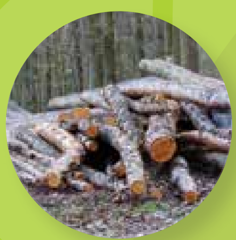
Update of the ARBOR benchmark report

Biomass for Energy in the North West European Region: statistics, targets and regional case studies.

June 2015



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*Improving **sustainable biomass utilisation** in North West Europe*

Colophon

This report was compiled in the framework of action 2 of the ARBOR* project.

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This report further received input from the other ARBOR partners on specific aspects related to the regional transferability of the investigated case study results. Willem Dhooge (FlandersBio, BE) also helped with text corrections and lay-out.

*Arbor is an Interreg IVB NWE project with 13 partners from 6 European regions dealing with the development of technological solutions and regional strategy development for improved sustainable biomass utilisation. ARBOR is cofunded by local authorities from the United Kingdom, Flanders, Saarland, Luxemburg, The Netherlands, and Ireland.

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Please check **www.arbornwe.eu** for the other reports that have been compiled within ARBOR:
- Five case study reports on a diversity of subjects like nutrient recovery, low impact energy crops, agro side streams, synergy parks and biomass closed-loop systems.
- An update of the 2012 Benchmark report on biomass for energy use in NWE
- A strategies report on biomass for energy for regional authorities in the North West European region.

Summary

ARBOR (an acronym for Accelerating Renewable Energies through valorisation of Biogenic Organic Raw Material) is an Interreg IVB project for North-West Europe and consists of a partnership between Belgium, Germany, Ireland, Grand Duchy of Luxembourg, The Netherlands and the United Kingdom. This report was set up to summarize, list and compare the current situation concerning bio-energy of these six countries. In 2012 the first version of the benchmark report was published. This report gives an update of the development of bio-energy and of the evolution towards the targets set for 2020.

In the first chapter, an overview is given of the current national statistics on renewable and bio-energy. The state-of-the-art situation for renewable (bio-)energy is compared to the 2020 targets. It appears that all countries except for The Netherlands and Ireland have achieved the intermediate bio-energy target for 2013 and are well on track for their 2020 targets. Furthermore, it can be seen that bio-energy plays an important role in the production of renewable energy and in all countries, except for Ireland, it attributes to more than half of the renewable energy production.

Chapter 2 elaborates on the origin of biomass. It lists how much biomass is expected to be locally available. Furthermore, it goes into detail on the share of imported biomass and on the sustainability criteria of biomass at the European level as well as at the member state level, restricted to the partner countries.

In the last chapter, for each country from the partnership at least two case studies that can serve as an innovative example in producing bio-energy in their country are mentioned. The cases were initially mentioned in the 2012 Benchmark report and are now updated presenting their progress and experiences. Also a comprehensive table was made of all ongoing bio-energy projects in the project region.

Project results

Details about the results of the ARBOR project can be found in separate thematic reports. An overview of the reports that were published within the ARBOR project is given below. These reports can also be consulted online on www.arbornwe.eu.

Pilots and investment report

Biomass for Energy in the Northwest European Region: An overview of pilots and investments
A number of pilots and investments were realized within the ARBOR project in order to showcase good practice examples of biomass utilization that contribute towards the EU 20 20 20 targets in a sustainable way. This report gives a description of the different pilots and investments carried out within the project.

Case study reports

Development of Low-Impact Energy Crops
Four types of low-impact energy crops were identified: short rotation coppice, cover crops, biomass-buffer strips, and energy crops on marginal land. These crops were tested at a pilot scale with regard to the multifunctional use, such that the competition for food production is minimized. The applied technology, biomass yield, bottlenecks and other aspects are discussed in the report.

Development of agro-side streams for bio-energy
The report describes how agricultural residues (straw from maize, leaves from leek and stems from Brussels sprouts) can be applied in anaerobic digestion and the use of manure in small scale digestion. Special attention is given to the challenges related to the collection on-field, the pre-treatment, the storage and the biogas production potential of the different agro-side streams.

Development of synergy parks
The report aims to offer insights on collaborative biomass usage within individual ARBOR-regions. In particular, the report brings together information on common and divergent policies and practices on biomass usage, with a focus on national and regional policies, applied technologies and potentials for enhanced biomass valorizations.

Nutrient recovery from digestate
Different types of recovered products were used in an open field trial and a greenhouse trial. The impact of applying digestate derivatives instead of mineral fertilizers and/or animal manure (traditional fertilization) on crop yield and soil quality were evaluated. Results of the field trials, and the relevant legislation can be found in this report.

Development of closed loop systems from biomass valorization by local authorities
By means of pilots in different regions, closed loop systems were evaluated: a supply chain of woody biomass by using own wood waste resources and dry digestion of grass from verges by commercial composting units. For the utilization of sewage sludge, greenery cuttings and landscape material, a sustainable strategy was developed. Further, it was investigated how social economy can be integrated in biomass sourcing. Methods and results are described in the report.

Strategy development report

Development of regional strategies for the acceleration of bioenergy in Northwest Europe
Based on the findings from numerous case studies as described in the case study reports, a comprehensive biomass strategy for the region of Northwest Europe was developed. For the different fields of application, including municipal, agricultural and industrial waste streams, strategic guidelines are formulated within the report. It is described how the biomass streams can be used for energy production and which challenges have to be dealt with.

Inventory reports

Inventory: techniques for nutrient recovery from digestate
The report gives an overview of the inventory made of existing nutrient recovery techniques from digestate in North-West Europe. It also shows how digestate can be used as a sustainable source of nutrients. A distinction is made between currently used digestate processing techniques and nutrient recovery techniques.

Inventory: biomass conversion technologies
The report gives an overview of existing methods for gas, liquid and solid biomass conversion in the partner countries. Well-established methods involve producing steam, which is then used to drive a steam engine or turbine generator. Gas turbines have been used with biomass as well, but have a lower thermal efficiency. In addition to direct combustion, biomass can be converted into gas fuel via gasification or pyrolysis. For all other biomass with higher moisture content like slurry, it can either be processed in a fermentation or anaerobic digestion system producing biogas.

Physicochemical characterisation and market analysis of recovered nutrients from digestate
A report was dedicated to the physicochemical properties of digestate and its derivatives, as derived from field experiences. The following products were used in the ARBOR field trials: ammonium sulphate, the liquid fraction (LF) of digestate, a mixture of digestate and the LF of digestate, struvite and the effluent of constructed wetlands. Results of the field trials and market analysis are described in the report.

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[1] These diagrams are based on most recent available estimates delivered by the partners of the ARBOR project and Eurostat: for Germany data was retrieved from Bundesministerium for Wirtschaft und Energie (2014), for Ireland from the SEAI (2014), for Luxembourg from STATEC and "Statictics from Institut Luxembourgeois de Régulation et Administration de l'Environnement" (2014), for United Kingdom from the Department of Energy and Climate Change (2014), for The Netherlands Centraal bureau voor de statistiek (2014) .

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List of abbreviations

ARBOR	Accelerating Renewable Energies through valorisation of Biogenic Organic Raw Material
AEBIOM	European Biomass Assocation
Av. red.	Aviation reduction
BOS	Biofuel Obligation Scheme
CHP	Combined heat and power
DECC	Department of Energy and Climate Change
EC	European Commission
EEG	German Renewable Energy Act
EU	European Union
FIT	Feed-in tarif
FQD	Fuel Quality Directive
FSC	Forest stewardship council
GEC	Green electricity certificates
GHG	Greenhouse gas
GWh	Gigawatthour
HWRC	Household waste recycling centre
KGW	Kitchen and Garden Waste
Ktoe	kiloton oil equivalent
ILUC	Indirect land-use change
IPPC	Integrated Pollution Prevention Control
ISCC	International sustainability carbon certification
LNG	Liquified natural gas
LPG	Liquified petroleum gas
LoW	European List of waste
MAP	Market incentive program
NGO	Non-governmental organisation
NREAP	National renewable energy action plan
NTA	Netherlands Technical Approach
ORC	Organic Rankine Cycle
PEFC	Programme for the Endorsement of Forest Certification
Ref	Reference scenario
SRC	Short rotation coppice
SRF	Solid recovered fuels
SEI	Sustainable Energy Ireland
SEAI	Sustainable Energy Authority Ireland
RED	Renewable energy directive 2009/28/EC
RES	Share of renewable energy
RHI	Renewable Heat Initiative
RO	Renewable Obligation
WFQA	Wood Fuel Quality Assurance Certification
WFTC	Wood Fuel Trading and Consulting

Introduction

This report describes the framework for the development of biomass use in North West Europe and is the starting point of the concluding documents for ARBOR, an Interreg IVB project for North-West Europe. ARBOR stands for Accelerating Renewable Energies through valorisation of Biogenic Organic Raw Material. It was approved in March 2011 as a strategic initiative for a duration of 4 years. The different ARBOR-partners are:

- From Belgium: FlandersBio, Ghent University, Inagro, Provincial Development Agency West Flanders (POM West-Vlaanderen), Flemish Coordination Centre for Manure Processing (VCM)
- From Germany: Institute for Future Energy Systems (IZES) gGmbH
- From Ireland: University College Dublin (NUID - UCD)
- From Luxembourg: Luxembourg Institute of Science and Technology (LIST), formerly known as the Public Research Centre Henri Tudor (CRP Henri Tudor)
- From The Netherlands: DLV Plant BV, Province of Utrecht, Wageningen University
- From the UK: Stoke-on-Trent city Council, Staffordshire University (lead partner)

Total budget for ARBOR is € 7 361 959.

The framework for ARBOR are the EU 202020 targets in order to mitigate climate change and the fact that biomass accounts for 50% of the renewables in Europe. Although a lot of expertise concerning biomass is available, it is noted that this information is not disseminated in a coordinated way, nor is it related to commercial exploitations. That is why the ARBOR-mission is to accelerate the sustainable development and use of biomass in North West Europe, to facilitate the achievement of the EU 20 20 20 objectives and to realise a world-class utilisation of biomass.

The aim of this document, as a part of the total ARBOR-project, is to get a comprehensive assessment on the use of biomass for bio-energy in the project regions prior to the project take-off (2005) and at the final stage of the project, based on the most recent data available (2013).

Data was gathered by means of a questionnaire that was filled out by the different partners. Another important source of information was the National Renewable Energy Action Plans (NREAP) that every Member State had to make in order to comply with article 4 of the Renewable Energy Directive (2009/28/EC) and the data available throughout SHARES, short assessment of renewable energy sources, from Eurostat.

Other frequently consulted documents/websites, are:

- Beurskens, L.W.M., Hekkenberg, M. & Vethman, P. (2011). Renewable Energy Projections as published in the National Renewable Energy Action Plans of the European Member States covering all 27 EU Member States with updates for 20 Member States. Version of 28th November 2011. European Environment Agency, 270p.
- Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC
- **www.aebiom.org**

The initial report and the update was composed by Inagro (Greet Ghekiere, Anke De Dobbelaere, Brecht Annicaert) and POM West-Vlaanderen (Geert Dangreau, Viooltje Lebuf, Brecht Vanhecke, Lien Loosvelt). FlandersBio (Willem Dhooge) took care of the final lay-out.

Chapter 1 – Statistics and targets of renewable energy and bio-energy

1.1 Targets for renewable energy and bio-energy to 2020

In table 1 the targets for renewable energy from the renewable energy directive 2009/28/EC (RED) are shown, including the trajectories to be followed.

Table 1: Overall renewable energy targets from the RED (share of renewable energy in gross final energy consumption (%)).[2]

	2005	2010	2015	2020
Belgium	2.2	4.4	7.1	13.0
Germany	5.8	8.2	11.3	18.0
Ireland	3.1	5.7	8.9	16.0
Luxembourg	0.9	2.9	5.4	11.0
The Netherlands	2.4	4.7	7.6	14.0
United Kingdom	1.3	4.0	7.5	15.0

In their National Renewable Energy Action Plan (NREAP) countries have specified till 2020 how much of the renewable energy will be coming from biomass. In table 2 these 'targets for bio-energy' are summarised. [3]

Table 2: NREAP targets for bio-energy specified by countries to achieve the targets for renewable energy by 2020 (%).

	2005	2010	2015	2020
Belgium	1.7	3.1	5.2	8.9
Germany	4.5	6.9	7.8	9.9
Ireland	1.5	2.8	5.4	6.9
Luxembourg	0.5	1.6	3.2	6.7
The Netherlands	2.0	3.1	5.3	7.5
United Kingdom	0.9	1.7	3.3	7.3

Based on the most recent available national statistic, an overview can be made of the current share of renewable energy and bio-energy. This can be seen in figure 1b and 2b and compared with the targetted shares in figure 1a and 2a for the different partner countries. It is clear that bio-energy will account for an important share of renewable energy in the near future.

[2] The targets shown for 2010 and 2015 are these calculated for the respective trajectory periods 2011-2012 and 2015-2016 following the equations defined in the RED: S2005+0,20*(S2020-S2005) for 2011-2012 and S2005+0,45*(S2020-S2005) for 2015-2016. The share of renewable energy is the amount of renewable energy in gross final energy consumption after a reduction for aviation is applied for some countries as defined in the RED.

[3] The targets for bio-energy, as we will call them here, are the amounts of bio-energy in final energy consumption according to the reference scenario without aviation reduction (when applicable) (reference: Beurskens *et al.* (2011)), since the data for the actual situation did not include aviation reduction and are based on final energy consumption. When comparing the shares of renewable energy with those of bio-energy this means that for some countries the share of biomass in gross final energy consumption would be a bit smaller than the shares based on final energy consumption. In short: when comparing the shares of renewable energy with bio-energy, bio-energy can be a little underestimated for some countries. The Netherlands don't have a reference scenario so numbers are based on the additional energy efficiency scenario.

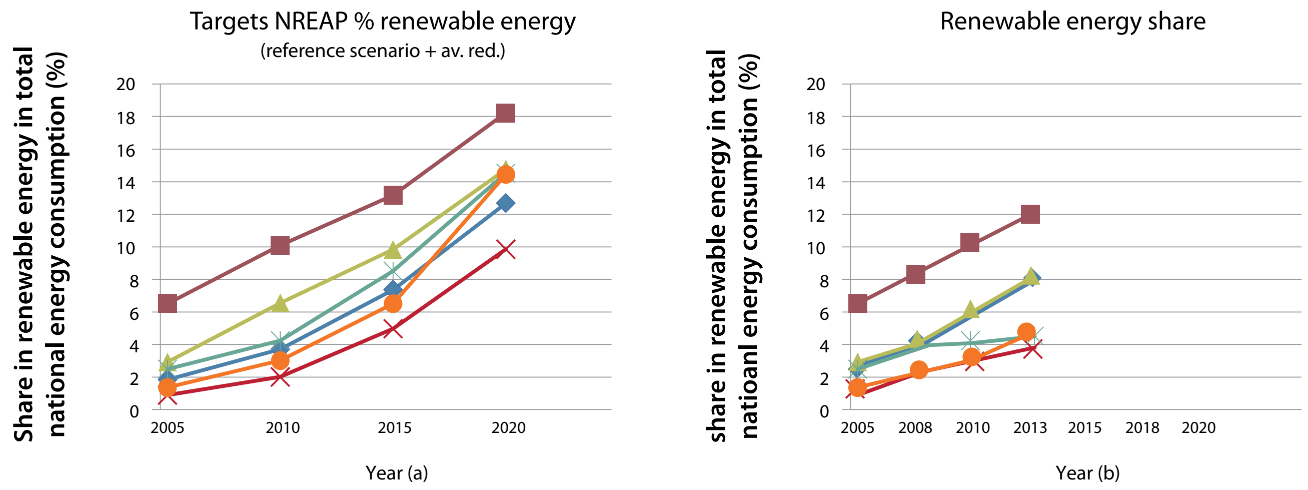


Figure 1: Evolution of the share in renewable energy according (a) to the targets specified in the RED (ref. incl. av. red.) and (b) in reality

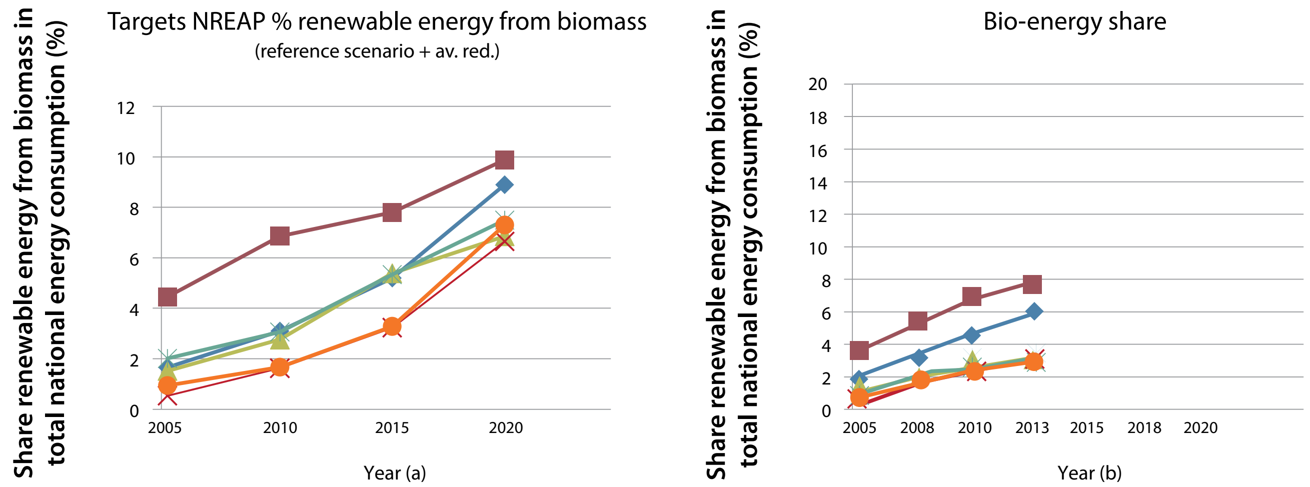


Figure 2: Evolution of the share in renewable energy from biomass according (a) to the targets specified in NREAP (ref. incl. av. red.) and (b) in reality

On the basis of the national statistics (figure 1) and the targets (table 1) it can be concluded that all countries except The Netherlands are well on track in reaching the targets for renewable energy according to their intermediate targets of 2010 and 2013. Nevertheless most countries predicted an exponential growth in renewable energy production and thus the largest rise in share for the period 2015-2020 this is, however, not reflected in the statistics. This can be seen in table 3 where the efforts for the year 2010 and 2013 in comparison with the target for 2020 are displayed. The data gives a clear indication that in 2013 the United Kingdom, The Netherlands and Luxembourg have achieved a third of their renewable energy target for 2020 while Ireland is halfway and Belgium and Germany have reached almost two thirds of their targets.

