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Bioenergy deployment in the Danube Region

Current status and progress according to National Renewable Energy Action Plans

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Abstract

The report aims to present a comprehensive analysis of current and expected deployment up to 2020 of bioenergy in 16 countries of Danube region: nine European Member States (Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Slovakia and Slovenia) and seven non-European countries (Ukraine, Republic of Moldova, Serbia, Bosnia and Herzegovina, Albania, Montenegro and The former Yugoslav Republic of Macedonia) based on available national renewable energy action plans and the most recent bi-annual progress reports presenting in details the progress actually achieved in deploying their renewable sources.

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May, 2014

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Preface

The EU strategy for the Danube Region (EUSDR) was adopted by the European Commission in December 2010 and endorsed in June 2011 by the European Council, who called for its implementation [7][1].

The area covered by EUSDR ranges from the Black Forest (Germany) to the Black Sea (Romania-Ukraine-Moldova), covers parts of nine EU countries (Germany, Austria, Hungary, the Czech Republic, Slovakia, Slovenia, Croatia, Bulgaria and Romania) and five non-EU countries (Serbia, Bosnia and Herzegovina, Montenegro, Ukraine and Moldova) and includes more than 100 million people [7].

The Danube region provides many benefits to its inhabitants, including rich environmental assets, abundant renewable energy sources, cultural, ethnic and natural diversity and substantial trade opportunities. However, the region also faces several challenges, including environmental threats, insufficient energy and transport connections, uneven socio-economic development and shortcomings in safety and security. Better coordination and cooperation between the Danube countries and key players are needed to address these challenges, in particular through planning and investing together and developing key links. The EUSDR addresses the main challenges faced by the region, with a special focus on mobility, energy, environment, socio-economic and security issues.

The Joint Research Centre (JRC), the European Commission's in-house science service, responded to the call launching the 'scientific support for the Danube strategy' initiative [11]. The JRC's initiative aims to provide scientific information relating to the EUSDR and is designed to support decision-makers and other stakeholders in identifying policy needs and large-scale projects needed to implement the strategy. It also contributes to strengthening ties and cooperation within the scientific community in the Danube region. The priority areas identified for the JRC's initiative are: waterways, energy, water quality, environmental risks, biodiversity, landscapes, quality of air and soils, knowledge society and ICT, and competitiveness [11]. These priority areas have been transformed into flagship clusters and activities aiming to tackle the scientific challenges faced by the Danube Region from an integrated, cross-cutting perspective, taking into account the interdependencies between various policy priorities.

Bioenergy plays a central role in the national renewable energy action plans (NREAPs) in countries in the Danube area, accounting for more than half of the projected renewable energy (RES) output in 2020. Due to its major role in the development of the area, bioenergy has been identified as one of the clusters in the JRC's initiative. The Danube bioenergy cluster will address the challenges for energy production in the Danube region while focusing on the development of bioenergy and its potential impact on the agriculture sector and on the environment [25].

As part of the EU 2020 strategy, the Renewable Energy Directive (2009/28/EC) sets a general binding target for the European Union to derive 20% of its final energy from renewable sources by 2020. The general target of 20% renewable energy in gross final energy consumption (GFEC) is divided into individual targets for EU Member States, which range from 10% (Malta) to 49% (Sweden) [14]. EU Member States adopted their NREAPs in 2010.[2] These indicate how much

[1] The number in brackets relates to the items in the reference section at the end of this report

[2] The NREAPs and bi-annual renewable energy progress reports for the 28 EU Member States can be found in their original language and in English at: http://ec.europa.eu/energy/renewables/reports/2011_en.htm.

renewable energy will contribute to achieving their renewable energy targets. Promoting renewable energy sources supports the energy policy objective of reducing greenhouse gas emissions in the EU by 20%, compared to levels in 1990.

Modern bioenergy (bioelectricity, bioheat and biofuels in transport) has the potential to significantly increase the role it plays in meeting policy objectives, such as CO_2 emission reductions and improved energy security, and social and economic development objectives [21].

This report aims to set the scene for the current and expected development of the bioenergy sector, through analysing the NREAPs prepared by EU (and some non-EU) countries in the Danube area and the most recent bi-annual progress reports from these countries, which set out progress actually made on deploying their renewable resources.

Executive summary

The Danube region covers an international river basin which, according to the International Commission for the Protection of the Danube River (ICPDR), is shared by 19 countries: Albania, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Italy, the former Yugoslav Republic of Macedonia, Republic of Moldova, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia, Switzerland and Ukraine. EU Member States which are contracting parties of the ICPDR are: Austria, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Romania, Slovakia and Slovenia. About 95% of the Danube basin area belongs to the 16 countries analysed here — see Annex 1.

The Danube region has a large natural potential for bioenergy development in all three main feedstock categories (agriculture, forestry and waste), supporting its three main uses of transport, heat and electricity. The aim of this report is to provide a comprehensive analysis of the current and expected use of bioenergy between 2005 and 2020 in the 16 countries in the Danube region: nine EU Member States (AT, BG, HR, CZ, DE, HU, RO, SK and SI) and seven non-EU countries (UA, MD, RS, BiH, AL, ME and the former Yugoslav Republic of Macedonia). The EU Member States are subject to the Renewable Energy Directive (2009/28/EC) and are asked to provide information through the NREAPs and corresponding Member State progress reports.

The non-EU countries of the Danube region are part of the Energy Community[3], which adopted Directive 2009/28/EC in 2012 (Ministerial Council Decision 2012/04/MC-EnC). As part of this, the countries in the Energy Community agreed to submit their NREAPs to the Energy Community Secretariat by 30 June 2013. All plans must be prepared in accordance with the template published by the European Commission. The plans map out each country's expected steps to reach its legally binding renewable energy target by 2020.

It should be noted that data discussed in this report are generally available at country level, and that a regional perspective was not usually provided in the NREAPs and progress reports. The direct applicability of the findings of this report to the Danube regions of the countries analysed therefore varies from country to country — see Annex 1 — with more than 90% of countries such as Hungary, Austria, Romania, Serbia and Slovakia being part of the Danube area, while other countries are less involved, down to Germany (where 16.8% of the country is in Danube river basin) and Ukraine (5.4%).

Nevertheless, it makes sense to discuss the role of bioenergy in the listed countries as a whole, especially when considering policy making, in light of the effect bioenergy has on countries as a whole and their energy mix. The expression 'Danube countries' will be used in the report to refer to the 16 countries listed above, which include EU and non-EU countries.

With 1351.7 PJ, bioenergy made up more than two thirds of the total energy from renewable energy sources produced in 2010 in the EU Danube countries, exceeding the bioenergy production level expected for 2015. This fast deployment has been attributed to faster development of bioelectricity and bioheat markets than originally expected in NREAPs in the

[3] The Energy Community is an international organisation dealing with energy policy. The organisation was established by an international law treaty in October 2005 in Athens, Greece. The Treaty came into force in July 2006. The parties to the Treaty establishing the Energy Community are the EU (17 Member States) and nine contracting parties from south east Europe and the Black Sea region: Albania, Bosnia and Herzegovina, Kosovo*, the former Yugoslav Republic of Macedonia, Moldova, Montenegro, Serbia and Ukraine.
* This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

EU Danube countries between 2005 and 2010. In 2020, bioenergy is expected to continue to be the main component of renewable energy in the EU Danube countries, providing 1 661 PJ and accounting for 57.8% of the total energy provided by renewable energy sources in the EU Danube countries.

Biomass used in the electricity and heat market was, and is expected to remain, the main contributor to bioenergy development in the EU Danube countries, reaching 1 303 PJ (78.4% of all bioenergy in the EU Danube countries) in 2020, up from 1 179 PJ (87.3% of all bioenergy in the EU Danube countries) in 2010.

Bioheat was the main bioenergy market in the EU Danube countries in 2010, accounting for 1 021.2 PJ (75.7% of total bioenergy in the EU Danube countries) and is expected to remain the largest user of bioenergy in 2020, with 1 053.6 PJ (63.4% of all bioenergy in the EU Danube countries).

Sustainable biofuels in the transport sector is the second biggest market for bioenergy in the EU Danube countries, and is expected to see the largest increase by 2020, doubling the use of biofuels, from 170.4 PJ in 2010 to 358 PJ in 2020. Imported biodiesel is expected to comprise more than a third of biofuels used. Biofuels' contribution to total amounts of bioenergy is expected to increase from 12.6% in 2010 to 21.5% in 2020.

Bioelectricity represents the third largest bioenergy market in the EU Danube countries. It is expected that bioelectricity will make up almost 15% of this market in 2020, with 249.4 PJ.

The biomass supply for energy services in the EU Danube countries accounted for 1 161.8 PJ in 2010.[4] Biomass supply for heat and electricity production in the EU Danube countries reached almost 1 157.7 PJ in 2010. Domestic biomass supplied the largest proportion of biomass in 2010, at 95% (1 099 PJ), and this is expected to remain the main component of total biomass supply in 2020 with 1 800 PJ.

Turning to the non-EU Danube countries, Ukraine used 60 PJ (1 433 ktoe) of bioenergy, or nearly 70% of the total renewable energy production in Ukraine. This was wholly used in the heating and cooling sector. In 2020, bioenergy use in Ukraine is expected to reach 4 592 ktoe, representing 53.8% of the country's expected renewable energy production. The bioheat sector is expected to be the largest user of bioenergy in Ukraine in 2020, using 87.1% (167.5 PJ) of the total amount of bioenergy. 8.5% of the total amount of bioenergy used in Ukraine in 2020 is expected to be used as biofuels in the transport sector, amounting to 16.3 PJ. The lowest use is expected in the power sector, where just 8.5 PJ of biomass is expected to be used in 2020, making up just 4.4% of the total amount of bioenergy used in Ukraine.

Development of renewable energy in Moldova is at an early stage. Moldova used 10.3 PJ of biomass in 2010 (used only for heat production), making up 97.2% of the country's total renewable energy production. Biomass is expected to be introduced into the power sector in Moldova in 2015, producing 5 GWh (0.02 PJ) of electricity, with an installed capacity of 2 MW. Bioheat is expected to be the main user of renewable energy in Moldova in 2020, with 14 PJ (334 ktoe) or 89% of the total energy provided by renewable energy sources. In 2020, 10.3% (1.6 PJ)

[4] Only two EU Member States (BG and SK) reported on biomass supply for transport in their 2009-10 bi-annual progress reports.

of all bioenergy in Moldova is expected to be used by biofuels, while the renewable electricity sector will use just 0.7% (2.7 ktoe).

Biomass sources in Serbia are estimated to provide 108000 TJ/year, with biomass from agriculture providing the largest contribution (65000 TJ/year). The rest comes from woody biomass, providing 43000 TJ/yr. The Serbian NREAP estimated that biomass use in the heating and cooling sector in Serbia in 2010 was 43.2 PJ or 1031 ktoe (50.2% of the total provided by renewable energy) and was the only source of total bioenergy that year. Biomass is expected to be introduced into the electricity sector in 2017 (using 0.2 PJ or 5.6 ktoe of bioenergy), while the use of biofuels in the transport sector is not expected before 2015 (with an expected use of 34 ktoe).

In 2020, nearly 62 PJ of bioenergy is expected to be used in Serbia. The heating and cooling sector will be the largest user of biomass, using 77.9% (48.2 PJ) of this bioenergy. The transport sector is expected to be the next largest user of bioenergy, with 10.3 PJ (16.6%), while the electricity sector will use just 3.4 PJ (5.5%) of bioenergy.

Biomass has been used as an energy source in Bosnia and Herzegovina for a long time, mainly in rural and sub-urban areas, as a primary source for heating and cooking in households and buildings. Biomass in Bosnia and Herzegovina is mainly used in the heating and cooling sector. In 2009, 789 ktoe (9176 GWh) of biomass was used for heat production. No increase in biomass use in this area is expected in Bosnia and Herzegovina by 2020, and biomass use in the electricity sector is expected to reach 10 GWh.

In Albania, the theoretical potential of biomass[5] use for energy is estimated at 4176 ktoe/year, potentially providing 16.9% of the country's energy balance. Municipal solid waste (organic and non-organic) and agriculture are expected to be the main sources of this theoretical potential, providing 37.8% (1576.4 ktoe) and 36% (1521 ktoe) respectively. The technical potential[6] of biomass is expected to be 3212 ktoe/year if used for heat, and 964 ktoe/year if used for electricity production, providing 13% and 14.6%, respectively, of the country's energy balance. In 2020, 16 ktoe, or 186 GWh, of biomass is expected to be used in the electricity sector in Albania.

Potential biomass resources in Montenegro could provide 12030 PJ, which is equivalent to 26% of the country's total primary energy supply. The technical potential of forest-based biomass is 3.3 PJ, 50% of which could be used for co-firing, producing 19 GWh of energy. Using firewood in households could produce a further 68 GWh of heat per year. Biogas has a theoretical potential of 0.83 PJ, 30% of which could be realised, producing 24 GWh of electricity annually. Energy crops could generate 362 GWh of electricity and 517 GWh of heat for industrial and medium-scale use and an additional 827 GWh of heat in households, if approximately 10% of pasture land is used for energy crop production.

[5] The theoretical biomass potential is defined as the total annual production of agricultural, forestry and other residues in a region representing the total quantity of agriculture residues generated in a region. It can be taken as the maximum amount of bioenergy that can be actually derived from cultivated crops in the area [36].

[6] Technical potential is not clearly defined in literature but includes potential limited by factors relating to current technology (land use, agricultural practices and forestry practices) and plant physiology (photosynthetic efficiency, respiration loss, partitioning, water use efficiency, crop yield and harvest index). The technical potential is what is achievable with current applied or best available technology and practices [36].

Biomass in the former Yugoslav Republic of Macedonia is mainly used by households and meets 30–33% of the total energy needs in the country. Around 430 000 households (76%) use biomass for heating. Wood and wooden coal account for 80% of the total biomass used for energy purposes. The electricity sector used 0.5 ktoe (6 GWh) of biomass in 2009, and this is expected to grow to 4.3 ktoe (50 GWh) in 2020 (an increase of 733%). In 2013, biomass used for heat production provided 330 ktoe and this is expected to increase by 7% by 2020 (353 ktoe).

In summary, this study reveals that, despite the fast development of renewable markets such as solar and wind power, bioenergy is expected to remain a competitive renewable energy market in both EU and non-EU Danube countries and is expected to play a major role, including in helping to meet Europe's '20-20-20' targets[7].

[7] The climate and energy package is a set of binding legislation which aims to ensure the European Union meets its ambitious climate and energy targets for 2020. These targets, known as the Europe's "20-20-20" targets, set three key objectives for 2020:
•A 20% reduction in EU greenhouse gas emissions from 1990 levels;
•Raising the share of EU energy consumption produced from renewable resources to 20%;
•A 20% improvement in the EU's energy efficiency.

Abbreviations

DRB- Danube River Basin
EU-DC's — European Union Danube Countries
EUSDR — EU Strategy for Danube Region
GFEC — Gross final energy consumption
GHG — Greenhouse gases
IPCDR — International Commission for the Protection of Danube River
JRC — Joint Research Centre
MS — Member States
Mtce — Metric tonnes carbon equivalent
MW — Megawatt
NREAPs — National Renewable Energy Action Plans
PJ — Petajoule
PR — Renewable Energy Progress Reports
RES — Renewable energy sources
RES-E — Renewable energy sources in electricity sector
RES-H/C- Renewable energy sources in heating/cooling sector
RES-T — Renewable energy sources in transport sector
TWh- Terrawatt-hour(s)

AL — Albania
AT — Austria
BG — Bulgaria
BiH — Bosnia and Herzegovina
CZ — Czech Republic
DE — Germany
FYROM — the former Yugoslav Republic of Macedonia
HR — Croatia
HU — Hungary
ME — Montenegro
MD- Moldova
RS — Republic of Serbia
RO — Romania
SI — Slovenia
SK — Slovakia
UA — Ukraine

Units

General conversion factors for energy
1 Mtoe = 41.868 PJ = 11.63 TWh
1 ktoe = 41.868 TJ = 11.63 GWh
1 PJ = 0.278 TWh = 0.024 Mtoe
1 TWh = 3.6 PJ = 0.086 Mtoe
1 TJ = 277.8 MWh
1 Mtce = 0.677 Mtoe

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1. Short description of Danube River Basin

The Danube is obviously a uniquely 'political' river since it is shared by so many countries as no other river basin in the world (IPCDR, 2002).

Figure 1. Countries of the Danube River Basin [6]

According to IPCDR nineteen countries are sharing the river: Albania, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Italy, the former Yugoslav Republic of Macedonia, Moldova, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia, Switzerland and Ukraine. EU member States which are contracting parties of ICPDR are: Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Romania, Slovakia and Slovenia.

Energy production is one of the key challenges faced by the Danube Region. Most countries of the Danube Region have a large natural potential to develop energy from renewable sources, including bioenergy. Resources for bioenergy production come from at least three main sectors: agriculture, forestry and waste management and the evaluation of the overall potential is quite a complex issue involving at least technological, environmental and economic issues.

Energy prices, in relative terms, are high in the region also because fragmented markets lead to higher costs and reduced competition. Reliance on too few external suppliers for some resources, such as natural gas, increases vulnerability, as periodic winter crises testify.

