfill gas, biogas from sewage sludge and other biogas (digestors). Landfill gas is the main biogas type in the UK and Spain, whereas 'other biogas' dominates the German, Dutch, Austrian, Belgian and many of the Eastern European markets, mainly based on agricultural biomass.

Austria is excluded from this graph since the 2020 target has already been achieved in 2009, indicating that Austria's policy ambitions for this sector were very low. In Greece electricity generation for biogas has been following a decreasing trend; that is why it scores negative in the graph.

As illustrated in the figure, Germany and the UK have experienced the largest growth rates for biogas electricity production among the 11 Member States. In absolute terms, these two countries produce approximately 90% of the total biogas electricity generation among the 11 countries and Germany alone represents more than 70%.

The main driver for the development of biogas in Germany has been the 'Renewable Energy Sources Act' (EEG), which guarantees grid access and provides a feed-in tariff for electricity from renewable sources. Since the introduction of the EEG in 2000, biogas has experienced a continuous growth. Different bonuses were implemented for the use of renewable raw materials and manure. From 2004 to 2012 the number of plants has increased from 2000 to 7500. The introduction of a bonus for feedstock in 2004 (e.g. maize) and for manure in 2009 pushed the development further. In 2012 the manure bonus was removed and the amount of maize as input was limited to a maximum share of 60%. As a consequence of these and different other factors (i.e. saturation effects) the installation rate and the size of the plants have decreased.

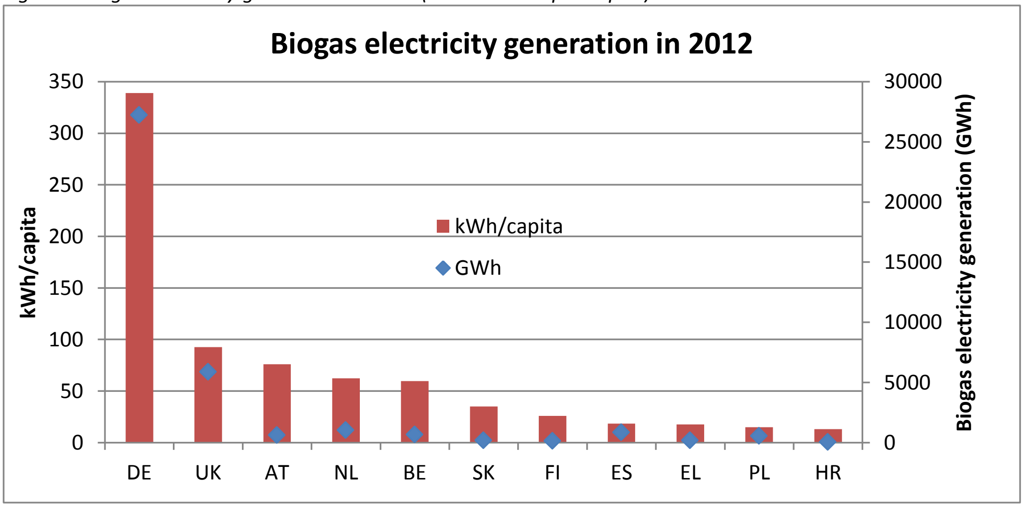
The UK scores second according to the policy impact indicator. The Renewables Obligation (RO) scheme, based on green certificates, has been favouring landfill gas, after onshore wind, as landfill biogas production costs are lower than many other renewable technologies. Consequently, in 2012 landfill gas was approximately 85% of the total biogas production in the UK.

Even though the increase in biogas production has been significant for Slovakia, Spain and to a lesser extend for Croatia these countries including also Poland, Greece, the Netherlands the total generation is very low (see below).

➢ ***Biogas electricity generation in 2012***

Figure 5 illustrates the per capita and total biogas electricity generation in 2012 for 11 Member States. Germany has the highest per capita and total biogas generation followed by the UK and Austria. All these countries have set relatively low 2020 targets and have already overachieved them for biogas electricity in the period 2009-2012.

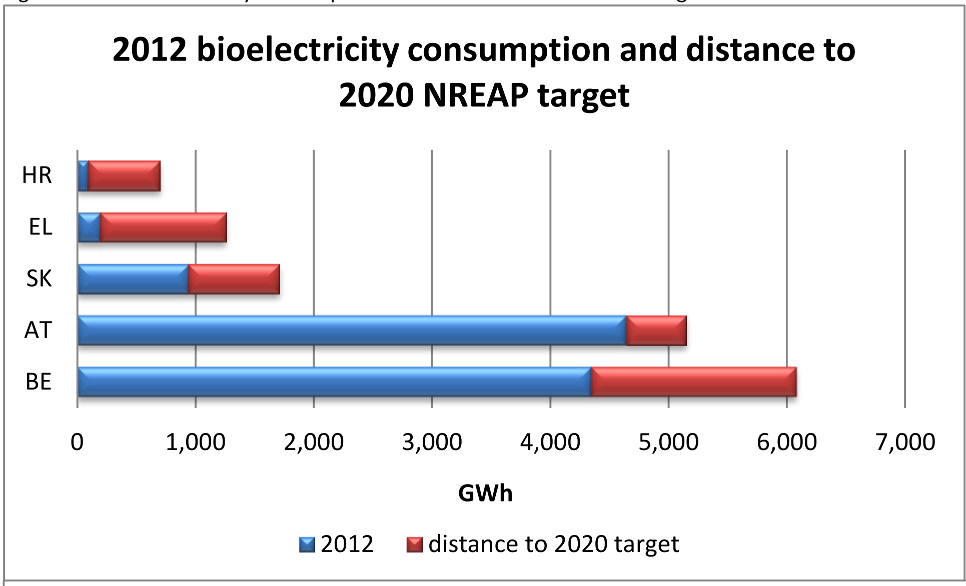
Figure 5 Biogas electricity generation in 2012 (absolute and per capita)

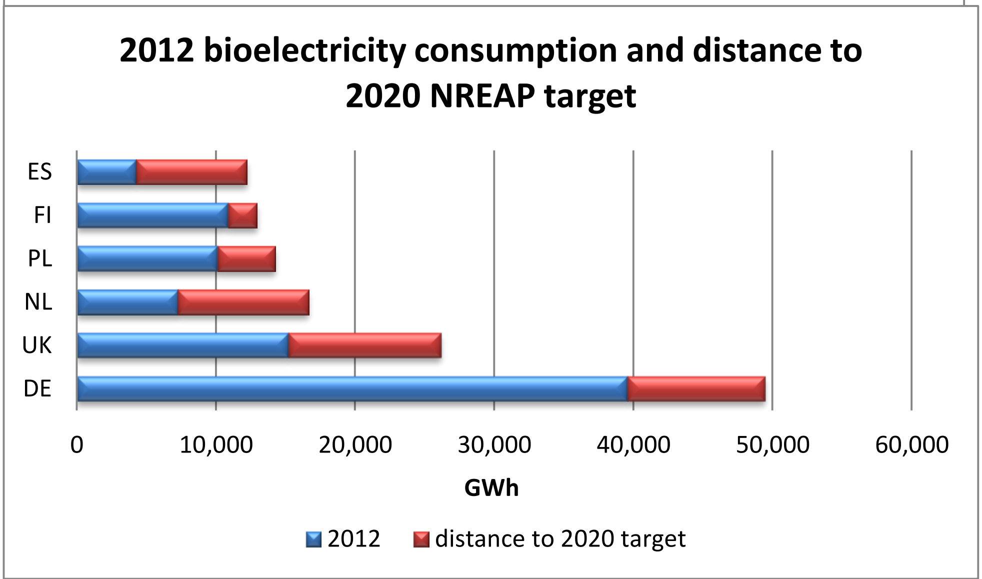


➢ **Distance to the 2020 bioelectricity targets**

Figure 6 and Figure 7 illustrate the bioelectricity generation in 2012 and the distance to the 2020 targets that are set by the Member States. In relative terms, Croatia and Greece will need to increase their 2012 consumption more than 6 times to achieve the 2020 targets. Spain and the Netherlands would also have to double the 2012 production, which will require significant efforts to achieve the set targets. In absolute terms the UK, followed by Germany and the Netherlands are the three countries that require more than 9 TWh additional bioelectricity generation between 2012 and 2020.

Figure 6 2012 bioelectricity consumption and distance to 2020 NREAP target



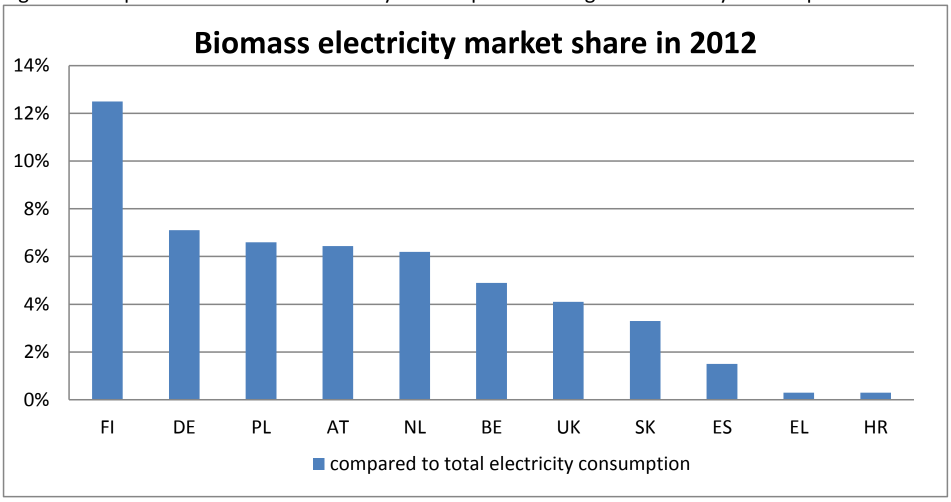


4.1.2 Market maturity

- **Production of bioelectricity as share in total electricity consumption**

Figure 7 illustrates the bioelectricity generation ratio when compared with the total electricity consumption in 2012. Finland comprises the largest share of bioelectricity consumption indicating that the maturity of the sector is high. In Finland most of RES electricity is produced in CHP plants (34.4% of electricity in Finland is produced by CHP) and most of these plants are co-firing forest wood. This is followed by Germany, Poland, Austria and the Netherlands.

Figure 7 Comparison of biomass electricity consumption to the gross electricity consumption in 2012

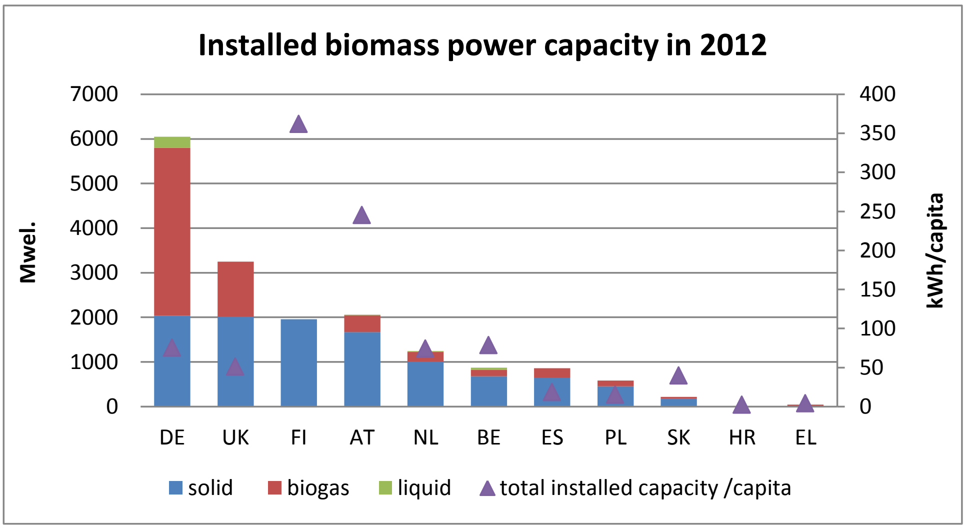


- **Installed capacity**

This indicator serves as a minimum threshold and reflects whether a minimum capacity of bioelectricity has been realized. In that case project developers, investors and banks have gained trust and experience in the national bioenergy market. Even if technologies are proven abroad: Only domestic projects are a proof that barriers in permitting, grid integration, support scheme and energy market access can be overcome (Held et al., 2010).

Figure 8 presents the installed biomass power capacity for the 11 MS in 2012. The figure also presents the per capita installed capacity. The solid biomass derived electricity installed capacities are comparable in Germany, the UK and Finland whereas for biogas Germany has the largest amount. Finland and Austria also score very high for per capita installed capacity when compared with the rest of the countries.

Figure 8 Biomass derived electricity installed capacities in the 11 Member States in 2012



4.1.3 Overview of the bioelectricity sector

Table 2 Overall evaluation of the bio-electricity sector[11]

	Policy impacts		Market maturity		Policy impacts		Market maturity		Distance to NREAP	Type of policy support					
	Solid and liquid biomass		Solid and liquid biomass		Biogas		Biogas		All	Feed-in tariff/premium	Green Certificate	Investment subsidy	Tax reduction	Loan scheme	Climate tax
	PII	Generation per capita (kWh/ca)	Consumption as share of total electricity	installed capacity[12]	PII	Generation per capita (kWh/ca)	Consumption as share of total electricity	installed capacity[13]	%						
AT	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	X		X			
FI	Red	Green	Green	Green	Green	Red	Red	Red	Green	X		X	X		X
DE	Red	Red	Green	Green	Green	Green	Green	Green	Green	X		X		X	
BE	Red	Yellow	Green	Red	Yellow	Yellow	Green	White	Red		X				
UK	Yellow	Red	Red	Green	Green	Green	Yellow	Green	Green	X[14] [15]	X				X
PL	Green	Yellow	Yellow	Red	Red	Red	Red	Yellow	Green		X	X	X	X	
SK	Green	Red	Red	Red	Yellow	Yellow	Red	Red	Yellow	X			X		
NL	Yellow	Yellow	Red	Yellow	Red	Yellow	Yellow	Yellow	Red	X			X		
ES	Red	Red	Yellow	Red	Red	Red	Yellow	Yellow	Red	X		X			
EL	Red	Red	Red	Red	Red	Red	Yellow	Red	Red	X		X	X		
HR	Red	Red	Red	Red	Red	Red	Red	Red	Red	X				X	

[11] The methodology is based on the average and the median figures for each indicator. Above average is coloured as green. Between average and median as yellow and below median as red.

[12] In 2012.

[13] In 2012.

[14] Feed-in tariff for small scale RES.

[15] In the UK also Contracts for Difference Scheme (CfD) has been introduced.

Table 2 presents the cross country comparison of the indicators presented in the previous sections. Countries are coloured comparative to average and median scoring. The table also summarises the type of the policy support provided to electricity produced from biomass resources.

Results confirm that Austria and Finland followed by Germany are relatively at a mature stage for solid bioelectricity generation, whereas Germany, the UK and Austria are doing well for biogas generation. These countries (except for the UK) have already utilised their low hanging fruit and the current policy process aims to sustain the existing generation levels on the one hand and to focus more on resource efficiency aspects on the other hand.

Croatia, Greece and Spain are lagging far behind when compared with the above countries, giving indications that the existing policy frameworks are not sufficient to cover the barriers in the entire bioenergy value chain. This is also the case for Poland and Slovakia even though both countries score very well in PII.

The NL and Belgium can be categorised as in between the well developed and lagging behind countries, both having a limited biomass feedstock potential and high dependency on exports. As such both countries give high priority to biobased economy and resource efficiency plays an important role.

In terms of policy measures all of the countries that score well apply feed-in tariff and investment subsidy combined with the tax incentives. This is also the case for the group of countries lagging behind. Only Poland, Belgium and the UK apply Green Certificate. The success of these instruments relate, among other things, to the sufficient levels of financial support provided to the sector. According to the 2012 progress reports a limited amount of financial support has been provided only to the biogas sector in Greece and Croatia[16,17].

Austria scores green in almost all indicators for the bioelectricity sector. This represents the well-functioning policy framework in the country. The Green Electricity Act is the most important policy support instrument in Austria providing feed-in tariffs to the renewable electricity injected into the grid. The feed-in tariff is set depending on the plant type, biomass used and other criteria like overall efficiencies[18]. Plants using waste material or by-products (like wood-processing residues) generally get lower tariffs than those using primary biomass streams (like forest wood chips or energy crops). There are exceptions from this rule: A 30%-share of manure (mass-based) is a precondition for small biogas plants (up to 250 kW) to be eligible for a relatively high tariff, and straw is treated as primary biomass rather than a by-product. For biogas plants, some further regulations apply: If they fulfil the efficiency criterion according to the CHP Act[19], they are entitled to an additional premium. If biogas is conditioned to biomethane, injected into the grid and used for power generation in a dedicated plant, a technology bonus is paid. The CHP plants also receive investment support (under the CHP Act) depending on the plant capacity.

Finland also scores very well for solid biomass electricity generation other than the PII[20]. As such, comparable to Austria, Finland has been performing very well in solid biomass electricity generation

16 Greece provided in total 20 M€ to biogas, in Croatia only 3.8 M€ to biogas.
17 For Spain, such information was not provided in the progress report.
18 Plants are qualified as 'highly efficient' if an overall fuel efficiency of at least 70% is achieved
19 CHP plants are eligible for funding only when they fulfil the efficiency criterion.
20 As explained previously, the relatively low PII relates to the ambitious NREAP target set for the electricity production for bioliquids rather than the solid biomass. Next to that, the sector in Finland has already matured and therefore the increase in solid biomass electricity production is lower when compared with other countries like Poland or Slovakia.

and the policy framework surrounding this sector has been successful. The policy support to renewable power consists of market-based feed-in tariffs (feed-in premiums). For wood-based bioenergy, however, a guaranteed subsidy (feed-in tariff) is given supported by an additional subsidy based on the price of greenhouse gas emissions credits[21]. This approach is used to favour the use of wood based energy over the use of fossil fuels. Another important subsidy that promotes renewables indirectly is the difference in taxation of energy production on fuel use.

Germany, with a relatively mature market in solid biomass energy scored red both in PII and the total generation per capita indicators. This can be explained by the changing policy priorities in the country. Also observed in Austria with a relatively lower PII (for instance when compared with Poland and Slovakia), the German government has shifted its focus more to other RES technologies considering the biomass sector as saturated.

The PII has been highest for Poland supported by the Green Certificate. As an inherent character of this scheme it favours cheaper technologies, which is biomass co-firing for Poland. While a significant increase in biomass co-firing has eased Poland in achieving the 2020 set targets, biomass import to feed the co-firing installations has increased substantially rather than mobilizing the indigenous resources. This in return has raised concerns related to sustainability issues. In the Netherlands the sustainability concerns around biomass co-firing are to some degree seized through setting a cap to biomass co-firing and obliging feedstocks to sustainability criteria.

Existing feed-in tariffs in Slovakia have also resulted in a large bioelectricity increase in the country between 2009 and 2012. This success, however, has been attributed to favouring bioenergy over other RES technologies.