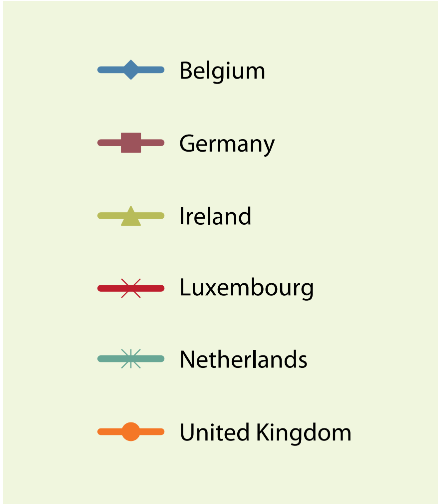


Table 3: Renewable energy efforts (presented as a factor = (target 2020)/(situation 2010 or 2013)) still to be made by the countries till 2020.

Efforts	Belgium	Germany	Ireland	Luxembourg	The Netherlands	United Kingdom
Renewable energy Situation 2010	2,3	1,7	2,9	3,8	3,8	4,6
Renewable energy Situation 2013	1,6	1,5	2,1	3,1	3,1	2,9

For bio-energy Germany, Belgium, Luxembourg and the United Kingdom are well on track as can be seen from table 2 and figure 2. Ireland and The Netherlands do not reach their intermediate targets for bio-energy set out in the NREAP. Similar conclusions can be drawn towards the bio-energy statistics and targets where the fastest growth of renewables is foreseen for the period in 2015-2020 but on the other hand statistics show a slower growth or even a stagnation for bio-energy production. In table 4 this is demonstrated by putting the effort needed to reach the targets of 2020 for bio-energy. For Germany, Ireland and Netherlands this data shows a small progress in regard to the efforts made between 2010 and 2013 for reaching the targets in 2020.

Table 4: Bio-energy efforts (presented as a factor=(target 2020)/(situation 2010 or 2013)) still to be made by the countries till 2020.

Efforts	Belgium	Germany	Ireland	Luxembourg	The Netherlands	United Kingdom
Renewable energy from Biomass Situation 2010	2,0	1,4	2,3	2,9	3,3	3,0
Renewable energy from Biomass Situation 2013	1,5	1,3	2,1	2,4	3,1	2,3

1.2 Targets for renewable energy and bio-energy to 2030 and 2050

For 2030 the EU stated that the share of renewable energy should be at least 27 %, and together with a increased energy efficiency achieving a 40 % reduction in greenhouse gas (GHG) emissions. In this 2030 framework it is further mentioned that in regard to biomass use the focus is on the deployment of second and third generation biofuels and on the development of an improved biomass policy to maximise the resource efficient use of biomass in order to deliver robust and verifiable GHG savings.[4]

The EU 2050 roadmap towards a low carbon economy attributes a great role for renewable energy from domestic resources such as local biomass in achieving the 80 % reduction of GHG emission.[5]

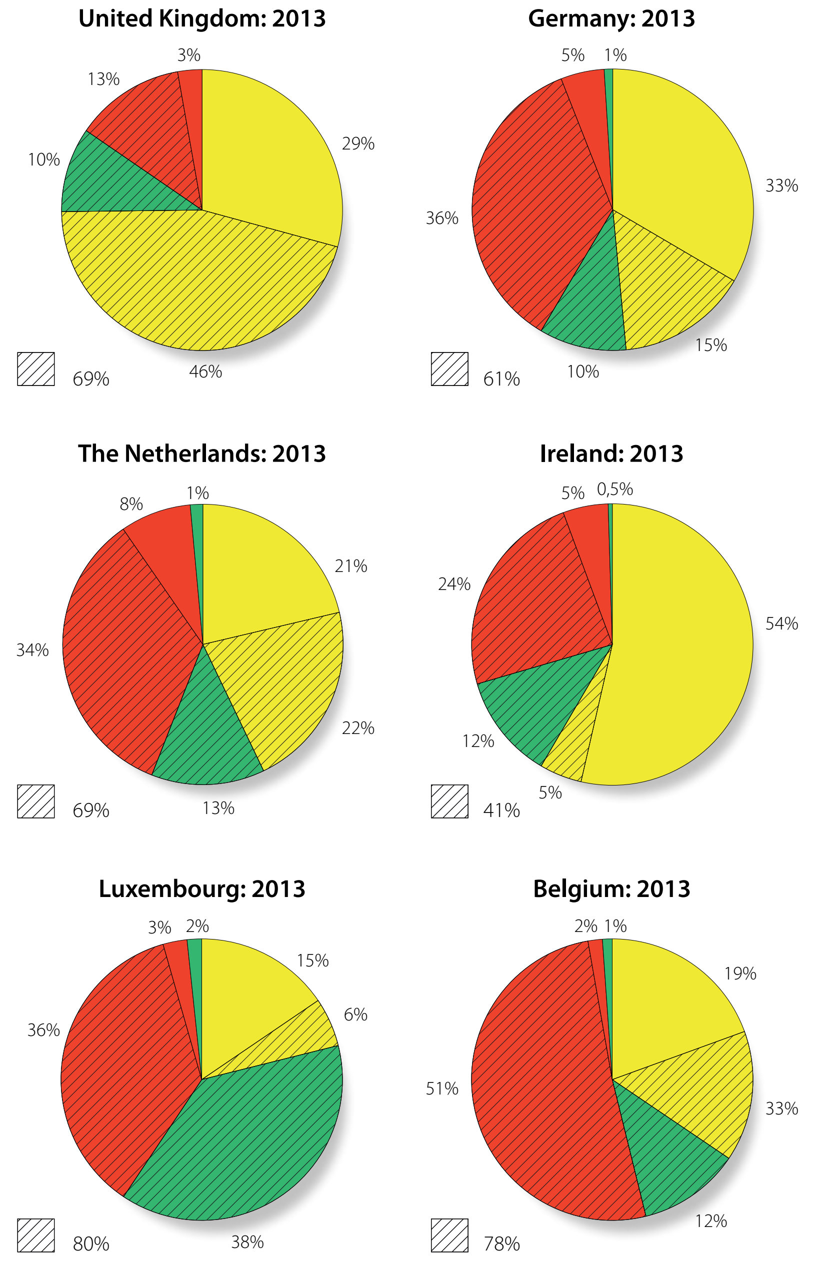
[4] COM(2014)15 "A policy framework for climate and energy in the period from 2020 to 2030"
eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52014DC0015

[5] COM(2011) 112 "A Roadmap for moving to a competitive low carbon economy in 2050"
eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0112

1.3 Renewable (bio-)energy for electricity, heating or cooling and biogenic fuels

Biomass and other renewable sources are used to produce electricity, heat (or cooling) and biogenic fuels. In figure 3 it is shown how inputs are divided over these three categories:

Figure 3: Production of renewable energy (from biomass (shaded areas)) for electricity (yellow), heating & cooling (red) and transport (green) in Belgium, Germany, Ireland, The Netherlands and United Kingdom for 2013 [6]



From these diagrams it can be concluded that for all six countries, with exception of Ireland, biomass is used to produce more than half of the renewable energy. In the United Kingdom, biomass is mainly used for electricity production, while in Belgium, Germany and Ireland it is mainly used for heating and cooling. In Luxembourg the largest share of biomass goes to the production biofuels.

Renewable electricity · Renewable heating and cooling · Renewable transport · Energy from biomass

1.4 Overview biomass targets divided in three categories: renewable electricity, renewable heating and cooling and renewable transport

In the following figures for the three categories (electricity, heating & cooling and transport) an overview [7] (for the six countries) is given of the evolution of the distribution of renewable energy coming from multiple inputs for the years 2005, 2010, 2015 and 2020. Again it can be concluded that biomass is expected to produce a large share of the renewable energy in the future. Next to the planned evolution the actual situation [8] in 2013 is given for comparison.

- Other renewables
- Biogas
- Liquid biomass + other biogenic
- Solid biomass
- Other biofuels
- Bioethanol
- Biodiesel

***Belgium:** planned distribution of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020.*

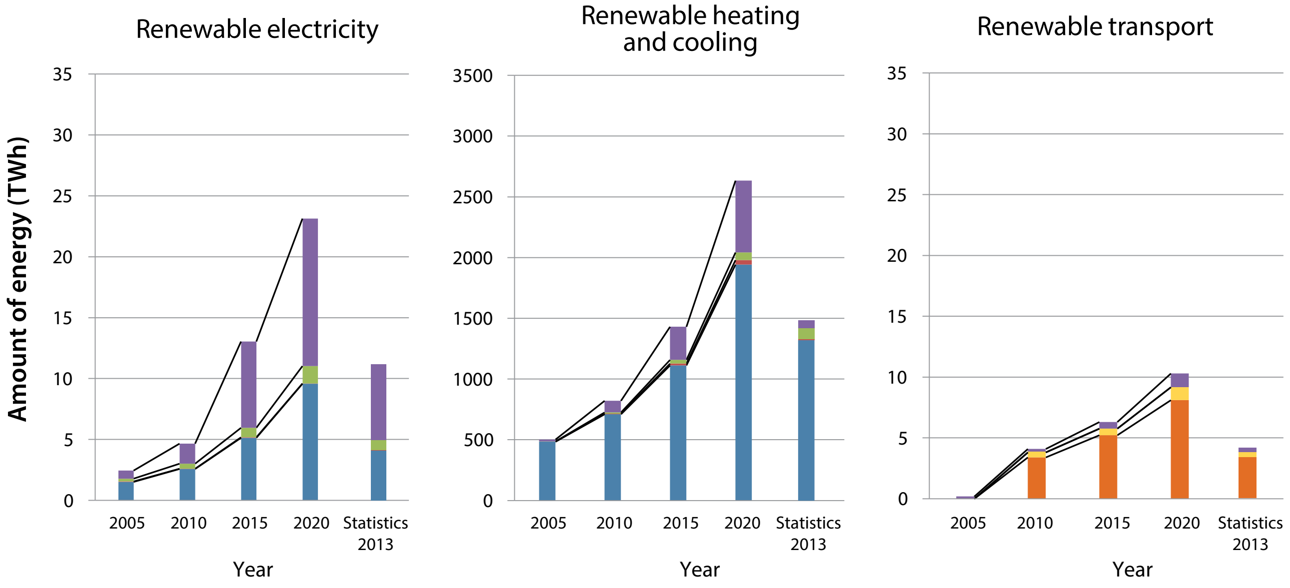


Figure 4: Planned distribution for Belgium of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020, divided over three categories: renewable electricity, renewable heating & cooling and renewable transport.

[6] These diagrams are based on most recent available estimates delivered by the partners of the ARBOR project and Eurostat: for Germany data was retrieved from Bundesministerium for Wirtschaft und Energie (2014), for Ireland from the SEAI (2014), for Luxembourg from STATEC and "Statictics from Institut Luxembourgeois de Régulation et Administration de l'Environnement" (2014), for United Kingdom from the Department of Energy and Climate Change (2014), for The Netherlands Centraal bureau voor de statistiek (2014) .

[7] Data are based on the data mainly coming from the NREAP according to: Beurskens *et al*. (2011).

[8] EUROSTAT SHARES, short assessment of renewable energy sources (2014) ec.europa.eu/eurostat/web/energy/data/shares

***Germany:** planned distribution of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020.*

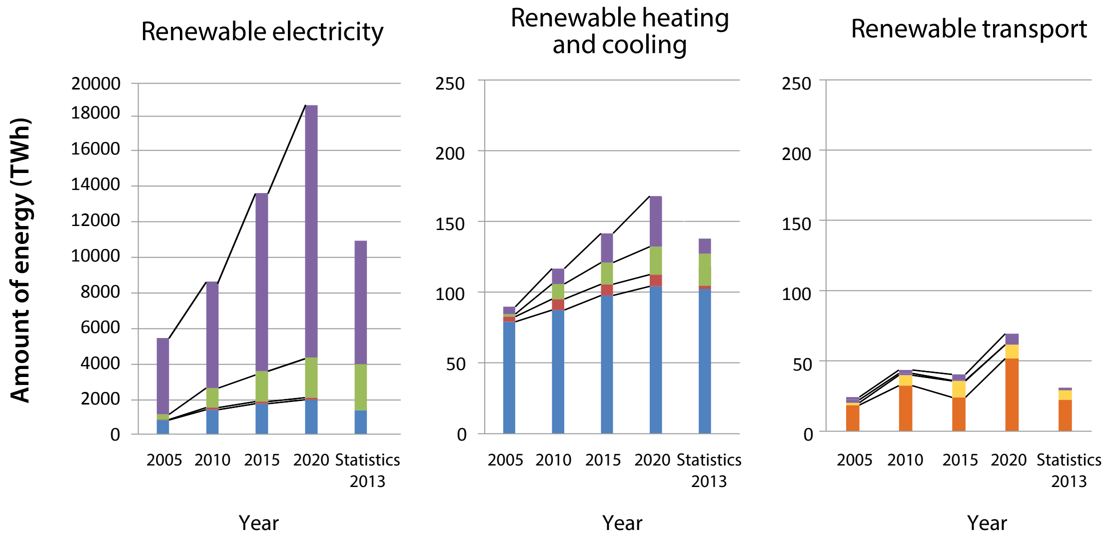


Figure 5: Planned distribution for Germany of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020, divided over three categories: renewable electricity, renewable heating & cooling and renewable transport. Comparison with state-of-the-art data from 2013.

***Ireland:** planned distribution of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020.*

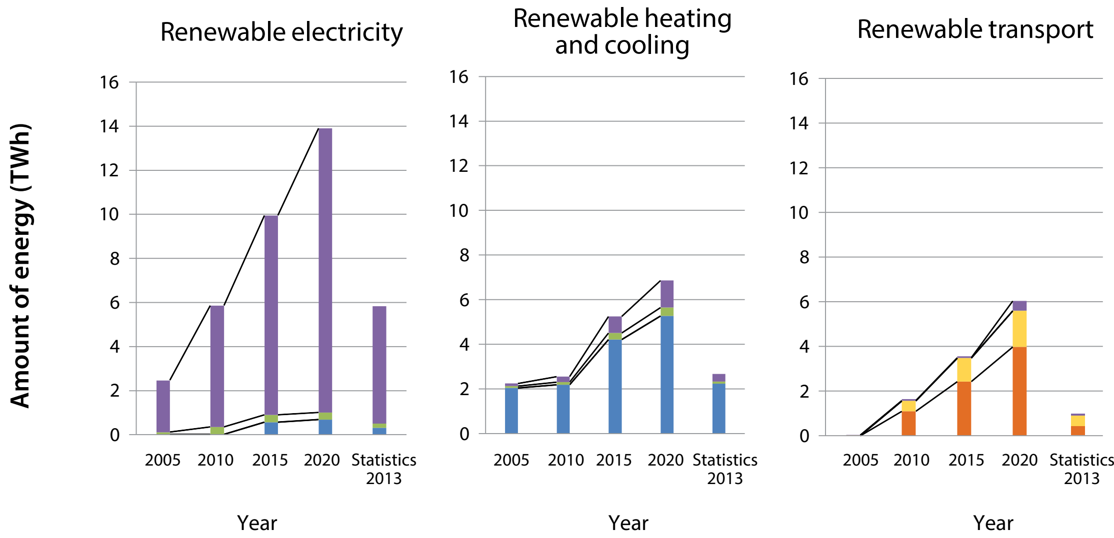


Figure 6: Planned distribution for Ireland of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020, divided over three categories: renewable electricity, renewable heating & cooling and renewable transport. Comparison with state-of-the-art data from 2013.

