Biomass for Energy in the Northwest European region:

An overview of pilots and investments

Carbor
Biomass for Energy

Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B.
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Improving **sustainable biomass utilisation** in North West Europe

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Table of content

1. Introduction

This document aims to present the various pilots and investments that are realised within 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:** IZES gGmbH – Institute for FutureEnergySystems
- **From Ireland:** University College Dublin (NUID - UCD)
- **From Luxembourg:** 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 20 20 20 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.

A number of pilots and investments are realised within ARBOR to showcase good practice examples of biomass utilisation in a sustainable way in order to contribute towards the EU 20 20 20 targets.

The report was produced by Staffordshire University (Sacha Oberweis) with contribution from the partners involved in the various pilots and investments.

Background

The European Union is currently subjected to a number of risks. Amongst them are the import dependencies of energy (often from politically unstable areas) and food. Other notable risks are the economic crisis and the resulting losses in growth and jobs as well as the continuous risk to the environment. One potential factor to reduce these risks is the development of sustainable forms of energy.

Economic impacts

The fact that oil is a limited resource means that there will come a point at which production capacity is at its maximum after which a terminal decline in output is inevitable. There is much debate over when this will occur, however if at this point demand is still increasing, it is possible that oil prices could spiral ever higher.

The 2020 energy and climate framework has made elements of the renewable energy sector one of the most recession-resistant areas of European economy. Currently contributing to around 1% of the EU's GDP, the binding 20%

renewable energy target could increase net GDP growth by 0.45% by 2030[1]. The energy sector employs around 1.2 million people, an increase of 30% on the 2009 figure[2] and this will increase to 2.7 million people by 2020[3].

Environmental impacts

The burning of fossil fuels has increased the abundance of CO_2 in the atmosphere to its highest level since humans have existed on the planet. Of further concern is that the atmospheric CO_2 concentration is increasing at an unprecedented rate. However, renewable energy deployment is not just about reducing CO_2 emissions: Renewables should help to avoid or reduce emissions or air pollutants, such as methane (CH_4), carbon monoxide (CO), nitrous oxides (NO_x), sulphur dioxide (SO_2), and ozone as well as reduce water consumption, thermal pollution, waste and adverse impacts on soil. The World Health Organisation estimates that in 2012 the death of 7 million people worldwide can be linked to air pollution[4].

Social impacts

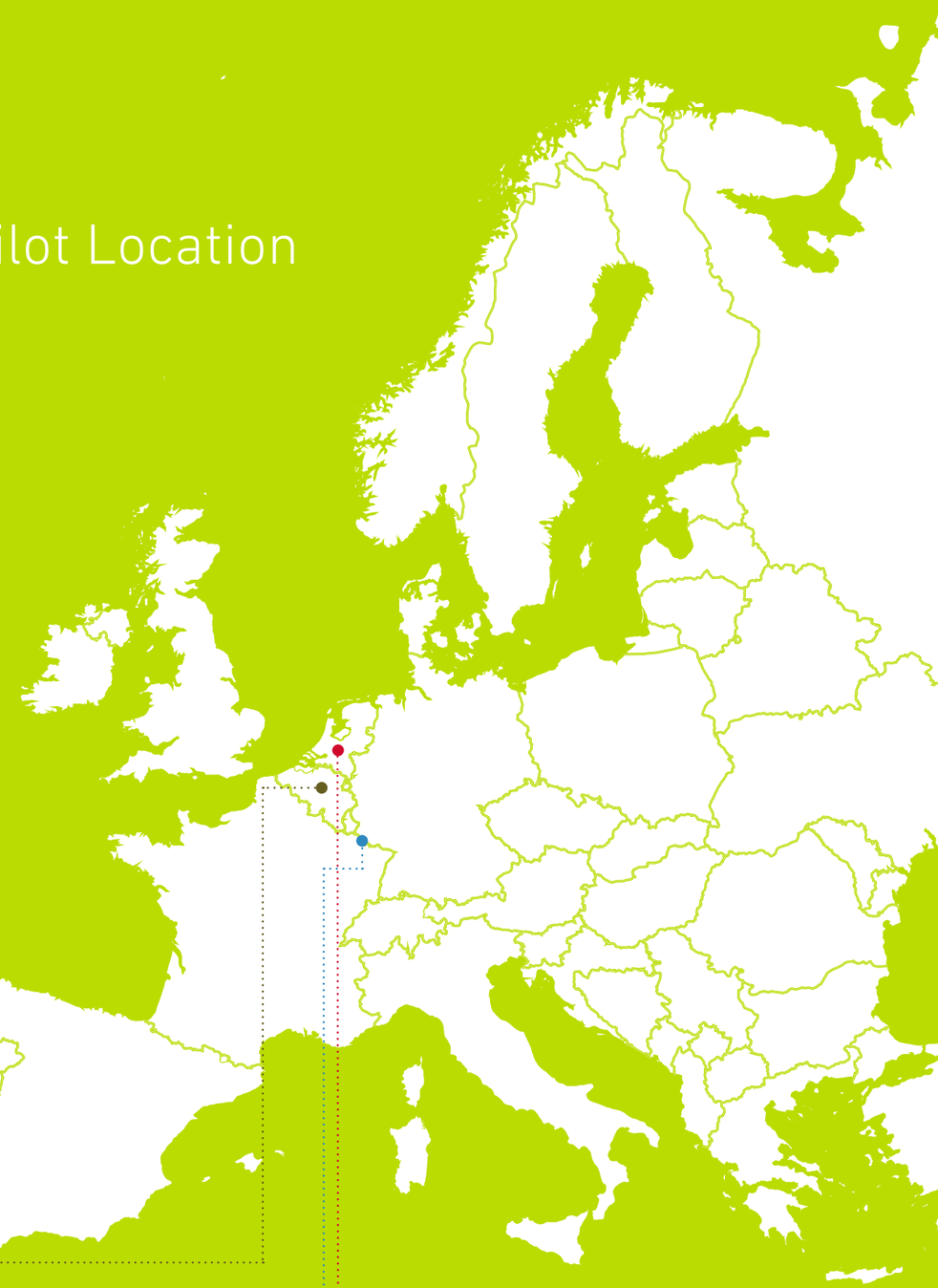
The social implications may not be as direct as the economic and environmental impacts but should be given the same degree of importance. The health and wellbeing of billions of people could be at risk due to the adverse impact of climate change on food production and water availability.