Germany and the UK are very advanced in biogas derived electricity scoring high in almost all indicators. Austria follows these countries. The results indicate the success of feed-in tariffs in supporting biogas technologies utilising agricultural feedstocks, whilst neither quota obligations nor tax incentives appear to be able to stimulate the market diffusion of agricultural biogas technologies. Quota obligations in the UK rather stimulate the development of the cheaper biogas technologies using landfill gas and sewage gas. In Germany agricultural feedstock based biogas generation is supported through feed-in tariffs and extra bonuses to maize and manure[22].

Overall, feed-in tariffs and premiums combined with investment support and further tax incentives and/or feedstock premiums appear to be effective if and when the level is sufficient. The feed-in tariffs, if well designed, usually provide more long-term certainty of support for investors, reducing investment risks compared to quota obligations (IEA, 2009).

Other important aspects, such as the promotion of sustainable forest management and availability of forest management associations that assist the private forest owners, contribute significantly to the success of renewable energy policy support.

[21] This feed-in rate has a maximum of 18€/MWh paid when the emissions credits for 1 ton of CO_2-equivalent costs 10€. It then decreases linearly to 0€ at an emission credit cost of 23€.

[22] In 2012 the manure bonus was removed and the amount of maize as input was limited. As a consequence of these and different other factors (i.e. saturation effects) the installation rate and the size of the plants have decreased.

4.2 Biomass derived heating and cooling

4.2.1 Policy impacts

Solid & liquid biomass heating & cooling

- ***Policy impact indicator***

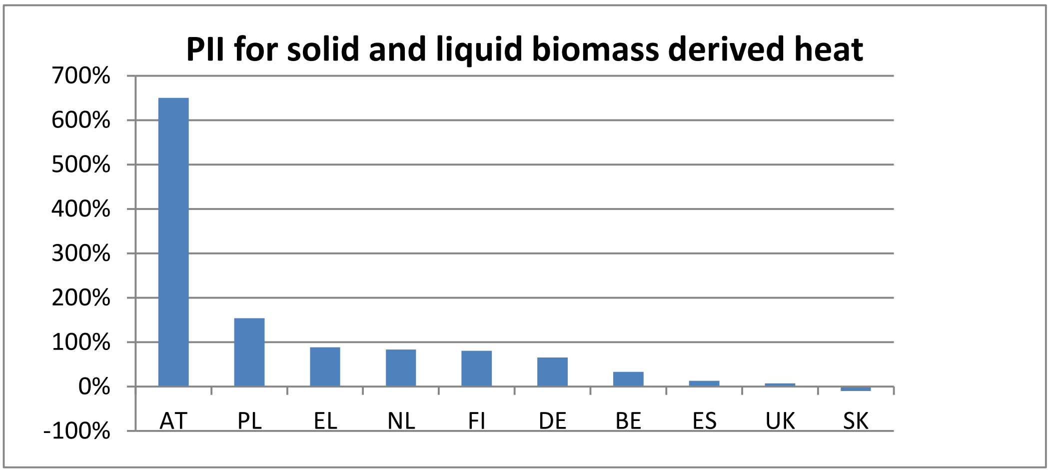
Figure 9 outlines the policy impact indicators for all solid biomass-derived heating applications, including centralised and decentralised installations. Croatia has been excluded from this indicator as the NREAP targets set for 2020 were far below the 2009 achievements in the heat sector[23].

According to this indicator Austria scores the highest followed by Poland as both countries set relatively low ambitions and already achieved their 2020 targets for this sector in 2011 and 2010, respectively.

Austria has been supporting centralised biomass heating plants as well as decentralized biomass heating systems effectively. Several factors, such as the tradition to use grid-connected heating systems with an existing infrastructure of district heating networks, the biomass availability and the sufficiently available heat demand certainly have an effect on the successful support of biomass-derived district heating and CHP plants. Biomass district heating has a long tradition in Austria, dating back to the early 1990s. In 2010, about 1,880 plants with a total capacity of 1,600 MW were in operation, supplying 3,200 GWh of heat to their customers. District heating plants used about 1.2 million tons of wood residues, bark and woodchips annually to supply this heat. Currently, a shift from big capacity units in the many MW range towards smaller units in the range of several 100 kW can be observed.

[23] In the absence of data sets for 2009 and 2010 we included the national statistics for the whole period of 2009 and 2012. There were quite some discrepancies between the 2013 submitted progress report's data and the statistics in the country.

Figure 9 PII between 20009-2012 on solid and liquid biomass derived heat[24]



* *Such a high score for AT related to the low policy ambitions set for 2020 for the heat sector.*

* *The biomass data for 2009 wasn't disagreed into solid, liquid and biogas. We included an assumption on this*.

- ***Solid and liquid biomass derived heat consumption in 2012***

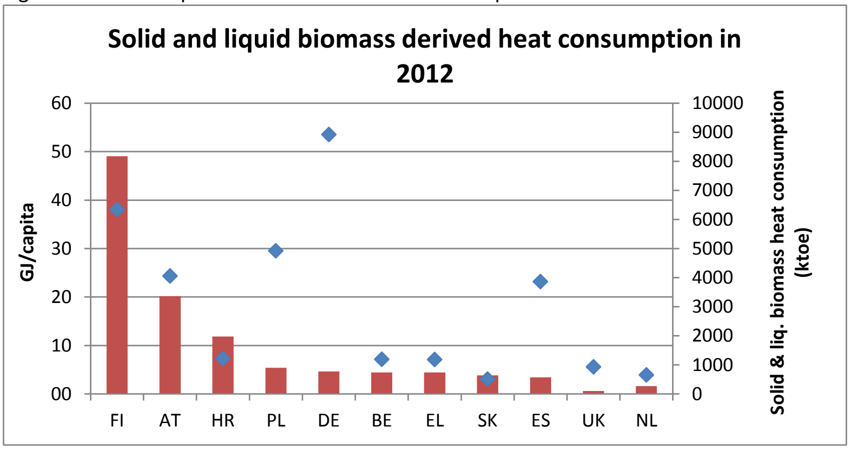
Figure 10 illustrates the solid and liquid biomass derived heat consumption per capita in 2012. It also includes the absolute consumption data. Per capita solid biomass derived heat consumption is largest in Finland followed by Austria whereas in absolute terms Germany holds the largest consumption amount.

In Finland the district heating systems and the CHPs play an important role in the heat sector. The use of wood in district heating and CHP production was 51.6 PJ and for separate heat production 9.9 PJ in 2013. A heat premium is paid for electricity produced in a wood fuel plant or a biogas plant, provided that the electricity production is based on the efficient cogeneration of electricity and heat in accordance with the CHP Directive in Finland. Also the production support for electricity from wood chips is primarily targeted at CHP plants. Hence, those support schemes constitute a significant indirect support for heat production although targeted at electricity. The use of renewable energy sources in heating and cooling is also supported by several investment support schemes. The aid for renewable energy sources and the increases in taxation duties on fossil fuels substantially speed up the transfer to the use of wood fuels.

In Croatia, biomass is traditionally used for heating purposes, mainly in the form of fuelwood originating from forest management practices. And there have been no incentives for heat production from biomass.

[24] Croatia is excluded from the graph due to discrepancies between the country statistics and the progress report data.

Figure 10 Solid & liquid biomass derived heat consumption



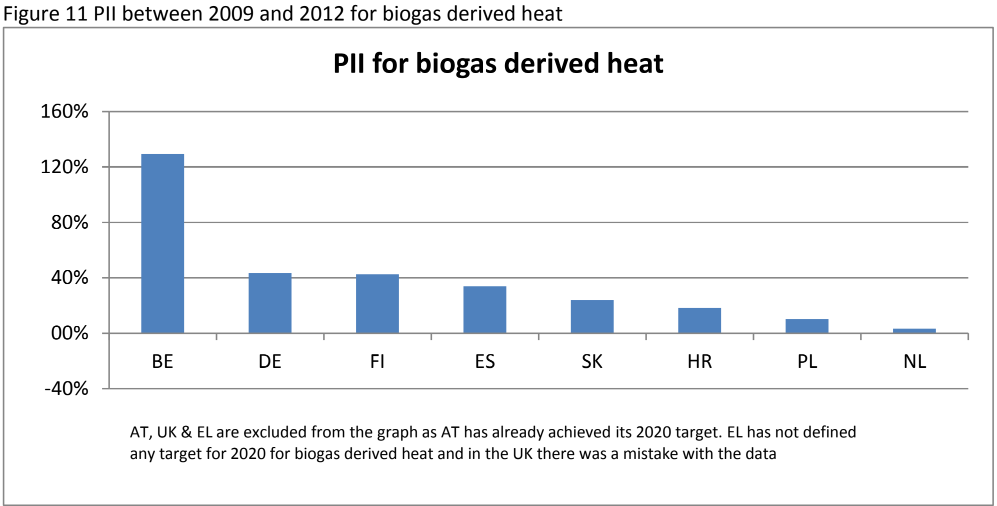
Biogas heat consumption

- ***Policy impact indicator***

According to the PII indicator Belgium has the largest growth rate as illustrated in Figure 11. This high score relates to biogas heat targets set for 2020 as already surpassed in 2012. There might have been a misjudgement in the distribution between solid and gaseous bio-heat target setting for 2020 or the policy ambitions for this sector might have been very low at the time the NREAPs have been prepared. Nevertheless, this sector has experienced the largest growth rate in Belgium when compared with the other countries (approximately tripled). Biogas heat is mainly from bio-CHPs, so the CHP promotion and Green Power certificates in Belgium has driven this growth.

For Austria as well the 2020 set biogas targets were even lower than the 2009 consumption. This is seen as an indication of low policy ambitions in the field of biogas, probably partly triggered by rising support costs for biogas plants subsidized under the Austrian Green Electricity Act.

Figure 11 PII between 2009 and 2012 for biogas derived heat



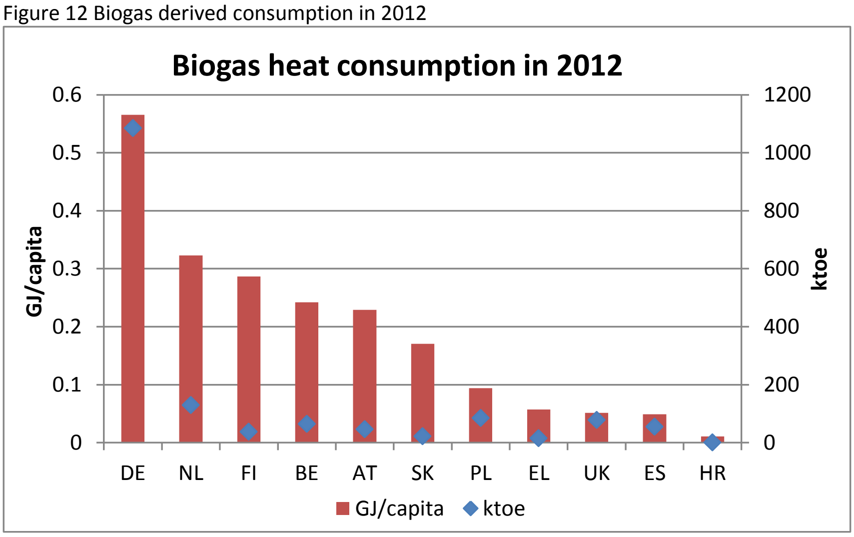
➢ *Biogas derived heat consumption in 2012*

Figure 12 illustrates the biogas derived heat consumption in 2012 for the 11 countries. Germany followed by the NL has the highest consumption levels in absolute terms. Also per capita Germany has the largest biogas derived heat consumption. About 12.5% of the biomass heat consisted of CHP from biogas plants in Germany. Three policy mechanisms work hand in hand to increase renewable heat and achieve the 14% RES target in 2020 in Germany. The Energy Saving Ordinance (‘Energieeinsparverordnung (EnEV)’) focuses on the increase of overall energy efficiency and energy savings. The Renewable Energies Heat Act (EEWärmeG) obliges part of the heating and cooling demand of buildings to be covered by renewable energies. The obligation concerns new erected buildings, existing public buildings (role model) as well as fundamentally renovated buildings. Regarding biomass the obligation is fulfilled if 50% of the final heat consumption is covered by liquid or solid biomass, which is used in high efficiency boilers. Alternatively gaseous biomass can be used to cover 30% of the final heat consumption, if it is used for combined heat and power production. The repayment bonus from the market incentive programme (MAP) and the soft loans with low interest rates offered by the public sector bank KfW encourages realisation of biomass heating plants, biogas pipelines and heat storages. And, the Renewable Energy Sources Act (EEG) requires to use a minimum of 60% of the waste heat from electricity production.

In the Netherlands renewable heat has been promoted through the Energy Investment Allowance (EIA). Biomass fired boilers or energy efficient cogeneration plants intended for the heating of buildings or processes are eligible for tax deduction. The amount of tax credit may be up to 41.5% of the total investments made in renewable energy or energy-efficiency technologies within one year. Since 2012, the SDE+ scheme also grants a premium on top of the market price to the producers of renewable heat.

The Renewable Heat Initiatives (RHI), introduced in the UK in 2011, only applies to non-domestic installations in the public, industrial and business sectors. During 2011, the number of anaerobic digesters in the UK rose by about a third to 78, not counting those used in the wastewater treatment industry. The reason for this surge in interest is the implementation of the new legislation Renewable Heat Incentives’ (RHI) to promote renewable heat.

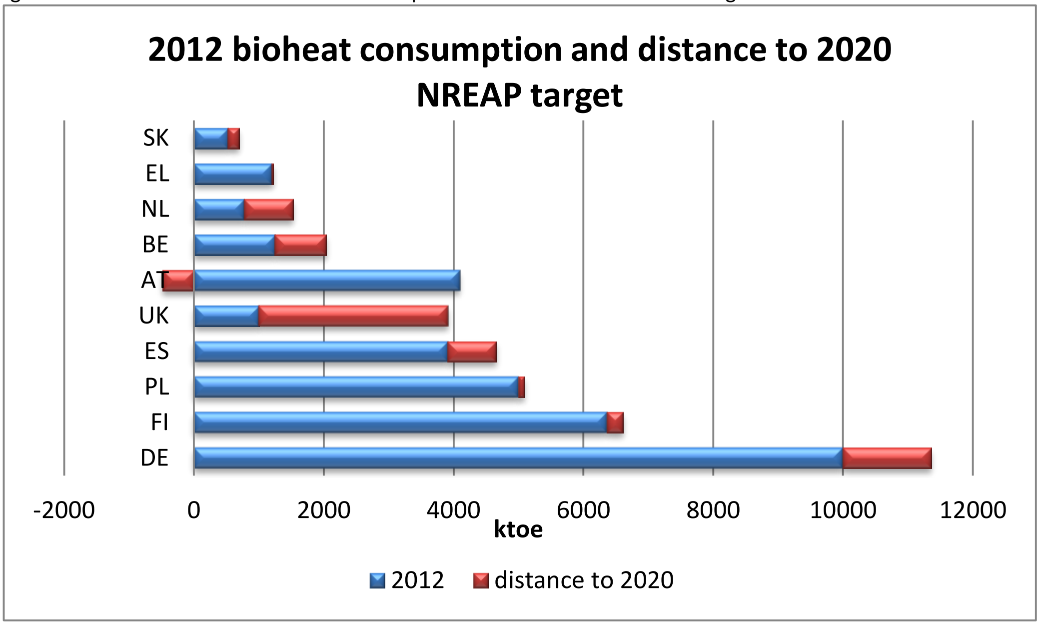
Figure 12 Biogas derived consumption in 2012



➢ Biomass heat distance to 2020 targets

As illustrated in Figure 13 and already introduced previously Austria has set a low ambitious bio-heat target for 2020 and already surpassed it in 2012. Other countries with very low ambitions are Greece and Poland. The UK will require the largest efforts to reach its 2020 targets. It will have to increase the biomass based heat with 4 times the 2012 consumption. The Netherlands will also have to increase biomass derived heat consumption with approximately twice the 2012 consumption, corresponding to 750 ktoe.

Figure 13 2012 Biomass derived heat consumption and the distance to 2020 target



- Croatia is not included in this graph since the data provided by the agency for 2009 were much higher than the NREAP target submitted to the Commission.

4.2.2 Market maturity

➢ Production of bio-heat as share in total heat consumption and the amount of renewable energy DH per capita

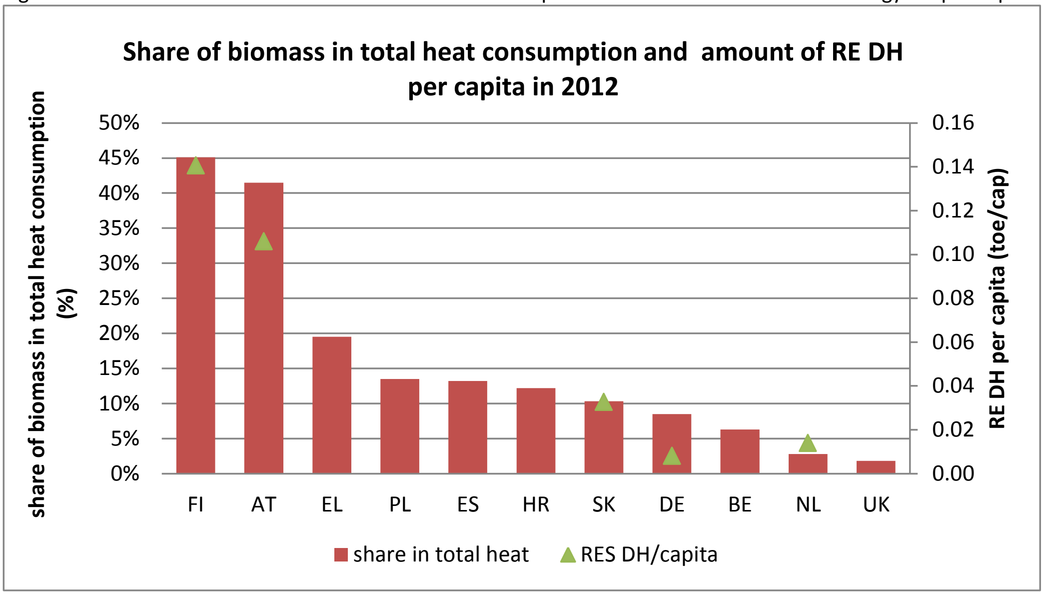
Figure 14 presents the share of biomass (solid, liquid and gaseous) derived heat in the total heat consumption in 2012. It also includes the amount of renewable energy DH per capita among the 11 countries as reported in the progress reports submitted in 2013 to the Commission[25]. We can observe that Finland and Austria have the largest biomass heat market share (more than 40%), giving clear indications of how mature the market is when compared with the other countries. This is also confirmed by the fact that the renewable energy DH per capita in these countries is very high.

While the market shares of biomass in Greece, Poland, Spain, Croatia and Slovakia are comparable Slovakia stands out as this country has a relatively high renewable energy DH consumption. Even though the DH installed capacity in Poland is large (58300 MW_{th} in 2011) the RES share was as low as 0.2% in 2011 (EuroHeat Statistics, 2013).