A greater diversity of supply through interconnections and genuine regional markets is expected to increase energy security. Other issues, like improved efficiency, enhanced energy savings and a more central role for renewable sources, are crucial for further developing the regional energy system [7].

2. Renewable energy development in EU-DC's, 2005-2010

This study is based on data provided according the requirements of the Renewable Energy Directive 2009/28/EC (RED), information from the Danube Countries (EU and non-EU) NREAPs and corresponding EU Member States progress reports. The NREAPs and progress reports provide information on present and expected development of gross final energy consumption and total renewable energy used in 3 main sectors: electricity, heating and cooling and transport as well as the development of renewable energy technologies in each sector during period 2005-2020. Both NREAPs and the latest available progress reports have been already analysed in great detail by the JRC[8] providing a comprehensive picture of the current and expected deployment of renewable energies in the EU area.

This study aims to quantify the specific deployment of bioenergy only in 16 countries of Danube Region: 9 European Member States of the Danube Region which are contract parties of IPCDR: Austria, Bulgaria, Croatia , Czech Republic, Germany, Hungary, Romania, Slovak Republic and Slovenia. This study includes also seven countries of Danube Region part of Energy Community: Ukraine, Moldova, Serbia, Bosnia and Herzegovina, Albania, Montenegro and the former Yugoslav Republic of Macedonia (hereafter non-EU-DC).

Projections of the expected development of bioenergy in three main sectors and the availability of three main feedstock categories: agriculture, forestry and waste up to 2020 have been provided by the 16 Danube region countries[9].

According to Article 2 of RED, gross final energy consumption means the energy commodities delivered for energy purposes to industry, transport, households, services including public services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission. The same article also defines energy from renewable sources as energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases.

The NREAPs and bi-annual progress reports[10] provide information on gross final energy consumption and renewable energy development in EU-DC's for period 2005-2010: in 2005 the gross final energy consumption in EU-DC's amounted to 15336 PJ or 29.8 % of the gross final energy consumption in EU-28, while in 2010 it has reached 14909 PJ maintaining almost the same share (29.6 %) in EU-28 gross final energy consumption.

[8] Renewable Energy Progress in EU 27 (2005-2020)
http://iet.jrc.ec.europa.eu/remea/renewable-energy-progress-eu-27-2005-2020
Snapshots of renewable energy developments in the European Union. — Status in 2010 and progress in comparison with NREAPs.
http://iet.jrc.ec.europa.eu/remea/snapshots-renewable-energy-developments-european-union-status-2010-and-progress-comparison-national
Renewable Energy Development in EU 27 (2009-2010)
http://iet.jrc.ec.europa.eu/remea/renewable-energy-development-eu-27-2009-2010.

[9] According to the Directive requirements the bioenergy includes the biomass used in electricity and heating/cooling sectors and biofuels used in transport sector. Biomass used in electricity and heating/cooling sectors comprises three categories: solid biomass, biogas and bioliquids.

[10] CZ has submitted a limited data in its First Progress Report. For this reason it is assumed that CZ has reached exactly its 2010 plans in Gross Final Energy Consumption and renewable energy development as reported in the updated NREAP.

2.1 Renewable power capacity in EU-DC's

During the five year period, 2005-2010, one-third of total renewable energy installed capacity in EU 28 was established in EU-DC's. In 2010 the renewable energy capacity in EU-DC's reached 83933 MW with an average increase of 12.5% per annum.

Table 1 reports the development of renewable energy installed capacity in EU-DC's and EU 28 during period 2005-2010 for different technologies.

Table 1. Development of RES installed capacity in EU-DC in comparison with EU 28, 2005-2010

	2005(NREAPs)	**2010 (PR)**	**Growth**	
	MW	MW	MW	Annual (%)
Hydropower	26257	26192	-65	-0.05
Geothermal	1	11	10	163.3
Solar	2003	19365	17362	173.4
Wind	19151	29650	10499	11.0
Biomass	4255	8715	4460	21.0
EU-DC's RES capacity	51667	83933	32266	12.5
EU 28 RES capacity	169804	243371	73567	8.7

90% of renewable energy installed capacity in EU-DC's in 2005 was composed by hydropower and wind facilities. In 2010 this contribution decreased up to 66.5% due to a slight decrease in hydropower capacities and the large expansion of renewable technologies such as solar, biomass and geothermal.

In absolute terms, wind had the largest capacity installed in EU-DC's in 2010 with 29650 MW increasing with an average rate of 11% per annum during 2005-2010. Nevertheless its share in total renewable energy capacity decreased from 37.1% in 2005 to 35.3% in 2010. In 2010 solar technology increased nine-fold the installed capacity in comparison with 2005 reaching almost 1/5 (19365 MW) of total renewable energy capacity in EU-DC's. Biomass facilities doubled during period 2005-2010 with an 11% increase per annum in average. Geothermal technology also increased by a factor of 9 the installed capacity during the five years period, 2005-2010, reaching in 2010 the amount of 11 MW. Despite of this increase geothermal technology remained a marginal contributor in total renewable energy capacity in EU-DC's.

In 2005, more than 50% (27898 MW) of total was installed in Germany. During the five year period, 2005-2010, Germany doubled its renewable energy capacity and in 2010 two-third of total renewable energy capacity in EU-DC's was in Germany. Austria and Romania had the second and third place in total renewable energy capacity in EU-DC's. During 2005-2010 period their renewable energy capacity slightly increased but their share in 2010 renewable energy capacity in EU-DC's decreased respectively to 12.1% (18.6% in 2005) and 8.1% (12.2% in 2010).

2.2 Renewable energy production in EU-DC's

Total renewable energy production in EU-DC's showed a positive trend during the five year period, 2005-2010. In 2005 the total renewable energy generated in EU-DC's amounted to 1317.5 PJ i.e., 1/3 of total renewable energy in EU 28 (4181 PJ). In 2010 the total renewable

energy in EU-DC's reached 1980 PJ with an average annual growth rate of 10 %. Its contribution in total renewable energy in EU 28 in 2010 remained almost the same compared with 2005.

Table 2 reports the development of total renewable energy production in EU-DC's and EU 28 during the period 2005-2010.

Table 2. Development of total RES production in EU-DC in comparison with EU 28, 2005-2010

	2005(NREAPs)	**2010 (PR)**	**Growth**	
	PJ	PJ	PJ	Annual (%)
Hydropower	334.4	350.1	15.4	0.9
Geothermal	2.8	10.2	7.3	52
Solar	18.7	71.8	53.1	57
Wind	101.0	170.0	69.0	14
Biomass	766.6	1179.2	416.2	11
Heat pumps	11.6	26.5	15.3	26
Biofuels	82.4	172.6	88.5	21
EU-DC's Total RES	1317.5	1980.0	665	10
EU 28 Total RES	4181	6260.0	2079	10

Biomass has the main source of total renewable energy generated in EU-DC's during 2005-2010 period. In 2005 energy production from biomass (including both electricity and heat) in EU-DC's reached 766.6 PJ representing 58 % of total renewable energy in EU-DC's. In 2010 biomass remained still the main source of renewable energy in EU-DC's with 1179.2 PJ with a contribution that increased to nearly 60 % of total renewable energy in EU-DC's.

Hydropower had the second highest renewable energy production in EU-DC's during this five year period but its share decreased from 25.4 % (334.4 PJ) in 2005 to 17.6 % (350.1 PJ) in 2010. Wind was the third contributor to total renewable energy production in EU-DC's in 2005 with 101 PJ (7.7 % of share). In 2010 renewable energy produced from wind facilities in EU-DC's increased to 170 PJ contributing with 8.6 % to the total renewable energy in EU-DC's.

Solar and geothermal technologies experienced the highest relative increases during this period. Renewable energy from solar facilities, mainly photovoltaic, amounted in 2010 to 71.8 PJ increasing 4 time-folds compared to 2005 (18.7 PJ). Its contribution to the total RES in EU 28 increased from 1.4 % in 2005 to 3.6 % in 2010.

2.8 PJ of renewable energy was produced in 2005 from geothermal technology. During the five year period, 2005-2010, the renewable energy from this technology increased by 52 % per annum in average reaching 10.1 PJ in 2010. Despite this increase geothermal technology remained a marginal contributor (from 0.2 % in 2005 to 0.5 % in 2010) in total renewable energy production in EU-DC's.

The use of biofuels in transport doubled during the 2005-2010 period in EU-DC's reaching 172.6 PJ in 2010 compared to 82.4 PJ in 2005. Biofuels share in total renewable energy in EU-DC's increased from 6.3 % in 2005 to 8.7 % in 2010.

Heat pumps technology also more than doubled its renewable energy production during the 2005-2010 period reaching 26.5 PJ in 2010 compared to 11.6 PJ in 2005. Its share in total renewable energy in EU-DC's increased from 0.9 % in 2005 to 1.4 % in 2010 remaining still a marginal renewable energy source in EU-DC's.

Germany, Austria and Romania were the leading countries in total renewable energy production from year 2005 to 2010. Their share in total renewable energy production in EU-DC's has been above 80% for the whole period, where Germany contributed to almost half of this share with 625 PJ in 2005 and 1052.3 PJ in 2010. The additional renewable energy for Germany during this period covered almost 2/3 of additional renewable energy in EU-DC's. Nevertheless, the highest relative increase of renewable energy production in EU-DC's took place in Hungary (from 0.2 PJ in 2005 to 62.4 PJ in 2010) influenced by the very low starting level of renewable energy production in 2005.

3. Bioenergy development in EU-DC's, 2005-2010

3.1 Total bioenergy (bioelectricity, bioheat and transport biofuels)

According to the Article 2 of the Directive 2009/28/EC, biomass is 'the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste'. Using various transformation processes such as combustion, gasification, pyrolysis the biomass is either transformed into transport biofuels, bioheat or bioelectricity. The development of total bioenergy in EU-DC's during period 2005-2010 is presented in the following table.

Table 3. Development of total bioenergy in EU-DC, 2005-2010

	2005(NREAPs)	2010 (PR)	Growth	
	PJ	PJ	PJ	Annual (%)
Bioheat	702.8	1021.2	318.4	9.1
Bioelectricity	63.8	158	94.2	29.5
Biofuels	82.4	172.6	90.1	21.9
Total bioenergy	849	1351.7	502.7	11.8

NREAPs and bi-annual progress reports reported the deployment of bioenergy in three EU 28 markets: bioelectricity, bioheat and transport biofuels. During the five year period, 2005-2010, bioenergy played an important role in overall EU-DC's energy picture representing nearly 2/3 of total renewable energy used in EU-DC's.

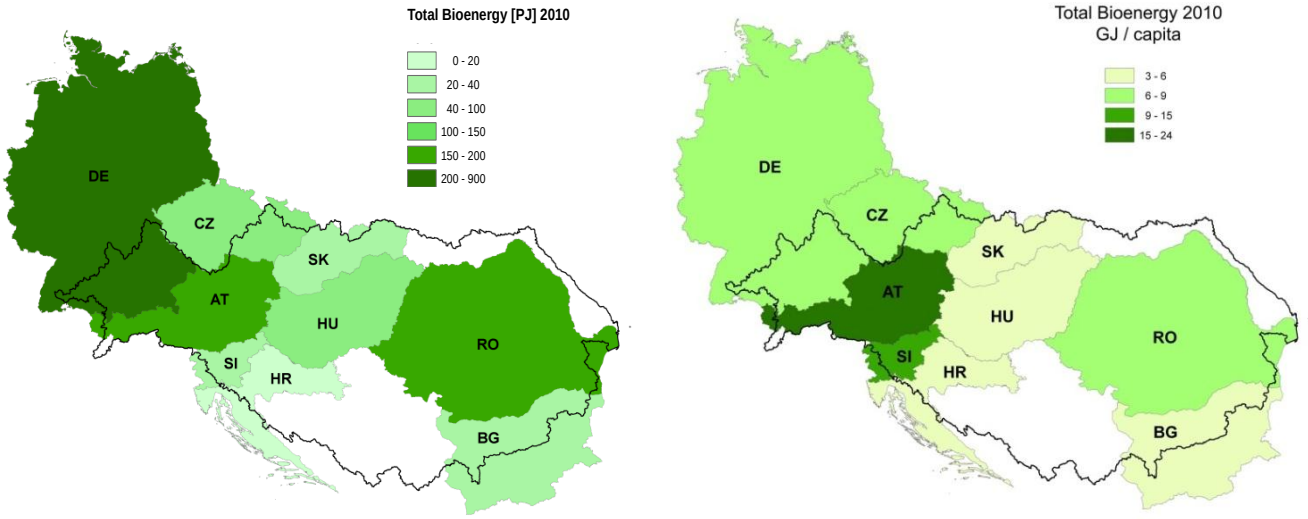

Figure 2. Development of total bioenergy in EU-DC's, 2010

With 849 PJ, bioenergy accounted in 2005 for nearly 5.5% of gross final energy consumption and two-third (64.4%) of total renewable energy in EU-DC's.

In the 2005-2010 energy production from bioenergy has shown an average annual increase of nearly 12% and in 2010 almost 9% of gross final energy consumption in EU-DC's was coming from bioenergy the share of which in the total renewable energy in EU-DC's was 68.2% (1351.7 PJ).

Due to the faster development of bioelectricity and bioheat markets in EU-DC's during the five year period, 2005-2010, compared with the NREAPs planned development, bioenergy production already reached in 2010 the expected level of year 2015 (1352.5 PJ).

Germany, Austria and Romania have been the bioenergy leading EU-DC's during period 2005-2010 accounting for almost 80% of bioenergy in EU-DC. In 2005 bioenergy deployment in Germany represented half of total bioenergy in EU-DC's with 434.8 PJ. In 2010 the contribution of Germany in total bioenergy in EU-DC increased to 54% reaching 731.7 PJ with an increase of 13.7% per annum in average.

During the 2005-2010 time span, bioenergy in Austria has shown an average annual increase of 8.2%, reaching in 2010 the amount of 195.8 PJ compared to 139 PJ in year 2005. Bioenergy in Romania increased by 5% per annum in average during 2005-2010 period reaching 165.7 PJ in 2010 compared to 132.6 PJ in 2005. Bioenergy in EU-DC deployed very fast in Hungary during this five year period due to the fast development in bioelectricity and bioheat markets compared with low level of year 2005.

Among EU-DC's Austria has the highest bioenergy consumption per inhabitants: 16.9 GJ/capita in 2005 and 23.4 GJ/capita in 2010 followed by Slovenia: 9.5 GJ/capita in 2005 and 13.8 GJ/capita in 2010. The consumption of total bioenergy in other EU-DC's during period 2005-2010 was found below 10 GJ/capita.

3.2 Bioelectricity and Bioheat

Biomass originates from forest (logs, bark, wood chips, sawdust, pellets etc.) agriculture (rape, wheat, maize etc.) and waste streams (municipal solid waste, post consumption wood waste, refuse-derived fuels, sewage sludge, etc.), and could involve virtually any kind of organic material. Each biomass resource has different characteristics in terms of calorific value, moisture, ash content, etc. that require appropriate conversion technologies for bio-energy production [32].

Modern biomass energy is expected to gain share in the future energy market, because the production and conversion costs of biomass energy are expected to be reduced, the resources are widely available in several countries and because of the expected increase in the demand for CO_2 neutral fuels [16].

Table 4. Development of bioelectricity and bioheat in EU-DC, 2005-2010

	2005(NREAPs)	**2010 (PR)**	**Growth**	
	PJ	PJ	PJ	Annual (%)
Solid biomass	595.2	1014.5	419.3	14.1
Biogas	22.7	122.7	100.1	88.3
Bioliquids	16.2	41.8	25.6	31.6
Bioelectricity + Bioheat	766.6[11]	1179.2	412.4	10.8

In 2005 bioelectricity and bioheat production in EU-DC's accounted for 766.6 PJ (almost 90% of total bioenergy in EU-DC's) and in this year around 31% of total biomass for electricity and heat production in EU 28 was used in EU-DC's.

[11] Romania reported in the NREAP only the total biomass used in heating/cooling sector for year 2005 (132.6 PJ). As no division in subcategories was reported, this number has been added to the last line value for 2005 only.

The production of bioelectricity and bioheat in EU-DC's increased by more than one half in the 2005-2010 period reaching 1179.2 PJ and showing an average per annum increase of 10.8% . Nevertheless, the development of biofuels market in the same period period in EU-DC's was two times faster than the development of bioelectricity and bioheat, thus decreasing the 2010 share of biomass originated energy in total bioenergy up to 87.4%. In 2010 almost one-third of biomass used for electricity and heat production in EU 28 was originated in EU-DC's.

In 2010 solid biomass provided the highest share (86%) in biomass used for electricity and heat production in EU-DC's with 1014.5 PJ, increasing by 14% per annum in average compared to 2005.

The use of biogas in EU-DC's had a fast development during 2005-2010 period showing an average annual growth rate equal to 88.3%, reaching in 2010 the amount of 122.7 PJ and more than tripling its share in the total biomass used in EU-DC's (3% in 2005 and 10.4% in 2010). As a result, the additional electricity and heat produced by biogas in 2010 in EU-DC in comparison with 2005 was nearly 5 times higher than electricity and heat produced from this biomass category in 2005.

Bioliquids[12] also experienced an important development during the 2005-2010 period with an average annual increase by 31.6% and reaching in 2010 the amount of 41.8 PJ. Despite of this fast increase the energy produced by this biomass category still remained a marginal contributor in total energy from biomass in EU-DC's (2.1% in 2005 and 3.5% in 2010).