Luxembourg: planned distribution of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020.

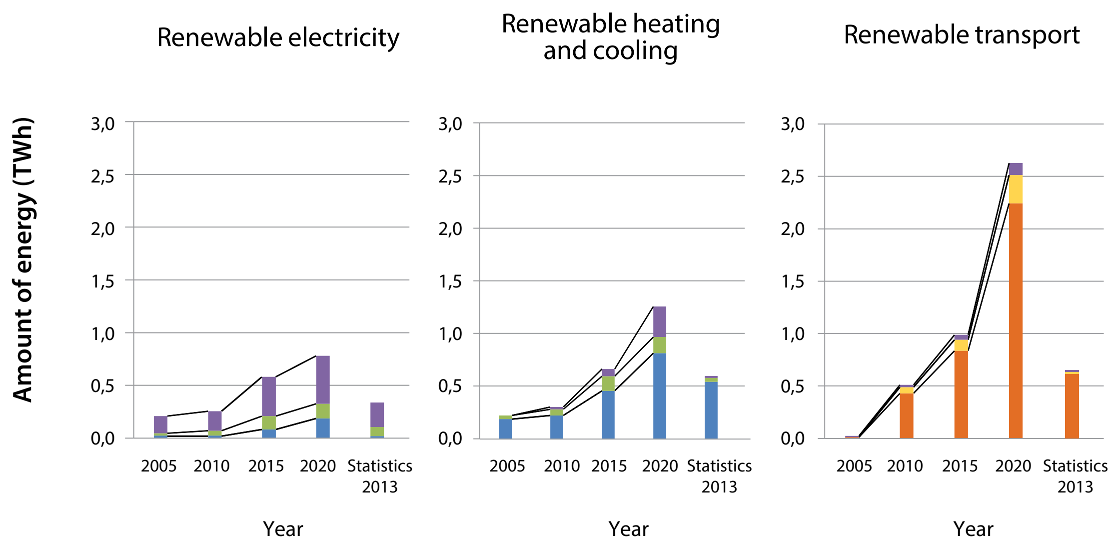


Figure 7: Planned distribution for Luxembourg of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020, divided over three categories: renewable electricity, renewable heating & cooling and renewable transport. Comparison with state-of-the-art data from 2012.

The Netherlands: planned distribution of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020.

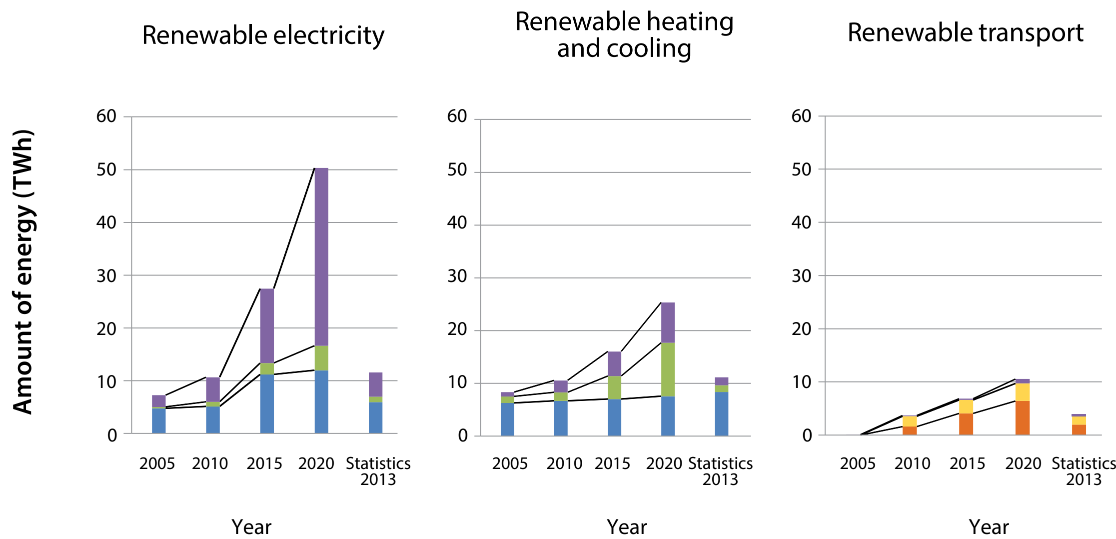


Figure 8: Planned distribution for The Netherlands of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020, divided over three categories: renewable electricity, renewable heating & cooling and renewable transport. Comparison with state-of-the-art data from 2013.

United Kingdom: planned distribution of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020.

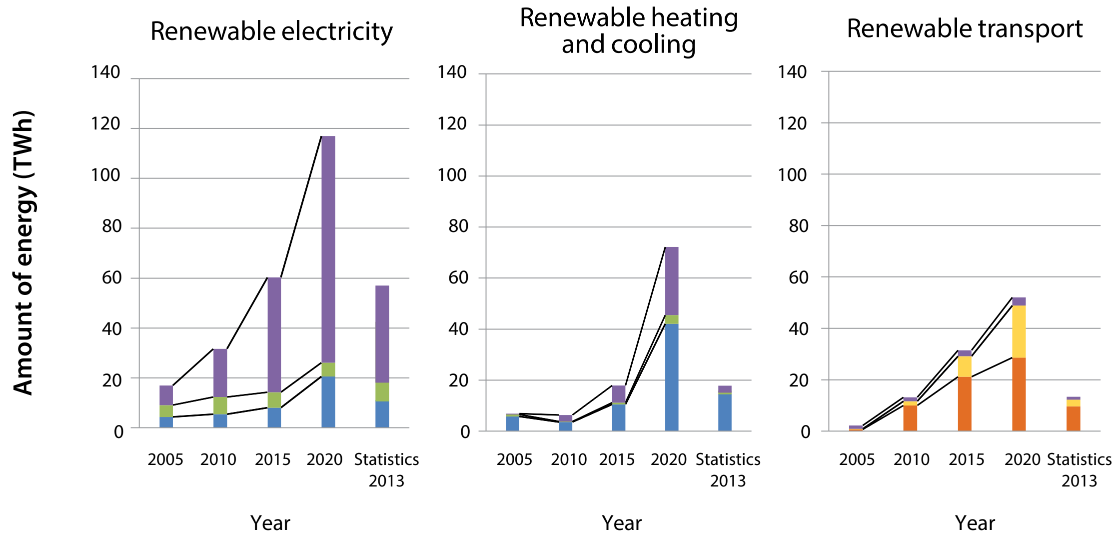


Figure 9: Planned distribution for the United Kingdom of multiple inputs for renewable energy in 2005, 2010, 2015 and 2020, divided over three categories: renewable electricity, renewable heating & cooling and renewable transport. Comparison with state-of-the-art data from 2013.

Biomass is expected to produce a large share of the renewable energy in the future.

Chapter 2 - Origin and sustainability of biomass

2.1 Evolution of local biomass

2.1.1 Reference and target scenario

The supply of biomass for heating and electricity in the year 2006 is shown in Table 5. Three categories of biomass are distinguished: woody biomass (including both direct supply, e.g. forests, and indirect supply, e.g. wood waste), agriculture and fisheries (including direct supply and by-products) and waste (including municipal waste, industrial waste and sewage sludge). The expected supply of biomass in the years 2015 and 2020 as given by the NREAPs is given in Table 6 and Table 7, respectively.

Table 5: Domestic resource of biomass in 2006 (ktoe) [9]

	Belgium	Germany	Ireland	Luxembourg	The Netherlands	United Kingdom
Woody biomass	450	9410	224	217	644	558
Agriculture and fisheries	84	5359	15	4.6	450	412
Waste	267	1058	6.8	49	1354	2196

Table 6: Expected amount (best scenario) of domestic resource in 2015 (ktoe) [9]

	Belgium	Germany	Ireland	Luxembourg	The Netherlands	United Kingdom
Woody biomass	723	12349	170	49	545	1226
Agriculture and fisheries	440	7978	382	25	1587	1424
Waste	483	2126	235	23	2354	12694

[9] Source: National renewable energy plan (ec.europa.eu/energy/renewables/action_plan_en.htm)

Table 7: Expected amount (best scenario) of domestic resource in 2020 (ktoe) [9]

	Belgium	Germany	Ireland	Luxembourg	The Netherlands	United Kingdom
Woody biomass	869	11966	258	107	868	1789
Agriculture and fisheries	1030	9482	775	39	2754	5296
Waste	457	2317	435	27	2965	18142

Summary

In 2006, Germany possessed the largest amount of domestic resources of woody biomass, as well as biomass from agriculture and fisheries. The UK possessed the largest domestic resource of biomass coming from waste. In Belgium, Germany, Ireland and Luxembourg, the major part of the biomass input stems from woody products. In The Netherlands and the UK, waste is the main source of biomass for energy and heat production.

Concerning the availability of biomass in 2015 and 2020, a large increase in all input categories is expected, especially between 2006 and 2015. In Belgium, Luxembourg, The Netherlands and the UK, the amount of biomass from agriculture and fisheries is attributed a high growing potential, whereas in the UK also the amount of biomass from waste products is expected to largely increase in the future. After 2015, further increases in the biomass supply are expected, with exception of Germany for which a slight decrease of woody biomass and biomass from waste is expected.

It should be noted that for the Netherlands, the expected amounts in 2015 and 2020 are highly variable: a huge, almost impossible, increase of biomass from agriculture and fisheries is expected,...., whilst woody biomass is expected to decrease with 40% between 2006 and 2015. This trend is not coherent with the available data for the years 2009-2012. Hence, these figures should be interpreted with caution.

2.1.2 Developments after 2006

Since 2006, the evolution in the supply of biomass is recorded by the EU countries in a progress report on renewable energy that is published by the European Commission every two years. Tables 8 to 11 summarize the availability of biomass in the period 2009-2012. In addition, the evolution in the domestic agricultural land use for the production of crops for energy production is given in Table 12.

Table 8: Domestic resource of biomass in 2009 (ktoe) [10]

	Belgium	Germany	Ireland	Luxembourg	The Netherlands	United Kingdom
Woody biomass	648	NA	149	NA	828	1086
Agriculture and fisheries	175	NA	4.5	NA	192	477
Waste	361	NA	60	NA	1157	4029

Table 9: Domestic resource of biomass in 2010 (ktoe) [10]

	Belgium	Germany[11]	Ireland	Luxembourg	The Netherlands	United Kingdom
Woody biomass	789	5492	159	50‡	808	1224
Agriculture and fisheries	210	3255	4.1	25‡	358	439
Waste	494	7040	64	84‡	1168	4139

Table 10: Domestic resource in 2011 (ktoe) [12]

	Belgium	Germany[13]	Ireland	Luxembourg	The Netherlands	United Kingdom
Woody biomass	1050	NA	138	NA	728	1487
Agriculture and fisheries	87	NA	41	NA	356	492
Waste	487	1167	68	NA	1269	2894

Table 11: Domestic resource in 2012 (ktoe) [12]

	Belgium	Germany[14]	Ireland	Luxembourg	The Netherlands	United Kingdom
Woody biomass	1139	9372	143	NA	831	1410
Agriculture and fisheries	94	NA	33	NA	331	633
Waste	522	1270	75	NA	1361	3118

Based on the progress reports and the expectations for 2020, following observations concerning the domestic resources of biomass van be made:

- **Belgium:** the supply of biomass from woody products and waste has gradually increased following the expected trajectory, while the amount of biomass from agriculture and fishery has considerably decreased between 2010 and 2012 towards an amount reaching 1/10th of the expected amount in 2020.

- **Germany:** the Progress report from Germany states that there has been no substantial change to the availability of biomass in Germany between 2006 and 2013. There has been an increase in area under cultivation for biogas substrates, in particular maize. Well over a quarter of the area planted with maize is used for energy in Germany at the present time.

- **Ireland:** all biomass inputs remained low over the last years, with the waste input being a fifth of the expected amount in 2020. The largest single stream, which is forest based biomass (although increasing in absolute terms), remained at a consistent 45% of total biomass for bio-energy over the period 2008-2010. The contribution from liquid biofuels has increased from 20% of total biomass in 2008 to 26% in 2010.

- **Luxembourg:** available data are scarce such that it is difficult to evaluate the evolution in biomass supply. Based on the data from 2010, it is observed that the supply from woody products has decreased but this was compensated by an increasing biomass supply from agriculture, fishery and waste.

- **The Netherlands:** similar as in 2006, most biomass for electricity generation and heating comes from waste from the Dutch domestic market. In addition, a great deal of waste wood is made available for energy purposes, for use both in The Netherlands and in other EU States. Another important stream is the importation of wood pellets for co-incineration in power stations. A large proportion of these comes from North America.

- **UK:** the biomass supply is steady with slight fluctuations, especially concerning the waste stream. The single largest feedstock for renewable energy in UK transport in 2009 and 2010 was soy with 1120 and 907 ktoe supplied, respectively. This was all imported from outside the EU. Sugar cane, primarily from Brazil also contributed a significant proportion of the energy. Oilseed rape is the largest EU feedstock with over 200 ktoe supplied in each year. The largest UK feedstock was sugar beet with 92 and 129 ktoe supplied in 2009 and 2010, respectively. There was a significant increase in the amount of used cooking oil (UCO) reported from all sources in 2010 reflecting the removal of the duty differential for all biofuels except those derived from UCO in April that year.

[12] Source: Renewable Energy Progress Reports – Data for 2011-2012 (ec.europa.eu/energy/renewables/reports/2013_en.htm)
[13] Source: BMU 2013, Zeitreihen zur Entwicklung der erneuerbaren Energien in Deutschland – unter Verwendung von Daten der Arbeitsgruppe Erneuerbare Energien-Statistik (A-GEE-Stat), Berlin.
[14] Source: Mantau (2013), Umsatzentwicklung energetischer Holzverwendung in Deutschland 2000 bis 2012. Studie im Auftrag der AGEE-Stat. Hamburg 2013

Table 12: Land used in the period 2006-2012 for low-impact energy crops [9,10,12]

	Land for short rotation coppice (ha)					Land for other energy crops (ha) *(reed canary grass, switch grass, Miscanthus, sorghum, ...)*				
	2006	**2009**	**2010**	**2011**	**2012**	**2006**	**2009**	**2010**	**2011**	**2012**
BE	0	78	139	145	165	0	81	82	138	190
DE	1200	2300	3600	4000	4900	1100	1800	2100	2000	3000
IE	63	360	548	689	839	617	2101	2166	2349	2413
LU	0	NA	NA	NA	NA	0	50	0	84	145
NL	0	12	8	13	6	10000	8193	10715	6091	6224
UK	4196	NA	NA	2720	2551	5316	NA	NA	8075	7517

Summary

In general there has been an increase in the availability of biomass for energy and heating between 2006 and 2012 with woody biomass and waste as the main suppliers. For these inputs the target amounts for 2020 will be reached as only a slight deficit is present. On the contrary, the supply of biomass from agriculture and fishery has not yet reached the target capacity and does not show further growing potential.

With exception of The Netherlands, all countries show an increase in the land used for energy production. Energy crops generally comprise most of the land use, while short rotation coppice is clearly less popular. Only in Germany, more land is made available for short rotation coppice than for energy crops.

2.2 Imported biomass

2.2.1 European Union

The European Commission Staff Working Document SWD (2014) 259 mentions a gap in 2020 of 21,4 Mtoe between primary energy from domestic (EU) biomass supply for electricity, heating and cooling and the total supply needs. This is equal to over 15% of EU primary bio-energy supply in 2020. This is likely to be met by imports from out of the EU and largely in the form of wood chips and densified wood, e.g. pellets. According to expert opinions wood pellets can be classified as the main traded commodity of solid biofuels [15]. The EU-27 is currently the largest global producer of wood pellets (10,5 million tonnes in 2012) and is also a net importer of wood pellets: in 2009 imports from non-member countries were about 1,7 million tonnes, by 2012 this amount increased to 4,5 million tonnes (Eurostat, 2013). According to AEBIOM [16] the consumption of wood pellets in the EU should rise to 18,3 million tonnes in 2013, compared to a global consumption of 23,2 million tonnes. EU production in 2013 was 12,2 million tonnes in 2013, meaning that the EU imported one third of its consumption that year. Imports will further increase strongly and are expected to be in the range of 15-30 million tonnes (equal to 6-12 Mtoe) by 2020 (Pelkmans *et al.*, 2012). The Impact assessment of the energy and climate policy up to 2030 foresees a continuous increasing biomass demand for heating and electricity after 2020, primarily through imports.