This is by no means an exhaustive list of risks and debates linked to the renewable energy sector.

In 2009 a number of people came together to prepare the ARBOR project in order to identify strategies and good practice examples to contribute towards a global solution of the above problems. ARBOR does not intend to compete with the food production or propose a single solution. The project is however presenting strategies to reduce these risks. The present document intends to give the reader a global overview of the pilots and investments established as part of the project and provide contact details for additional information.

1 Fraunhofer ISI et al.: EmployRES. *The impact of renewable growth and employment in the EU.* 2009
2 EurObser'ER: *The State of Renewable Energies in Europe.* 2012
3 EREC. 45% by 2030. *Towards a truly sustainable energy system in the EU.* 2011
4 WHO press release. *7 million premature deaths annually linked to air pollution.* 2014

2. Pilot Location



BELGIUM

NETHERLANDS

GERMANY

Pilot 1. Valorisation of corn stover

Location: **West-Flanders, Belgium**
Contact: **Anke De Dobbelaere** (anke.dedobbelaere@inagro.be),
Bram Vervisch (bram.vervisch@inagro.be), **Bart Ryckaert** (bart.ryckaert@inagro.be)

Synopsis: The goal of this pilot is to investigate how residues of corn maize grown for the use of the corn can be harvested, collected and used for energy purposes. When corn is harvested, the stover is normally left on the field. Because of the large area in which maize is grown in Flanders, corn stover shows a large total biomass potential with more than 450,000 tons of dry matter. The purpose of this action is to examine options for harvest, collection and preparation together with analysis for biomass and biogas or energy potential.

Outcome(s): In 2011 a field trial on biomass potential was carried out together with lab scale anaerobic digestion tests. In 2012 two trials were carried out to investigate the biomass potential of several crop residue parts, for ten different maize varieties. At the moment the focus is on existing types of harvesting machines with particular interest on corn cobs. A harvest demonstration was organized in 2013 with a series of machines that together made it technically possible to collect the stover. Two trials of corn stover have been tested in the pilot digester of Inagro with the focus on pre-treatment techniques. A pilot on corn cobs has also been organised with a special harvester. The corn cobs will be tested in two ways for energy production: an experiment on combustion of dried corn cobs and an experiment on anaerobic digestion (pilot and large scale) of ensiled corn cobs. Next to the scoping study of technical and economic feasibility of corn stover valorisation, special attention will also be given to the environmental impact.

Involvement: POM West-Flanders is involved (cf. synergy parks) for the research on feasibility of drying biomass with industrial heat. FlandersBio is making the link with the IWT VISIONS project in which corn stover is set out to be a potential stream for the bio-refinery industry. The chain development for corn stover is problematic in that farmers and manufacturers will not invest in specialised machinery unless the demand for the product is guaranteed (at a sufficient price).