Leading country among EU-DC's in biomass used for energy during period 2005-2010 was Germany with 354.5 PJ (46.2% of total biomass used for energy in EU-DC) in 2005 and 604 PJ (51%) in 2010. Romania and Austria followed with a contribution that decreased in relative terms from 17% in 2005 to 14% in 2010 but increased in absolute quantities. Contribution of these three countries during period 2005-2010 accounted for 80% of total biomass used for bioheat and bioelectricity in EU-DC. Biomass for bioheat and bioelectricity has shown the largest development in Germany and Slovak Republic during period 2005-2010 with an annual average increase respectively equal to 14% (+70.4 PJ in the five years) and 13% (65.6 PJ in the five years).

3.2.1 Bioelectricity

3.2.1.1 Bioelectricity capacity

Biomass generated electricity provided a relatively small contribution in total renewable electricity capacity in EU-DC's. In 2005 the biomass drove capacity in electricity sector in EU-DC's amounted to 4255 MW contributing with only 8.2% in total renewable energy capacity in EU-DC's. In 2010 the biomass plants capacity for electricity purposes increased 2 times, reaching 8713 MW, resulting in a 10.4% contribution to the total renewable energy capacity in EU-DC's.

[12] Article 2 of Directive 29/28/EC defines bioliquids as liquid fuel for energy purposes other than for transport, including electricity and heating and cooling, produced from biomass.

Solid biomass represented almost 80% of bioelectricity capacity in 2005 with 3383 MW and increased in 2010 up to 5050 MW, but its share in total bioelectricity capacity in EU-DC's decreased up to 58%.

In 2010 biogas facilities used for electricity production increased 4 times their capacities (3066 MW) compared with 2005 (806 MW), doubling the share in total bioelectricity capacity in EU-DC's (from 19% in 2005 to 35% in 2010).

Table 5. Development of biomass electricity capacity in EU-DC's, 2005-2010

	2005(NREAPs)	**2010 (PR)**	**Growth**	
	MW	MW	MW	Annual (%)
Solid biomass	3383	5050	1667	9.9
Biogas	806	3066	2260	56.1
Bioliquids	66	604	538	163
Bioelectricity	4255	8715	4460	21

A very large expansion took also place in bioliquids electricity capacity: bioliquids plants capacity increased nine time-folds, from 66 MW in 2005 to 604 MW in 2010. The contribution of bioliquids plants capacity in total bioelectricity capacity in EU-DC's increased from 1.6% in 2005 to 6.9% in 2010.

3.2.1.2 Bioelectricity production

Almost 22% gross final energy consumption in EU-DC's in 2005-2010 consisted of gross electricity consumption (3352.5 PJ in 2005 and 3402 PJ in 2010). The share of renewable electricity in the gross electricity consumed during this period in EU-DC's increased from 15% (140 TWh or 504 PJ) in 2005 to 21.2% (200.8 TWh or 723 PJ) in 2010.

Among renewable electricity, bioelectricity produced in EU-DC's during period 2005-2010 increased by 29.5% per annum on average and reached 43881 GWh in 2010 to be compared with 17726 GWh in 2005. The share of bioelectricity to gross electricity consumption in EU-DC's increased from 7.5% in 2005 to 11.7% in 2010.

Table 6. Development of biomass electricity in EU-DC's, 2005-2010

	2005(NREAPs)	**2010 (PR)**	**Growth**	
	GWh	GWh	GWh	Annual (%)
Solid biomass	13231	23175	9945	15.0
Biogas	4133	17774	13641	66.0
Bioliquids	362	2932	2570	142
Bioelectricity	17726	43881	26156	29.5

Solid biomass was the main resource for bioelectricity production in EU-DC's all along the 2005-2010 period. In 2005 almost 77% (13231 GWh) of bioelectricity in EU-DC's was originated from solid biomass while in 2010 this contribution decreased up to 52.8% despite the increase in absolute contribution (23175 GWh).

Biogas plants produced in 2010 4 times more bioelectricity (17774 GWh) than in 2005 (4133 GWh) almost doubling their share in total bioelectricity in EU-DC's (from 23.3% in 2005 to 40.5% in 2010).

The fastest development during period 2005-2010 in renewable electricity production was experienced in bioliquids. In 2010 the renewable electricity produced from bioliquids amounted to 2932 GWh, increasing 8 time-folds from 2005 level. The additional bioelectricity produced from bioliquids in 2010 in EU-DC's was 7 times the 2005 bioelectricity produced from this biomass category, increasing its share in total bioelectricity in EU-DC's up to 6.7%.

The leading country among EU-DC's in bioelectricity market during period 2005-2010 was Germany with a contribution that stayed above 75% (14025 GWh in 2005 and 33900 GWh in 2010). Austria followed with 2823 GWh (16% of contribution) in 2005 and 4555 GWh (10.4% of contribution) in 2010. During this period bioelectricity developed very fast in Slovak Republic increasing 21 time-folds in 2010 (668 GWh) compared to 2005 (32 GWh) even that the contribution in total bioelectricity market in EU-DC's remained low (1.5%).

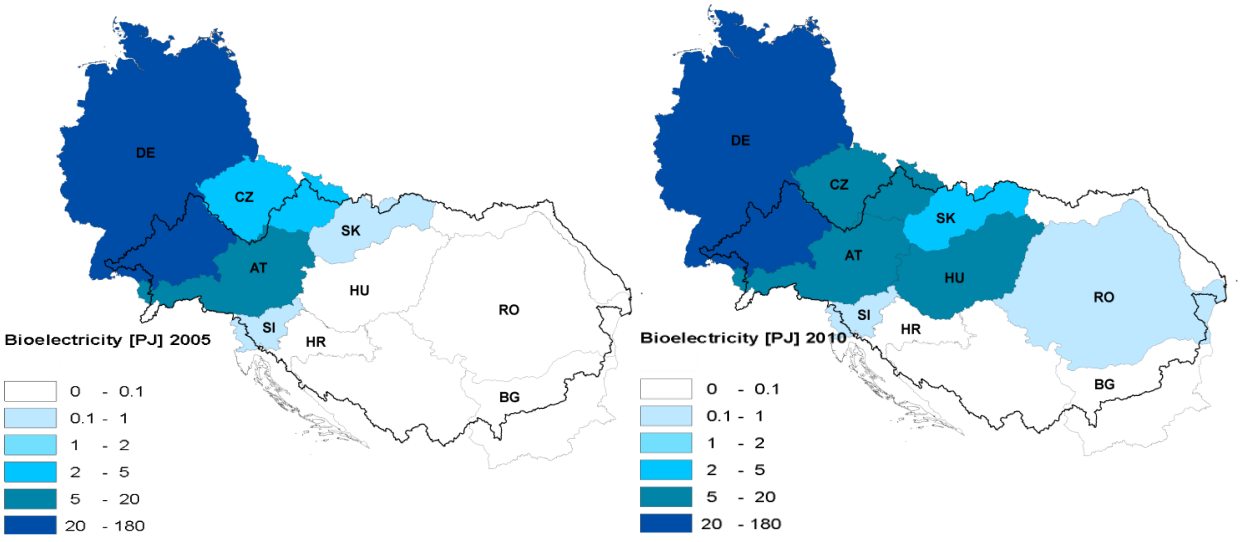

Figure 3. Development of biomass electricity in EU-DC's, 2005-2010

In capita terms Austria had the highest consumption of biomass in electricity sector per inhabitants, 1.96 GJ/capita, together with Germany, 1.49 GJ/capita. The other EU-DC's had biomass consumption in electricity sector per inhabitants less than 1 GJ/capita.

3.2.2 Biomass for heating/cooling

In 2005 almost 53% (8158.3 PJ) of gross final energy consumed in EU-DC's was employed for generating heat or cool either in domestic and industrial use. In 2010 this share slightly decreased to 52% reaching 7762 PJ. Table 7 reports the development of biomass in heating and cooling sector during period 2005-2010.

Contribution of biomass in heating/cooling sector in EU-DC's was dominant in bioenergy development in EU-DC's during period 2005-2010. In 2005 the heat produced by biomass amounted to 702.8 PJ representing 82.8% of total bioenergy and 91.7% of total biomass used in EU-DC's.

Heat produced from biomass in EU-DC's increased by a 9.2% per annum in average during the 2005-2010period, reaching in 2010 the amount of 1024.8 PJ. The additional heat produced from biomass in EU-DC's was almost half of 2005 level (+322 PJ). Despite of this, the heat produced

from biomass in 2010 in EU-DC's was not enough to maintain at the same level the above mentioned shares which decreased respectively to 75.7 % and 86.6 %.

Table 7. Usage of biomass for heating and cooling in EU-DC's, 2005-2010

	2005(NREAPs)	2010 (PR)	Growth	
	PJ	PJ	PJ	Annual
Solid biomass	547.5	931.1	387.1	14.1
Biogas	7.8	58.8	51.1	131.2
Bioliquids	14.9	31.2	16.3	21.9
Bioheat	**702.8**[13]	**1021.1**	**322**	**9.2**

In 2005 solid biomass in EU-DC's was the main type of biomass for heating and cooling production with 547.5 PJ (~78 % of contribution). In 2010 heat/cool produced from solid biomass amounted to 934.7 PJ or 91 % of total heat/cool produced from biomass in EU-DC's.

Biogas in EU-DC was a very marginal contributor for heating/cooling sector in year 2005 reaching only 7.8 PJ (1.1 %). Heat produced from biogas increased considerably during 2005-2010 period with a 131.2 % average per annum rate reaching in 2010 the amount of 58.9 PJ. Despite such an increase the overall contribution of biogas in total heat produced from biomass in EU-DC's remained low, only 5.7 %.

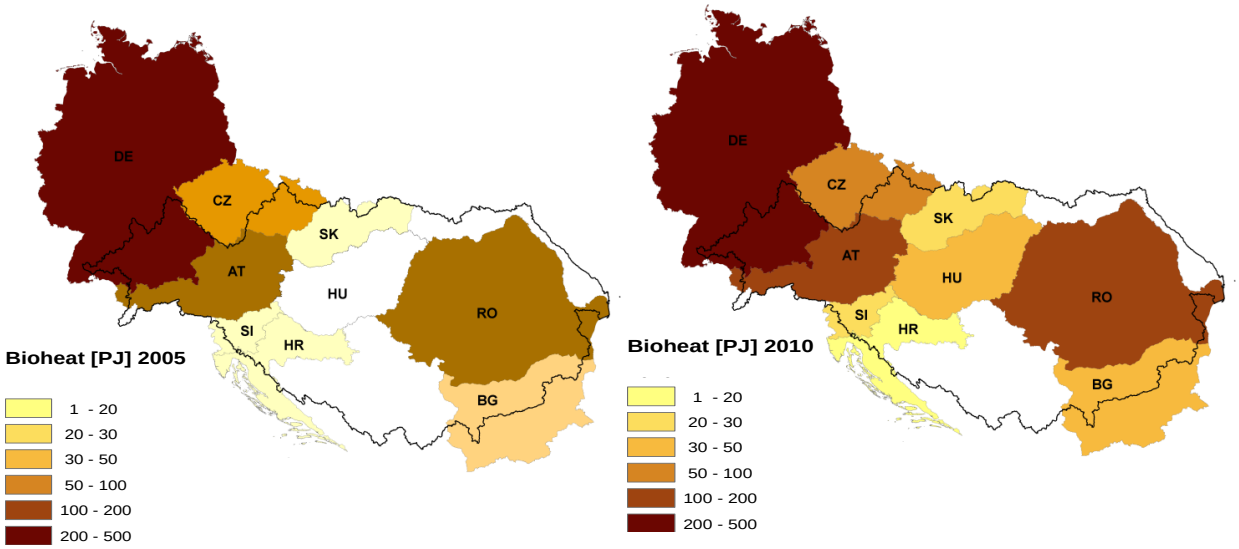

Figure 4. Development of biomass for heating/cooling in EU-DC's, 2005-2010

Bioliquids doubled their contribution in heating and cooling increasing from 14.9 PJ in 2005 to 31.2 PJ in 2010. Nevertheless bioliquids share in biomass used for heating and cooling just slightly increased from 2 % in 2005 to 3 % in 2010.

About uses of bioheat, biomass in heating/cooling sector in EU-DC's is used mainly in domestic sector (households) for heating or, more rarely, for cooling. Households in 2005 accounted for 75.6 % (531.2 PJ) of bioheat use. During the 2005-2010 period biomass used in domestic sector

[13] Romania reported only the total value of biomass used in heating/cooling sector (132.6 PJ) for year 2005 without dividing it in biomass categories.

in EU-DC's increased up to 619.1PJ, but its fraction in the overall bioheat market decreased up to 60.6%.

Table 8. Use of bioheat in EU-DC's, 2005-2010

	2005(NREAPs)	2010 (PR)	Growth	
	PJ	PJ	PJ	Annual
District heating	19.8	43.2	22.4	22.6
Bioheat in households	531.2	619.1	89.7	3.4

Bioheat employed in district heating of residential and commercial areas represented a small share in total bioheat market during period 2005-2010 in EU-DC's. This share increased slightly, from 2.7% (19.8 PJ) in 2005 to 4.0% (43.2 PJ) in 2010 with 22.6% per annum in average.

Germany was the leading EU-DC in bioheat market during period 2005-2010. Its contribution in this market in 2010 rose up to 47% with 482 PJ compared to 43.3% (304 PJ) in 2005. Romania and Austria followed with an increase in absolute contribution in bioheat market in EU-DC's but their share decreased from ~18% in 2005 to ~16% in 2010. The average annual increase of bioheat market in other EU-DC's during the five year period 2005-2010 was ranging from ~5% to 10%.

Austria and Slovenia consumed the highest biomass amount per inhabitant in heating/cooling sector in year 2010: 18.3 GJ/capita and 12.3 GJ/capita respectively. Romania, Czech Republic and Germany followed with 7.7 GJ/capita, 7.3 GJ/capita and 5.9 GJ/capita.

3.2.3 Biofuels in transport

Biofuels produced sustainably[14] and under efficient processes, are a low-carbon alternative to fossil fuels in the EU's energy mix and for transport in particular. Biofuels are easy to store and deploy, have a high energy density and typically emit substantially less greenhouse gases than oil, gas or coal [12]. Current trends in this regard focus on the stimulation of the development of alternative, so-called second generation biofuels from non-food feedstock, like waste or straw, which should emit substantially less greenhouse gases than fossil fuels and do not directly interfere with global food production.

Table 9 reports the development of the amount transport biofuels used in EU-DC's during period 2005-2010.

Table 9. Development of biofuels in EU-DC, 2005-2010

	2005	2010	Growth	
	PJ	PJ	PJ	Annual %
Bioethanol	6.2	39.7	33.5	107.4
Biodiesel	68.5	125.2	56.7	16.5
Other biofuels	7.7	7.66	-0.04	-0.1
Total biofuels	82.4	172.6[15]	90.1	21.5

[14] Sustainability criteria laid down under Article 17-19 of Directive 2009/28/EC.

[15] Due to sustainability criteria Romania and Slovenia didn't report on biofuels in their first bi –annual Progress Reports.

With 3457 PJ in 2005 and 3439 PJ in 2010 EU-DC's energy consumption in transport sector made nearly 23% of overall gross final energy consumed in EU-DC's and almost 7% of gross final energy consumed in the whole EU 28.

The final use of biofuels in transport sector in EU-DC's doubled during the 2005-2010 period from 82.4 PJ in 2005 to 172.6 PJ in 2010 increasing the share in gross final energy consumption in this sector from 2.3% in 2005 to 5% in 2010.

In relative terms, 9.7% of total bioenergy and almost 2/3 of biofuels used in transport sector in EU 28 came from EU-DC's transport biofuels in 2005. In 2010 the use of transport biofuels in EU-DC's accounted for a 12.6% share of total bioenergy in EU-DC's, but for only 30.6% of total biofuels used in EU 28.

Biodiesel was the most popular biofuel in EU-DC's in 2005-2010. In 2010, use of biodiesel doubled, from 68.5 PJ (83% of total biofuels) in 2005 to 125.2 PJ (73.5% of total biofuels) in 2010, increasing by 16.5% per annum on average.

Bioethanol and other biofuels in EU-DC's amounted in 2005 respectively to 6.2 PJ (7.5% of total biofuels) and 7.7 PJ (9.3% of total biofuels). In 2010 bioethanol use in EU-DC's increased 6 time-folds compared with year 2005 reaching nearly 40 PJ or 23% of biofuels used in EU-DC's in this year. While the use of other biofuels (biogas, vegetable oil etc.) remained almost constant during the 2005-2010 period, with 7.7 PJ its share in total biofuels used in EU-DC's decreased 2 time-folds, from 9.3% in 2005 to 4.4% in 2010.

Imported biofuels[16] in 2005 accounted for only 2% (1.7 PJ) of total biofuels used in EU-DC's. In 2010 imported biofuels increased five time-folds their contribution in total biofuels used in EU-DC, amounting to 18.5 PJ (10.8% of total biofuels). No use in EU-DC's of biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material (biofuels defined in Article 21.2 of the Directive 2009/28/EC) was reported for period 2005-2010.