[25] Many MS did not submit this info in their progress reports and therefore they are not included in the graph.

Among the 11 countries UK and the NL have the lowest market share of biomass derived heat.

Figure 14 Biomass derived heat share in total heat consumption and amount of renewable energy DH per capita in 2012



*Data are derived from progress reports, capita data from Eurostat for 2012.

4.2.1 Overview of biomass derived heat sector

Table 3 Overall evaluation of the bio-heat sector[26]

	Policy impacts		Market maturity	Policy impacts		Market maturity	Distance to target	Policy support						
	Solid & liquid		Solid & liquid	Biogas		Biogas	All	Investment subsidy	RE Heat obligation	Feed-in tariff/ premium	GC	CO_2 tax exemp.	loan	Tax relief
	PII	consumption per capita	as share of total heat	PII	consumption per capita	as share of total heat								
AT	Green	Green	Green	Green	Green	Green	Green	X[27]		CHP premium[28]				
FI	Yellow	Green	Green	Green	Green	Yellow	Green	X(CHP)		CHP 'heat bonus'[29]		X		
DE	Yellow	Yellow	Red	Green	Green	Green	Green	X	X[30]				X[31]	
BE	Red	Yellow	Red	Green	Green	Green	Red	X			X(CHP)			
NL	Yellow	Red	Red	Red	Green	Green	Red	X		X				X
HR	32 (Grey)	Green	Green	Red	Red	Red	*33 (White)							
EL	Yellow	Yellow	Green	* 34 (Grey)	Red	Red	Green	X					X	X
PL	Green	Yellow	Yellow	Red	Red	Red	Green	X						
SK	Red	Red	Red	Yellow	Yellow	Green	Yellow	X						
ES	Red	Red	Yellow	Green	Red	Red	Yellow	X						
UK	Red	Red	Red	Orange	Red	Red	Red			X(RHI)				

26 The green colour in the table indicates that the country scores relatively well (above average) when compared with the other countries. The yellow colour indicates that the country performs below average but still higher than the median. The red colour reflects the country performing below median and considered as least performing.

27 The Climate and energy Fund, Environmental Assistance Fund, Rural Development programme and federal level funds provide subsidies for measures in the public, commercial and private sector in Austria.

28 CHP plants receive an additional bonus if they comply with the efficiency criterion which takes the amount of heat fed into a district heating grid or utilized as process heat into account.

29 The bonus is fixed at €50 per MWh for CHP plants working on biogas, and at €20 per MWh for wood fuel.

30 Obligation to use RE in new buildings (min 50% for solid biomass, min 30% for biogas and biomethane CHP).

31 For biogas purification and local heating networks.

32 In Croatia the 2020 target set is far below the 2009 heat consumption data provided.

33 There are inconsistencies between the 2009 statistics and the 2020 target setting.

34 No 2020 target is set in Greece for biogas. Therefore the PII indicator is not calculated.

Table 3 presents a cross country comparison based on the indicators introduced previously.

The most common policy instrument applied to the bioheat sector is the investment support. In the UK and the Netherlands there is dedicated support to the heat sector in the form of RHI and feed-in premium.

Similar to the bioelectricity sector, Austria and Finland score well in both solid and biogas heat generation. Both countries provide a range of investment support to both centralised heating plants and decentralised heating systems. In Finland the renewable heat sector also supported indirectly through the CO_2 tax applied to fossil competitors. Additionally, the cogeneration of heat and electricity is promoted by giving CHP plants working on biogas and wood fuel the right for an increased fixed 'heat bonus'. In Austria, an integrated policy package supports bioenergy use for heating purposes. The Austrian federal feed-in tariff supports renewable heat through a CHP premium (the premium is linked to the efficiency criterion). Subsidies for District Heating generators are included in 2009 CHP Law. The commercial sector is entitled to receive investment grants as part of the Environmental Support Act. Furthermore, different legislations apply in provincial scale to support renewable heat[35].

The critical success factors for biomass heat market development in both countries relate to the long tradition in both district heating and biomass utilisation, strong and advanced forestry industry (that enabled an effective supply chain of biomass as both producers and users of bioenergy), public support to heat entrepreneurship and wood energy advisory services and of course governmental investment support. District heating accounts for almost 50% of the total heating market in Finland and more than 70% of DH was generated in CHP plants. In Austria, the importance of district heat in the total heat market (including industrial applications) is significantly lower (about 15%), and about 60% of district heat is produced in CHP plants.

Biogas heat generation also scores very well in Germany followed by Belgium. While Germany applies investment subsidies, the 2011 amendment of the German Act on the Promotion of Renewable Energies in the Heat Sector, first implemented in 2008, extends the renewable heat obligation initially applying to new buildings to all existing public buildings used for legislative or executive purposes. This public procurement programme is paving the way for the obligation to become standard for the entire building stock. In Belgium the combination of the Green Certificate scheme and the investment subsidy moves the sector forward giving indications that if the policy support is designed properly, fitting to the country circumstances, they could be successful.

The MS' heat markets differ considerably, as a result of the variety of their climate conditions, their heat-producing histories and conventions and existing infrastructures (e.g. gas distribution, district heat, or indeed no infrastructure in warm climates where heat is often produced by electricity). As a result, each market may require different, customised renewable heat policy approaches suited to local conditions (Beerepoot & Marmion, 2012).

Moreover, more attention is needed for differentiation of renewable heat policies along different renewable heat sectors. As stated by Beerepoort and Marmion (2012):

- Feed-in-tariffs or renewable heat portfolio standards may be considered for commercial heat, which shows metering and grid similarities with the electricity sector.

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[35] In Upper Austria, farmer cooperatives receive an investment grant – 40% of their initial investment cost – if they create and feed a biomass district heating system connecting surrounding areas. In Burgenland Province, households can apply for installation grants for domestic biomass heaters and income tax reduction for energy saving (Beerepoot & Marmion, 2012)

- Subsidies and tax incentives may be useful approaches for renewable heat technologies in end-use sectors, which do not have metering or a heat grid.

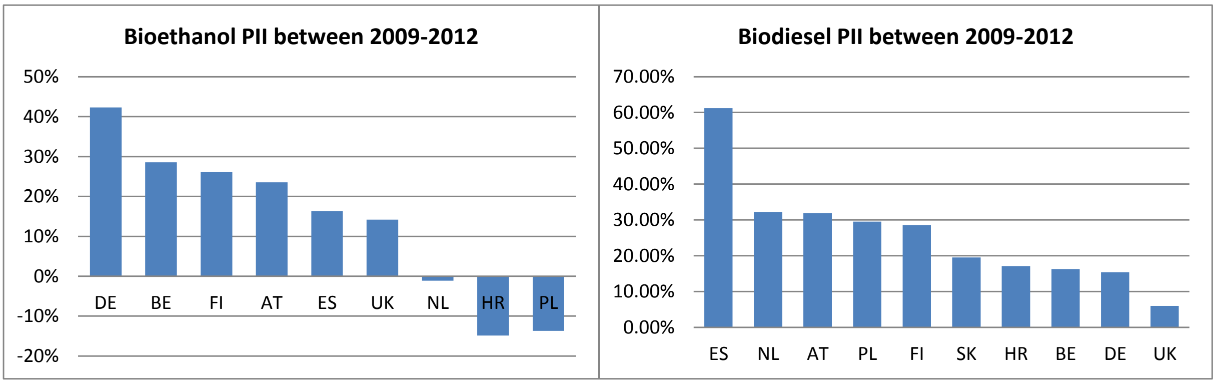
It is also important to highlight that renewable heat investments may compete with the energy efficiency investments and to avoid this renewable heat policy should address energy efficiency and ensure sufficient amounts of subsidisation.

4.3 Biofuels

4.3.1 Policy impacts between 2009-2012

➢ ***Policy impact indicator***

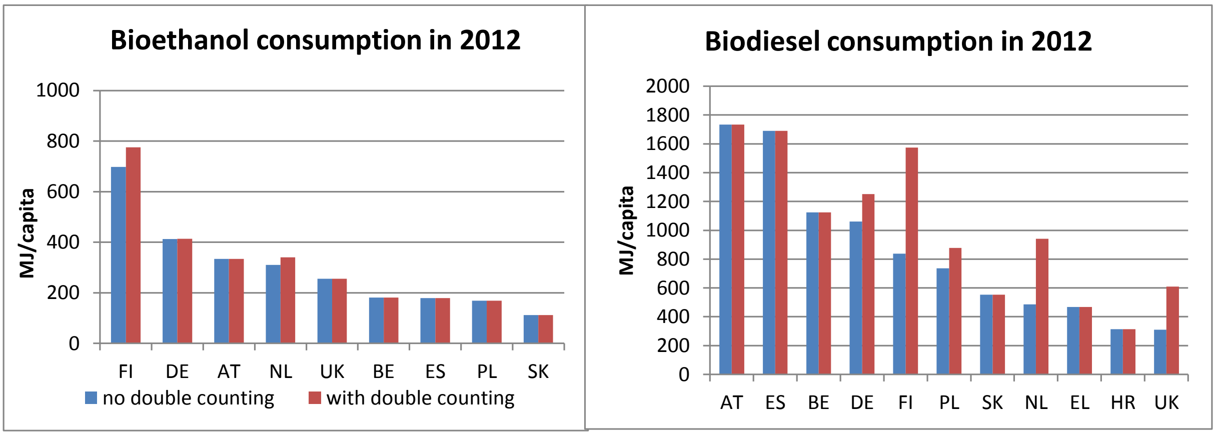
Figure 15 Biofuel PII 2009-2012 (Double counting is included in the figures)



*Greece has been excluded from the graphs as (i) the country doesn't have any bioethanol consumption, and (ii) the inconsistency between the data on biodiesel consumption from the progress reports and the country statistics were very large. In Slovakia bioethanol consumption has been constant between 2009 and 2012, therefore the PII results in zero.

➢ ***Biofuel consumption in 2012***

Figure 16 Biofuel consumption per capita in 11 MS between 2009 and 2012



*Bioethanol consumption in Greece and Croatia has been recorded as zero in 2012.

➢ *Biofuels distance to 2020 target*

Figure 17 Biofuel consumption in 2012 and distance to 2020 target

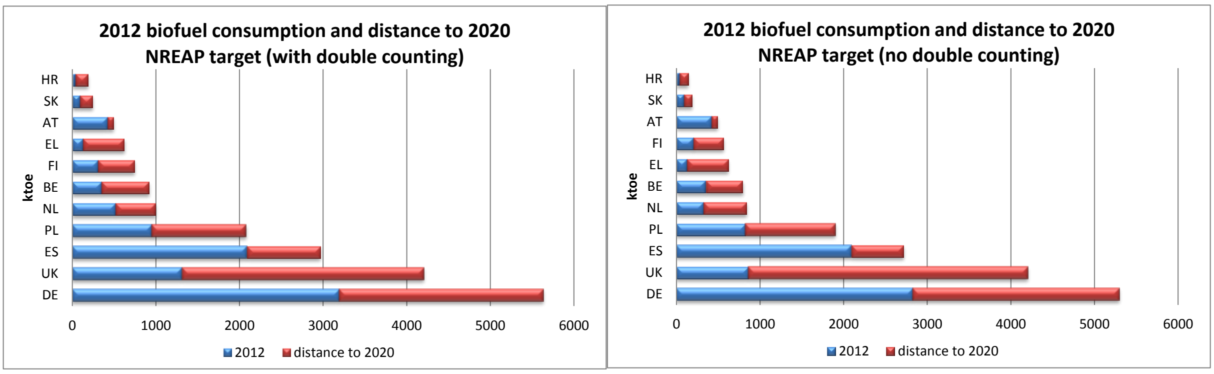


Figure 15 illustrates the policy impacts indicator for the period 2009 and 2012 and Figure 16 presents the 2012 biofuel consumption (both bioethanol and biodiesel) per capita in 2012. Finally Figure 17 presents the total biofuel consumption in 2012 and the distance to reach the 2020 set targets for the 11 MS. All figures include double counting effects in line with the Article 21 of the EC RED (EC, 2009). This Article informs that the contribution made by biofuels produced from wastes, residues, non-food cellulosic material, and lignocellulosic material shall be considered to be twice that made by other biofuels.

In terms of the policy impacts indicator Germany has experienced the highest growth rate for bioethanol whereas it was Spain for biodiesel in the period 2009-2012. Such high scores had to do with (i) the relatively high increase in consumption between 2009 and 2012 and (ii) the ambition levels set for 2020. For instance, in Germany the increase between 2009 and 2012 was approximately 39% for bioethanol and the country already achieved more than 60%[36] of the 2020 set bioethanol target already in 2012.

All MS apply quota obligations for biofuel production[37]. The introduction of E10[38] in 2011 (a fuel mixture of 10% ethanol) and the increase of the sub-quota for bioethanol has resulted in increased bioethanol consumption in the period 2009-2012 in Germany, with an average annual increase of 12%. The biodiesel generation, on the other hand, experienced a small growth rate (on average >1% per year). The introduction of double counting in 2011 (that resulted in a sharp increase of biodiesel generation from used cooking oil methyl ester (UCOME)) and the surpassing of the quota in the years before 2009 have been the reasons for the decreasing trend of biodiesel. Furthermore the tax reductions for pure biofuels were gradually reduced until 2012. While Germany has consumed in total approximately 792 ktoe of bioethanol (it was only 90 ktoe in Finland) the per capita consumption was highest in Finland (see Figure 16).

The UK has also experienced a significant increase in bioethanol consumption for the same period (consumption more than doubled) but the country is far away from the 2020 target (see Figure 17). Therefore it scores low in the policy impact indicator.

36 Double counting is included into the calculations.
37 Since the beginning of 2015 no operational incentive in Croatia.
38 The EU legislation to offer E10 has been in place since 2009.

Spain scores the highest in policy impact indicator for biodiesel, already achieving over 65% of the 2020 set biodiesel target. The Netherlands, Austria, Poland and Finland follow Spain with a much lower score. In absolute terms the largest consumption was in Germany (approx. 2Mktoe) followed by Spain (approx. 1.9) in 2012. Per capita consumptions were the highest both in Austria and Spain.

The double counting biofuels play an important role in Finland, German, the Netherlands and the UK in 2012 as can be observed in Figure 16. These biofuels are mainly derived from used cooking oil and animal fat. Finland, Germany and the Netherlands consider filling significant shares of their biofuel target (in 2020) with these types of biofuels.

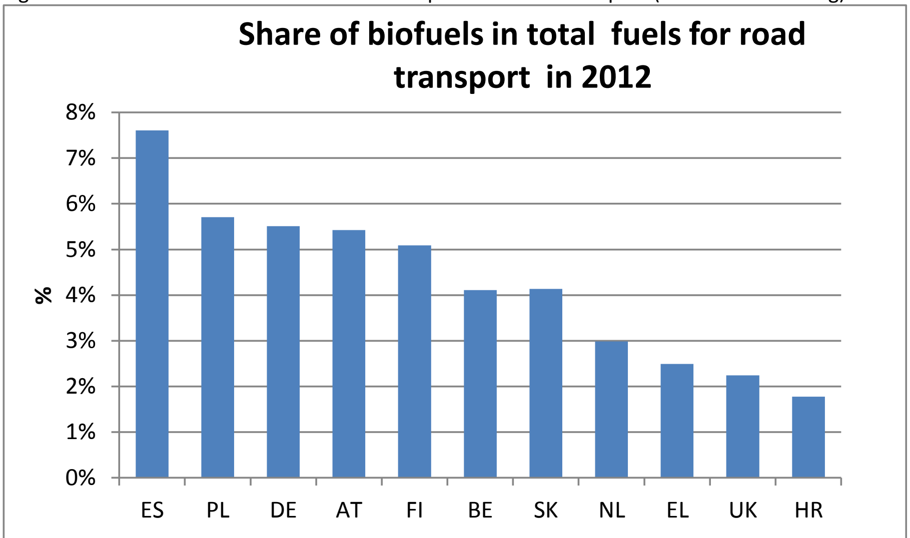
When we look at the 2012 consumption data and the 2020 set targets as presented in Figure 17 we observe that in absolute terms the UK, followed by Germany, will require the largest increase in biofuels consumption and thus significant policy efforts to achieve the targets. In relative terms, Greece will have to increase the 2012 consumption fourfold in the coming 8 years followed by the UK that has to increase the total consumption threefold.

4.3.2 Market maturity

- **Sub-indicator A: consumption of biofuels as share in total fuel consumption for road transport**

As illustrated in Figure 18 the largest market shares of biofuels are in Spain and Finland while the largest absolute consumptions are in Spain and Germany. Austria, Germany and Poland have a market share of slightly above 5.5% in 2012. Croatia followed by Greece has the lowest share, which is less than 2.5% of the total fuels for road transport.

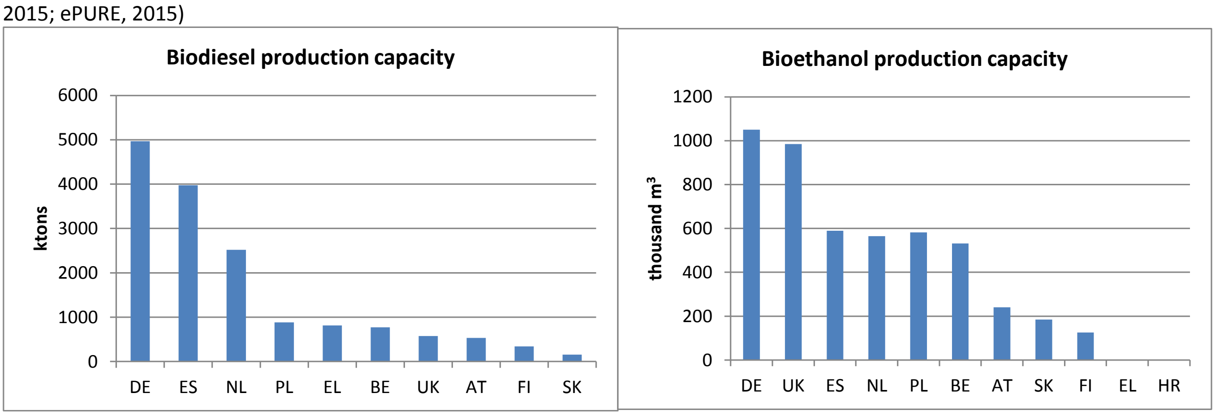
Figure 18 Share of biofuel in total fuel consumption for road transport (no double counting)



➢ Sub-indicator C: Installed capacity

As illustrated in Figure 16 biodiesel and bioethanol production capacities have been the highest in Germany and Spain. The biodiesel production capacity in Spain experienced a sharp growth over the past decade. To a great extent, many projects were undertaken because of the expectation derived from the blending obligation. As a consequence of this growth, currently, the installed production capacity reaches roughly 4 million tons oil equivalent which nearly doubles projected consumption in 2020. As a result of the overcapacity compared to blending obligation, many biodiesel plants have remained idle and some others have closed over the past years.