[15] Pelkmans *et al.* (2012), Benchmarking biomass sustainability criteria for energy purposes, VITO consortium
[16] European Biomass Association, European Bioenergy Outlook 2014, consulted in the solid biomass barometer January 2015 of Eurobserv'ER

According to the EC renewable energy progress report (COM(2013)175) on the feedstock needs for biodiesel production in the EU, 60% of the biodiesel is produced within the EU. Biodiesel is the main biofuel for road transport in the EU, accounting for 79% of the total biofuel consumption on energy content base in 2013 (Eurobserv'ER, 2014) The share for bio-ethanol is larger: about 80% of all used feedstock for bio-ethanol serving transport is covered by EU resources.

Since imported volumes of biomass vary largely among the partner countries, the current and future expected imports of biomass for the ARBOR-countries are outlined below, in addition to the abovementioned overview of biomass imports for the EU as a whole.

2.2.2 Belgium

The imported amount of wood pellets increased more than three times between 2010 and 2012: from 315 000 tonnes in 2010 to 972 000 tonnes in 2012 (Eurostat, 2013). In 2012 the total consumption in Belgium was 1,7 million tonnes of pellets, so 57% was imported. Most pellets are consumed by large scale power plants, minor volumes for residential use. Since the Flemish government stopped temporarily (March-September 2013) the issuing of Green Electricity Certificates to the largest biomass power plant in Belgium and since another big biomass power plant in the Walloon region also temporarily stopped production, imported and consumed quantities in 2013 decreased to respectively 896 000 and 800 000 tonnes (an import rate of almost 90%).

In the Flemish region the government decided in mid-2014 to stop granting abovementioned Green Electricity Certificates for new biomass power plants with a capacity larger than 20 MW, except for two new large biomass power plants which were already granted permission. The Flemish Energy Agency VEA foresees that power production out of biomass will double from 2016 due to these two new plants which rely almost only on imported biomass (wood pellets and energy crops). For the trajectory 2020-2030 three scenarios were forecasted (VITO, 2014): the 'low bio' scenario stipulates a stand still in biomass use against 2030 compared to 2012 and assumes that two thirds of the biomass will be produced locally. In contrary, the 'medium' (25% renewable energy) and 'high' (30% renewable energy) scenarios need both an increase of imported biomass.

2.2.3 Germany

Electricity: In Germany several studies have dealt with the acceleration scenarios of renewable energies in Germany up to the target year 2050. Summarizing the findings, Germany has no strategy to import biomasses and is so far not calculating with net-imports from energetically used biomass despite the sectors biomass fuels for transport and partly biomethane. Different studies prospect different energy demand coverages, as summarized in the German study: "Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global, 2012 [17]":

- Biofuels 2050: between 436-2369 PJ/a
- EE methane 2050: 0-266 PJ/a

Germany is the third largest wood pellet producer in the world after the United States and Canada. The total domestic production in 2013 was 2,25 million tonnes of which about 2 million tonnes were produced from residues of the timber industry. The market for pellets in Germany depends mostly on domestic production: the total import of pellets is rather low (about 450 000 tonnes in 2013) compared to EU countries as the UK, Denmark and Italy (USDA, 2014).

[17] http://www.dlr.de/dlr/Portaldata/1/Resources/bilder/portal/portal_2012_1/leitstudie2011_bf.pdf

2.2.4 Luxembourg

According to Eurostat-figures import of wood pellets in Luxembourg is negligible (4000 tonnes in 2010). No further data is available, except from the NREAP: in 2006 the import of woody biomass from forestry was 1,6 ktoe. It is expected that this amount will increase up to 45 ktoe in 2020. A large share of the renewable energy targets is planned to be obtained by biofuel imports, since the transport sector currently represents more than half of the country's final consumption (Resch, G., 2014).

2.2.5 Ireland

Data for precise numbers and ratios of imports of biomass into Ireland are not recorded by government. In the NREAP of Ireland one scenario estimates that imported biomass will account for about 350 ktoe of total required biomass supply of 1100 ktoe or 32% by 2020. A second scenario estimates higher amounts: 510 ktoe will be imported of the total biomass supply of 1260 ktoe by 2020 (40%). The forestry research agency COFORD recorded in 2006 a small import of 2 182 m^3 fellings compared to 15 316 m^3 domestically resourced (12% imported). Almost all other biomass from forestry had a domestic origin.

As part of the NREAP for Ireland, an estimation of the total contribution expected from all renewable energy technologies in Ireland to meet the binding 2020 targets and the indicative interim trajectory for the shares of energy from renewable resources (in electricity, heating and cooling and transport) was presented. Extraction from this data shows a percentage of bio-energy in the Ireland energy mix of about 3 to 4% in the trajectory 2010-2020, while the large majority of Ireland renewable energy projected to come from wind power. The SEAI report 'Energy forecast for Ireland to 2020' points a growth in the use of biomass for electricity generation, with a maximum of 5% to Irelands electricity mix in 2020. It shows in its predictions also clearly the Irish Government focus on wind energy. It is therefore highly likely that biomass based energy will not become a significant contributor to Irelands electricity generation mix in the next 10-20 years.

Estimated figures for biomass utilisation beyond 2020 are included in the Ireland energy roadmap to 2050, published by the SEAI. One predicts growth in the available biomass resource in Ireland with significant contributions from municipal solid waste, grass, energy crops and forestry material. It is therefore possible that Ireland could meet a significant amount of its required biomass demand with domestically produced material. Appropriate support from the government (financial and policy based) already is and could be a further driver for this.

2.2.6 The Netherlands

Biomass co-firing was capped by the Energy Agreement at a net energy output of 25 PJ per year (equivalent to about 3,5 million tonnes of wood pellets). Total import of wood pellets in 2012 was about 1 million tonnes and halved to 0,543 million tonnes in 2013. The total wood pellet consumption in 2012 was 1,25 million tonnes, corresponding to an import share of 80% (USDA, 2013 and 2014).

In 2006, the import of biomass accounted for 28% of biomass supply for energy (Rabou *et al*., 2006). For the future the maximum energy amount out of domestic biomass is predicted to be 200 PJ in 2020[18] and 290 PJ in 2050[19]. The total demand from bioenergy in The Netherlands is uncertain but assumed to be 1600 PJ in 2050, so in that scenario large quantities of biomass need to be imported. Another source[20] expects that in 2030 an amount of 900 PJ of biomass is required to achieve a biomass share of 23% in the total energy supply. The maximum availability of domestic biomass in 2030 is estimated to be 450 PJ, though it is not likely that this maximum availability will be reached. Producing energy crops is less interesting for farmers than crops for food or feed.

[18] http://www.pbl.nl/sites/default/files/cms/publicaties/PBL-2011-Routekaart-energie-2050-500083014.pdf
[19] http://infographics.pbl.nl/biomassa/
[20] http://edepot.wur.nl/50725

2.2.7 United Kingdom

In the initial Benchmark Report (2012) we stated that there was an expectation for the UK " to have sufficient biomass resource potential to meet the demand for heat and power". Despite this, import of wood pellets increased from 551 000 tonnes in 2010 up to about 1,5 million tonnes in 2012 (Eurostat, 2013) and 3,4 million tonnes in 2013. Based on the imported amounts in 2013 and the consumption in 2014 the UK is the largest pellet importer and consumer in the EU (USDA, 2014). The share of imported wood pellets for 2013 is about 40%. As set out in the 2011 UK Renewable Energy Roadmap, electricity and heat from biomass and renewable transport are technologies will play an important role in the plans to meet the RED directive in 2020. The following UK Bio-energy Strategy Analytical Index[21] indicates in its restricted supply scenario[22] an increase in the utilisation of resources between 2015 and 2020 (to meet the RED target) and a declining amount from 2040 up to 2050. This is reflected in the amounts of used imported woody biomass: about 6000 ktoe in 2020, 9500 ktoe in 2030 and 7700 ktoe in 2050. In the ambitious supply scenario[23], one expects increasing amounts of the available resources until 2045, the largest increase being from imports of woody biomass: about 17 000 ktoe in 2040 and 26 000 ktoe in 2045.

2.3 Sustainability criteria for biomass use

2.3.1 European framework

2.3.1.1 Biofuels

The European biofuel policy is largely designed by two important instruments. The Renewable Energy Directive (RED, 2009/28/EC) stipulates the target to achieve 10% renewable energy in road transport by 2020 and the Fuel Quality Directive (FQD, 2009/30/EC) includes the binding 2020-target to reduce lifecycle greenhouse gas emissions of fuels by 6%. Both directives include sustainability criteria (e.g. conserving biodiversity and carbon stocks) and minimum greenhouse gas saving thresholds: greenhouse gas savings from the use of biofuels should be at least 60% from 1 January 2018 for installations starting production on or after 1 January 2017 (European Commission, 2009; Ecofys, 2013). Member states have the responsibility to verify if companies are implementing the sustainability criteria. One way to comply with the criteria is to participate in a voluntary scheme. Currently, there are already 19 privately run voluntary schemes are recognised by the European Commission[24].

The criteria of the RED and FQD are focused on direct impacts. Since several years and till now the indirect impact by way of Indirect Land Use Change (ILUC)[25] dominates the European debate on biofuels. The European Commission launched a proposal (COM(2012)595) to amend both directives in order to reduce possible effects of ILUC. The proposal considers:

- Setting a 5% cap on conventional biofuels (first generation food-crops based biofuels: from cereal and other starch rich crops, sugars and oil crops) counting towards the RED transport target
- Encouraging advanced (low-ILUC) biofuels: the contribution of some fuels is counted double or quadruple towards the target
- Including ILUC factors in yearly reports
- Raising the greenhouse gas saving threshold for new installations operating after 1st July 2014 to at least 60% (based on direct emissions)

The legislative procedure is at the moment of writing in its second reading phase. An agreement is expected to be reached later on in 2015 (VITO, 2014).

[21] https://www.gov.uk/government/publications/uk-bioenergy-strategy
[22] Restricted supply scenario: low biomass prices (up to £4/GJ) with high constraints to deployment of feedstocks and low international development. Of the supply that could be available to trade internationally, UK has access to 10% to 2020 reducing to 1.5% in 2050 as carbon constraints tighten and competition for resources intensifies.
[23] Ambitious supply – high biomass prices (up to £10/GJ), low constraints to deployment of feedstocks and a high international development. The UK has access to 10% of internationally traded biomass up to 2020 reducing to 3% in 2050. In order to be cautious on medium term availability this scenario assumes a downward linear trajectory from 2025.
[24] ec.europa.eu/energy/node/74

2.3.1.2 Solid and gaseous biomass

As stated above the Renewable Energy Directive contains mandatory sustainability criteria for biofuels and bioliquids. The RED mandated the European Commission to report on the requirements for a sustainability scheme for energy use of biomass other than biofuels and bioliquids, which resulted in the recommendation to Member States (COM(2010)11) to use the same approach for solid and gaseous biomass sources as mentioned in the RED and the FQD, for biomass installations with a minimum of 1 MW electric or thermal capacity. Default and typical figures of greenhouse gas savings for solid and gaseous bio-energy pathways were also included.

The Commission Staff Working Document on State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU (SWD(2014)259) provides an update of the figures and the approach defined in COM(2010)11, by means of an attached scientific report from JRC. It concludes that only a limited number of Member States have adopted broadly consistent sustainability schemes, so far no apparent internal market barriers have been identified and the vast majority of the biomass used today in the EU for heat and power is considered to provide significant greenhouse gas savings compared to fossil fuels. No new legal actions will be taken in the pre-2020 period. Nevertheless, the Commission announced to monitor closely the biomass market and to execute further analysis and research, in order to avoid negligible or negative greenhouse gas savings or other sustainability impacts (JRC, 2014; European Commission, 2014).

In the meanwhile the biggest solid biomass importers are developing their own verification and certification schemes for wood pellets and other types of biomass for industry- or domestic use.

2.3.1.3 Framework for 2030

On 22 January 2014 the European Commission announced its policy framework for climate and energy in the period from 2020 to 2030 (COM(2014)15). A proposed revision of the RED concerning an improved biomass policy includes the necessity to deliver robust and verifiable greenhouse gas savings and to address Indirect Land Use Change as with biofuels. The European Parliament asked the Commission in a resolution (2013/2135(INI)) to propose sustainability criteria for solid and gaseous biomass, taking into account lifecycle greenhouse gas emissions. Furthermore, in October 2014 the European Council calls in her conclusions for a rapid adoption of the earlier mentioned proposal for a Directive pursuant to the FQD, laying down the approach for ILUC when using biofuels.

2.3.2 Belgium

The Flemish Government set up a GEC supporting green electricity per MWh produced from renewable sources. Fossil energy needed for transport and pre-treatment of biomass and on-site-electricity need is subtracted from the net energy production of the plant. Electricity production from high quality wood streams (which can be used as industrial raw material) is not eligible for GEC. Minimum GEC prices for installations in use before the 1st of January 2013 depend on the technology used. New installations after this date are subject to a fixed minimum price per GEC adjusted with a so called banding factor, taking into account actual technology investment- and exploitation costs, electricity market prices, etc, in order to avoid oversubsidizing. Combined Heat and Power (CHP) biomass and biogas installations in the Flemish region are supported under certain conditions also with Green certificates for CHP.

Furthermore, new Flemish projects for green heat with a capacity of at least 1MW can twice a year call for investment subsidies. The used biomass for green heat has to comply with the same sustainability criteria as for the GEC system: amongst others at least 95% of the feedstock need to be of organic-biological origin for at least 10 years. Only projects non eligible for Green electricity- or CHP certificates nor ecology subsidies can be subsidized.

In the Walloon region the Green Certificates system is similar to the Flemish region but is based upon avoided greenhouse gas emissions compared to a reference technology for electricity and heat production. The Brussels region set up its own Green Certificates scheme similar to the Walloon system.

[25] When biofuels are produced on existing agricultural land, the demand for food and feed crops remains, and may lead to someone producing more food and feed somewhere else. This can imply land use change (by changing e.g. forest into agricultural land), which implies that a substantial amount of CO2 emissions are released into the atmosphere. (EC Memo on ILUC, 17 October 2012)

<u>Progress reports</u>

- Greenhouse gases: see table 13
- Estimated impacts of biofuel and liquid biomass production on biodiversity, water resources, water quality and soil quality (progress report 2013):

The share of feedstock for biofuels produced in Belgium is estimated to be maximum 1% of the total agricultural area. It can be concluded that the effect on these parameters will be negligible.

- Land use:

The Federal administration conducted a study to investigate a methodology for quantifying the biomass streams which are imported, produced and exported.

Table 13: Net savings of GHG emission by use of renewable energy (t CO_2 eq.) in Belgium

	2009	2010	2011	2012
Electricity produced from renewable sources	3 234 185	3 911 810	4 993 590	6 102 208
Heating and cooling produced from renewable sources	2 127 645	2 514 273	3 604 362	3 910 661
Renewable energy in transport	657 062	1 014 620	482 205	4935

2.3.3 Germany [26]

The German Renewable Energ Act (EEG) was reformed in 2014. The prior Bonuses and Input Category System for single biomass fraction promotions are generally cancelled. As an example, energy crops and landscaping materials have no longer a separate promotion, giving the reason to avoid a further cost increase of the biogas production. Only small scale biogas plants from manure as well as the valorisation of organic waste are encouraged by prioritizing incentives as these biomass sources are defined as low cost input materials. The former existing claim for a biomethane bonus is additionally cancelled. The prior Input category system was bound on keeping sustainability and efficiency criteria, as e.g. more payments for short rotation coppice (SRC) if sustainable cultivation criteria are fulfilled (such as no cultivation on grassland) and higher payments for forest residues certified PEFC and FSC, a minimum heat recovery requirement for energy crop biogas plants as well as mass input limitations of maize and corn in biogas plants. According to the abandon of the prior steering incentive scheme also these criteria are not any longer eligible in EEG 2014. Actually the EEG 2014 provides an authorization for setting legal sustainability criteria within the German Biomassestrom-Nachhaltigkeits Verordnung (BioSt_NAchV). This ordinance is already in force since 2009 (latest amendment 21.07.2014) and can be amended for all biomasses (solid, liquid, gaseous). Further requirements on the cultivation areas off biomass can be addressed in terms of indirect and direct land use changes. Within this ordinance also European set measures shall be incorporated.