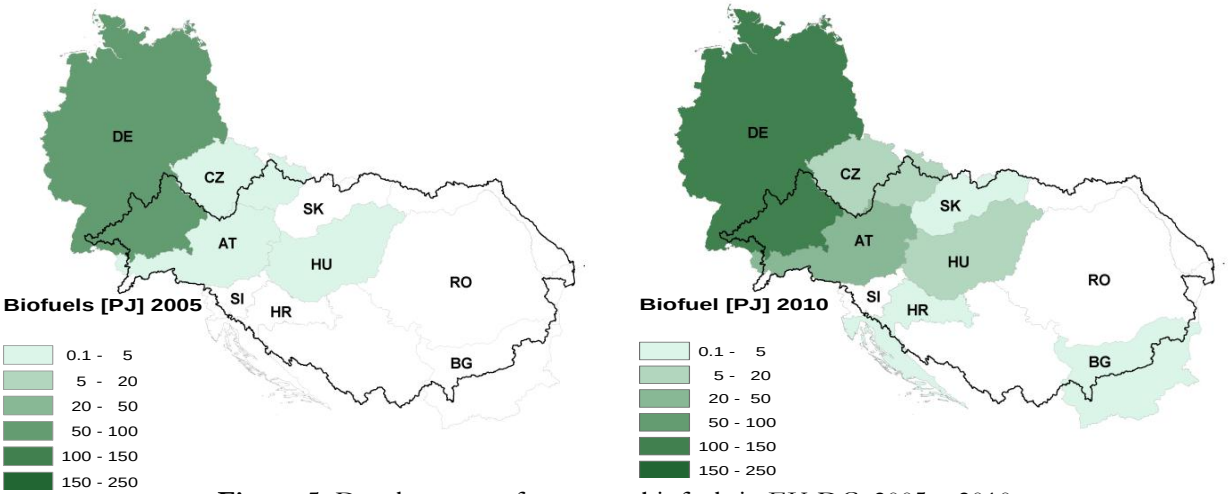

Figure 5. Development of transport biofuels in EU-DC, 2005 – 2010

[16] In their NREAPs and Progress Reports MS didn't provide information regarding the origin of imported biofuels.

97% of EU-DC total biofuels in 2005 was consumed in Germany mainly composed by biodiesel (97.7%). In 2010 Germany remained the larger consumer of biofuels in transport sector but its contribution decreased to 75% due to the very fast increase of biofuels in other EU-DC's. During period 2005-2010 biofuels used in transport sector in EU-DC's show a very fast increase in Czech Republic with 77 time-folds, from 0.1 PJ to 9.8 PJ. Hungary also increased the use of biofuels from 0.2 PJ to 7.4 PJ (35 time-folds) during this period. Biofuels experienced a considerable increase in Austria from 1.8 PJ to 21.7 PJ (12 time-folds).

In 2010 the biofuels in transport sector in capita terms founded the highest use in Austria with 2.6 GJ/capita followed by Germany with 1.6 GJ/capita and Slovenia with 1 GJ/capita. At the rest of EU-DC's the use of biofuels in this year was found below the 1 GJ/capita.

4. Biomass availability in EU-DC, 2009-2010[17]

The progress Reports provide quite a detailed estimate of both domestic and imported biomass resources the EU countries are counting on in order to meet the renewable energy targets. The reports include the estimation of both direct and indirect biomass supply from wood forests and other wooded land for energy generation, from agriculture crops and fishery products and biomass from waste (industrial, municipal and sewage sludge).. Unfortunately, the estimates of the raw biomass are based on differing assumptions on conversion efficiency and are provided in non-homogeneous units, hampering the direct use of data. Nevertheless, progress reports also provide data in PJ of gross final energy generated that can be more easily compared: Table 10 reports the development of biomass supplied in EU-DC's for energy purposes during period 2009-2010. No data were reported in NREAPs on the base year 2005.

According to EU-DC's bi-annual progress reports in 2009 the total supply of biomass amounted to 1136.2 PJ mainly domestically originated (95.5% in contribution). Forestry (directly from fuel wood or forest residues, or indirectly from industry by-products such as sawdust and black liquor) was the main feedstock category in total biomass supply in EU-DC's with 816.8 PJ (72% in contribution).

Agricultural (by-products/processed residues and energy crops) was the second source of biomass supply in EU-DC's in 2009 with 259.6 PJ (23% in contribution).

The rest mostly consisted in waste (municipal, industrial and sewage) which in 2009 amounted to 43.6 PJ (less than 4% in contribution).

In 2009 energy crops and short rotation forestry supplied for heating and electricity in EU-DC's accounted for 0.46 PJ (0.04% in contribution).

Table 10. Development of primary energy production from biomass in EU-DC, 2009-2010

	Domestic		**Imported from EU**		**Imported from non EU**		**Total**	
	2009	2010	2009	2010	2009	2010	2009	2010
	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Biomass for heating and electricity	1081[18]	1099.1	47.5	53.4	3.8	5.2	1132.3	1157.7
Forestry	765.5	782.4	47.5	53.4	3.8	5.2	816.8	841.0
Agriculture	259.6	259.6	0.0	0.0	0.0	0.0	259.6	259.6
Waste	43.6	43.6	0.0	0.0	0.0	0.0	43.6	43.6
Energy crops & short rotation trees	0.46	0.51	0.0	0.0	0.0	0.0	0.46	0.51
Other	0.38	0.38	0.0	0.0	0.0	0.0	0.38	0.38
Biomass for transport	3.8	4.0	0.0	0.0	0.0	0.0	3.8	4.0
Total biomass supply	1085	1103	47.5	53.4	3.8	5.2	1136.2	1161.8

The overall increase of total biomass supply for energy purposes in EU-DC's during 2009-2010 amounted to 2%, mainly in forestry. In 2010 the supply from agriculture and waste in EU-DC's remained almost the same as in year 2009.

[17] Only two MS (BG and SK) reported on biomass supply for transport in years 2009 and 2010. Due to this the data in Table 10 for this category are not comparable with the respective data presented in Table 8 of this report.
[18] For year 2009 Slovenia reported only the total primary energy from biomass used in heating and cooling sector (11.5 PJ). No division in feedstock categories was reported.

In 2010 forestry in EU-DC's had an additional supply of 24.2 PJ from year 2009. It reached 841 PJ maintaining the almost 2009 contribution in total biomass supply in EU-DC's. The contribution of forestry in domestic biomass supply in EU-DC's was originated in almost equal parts from direct (396.2 PJ or 50.6 % in contribution) and indirect supply of wood biomass (386.2 PJ or 49.4 % in contribution). Biomass for heating and electricity reached 1157.7 PJ in 2010 maintaining the same contribution in total biomass supply as in 2009.

According to bi-annual progress reports the land used in EU-DC's exclusively for energy purposes (common arable crops, oilseeds, short rotation trees and other energy crops) during period 2009-2010 amounted around 6 million hectares.

Biomass imports in EU-DC's during period 2009-2010 were very low, mostly happening in wood biomass from forests. Biomass was imported mainly from EU countries (more than 90 %) In 2009, EU-DC's imported between them 47.6 PJ (4.2 % in contribution) biomass supply in EU-DC's. In 2010 the imported biomass supplied between EU-DC's increased slightly to 53.8 PJ (4.6 % in contribution).

Germany was during 2009-2010 time span the leading country among EU-DC's in biomass supply for energy purposes with 700 PJ (64 % of total biomass supply in EU-DC's) almost totally domestically originated. Austria and Romania covered both 26 % of total biomass supply in this period, used totally in heating and electricity sectors. In Austria the imported biomass supply during 2009-2010 reached the highest level among EU-DC's, 48.1 PJ or 27.8 % of total biomass supplied for energy purposes by this country.

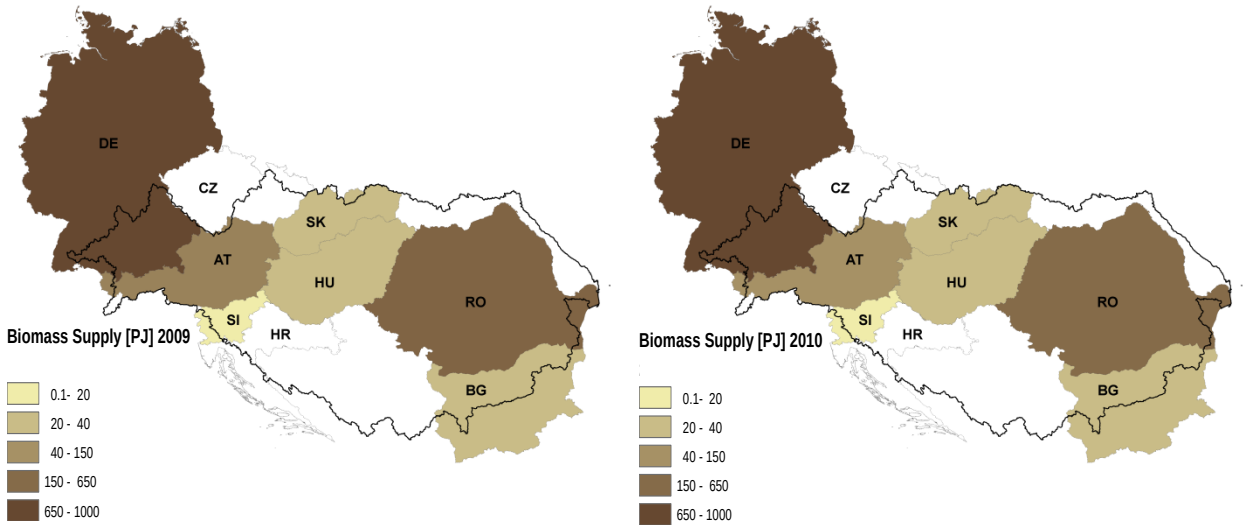

Figure 6. Development of biomass supply in EU-DC's, 2005-2010

The highest supply of biomass per capita in 2010 was found for Austria: 20.7 GJ/capita. Germany had a supply for capita in this year equal to 8.6 GJ/capita followed by Romania with 7.8 GJ/capita, Slovakia with 6.5 GJ/capita, Slovenia with 6.2 GJ/capita, Bulgaria with 5.2 GJ/capita and Hungary with 3.4 GJ/capita.

5. Expected development of renewable energy and bioenergy in EU-DC's

5.1 Energy consumption and renewable energy in EU-DC's

According to NREAPs, in order to be in good track with 2020 target in gross final energy consumption of 14295 PJ (calculated as sum of each EU-DC's 2020 target), the EU-DC's are expected to decrease by 4.4% per annum in average their gross final energy consumption during 2010-2020 time span. All European countries are expected to follow a similar path and the contribution of EU-DC's gross final energy consumption in EU 28 gross final energy consumption is expected to decrease slightly from 29.6% in 2010 to 28.8% in 2020.

5.1.1 Renewable energy capacity

Renewable energy capacity in EU-DC's is expected to reach 154204 MW in 2020 increasing by 8.5% per annum in average during 2010-2020 period. Nevertheless the share of EU 28 renewable energy capacity installed in EU-DC's is expected to decrease to 32.3% compared with 34.5% in 2010. Additional renewable energy capacity to be installed in 2010-2020 decade EU-DC's is nevertheless expected to be more than 2 times larger (+70271 MW) than the additional renewable energy capacity installed in the 2005-2010 period (+32211 MW).

In 2020 wind technology is expected to be the main component of renewable energy capacity in EU-DC's with 55947 MW (36.3% in contribution) with an increase of 8.9% per annum in average from year 2010.

Solar technology is expected to be in 2020 the second contributor in total renewable energy capacity in EU-DC's reaching 55310 MW (35.9% in contribution) increasing with 18.6% per annum in average from year 2010.

Hydropower capacity is expected to pass in the third place in total renewable energy capacity in EU-DC's in 2020 amounting to 30245 MW (20% in contribution) increasing by 1.5% per annum in average from 2010.

Biomass is expected to reach in 2020 the capacity of 12328 MW (8.0% in contribution) increasing annually with 4.1% from year 2010. The fastest development in total renewable energy capacity in EU-DC's is expected by geothermal technology reaching 374 MW (0.2% in contribution) in 2020 from 11 MW (0.01% in contribution) in 2010.

5.1.2 Renewable energy production

Renewable energy production in EU-DC's during period 2010-2020 is expected to follow the increasing trend of total renewable energy capacity. In 2020 it is expected that EU-DC's will contribute with 2873.1 PJ (68.6 Mtoe) in total renewable energy in EU 28 increasing annually with 4.5% from year 2010. During period 2010-2020 the development of renewable energy production in EU-DC's is expected to be slower than the development of renewable energy production in EU 28 dropping thus the share from 31.6% in 2010 to 28.1% in 2020.

Renewable energy produced from biomass in EU-DC's in 2020 is expected to be the main component in total renewable energy production in EU-DC's with 1303 PJ (45.4% in renewable energy share) and 1.0% increase per annum in average from year 2010.

Wind is expected to be the second contributor in total renewable energy production in EU-DC's during 2010-2020 reaching an energy production of 448.0 PJ (15.6% in renewable energy share) in 2020 increasing by 16.4% per annum in average from year 2010.

Hydropower is expected to occupy the third place in total renewable energy production in EU-DC's contributing with 380.7 PJ (13.3% in renewable energy share) with an increase of 0.9% per annum in average from 2010.

The use of biofuels in EU-DC's in 2020 is expected to amount to 358 PJ (12.5% in renewable energy production share) increasing annually by 10.7%.

Solar technology, compared with year 2010, is expected to produce more than 3 times renewable energy in EU-DC's reaching 241.8 PJ (8.4% in renewable energy share) in 2020 increasing annually with 23.7%.

In 2020 renewable energy in EU-DC's from heat pumps will increase 3 times from year 2010, reaching 78.8 PJ (2.7% in renewable energy share) with a growth rate of 19.7% per annum in average.
Geothermal technology in EU-DC's is expected to have a significant growth in 2020 with an increase of 51.8% per annum in average from year 2010 but still remaining a marginal contributor in total renewable energy production. In 2020 the renewable energy produced by this technology is expected to reach 62.8 PJ (2.2% in contribution) from 10.2 PJ (0.5% in contribution) in 2010.

5.2 Expected bioenergy development in EU-DC's

Bioenergy (bioelectricity, bioheat and transport biofuels) in EU-DC's developed during 2005-2010 faster than planned in NREAPs. In order to be in good track with 2020 NREAPs targets bioenergy has to just increase moderately in EU-DC's during 2010-2020 time span compared with the fastest increase that took place in 2005-2010

Figure 7 presents the growth of bioenergy (bioelectricity, bioheat and transport biofuels) in EU-DC's in the period 2005-2010 period (left) compared with the growth still needed in 2010-2020 (right) in order to reach the 2020 NREAPs forecasted figures.

Bioenergy as a whole is expected to reach in 2020 the amount of 1661 PJ with an average per annum increase of 2.3%. Nevertheless in 2020 the contribution of bioenergy in total renewable energy production in EU-DC's and in EU 28 is expected to decrease respectively up to 57.8% and 16.2%.

The additional renewable energy produced from other renewable technologies in EU-DC's during period 2010-2020 is expected to be almost 2.0 times higher (+583.7 PJ) than the additional renewable energy produced from bioenergy (+309 PJ). In 2005-2010 time span the additional renewable energy from bioenergy was 3 times larger (+502.7 PJ) than additional renewable energy from other renewable technologies (+160 PJ).

In 2020 bioheat and bioelectricity markets are expected to cover nearly 80% of total bioenergy in EU-DC's with 1303 PJ.

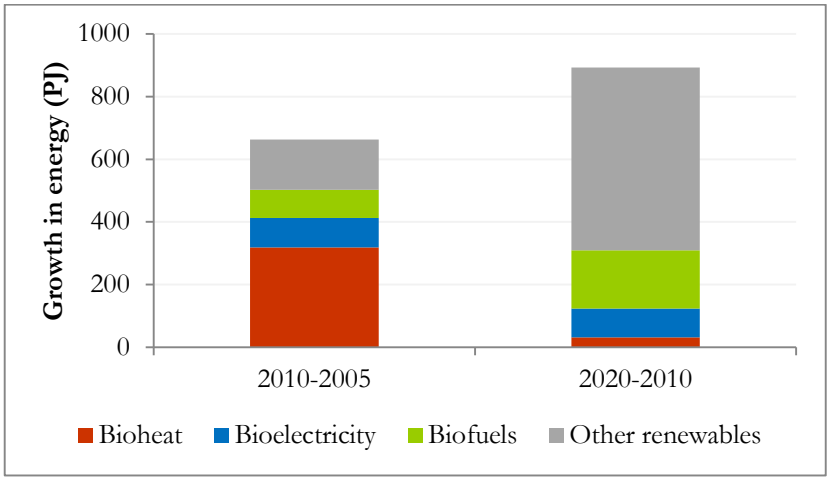

Figure 7. Growth of renewable energy in EU-DC's, 2005-2020

The main development in 2020 bioenergy in EU-DC's will be expected in biofuels use for transport while during period 2005-2010 the main development took place in bioheat market.

Bioheat market is expected to develop very slowly during period 2010-2020 with an additional heat production of almost 10 times lower (+32.4 PJ) compared with additional bioheat put in place in the 2005-2010 period (+318.4 PJ).