Figure 19 Biodiesel production capacities in 2012 and bioethanol production capacities in 2013 (Sources: European Biodiesel Board, 2015; ePURE, 2015)



*Bioethanol production capacity is for 2013.

4.3.3 Overview of biofuels

Table 4 Overall evaluation of the biofuel sector[39]

Biofuels	Policy impacts		Market maturity	Policy impacts		Market maturity	Distance to target	Policy support		
Biofuels	Bioethanol		Bioethanol	Biodiesel		Biodiesel	Biofuels	Quota obligations	Tax exemption/reduction	Subsidy programme
	PII	Consumption per capita	As share of total fuel	PII	Consumption per capita	As share of total fuel				
AT	green	green	red	green	green	green	green	X	X[40]	
FI	green	green	green	green	yellow	red	yellow	X	X[41]	
DE	green	green	green	red	green	yellow	yellow	X	X[42]	
ES	yellow	red	red	green	green	green	green	X	X[43]	
BE	green	red	red	red	green	yellow	red	X	X[44, 45]	
NL	red	green	green	green	red	red	yellow	X	?	X[46]
PL	red	red	yellow	green	yellow	green	yellow	X		
EL	red	red	red	green	red	red	red	X		
UK	yellow	yellow	yellow	red	red	red	red	X		
HR	red	red	red	red	red	red	red	X[47]	X[48]	
SK	red	red	red	red	red	red	red	X	X	

39 The methodology is based on the average rates. If a country scores above average it receives a green. Between average and median the countries receive yellow and below median the countries are scored as red.

40 Petrol and diesel with a minimum content of 4.6% resp. 6.6% of biogenic material are subject to a lower mineral oil tax. Mineral oil solely from biogenic material and E85 (fuel with 85% ethanol content) are exempt from this tax.

41 Excise duty on liquid fuels is collected on all types of fuels, including biofuels. The latest amendment to the Act of Excise Duty on Liquid Fuels sets out a taxation system, according to which each component of a liquid fuel is taxed separately, based on its energy content and carbon dioxide emission, meaning reduced taxation for biofuels (§1 Act No. 1472/1994).

42 The tax deduction is only granted if the produced amount of biofuel is pure and not used to fulfil the biofuel quota. Some biofuels are exempted from this rule, namely:
- Synthetic hydrocarbons or synthetic hydrocarbon mixtures which are obtained by thermochemical conversion of biomass.
- Alcohols, that have been produced through biotechnological processes to reveal cellulose.

43 Since January 2013 the legal incentive for biofuels consumption in Spain is only based on a consumption mandate, as the tax exemption for biofuels expired.

44 Reduced excise rate for petrol and diesel products containing a minimum share of biofuel (minimum 7%vol bio-ethanol in petrol ; minimum 3,37%vol FAME in diesel).

45 Biofuel from rapeseed oil produced by a natural or legal person who directly sells its production to the end consumer without intermediary can be exempted from excise duty. These limitations don't apply for public transport using pure rapeseed oil.

46 Subsidy programme sustainable mobility: driving on biogas and high blend biofuels. The government encourages the purchase and the use of new vehicles that run on these fuels.

47 Although the Act on Biofuels for Transport sets the frame for stimulation of production of various types of biofuels, the Regulation implements the incentive scheme currently only for biodiesel produced from rapeseed and bioethanol produced from maize.

48 The Excise Duty Act sets the excise duty on pure biofuels to 0 in order to increase their distribution.

Table 4 presents the overall indicators used for biofuels for the transport sector.

- Results indicate that a quota obligation alone is not sufficient to promote biofuels. In fact, countries with only a quota obligation, Poland, Greece, Croatia (just tax exemption to pure biofuels) and the UK in general score low in almost all indicators

- Spain and Austria score high in almost all indicators related to the biodiesel sector driven by the mandates imposed since 2009 and the hydrocarbon/mineral oil tax exemptions provided to biodiesel. However, the mandates in Spain were revised down at the beginning of 2013[49].

- The combination of tax relief and quota obligation seems to function well. An obligation creates demand for biofuels, while financial incentives facilitate the development of production capacity. Tax relief is considered especially suitable for early stages of development and it is strongly dependent on the initial levels of the excise: it is effective where these levels are significantly high. However, it creates fiscal revenues loss whereas the blending obligation does not involve additional costs for the public budget and is more suitable for the more advanced stages of development.

- The successful implementation of biofuel policies also relate to the adaptation of vehicles. While minor shares of ethanol and biodiesel can be blended with their fossil equivalent without problems, use of biofuels in higher blends or in pure from require specific vehicle alteration. The existing policies among the 11 MS does not seem to sufficiently address this issue. Only in the Netherlands there is a subsidy programme dedicated to sustainable mobility: driving on biogas and high blend biofuels. The government encourages the purchase and the use of new vehicles that run on these fuels. The delivery stations for the high-blend biofuels B30, B100, E85, E95, biomethanol, or PPO as motor fuels for vehicles, consisting of a delivery point and buffer stock for biofuel are eligible for the Environmental Investment Allowance (MIA) tax deduction. For the high-blend biofuel delivery system 13.5% MIA tax reduction in combination with 75% depreciation applies.

- The results also show that existing policies (double counting of advanced biofuels) have been mainly favouring conventional biofuels and the majority of double counted biofuels in the EU are produced from used cooking oil or animal fat. In 2012, the highest consumption of Art 21.2 and 'other biofuels' (mainly vegetable oils used pure), was reported in Germany.

4.4 Sustainability and resource efficiency consideration

A long-term successful bioenergy strategy needs to take into account sustainability issues and the resource efficiency considerations. As such, this section aims to present the current overview of the sustainability and resource efficiency considerations of 11 MS in a comparative manner.

The existence of sustainability requirements for bioenergy (other than biofuels for transport or bioliquids) and strategy documents on resource efficiency are used as indications to help us assess the 11 MS. Next to that the study conducted by IEA task 42 ‘Assessment of Biobased Economy Strategies’ of 22 countries is used to reflect on the policy status in terms of how far the biobased

[49] Biodiesel specific and overall mandate are both now 4.1 compared respectively to the previous values of 6.5 and 7 percent.

economy concept has been included in the policy frameworks of the countries. This study covers Austria, Belgium, Germany, Finland, the Netherlands and the UK.

The EU Renewable Energy Directive (RED) lays down sustainability criteria for biofuels for transport and bioliquids but not for solid and gaseous biomass used for electricity, heating and cooling. In 2010, the Commission decided to present non-binding recommendations to Member States that had already introduced or planned to introduce national biomass sustainability requirements. In 2014, in its Communication (EC, 2014[a]) 'A policy framework for climate and energy in the period from 2020 to 2030', the Commission stated that *'[a]n improved biomass policy will also be necessary to maximise the resource efficient use of biomass in order to deliver robust and verifiable greenhouse gas savings and to allow for fair competition between the various uses of biomass resources in the construction sector, paper and pulp industries and biochemical and energy production. This should also encompass the sustainable use of land, the sustainable management of forests in line with the EU's forest strategy and address indirect land use effects as with biofuels*'. Early 2014, in its resolution on the 2030 climate and energy framework, the European Parliament asked the Commission to propose sustainability criteria for solid and gaseous biomass, taking into account lifecycle greenhouse gas emissions in order to improve the climate balance of the bioenergy sector.

Table 5 presents the overview of sustainability and resource efficiency considerations of the 11 MS. While all 11 Member States have adopted regulations promoting higher efficient production of bioenergy (i.e. efficient CHP), only Belgium and the UK have adopted sustainability criteria for biomass used in electricity and heating & cooling. Germany has introduced sustainability criteria for liquid biomass that is used for combined heat and power production. More recently, the Netherlands has also adopted a comprehensive set of sustainability criteria for wood pellets for co-firing addressing, amongst others, impacts on forest carbon stocks and on indirect land use change (ILUC). In Austria and Germany subsidies under most programmes are also tied to certain sustainability criteria.

A few countries have introduced regulations aimed at addressing potential competition with existing biomass uses. In Flanders (Belgium) for example, woody feedstocks suitable for the wood-processing industry are not eligible for Green Power Certificates. Moreover, Poland has adopted a policy increasingly excluding the use of stemwood (with a diameter above a certain size) from being eligible for national financial incentives for renewables. Due to the high utilisation rate of waste wood in Germany, newly erected biomass power plants cannot get feed-in tariffs for waste wood as feedstock. Also in Finland the aid scheme 'Operating aid for forest chips fired power plants' has been recently modified in order to address potential distortion of competition in the future. The modification has not yet entered into force, and this is subject to Commission's state aid approval. According to the modification the aid level for electricity produced with forest chips would be reduced by 40% (i.e. the reduced feed-in premium would be 60% of the full feed-in premium), if the forest chips are produced from industrial roundwood (i.e. logs or pulpwood) originating from a felling site of large-sized trees and not for industrial wood residues.

Table 5 Overview of the sustainability considerations, promotion of efficient CHP, status of biobased economy and cascading use concepts in 11 MS

Country	Sustainability considerations for solid and gaseous biomass	Promotion of efficient CHP	Promotion of biobased economy and cascading use
AT	For the heat sector subsidies under most programmes are tied to certain sustainability criteria.	Fuel efficiency of at least 60%. Special tariffs for high efficient small scale CHP plants (≥70%).	Certain support schemes are targeted at industrial auto producers. Cascading use as a principle of waste management strategy.
BE	Green certificates are linked to value chain GHG savings in Wallonia/Brussels and value chain energy use in Flanders. SFM requirements for non-industrial wood pellets. Large pellet importers need to report on their feedstock sourcing (demonstrate that their sourcing is not disturbing the local biomass market in the country of origin).	Flanders: no efficiency requirements for green power certificates; CHP certificate system (in general) includes efficiency requirements to be qualified as 'qualitative' CHP. Wallonia/Brussels: Green certificates – also for CHP – based on GHG savings compared to best available technologies for electricity (STAG) and heat (NG boiler) production.	No specific policy promoting biobased economy. High focus on circular economy and material hierarchy in Flanders (particularly for waste and residue materials). Certain biomass (waste) streams which can be used as materials are exempt from support for energy production.
DE	Biogas/biomethane plants have to avoid methane slip Biomass power plants must provide their process energy from renewable energies. For small and medium sized boilers, the feedstock type, the thresholds for certain emissions and the efficiency of the applications are regulated.	Requires 60% of heat usage from biogas and 100% heat usage from biomethane.	Power production from biogas that is derived from anaerobic digestion of biowaste is eligible for higher values if the digestate is used for material purposes. The Closed Cycle and Waste Management Act (krwg) contains a distinction between waste and resides.
EL	No	No	No
ES	No, currently even the RED sustainability criteria are in suspension.	No	No
FI	In forest legislation and PEFC certification RED implementation for liquid biofuels.	By investment subsidy, CO_2 tax for fossil fuels in heat part of CHP plant.	Aid level for electricity produced with forest chips would be reduced by 40% (i.e. The reduced feed-in premium would be 60% of the full feed-in premium), if the forest chips are produced from industrial roundwood (i.e. Logs or pulpwood) originating from a felling site of large-sized trees. No support for industrial wood residues,
HR	No	The current Tariff system favours usage of CHP, efficiency of at least 50%.	No concrete policy on biobased economy. Through waste management hierarchy set by the sustainable Waste Management Act.

NL	Wood pellets for co-firing will be linked to sustainability criteria in 2015. Ongoing discussions related to sustainability of wood pellets for other uses.	Not explicitly. However, SDE takes this into account and allows only when heat is used the CHP plant becomes economically rational.	Yes, through Green Growth and SER (the Dutch Energy Agreement for Sustainable Growth).
PL	Wood pellets are linked to the existing sustainability criteria for biofuels.	'certificate of origin from cogeneration'	--
SK	No	At least 50% of annual production of heat to be used. If not the price for electricity CHP is reduced by 30%.	No
UK	Minimum GHG saving threshold for solid and gaseous biomass, land use criteria for agricultural biomass, timber standard for wood fuel for heat and electricity, adopted in 2013.	Good Quality CHP plants[50] are eligible to apply for Enhanced Capital Allowances (ECA), a fiscal benefit, which enable a business to write off 100% of investment in new CHP plants in the first year after investment. Good Quality CHP benefits also from a preferential business rates regime. Good Quality CHP plants could apply for CHP Levy Exemption Certificates (CHP lecs), which can be sold to energy suppliers.	Biobased economy and cascading are supported as principles in the overall strategies.

IEA Bioenergy Task 42 conducted an assessment in which they assessed the biobased economy strategies in 22 member countries of the IEA Bioenergy Implementation Agreement. The assessment of these strategies was done in relation to scope (governmental, regional, industry sectors), position of bioenergy (including biofuels) in a future bioeconomy, main economic sectors in a future bioeconomy, current focus of implementation (R&D, transition to markets, policy development) and vision and (measurable) targets. This study does not cover Greece, Spain, Croatia, Slovakia and Poland. The summary of the results for the relevant countries are presented in Annex II. Study results indicate that bioeconomy is an important part of national transition strategy in Austria, Finland, Germany, the Netherlands, and the UK. The energy sector within bioeconomy is considered equally important in all countries except Belgium. Interestingly Flanders (Belgium) gives less importance to bioenergy within their bioeconomy strategy (higher priority for material use of biomass). Most countries have a bioeconomy vision and general target. Only the Netherlands (Monitoring biobased economy in Nederland (2012)) and Finland include measurable targets for the bioeconomy.

4.5 Barriers to bioenergy sector & good (policy) practices

Existing barriers to bioenergy sector have been discussed during the national consultations that have taken place in 11 MS. This section presents existing policies that directly or indirectly deal with some of the barriers and the good practices.

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[50] Schemes with total installed capacity of • 0% primary energy savings compared with the Cogeneration and Energy Efficiency Directives' harmonized reference values for separate production of heat and electricity; • ≥1MWe - provide ≥10% primary energy savings compared with the Directives' harmonized reference values for separate production of heat and electricity; • >25MWe - have an overall efficiency of above 70% (based on Net Calorific Value). See https://www.gov.uk/guidance/combined-heat-power-quality-assurance-programme For further details.

An important barrier defined was the **biomass feedstock mobilisation issue**. Fragmented small scale farmers and forest owners make it difficult to get access to sufficient biomass sources. Small forests owned by private owners (i.e. over 50% of Austrian forests are owned by private persons and in Finland more than 60%) are difficult to manage and mobilise. Lack of required knowledge and expertise, low awareness of existing biomass markets (i.e. in Croatia) make it difficult to supply biomass feedstocks. Next to these, lack of infrastructure, long distances and unavailability of infrastructure between resources and demand centres, particularly for biogas plants, hamper biomass mobilisation.

- Finland's success in mobilising its forests relates to a combination of several factors. Three quarters of the land area, approx. 23 million hectares, is under forests. Relative to its size, Finland is more dependent on forests and the forest industry than any other country in the world. As a consequence, Finland has accumulated an expertise in forestry and industrial manufacturing of forest products that is unique in Europe. The majority of forest industry companies produce their own energy using bark, sawdust and chippings as well as logging residue from thinning and regeneration fellings and spent liquors from industrial processes, which makes them energy self-sufficient (IEA, 2008). The biomass supply network for wood already exists due to the forest industry.
- Besides, the Finnish Government launched a policy package consisting of three interrelated incentive systems directly and indirectly promoting the mobilization of wood from forestry and forest based industries in 2010 to further increase the use of wood based energy. This policy package includes
  - a harvesting subsidy for the first thinning chipping;
  - support for increased wood fuel consumption in existing power plants;
  - a feed-in tariff for electricity production in CHP plants.

An important success factor in Finland has been the existence of the forest management associations assisting private forest owners in improving the profitability of forest management, safeguarding the production of high-quality products and maintaining the biodiversity of forests. These associations are funded by the fees from the private forest owners. This might not be the case for countries such as Croatia, where the awareness is very low. Governments can incentivise development of such associations until they become self-sufficient and increase the awareness among forest owners.

- In Austria, despite the maturity of the bioenergy sector, local biomass markets (especially for log wood and wood chips) are often fragmented and market participants suffer from a lack of information. The basic idea of biomass logistics and trade centres (Biomassehöfe) is to improve market transparency for providers as well as buyers/users of biomass fuels, provide information, logistics, temporary storage facilities and quality assurance. Furthermore, economic benefits can be achieved through economies of scale and exploitation of synergies. In a next step, biomass trade centres can expand the business by serving large customers or operating as energy contractors. A biomass trade centre located in the Austrian province Styria represents an internationally recognized best practice example for small scale forest management.

- In 2008, the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) initiated the nationwide competition to establish regional networks in the field of bioenergy. 25 regions have qualified for BMELV funding through a two-stage selection process. Each of them receives up to 400,000 euros over the period of three years until the year 2012. Investments are not considered for funding as part of this project. The funds allow the regions to implement their regional development plan. This involves exploiting the region's bioenergy potential and capitalising on each region's particular strengths. Over this period, the regions are assisted through workshops and a scientific study. The focus of the project is the exchange of information between stakeholders. These regions also serve as showcases. The 'Bioenergy Regions' project aims to contribute to the expansion of the bioenergy sector in Germany and to promote development in rural areas. The competition mobilises existing resources in order to add value within the regions and create new jobs

- Mobilisation of agricultural feedstocks from farmers has been successful in Germany for biogas production. Germany's generous feed-in-tariffs for renewable energy are typically given the credit for promoting investment in on-farm anaerobic digestion but the particular character of farming in Germany has played a critical role in the diffusion of on-farm AD plants across the country. The regulation on its own wouldn't have been sufficient to encourage large number of farmers to invest in anaerobic digestion unless the socio-economic character of farming in Germany was existing (Wilkinson, 2011). Biomass production based on the use of the manure slurry and bioenergy crops (e.g. maize for silage) in an on-farm anaerobic digestion system is complementary to intensive animal production. For example, dairy production systems in the country are well-suited to the efficient capture of manure slurry. Animals are typically housed in free-stall barns and fed a ration of grain and silage. The Nitrate Directive and difficulty in complying with this regulation (that requires either new storage facilities or the manure must be transported away from the farm) have also facilitated investment in anaerobic digestion technology (Wilkinson, 2011).

Another barrier defined was the **limited diversification of resources**. Existing plants mainly run on (clean) wood chips and wood pellets and existing biofuels are derived from conventional crops. Lack of support for technological development that help diversify resources in respect to providing intermediate products that are use varying types of feedstocks and technologies that can utilise multiple feedstocks is considered as a barrier to the sector.

- In Germany, the thermo-chemical wood gasification has been constantly growing since 2010 thanks to the policy support. In 2013, 126 wood gasification plants[51] with an installed capacity of 13 MWel have been in operation. While this is a positive note diversification of feedstocks from wood to other resources is yet to happen. Further efforts are needed to enable technologies that can handle multiple resources. Increasing R&D to bring technologies such as torrefaction and gasification to commercial scale are needed. EEG involves incentives to foster new technologies with higher energy efficiency and for extended use of biogenic waste and waste substances. Under the MAP bioenergy receives subsidies when highly efficient technologies are applied or when district heating is generated partly by RES or CHP. Next to these, The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has drawn up a programme for 'Promoting projects to optimise biomass energy use' in the framework of 'Germany's National Climate Initiative'. This programme will focus on the development and optimisation of climate-friendly and energy efficient technologies for the utilisation of biomass for energy, taking into consideration their sustainability and climate protection aspects.