Latest in 2017, a technology oriented acceleration for renewable energy will be steered via public tenders. The annual additional biomass installations are limited to only maximum 100 MW, compared to much higher figures for land-based wind- and solar power (both 2500 MW/year). The biogas production will be steered towards the use of low-cost biomass in the future, especially residual and waste biomass materials [27]. It is expected that the acceleration of biogas plants will continuously decrease due to the amended Feed-In-Tariff, except small scale biogas installations using liquid manure from livestock or organic waste plants, which are encouraged by prioritizing incentives.

[26] Communication with Msc. Weiler, Katja from Izes Saarbrücken
[27] http://www.bmwi.de/EN/Topics/Energy/Renewable-Energy/2014-renewable-energy-sources-act.html

The Biomass Ordinance defines the eligible biomass under the EEG-act, technical procedures and environmental requirements for electricity production from biomass. Since the amendment in 2014 there are no specifications concerning sustainability criteria included.

The Market Incentive Programme (MAP) was introduced in 1999 to increase heat generation from biomass and other renewable technologies. Grants are restricted to heating systems that use solid biomass and from August 2012 the support guidelines of the programme were modified introducing new minimum rates for biomass boilers (IEA, 2014). The MAP 2015 will be published in April 2015. For pellet boilers the investment grants raise from 2 400 EURO to 3 000 EURO. Combining pellet boiler with buffer tanks the grant increases to 3 500 EURO per plant. Installing a pellet boiler with water tank an allowance of 2 000 EURO is provided. MAP targets in general the acceleration of technical efficiency in heating systems than sustainability aspects (e.g. place of origin of biomass).

Progress reports

- Greenhouse gases: see table 14
- Estimated impacts of biofuel and liquid biomass production on biodiversity, water resources, water quality and soil quality (progress report 2013):

The area of land in Germany used to grow materials for biofuel production has decreased slightly. Rape, for example, accounts for most of the land for biofuel production causes an excess of nitrogen on the land and it is associated with a relatively high use of pesticides. So the decrease in the area under rape potentially reduces groundwater contamination.

- Land use:

The area used for producing biogas substrates increased, in contrary to the area used for biofuel production. The biogas feedstock cultivation increased from 650 000 ha in 2010 to 1.158 000 ha in 2012. Maize accounts for by far the greatest area.

Table 14: Net savings of GHG emission by use of renewable energy (Mt CO_2 eq.) in Germany

	2009	2010	2011	2012
Electricity produced from renewable sources	69	75	89	102
Heating and cooling produced from renewable sources	33	40	35	37
Renewable energy in transport	5	5	5	6

2.3.4 Luxembourg [28]

The RED sustainability criteria were transposed into the national law by the Grand-Ducal Regulation of 27 February 2011 laying down sustainability criteria for biofuels and –liquids. The new government of Luxembourg, which came into office in December 2013, has pronounced itself against first generation biofuels and plans not only to limit their maximum incorporation rate but also to condition their support upon social and ecological criteria (Resch, G., 2014).

[28] Communication with Golkowska K. and Koster D., Luxembourg Institute of Science and Technology (LIST)

No sustainability criteria are enforced for gaseous biomass other than biogas and solid biomass. Biogas plants are imposed to the law of 18 April 2008 stating that owners need to follow four rules about the feedstock used, for receiving complete investment subsidies. Only national agro-industrial waste materials shall be used in case waste materials are used as feedstock; feedstock import from the border region is prohibited; national input materials need to come from a radius of 25 km around the biogas plant and supply contracts for feedstocks need to be presented covering a period of at least 10 years.

For electricity produced from renewable sources a Feed-in tariff (FIT) is applied. The FIT-levels vary depending on the type of biomass and generation capacity of the plant. An additional bonus is introduced for commercialised heat generated by combined heat and power based on biomass, biogas and wood waste (IEA, 2014). The tariffs were recently raised for almost all renewable energy sources.

Progress reports

- Greenhouse gases: see table 15
- Estimated impacts of biofuel and liquid biomass production on biodiversity, water resources, water quality and soil quality (progress report 2013):

It is expected that there will be no impacts in Luxembourg, due to the small proportion of agricultural land used for biofuels.

- Land use:

The area of grassland used for energy purposes has increased by a factor of 4 since 2010. Other figures on land use do not exist.

Table 15: Net savings of GHG emission by use of renewable energy (t CO_2 eq.) in Luxembourg

	2009	2010	2011	2012
Electricity produced from renewable sources	NA	NA	440 080	452 900
Heating and cooling produced from renewable sources	NA	900	298 550	305 390
Renewable energy in transport	NA	141 000	141 530	147 510

2.3.5 Ireland [29]

The central part of Ireland's strategy towards a renewable future targets the consumption of the transport sector (the largest energy consumer in Ireland) with the "Biofuel Obligation Scheme (BOS)" introduced in July 2010. The BOS legislation, under the Energy (Biofuel Obligation and Miscellaneous Provisions) act 2010, is a quota scheme requiring fuel suppliers to include a certain percentage of biofuels into the road transport fuels. It is stated in the Bio-energy Plan of 8 July 2014 to support measures that incentivise the use of advanced biofuels, which will be included in the transposed European ILUC Directive.

An Afforestation Programme is in operation since 2007 and support for it continues, trying to ensure a sustainable level of future wood supply for bio-energy. Additional biomass will begin to become on stream from 2025 at the earliest. Sustainability criteria such as quota for the so called Areas of Biodiversity Enhancement are applicable. Furthermore, the Bio-energy Scheme for production of non-food crops provides establishment grants to farmers to grow miscanthus and willow for using the biomass crop as a source of bio-energy[30]. Land use for a particular crop

[29] Communication with Keogh C., University College Dublin
[30] http://www.agriculture.gov.ie/farmingsectors/crops/bioenergyscheme/

must be suitable for that particular use, while at the same time avoiding direct competition with food Crops (Pelkmans *et al*, 2012).

The REFIT 3 programme, specifically for biomass technologies, is a feed-in tariff designed to incentivise 310 MW of electrical capacity on to the Irish grid. The applied tariffs are the highest for combined heat and power and are in favour for using energy crops in case of non-CHP biomass combustion. The Irish Bio-energy Plan foresees furthermore to introduce a Renewable Heat Incentive (RHI) in 2016 which will reward heat produced from sustainable biomass at larger installations outside the ETS. In addition, the RHI will take into account air quality risks associated with the combustion of biomass (DCENR, 2014).

<u>Progress reports</u>

- Greenhouse gases: see table 16
- Estimated impacts of biofuel and liquid biomass production on biodiversity, water resources, water quality and soil quality (progress report 2013):

There is only a small mix of feedstock production, the domestic production of biofuels has no detectable impacts.

- Land use:

In 2012 99,75% of biofuels produced in Ireland and placed on the market were from waste materials. Just over 3200 ha was devoted to growing energy crops, miscanthus and willow. There was no detectable influence on land use.

Table 16: Net savings of GHG emission by use of renewable energy (t CO_2 eq.) in Ireland

	2009	2010	2011	2012
Electricity produced from renewable sources	2 032 700	1 856 870	2 723 199	2 738 072
Heating and cooling produced from renewable sources	767 414	824 780	771 409	831 034
Renewable energy in transport	216 650	259 020	146 212	138 675

2.3.6 The Netherlands [31]

The latest Dutch Government signed an Energy Agreement ("Energieakkoord", 2013) together with more than forty Dutch organizations representing NGO's, labor unions and the energy and construction sector. The national goal of sustainable energy generation in 2020 was reduced from 16% to 14%, the goal of 16% was now set for 2023. The Agreement states that the co-firing of biomass will be funded from 2014 to 2023 (limited to power plants build after 1990) through the Support Sustainable Energy Production (SDE+) program. Five older power plants will be closed during 2016 and 2017 and will be replaced by three new plants.

In 2011 The Netherlands Technical Approach (NTA) 8080 on sustainability criteria for solid, liquid and gaseous biomass was developed. Recently, a working group consisting of representatives from biomass producers and –users, NGO's, research institutes, the government itself and certification bodies are discussing a revision ot the NTA 8080. Changes include a scope covering of both bioenergy and biobased products and a the standard will be published in two parts: one containing the sustainability requirements and a second part the chain-of-custody requirements. Furthermore the revised NTA 8080 is harmonised with most recent published European sustainability standards (CEN) and the ISO sustainability standard in development. Actual subjects as carbon debt, ILUC and biomass cascading are on the agenda. A few months ago the revised NTA 8080 was published in draft version for comments.

[31] Communication with Frank Duijzer and Cor Van Oers, DLV Plant

<u>Progress reports</u>

- Greenhouse gases: see table 17
- Estimated impacts of biofuel and liquid biomass production on biodiversity, water resources, water quality and soil quality (progress report 2013):

Rapeseed is the only crop used for the production of biodiesel, on a relatively small area of less than 2100 ha. A small proportion of the area of forage maize is used for energy crop cultivation as feedstock for anaerobic digestion. There will be no impact.

- Land use:

There were no significant changes in land use associated with increased use of biomass and other forms of energy from renewable sources.

Table 17: Net savings of GHG emission by use of renewable energy (t CO_2 eq.) in The Netherlands

	2009	2010	2011	2012
Electricity produced from renewable sources	6 359 000	6 883 000	6 957 000	7 648 000
Heating and cooling produced from renewable sources	1 458 000	1 511 000	1 536 000	1 621 000
Renewable energy in transport	730 000	518 000	786 000	839 000

2.3.7 United Kingdom [32]

Under the Renewables Obligation (RO) reporting on sustainability criteria for solid biomass and biogas was already mandatory. The UK's Department of Energy and Climate Change (DECC) announced in 2013 new sustainability criteria applicable from April 2015. According to DECC the new criteria will not change before 2027. Biomass generators of 1 MW and above will have to meet an annual target of 200 kg CO_2 eq per MWh by 2020 in order to claim support under the RO. From 2025 this amount will be reduced to 180 kg. An independent sustainability audit will also be required. Biomass generators with capacities between 50 kW and 1 MW will be required to report against the criteria, but not to comply with it.

A introduced cap of 400 MW on the total new-build dedicated biomass capacity that can expect support under the RO, puts the priority on converting existing coal-fired power plants to run as cogeneration plants. Producers already converted big power plants to biomass (of them the UK's biggest power plant) and plan to convert further in the future. The transformations will end up importing substantial amounts of imported wood pellets (DECC, 2013; EurObserv'ER, 2015, Financial Times, 2013).

The Renewable Heat Incentive (RHI) provides support for (amongst others) renewable heat plants larger than 1 MWh. They are required to report quarterly on the sustainability of their biomass feedstock for combustion (including GHG savings), nor the feedstock is domestic sourced or imported. [33]

For biofuels and bioliquids mandatory sustainability criteria have already been introduced to the RO as required by the RED.

[32] Communication with prof. Al-Shemmeri, T from Staffordshire University
[33] www.rhincentive.co.uk

Progress reports

- Greenhouse gases: see table 18
- Estimated impacts of biofuel and liquid biomass production on biodiversity, water resources, water quality and soil quality (progress report 2013):

One recent study found no evidence to suggest that biofuel (or bioliquid) production in the UK, using domestic crops, was having an adverse impact on bird populations.. The bird population data were used as a proxy for broader biodiversity.

- Land use:

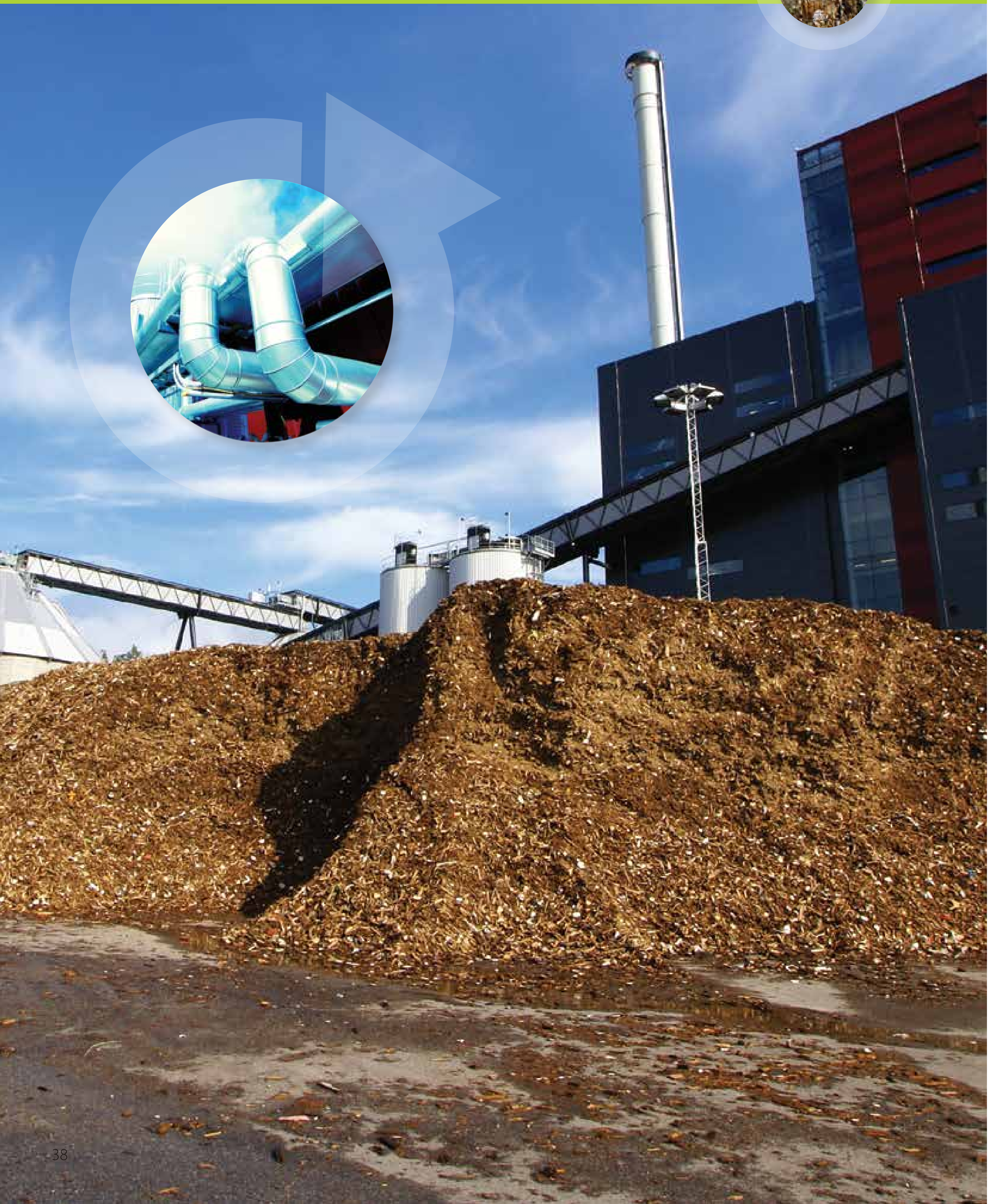
Land used to grow woody energy crops in the UK for generating electricity tends to be lower quality, marginal or idle land which is generally unsuitable for food production.

Data estimate that there was a 363% increase in the biofuel crop area from 2009 to 2010, and although it was a large increase, this still only represented 1,7% of the total arable area of the UK in 2010. The area of land involved was therefore quite small.

Table 18: Net savings of GHG emission by use of renewable energy (t CO_2 eq.) in the United Kingdom

	2009	2010	2011	2012
Electricity produced from renewable sources	9 300 535	10 449 675	20 056 863	28 169 890
Heating and cooling produced from renewable sources	NA	NA	NA	NA
Renewable energy in transport	1 823 690	1 917 385	2 192 207	1 983 928

Chapter 3 - Regional case studies



The ARBOR project consists out of 13 different partners in 6 different countries. In this chapter, cases realized within the ARBOR project as well as other related cases are presented here to give an idea of the different innovative concepts in North West Europe.

3.1 Belgium – Flanders

3.1.1 Innovative case 1: Biogas Boeye - co-digestion in agricultural areas

Biogas Boeye is a co-digestion plant which processes manure, organic biological waste and energy crops. The plant was brought into service in 2008, initially with a total input capacity of 40 000 tonnes per year. In 2011, the input capacity was expanded to 60 000 tonnes per year. At that time also the input installation was renewed in order to be able to handle liquid biomass streams such as sludge coming from water treatment installations in the food industry. Three combined heat and power installations produce each 716 kWh electricity and 1000 kWh heat per year. Electricity is put into the grid and provides energy for about 5 000 families. The produced heat is almost completely (99%) used in the digestion process, drying of the solid fraction of the digestate, heating of the stables (chicken farm) and buildings.