Bioelectricity expansion will account nearly for the same additional renewable energy during period 2010-2020 (+91.4 PJ) than the additional bioelectricity deployed in the 2005-2010 period (+94.2 PJ). The use of biofuels is expected to increase in 2010-2020 period 2 times (+185.4 PJ) the expansion that took place in the 2005-2010 period (+90.1 PJ).

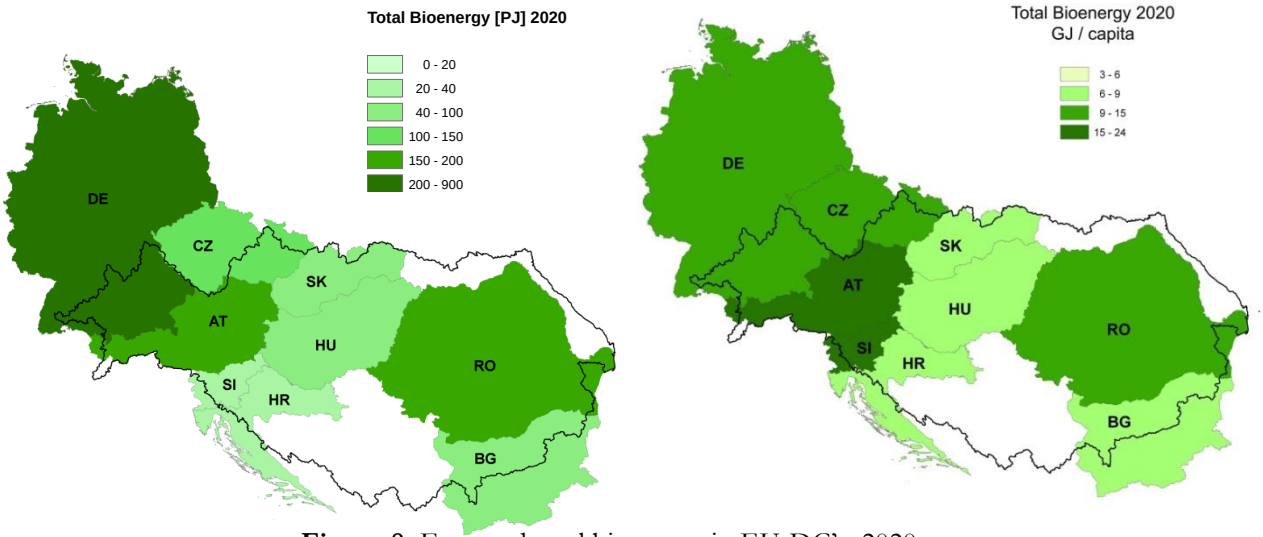

Figure 8. Expected total bioenergy in EU-DC's, 2020

Except Austria, all EU-DC's are expected to increase their total bioenergy during period 2010-2020. This increase is expected to be moderate due to the fact that the expected 2015 plan in total bioenergy was already overcome from the main contributing countries in EU-DC's since in year 2010.

Germany will remain the leading country in total bioenergy in 2020 contributing with 882.6 PJ, more than half of total bioenergy in EU-DC's. Together with Austria (194 PJ), Romania (193.6 PJ) and Czech Republic (143 PJ) it will cover nearly 85% of total bioenergy expected in EU-DC's in 2020. Contribution of other EU-DC's will remain marginal in the development of total bioenergy during period 2010-2020 (Figure 8).

In per capita terms the bioenergy consumption in year 2020[19] is expected to increase almost in all EU-DC's except Austria due to the fact that in 2010 this country has reached its NREAP 2020 target in total bioenergy consumption. Nevertheless Austria will still have the highest bioenergy consumption per inhabitants with 22.3 GJ/capita. Slovenia is expected to have the second highest value in total bioenergy use in per capita terms with 15.5 GJ/capita followed by Czech Republic with 13.1 GJ/capita, Germany with 10.8 GJ/capita, Romania with 9.1 GJ/capita, Bulgaria and Hungary with 8.8 GJ/capita each, Slovakia with 7.9 GJ/capita and Croatia with 6 GJ/capita.

5.3 Expected development of bioelectricity and bioheat markets

In 2020 biomass used for electricity and heat production in EU-DC's is expected to reach 1303 PJ (31.4 Mtoe) covering 78.4% of total bioenergy in EU-DC's. Biomass in EU-DC's is expected to decrease its share in total renewable energy in EU-DC's, from 59.6% in 2010 to 45.4% in 2020 due to the slower development that is expected to take place in the bioheat market during 2010-2020 period.

Figure 9 present the growth of bioelectricity and bioheat markets in EU-DC's during period the period 2005-2010 (left) and the growth still needed in 2010-2020 for reaching the NREAPs forecasted values (right).

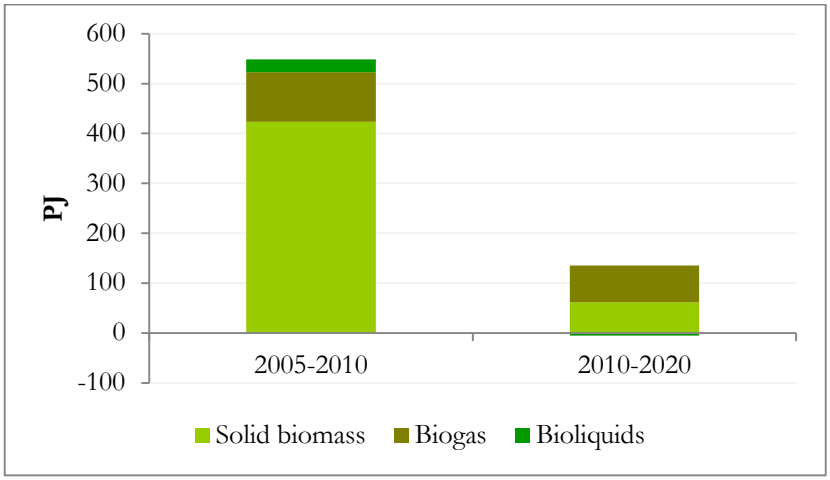

Figure 9. Growth in energy from biomass in EU-DC's, 2005-2020

In 2020 solid biomass is expected to remain the main source in biomass used for renewable electricity and heat production in EU-DC's with 1079.3 PJ (82.2 % in share). A major development of solid biomass for electricity and heat production in EU-DC's took place in 2005-2010. Due to this fast development, in order to be in good track with 2020 target, in EU-DC's a significant increase of solid biomass use for electricity and heat production is not expected in 2010-2020. The additional electricity and heat produced from this biomass source

[19] FAOSTAT 2020 population estimation — http://faostat3.fao.org/faostat-gateway/go/to/download/R/*/E.

during 2010-2020 period is expected to be nearly 7 times smaller (+64.8 PJ) than the increase in electricity and heat production that took place in the 2005-2010 period (+419.3 PJ).

Also in the case of biogas, the production increase expected in 2010-2020 (+74.6 PJ) will be lower than the 2005-2010 increase (+100.2 PJ). In 2020 the use of biogas for electricity and heat production is expected to reach 197.4 PJ (15 % in share).

In the case of bioliquids for electricity and heat production in EU-DC's, the 2020 NREAPs target of 36.8 PJ (2.8 % in share) has been already achieved in 2010 with a production of 41.8 PJ (3.5 % in share).

Germany is expected to remain in 2020 the main user of biomass for electricity and heat production among EU-DC's with ~653 PJ or ~50 % of biomass expected to be use in EU-DC's. Romania and Austria are expected to produce electricity and heat from biomass respectively 172.7 PJ and 169.6 PJ in 2020. In 2020 these three countries are expected to cover 75.8 % of electricity and heat produced from biomass in EU-DC's.

5.3.1 Growth in bioelectricity

5.3.1.1 Bioelectricity capacity

Bioelectricity capacity in EU-DC's is expected to reach 12328 MW in 2020, increasing annually by 4.1 % from 2010 accounting for 8.0 % of total installed renewable energy capacity in 2020 and solid biomass and biogas are expected to account for 98 % of bioelectricity capacity in EU-DC's.

Figure 10 present the growth in bioelectricity installed capacities in EU-DC's in 2005-2010 (left) and the growth still needed in 2010-2020 for reaching the NREAPs forecasted values (right).

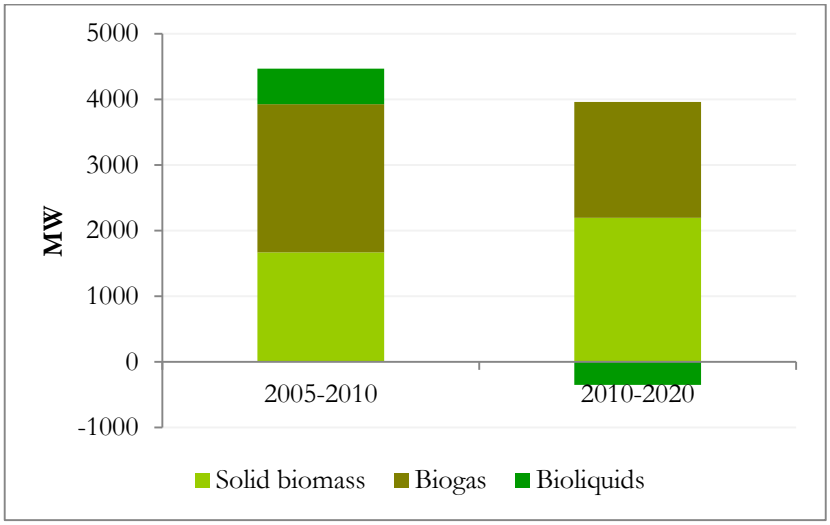

Figure 10. Growth in bioelectricity installed capacities in EU-DC's, 2005-2020

Solid biomass is expected to reach in 2020 a capacity of 7243 MW (59 % of share) increasing annually by 4.3 %. Solid biomass is expected to be the only biomass category for which the additional capacity to be installed in 2010-2020 (+2193 MW) will be larger than the additional capacity installed in 2005-2010 (+1667 MW).

The installed biogas capacity for electricity production in EU-DC's is expected to reach in 2020 the amount of 4833 MW (39.2% in contribution) with an increase of +1767 MW expected for 2010-2020, smaller than the biogas increase that already took place in the 2005-2010 period (+2260 MW). The average annual growth rate of biogas capacity in electricity production in EU-DC's during 2010-2020 time span is expected to be 10 times lower (5.8%) than the average annual growth rate of biogas capacity that took place in the 2005-2010 period (56%).

The installed capacity of bioliquids electricity production in EU-DC's reached 604 MW in year 2010 exceeding the expected 252 MW capacity for 2020.

Germany will remain in 2020 the leading country in bioelectricity capacity among EU-DC's with 8825 MW. Together with Austria (1281 MW) these countries will cover 82% of biomass capacities used for electricity production in EU-DC's.

In per capita terms Austria will have the highest installed bioelectricity capacity with 0.15 MW/1000 inhabitants followed by Germany with 0.11 MW/1000 inhabitants.

5.3.1.2 Bioelectricity production

According to NREAPs, the EU-DC's countries have planned to keep almost at the 2010 level (945 TWh) the gross final electricity consumption in 2020 (947.4 TWh). Renewable electricity contribution in total renewable energy production in EU-DC's in 2020 is expected to increase up to 43.5% reaching the amount of 347 TWh.

Figure 11 present the growth in bioelectricity production in EU-DC's in 2005-2010 (left) and the growth still needed in 2010-2020 for reaching the NREAPs forecasted values (right).

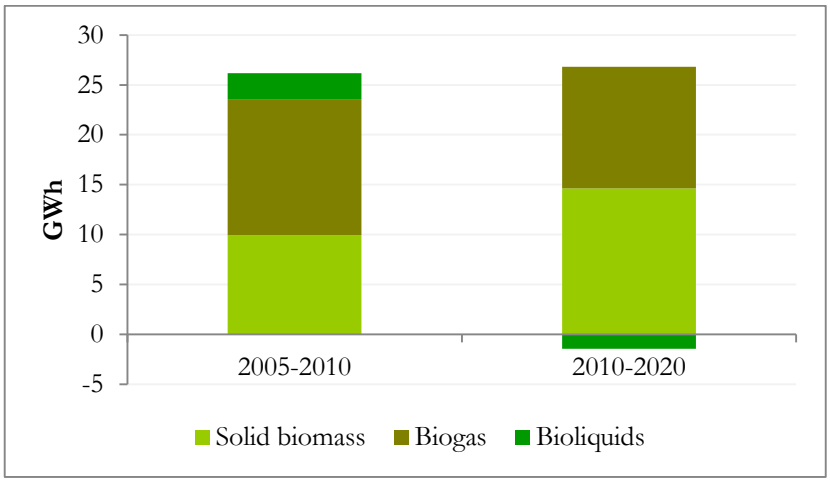

Figure 11. Growth in bioelectricity in EU-DC's, 2005-2020

In 2020 bioelectricity production in EU-DC's is expected to reach 69261 GWh representing the 15 % of contribution in total bioenergy in EU-DC's. The additional electricity production from biomass in EU-DC's during period 2010-2020 (+25379 GWh) is expected to be slightly lower than the increase in bioelectricity production that took place in the 2005-2010 period (+26156 GWh).

In 2020 solid biomass is expected to remain the main component of bioelectricity production with 37796 GWh (54.6 % in share). The additional renewable electricity from solid biomass in EU-DC's expected to be produced during period 2010-2020 is expected to be 14620 GWh

higher than its increase during the 2005-2010 period (+9945 GWh) and the highest compared with additional renewable electricity from other biomass categories.

Renewable electricity from biogas in 2020 in EU-DC's will increase to to 29979 GWh (43.3% of contribution). Nevertheless the increase in biogas electricity production in EU-DC's during 2005-2010 was the most consistent among bioelectricity sources and because of this fast development biogas electricity production is expected to increase 10 times slower (annual growth 6.9%) in 2010-2020 than in 2005-2010 period (66% annual growth)

Bioelectricity production from bioliquids has already reached and overcome in 2010 the 2020 target of 1486 GWh but its contribution in bioelectricity in 2020 is expected to be very marginal, only 2.2% ().

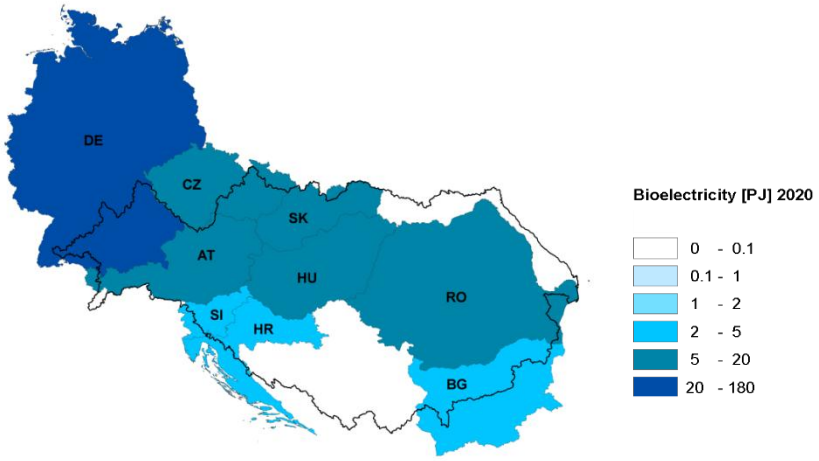

Figure 12. Expected bioelectricity market in EU-DC's, 2020

Germany is expected to remain the leading country in bioelectricity in 2020 with 49457 GWh covering 72% of renewable electricity from biomass in EU-DC's. Solid biomass category is expected to comprise half of Germany contribution in EU-DC's in 2020. Contribution of other countries in total bioelectricity expected to be produced in EU-DC's in 2020 will be less than 10% where Austria will have the largest with 7% (5147 GWh). Bioelectricity in 2020 is expected to have a fast expansion compared with year 2010 in Bulgaria (54 time-folds), Romania (42 time-folds) and Croatia (25 time-folds).

Germany is expected to have the highest consumption per inhabitant of biomass in electricity sector in year 2020 with 2.2 GJ/capita followed by Austria with 2.1 GJ/capita.

5.3.2 Biomass for heating/cooling

NREAPs of EU-DC's foresees that in 2020 bioheat market will still have the main share in total bioenergy in EU-DC's with 1053.6 PJ (63.4%).

Figure 13 present the growth of bioheat market according to biomass categroies in EU-DC's in 2005-2010 (left) and the growth still needed in 2010-2020 for reaching the NREAPs forecasted values (right).

Due to the fast development of bioheat market during period 2005-2010 in Germany, Austria and Romania, the increase in bioheat production in EU-DC's in 2010-2020 period is expected to be nearly 8 times smaller (+32.4 PJ) than its increase in 2005-2010 (+318.4 PJ[20]).