Additional information: Visions (**http://www.bbeu.org/nl/visions-0**)

Pilot 2. Valorisation of Brussels sprout stems

Location: **West-Flanders, Belgium**
Contact: **Anke De Dobbelaere** (anke.dedobbelaere@inagro.be),
Bram Vervisch (bram.vervisch@inagro.be), **Bart Ryckaert** (bart.ryckaert@inagro.be)

Synopsis: The purpose of this pilot is similar to the pilot on maize residues: the goal is seeking solutions of how to harvest, collect, store and energetically valorise residues from Brussels sprouts: in this case the stems.

Outcome(s): A first study is carried out on harvesting machines that can separately harvest residues of Brussels sprouts. In Flanders there are two farmers with a special harvesting machine that can harvest the stems separately. To investigate the biomass potential of this side-stream a field experiment was set out in which residues left on the field were collected. A comparison was made between residues where the machine collected stems and residues on parts of the field where sprouts were harvested without stem collection. During the winter of 2013-2014 soil samples were taken to look at nutrient leaching and the effect that collecting stems might have on this. Stems of Brussels sprouts were tested for biogas production in the biogas lab of Inagro. In January 2013 a first pilot test on the stems was carried out in the pilot digester of Inagro. In December 2013 a new load of stems was brought to Inagro for an ensiling experiment in which stems were mixed with corn cobs. The goal of this experiment was to check whether the stems can be stored for a longer period this way.

Involvement: Complementarity is sought between this pilot and the action of Synergy parks carried out by POM. A GIS study will show the biomass potential of residues in the close neighbourhood of Inagro. Extra information on the use of residues from Brussels sprouts for uses other than bio-energy (e.g. application in feed) was exchanged with DLV Plant.

Additional information: VLM harvest residues project, the GeNeSys project (**http://www.ilvogenesys.be/**)

Pilot 3. Valorisation of leek leaves

Location: **West-Flanders, Belgium**
Contact: **Anke De Dobbelaere** (anke.dedobbelaere@inagro.be),
Bram Vervisch (bram.vervisch@inagro.be), **Bart Ryckaert** (bart.ryckaert@inagro.be)

Synopsis: In this pilot (similar to the pilots on maize and Brussel sprout residues) the purpose is to investigate the potential of leek residues for bio-energy use. Leaving them on, or bringing back leek residues to the field has shown that problems like bad odour, plant diseases and nitrate leaching might occur. Removing and using these residues for other useful applications like bio-energy might reduce those problems. Other crops that have a larger biomass potential and that can show the problems mentioned above are, cabbages (like cauliflower, white cabbage, etc). Because of the higher biomass potential, cabbages are also considered in this pilot.

Outcome(s): Field experiments have shown that the biomass (dry matter) potential of leek residues to be harvested separately on-field is low. For this reason, constructors of harvesting machines said, in a meeting with Inagro, that they were reluctant to build a specialised harvester to collect those residues. Very wet field conditions and the fact that fields with leek are mostly not harvested all at once, but divided over time, confirmed the low potential for adapted harvesters. The residues which are already collected on site by cleaning leek for the fresh market could however show potential for valorisation. Using this side-stream involves some challenges. When cleaning leek a lot of soil clings onto the residues. Low energy content is expected and an additional step is required, in which the residues are chipped into smaller pieces. These problems might also prevail using other side-streams from vegetables. For cabbages Inagro also did a harvest trial using a beet defoliator to harvest residues of cauliflowers. To investigate this opportunity a feasibility study is carried out for adaptation of Inagro's pilot digester.

Involvement: Complementarity is sought between this pilot and the action of Synergy parks carried out by POM. A GIS study will show the biomass potential of residues in the close neighbourhood of Inagro.

Additional information: During this pilot Inagro had contact with a PhD student who performed research on the use of leek residues for food applications.

Pilot 4. Valorisation of grass verges

Location: **Province of Utrecht, Netherlands**
Contact: **Sieta de Vries** (sieta.de.vries@provincie-utrecht.nl)

Synopsis: In this pilot the concept of using biomass for energy from the community, for the community, by the community will be established. Considering the complexity of such a concept, expertise is needed in different domains (technological, economical, supply chain) which is provided by the different partners in the project. Local authorities across NWE are dealing with quite large amounts of biomass as a result of maintenance of the landscape and verges. Dealing with this biomass is a high cost for the authorities, while in principle this biomass could be used as a source of energy. Connecting the social economy in waste processing with the renewable energy production contributes to both socio-economic and ecological sustainability. A study will be made on the collection of roadside grass in the region of Utrecht. Is it possible to create a profitable collecting structure? What will this collecting structure look like? Which of the parties can and will join the collecting structure?