The digestion process is thermophilic (at 55°C) , because this leads to a higher biogas production than a mesophilic process. However, the process should be followed up more strictly due to restrictions in the nitrogen content of the biomass input. The digestate is separated into a solid and a liquid fraction. The liquid fraction is filtrated, which leads to a concentrate of the nutrients and a permeate which can be ejected on surface water. The solid fraction is dried and is mainly exported to France. In Flanders, application of the digestate as fertilizer for agricultural practices is restricted by the Flemish legislation but alternatively the digestate can be used as soil conditioner for private use in gardens. It is expected that in the future, the legislation will be adapted such that digestate products can be used as mineral fertilizers.

The main threat for the company is the economic rentability after 2018 because of the uncertainty regarding the funding ('groenestroomcertificaten' (GEC)) provided by the regional government. Normally, these GSC are awarded for a period of 10 years and can be prolonged twice for a period of 5 years. Because the prolongation can only be requested one year before expiration of the current GSC, future investments to renew, expand or optimize the co-digestion plant will be postponed.

More information: www.biogasboeye.be

3.1.2 Innovative case 2: Ecowerf - digestion before composting

Ecowerf is an intermunicipal cooperation of 27 municipalities in the province of Vlaams-Brabant. The cooperation's main goals are to prevent, collect and process waste in this region. The energy demand of the cooperation is about 60 000 GJ, mainly for the aeration during the composting process. If their input materials (KGW, garden waste from HWRC, organic-biological waste, waste from road shoulders) were to be put in a digester before composting, 97 000 GJ of energy could be recovered from organic matter, so this process could make Ecowerf self-sufficient concerning energy production. If the company considers to sell electricity/heat to surrounding companies, they could increase their capacity and include other input streams, such as sewage sludge from a nearby water treatment plant. An energy study was performed to estimate the capacity of the digester that should be installed and to identify the most efficient application of the produced biogas.

The study pointed out that the digester should have a capacity of 40 000 tonnes per year, from which 4 017 000 Nm^3 per year of biogas could be produced. Three different scenarios for the valorisation of the biogas were evaluated:

- The biogas is valorised at the Ecowerf site using a CHP with an annual production of 9 773 MWh of heat and 8 304 MWh of electricity. The produced electricity is used for aeration during the composting process and for operational practices at Ecowerf. The produced heat is mainly used for heating the digester and for drying of the compost. As such, the emission of CO_2 is reduced with 2 700 tonnes per year.

- The produced biogas is entirely sold to a 3rd party. No CHP installation at Ecowerf is installed, such that no heat nor electricity can be recovered for local use. The study pointed out that it is difficult to find a 3rd party that could be interested in buying the biogas. The low heat-capacity of the CHP and difficulties in reaching heat-consuming opportunities also hamper the feasibility of this scenario.

- The biogas is upgraded to biomethane and is partly used as transport fuel for the Ecowerf trucks and/or partly (completely) injected in the gas grid. This assumes that the legislation allows injection of biomethane in the gas grid, which is currently not the case.

Unfortunately, none of these scenarios turned out to be economically feasible in the actual support system of the Flemish Government. In addition, the current legislation does not allow to use the produced digestate, which is about 33 000 ton per year, as soil fertilizer. The liquid fraction of the digestate could be treated in the communal waste water treatment plant and the solid fraction of the digestate should be exported abroad. The total investment cost is in all scenarios about 10 Million euro while savings are maximum 2 Million euro per year.

More information: www.ecowerf.be

3.1.3 Innovative case 3: small digestion at Hendrickx dairy farm

The Hendrickx farm was the first one in Belgium to install a small-scale manure digester in cooperation with Biolectric, who developed this technology in Flanders. Only manure produced on-farm by 65 dairy cows is digested. The heat and electricity produced is sufficient for the energy supply of the whole farm plus the adjacent bed and breakfast, run by the farmer and his wife.

Currently the digester processes about 1800 ton of manure and produces around 60 MWh electricity per year. Problems associated with this first pocket digester are:

- Suboptimal construction of the cowshed and manure storage through which manure is lost and methane is produced. As such, the energy content of the manure is reduced.
- Difficulties with the correct assessment of manure biogas potential in order to determine the power of the CHP unit.

Based on these lessons learned, newer installations could retrieve more energy-rich manure and enhance the power output. Pocket digestion remains an excellent example of decentralized energy production which leads to self-sufficiency. Currently more than 80 pocket digesters have been built in Flanders on dairy farms.

3.2 Germany – Saarland

3.2.1 Innovative case 1: Methavalor

Sydeme (Syndicat Mixte de Transport et de Traitement des déchets Ménagers de Moselle-est) is responsible for the transport and the treatment of the municipal solid waste in the East-Moselle area. In order to manage this task under efficiency and ecological aspects, SYDEME decided to implement a whole new waste collection system involving colour coded bags (orange for recyclables, green for organic waste, blue for residuals). The three bag colours are collected simultaneously in one and the same bin. The three material flows are then separated in an innovative optical sorting pant, where a camera recognises the bag colours and redirects them to the appropriate valorisation path. The green fraction is conveyed into the biogas plant "Methavalor", based on a dry fermentation process, producing electricity, heat, biofuel and/or natural gas (grid injection).

The construction started in June 2009 and the plant became operational in October 2011. The capacity of the plant is 42 000 ton/a household waste.

In 2015, Sydeme is investing into a mono greenery cutting anaerobic fermentation plant in Saareguemines, Lorraine France.

More information: http://www.sydeme.fr

3.2.2 Innovative case 2: Innovative case 2: Bioenergie Merzig GgmbH

A biogas plant using input of arable renewable raw materials coming from local farmers: corn input, grass, triticale, whole plant silage and arable crops. The average distance is 15 km to the plant. Inputs are also coming from neighbouring French farmers. The produced biogas is processed into suitable biomethane for injection into the local gas grid. A gas treatment plant is located on site at the biogas plant. 60% of the methane is consumed locally. The plant has a sound eco balance with 1 kWh biomethane equal to 250 g CO_2 reduction.
The plant became operational on the 28th of June 2011. The capacity of the plant is 2 MW and 51 million kWh of biomethane is produced every year.

More information: http: //www.enovos.eu/index.php?id=41&L=0

3.2.3 Innovative case 3: Biomass cogeneration plant Warndt

Constructed by the STEAG GmbH on the former Saarland Warndt mine area, the Warndt Cogeneration Heat and Power Plant (CHP) with Organic Rankine Cycle (ORC) went into regular operation in 2010 as the first biomass CHP and ORC plant in Saarland on the basis of untreated woodscrap. The plant generates 13,400 megawatt hours of electricity and up to 51 000 megawatt hours of heat per year. The electricity output is sufficient to supply around 3 350 single family households and the generated heat supplies 2,844 single family households. The heat is partly fed into the district heating network of the community in Großrosseln. The electricity is fed into the public grid on the basis of the German Renewable Energy Source Act (EEG 2009). The CO_2 neutral combustion saves around 21 500 tonnes of carbon dioxide annually.

Source IZES gGmbH: 3rd Transnational Advisory Board Meeting Excursion to Warndt Biomass Cogeneration Plant 11/2015.

More information: www.steag-newenergies.com

3.3 Ireland – South East Region

3.3.1 Innovative case 1: Inchydoney Island Lodge and Spa

Inchydoney Island Lodge and Spa is a luxury 4 star, 67 bed hotel, conference, spa and leisure centre, located near Clonakilty, West Cork, Ireland. The hotel has a very considerable (and increasing) heating demand both in terms of space heating for the hotel and spa facilities and the hot water demand. In the framework of the SEI Bioheat Programme, the hotel performed following modifications to the heating system:

- Conversion from a LPG gas system to a wood pellet system. The consumption of wood pellets is 360 tonnes per year. The boiler has a capacity of 450 kW (3x150kW).
- Improving and increasing the insolation of the hotel.
- Construction of a solar heating system, which consists of 80 m^2 of flat plate collectors. This made it Ireland's largest commercial renewable heating system.

These actions induced a reduction of 50% in the cost for heating and hot water as compared to the old LPG system. The total investment cost was €300 000, but saving amount up to €50 000 per year. Savings are generated by the reduced fuel costs of wood pellets, a highly efficient boiler and hot water preparation system and the energy from the solar thermal installation. However, the significant savings made by the hotel in fuel costs started to decrease after 4-5 years due to a number of reasons, including ongoing increases in the price of woodchips (which tracked increases in oil costs), increasing maintenance costs, uncertainty in supplier/repair maintenance companies and contracts, bulk delivery issues (with a requirement of 360 tonnes per year), adverse weather conditions and non-localised suppliers.

The result of these issues has been a move back to LPG based heating systems, which in recent years has been more cost effective to operate, due to lower fuel cost, better supply networks and significantly longer major repair intervals (5 years for biomass versus 15 years for LPG). The main non-technical issues faced by the hotel regarding the biomass boiler resulted from poor ongoing governmental financial support for biomass utilisation, a lack of expertise in the maintenance field due to company closures (a direct result of Ireland's economic recession). These issues could potentially lessened through improved biomass fuel price regulation, establishment of improved technical support networks and governmental encouragement to form local biomass co-operatives to bulk buy fuel material, improving per tonnes prices while also smoothing out some of the delivery issues.

More information: http://www.kwb.at (wood boiler manufacturer)
http://www.balcas.com (wood pellet fuel supplier)

3.3.2 Innovative case 2: Teagasc Crops Research Centre

An automatic wood heating system has been installed and commissioned by Natural Power Supply (NPS) Ltd. at Teagasc, the Agriculture and Food Development Authority, at its Crops Research Centre at Oak Park, Carlow. Teagasc at Oak Park have been pioneers in researching and testing sources of sustainable and renewable energy for several decades. It is recognised as one of the leading research establishments in this particular field.

The wood chip fuelled boiler was installed by John Wills and Damien Dolan of Complete Corporate Support Services, Dublin with Christian Luttenberger, of Conness, distributors of Austrian- manufactured KWB wood heating boilers. The boiler is a KWB USV 100, with an output capacity of 100kW and has an efficiency of over 90% at rated output and 90% on part load. Currently, the boiler is powered by wood chips made from short-rotation willow crops and heats nearly 1 000 m^2 of office, laboratory and workshop space.

Teagasc has been conducting a range of short rotation willow crop testing to establish optimum planting, cultivation, harvesting and processing methods with a view to supplying valuable knowledge to current and potential future growers in Ireland. Further, the unit is also used for trials with other fuels such as cereal straws, a by-product of arable farms, rape straw and Miscanthus. The gained knowledge is communicated by means of:

- *Publications:* aim to inform the public, farmers and policy makers of the best practice in Ireland for the planting, cultivation, harvesting and utilisation of both Short Rotation Coppice Willow and Miscanthus. Two publications are due for release in September 2014 and are supported by ARBOR.
- *Demonstrations:* cover aspects such as harvesting options, live demonstrations, yield estimations and other growth practices as well as practicalities. Teagasc has been running willow harvesting demonstrations at their facility in Oakpark, which are open to all interested parties.

3.3.3 Innovative case 3: Gartan Outdoor Education Centre

Gartan Outdoor Education Centre is located on the shores of Gartan Lough close to Letterkenny, Co Donegal. Over 6,000 people visit Gartan each year and take part in a range of water sport and mountaineering courses. The Centre is owned by Donegal Vocational Education Committee (VEC) and caters for the needs of primary, secondary and third level education, as well as the tourism and private sectors. Recently, a new boathouse was built on their 35 ha property, incorporating shower and changing facilities, a meeting room, coffee shop, boat and equipment storage, work shop and a drying room. The Gartan Centre decided to install a wood chip heating system in the new boathouse building, because "*Wood heating was a sustainable choice but also makes economic sense for us as we are making fuel savings in the order of €2 600 per year*", as commented by Ursula McPherson, the Centre's director.

The heating system was installed by Rural Generation, Derry, N. Ireland; Carr & Co., Ballybofey, Co. Donegal and Delap and Waller, Derry, N. Ireland and caters for the full heating and hot water needs. It is fuelled by willow chips which are supplied by Rural Generation Ltd by trailer. In order to avoid manual handling, the fuel chip are blown directly into the store. This is a practical solution in cases where access to the fuel store is difficult as such systems can blow chips a distance of 30 metres. The biomass boiler is still in successful operation in Gartan OEC, with little maintenance required (serviced once a year). The only major change to operation in this case was a move from wood chips to wood pellets. Rural Generation Ltd closed a few years ago, such that Gartan had to move to new suppliers. However, these suppliers were not able to supply a reliable consistent biomass quality because of significant variations in the moisture content of the supplied wood chips. They experienced a relatively stable biomass price (circa €220 per tonne), but as they are an Outdoor education centre they have some flexibility acceptable pricing due to their goal of education & promoting environmentally friendly practices. No delivery issues we experienced in this case, possibly due to the fact they operate a shared delivery function with a large local leisure (Gartan only has storage for 10 tonnes of biomass) centre, allowing larger deliveries to occur this reducing year delivery amounts.

Gartan OEC is the first outdoor education centre in the Republic of Ireland to venture down the wood heating road, and will continue to pursue this policy, with plans to use wood chip from its own estate. "*We are satisfied that the technology works and are now planning to investigate using wood chip from the woodlands and hedges of our own estate and locally to fuel the system in the future*" said Ms. McPherson. Although Gartan is very happy with the experiences utilising biomass, they would like some ongoing support to help them keep using biomass (remark that the initial project was support by INTEREGG). This support can consist of a biomass fuel subsidy or more economical and technical support from the local government.

3.4 Luxembourg

3.4.1 Innovative case 1: Naturgas Kielen

Naturgas Kielen is an association of 30 agricultural enterprises with the goal of the construction and operation of a biogas plant being coupled to the natural gas supply network. The biogas site is operational since 2009. This was the first biogas plant in Luxemburg using a cleaning and upgrading technology to produce bio-methane (injection into the natural gas grid). Furthermore, it was the first biogas plant in the country using a sanitation stage (thermic pre-treatment of the waste streams - min. 1 hour at 70°C) and thereby being able to co-digest organic wastes. The biogas plant with a fermentation capacity of 50 000 t per year produces 2.8 Mio m^3 gas (equalling the consumption of 1 000 houses) per year. The input materials are: agricultural residues (mainly manure), energy crops (maize silage, other whole plant silage and sunflowers), bio waste and other commercial organic wastes. The produced biogas is being upgraded (extraction of the CO_2) to the natural gas quality level (>98% CH_4) and injected into the natural gas grid.

However, since 2011 there are two further biogas plants constructed, which co-digest agricultural wastes and organic wastes and inject the biogas into the biogas grid in Luxemburg. One of them, Minett-Kompost, uses an innovative plug flow fermenter and the thermophilic (55°C) digestion. This system has an annual input of 25 000 tonnes with an annual production of 1,4 Mio. m^3 of bio-methane.

More information: http://www.naturgaskielen.lu
http://www.minett-kompost.lu/de-DE/das-werk/vergarung/schema http://bakona.lu/

3.4.2 Innovative case 2: Valortech

The project Valortech, started in June 2012, focuses on a new concept of energetic recovery of waste products through a process of polygeneration. Waste streams with low heating value such as sewage sludge mixed with greenery cuttings, wood chips or comparable green waste can, through conversion in the innovative gasification process, generate useful energy (heat and electricity) as well as produce combustibles in form of industrial pellets.

The project benefits of a consortium of dedicated partners such as Soil-Concept, Energolux, Gradel, Université de Luxembourg and Luxembourg Institute of Science and Technology (LIST).

Within the project, a demonstration plant has been installed in Diekirch, North of Luxembourg, and is operated by Soil-Concept. The installation comprises a primary treatment of the waste inputs to produce 'basic fuel' that is subsequently burned in a fluidized bed gasifier. The produced gas, so called syngas, is then cleaned and valorised through the production of heat and electricity in a combined heat and power plant and providing the energy for the production of industrial pellets and heat for a future industrial zone. In parallel to the demonstration installation, the complete energy assessment (including energy and exergy analysis) of all the processes will be conducted by LIST.

The Valortech project has great potential to offer a concept of polygeneration that is innovative and competitive at international level by integrating biomass gasification, pellet production and combined heat and power generation. The project will produce state of the art data, contributing to the global discussion on energy management.

More information: www.valortech.lu

3.4.3 Innovative case 3: Factory of the Future

In June 2012 Kronospan Luxembourg launched its activities linked to the project "Factory of the Future: Demonstration of the production of wood panels with near-zero environmental footprint", in the framework of the EU Life+ programme. Kronospan Luxembourg has a factory in Sanem, Luxembourg, that primarily produces medium and high density fibreboard (MDF/HDF) and oriented strand board (OSB). The company has made considerable efforts to reduce its environmental impact with the goal of achieving an autonomous factory with near-zero environmental footprint. The Factory of the Future project was launched in order to take a big step towards this goal and to show that it was possible.

The goal of Factory of the Future is to optimise Kronospan's wood panel production plant while demonstrating that a company's environmental footprint can be greatly reduced while maintaining production quality and volume in an economically viable way.