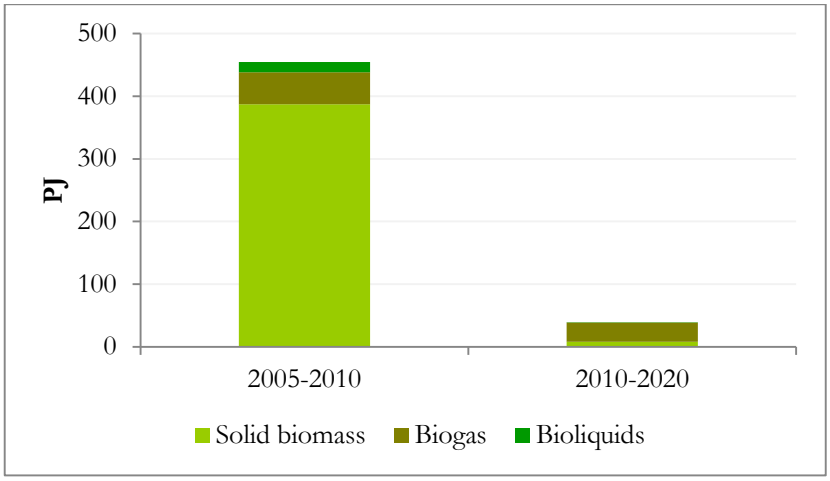

Figure 13. Growth in biomass for heating and cooling in EU-DC's, 2005-2020

In 2020 the production of heat from solid biomass in EU-DC's is expected to reach 935.1 PJ remaining still the main component in bioheat market with a share of 88.7 %. Despite this the increase in heat production from this biomass category is expected to be 95 times lower (+4.0 PJ) than its growth period 2005-2010 (+385.3 PJ) having substantially reached the NREAP target already in 2010.

Biogas is expected to produce 87.1 PJ of heat in 2020 in EU-DC's accounting for an 8.3 % of share in total bioheat market. The increase in biogas heat production from this biomass category in EU-DC's during period 2010-2020 will be 1.8 times lower (+28.3 PJ) compared with its increase in 2005-2010 (+51 PJ).

The lowest contribution in bioheat market in EU-DC's is expected to be from bioliquids. In 2010 this biomass category reached 31.2 PJ missing with only by 0.2 PJ the 2020 target (31.4 PJ).

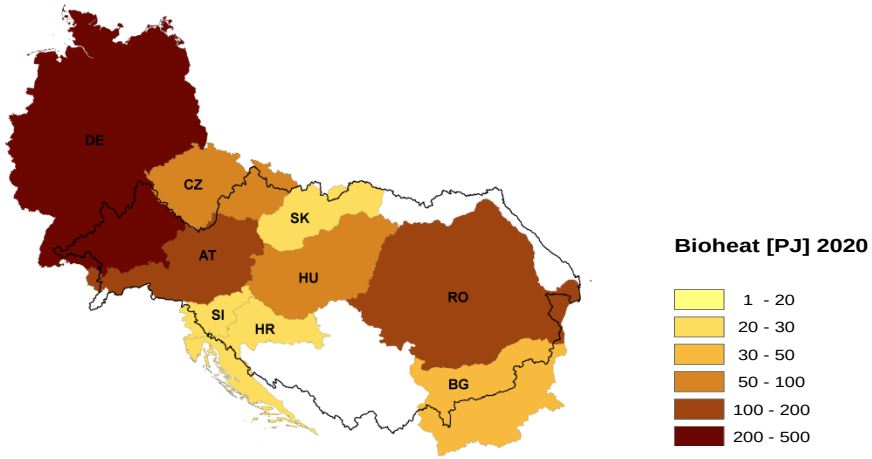

Figure 14. Expected bioheat market in EU-DC's, 2020

[20] The additional heat production from biomass in EU-DC's during period 2005-2010 takes into account the total biomass used from Romania in this sector in year 2005 (132.6 PJ). For this reason the additional heat produced during period 2005-2010 in EU-DC's is smaller than the sum of additional heat produced from each biomass category in EU-DC's during the same time span.

Germany, Austria, Romania and Slovenia reached since in 2010 the 2020 target in bioheat market in EU-DC's. According to their NREAPs their contribution should reach 810.7 PJ or 76.2% of total bioheat market in EU-DC's.
The highest increase in bioheat production in EU-DC's during period 2010-2020 is expected to happen in Czech Republic with 21 PJ followed by Croatia with ~10 PJ (Figure 14).

Biomass consumption in heating/cooling sector in terms per capita is expected to increase in all EU-DC's in 2020. Austria and Slovenia are expected to have in this year the highest bioheat consumption per inhabitant respectively 17.3 GJ/capita and 10.5 GJ/capita.

5.3.3 Growth of biofuels used in transport in EU-DC's

In 2020 biofuels use in transport sector in EU-DC is foreseen to double their absolute contribution reaching 358 PJ from 172.6 PJ in 2010. In this year the contribution of biofuels use in transport sector in EU-DC's is expected to cover almost one-third of expected use of transport biofuels in EU 28.

Figure 15 present the growth in use of transport biofuels in EU-DC's in 2005-2010 (left) and the growth still needed in 2010-2020 for reaching the NREAPs forecasted values (right).

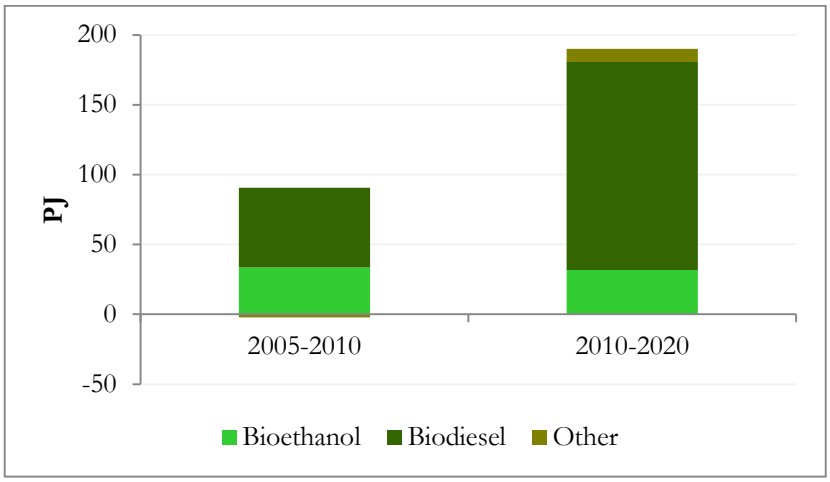

Figure 15. Growth in biofuels use in EU-DC's, 2005-2020

Biodiesel and bioethanol are expected to cover almost 96% (343.5 PJ) of total biofuels expected to be used in EU-DC's in 2020.

Biodiesel is expected to have in 2020 the highest share in transport biofuels in EU-DC's with 272.2 PJ (76% in contribution) increasing by 11.7% per annum in average. Biodiesel is expected to show the highest increase (+147 PJ) in 2010-2020 compared bioethanol and other biofuels. Imported biodiesel is expected to reach 132.5 PJ (48.3% in contribution) in 2020 covering almost 91% of transport biofuels expected to be imported in EU-DC's.

Bioethanol use in transport sector in EU-DC's in 2020 is expected to reach 71.3 PJ (19.9% in contribution) with an average increase of 7.9% per annum. The increase of bioethanol in EU-DC's in 2010-2020 is expected to be slightly lower (+31.5 PJ) its increase in 2005-2010 (+33.5 PJ). Imported bioethanol in EU-DC's is expected to reach 13.7P J (19% in contribution) in 2020 covering 9% of biofuels expected to imported in EU-DC's this year.

Other biofuels (biogas, vegetable oil, etc.) are expected to have the second highest relative increase in EU-DC's in 2010-2020 with 9% per annum in average reaching 14.5 PJ (4% in contribution) in 2020. Other biofuels in EU-DC's are expected to increase by 6.9 PJ in 2010-2020 in comparison with the decrease (-0.04 PJ) shown in 2005-2010.

Imported biofuels are expected to increase by 69% per annum in average in 2010-2020 in biofuels use in transport sector in EU-DC's will be expected in with. In 2020 it is expected that imported biofuels will cover 40.8% (146.2 PJ) of total biofuels expected to be used in transport sector in EU-DC's.

Biofuels produced from wastes, residues, non-food cellulosic material, and lingo-cellulosic material (biofuels defined in Article 21.2 of the Directive 2009/28/EC) are expected to reach in 2020 the amount of 39.7 PJ having a contribution of 11.1% in total biofuels in EU-DC's.

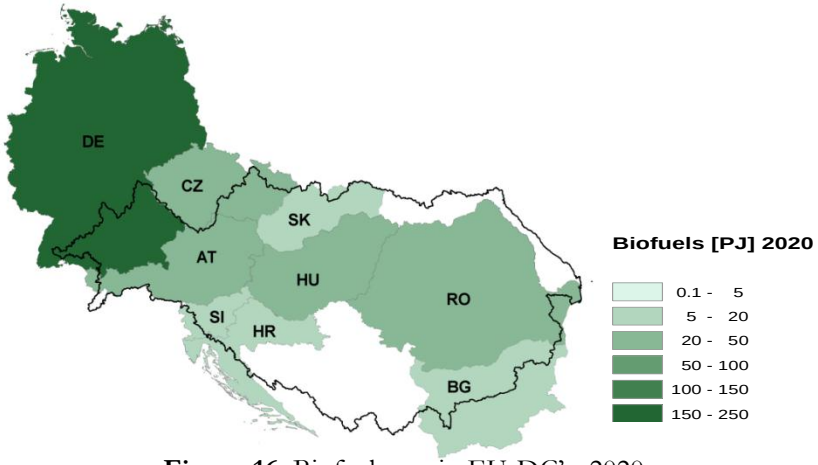

Figure 16. Biofuels use in EU-DC's, 2020

Three leading countries in biofuels use in transport sector in 2020 in EU-DC's will be Germany with 229 PJ (64% share), Czech Republic with 28 PJ (7.8% share) and Austria with 24 PJ (6.7% share). These MS will cover a 78% share of total biofuels expected to be used in EU-DC's in 2020. Bulgaria and Croatia are expected to have the fastest developments in biofuels use in transport increasing respectively the use by a factor of 26 and 14.

In 2020 it is expected that Slovenia will have the highest biofuels use per inhabitant with 3.8 GJ/capita. Austria and Germany are expected to have the same biofuel use per inhabitant with 2.8 GJ/capita each. Croatia and Bulgaria are expected to have the highest increase in biofuel use per capita in 2020 compared with 2010: respectively from 0.03 GJ/capita and 0.06 GJ/capita in 2010 to 1.4 GJ/capita and 1.8 GJ/capita in 2020.

5.4 Expected biomass potential development in EU-DC's

There are several difficulties in estimating the potential biomass supply, particularly that for the long term. Since the biomass supply is closely linked to forestry and agricultural activities, the development of these sectors has a significant impact on the biomass potential, both directly and indirectly. The development of these sectors directly determines the amount of primary and secondary residues and indirectly determines the area of land available for energy crops [15].

The domestic biomass expected to be converted to energy services during period 2010-2020 will make the lion part in total biomass supply for energy production in EU-DC's. According to NREAPs the domestic biomass supply in EU-DC's available for energy production in 2020 is expected to reach 1800 PJ increasing by 6.4% per annum in average from year 2010.

In 2020 forestry is still expected to be the largest component of domestic biomass supply for energy production in EU-DC's with 980.4 PJ (54.5% in contribution). About two-third of this contribution is expected to come from direct supply of wood biomass from forests with 642.2 PJ.

The biomass supply for energy purposes from agriculture (agricultural by-products /processed residues and fishery by-products) will be the second source of domestic biomass supply in 2020 with 689 PJ (38.3% in contribution) increasing by an average 16.5% per annum from year 2010.

The main contribution in agricultural supply is expected to come from agriculture crops and fishery products with 442 PJ (65% in share) while agricultural by-products and residues will cover the remainder part of 247 PJ (35%).

Waste will account for a 7.2% share in domestic biomass supply in EU-DC's in 2020 but in absolute terms its contribution will be increased 3 time-folds from 43.6 PJ in 2010 to 130 PJ in 2020 The biodegradable fraction of industrial solid waste will make the main part of domestic biomass waste to energy with 65.8 PJ (50.6%) while the biodegradable solid municipal waste will be the second large source with 48.8 PJ (37.5% in contribution. The rest will be covered by sewage sludge with 15.6 PJ (12% in contribution).

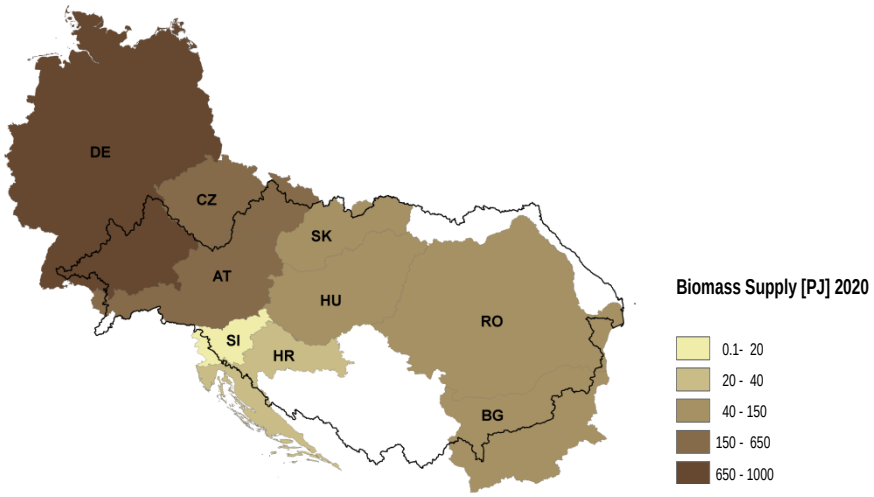

Figure 17. Expected biomass supply in EU-DC's, 2020

In 2020 the three leading countries in biomass supply for energy services in EU-DC's are expected to be Germany with 980.5 PJ (54.5% in contribution), Austria with 199 PJ (11% in contribution)) and Czech Republic with 153.8 PJ (8.6% in contribution). Germany will have the highest relative contribution in biomass supply from waste with 75% (97 PJ) while the contribution in agriculture and forestry will be respectively 56% (382.5 PJ) and 50.8% (501 PJ). Austria will have the second highest relative contribution in forestry with 16.4% (162 PJ) while Czech Republic will have this place in waste with 10.4% (13.5 PJ).

In per capita terms Slovakia is expected to have in 2020 the highest biomass supply with 26.8 GJ/capita, followed by Austria with 22.8 GJ/capita, Czech Republic with 14.1 GJ/capita, Germany with 12 GJ/capita, Bulgaria with 7.9 GJ/capita, Hungary with 7.6 GJ/capita, Romania and Slovenia with 6.7 GJ/capita each and Croatia with 5.7 GJ/capita.

6. Bioenergy status and forecast in non-EU Danube countries

A survey on bioenergy deployment covering the period between 2010 and 2020 has been partly carried out for seven non-EU Danube countries: Ukraine, Moldova, Serbia, Bosnia and Herzegovina, Albania, Montenegro and the former Yugoslav Republic of Macedonia. The survey is based on literature or studies communicated by JRC partners and available NREAPs that these countries have prepared as a requirement of membership of the Energy Community.

6.1 Ukraine

Ukraine has a 2020 target of 11% of energy to be produced from renewable sources, up from 5.5% in 2009. According to Ukraine's draft NREAP, an increase of 63.1 PJ (17 539 GWh), or 61%, in projected renewable energy consumption will be accompanied by an increase of 40.2 PJ (11 156 GWh), or 17%, in projected final energy consumption. Ukraine is planning a significant expansion of renewable electricity generation, in particular from wind power but also from solar PV, biomass, and large-scale hydro power [24].

In 2009, total bioenergy use in Ukraine amounted to 60 PJ (1 433 ktoe), used in the heating and cooling sector. This amount represented nearly 70% of the total renewable energy consumed in Ukraine in 2009 [28].

The heating and cooling sector is the main user of biomass in Ukraine. In 2010, an estimated 63 PJ (1 505 ktoe) or 2.16 Mtce (metric tonnes carbon equivalent[21]) of biomass was used for heat production in Ukraine, representing 6.4% of the total biomass potential. In 2010, the installed capacity of biomass in the heating and cooling sector was 3 586 MWth. In 2020 it is expected that this capacity will double, reaching 7 665 MWth [14].

No use of biomass in the electricity sector was reported in 2010 in Ukraine's NREAP. Biomass is expected to be introduced into the electricity sector in Ukraine in 2015, using 1.5 PJ (35.8 ktoe) of bioenergy, increasing to 8.5 PJ (203 ktoe) in 2020 [27]. According to the National Electricity Regulatory Commission of Ukraine, in 2012 there were three biomass and six biogas power plants, with an installed capacity of 10.2 MW, producing 21.2 GWh (0.08 PJ).

No data were reported for the use of biofuels in the transport sector in Ukraine's NREAP for 2009. According to the NREAP, 1.3 PJ (31 ktoe) of biofuels was expected to be used in the transport sector in 2013.

In 2020, it is expected that 53.8% (4 592 ktoe) [28] of the total renewable energy used in Ukraine will be bioenergy.

In 2020, the bioheat sector will be the largest user of bioenergy in Ukraine, at 87.1% (167.5 PJ) [28] of the total. In 2020, the use of biomass in this sector is expected to double, reaching 7 665 MWth [14] and producing 14% of heat in Ukraine.

[21] Unit representing energy generated by burning one metric tonne (1 000 kilograms or 2 204.68 pounds) of coal, equivalent to the energy obtained from burning 700 kilograms (5.2 barrels) of oil or 890 cubic meters of natural gas that is equal to 29.39 gigajoules (GJ) or 27.78 million Btu (MMBtu) or 8.14 megawatt hours (MWh) or 0.697 Mtoe.