An overall barrier to renewable energy development, including the bioenergy sector, has been the **economic support provided to conventional fossil fuels**, distorting the market price signals and decreasing the competitiveness of the renewable energy/bioenergy sector.

- Since 90s Finland has a carbon tax on energy. Currently, energy taxation takes account of the energy content, carbon dioxide emissions and local emissions. They are levied on electricity,

[51] With the typical use of natural wood – chipped or pelletized

coal, natural gas, peat, tall oil1[52] and liquid fuels. The CO_2 tax is levied on both fossil fuels and biofuels. As such it is fuel-neutral, supporting those fuels that are most environmentally friendly[53]. The energy taxation does not apply to solid or gaseous biofuels (e.g. wood and biogas) and a flat-rate reduction of 50% is applied to all combined heat and power (CHP) plants in Finland.

- The **Climate Change Levy** (CCL) in the United Kingdom is a tax levied on energy delivered to non-domestic users with an aim is to provide an incentive to increase energy efficiency and to reduce carbon emissions. Renewable producers in the UK have been exempted from Climate change Levy since its introduction in 2001 to support renewable investment[54]. The exemption, provided through Levy Exemption Certificates (LECs).

Public acceptance of bioenergy systems has been an issue for a very long time, starting with biofuels for the transport sector and expanding to bioenergy in general. Social acceptance of biomass energy due to the debate on socio-economic and environmental impacts has been very poor and the public opposition to biofuels from agricultural crops, as linked to food displacement has been fierce.

While **sustainability concerns** related to biofuels and bioliquids have been addressed in the RED and adopted by all of the Member States, the controversy related to indirect land use change has not been resolved at the EU level yet. Besides, the possibility to expand sustainability criteria to the power and heat sector has been postponed.

- In Germany the change from a biofuel quota in terms of energy to a quota obligation that is based on the reduction of greenhouse gases was introduced in 2015. The evaluation of the first quarter of 2015 shows that in comparison to last year´s average GHG emission reduction an improvement for all biofuels can be observed. This mechanism has started a process of improving the production and provision of biofuels in terms of GHG emissions and efficiency and may eventually increase the trust and improve the public acceptance.
- Belgium and the UK have adopted sustainability criteria for biomass used in electricity and heating and cooling. Germany has introduced sustainability criteria for liquid biomass that is used for combined heat and power production. More recently, the Netherlands has adopted a comprehensive set of sustainability criteria for wood pellets for co-firing addressing, amongst others, impacts on forest carbon stocks and on indirect land use change (ILUC). In Austria and Germany subsidies under most programmes are also tied to certain sustainability criteria.

Resource competition with other sectors, mainly the paper and pulp industry as well as the panel board industry, has been recognised by the industry and bioenergy subsidies have been criticised to affect those industries negatively.

- In the Flemish Energy Decree, specifically for waste wood a special criterion has to be fulfilled, i.e. only waste wood not usable at the moment for recycling (in the panel board or paper industry) can receive green power certificates or green heat investment support. This criterion is controlled case by case by the Flemish Energy Agency supported with the advice of the Flemish Waste agency and the federations of the wood processing industries and pulp and paper industries. The advice of the Public Waste agency will always be based on the

52 Tall oil is a fuel obtained as a by-product of pulping (mainly coniferous) trees

53 Biofuels are classified into three categories, that are based on the RED division: those that achieve less than 35% CO_2 emission savings relative to equivalent fossil fuels are subject to the full CO_2 tax rate that is levied on fossil fuels; those that achieve between 35% and 60% of CO_2 emission savings are subject to half of the full CO_2 tax rate; second-generation biofuels (their CO_2 emission savings exceed 60%) are not taxed.

54 The exemption expired on 1 August 2015 and was replaced by the carbon price floor (CPF), a tax on fossil fuels used to generate electricity.

philosophy of the Material Decree (material hierarchy). In this way an indirect link between the energy legislation and the waste/material legislation is established. Because of changing technologies in recycling waste wood for panel boards, fluctuating markets for panel boards and energy, the balance between waste wood usable 'at the moment' for energy versus panel boards remains very fragile.

- Poland has adopted a policy increasingly excluding the use of stemwood (with a diameter above a certain size) from being eligible for national financial incentives for renewables.
- Due to the high utilisation rate of waste wood in Germany, newly erected biomass power plants cannot get feed-in tariffs for waste wood as feedstock.
- In Finland reduced support is given for stem wood (large stems) for energy production (60% feed-in tariff). For industrial wood residues no support is given. Only forest chips from thinning and loggings residues receive policy support.

For **biofuels for transport** one of the barriers is related to the lack of support to high blend biofuels. High blend biofuels have almost completely lost support in the past years. This resulted in:

- lack of incentives for acquisition of vehicles warranted to use high blends,
- lack of consideration of high blends in the design of new vehicles,
- lack of technical specifications for high blends,
- branded filling stations don't supply high blends of biofuels,
- quality assurance, acceptance by vehicle manufacturers, and availability of filling stations are necessary to achieve widespread use of high blend biofuels.

- In Germany, tax exemption is applied to certain types of biofuels including biomethane as well as so called 'pure biofuels' with a 70-90% bioethanol content. The tax exemption ends in 2015.
- In the Netherlands, delivery stations for the high-blend biofuels B30, B100, E85, E95, biomethanol, or PPO as motor fuels for vehicles, consisting of a delivery point and buffer stock for biofuel, are eligible for the Environmental Investment Allowance (MIA) tax deduction. For the high-blend biofuel delivery system 13.5% MIA tax reduction in combination with 75% depreciation applies.
- In Austria, pure biofuels and the biogenic share of E85 are exempt from mineral oil tax.

The biomethane market in most European countries is very small and **missing targets/strategies for biomethane and** lack of incentive to biomethane injection into the gas grid is considered as an important barrier. Among the 11 countries, Austria, Finland, Germany, The UK and the Netherlands are injecting biomethane into their gas grids.

- Biomethane injection is supported by the SDE+ scheme. The SDE+ scheme provides a feed-in subsidy covering the difference between production costs and energy price. In 2012 for biomethane there are five categories related to project costs. Biomethane is also eligible to fulfil the obligatory quota for biofuels and generate biotickets which are tradeable at the biofuel market in the Netherlands.
- In Germany electricity from biomethane (supplied via gas grid) is rewarded with a bonus on top of the FiT that's paid for biogas CHP at site. In order to justify the effort for upgrading a heat utilisation of 100% from the biomethane CHP is required.
- For biomethane to be fed into the natural gas grid, the GasNZV in Germany provides different means of support. Grid operators on all pressure levels are obliged to grant preferred grid access to plants which have applied for connection. The grid access costs are split up between the grid operator and the biomethane supplier: The former has to pay 75% of the overall costs, the latter 25%. In order to avoid delays in the grid access process, the GasNZV includes 'realization roadmaps' which are to be designed and agreed on by grid operator and biomethane supplier and are to be presented to the Federal Network Agency

together with the grid access contract. The roadmap defines all relevant steps to realize the grid access. The grid operator is responsible for providing grid access availability of 96%. And he has to account for the operation expenditures as well. This supports the development of a biomethane infrastructure, minimizes the project risks and brought wide reaching experience on feed-in stations.

- Biomethane injection can apply for subsidies in the Green Heat Support scheme in Flanders, in Belgium.

Other barriers such as an **unstable regulatory framework**, too many modifications to renewable energy promotion schemes and lack of coordination among the different public administrations increase the uncertainty and discourages the investments. The economic viability of projects undertaken under the previous framework is affected by the implementation of the new systems.

5. Selected value chains

Within WP2 of the Biomass Polices project a number of bioenergy 'value chains' have been identified based on key considerations such as:

- Existing biomass feedstocks that are large in quantity but not necessarily utilised
- Future large potentials
- Resource efficiency considerations for the future.

Deliverable 2.4 'SWOT analysis of biomass value chains' (Pelkmans, et al, 2015) details the value chain selection process and conducts a SWOT analysis for each value chain. Figure 20 summarises the outcomes of this exercise.

In this study, we present the state-of-the-art information in terms of the current deployment of selected feedstocks, existing barriers to their mobilisation and further utilisation and exemplary practices among the 11 MS (in some cases among the EU28) to draw lessons learned and set the basis for the subsequent work that will focus on identifying policy options to overcome the existing barriers and increase their contributions to the energy sector.

Figure 20 Selected value chains and their impacts on environmental (land, biodiversity, soil, waster) and competition and mobilisation aspects

Type of feedstock	Country	Conversion technologies	Land use impacts	Biodiversity	Soil	Water	Mobilisation	Competition
Primary forest residues	AT,ES,FI, PL, SK	Combustion, Gasification & CHP; IGCC, pyrolysis	None	When harvesting loss of dead wood and stumps may negatively influence species diversity and soil fauna. Contrary to this, leaving them all on the ground may result in increased fertilisation (N and wood ash) and negative impacts on vegetation	Increased risk of soil erosion; risk to loose soil organic carbon; risk to loose nutrients and risk of reduced soil fertility and soil structure when overharvesting forest residues	No effect on the quantity; If no removal leads to increased fertilisation the leaching on N to water may increase.	Disperse availability of resources (mobilisation issue)	None
Lignocellulosic crops	AT, UK	Ligno. Hydrolysis and fermentation; Combustion (medium scale - heat driven); Combustion (heat driven) household level (pellets); CHP district heating, public buildings; Pyrolysis & upgrading to diesel	Higher land productivity when marginal lands used; in case of agricultural lands potential (indirect) land use change;	Can provide winter shelter; birds nesting inside plants; may, however, destroy sensitive habitats (e.g. Steppic habitats, High Nature Value farmland, biodiversity rich grasslands) when introduced.	Potential use of marginal lands, which can increase soil quality and soil carbon stock; Can damage soil structure (e.g. Harvesting, root removal after 20 years),	In arid circumstances ground water abstraction and depletion possible because of deep roots; Some use of fertilisers / pesticides which can be leached to ground water and pollute habitats, but effect is very limited.	Limited financial attractiveness for farmers. Farmers not familiar with these types of crops	Competition with food production in terms of land use (not in case of marginal land).
Organic waste	AT, BE, DE, EL,ES, FI, NL,SK, UK	AD and upgrading to SNG; AD (medium scale) & local CHP; Production of chemical building blocks (e.g. Bio-naphta, bio-methane); Waste incineration & energy recovery	None	Positive in regions where it avoids landfill	Positive in regions where it avoids landfill; Digested organic waste is a source of soil improving material.	Lower risk of water pollution in regions where it avoids landfill	Various EU countries have not organised separate collection of organic waste. To separate organic waste from mixed waste is more difficult and will lead to impurities.	Waste, low competition
Straw	AT, EL, ES,PL, SK, DE	Biochemical – lignocell. Hydrolysis and fermentation; Combustion (medium scale - heat driven); Combustion (heat driven) household level (pellets); CHP district heating, public buildings; Pyrolysis & upgrading to diesel	None	Biodiversity loss when harvesting too many crop residues. This may also have adverse effect on soil biodiversity.	Risk to loose soil organic carbon when overharvesting crop residues; risk to loose nutrients when overharvesting	None	Straw markets exist. Cereal straw harvesting is common practice; Stover/stubbles are difficult to harvest and no common practice.	There are competing markets for animal bedding.

Industrial wood residues / wood waste	BE,FI	Heat driven medium and large scale CH, pyrolysis	None	None	None	None	Central availability of resources, usually in hands of industry	Clean wood residues and sawdust can also be used by the paper or wood panel industry.
Manure	BE, NL, PL, UK	Liquid manure: Anaerobic digestion (micro – on-farm) & large scale manure treatment (mono-manure);	None	A shift from solid manure application to artificial fertiliser may reduce the soil and invertebrate diversity. If grazing is reduced to collect manure in stables for energy production this may have adverse effects on floristic diversity in species-rich grasslands.	When digestate is used as fertiliser instead of liquid manure, the carbon content is reduced; When ashes are used as fertiliser instead of solid manure, the carbon content is reduced (much more than in the case of digestate).	May reduce N-surplus and N-leaching if manure/dried digestate is exported.	High moisture content, so transport is an issue	Competition with use as fertiliser (especially in regions with shortage of manure)
Landscape care wood and prunings	EL	Combustion (as logs, pellets); Pyrolysis & upgrading to diesel	None	Management of landscapes can improve biodiversity; Biodiversity loss when overharvesting and also habitats disturbance when harvested regularly	Management of landscapes can improve soil conditions; Potential soil erosion caused during harvesting (depends on practice). Removal of prunings from permanent crops may reduce soil carbon when overharvested.	None	Disperse availability of biomass (mobilisation issue)	None
Biomass crops – Sugarbeet	NL	Biochemical - sugar/starch hydrolysis and fermentation	Requires high quality land and therefore competes with food and feed crops leading to (indirect) land use changes	Provides food and habitat resources for certain species. Some limited provision of nesting and shelter in autumn to some common faunistic species; Direct negative impacts on habitat quality through pesticide and nitrogen applications.	Sugar beet naturally improves soil structure and soil biological status in the lower soil strata; Risk for soil erosion relatively large as it is a root crop with limited soil cover, also after establishment. Heavy machinery use for both input spreading and particularly when harvested. Often late harvest on wet soils. Implies large compaction risk.	Water consumption of agricultural crops - may need irrigation in dry regions/periods ;	Crops commonly known to farmers; supply chain already exists. In 2017 the EU will lift production and import quota for sugars and iso-glucose, creating a free market and significantly impacting production volumes.	Competition with food production, needs fertile land

- *The table is derived from D2.4 SWOT analysis.*

5.1 Current use of selected value chains, existing good practices and future prospects

The selected feedstocks are not necessarily the most common biomass energy resources. The 11 Member States do not hold statistics in such detail that we can receive actual data on historical utilisation of each feedstock for energy purposes. Therefore, the RESolve biomass model reference scenario results are used to give some indications and enable the comparison of selected feedstock use for energy production among the 11 Member States. In this respect, it is important to highlight that these figures don't reflect the actual use of selected feedstock for energy purposes. Instead, they should be interpreted as some indications of relative use among the 11 countries.

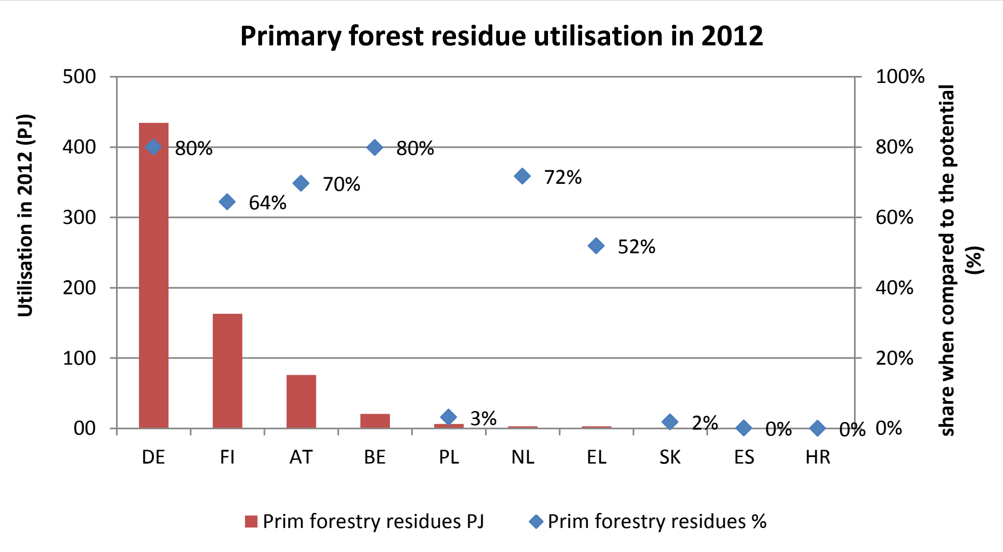
5.1.1 Primary forest residues

Primary forest residues in this project include early thinning and final fellings including fuelwood and logging residues.

Austria, Spain, Poland and Slovakia country representatives have selected this feedstock as a priority value chain. The main motivations for this selection are twofold: the potential is very high and they can easily be converted into electricity and heat through CHP and heat plants once they are effectively mobilised; in the future gasification based CHP or Integrated Gasification Combined Cycle (IGCC) options could replace the existing conversion plants that reach their lifetime and contribute to resource efficiency.

Figure 21 illustrates the modelling results of the primary forest residue utilisation for energy purposes for the 11 Member States. It shows both the absolute utilisation (PJ) and the corresponding share when compared to the potentials in each country. As can be seen Germany, Finland and Austria use large amounts of primary forestry residues for energy purposes, which correspond to approximately 80%, 64% and 70% of the potentials, respectively in 2012. Belgium and the Netherlands also already use more than 70% of the primary forestry residues potential. Primary forestry residue utilisation in Croatia, Poland, Spain and Slovakia, on the other hand, are very limited representing less than 5% of their respective potential.

Figure 21 Primary forest residue utilisation (PJ) and the shares in comparison to potentials in 2012 (RESolve-Biomass modelling results)



*UK is excluded from the graph due to some discrepancies in potentials data

The barriers to primary forest residue mobilisation can be summarised (Committee, 2008) as:

- the relatively high costs of production for wood chips and pellets, and increasing transport costs can limit further expansion. The lack of appropriate market structures, market transparency and market information related to actual or expected wood prices reduces the motivation of forest owners.
- private forest owners are often not market-driven actors. Harvesting for traditional firewood for instance is (in Central Europe) often the only management activity, carried out just for self-supply.
- the high fragmentation of private forest ownership or absentee ownership in many cases, in the EU influences management intensity.
- the personal capacities – the availability of a skilled work force – whether at forest enterprise, contractor or forest entrepreneur's level – form a bottleneck for effective wood mobilisation not only in small scale private forests but for all property types and sizes.
- the lack of appropriate forest infrastructure (forest road network), specifically on small scale private forest properties, is another barrier that hinders active forest management and market supply.

The forestry management associations can play a significant role in forest management and mobilisation of resources. To increase the efficiency of forestry associations a performance bonus (so-called mobilisation premium) was introduced for the independent industry-wide marketing of wood supply through a forestry association in Germany, in 2007. Furthermore, training measures were implemented for further professionalization of the management in forestry associations. Several federal states directly support (sustainable) wood mobilisation for bioenergy, e.g. through information, advice, or financial support (investment grants). The German Government is funding research with the aim to increase the production of biomass in forests and to develop and improve, from a technical/economic perspective, systems for managing forest residues. The support schemes for electricity, heat/cold and fuel from biomass indirectly encourage biomass mobilisation and supply and from forests and forest based industries. Sustainable forest management is ensured through federal and federal state forest legislation and nature conservation legislation (Krug & Martikainen, 2012).