Factory of the Future specifically aims to:

- reduce the amount of fossil fuels used for thermal power generation by 90% by using wood by-products from panel production for energy production
- reduce potable water consumption by 70-75% by collecting and storing rain water, capturing and recycling water from the production process, and reducing wastage
- reduce CO_2 emissions from fossil fuel use by 80% by optimising processes and equipment, reducing production wastage, and improve overall energy efficiency
- evaluate and communicate on improvements made and identify further opportunities through Life Cycle Assessment and calculation of the carbon footprint of wood panel production and of the production site

Kronospan is working together with the Researchers from LIST, who will provide a cradle-to-grave Life Cycle Assessment of the products, and calculate the annual carbon footprint of the site and production processes. By the project end, all water and energy optimisation will be implemented.

Factory of the Future will allow Kronospan Luxembourg to implement energy-efficient technology and processes to achieve its goal of having near-zero CO_2 emissions originating from fossil fuels. It will provide a positive model for other companies in the European wood board industry as well as other production sectors to follow in order to make their own factories more sustainable. The project's efforts will have a positive economic benefit for the company and a strong environmental benefit for Luxembourg, as it will result in less water and energy consumption as well as less deforestation in the region. With the factory, Kronospan hopes to achieve an annual reduction in use of natural gas equal to the household use of 4% of the population of Luxembourg, and through the eventual installation of cogeneration equipment (combined heat and power), to provide electricity for 4% of the population of Luxembourg

More information: http://www.list.lu/en/project/factory-of-the-future

3.4.4 Innovative case 4: Kiowatt

Kiowatt is a joint venture between Groupe Françpois and Lux Energie S.A. and was launched in 2008. The already operational tri-generation plants in Roost combines heat, cold and electricity production based on the utilization of wooden residues with the production of Badger Pellets®. The unit can process up to 35000 tonnes of waste wood from Luxemburg (which up to now has been exported and not accounted for energy production from renewable energy sources in Luxembourg) for the production of 21 GWh electricity to be fed into the electricity grid. Moreover nearly 93 GWh heat which will be produced in the site will be used to a) heat dry air for the Kiowatt pellet- production dryer system, b) produce cooling for the nearby data centre, which thus become the first "Green Datacentre" in the world, c) supply with heat the heat network close to the town of Bissen.
The plant has not yet reached its full capacity. The current production of heat and electric power is respectively 11.5 MW and 2.7 MW, while reaching the full capacity of energy and electricity production is planned for 2015.

More information: http://www.kiowatt.lu/en

3.5 The Netherlands – regions Utrecht and Gelderland

3.5.1 Innovative case 1: A. van de Groep en Zonen

Van de Groep is a company active in the fish industry (catch to consumer market). The plant became operational in January 2007 and the produced biogas was used to supply energy for the company. The capacity of the plant is 5.5 million m^3 of input material per year, which exclusively consists of waste from fish and vegetables (no manure!). In 2010, the plant was upgraded with a CO_2-scrubber, a Bio2Net installation and a drier for the digestate. This investment allowed the company to produce high quality biogas that can be injected in the regional gas grid. With Bio2Net, the volume, the pressure and the chemical characteristics of the produced biogas is continuously monitored. If the required gas quality is not attained, the gas is returned to the CO_2-scrubber.
The idea for a co-digestion plant started when they were searching for a more sustainable and economically acceptable use for their waste products. To be able to maintain the digestion process, different sources of input where found. At the moment, the digestion process is more or less manageable with very diverse input products arriving at irregular intervals. The idea behind the upgrading from biogas to green gas, was to increase the economic profitability of the plant. During the operation of the plant, following problems were encountered:

- The legislation did not allow the company to benefit from financial support by the government as this was only applicable to co-digestion of manure with products from a specified list. Eventually, the legislation was adapted accordingly such that the company received financial support by the government. However, this does not guarantee the economic feasibility of the plant as it still depends on the price of the biomass input and on the price of the green gas and digestate.
- There have been a lot of complaints concerning odour coming from the digester. Consequently, several tests have been performed but the reason for the problems with odour could not be identified. The company decided to install an odour screen on top of the digesters together with an active carbon filter. These measures should reduce the complaints due to odour.

More info:
http://www.energieconsultant.nl/nieuws/2011/Groen-gas-uit-vissenkoppen-en-stroopwafels (in Dutch)
http://www.rvo.nl/sites/default/files/bijlagen/Groen%20gas%20uit%20visafval.pdf

3.5.2 Innovative case 2: Simon Zwarts

Simon Zwarts is a breeder of ornamental flowers (15 000 m²) who annually uses 800 000 m³ of fossil gas and 1,5 million kWh of electricity, which is generated by a combined heat and power installation with a capacity of 800 kWh. Research was performed to determine the technical possibilities and the economical feasibility of installing a biomass gasifier, in which wood chips and grass will be gasified at a temperature of 800 °C. There were three suppliers who could install a gasifier with CHP that can use side streams such as reed, next to wood. Main benefit of these side streams is the low price compared to wood. The recovery of CO_2 from this process is not economically feasible. From the feasibility study, it is clear that installing a biomass digester would result in:

- *Economical benefit*: the investment for the gasifier-CHP-installation is about 2 to 3 million euro, which is 5 to 10 times higher than a natural gas CHP. The investment for the gasifier is however only feasible with subsidies for the energy produced and subsidies for the investment. In the long run, the gasifier should also be profitable without the funds.

- *Ecological benefit*: fossil gas would no longer be needed as all power for the company could be supplied by the current CHP running 2000 hours per year. In addition, green energy could be provided to about 1000 families by upgrading the CHP power to 6000 hours per year. gasifies wood and water reed (Phragmites australis) and uses the gas for a CHP.

So far, the poject has not been realized because of problems in obtaining an environmental permit for the biomass gasifier. Using biomass as source of energy is subjected to stricter conditions as compared to the use of gas or oil as energy supplier. The local government is searching for a solution to this specific problem.

3.5.3 Innovative case 3: region Arnhem - Nijmegen

In Arnhem, Nijmegen and the surroundings it is the intended to switch all public transportation to biogas, ideally Bio-LNG. For such a large project 12 million m³ (Bio)-LNG per year should be produced. Waste processor ARN already invested in a digester to produce over 6 million m³ biogas per year to be injected in the national gas grid. This was partially enabled by subsidies. Another investor is currently collaborating with Imtech to prepare a 2012-investment for a digester, producing over 6 million m³ green gas per year.

Currently, 218 busses are driving on biogas and 45 trolleybusses are driving on green electricity. There is also 1 bus operational that is using hydrogen gas as fuel. If this experiment turns out positive, more busses using hydrogen will be purchased.

3.5.4 Innovative case 4: municipality Nijmegen

The huge paper mill NSP in Renkum strives to reduce running costs and to transform to a bio-based oriented company. Green deals are agreed upon to process biomass from water purification stations in the region to be processed in a coupled heat power installation. Furthermore, woody biomass and recycled paper processed into pulp is to be used for various bio-based activities such as a biorefinery testing site, and fish farming.

Unfortunately, the factory went bankrupt and was bought by foreign investors. These new owners do not support the idea for an experimental site concerning bio-based activities such that the focus is again on the core business of the company which is the production of paper.

3.6 UK – Stoke-on-Trent and Staffordshire

3.6.1 Innovative case 1: John Pointon and Sons Ltd

John Pointon and Sons Ltd (JPS) in Staffordshire have announced plans to construct a £12 million, 60 000 tonnes per annum Food Waste Anaerobic Digestion and renewable energy facility at their site in Cheddleton, Staffordshire. The scheme has been granted planning permission and will be co-funded by a £1.44 million capital grant fund from WRAP and Advantage West Midlands (AWM).

The facility should have been completed in October 2011. It has the capacity to process 60 000 tonnes of food waste with a generating capacity of 2MW of renewable energy per annum, saving 85 000 tonnes of CO_2. In total, it is estimated that 195 000 tonnes of combined commercial and industrial waste will be diverted from landfill in the first five years of operation.

It is the first of its kind in the region of the West Midlands, primarily put in place to use as convincing argument that biomass is a feasible substitution to fossil fuel. Policy makers in the UK still believe that the natural resources of fossil fuel are enough for UK's energy demand. The biomass market is only recently launching and there is a severe lack of know-how among retailers. Further, the company recently managed to achieve International Sustainability Carbon Certification (ISCC), a standard for certification of sustainable biomass and biofuels. In fact they are one of the first animal rendering and food waste recycling companies in the United Kingdom to attain the global accreditation for ISCC.

ISCC focuses on greenhouse gas reduction through the value chain, sustainable land use, protection of natural habitats and social sustainability for the feedstock production. Based on the EU RED Directive ISCC requires a minimum GHG emissions saving of 35% (rising to 50% in January 2017 and to 60% in January 2018; i.e. for installations in which production starts from 2017 and onwards). Feedstock production also needs to comply with 6 principles. The ISCC audit addresses the following topics:

- Conservation of biodiversity and ecosystem services and conservation of land with a high carbon stock.
- Quality of the soil, water and air and the application of Good Agricultural Practices.
- Working conditions.
- Human, labour and land use rights. Responsible community relations.
- Legality.
- Good management practice.
- Greenhouse gas emissions.

More information:
http: //www.pointon.co.uk/
http://www.pointon.co.uk/credentials/iscc-international-sustainability-carbon-certification

3.6.2 Innovative case 2: Staffordshire County Council

In 2010, Staffordshire County Council commissioned a new building with a large proportion of its heating use covered by a biomass boiler, fuelled by wood chips sourced from local woodlands, provided by a newly formed in house fuel production section. Happily in 2014, Staffordshire Place is a fully functioning and comfortable building to work in, which houses most of the managerial and administrative staff in Staffordshire County Council. The green heating system leads to a huge reduction in the use of fossil fuels and creates financial savings. The biomass wood fuel supply is also used to generate the majority of Tipping Street's hot water including the 12 showers that are being provided to encourage staff to leave their cars at home and cycle, walk or even run to work. The new biomass system contributes to reducing CO_2 emissions by 1750 tonnes each year, saving thousands of pounds for the tax payer. It also improves Staffordshire County Council's ranking on the government's Carbon Reduction Commitment Energy Efficiency scheme, meaning more money is returned to the council from the central CRC pot. Just like the food waste anaerobic digester of John Pointon, this is also the first of its kind in the region of the West Midlands.

Today, Wood Fuel Trading and Consulting (WFTC) leads the biomass development within Staffordshire County Council and is going from strength to strength. WFTC is a dedicated section located within the Business Support team in Economic Regeneration. The unit has three distinct business streams:

- A biomass consultancy: whilst also providing consultancy advice to others, thinking of venturing into the biomass and biofuels market from experience gained in developing a local biomass.
- Wood fuel supplier chain : Staffordshire has a sustainable local source of timber from Cannock Chase, surrounding woodlands and woodland owned by the County Council. Utilising locally sourced wood from sustainably managed woodland reduces net carbon dioxide emissions compared to using fossil fuels. This contributes substantially to the County Councils carbon reduction targets. Utilising locally sourced fuels supports local jobs in the fuel supply chain, fuel processing and delivery, recycling this revenue within the County.
- Energy Supply Contracts (ESCO's): offer clients a long term contract (10 years or more) to buy metered green energy from biomass installations at a pre-agreed index linked price. For the client this is a low risk option that delivers energy cost savings and carbon emission reductions with no capital cost, design, installation or operational responsibility. The energy delivered through a biomass ESCO is clean, green and affordable and will protect the client from sharp increases experienced in fossil fuel powered heating. The ESCo delivered by WFTC in 2013-2014 to multiple properties has realised the following objectives:

    - Saving 843 tonnes of CO_2 per annum.
    - The saving of 310 000 litres of heating oil per annum.
    - The energy cost saving to properties of £30 000 per annum.
    - The generation of further savings of £60,000 to SCC per annum.
    - The kudos of being a forward thinking authority and the first Local Authority to deliver a biomass powered ESCO in the UK.
    - Providing the pupils of the schools an opportunity to learn about renewable energy on their own campus.

Through WFTC, Staffordshire County Council has the skill base and resources to drive the biomass opportunity, to provide low carbon heating solutions to Staffordshire County Council premises. The biomass system has proved a reliable addition and has inspired the authority to invest in more biomass systems and expand its fuel production business market and supply chain.

More information: http: //www.staffordshire.gov.uk/environment/woodfuel/home.aspx

3.6.3 Innovative case 3: Veolia Environmental Services Plc

A new state of the art energy recovery facility which will save Staffordshire taxpayers £250 million over 25 years was officially opened on May 14th 2014 in Staffordshire by HRH the Duke of Gloucester KG GCVO. The development of the new plant was ordered by the vice President of Veolia after being awarded a 25 year PFI contract, which is the biggest in Staffordshire County Council's history and is set to deliver tax savings to the residents of Staffordshire of about £10 million a year to a total of over £250 million during its twenty-five year life.

The plant is part of the Zero Waste to Landfill strategy, which is tackling head on the growing problem of domestic waste. The strategy aims at maximising recycling first, and then recovering energy from the leftover residual waste. New infrastructures like this are vital if the UK is to meet landfill diversion targets and reduce carbon emissions. It can also bring significant economic benefits and by working closely with Staffordshire County Council it also helps to stimulate economic growth and to improve environmental performance.

The facility, which has been built with the latest technologies, has been developed by Veolia in partnership with CNIM Clugston Staffordshire Ltd and is helping Staffordshire County Council to reach its target of Zero Waste to Landfill. The facility will generate enough power for 35 000 homes and has created 40 new jobs. During construction, this project has helped the local economy by sourcing 87% of the workforce and a large proportion of the supply chain locally.

More information:
http://www.veoliaenvironmentalservices.co.uk/Staffordshire/About-us/News/Press-releases/HRH-the-Duke-of-Gloucester-opens-state-of-the-art-energy-recovery-facility/

Appendix 1: Overview of relevant biomass projects in North-West Europe (AD=anaerobic digestion, CO=combustion, BF=biofuel, EC=energy crops, BS=biomass supply, NR=nutrient recuperation, OT=other category).

	Focus	Project region	Project period	Brief description	Weblink
Graskracht	AD	Flanders	2010-2012	Evaluation of the potential of mowed grass for energy.	www.biogas-labo.be/nl/efro-project-graskracht
Optibiogaz	AD	North-West Europe	2008-2012	Optimisation of biomass conversion to biogas by supporting of process and use of optimised feeding doses. Regional inventory and material flow/efficiency analysis for exemplary biogas plants in the greater region. Identification of new ways of utilisation and valorisation for the side-products of biogas-production, evaluation of their environmental compatibility (heat, digests, organic fertilizers). Creation of a competence network in the field of biogas technology in the greater region.	http: //www.optibiogaz.eu
LUCAS	AD	Luxembourg	2010-2013	LCA method development for the integration of indirect land use change effects into the life cycle assessment of bio-energy. Case study: indirect land use change effects caused by the expected increase of the biogas production in Luxembourg according to the set of aims in the framework of NREAP.	http://www.fnr.lu/fr/calls2/projects/indirect-land-use-change-effects-in-consequential-life-cycle-assessment-of-bioenergy-lucas
MUSA	AD	Luxemburg	2013-2016	MUlti agent Simulation for consequential Life Cycle Assessment of Agrosystems - MUSA will analyse the agricultural and economic consequences of future possible scenarios related to biogas production from maize in Luxembourg over the long-term.	http://www.list.lu/en/project/musa/
ECOBIOGAZ	AD	Luxembourg, Belgium, France, Germany	2012-2014	The project should support the economically feasible development of biogas industry in the "Great region" through: 1. Study on innovative management of the biogas plants; 2. Study of plant cultures for biogas production as well as digestate application on the fields; 3. Support in economic valorisation of biogas by-prodacts (e.g. digestate, heat, etc.) 4. Knowledge transfer in the Great Region	http://www.ecobiogaz.eu
CO4energy	AD	Belgium	2013-2014	The goal of the Co4 Energy project is to design a scheme for a cooperation on small-scale digestion	http://www.dlvinnovision.be/dlvinnovision/en/co4energy
SUSTAINGAS	AD	Germany, Netherlands, UK	2012-2015	Promoting the production of biogas from organic farm wastes through several steps: - Set-up of a strategy for increased biogas production in organic farming - Elaboration of sustainability standards for biogas production - Identification of best practice examples - Training of organic farmers and their representatives, biogas consultants and asscociations, and communication to the consumers.	http://www.sustaingas.eu
GERONIMO II-BIOGAS	AD	Germany, UK, Belgium, Netherlands, Luxembourg, Ireland	2011-2013	Triggering investments in biogas plant installations in dairy and pig farms, producing feasibility studies and accompanying the farms in the first steps of a plant construction.	http://www.energy4farms.eu
FABbiogas	AD	Germany	2013-2015	Triggering the implementation of biogas units in food and beverage industry or supply contracts between the food and beverage industry and biogas plants for the use of food waste as renewable energy source.	http://www.fabbigoas.eu
BIGOAS3	AD	Germany, Ireland	2014-2017	The aim of the project is to promote the sustainable production of renewable energy from the biogas obtained from agricultural residues and from the food and beverage industry wastes in small-scale projects for energy self-sufficiency.	http://www.biogas3.eu
Prograss	AD + CO	Herbstein – Hessen & SW Germany	2009-2012	The University of Kassel developed a technological and process orientated approach (PROGRASS) to produce bio-energy (electricity and solid fuel) also from mature grasslands. Conservation of NATURA-grassland area through decentralised energy production.	http://www.prograss.eu/