In 2020, the transport sector is expected to use 8.5% of all bioenergy in Ukraine, amounting to 16.3 PJ. The lowest use is expected in the power sector, where 8.5 PJ of biomass is expected to be used in 2020, just 4.4% of all bioenergy in the country [28].

6.2 Republic of Moldova

Development of renewable energy in Republic of Moldova is at an early stage. In 2009, total renewable energy production in Moldova was estimated to be 10 PJ (242 ktoe), providing 11.9% of all energy used, at 86.7 PJ (2071 ktoe). The 2020 target for Moldova is set to 17% expecting to reach the amount of 15.4 PJ (367.2 ktoe) from renewable energy sources [29].

Biomass consumption in Moldova currently comes from wood, agricultural crops (fully exported) and agricultural waste [29]. Biomass potential for energy in Moldova is estimated to be 21 042 TJ, with sunflower, rapeseed and tobacco together providing 59.5% of this potential, cereals 18.6%, corn 14.4%, forestry 2.3% and vineyards 2% [38].

According to its NREAP, Moldova used 10.3 PJ of biomass in 2010 (used solely for heat production), representing 97.2% of the total renewable energy production. No biomass use in other sectors was reported in Moldova's action plan for 2010. Bioheat is expected to remain the main source of renewable energy in Moldova in 2020, providing 14 PJ (334 ktoe) or 89% of the total [29].

Biomass is expected to be introduced into Moldova's power sector in 2015, generating 0.02 PJ of electricity, with an installed capacity of 2 MW [29].

The transport sector in Moldova has no consumption of renewable energy sources. There is however production of biofuels in Moldova, which is currently exported to Germany [29]. Moldova's transport sector is expected to use 0.3 PJ (6.4 ktoe) [38] of bioenergy in 2015.

Total renewable energy consumption in Moldova in 2020 is expected to be 15.7 PJ (375.2 ktoe), or 17% of the expected total energy consumption of 90.4 PJ (2160 ktoe) [29]. Currently, renewable energy sources used in Moldova consist mainly of biomass heating, which is expected to moderately increase. Moldova's draft NREAP shows a small increase in hydro capacity and a large increase in wind energy. An increase of 7.7 PJ (184 ktoe), or 76%, in projected renewable energy consumption in 2020 will be accompanied by an increase of 0.3 PJ (7.2 ktoe), or 4% in projected total energy consumption [24].

In 2020, biomass is expected to provide 14 PJ (334 ktoe) of heat, which is 89% of expected total bioenergy use in Moldova [29].

In 2020, Moldova expects that 10% of electricity will be produced from renewable sources [38]. The installed capacity of biomass in the electricity sector is expected to increase to 10 MW, producing up to 0.1 PJ (2.7 ktoe) of renewable electricity. The bioelectricity sector is expected to provide 0.7% [29] of Moldova's total bioenergy in 2020.

In 2020, 10% of all fuels are expected to be biofuels, with an intermediate target of 4% by 2017 [38]. Biofuels in Moldova's transport sector are expected to provide 1.6 PJ (38.5 ktoe) of bioenergy, representing 10.3% of all bioenergy in Moldova in 2020 [29].

6.3 Serbia

Serbia has a target of producing 27% energy from renewable energy sources by 2020, up from 21.2% in 2009. An increase of 26 PJ (621 ktoe), or 32%, in projected renewable energy consumption will be accompanied by an increase of 14.4 PJ (345 ktoe) or 3.8% in projected final energy consumption [24].

The renewable energy potential in Serbia is estimated at 6 Mtoe, with biomass providing the largest proportion of this, at 3.7 Mtoe (62%). Biomass sources in Serbia are estimated to provide 108000 TJ/year and biomass from agriculture provides the largest part of this, with 65000 TJ/year. The rest comes from woody biomass, with 43000 TJ/year [27].

The Serbian NREAP estimated that biomass use in heating and cooling sector in Serbia in 2010 represented 50% of all renewable energy consumption, with 43 PJ (1025 ktoe) and was the only source of total bioenergy use that year. Biomass is expected to be introduced into the electricity sector in 2017 (generating 0.2 PJ or 5.7 ktoe), while use of biofuels in the transport sector is not expected before 2015 (with an expected use of 1.4 PJ or 34 ktoe) [30].

In 2020 the electricity from renewable energy sources will make up 36.6% of gross final energy consumption in Serbia. The proportion of heating and cooling from renewable energy is expected to reach 30% and 10% of transport is expected to use renewable energy. In 2020, Serbia is expected to use nearly 62 PJ (1478 ktoe) of bioenergy. The heating/cooling sector will be the largest user of this, at 48.2 PJ (1152 ktoe). The transport sector is expected to be the second largest user of bioenergy, with 10.3 PJ (245 ktoe), while the electricity sector will use just 3.4 PJ (81.3 ktoe) of bioenergy [30].

6.4 Bosnia and Herzegovina

Bosnia and Herzegovina has significant potential renewable energy sources and is consequently one of the countries which are able to develop their energy sector based mainly on renewable energy. Hydro power, biomass, geothermal power, wind power and solar power could play an important role in the overall economy in the future. The proportion of renewable energy compared to total energy consumption in Bosnia and Herzegovina is relatively high, with the largest proportion of renewable energy being produced from large hydro power plants [20].

Bosnia and Herzegovina has a target of producing 40% of energy from renewable energy by 2020, up from 34% in 2009. The country is still in the process of drafting a National Renewable Energy Action Plan, which was expected to be submitted to Energy Community by mid-2013. In 2012, 66.6% of electricity came from coal, 32% from hydro power and just 1.3% from other renewable energy forms. In 2012, the first eight solar plants were installed in Bosnia and Herzegovina.

By 2020, final energy demand in Bosnia and Herzegovina is expected to rise by 16.2 PJ (388 ktoe), or 14%, according to Energy Community projections. The country plans a significant expansion of electricity generated by hydro power and wind power. In 2009, large hydro power plants produced 19.3 PJ (462.2 ktoe). This is expected to increase by 194% by 2020, reaching 56.9 PJ (1359 ktoe) [24].

Biomass has been used as an energy source in Bosnia and Herzegovina for a long time, mainly in rural and sub-urban areas, as a primary source for heating and cooking in households and

buildings. However, since energy demand and the price of fossil fuels have risen rapidly, forest-based biomass resources other than wood are now also being considered for use in producing energy. These include forest residues and bark, and residues and by-products from industrial wood processing [20].

The main use of biomass in Bosnia and Herzegovina is in the heating and cooling sector. In 2009, 33 PJ (789 ktoe) of biomass was used to produce heat. This is not expected to increase by 2020. The electricity sector is expected to use 10 GWh [24] of biomass.

Forests and forestland[22] cover ~43% of Bosnia and Herzegovina, approximately 2.7 million hectares. The forested area decreases by around 0.1% each year. It is estimated that wood waste in Bosnia and Herzegovina can produce approximately 18.7 PJ (447 ktoe) of electricity per year, with an additional 600 MW of installed capacity [13].

Landfill gas is being produced in a pilot project in Sarajevo with 350 kW of electric capacity. There is significant potential for the collection and use of residues from field crops, fruit tree plantations, livestock activities and waste, including manure from intensive farms that undergoes incineration or anaerobic digestion [13].

The vast majority (82%) of households in Bosnia and Herzegovina use some type of biomass for heating, cooking or heating water. This rises to 92% in rural areas, and is 72% in urban areas. Firewood is used by 99% of the households that reported biomass consumption. A small proportion (1.4%) use pellets and briquettes [3].

6.5 Albania

Albania has a target of producing 38% of its energy from renewable energy by 2020, up from 31.2% in 2009. Albania's electricity is generated almost entirely from hydro power, which is expected to see significant expansion by 2020. Electricity production from large hydro power plants is expected to increase by 88% by 2020, from 14 PJ (3 877 GWh) in 2009. Other electricity-generating technologies such as wind or biomass play only a small role, although Albania has large potential in these areas. Albania plans to strongly increase heating provided by renewable sources — this is currently provided by an inefficient use of firewood [24].

In 2009, total heat generation in Albania was 9.2 PJ (219.2 ktoe). This is expected to rise to16.4 PJ (391 ktoe) by 2020 (an increase of 78%). An increase of 27.3 PJ (652 ktoe), or 115%, in projected renewable electricity and heat consumption is expected to be accompanied by an increase of 48 PJ (1 145.7 ktoe), or 61%, in Albania's projected final energy consumption in 2020. Most biofuels in the transport sector are expected to be imported; the sector is expected to use in 2020 4.4 PJ (105.4 ktoe) of bioenergy [24].

In 2009, no use of biomass in producing electricity was reported in Albania. In 2020, biomass in the electricity sector is expected to generate 0.7 PJ (186 GWh). The theoretical potential of biomass used for energy in Albania is estimated to be 4 176 ktoe/year, representing 16.9% of the country's energy balance. Municipal (organic and non-organic) solid waste and agriculture account for the largest proportions of this theoretical potential, with 37.8% (1 576.4 ktoe) and 36% (1 521 ktoe), respectively. The technical potential of biomass categories is estimated at 3 212

[22] Forestland is a section of land covered with forest or set aside for the cultivation of forests.

ktoe/year if used for heat, and 964 ktoe/year if used to produce electricity, representing 13% and 14.6% of the country's energy balance [31].

Wood is a significant source of energy in Albania, representing 10-11% of the total energy consumption. Wood reserves in Albania are estimated at 125 million m^3 (14.8 Mtoe). Forests in Albania consist of high-stem forests (47-50%), coppices (29-30%) and bushes (24-25%). 10% of high-stem forests, 50% of coppices and 100% of bushes are used for fuel. Single-species forests make up 72.3% of the total forest area and mixed-species forests make up 27.7% [31].

The amount of solid urban waste generated in Albania increased by an average of 11.3% per year between 2005 and 2012, from 696 596 tonnes (0.23 tonne/capita) in 2005 to 1 136 802 tonnes (0.4 tonne/capita) in 2012 [27].

6.6 Montenegro

Under the Energy Community Treaty, Montenegro has a target of ensuring that 33% of its energy comes from renewable sources, up from 26.3% in 2009. The country has not yet published its NREAP. Montenegro's electricity is mainly generated by hydro power (two large hydro power plants) and a coal-fired thermal power plant. By 2020, the country aims to significantly increase the amount of electricity generated by small hydro power plants and, to a lesser extent, from wind and biomass. In the heat sector, bioheat is expected to play a significant role, while solar heat is expected to play a minor role in 2020. An increase of 8.9 PJ (211.8 ktoe), or 108%, in projected renewable energy consumption is expected to be accompanied by an increase of 17 PJ (406 ktoe), or 57%, in projected final energy consumption [24].

According to analysis by the Energy Community, almost three quarters of households (70.6%) in Montenegro use some type of biomass for heating, cooking or heating water. This percentage is much higher in rural areas, where most households (94%) reported using biomass for their daily needs, while the percentage is significantly lower in urban areas (56%) [4].

Potential biomass resources in Montenegro total 12 030 PJ, equivalent to 26% of the country's total primary energy supply. The technical potential of forest-based biomass is 3.3 PJ, 50% of which could be used for co-firing. Existing solid fuel power facilities could generate 2.5 ktoe (29 GWh) energy. Using firewood in households could generate a further 5.8 ktoe (68 GWh) of heat per year. The theoretical potential of biogas is 0.83 PJ, of which 30% has been realised, producing 2 ktoe (24 GWh) electricity annually. Energy crops could generate 1.3 PJ (362 GWh) of electricity and 1.9 PJ (44.5 ktoe) of heat for industrial and medium-scale use, along with an additional 3 PJ (71 ktoe) of heat in households, if approximately 10% of pasture land is turned into energy crop production [36].

6.7 The former Yugoslav Republic of Macedonia

Under the Energy Community Treaty, the former Yugoslav Republic of Macedonia's target for energy from renewable sources is 28% by 2020, up from 21% in 2009. Its electric power system is based on 580 MW from hydro power plants, 800 MW from thermal plants fuelled by lignite and 210 MW from thermal plants run on heavy fuel oil. The country plans to significantly expand its network of large hydro power plants and increase the amount of energy generated by wind power, geothermal power, small hydro power and biomass heat. Solar electricity is expected to play only a minor role in generating energy [24].

In 2005, with 13.8% of its energy coming from renewable energy, the former Yugoslav Republic of Macedonia had a relatively high use of renewable energy sources. In 2005, renewable energy provided 3016 GWh. Of this, biomass produced 1767 GWh, representing 59% of all energy from renewable energy. Biomass is mainly used by households and meets 30–33% of total energy needs. Around 430000 households (76%) use biomass for heating purposes. Wood and wood coal in the former Yugoslav Republic of Macedonia account for 80% of all biomass used for energy [34].

Biomass use in the electricity sector in the former Yugoslav Republic of Macedonia amounted to 6 GWh in 2009. It is expected to reach 50 GWh in 2020 (an increase of 733%). The main use of biomass is in the heating and cooling sector. In 2013, 330 ktoe (3838 GWh) of biomass was used for heat production and this is expected to increase by 7% by 2020 (353 ktoe or 4105 GWh). An increase of 214.2 ktoe (2491 GWh), or 45%, in projected renewable energy consumption from 2013 to 2020 is expected to be accompanied by an increase of 322 ktoe (3745 GWh), or 15%, in projected final energy consumption in the energy efficiency scenario [24].

The total area of forestland in 2013 was 11596 km^2 (1159000 ha), of which forests make up 988835 ha. The total wood mass is 74343000 m^3, with a total annual increase of 1830000 m^3. The average annual increase amounts to 2.02 m^3 per hectare [35].

Crop residues are under-used, due to low bulk density and the high cost of transportation. In 2012, straw production was 522698 tonnes, mostly from winter wheat (59.1%) and barley (29.9%). Cereal straw is used as litter and fodder, and corn stubble is used mainly as fodder. There are some surpluses of cereal straw that could be used as an energy source (137972 t). Biomass production from orchards in this year was 30204 tonnes [7].

Biomass use for combustion in 2020 is expected to be almost 19% higher than in 2006, representing the largest proportion (42.7%) of the renewable energy mix in 2020, at 238 ktoe (2765 GWh). Hydro power is expected to provide 36.3%, followed by biofuels (8.6%), geothermal energy (6.8%), wind power (4.2%) and solar energy for heating (0.9%). Electricity from biogas, waste biomass for thermal power plant–heating plants (TPP-HP), and electricity from photovoltaic systems are expected to provide a total of 0.9%. In 2020, the former Yugoslav Republic of Macedonia expected to use 287.7 ktoe (3345 GWh) of bioenergy, representing 55.8% of the total renewable energy mix [32].

The way forward

In the European Union and in the Danube countries studied in this report, bioenergy (defined as the use of biomass for heat, electricity and transport) plays and will continue to play a significant role in meeting Europe's '20 20 20' targets. These targets require that, by the year 2020, greenhouse gas emissions should be reduced by 20%, renewable energy sources should represent 20% of Europe's final energy consumption and energy efficiency should increase by 20% compared to projections[23]. This statement on bioenergy implementation is based on the targets set out in the EU Member States' renewable energy action plans and the analysis of progress reports (using 2010 reference data).

In 2020, bioenergy is expected to reach 1 661 PJ, representing 57.8% of the total renewable energy used in the EU Danube countries. It will therefore be an essential renewable energy source in these countries. The proportion of all renewable energy provided by bioenergy in the countries in 2020 is expected to be smaller than in 2010, due to the fast increase of other renewable technologies such as solar (mainly photovoltaic) power, geothermal power and wind power.

This study analysed the situation of 16 Danube region countries: nine EU Member States and seven non-EU countries. Several (Ukraine, Moldova, Serbia, Bosnia & Herzegovina, Albania, Montenegro and the former Yugoslav Republic of Macedonia) are members of the International Commission for the Protection of the Danube River (ICPDR).

For the Danube countries, organic waste is an asset, regardless of the size of the country and the agricultural and forestry resources it has. The Danube region is also a particular case, in the sense that it includes countries (such as Germany and Austria) which are global leaders in renewable energy and bioenergy, allowing for a possible exchange of experience on feedstock assessment, biomass conversion, markets, sustainability and supply chain operation.

Meeting bioenergy targets will depend on biofuel sustainability schemes being implemented, some of which were already operational at the end of 2013. Additional schemes for managing solid biomass are currently being discussed. If there is large-scale deployment, the cost competitiveness of bioenergy and other renewable energy sources may improve. However, having large biomass resources is not necessarily linked to high rates of biomass use. The short-term development of bioenergy depends on the putting in place of public support mechanisms. A spatial data infrastructure combining geographical information with information on bioenergy and other renewable energy sources would be useful for the formulation, implementation and monitoring of bioenergy policies.

Future activities in the field of bioenergy must refer to the Danube region biomass action plan, which contains a description of the biomass policy framework, an assessment of the countries in the EUSDR and a regional analysis [9].