As stated in the barriers and good practices section, mobilisation of feedstocks, even in the case of high share of privately owned forests, has been successful in Finland. The Finnish Government launched a policy package consisting of three interrelated incentive systems directly and indirectly promoting the mobilization of wood from forestry and forest based industries in 2010 to further increase the use of wood based energy. This policy package includes:

- a harvesting subsidy for the first thinning chipping;
- support for increased wood fuel consumption in existing power plants;
- feed-in tariffs for electricity production in CHP plants.

Energy support for small-sized wood is paid for all wood chips obtained from trees at the first thinning and made available for energy use in Finland. The subsidy is financed from the state budget and the corresponding scheme commits forest owners to comply with general sustainability criteria through the Act. The system would increase first thinning, because improving the energy wood market will substitute low demand of stemwood market in young forests.

Even though the existing policies and policy measures clearly play an important role in mobilisation of primary forest residues, mobilisation of wood depends on a number of areas and measures that are beyond the energy policy arena. Good practice guidance can be found in the UNECE web page: http://www.unece.org/fileadmin/DAM/publications/oes/Timber_wood-mobilization-good_practice-guidance.pdf.

5.1.2 Industrial wood residues & wood waste

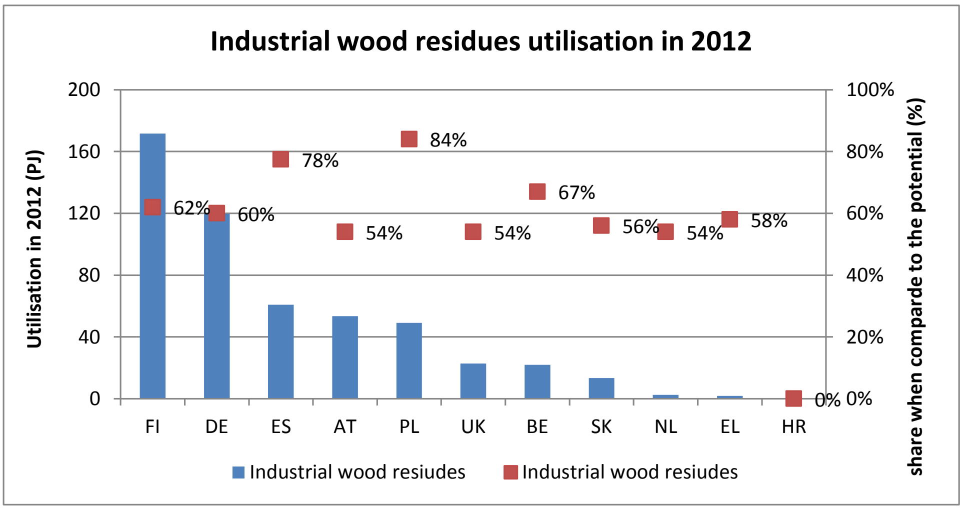
Industrial wood residues and wood waste in this study consider (Elbersen, et al., 2015):

1) *Sawmill by-products and sawdust from sawmills*: originating from the sawmill industries and produced as a by-product during the processing of stemwood. They consist of bark, sawdust, slabs and chips from coniferous as well as non-coniferous stemwood.
2) *Other forestry industry by-products*: from the processing of primary and further processed timber products, such as sawn wood, wood based panels, joinery products, etc., into for instance window frames, furniture, doors etc. Different than the sawmill by-products, which are seen as a by-product, these biomass potentials are mostly considered as a waste stream.
3) *Black liquor*: a by-product of the paper and pulp industry. It is mostly used by the industry itself as an important source of biomass to be converted into bio-electricity and heat
4) Wood waste: these wastes are wooden packaging, sawdust, shavings, cuttings, waste bark, cork and wood from the production of pulp and paper; wood from the construction and demolition of buildings; and separately collected wood waste. In statistics there may be overlap with the first three categories.

Belgium and Finland have selected industrial wood residues and wood waste as a priority value chain as the policy makers in the country are paying a lot of attention to recycling and cascaded use of materials. In fact, the Flemish government has recently approved a Flemish Action Plan 'sustainable management of biomass (waste) streams 2015-2020' that focuses on three biomass categories: food residues and waste, biomass from landscape management, wood waste and residues. Resource efficiency, material hierarchy, circular economy and cascading are basic principles of this action plan. The biomass availability in Belgium, and specifically in the Flemish Region is rather limited. The potential of local biomass is situated in the (separated) biomass waste collection and residues from industries. Industries in Flanders are very internationally oriented and a substantial part of the feedstock they process is imported. The wood panel industry is an important sector processing around 1.2 million tonnes of wood (d.m.), of which around 50% residues and waste wood. So energy support for these kinds of materials immediately impacts this sector and may create competition issues.

Figure 22 illustrates the modelling results of industrial wood residues utilisation in 2012 for energy purposes and also includes the utilisation as share of the total industrial wood residue potential. Results indicate that in almost all MS more than half of the potential was used for energy purposes in 2012. Modeling results show that only in Croatia industrial wood residue use for energy purposes is non-existing. However, according to the project partner from croatia majority of the industrial wood residues are being used, but there is no official statistics on this to calibrate the model. In absolute terms utilisation is largest in Finland and Germany. In Finland the forestry industry uses the majority of wood residues for their own purposes.

Figure 22 Industrial wood residue utilisation (PJ) and the shares in comparison to potentials in 2012 (RESolve-Biomass modelling results)



* Model presents industrial wood residue utilisation as null. However, according to the national partner the majority of the industrial wood residues are being used, but there is no official statistics on this.

The main barrier considered for industrial wood residues are the competition concerns from the industry. The Sawmill by-products have many competing uses particularly for the plywood industries and the paper and pulp industry. The slabs and chips from sawmills are mainly sold to the wood based panel industry or the paper and pulp industry. For instance, in Germany at least 67% of the sawmill by-products were sold to the wood based panel industry or the paper and board industry in 2010 (Döring & Mantau, 2012). Sawdust and shavings from both sawmills and wood processing industries are also used for animal bedding. Overall, however, it is clear that a large share of the sawdust and shavings already goes to energy production either directly into electricity and/or heat installations or first transformed into wood pellets and then used in both industrial application as well as by private households (Elbersen, et al., 2015).

In the Flemish Energy Decree, specifically for waste wood a special criterion has to be fulfilled, i.e. only waste wood not usable at the moment for recycling (in the panel board or paper industry) can receive green power certificates or green heat investment support. This criterion is controlled case by case by the Flemish Energy Agency, supported with the advice of the Flemish Waste agency and the federations of the wood processing industries and pulp and paper industries. The advice of the Public Waste agency will always be based on the philosophy of the Material Decree (material hierarchy). In this way an indirect link between the energy legislation and the waste/material legislation is established. Because of changing technologies in recycling waste wood for panel boards, fluctuating markets for panel boards and energy, the balance between waste wood usable 'at the moment' for energy versus panel boards remains very fragile.

In Finland, there is no support to industrial wood residues but only for forest chips from thinning and loggings residues to avoid the possible competition effects. Industrial wood residues are already utilised in forest industry plants and also heat and CHP plants. They (wood chips, bark, sawdust) are already efficiently traded in Finland. Heating and CHP plants use about 61% of industrial wood residues.

In Austria, feed-in tariffs under the Green Electricity Act are differentiated by feedstock types for the electricity sector. Primary biomass like forestry residues (i.e. forest chips) or energy crops is preferred over waste material and by-products, such as industrial wood residues or waste wood. Tariffs for biomass and biogas plants using waste material are generally lower than those for plants using primary resources. For example, using demolition wood results in a reduction of feed-in tariffs by 40%; for wood-processing residues the reduction is 25%.

5.1.3 Landscape care wood & prunings

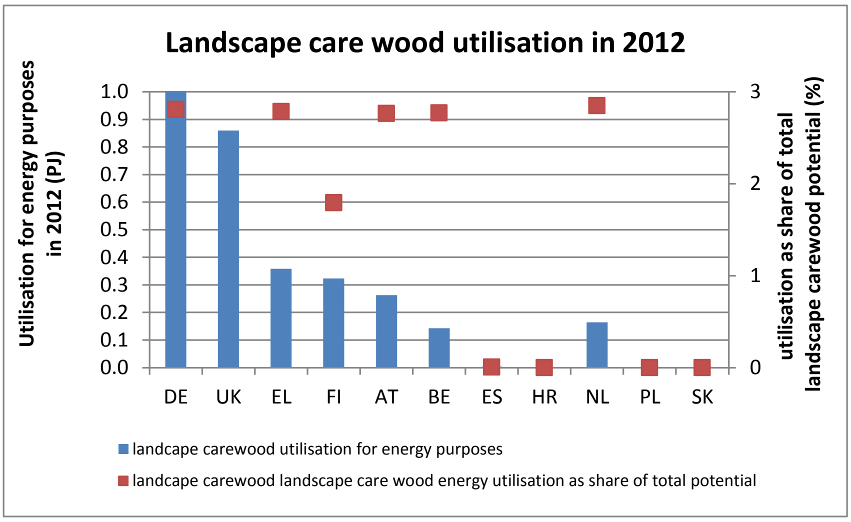
Landscape care wood considers biomass from trees/hedges outside forests including landscape elements (segregated wood from gardens, parks, vineyards, fruit orchards and driftwood from freshwater). It excludes road side verges (Elbersen et al., 2015).

Prunings are cuttings from apple, pear, soft fruit and citrus orchards and for vineyards and olive plantations. Especially in South Europe there are large areas with vineyards and olive plantations, which can yield considerable amounts of biomass from cuttings. Pruning is part of conventional management of the main crop.

Greece (landscape care wood) and Spain (prunings) have selected these feedstocks.

Figure 13 illustrates the modelling results for landscape care wood utilisation in 2012. According to the modelling results energy production from landscape care wood is very limited, the largest amount being 1 PJ for Germany.

Figure 23 Landscape care wood utilisation (PJ) and the shares in comparison to potentials in 2012 (RESolve-Biomass modelling results)



In terms of feedstock for further processing or energy conversion, landscape care wood and prunings are comparable to forest residues. The main barrier they face relates to the mobilisation. The high 'procurement costs' associated with small volumes of biomass from scattered locations and of low density (Mantau *et al*, 2010) make these feedstocks difficult to utilise for energy purposes.

As the modelling results indicate the existing policies have not been sufficient to address the barriers and mobilise this feedstock for energy purposes. There haven very limited attention to this feedstock only Germany introducing a bonus for using landscape care wood. The German Renewable Energy Sources Act (EEG) was amended in 2009 and in 2011 and some of the amendments envisaged to optimize the feed-in tariff support scheme towards more sustainable production and use of biomass with the aim to increase climate mitigation efficiency, resource efficiency and energy efficiency, particularly of biogas use, and to minimize land use conflicts between energy crop, food and fodder production.

The amendments included new bonuses for using landscape management and conservation material were introduced.

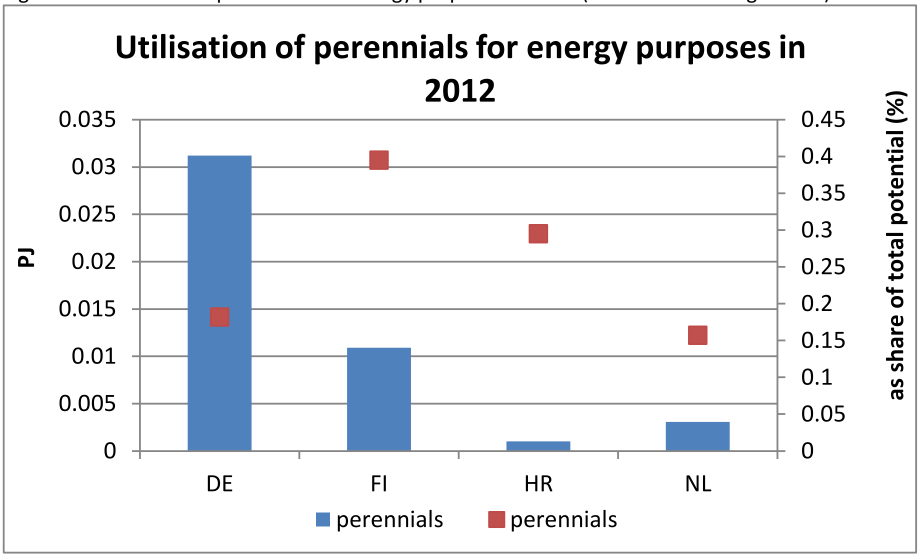
5.1.4 Energy crops (Perennials)

Two types of perennial energy crops are considered: woody (e.g. willow, poplar) and herbaceous or grassy crops (e.g. miscanthus, reed canary grass). The main perennial energy crops cultivated for bioenergy in the EU28 are: miscanthus in UK, Germany, Spain and Portugal; willow in UK, Sweden and Germany; reed canary grass in Finland and Sweden; poplar in Italy and Spain (Panoutsou, et al., 2011).

Perennials have been selected by Germany, Austria and the UK. The main motivation behind this was the possibility to mobilizing currently unused potentials, especially in rural areas where heat demand is largely covered with forest biomass.

According to the modelling results there is a very limited use in Germany, Finland, Croatia and the Netherlands representing less than 1% of the potentials in each country as illustrated in Figure 24.

Figure 24 Utilisation of perennials for energy purposes in 2012 (RESolve modelling results)



The main barriers to dedicated perennial crops can be summarised as the farmers lack of willingness to produce perennials for long time periods (lack of suitability to current farming activities, farm size, farmer age, farm location influencing the willingness) and related to this, profitability of dedicated energy crops in relation to current investments and uncertainty of financial returns.

For biomass power plants that were put into operation between 2009 and 2012 the EEG provided a bonus on the feed-in tariff for the utilisation of material from landscape management in Germany. So far, the bonus had only little impact on the development of perennials. Most farmers are used to react to market developments on a yearly basis. For them, perennials means a commitment to one crop for a couple of years. The programme 'Gemeinschaftsaufgabe Agrarstruktur und Küstenschutz' seeks to provide farmers with financial support for the cultivation of short rotation coppices. The measure is applied in some federal states and is limited to the period 2014-2018. It is required that at least 3000 trees are planted per hectare and that the land under cultivation is not dedicated to other crops for a period of 12 years.

In the UK, the energy crop market has been supported by a number of government policies targeting both farmers and energy producers, such as the Energy Crops Scheme (ECS), renewables obligations and renewable heat incentives. The aim of the ECS was to encourage farmers and landowners to grow energy crops as a sustainable substitute for fossil fuels. Approved crops under the scheme are short rotation coppice (including willow, poplar, hazel, silver birch, sycamore, sweet chestnut and lime) and miscanthus. Crops must be used for heat, combined heat and power (CHP) or power generation. The Energy Aid Payment Scheme (EAPS), also known as the Aid for Energy Crops Scheme was also offered from 2005 until 2009 but was then subsumed into the Single Payment scheme. This scheme was administered by the Rural Payments Agency. Farmers were able to claim under both EAPS and the ECS for the same crop and it is expected that most claimants would have applied for both payments. (DEFRA, 2014). However, the uptake of these crops has been limited (Alexander & Moran, 2014), indicating that financial assistance alone has not been sufficient to incentives large scale production of energy crops (Wilson et al., 2014).

In Finland, the most common arable crop used for energy production is reed canary grass, a perennial plant that grows naturally in Finland around waterways and wetlands. However, there are no measures in Finland to encourage the dedicated energy crop production as the forest residue potential is extensive in the country.

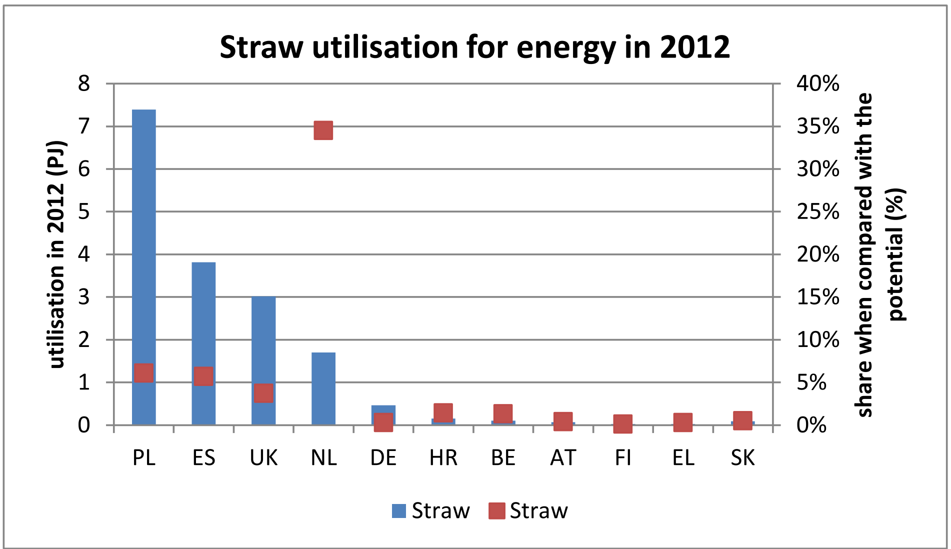
5.1.5 Straw

In this study crops delivering straw include all cereals, rice, and maize, sunflower and oil seed rape.

Straw has been selected by Austria, Greece, Spain, Poland and Slovakia as a priority feedstock to be combusted in a medium scale heat plant, in a CHP plant connected to district heating or to produce biofuels through cellulosic hydrolysis.

Figure 25 illustrates the modelling results of straw energy uptake in the 11 MS. According to the modelling results Poland consumes the largest amount of straw (in absolute terms) when compared with the other 10 MS. However, the share is as low as 5% of the total potential in 2012. Unfortunately the real straw utilisation for energy purposes is not known as there are no available data or statistics showing the overall amount of straw-fired installations in Poland. However, several local companies which provide e.g. heat and warm water already use straw-fired boilers (e.g. in Lubań – the installation has a total power output of 8 MW (Wójcik, 2014). Besides, pellet production from straw has been over 300 thousand tons.

Figure 25 Modelling results of straw utilisation in the 11 MS



The main barriers with straw based energy production relate to its low energy density and the chemical composition that makes straw very expensive for combustion. Baled straw has a rather low energy density (when compared to wood) and the costs for collecting, transportation and handling are high. Consequently the market is predominantly focused at local applications.

An inherent problem with straw compared to wood and coal is the high content of ash and in particular the content of alkali metals (sodium and potassium) together with chlorine and silicon. During incineration potassium and chlorine can cause a number of technical problems, such as corrosion of super heaters, slagging and fouling and deterioration of catalysts for NO_x reduction. Ash from coal fired plants is widely used in the cement production, but ash from straw cannot meet the quality and specifications needed for this purpose. Different solutions to minimise the waste problem have been tested and implemented. For example co-firing with coal has been broadly used to 'dilute' the problem, but new boiler designs and use of new alloys have also been developed.

Germany is a large producer of agricultural commodities resulting in a significant potential of straw. However, to date there is only little use of it for energy. This is due to economic reasons, as production costs of conversion technologies for heat, power and fuel for transportation are all higher than the production costs of reference technologies. The support mechanisms in force aren't sufficient to create economic viable concepts for straw as feedstock.