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Biomass use from nature reserves	AD + CO	Saarland	2004-?	Study on the potential of the energetic use of biomass from nature reserves in Saarland. Use of the grassy biomass for AD and the woody biomass for heating.	http://www.lpv.de/
VerKOHt	CO	Flanders	2009-2011	Demonstration project on short rotation coppice for farmers. Focus on local applications and biodiversity.	http://www.bosplus.be/nl/onzeprojecten/voorbije-projecten/verkoht
Pilot Miscanthus to Energy	CO	Rhenen	2008-2010	Use of Miscanthus in an advanced combustion installation, for heating water needed in the stables where calves are reared for meat.	http://www.adbrevio.nl/projecten-verbrandingmiscanthus.html
Wood chips on a dairy farm	CO	Oudewater	2008-2010	Use of wood chips and other wooden residues as a result of clearing and pruning. The heat is used directly in the production process of making yoghurt.	http://www.zuivelboerderij.nl/
Analysis of wood species for use as biomass	CO	Ireland	2010-2014	Chemical and physical analysis of different wood species and assortments from various geographical locations. Assessing suitability as a solid biofuel with respect to ash content, energy values, major and minor elements.	http://www.wit.ie/research Research GroupsCentres/Groups/Forestry/Projects
Novel Solid Biofuel	CO	Ireland	2009-2013	Development of an energy efficient and environmentally safe novel solid biofuel from forest and sawmill residues mixed with solid pig manure.	http://www.wit.ie/research ResearchGroups Centres/Groups/Forestry/Projects
Bioenergy Research UCC	CO	Ireland	Ongoing	Investigating & developing Bionergy and Biofuel research on areas such as sustainable biofuels, grass land optimisation, biomass production and aerobic digestion	http://www.ucc.ie/en/serg/
DIBANET	CO	Ireland	2008-2014	DIBANET will develop technologies to help towards eliminating the need for fossil diesel imports in the EU & LA by advancing the art in the production of ethyl-levulinate from organic wastes and residues.	http://www.carbolea.ul.ie/project.php?=dibanet
ReUseWaste	CO	Ireland	2012-2014	The ReUseWaste network will train a group of young researchers in developing new technologies for socially and environmentally sustainable utilisation of resources in animal waste.	http://www.reusewaste.eu/
TCBB	CO	Ireland	Ongoing	Ireland's national Technology Centre for Biorefining and Bioenergy (TCBB) research programme will concentrate on developing efficient industrial processes that will make the bio-industry a reality, and will integrate these activities with the feedstock research and development programmes of its specialist affiliates, and with product development programmes of its industry members, to establish a complete end-to-end value chain for the Irish bio-industry.	http://www.tcbb.ie/
MABFUEL	BF	Ireland	2009-2013	Investigate the feasibility of using algae (micro and/or micro) as a feedstock for producing bio-fuels in Turkey and Ireland	http://www.dommrc.com/project-mabfuel.html
VALORTECH	BF	Luxemburg	2013-2018 2013-2015 (LIST part)	Energy recovery from sewage sludge: development of new products and innovative technologies. The Valortech project has great potential to offer a concept of polygeneration that is innovative and competitive at international level by integrating biomass gasification, pellet production and combined heat and power generation. The project will produce state of the art data, contributing to the global discussion on energy management.	http://valortech.lu/
IKEBANA	EC	Flanders	2010-2011	Stimulate scientific research on environmental aspects when cultivating bamboo, stimulate Good Agricultural Practives, create a network of stakeholders and cultivators.	http://www.ikebana-bamboo.eu/
Innovation in miscanthus	EC	Zeeland	2010-2012	Optimisation of the cultivation of Miscanthus.	www.dlvplant.nl
Energy crops trial	EC	Zeeland/ Noord-Brabant	2008-2010	Testing different energy crops.	http://www.babg.nl/

Appendix

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Energy from miscanthus	EC	Noord-Holland	2006-2010	Testing, growing and processing Miscanthus (burning).	http://www.oostwaardhoeve.nl/
Energy crops for wastelands in The Netherlands	EC	Netherlands	In development	Using low input crops in abandoned industrial areas and wastelands.	
Energy from bufferstrips	EC	Zeeland, Zuid-Holland, West-Brabant	2011-2014	Looking for new possibilities for the use of buffer strips as an energy source and as an improvement of water quality.	http://www.duurzameakkerrand.nl/
FORSITE	EC	Ireland	2007-2014	The ForSite project is assessing the nutrient impact of increased biomass harvesting in Irish forests, by developing databases of forest nutrient exchanges, and a tool for policymakers to assess biomass-harvesting scenarios against the new concept of critical biomass removal.	http://www.ucd.ie/forsite/
ELUM	EC	UK	2011-2014	Ecosystem Land Use Modeling and Soil Carbon GHG Flux Trial (ELUM) aims to produce a framework for predicting the sustainability of bioenergy deployment across the UK with many of the outcomes also applicable internationally. The project combines a large number of field studies (ca. 100) with state-of-the-art process models, to facilitate the mapping of the UK bio-energy carbon opportunity up to 2050.	http://www.ceh.ac.uk/sci_programmes/elum-project.html
Energy Conversion Parks	BS	Flanders Netherlands	2010-2013	An Energy Conversion Park combines several sources of biomass and applies a highly integrated set of conversion technologies. The Energy Conversion Park project will demonstrate the economic advantages, develop 5 parks, develop a knowledge platform and disseminate the concept.	http://www.ecp-biomass.eu/
Nature Management Residues	BS	Flanders	2009-2011	Demonstration of how woody and grassy residues of nature management can be used to produce bio-energy. Bring supply and demand sides of these residues in contact with each other.	http://www.enerpedia.be/
BioMob	BS	Ireland	2009-2011	Development of research-driven clusters for biomass mobilisation.	http://cordis.europa.eu/project/rcn/92999_en.html
WoodEnergy and ForestEnergy	BS	Ireland	?	Public demonstration and workshops on harvesting first thinning. The project also determines a number of parameters relevant to fuel quality: moisture content, bulk density, ash content etc.	http://www.wit.ie/research/__centres_and_groups/forestry_research_group#tab=panel-3
EnAlgae (Energetic Algae)	BS	North West Europe	2011-2015	Accelerated development of sustainable technologies for algal biomass production, bio-energy and greenhouse gas mitigation	http://www.enalgae.eu/
RUBIN Biomass	BS	North West Europe	2005-2008	Regional strategy for the sustainable usage of biomass (wood, biogas from animal manure, grass and straw) by the establishment of a network of different actors in the biomass sector on a regional level to initiate and support biomass projects and to develop a strategic master plan for the biomass production in this region	http://ec.europa.eu/regional_policy/conferences/od2006/doc/presentations/c/bemman_10c02.pdf
Regional concepts for the expansion of bio-energy-generation from wood	BS	Saarland	2009-2012	Promotion and support of biomass networks in the Federal State of Saarland, analysis of existing increasing potentials of wood energy, mobilisation of wood fractions which are difficult to access.	https://www.energetische-biomassenutzung.de/index.php?id=3&L=0
BioRegio	BS	Saar-Hunsrück, Südlicher Oberrhein, Emscher-Lippe, Nordostvorpommern, Mittelsachsen, K.E.R.N.-Region (all in Germany)	2005-2008	Development of an optimised biomass utilisation strategy for each model region. Development of concrete regional biomass scenarios and strategies, investigation of the potentials of regional added value-creation resulting from the bio-energy projects. Identification of possible hindering factors in the regional project implementation. Development of a tool for technology assessment.	http://www.energieregion-el.de/contents/competencies/biomasse/projects/bioregio.php?PHPSESSID=799de60988b88f61ff0956a4e384b1a
MixBioPells	BS	Germany	2010-2012	Promoting the production and use of alternative pellets (from agriculture residues) and developing a concept for a labelling system for Europe.	http://www.mixbiopells.eu

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Combine	BS	North West Europe	2011-2015	Converting Organic Matters from European urban and natural areas into storable bio-Energy	http://www.combine-nwe.eu/
GR3	BS	Belium, Germany, Italy, Denmark, Portugal	2013-2016	Energy from landscapes by promoting the use of grass residue as a renewable energy resource	http://www.grassgreenresource.eu/
SRCplus	BS	Germany	2014-2017	The overall objective of the project is to support and speed up the development of local supply chains of short rotation coppice by implementing various capacity building measures and regional mobilisation actions for the key actors in local supply chains.	www.srcplus.eu
Bioenergy value chains: whole system analysis and optimisation	BS	UK	2013-2017	The project is investigating the potential and risks of different biomass technologies, and the interfaces between competing requirements for land use, as well as the cost reductions, lifecycle environmental profiles and system implications of bio-energy and biorenewables.	http://www.supergen-bioenergy.net
Energy from rice straw	BS	UK	2013-2016	This project will take rice straw, which is currently a waste material creating environmental problems in intensive rice systems across South and South-East Asia, and demonstrate the feasibility of converting it to a useful energy resource. The research will focus on addressing the very challenging physical and chemical properties of rice straw as an energy feedstock in a way that yields direct benefits for local communities.	http://www.supergen-bioenergy.net
FOREST	BS	UK	2010-2012	Working directly with businesses in the biomass supply chain, from farmers and foresters to architects and designers, to develop and consolidate long-term supply partnerships to increase end-user confidence and to encourage greater investments in renewable biomass heat.	www.forestprogramme.com
WHS	BS	UK	2008-2011	Mobilising wood biomass potential for heat generation from private forests and from agricultural land by increasing cooperation among farmers and forest owners, promoting new quality assurance standards for solid biofuels.	http://www.woodheatsolutions.eu
SUCELLOG	BS	Germany	2014-2017	The main objective of the project is to widespread the participation of the agrarian sector in the sustainable supply of solid biofuels in Europe.	http://www.sucellog.eu
AFO	BS	UK	2009-2012	Activating private forest owners to increase forest fuel supply though workshops, study tours and face-to-face meetings. Wood fuel supply clusters were established.	http://www.afo.eu.com
Biorefine	NR	North West Europe	2011-2015	The Biorefine project aims to provide innovative strategies for the recycling of inorganic chemicals from agro- and bio-industry waste streams	http://www.biorefine.eu/
Nutricycle	NR	Flanders	2012-2014	The recuperation and valorization of nutrients from manure and digestate and their reuse as a green alternative to chemical fertilizers.	http://www.mipvlaanderen.be/nl/webpage/155/nutricycle.aspx
Digesmart	NR	Spain, Belgium, Italy, France	2012-2016	Recycling and upgrading process of anaerobic digestion effluent (digestate).	http://www.digesmart.eu/eng/
INEMAD	NR	Belgium, Bulgaria, Croatia, Denmark, France, Germany, Hungary, The Netherlands	2012-2016	Reconnecting livestock and crop production.	http://www.inemad.eu/nl/
Fertiplus	NR	Netherlands, Germany, UK, Belgium, Spain, Italy Flanders	2011-2015	Reducing mineral fertilisers and agro-chemicals by recycling treated organic waste as compost and bio-char products.	http://www.fertiplus.eu/Fertiplus/index.xhtml

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	Focus	Project region	Project period	Brief description	Weblink
Energy-conscious farming	OT	Flanders	2010-2012	Project aims to raise awareness among farmers and to assist them in investing in innovations that are energy efficient or that make use of renewable energy.	www.enerpedia.be
ELKE	OT	Germany	2007-2013	Evaluate the environmental effects of certain extensive land-use systems for the production of renewable resources. The major points of interest are effects on biodiversity and protection of abiotic resources (e.g. soil conservation and fertility, avoidance of erosion, water protection…).	www.landnutzungsstrategie.de
BioEnergyfarm I BioEnergyfarm II	OT	Belgium, Germany, The Netherlands	2010-2013 2014-2017	All aspects of energy saving and the implementation of renewable energy on arable farms. Increasing the production and use of bio-energy by farmers (biogas, bioheat, energy crops), supporting them in determining the profitability and feasibility of different bio-energy options.	http://www.bioenergyfarm.eu/
Social and economic feasibility of bio-energy regions in Flanders	OT	Flanders	2010-2011	Feasibility study and development of possible scenarios for the development of a Flemish "bio-energy village".	http://www.mipvlaanderen.be/nl-be/webpage/146/bio-energieregios-eng.aspx
SEDIS	OT	Saarland	2003-2007	Researching and realising the so-called ETVS process (producing drainage-drying-gasification-electricity). This procedure is for the decentralised processing of liquid, and also paste-like and solid biological waste materials, such as e.g. sewage sludge and matured timber, and its conversion into electrical energy and mineral ashes directly at the place where these wastes arise. The process was analysed by the example of sewage sludge.	http: //cordis.europa.eu/fetch?CALLER=PROJ_ICT_TEMP&ACTION=D&CAT=PROJ&RCN=71342
VALUES	OT	Luxemburg, The Netherlands	2014-2017	VALUing Ecosystem Services for environmental assessment. VALUES project aims at improving the assessment of biodiversity and ecosystem services in the LCA methodology. It aims to develop a method for characterizing environmental goods and services, which are currently not sufficiently taken into account in LCAs.	http://www.list.lu/en/project/values/
EPA STRIVE	OT	Ireland	2007-2014	The EPA STRIVE program has funded a project at Carbolea that will involve the collection, preparation and analysis (via wet chemical and NIR methods) of a variety of lignocelluosic wastes that may offer value for biorefining activity.	http://www.carbolea.ul.ie/project.php?=strive
Supergen Bioenergy Hub	OT	UK	2012-2017	Supergen Bio-energy hub brings together industry, academia and other stakeholders to focus on the research and knowledge challenges associated with increasing the contribution of UK bio-energy to meet strategic environmental targets in a coherent, sustainable and cost-effective manner. It does this by taking a "whole systems" approach to bio-energy, focusing on the benefits that new technologies can bring within the context of the whole production and utilisation chain.	http://www.supergen-bioenergy.net
GreenGasGrids	OT	Germany, The Netherlands, UK	2011-2014	Boosting the European market for biogas production, upgrade and feed-in into the natural gas grid. Roadmaps for integration of biomethane in the natural gas grid, working groups at national and EU level involving relevant stakeholders from the private sector.	http://www.greengasgrids.eu
GasHighWay	OT	Germany	2009-2012	Promotion of biogas production and use as a vehicle fuel, creation of a network of biogas and CNG filling stations.	http://www.ngvaeurope.eu/the-gashighway
BIOMASTER	OT	UK	2011-2014	Promotion of the use of biomethane as transport fuel through the creation of biomethane networks, investments in biogas plants, grid injection points and filling stations, etc.	http://www.biomaster-project.eu
BIOGASHEAT	OT	Belgium, Germany	2012-2015	Pre-feasibility studies on strategies and business models for the utilisation of heat from biogas plants as well as policy recommendations	http://www.biogasheat.org

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SolidStandards	OT	Germany	2011-2014	Supporting the implementation of EU standards for solid biofuels by delivering trainings.	http://www.solidstandards.eu
BEN	OT	UK	2008-2011	Development of a local bio-energy planning tool indicating regional energy sinks as well as biomass potentials for energy production in a web based geographic information system.	http://regions202020.eu/cms/sec/eu-actions/iee/ben/
BioEnerGIS	OT	Ireland	2008-2011	Development of a GIS-based web tool to identify the location of biomass sources and main heat sinks at regional level which helps to best locate bio-energy plants in terms of economic energetic and environmental sustainability.	http://www.bioenergis.eu
BIOTEAM	OT	Netherlands, Germany	2013-2016	Production of a market mapping analysis, leading to better selection of the most sustainable bio-energy pathways and the shaping of the policy frameworks to promote them.	http://www.sustainable-biomass.eu
BiomassPolicies	OT	Belgium, Germany, Ireland, Netherlands, UK	2013-2016	Development of integrated policies for the mobilisation of resource efficient indigenous bio-energy value chains in order to contribute towards the 2020 bio-energy targets.	http://www.biomasspolicies.eu

Notes

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This project has received European Regional Development Funding through INTERREG IV B.

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