[23] Directive 2012/27/EU: Projections made in 2007 showed a primary energy consumption in 2020 of 1 842 Mtoe. With the accession of Croatia the 2020 target of energy consumption was revised to "1 483 Mtoe primary energy or no more than 1 086 Mtoe of final energy"

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ANNEX I

General information on Danube Region Countries

Table A I. General information on Danube Region Countries (DRB)[24]

Country*	Code	Coverage in DRB (km²)	% in DRB	% of DRB in country	Population in DRB (Million)
Albania	**AL**	**126**	**< 0.1**	**0.01**	**< 0.01**
Austria	**AT**	**80423**	**10.0**	**96.1**	**7.7**
Bosnia and Herzegovina	**BA**	**36636**	**4.6**	**74.9**	**2.9**
Bulgaria	**BG**	**47413**	**5.9**	**43.0**	**3.5**
Croatia	**HR**	**34965**	**4.4**	**62.5**	**3.1**
Czech Republic	**CZ**	**21688**	**2.9**	**27.5**	**2.8**
Germany	**DE**	**56184**	**7.0**	**16.8**	**9.4**
Hungary	**HU**	**93030**	**11.6**	**100.0**	**10.1**
Italy	IT	565	< 0.1	0.2	0.02
the former Yugoslav Republic of Macedonia		**109**	**< 0.1**	**0.2**	**< 0.01**
Republic of Moldova	**MD**	**12834**	**1.6**	**35.6**	**1.1**
Montenegro	**ME**	**7075**	**0.9**	**51.2**	**0.2**
Poland	PL	430	< 0.1	0.1	0.04
Romania	**RO**	**232193**	**29.0**	**97.4**	**21.7**
Serbia	**RS**	**81560**	**10.2**	**92.3**	**7.5**
Slovak Republic	**SK**	**47084**	**5.9**	**96.0**	**5.2**
Slovenia	**SI**	**16422**	**2.0**	**81.0**	**1.7**
Switzerland	CH	1809	0.2	4.3	0.02
Ukraine	**UA**	**30520**	**3.8**	**5.4**	**2.7**

*Countries included in this report are listed in bold

[24] http://www.icpdr.org/main/danube-basin/countries-danube-river-basin.

ANNEX II

Land use in Danube region

Table A II. Land use in Danube region, 2011 (1000 ha)[25]

	Agricultural area	Arable land	Forest area	Land area	Country area
AT	2869	1363	3892	8241	8388
BG	5088	3250	3982	10856	11100
HR	1326	897	1923	5596	5659
CZ	4229	3164	2659	7724	7887
DE	16719	11875	11076	34857	35713
HU	5337	4395	2038	9053	9303
RO	13982	8995	6609	23016	23839
SK	1930	1391	1933	4809	4904
SI	459	169	1255	2014	2027
Total EU-DC	**51938**	**35498**	**35368**	**106166**	**108819**
AL	1201	622	775	2740	2875
BA	2151	1005	2185	5100	5121
The former Yugoslav Republic of Macedonia	1118	414	1003	2522	2571
MD	2459	1810	391	3285	3385
ME	512	172	543	1345	1381
RS	5061	3294	2760	8746	8836
UA	41281	32499	9731	57932	60355
Total non-EU-DC's	**53783**	**39816**	**17388**	**81670**	**84524**
Total DC's	**105721**	**75314**	**52756**	**187836**	**193343**
Total EU	**188761**	**109087**	**169262**	**459371**	**476192**

[25] Source: Food and Agriculture Organisation of the United Nations (FAO), last access March 2014.

ANNEX III

European Danube Countries in AEBIOM 'European Bioenergy Outlook 2013'

Table A III.1 Final energy consumption, overall RES and biomass in EU-DC's, 2011 (ktoe)[26]

	Total Energy Consumption	RES	% RES in TEC	Biomass	% biomass in TEC
AT	27328	8648	31.65	4566	16.71
BG	9287	1480	5.94	962	10.36
HR	6181	883	14.29	445	7.2
CZ	24634	2771	11.25	2193	8.9
DE	207093	26616	12.85	16240	7.84
HU	16276	1528	9.39	1332	8.18
RO	22576	5139	2276	3620	16.03
SK	10795	1252	11.6	774	7.17
SI	4951	944	19.07	558	11.27

Table A III.2 Harvest production of some of the main crops 2012 (1000 tons)[27]

	Cereals* (including rice)	Cereals (excluding rice)	Sugar beet	Rape	Sunflower	Wheat (including spelt)	Barley
AT	1826	1826	5735	7		1302	206
BG	6988	3012	4830			1835	364
HR							
CZ	6596	6596	3869	1109	57	3519	1617
DE	45397	45397	27687		63	22409	10391
HU	153	153		15		79	38
RO	1178	991	19		10	59	21
SK	576	576		17		188	85
SI	12824	12773	720	146	1398	5298	986

*Cereals for the production of grain

Table A III.3 Cellulosic energy crops in 2011 (ha)[28]

	Hemp	Switchgrass	Reed Canary grass	Willow	Poplar	Miscanthus
AT				220-1100	880-1100	800
BG						
HR						
CZ						
DE				4000	5000	2000
HU						
RO		50000				
SK						
SI						

[26] Source: European Bioenergy Outlook 2013 , AEBIOM , Table 2.7 , pp 17.
[27] Source: European Bioenergy Outlook 2013 , AEBIOM , Table 3.2 , pp 36.
[28] Source: European Bioenergy Outlook 2013 , AEBIOM , Table 3.3 , pp 38.

ANNEX IV

Summary of bioenergy deployment in European Danube Countries
NREAPs and bi-annual progress reports
(AT, BG, CZ, DE, HR, HU, RO, SI, SK)

Table A IV. 1 RES electricity capacity in EU-DC's, 2005-2010

	2005(NREAPs)	2010 (PR)	Growth 2005-2010		Growth 2010-2020		2020 (NREAPs)
	MW	MW	MW	%	MW	%	MW
Hydropower	26257	26192	-65	-0.25	4053	15.5	30245
Geothermal	1	11	10	1000	363	3300.0	374
Solar	2003	19365	17362	866.8	35945	185.6	55310
Wind	19151	29650	10499	54.8	26297	88.7	55947
Biomass	4255	8715	4460	104.8	3613	41.5	12328
EU-DC's RES capacity	51667	83933	32266	62.4	70271	83.7	154204
EU 28 RES capacity	169804	243371	73567	43.3	232877	95.7	476248

Table A IV. 2 Total RES generation in EU-DC's, 2005-2020

	2005(NREAPs)	2010 (PR)	Growth 2005-2010		Growth 2010-2020		2020 (NREAPs)
	PJ	PJ	PJ	%	PJ	%	PJ
Hydropower	334.4	350.1	15.7	4.69	30.6	8.7	380.7
Geothermal	2.8	10.2	7.4	264.29	52.6	515.7	62.8
Solar	18.7	71.8	53.1	283.96	170	236.8	241.8
Wind	101.0	170.0	69	68.32	278	163.5	448.0
Biomass	766.6	1179.2	412.6	53.82	-	-93.3	78.8
Heat pumps	11.6	26.5	14.9	128.45	1276.5	4817.0	1303.0
Biofuels	82.4	172.6	90.2	109.47	185.4	107.4	358.0
EU-DC's Total RES	1317.5	1980.0	662.5	50.28	893.2	45.1	2873.2
EU 28 Total RES	4181	6260.0	2079	49.72	3959	63.2	10219

Table A IV. 3 Bioenergy in EU-DC's by sector, 2005-2020

	2005(NREAPs)	2010 (PR)	Growth 2005-2010		Growth 2010-2020		2020 (NREAPs)
	PJ	PJ	PJ	%	PJ	%	PJ
Bioheat	702.8	1021.2	318.4	45.30	32.4	3.2	1053.6
Bioelectricity	63.8	158	94.2	147.65	91.4	57.8	249.4
Biofuels	82.4	172.6	90.2	109.47	185.4	107.4	358
Total bioenergy	849	1351.7	502.7	59.21	309.3	22.9	1661

Table A IV. 4 Bioelectricity and Bioheat in EU-DC's, 2005-2020

	2005(NREAPs)	2010 (PR)	Growth 2005-2010		Growth 2010-2020		2020 (NREAPs)
	PJ	PJ	PJ	%	PJ	%	PJ
Solid biomass	595.2	1014.5	419.3	70.45	64.8	6.4	1079.3
Biogas	22.7	122.7	100	440.53	74.7	60.9	197.4
Bioliquids	16.2	41.8	25.6	158.02	-5	-12.0	36.8
Bioelectricity + Bioheat	766.6[29]	1179.2	412.6	53.82	134.3	11.4	1313.5

[29] Romania reported in its NREAP only the total biomass used in heating/cooling sector for year 2005 (132.6 PJ). As no division in subcategories was reported, this number has been added to the last line value for 2005 only.

Table A IV. 5 Bioelectricity capacity in EU-DC's by source, 2005-2010

	2005(NREAPs)	2010 (PR)	Growth 2005-2010		Growth 2010-2020		2020 NREAPs
	MW	MW	MW	%	MW	%	MW
Solid biomass	3383	5050	1667	49.28	2193	43.4	7243
Biogas	806	3066	2260	280.40	1767	57.6	4833
Bioliquids	66	604	538	815.15	-352	-58.3	252
Bioelectricity	4255	8715	4460	104.82	3613	41.5	12328

Table A IV. 6 Bioelectricity production in EU-DC's, 2005-2020

	2005(NREAPs)	2010 (PR)	Growth 2005-2010		Growth 2010-2020		2020 (NREAPs)
	GWh	GWh	GWh	%	GWh	%	GWh
Solid biomass	13231	23175	9944	75.16	14621	63.1	37796
Biogas	4133	17774	13641	330.05	12205	68.7	29979
Bioliquids	362	2932	2570	709.94	-1446	-49.3	1486
Bioelectricity	17726	43881	26155	147.55	25380	57.8	69261

Table A IV. 7 Bioheat in EU-DC's, 2005-2020

	2005(NREAPs)	2010 (PR)	Growth 2005-		Growth		2020 (NREAPs)
	PJ	PJ					PJ
Solid biomass	547.5	931.1	383.6	70.06	12.1	1.3	943.2
Biogas	7.8	58.8	51	653.85	30.7	52.2	89.5
Bioliquids	14.9	31.2	16.3	109.40	0.2	0.6	31.4
Bioheat	**702.8**[30]	**1021.1**	318.3	45.29	43	4.2	1064.1

Table A IV. 8 Usage of bioheat in EU-DC's, 2005-2020

	2005(NREAPs)	2010 (PR)	Growth		Growth		2020 (NREAPs)
	PJ	PJ					PJ
District heating	19.8	43.2	23.4	118.2	203.4	470.8	246.6
Bioheat in households	531.2	619.1	87.9	16.5	35.1	5.7	654.2

Table A IV. 9 Biofuels use in transport sector in EU-DC's, 2005-2020

	2005	2010	Growth 2005-2010		Growth 2010-2020		2020 (NREAPs)
	PJ	PJ	PJ	%	PJ	%	PJ
Bioethanol	6.2	39.7	33.5	540.32	31.6	79.6	71.3
Biodiesel	68.5	125.2	56.7	82.77	147	117.4	272.2
Other biofuels	7.7	7.66	-0.04	-0.52	6.84	89.3	14.5
Total biofuels	82.4	172.6[31]	90.2	109.47	185.4	107.4	358.0

[30] See reference 28

[31] Due to sustainability criteria Romania and Slovenia didn't report on biofuels in 2010.

Table A IV. 10 Primary energy production from biomass in EU-DC's, 2009-2010

	Domestic		Imported from EU		Imported from non EU		Total	
	2009	2010	2009	2010	2009	2010	2009	2010
	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Biomass for heating and electricity	1081[32]	1099.1	47.5	53.4	3.8	5.2	1132.3	1157.7
Forestry	765.5	782.4	47.5	53.4	3.8	5.2	816.8	841.0
Agriculture	259.6	259.6	0.0	0.0	0.0	0.0	259.6	259.6
Waste	43.6	43.6	0.0	0.0	0.0	0.0	43.6	43.6
Energy crops & short rotation trees	0.46	0.51	0.0	0.0	0.0	0.0	0.46	0.51
Other	0.38	0.38	0.0	0.0	0.0	0.0	0.38	0.38
Biomass for transport	3.8	4.0	0.0	0.0	0.0	0.0	3.8	4.0
Total biomass supply	1085	1103	47.5	53.4	3.8	5.2	1136.2	1161.8

Table A IV. 11 Expected growth of biomass availability in EU-DC's, 2010-2020

	2010 (PR)	Growth 2010-2020		2020 (NREAPs)
	PJ	PJ	%	PJ
Forestry	782.4	198	25.3	980.4
Agriculture	259.6	420.4	161.9	680.0
Waste	43.6	85.1	195.2	128.7
Total	1099.0	690	62.8	1789.0

[32] For year 2009 Slovenia reported only the total primary energy from biomass used in heating and cooling sector (11.5 PJ). No division in feedstock categories was reported.

ANNEX V

Summary of renewable energy and bioenergy in NREAPs of non-EU Danube Countries
Ukraine, Moldova, Serbia, Albania

Ukraine [27]

Table A V. 1 Renewable Energy Contribution in each sector in Ukraine, 2009 – 2020

	2009	2013	2014	2015	2016	2017	2018	2019	2020
RES H/C (ktoe)	1473	2695	2955	3277	3690	4095	4575	5140	5850
RES E (ktoe)	980	1140	1275	1427	1525	1670	1840	2000	2175
RES T (ktoe)	52	90	174	221	298	351	395	445	505
RES total (ktoe)	2505	3925	4404	4925	5513	6116	6810	7585	8530
RES share in GFEC (%)	3.8	5.6	6.1	6.8	7.5	8.2	9.0	9.9	11.0

Table A V. 2 Bioenergy deployment in Ukraine, 2009-2020

	2009	2013	2014	2015	2016	2017	2018	2019	2020
Biomass H/C	1433	2480	2550	2680	2900	3100	3350	3650	4000
Biomass E				37			135		202
Biofuels		30	110	150	220	265	300	340	390
Bioenergy	1433	2510	2660	2867	3120	3365	3785	3990	4592
Bioenergy share in RES (%)	57.2	63.9	60.4	58.2	56.6	55.0	55.6	52.6	53.8

Moldova [28]

Table A V. 3 Renewable Energy Contribution in each sector in Moldova, 2009 – 2020

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
RES H/C (ktoe)	237	245.8	254.6	263.5	273.3	283.1	292.9	302.7	312.6	322.4	332.2	342
RES E (ktoe)	5	7	7	7	7	7	7.4	9.9	17.8	25.8	33.7	41.7
RES T (ktoe)							6.4	13.6	20.9	28.1	35.3	42.5
RES total (ktoe)	242	253	262	271	280	290	307	327	354	380	406	432
RES share in GFEC (%)	11.7	11.9	12.2	12.6	13	13.5	14.3	15.2	16.5	17.7	18.8	20

Table A V. 4 Bioenergy deployment in Moldova, 2009-2020

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass H/C (ktoe)	237	245.8	254.6	263.5	272.3	281.1	289.9	298.7	307.57	316.4	325.2	334
Biomass E (ktoe)							0.43	0.86	1.29	1.81	2.24	2.67
Biofuels (ktoe)	0.0	0.0	0.0	0.0	0.0	0.0	6.4	12.8	19.3	25.7	32.1	38.5
Bioenergy (ktoe)	237.0	245.8	254.6	263.5	272.3	281.1	296.7	312.4	328.2	343.9	359.5	375.2
Bioenergy share in RES (%)	97.9	97.2	97.2	97.2	97.3	96.9	96.7	95.5	92.7	90.5	88.6	86.8

Serbia [29]

Table A V. 5 Renewable Energy Contribution in each sector in Serbia, 2009 – 2020

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
RES H/C (ktoe)	1059	1031	1040	1043	1031	1043	1075	1092	1127	1143	1152	1167
RES E (ktoe)	884	1022	744	812	951	962	992	1004	1031	1059	1109	1151
RES T (ktoe)							34	74	117	159	203	24
RES total (ktoe)	1943	2053	1784	1855	1982	2005	2101	2170	2275	2361	2464	2564
RES share in GFEC (%)	21.2	20.9	17.5	17.8	19.3	19.7	20.9	21.8	23	24.3	25.6	27

Table A V. 6 Bioenergy deployment in Serbia, 2009-2020

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass H/C (ktoe)	1054	1025	1034	1037	1025	1036	1066	1082	1115	1130	1137	1152
Biomass E (ktoe)									5.7	8.5	23.0	81.3
Biofuels (ktoe)	0	0	0	0	0	0	34	74	117	159	203	245
Bioenergy (ktoe)	1054	1025	1034	1037	1025	1036	1100	1156	1237.7	1297.5	1363	1478.3
Bioenergy share in RES (%)	54.2	49.9	58.0	55.9	51.7	51.7	52.4	53.3	54.4	55.0	55.3	57.7

Albania [30]

Table A V. 7 Renewable Energy Contribution in each sector in Albania, 2009 – 2020

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
RES H/C (ktoe)	219	225	233	249	266	283	301	318	336	354	372	391
RES E (ktoe)	342	380	373	396	447	494	513	560	579	667	686	760
RES T (ktoe)	0	0	0	3	7	13	23	34	47	62	80	105
RES total (ktoe)	562	605	606	647	720	790	836	912	962	1083	1138	1256
RES share in GFEC (%)	29.79	30.54	28.80	29.02	30.56	31.80	31.99	33.22	33.40	35.90	36.06	38.06

Table A V. 8 Biomass deployment in electricity sector in Albania, 2009-2020

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass E (ktoe)				2.0	4.0	6.0	8.0	10.0	12.0	8.0	14.0	16.0

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