Straw use is (indirectly) promoted through the biofuels quota obligation and the Energy Tax Act in Germany. Straw as feedstock for the production of lignocellulose ethanol biofuels can be counted towards quota obligations and benefit from an energy tax relief in Germany. The Energy Tax Act includes a paragraph under which a number of specifically defined biofuels can be exempt from the energy tax. The definition of these advanced biofuels includes biofuels from straw (e.g. ethanol from lignocellulosic biomass). Another support mechanism is the EEG. Biomass power plants that were put into operation between 2009 and 2014 can receive a bonus for the power production from straw. The utilisation of straw in boilers smaller than 100kW benefit from emission thresholds that are higher than for biomass feedstock. In contrast to that the requirements for the utilisation of straw in boilers larger than 100kW are very strict. These strong thresholds for direct emissions from straw combustion lead to significantly higher technical effort and investment costs for straw combustion plants (for instance when compared with Denmark). The current number of installed straw combustion units in Germany is estimated at approximately 130 plants (Herin, 2012; Gawor, et al. 2014).

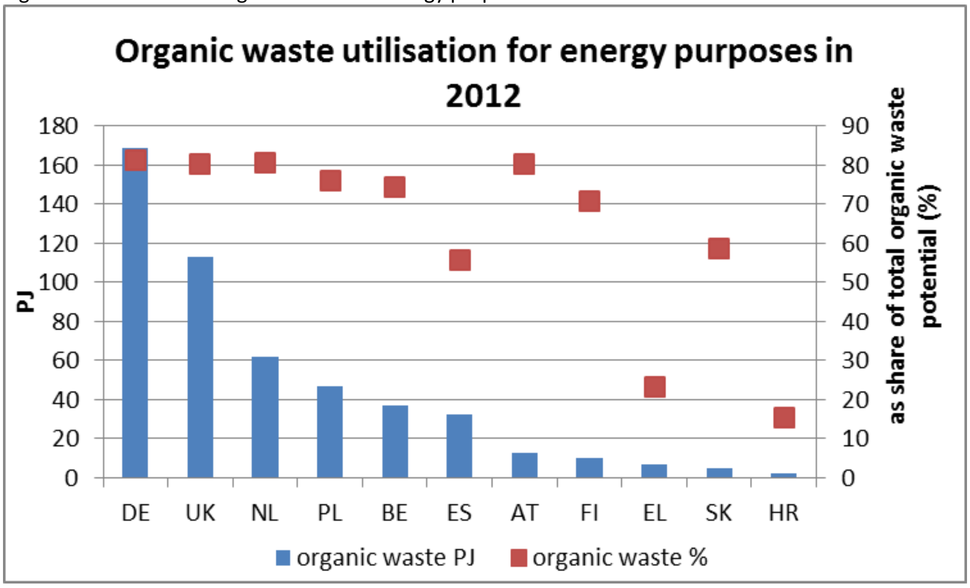
5.1.6 Organic waste

In this study the organic waste category consists of biodegradable garden and park waste, food, kitchen and catering waste and comparable waste from food processing plants. It also includes the organic fraction of municipal solid waste (MSW).

Organic waste has been chosen as one of the priority value chains by most of the participating countries (Austria, Belgium, Germany, Greece, Spain, Finland, Slovakia, the Netherlands and the UK) as the potential is significant and there is ample room for further improvements that can contribute to resource efficiency and to the energy sector.

Figure 26 illustrates the modelling results for organic waste. According to the modelling exercise Austria, Germany, the UK, and the Netherlands use more than 80% of their organic waste potential for energy purposes. The countries that have a large household waste potential in combination with low energy recovery, thus high disposal and incineration without energy recovery rate, are particularly Spain, Slovakia, Poland and Greece (Elbersen et al., 2015). In the UK the recovery rate is relatively high, but from the waste that is not recovered there is practically no energy recovery which implies that it is largely disposed of in landfill or incinerated without energy recovery. In Poland energy recovery of non-recovered waste is important for household wood waste and vegetable waste (Elbersen et al., 2015).

Figure 26 Utilisation of organic waste for energy purposes in 2012



Main barriers for this feedstock category to be used for energy purposes relate to:

- the waste management practices in each country (to what degree it is separated, recycled, reused)
- lack of economic and regulatory instruments to divert waste from landfill. The landfill directive is progressively banning bio waste from landfilling, but many Member States are still lagging behind the EU targets for maximum percentage of biowaste going to landfills.
- acceptance by citizens (for instance strong opposition to waste- to-energy plants in some countries)
- very high upfront investment costs. Biogas is particularly capital intensive and needs long term financing possibilities and security of income.
- the regulatory barriers surrounding the biogas sector in general. Many regulations related to waste management, soil protection, prevention of water table pollution by nitrogen, etc. The excess of such non-technical barriers is a main obstacle to a quicker implementation of biogas plants in Europe.

Recently a study has been conducted for the European Commission that analyses the waste management programmes and strategies in Europe (BiPRO, 2012). The report grades the 27 EU Member States against 18 criteria such as total waste recycled, pricing of waste disposal, and violations of European legislation, etc. Austria, the Netherlands, Germany, Finland, the UK and Belgium are among the best performing countries. These countries all have comprehensive waste collection systems, landfill generally less than 5% of their waste, have well developed recycling systems, sufficient treatment capacity, and they perform well with biodegradable waste. In the same study Spain is ranked as average performing, indicating that not all households are connected to waste collection, planning of future treatment capacity is not sufficient and waste prevention is not yet on the political agenda. Slovakia and Greece are grouped under the largest implementation gaps, showing severe deficits within all criteria including prevention policies, lack of applying economic and regulatory instruments to divert waste from landfill and insufficient adaptation of existing infrastructure to EU requirements (BiPRO, 2012). These Member States still have high levels of landfill.

According to Eurostat statistics[5]:

- In 2012, recycling and composting of municipal waste together accounted for more than 50% of waste treated in **Germany** (65% of waste treated), **Austria** (62%) and **Belgium** (57%).
- Recycling and composting was also the major part of waste treatment in the **Netherlands** (50%), the **United Kingdom** (46%). In **Finland** composting & recycling and incineration had equal shares (both 34%).
- The highest shares of municipal waste landfilled were recorded in **Croatia** (85%), and **Greece** (82%).
- Highest levels of incinerated municipal waste (with energy recovery) were recorded in the **Netherlands** (49%), **Belgium** (42%), **Germany** and **Austria** (both 35%) and **Finland** (34%).

The EEG in Germany supports the anaerobic digestion from organic wastes by means of higher feed-in tariffs. To be eligible for the bonus, the biogas has to be produced by a minimum of 90% biodegradable waste within the period of one year.

All municipal waste incineration plants in Austria feature energy recovery for district heating (Herczeg, 2013). For biowaste and packaging paper waste, there is an obligation for separate collection. An effective waste paper collection system is in place, providing separate bins for almost every household (Herczeg, 2013). Originators of biogenic waste are obliged to deliver the waste either to home or community composting facilities, make it available for separate collection or bring it to an appropriate collection point (BMLFUW, 2011). EU legislation aimed at diverting biodegradable municipal waste from landfills has been adopted in Austria before respective regulations under the EU Landfill Directive came into force (Herczeg, 2013). A reduction of biogenic MSW landfilling to almost zero was achieved through a landfill ban for untreated waste with total organic carbon content over 5%. This ban already came into effect in 2004 (with exemptions until 2008). Furthermore, a special tax for landfilling waste is in place (Herczeg, 2013).

In Belgium, in Flanders, the use/treatment of waste is regulated by the Material Decree and Vlarema. Historically composting was one step higher on the priority ranking than digesting and combustion. New insights based on life cycle thinking have opened possibilities (evaluated case by case) for digestion of organic waste combined with composting of organic waste. Encouragement by the Flemish Waste Agency (OVAM) is present. The compost/digestate coming out the composting/digestion facilities is bound to very strict regulations before it can be declared as fertilizer/soil improvement material. Green power certificates can also be obtained for biogas produced from organic waste. Depending on the different organic waste streams and on the installation (only electricity production or combined heat and power, size of the installation) a specific banding factor is applicable and yearly adjustable by the Flemish Government. In Belgium (Flanders) certain aspects of the waste and energy legislations are aligned. The waste agency has an advisory role in admitting green certificates for certain biomass waste streams. Waste material suitable for recycling is excluded from green certificates.

The Netherlands has implemented a strategic initiative in order to promote anaerobic digestion of MSW-derived organics. The country has a very well developed infrastructure for natural gas, the government intends to produce a large amount of biomethane which can be distributed across the country. The Netherlands has the ambition to replace 15 to 20% of the natural gas by green gas by 2030.

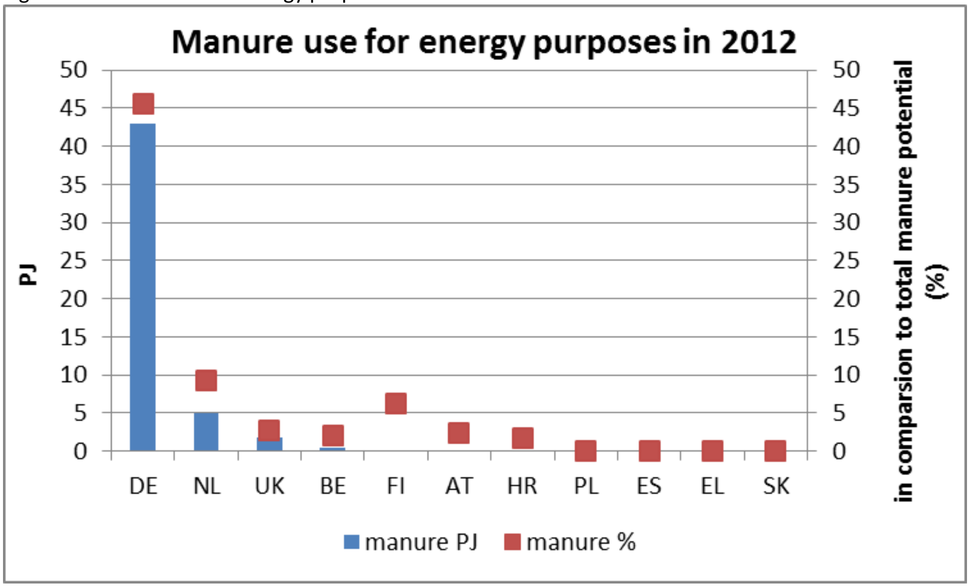
5.1.7 Manure

The manure category consists of both the wet and dry manure from poultry, cattle, pig, sheep and goats.

This feedstock category has been selected by Belgium, the Netherlands, Poland and the UK. The main motivation relates to excess manure potential in these countries and the importance of utilising them.

Figure 27 illustrates the modelling results concerning manure utilisation for energy purposes. According to the modelling results only in Germany a large amount of manure was used to produce energy in 2012, corresponding to 45% of the German manure potential[55]. Results also show that small amounts of manure has been utilised for energy in the Netherlands, the UK and Belgium.

Figure 27 Manure use for energy purposes in 2012



Currently, manure-based biogas is not economically feasible and it requires significant amounts of financial incentives. Either large volumes of manure must be available within a short distance to apply economies of scale and or small on-farm plants facing relatively high investment costs.

To improve biogas yields, co-digestion of dairy manure with certain co-digestate is one of the methods used to enhance biogas production. Large volumes of co-digestate (around 50%) such as maize are used to obtain higher biogas yields and therewith a better economy of the biogas plant[56]. However, the sustainability concerns around energy crops and their increasing prices call for other solutions. Besides the mono digestion option there is an increasing interest in the application of other co-substrates like grass, straw, organic waste etc.

Manure falls under different regulatory frameworks which complicates the use of manure for biogas generation. The Nitrates Directive makes no distinction and defines livestock manure under article

[55] It is important to indicate that these modelling results do not necessarily reflect the real circumstances. In the absence of available statistics on manure based energy production we could not calibrate the results.

[56] One tonne of manure will yield 20-25 cubic metres of gas whereas a tonne of maize easily produces 200 cubic metres.

2(g) as: *'waste products excreted by livestock or a <u>mixture of litter and waste products excreted by livestock</u>, <u>even in processed form</u>'*. This implies that all digestate from animal manure origin retains the status of animal manure. As a consequence of the wording, the directive leads some member states to take a very stringent interpretation where any organic material which is co-digested with manure automatically becomes manure. There are mainly two diverging legal interpretations across the EU on spreading co-digested manure: a) Certain member states take a stringent approach, where it is assumed that all nutrients in digestate retain the animal manure status. This implies that the additional nutrients coming from other sources are automatically converted to animal manure status. b) Other member states uphold the more open 'pro rato' principle stating that only the nutrient fraction coming from manure will be considered as manure and will be counted towards the 170 kg/ ha limit (EBA, 2014)[57].

Animal by-products subject to Animal by-product regulation (ABPR) are generally excluded from the scope of the current Waste Framework Directive (WFD), except those which are destined for incineration, landfilling or use in a biogas or composting plant. Therefore, once manure is destined for the use in biogas plants, it has to fulfil all legal requirements for waste while this is not necessary as long as it is used directly as fertiliser[58].

The political framework surrounding manure based biogas differs from country to country. The introduction of a bonus for feedstock in 2004 (e.g. maize) and for manure in 2009 pushed the development of manure co-digestion in Germany. In 2012 the manure bonus was removed and the amount of maize as input was limited. To promote the utilisation of manure, the updated EEG from 2012 includes a special feed-in-tariff[59] for small biogas plants up to 75 kWel that use at least 80% manure to produce biogas. Still, this measure led only to 100 new small biogas plants built until end 2012. Most of these plants were built in Bavaria as in South Germany smaller farms are more common (Luostarinen, 2013).

In the Netherlands the trend is more towards using other types of co-digestates such as a mix of 50% manure combined with about 30% residual flows and 20% energy crops. Bio-glycerine for example has become a popular co-substrate in the Netherlands until the price of these co-digestates rose. The search is now focusing on other (lower value) co-substrates like roadside grass. SDE+ provides a premium for manure co-digestion with no more than 50% co-substrate. Next to that, since 2012, manure mono-digestion has also been included into the SDE+.

5.1.8 Sugar beet

The Dutch country representatives have selected sugar beet and the biochemical conversion route (sugar/starch hydrolysis and fermentation) as one of the priority value chains due to the shifting policy process related to sugar quota. Recent reforms to the EU Common Agricultural Policy (CAP) has included changes to the region's sugar regulations, with a new sugar regime entering into force in 2017.

[57] http://european-biogas.eu/wp-content/uploads/2014/12/Digestate-in-the-Nitrates-Directive_EBA-Position-paper.pdf

[58] In some MS for instance in Finland there is agri-environmental subsidy for injecting manure into soil. It is applicable only for raw manure, while processed manure is not eligible. This makes manure digestion less interesting.

[59] 23,73 €cent/kWh for electricity from at least 80% manure fed AD.

According to the EU's Joint Research Centre (JRC) Institute for Prospective Technological Studies' **assessment of what might happen to the EU sugar market** as a result of the abolition of sugar quotas' the sugar beet production might stay steady even though the sugar beet prices might decrease in 2020 (22% below the price in a counterfactual reference scenario) (Burrell et al., 2014). Still, the future of sugar beet is to be seen as it will depend on a number of parameters such as the possible shifts in the EU supply curve in response to quota removal, the supply responsiveness of preferential exporters to changes in the EU price, the level of world market prices, and the share of the sweetener market taken by isoglucose.

EU sugar policy (DG Agriculture, 2015)

The European Union is the world's biggest producer of beet sugar and the principal importer of raw cane sugar for refining. The EU sugar market is regulated by production quotas, a minimum beet price and trade mechanisms.

The quota management will end as of 30 September 2017.
The total EU production quota of 13.5 million tonnes of sugar is divided among nineteen Member States. Production in excess of the quota is known as 'out-of-quota' sugar and strict rules govern its use. It can be exported up to the EU's annual World Trade Organisation (WTO) limit of 1.374 million tonnes, sold for biofuel or other industrial non-food uses, or counted against the following year's 'quota' sugar. There is also a small quota of 0.72 million tonnes for the competing sweetener isoglucose (also known as Glucose Fructose Syrup).

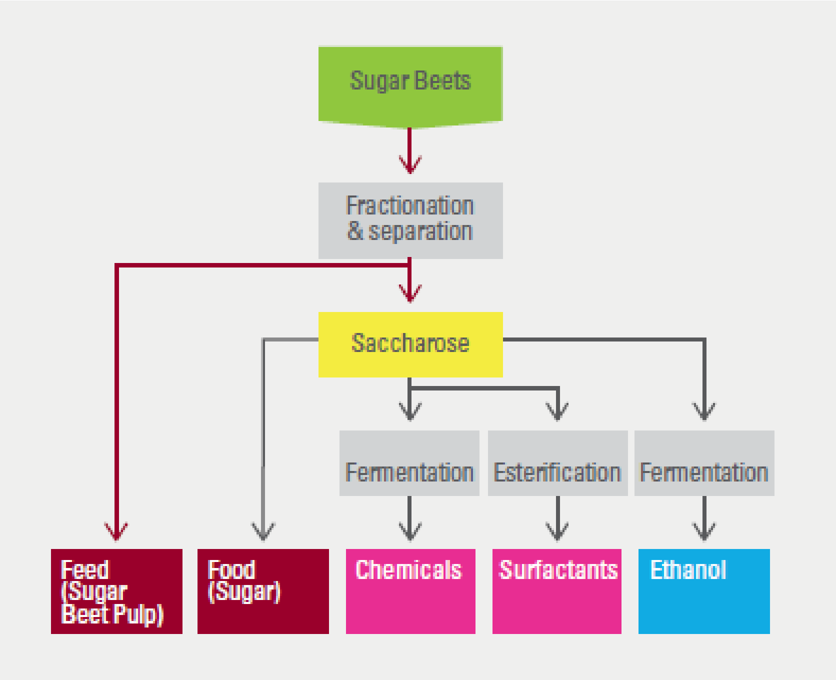
Assuming that the elimination of the sugar quota may result in higher competition among suppliers this can cause (i) minimising unit costs by maximising factory throughput and capacity utilisation; (ii) increase sugar beet production by increasing the growing area or extending the growing period (Rabobank, 2013).

Currently, most production is going to crystallised or liquid sugar for food applications. The residue of sugar beet pulp is used for animal feed, while molasses from the refining process go into feed or are fermented to produce bioethanol. Sugar is also processed into alcohol for the beverage industry and used by the chemical sector in fermentation processes. Currently only 2% of the total sugar production is used in non-food applications (Star-colibri, 2011).

In the future, innovative techniques could enable diversification of products from sugar and starch-derived C6-sugars (hexoses) towards other alcohols, chemicals and organic acids, as new biological and chemical processes to produce platform chemicals become available and competitive. A specific route currently under development, and likely to be commercialised by 2030, is the fermentation of sugar to lipids, which could be used by the oleochemical industry or to produce jet fuels, providing further integration potential between existing value chains (Star-colibri, 2011) .

Figure 28 presents a schematic diagram of the sugar beets biorefinery.

Figure 28 *Schematic diagram of sugar beets biorefinery* (Star-colibri, 2011)



6. Discussions, conclusions and lessons learned

The countries analysed in this study are at very different stages of bioenergy sector development and in line with the fact that they have different policy ambitions for the sector. They can be categorized into three groups.

In Group 1, Austria, Finland and Germany, the sector has achieved significant amounts of bioenergy utilisation (mainly for power and heating & cooling), and policy attention currently is on the one hand to sustain the existing deployment rates and on the other hand to move towards resource efficiency. A more market based policy approach is likely to be introduced in these countries in the coming years[60] and the implications of such mechanisms on bioenergy sector is yet to be seen. Next to that, a clear understanding of the effects of resource efficiency on the existing markets and future transition to more resource efficient pathways is missing. Unfortunately, it is not possible to draw robust policy conclusions and recommendations for these issues solely based on the benchmarking study, since the study is limited to current approaches. The future policy frameworks that will be discussed in details within the upcoming work (D4.1 and 4.2) will, however, cover these issues in further detail. Nevertheless, some initial discussions are introduced below.

Group 2 includes Greece, Spain, Croatia, the UK, Poland and Slovakia[61]. These countries hold significant amounts of biomass potential but the bioenergy sector is immature. The existing policies in these countries have not been sufficient to address the barriers in the entire bioenergy value chain. The mobilisation of resources and increase in bioenergy sector are a more urgent issue to tackle. Therefore, strategies for these countries should focus on overcoming the existing barriers and maturing the sector on the one hand. On the other hand, the policy approach should take into account the lessons learned from the more mature markets and ensure that the sector can evolve in transition to resource efficiency.

Group 3 concerns countries like Belgium and the Netherlands. While the bioenergy sector is also less mature in these countries, they differ from Group 2 due to very limited resource availability and dependence on imports. Next to that, the biobased economy concept plays a crucial role and the resource efficiency is high in their agenda similar to the countries in Group 1.

- ***sustaining the existing deployment rates***

Policy support has been given to the bioenergy installations for a certain period of time to provide investment security and allow for financial closure. The continuation of these plants, once the life time of the support ends, will depend on the electricity market prices and will be very vulnerable to feedstock price fluctuations. In the absence of any policy support these installations may not be competitive enough and shut down. This could result in a large decrease in bioenergy production unless the more efficient new installations bridge such possible gaps. Subsidies can be elongated for retrofitting purposes (increasing the efficiency, further use of heat) and to keep the production alive until these plants reach their lifetime. This has been applied in the Netherlands to the projects for which the previous policy support (MEP) has been expired to ensure 2020 target achievement.

[60] In line with the State Aid Guidelines. See http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52014XC0628(01)

[61] Acknowledging that there are wide differences among these countries. For instance in Poland, followed by Slovakia, the bioenergy sector has been experiencing a significant growth rate in the last years and in Spain, the growth in biofuels for the transport sector has been one of the strongest. Based on the overall sector deployment these countries can be considered as 'laggards'.

- ***transition to resource efficiency***

Moving from existing bioenergy applications towards resource efficiency will require a clear understanding of what the most resource-efficient uses of biomass are through the whole biomass-to-(energy) production chains. A number of indicators have been defined and introduced in D2.4 to reflect the different aspects of resource efficiency. They are grouped into;

- efficient use of resources (including energy efficiency, functionality and land use productivity),
- ecosystem (climate change, biodiversity, soil, water and air quality),
- business cases and markets and
- socio-economics (job creation and local economy).

Among these aspects the ecosystem services are a cross cutting issue as the biomass feedstocks can be traded among the MS or imported. Through the RED sustainability concerns related to biofuels for transport have already been addressed, however, a more holistic approach that covers the whole biobased economy is needed. The other three aspects are more of a national matter but the EU can play a guiding role, at least to ensure that certain aspects of resource efficiency are prioritised in the national agendas. So far Finland, Germany, the Netherlands and Belgium have set biobased economy strategies that strive for low-carbon, resource efficient, improved economic growth and employment.

6.1 Conclusions and lessons learned related to the bioenergy sector

Electricity & heat

Solid biomass

Feedstock mobilisation and provision of sufficient financial support to close the gap between the conventional fossil fuel based power & heat production and bioenergy production are considered as the two important barriers for electricity and heat production from solid biomass resources. For the heat sector the availability and the efficiency of district heating systems are also important aspects to take into consideration.

For the electricity sector a combination of feed-in tariffs (or premiums) combined with investment support and further tax incentives and/or feedstock premiums appears to be effective if and when the level is sufficient for closing the financial gap. They provide long-term certainty for investors reducing the investment risk. Such policy instruments appear to be more effective in mobilising resources when compared with the more market based instruments, such as the Green Certificate Schemes. Market based instruments, in fact, favour more cheaper feedstocks and conversion technologies; biomass co-firing being one of them. On the one hand, biomass co-firing can help mobilise resources and reduce the financial pressure on the governments. On the other hand, such policy support can result in more feedstock imports rather than mobilising domestic feedstocks (as has been the case in Poland for instance). It is, therefore, crucial to define the exact policy ambition (be it least cost target achievement or least cost indigenous resource mobilisation) and design it accordingly so that unintended effects are limited. Another important aspect is the long-term sustainability and resource efficiency of biomass co-firing. In the short-term linking the policy support to sustainability criteria and to efficiency increase requirements for co-firing technologies can help reduce the overall policy support costs. Such gains, however, should be directed to promoting more resource efficient pathways. Once the biomass supply logistics are established the feedstocks can be diverted to more efficient uses such as biomass gasification or biorefineries.

For the heat sector, the successful countries apply a combination of investment subsidy, CHP heat bonus and/or CO_2 tax. However, it is important to take into account the differences in heat markets, the different climate conditions, country specific heat producing histories and existing infrastructures (such as the gas distribution, district heating systems, etc.) to define the right mix of policy incentives for the MS.

In principle subsidies and tax incentives are useful approaches for countries where the market is at its early stages and the DH systems are not in place. it is crucial that any renewable heat policy also would address the energy efficiency policies.

Biogas

Biogas production can take the form of farm-scale plants and centralised co-digestion plants depending on the local circumstances. The most significant barriers to biogas production are

- the expensive infrastructure,
- uncoordinated energy, agricultural and environmental policies (i.e. poor implementation of EU agro-environmental legislation which could become a barrier to biogas production, the nitrate directive and biofertiliser trading permissions) and,
- a complicated regulatory and spatial planning (environmental planning permission for biogas plants is difficult to obtain).

The results indicate the success of feed-in tariffs in supporting biogas technologies, whilst neither quota obligations nor tax incentives appear to be able to stimulate the market diffusion of agricultural biogas technologies. Quota obligations in the UK rather stimulate the development of the cheaper biogas technologies using landfill gas and sewage gas. The success of financial instruments, however, are also related to the efficient and reliable frameworks for permitting procedures for biogas plants, as has been the case in Germany. Removal of certain regulatory and economic barriers and the creation of financial incentives can create the suitable conditions for either system to succeed.

Transport-Biofuels

The results indicate that a quota obligation alone is not sufficient to promote biofuels. The combination of blending obligations supported by tax exemptions appear effective only when the level of tax relief is high enough. Next to that, the existing policies have mainly been favouring conventional biofuels and the majority of double counted biofuels in the EU are produced from used cooking oil or animal fat.

Value chains

Different value chains are selected by the MS to further analyse the mobilisation effects of existing policies. Modelling results indicate that a large share of primary forestry residues (>50%) are already utilised in Austria, Belgium, Finland, Germany, the Netherlands and Greece. The current use of these resources for energy purposes are very low in Croatia, Spain, Poland, Slovakia and the UK.

- The (further) utilisation of forestry primary residues relates to mobilisation related barriers. Among other things (i.e. further development of the forestry industry, strong sustainable forest management and application of good practices), dedicated policy incentives to harvesting for energy purposes and sufficient levels of policy support to electricity and heat production are needed. For countries, for which the mobilisation is very expensive (due to slopes, mountains areas etc.) local use should be promoted.

- Industrial wood residues have already been one of the commonly used feedstocks for energy production, mainly by the industry itself for self-consumption. The modelling results also indicate high shares of utilisation for almost all of the 11 MS. The main concern related to this feedstock has been the subsidy supports to RES that can increase the feedstock price and negatively affect the industry that also use some of these feedstocks for their processes[62]. This concern has been acknowledged by some of the MS and included into the existing or upcoming policy processes.
  - In the Flemish Energy Decree, only waste wood not usable for recycling at the moment (in the panel board or paper industry) can receive green power certificates or green heat investment support.
  - In Finland, the aid scheme 'Operating aid for forest chips fired power plants' has been modified in order to address potential distortion of competition in the future[63]. According to the modification the aid level for electricity produced with forest chips would be reduced by 40% (i.e. the reduced feed-in premium would be 60% of the full feed-in premium), if the forest chips are produced from industrial roundwood (i.e. logs or pulpwood) originating from a felling site of large-sized trees.

- Current straw use in the selected MS is low (on average approximately 5% of the potential) and is mainly based on local applications in boilers to produce heat. The low bulk density and the high ash and alkali content make it very costly to transport and convert it into energy. Feedstock bonus, to mobilise this feedstock has been implemented for instance in Germany but the success rate was very low.

- The success of energy production in organic waste relates mainly to the existing waste management practices. Countries that have comprehensive waste collection systems, with well-developed recycling systems perform also better in energy production i.e. Austria, the Netherlands, Germany, Belgium and Finland. These countries also have the highest levels of incinerated municipal waste with energy recovery. Greece, Spain, Croatia, Slovakia and Poland still have high levels of landfill without energy recovery.

- Manure-based biogas requires significant amounts of financial incentives. To improve biogas yields, co-digestion of dairy manure with certain substrates has been one of the methods used to enhance biogas production. Small-scale mono-digestion has also been promoted for instance in Germany and the NL but the success rates have been very low.

6.2 Policy conclusions and recommendations

The bioenergy policies should address all barriers in the entire bioenergy value chain and provide incentives to overcome them. A perfect, one-suit-fits-all package of policy instruments is unlikely to exist. The appropriate combinations of policy support (the optimal mix) depends on the country-specific situations, such as the capacity to produce and harvest biomass feedstocks efficiently, the availability of supply infrastructure, the maturity of the technology, the logistics and the end use.

Biomass electricity generation

[62] I.e. sawmill residues can be utilised in pulp and paper production, pellet or briquette production and/or heat and power production. Sawdust can also be used by other wood processing industry such as plywood, particle board and furniture industry

[63] The modification has not yet entered into force, and this is subject to Commission's state aid approval

- The feed-in tariff (or premium), with its advantage of creating a relatively stable investment climate, combined with investment support and further tax incentives, appear to be effective in promoting bioelectricity sector. The MS that are lagging far behind also apply similar policy mixes. This indicates that the level of support provided in these countries are not sufficient enough to overcome the existing barriers. Policy frameworks for these countries should be tailored to the existing country-specific barriers.
- Dedicated policy support to certain feedstocks, be it a feedstock bonus or a dedicated subsidy for harvesting for energy purposes, can be successful with the pre-condition that other barriers in the value chain are also sufficiently addressed (i.e. enough financial support is provided for instance for the conversion technologies, the high efficiency in CHP is promoted etc.). This, however, needs to happen hand in hand with other policy domains to establish strong sustainable forest and agricultural management practices that are key to the success of bioenergy policy support.
- While least cost options such as biomass co-firing can be supported in the short-term, they should be considered as transition technologies that can enhance feedstock supply and at the same time ensure target achievement. The design of such support mechanisms should take into account the sustainability concerns and at the same time give priority to indigenous feedstocks, mainly primary forest residues, straw, landscape care wood, perennial crops etc.
- Environmental benefits of biogas production from waste should be emphasised both at the national and the EU level policy making.
    - As such the implementation and enforcement of existing legislations, such as the Nitrates, Sewage Sludge, IPPC, Water Framework, Waste Framework Directive, should support the biogas development.
    - The avoided methane emissions should be emphasised and such benefits need to be translated into the appropriate policy frameworks that promote biogas systems (i.e. obligations to avoid methane emissions or further bonus/financial support due to avoided emissions to biogas).
- Both at the EU and national level research and development should be encouraged to improve the technical development of biogas plants, and the possibilities for improving the yields of biogas production from animal manure alone or mixed with organic waste.
- It is advisable to have dedicated, innovation funds to further support manure mono-digestion .
- Best practises from successful biogas operations should be widely disseminated to counter the current lack of awareness amongst many farmers, economic actors, municipalities and other stakeholders about the benefits of biogas technology for rural communities.

Biomass heat generation

- Policy incentives given to high efficiency CHP plants and the use of heat through District Heating systems proved to be the key success factors in countries like Finland and Austria.
- The right mix of policy incentives depends on the country-specific conditions (climate conditions) and the heat sector (i.e. existence of infrastructures). However, combinations of investment subsidy and tax incentives are useful approaches, especially, for countries where the markets are at their early development stages and the DH systems are not existing.
- It is crucial that any renewable heat policy would also consider the energy efficiency policies and design the policy framework accordingly.

Biofuels

- Combination of blending obligation supported by tax exemptions can be effective with the pre-condition that the level of tax relief is high enough. Biofuels deployment is directly dependant on adequate regulatory frameworks, both for current biofuels and advanced biofuels.
- Existing support – double counting of advanced biofuels – has not been sufficient enough to bring the more advanced technologies into the market. Additional policy mechanisms that would reduce investment risk and ramp up the production of advanced biofuels are needed.

Resource efficiency

- A clear guidance/harmonised approach/workable format from the EU on how to define the most resource-efficient uses of biomass through the whole biomass-to-(energy) production chains is needed. In line with this guidance the national governments should draw their strategies and provide the frameworks to move from existing bioenergy applications towards resource efficiency.
    - Cost efficiency might be an important aspect of resource efficiency but should not be considered as the leading principle unless all other aspects (such as externalities related to environment and society) are sufficiently covered.
- The winning options would be the pathways (combinations of feedstocks, conversion processes and end products), which best address combined strategic and sustainability targets: environmental performances (greenhouse gas reduction, biodiversity, water, local emissions), security and diversification of energy supply, economic competitiveness and public awareness.

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ANNEXES

Annex I Definition of wastes used in this project

Household (HH)/ economic sectors (NACE)	Waste type	Definition	Kton DM for EU-28 in 2010 *
HH	Paper	See underneath NACE 'Paper cardboard'	**17,180**
HH	Wood waste	These wastes are separately collected wood wastes from households.	**3,880**
HH	Animal and mixed food	See underneath NACE 'animal and mixed food'	**5,810**
HH	Vegetal waste	See underneath NACE 'vegetal waste'	**20,320**
HH	Municipal Solid Waste (MSW)	Household and similar wastes are mixed municipal waste, bulky waste, street-cleaning waste like packaging, kitchen waste, and household equipment except separately collected fractions. They originate mainly from households but can also be generated by all sectors in canteens and offices as consumption residues.	**138,260**
HH	Common sludges	See underneath NACE 'common sludges'	**230,000**
NACE	Paper and cardboard wastes	These wastes are paper and cardboard from sorting and separate sorting by businesses and households. This category includes fibre, filler and coating rejects from pulp, paper and cardboard production. These wastes are largely generated by three activities: separate collection, mechanical treatment of waste and pulp, and paper and cardboard production and processing. All paper and cardboard wastes are non-hazardous.	**39,550**
NACE	Wood waste	These wastes are wooden packaging, sawdust, shavings, cuttings, waste bark, cork and wood from the production of pulp and paper; wood from the construction and demolition of buildings; and separately collected wood waste. They mainly originate from wood processing, the pulp and paper industry and the demolition of buildings but can occur in all sectors in lower quantities due to wooden packaging. For some countries this category is corrected (e.g. PO, SK, ...) Because this category overlaps with the forest potential category 'secondary forestry residues' particularly with the sub-category 'Other forestry industry by-products'. Wood wastes are hazardous when containing hazardous substances like mercury or tar-based wood preservatives, which makes it only suitable for incineration and not recycling.	**55,300**
NACE	Animal and mixed food	Animal and mixed food wastes (09.1): item 31. These wastes are animal and mixed wastes from food preparation and products, including sludges from washing and cleaning; separately collected biodegradable kitchen and canteen waste, and edible oils and fats. They originate from food preparation and production (agriculture and manufacture of food and food products) and from separate collection. Animal and mixed waste of food preparation and products are non-hazardous.	**32,770**
NACE	Vegetal waste	Vegetal wastes (09.2): item 32. These wastes are vegetal wastes from food preparation and products, including sludges from washing and cleaning, materials unsuitable for consumption and green wastes. They originate from food and beverage production, and from agriculture, horticulture and forestry. Vegetal wastes are non-hazardous.	**33,130**
NACE	Used fats & oils (UFO)	Used animal fats and vegetal oils.	
NACE	Municipal Solid Waste (MSW)	See MSW from HH above.	**47,970**
NACE	Common sludges	These are waste water treatment sludges from municipal sewerage water and organic sludges from food preparation and processing. They mainly originate from households and industrial branches with organic waste water (mainly pulp and paper as well as food preparation and processing). They can also occur in waste water treatment plants or in the anaerobic treatment of waste. All common sludges are non-hazardous. Comparability can be problematic between countries using different statistical units as they will not assign the waste to the same economic sector.	**18,930**

Annex II-IEA Task 42 'assessment of bioeconomy strategies'

country	assessed strategies				scope of strategies			position of bioenergy in a bioeconomy		
	Governmental bioEconomy strategies	industrial strategies	regional strategies	poliyc advice, by research and consulting	bioeconomy	biobased economy	biobased industry	priority	equal to other sectors	less important
AT	(√)	x	x	√	x	x	√	x	√	x
BE	x	√	√	x	√	√	x	x	x	√
HR	x	x	x	x	x	x	√	x	√	x
FI	√	x	x	x	√	√	√	x	√	x
DE	√	√	√	√	√	√	x	x	√	x
NL	√	x	x	√	x	√	x	x	√	x
UK	√	√	x	√	x	√	√	x	√	x

√	applicable
x	not applicable
(√)	No governmental bioeconomy strategy, but high governmental attention (e.g. national blue print, green economy strategy …)

country	economic sectors in the focus strategy							Vision and targets		current focus of implementations		
	agricultue+forestry	food	energy	pulp+paper	wood processing	chemical industry	medical industry	vission and general target	measurable target	R&D	transition to market	policies
AT	√	√	√	√	√	√	√	√	x	√	x	x
BE	√	√	√	√	√	√	√	x	x	√	x	x
HR	√	x	√	√	√	x	√	x	x	√	x	x
FI	√	√	√	√	√	√	√	√	√	√	√	x
DE	√	√	√	√	√	√	√	√	x	√	√	√
NL	√	x	√	x	x	√	√	√	√	√	√	x
UK	√	√	√	x	√	√	√	x	x	√	√	√