Outcome(s): A report is written with the outcomes of the study. There are 44 parties in the region of Utrecht involved with the collection of verges. In total there are 60,000 tonnes of roadside grass available.The study shows that a profitable collecting structure is possible. Instead of working all together in one collecting structure, it would be better to follow the same strategy in tendering the roadside grass management. Already 10 parties have agreed to participate in the next step of the roadside grass collection project. Together they provide half of the total amount of roadside grass. This pilot is closely linked to the biogas hub (investment 3) and provides an additional benefit of transport reduction of the roadside grass.

Additional information: The grass will be needed for the digesters of the biogashub (Investment 3).

Photos © Sieta de Vries

Pilot 5. Valorisation of organic waste

Location: **Saarland (Germany)**
Contact: **Katja Weiler** (weiler@izes.de)

Synopsis: The case study is conducted in the Federal State of Saarland, Germany to analyse and evaluate the current organic waste management scheme with ARBOR's optimised scenarios. The purpose of the research is to demonstrate sound regional, sustainable closed loop solutions for the acceleration of bioenergy from organic residues. In terms of organic wastes the study conducts mainly the following types of waste biomasses as wooden and grass biomasses from greenery cuttings and verges as well as separately collected organic wastes from households. Additionally organic wastes from industrial and commercial sectors as well as waste wood have been partially integrated as much as the current situation of data gathering was sufficient.

Outcome(s): An inventory report will be completed to describe the potential economic and environmental benefits of the use of organic waste.

Involvement: The project mainly addresses responsible administration bodies, such as ministries (Ministry for the Environment and Consumers Protection; Ministry for the Economy, Employment, Energy and Traffic; down-level administrations); Disposal Association Saar (EVS) and municipalities as well as the Saarland regional government. The direct public involvement is reached via dissemination activities. According to the interregional aspect of the designated scenarios, the enhancement of the existing cooperation with the waste management authority (SYDEME) in Lorraine, France is prosperous.

Additional information: This case study is conducted together with case study 7 for valorisation of greenery cuttings as ARBOR scenarios also result in co-digestion of grass like greenery cuttings and biowaste. The wooden parts are utilised in decentralised woodchip-combustion installations with 500 kWth and/or a central heating plant technology (Organic Rankine Cycle). The Saarland case study activities meet the biomass targets of the Federal State of Saarland to accelerate the organic waste situation. Hence, this case study is conducted in parallel with the ARBOR case study on valorisation of sewage sludge in Saarland. The Saarland case studies are interlinked with the Interreg project IV B NWE BioennW and the project GR3 in Intelligent Energy Europe IEE programme as well as INEMAD from 7th Framework Programme.

Photo by: IZES gGmbH

Pilot 6. Valorisation of sewage sludge

Location: **Saarland (Germany)**
Contact: **Katja Weiler** (weiler@izes.de)

Synopsis: The case study is based in the Federal State of Saarland, Germany to analyse and evaluate the current sewage sludge management as well as optimised scenarios developed within ARBOR. The study is focusing exclusively on sewage sludge, which is treated by the public wastewater management authority (EVS) in Saarland. The sewage sludge derived from public waste water treatment plants amounts to 18.800 Mg dry matter/a. 47% of the sludge is burnt in combustion plants e.g. in coal industries. 43% is utilised in agriculture. About 10% are used for re-cultivation measures. In general, 30% of sewage sludge (dry matter) is regionally recycled (Saarland) and the remaining quantities are exported and valorised outside Saarland.
The German fertilizing ordinance is abandoning polymer based flocculating agents from 2017 for agricultural uses, but the actual sludge dewatering processes are depending on those flocculants. Other substituting products or processes are currently not ready for market. Therefore, alternative recycling schemes are urgently needed.

Outcome(s):

- Development of sustainable, regional sewage sludge management strategies.
- Development of sustainable value chains for energy and nutrient recovery from sewage sludge, economic and ecological assessment of current situation and of newly developed improvement scenarios.
- A consultation document to describe the overall results of the study with an inventory of recoverable nutrients from sewage sludge.

Involvement: Based on ARBOR's project research, IZES was contacted by the waste water authorities and research institutes of the region Lorraine in France and Luxembourg for interregional know-how exchange on sewage sludge recycling. It is planned to accelerate the interregional cooperation between Saarland, Lorraine and Luxembourg on a long-term view and to supplement ARBOR's improvement scenarios. The project mainly addresses responsible public entities such as ministries (Ministry for the Environment and Consumers Protection; Ministry for the Economy, Employment, Energy and Traffic; down-level administrations); Wastewater Management Authority of the Saar (EVS) and municipalities as well as the Saarland regional government.

Additional information: The Saarland case studies are interlinked with the Interreg project IV B NWE BioenNW in terms of technology assessment.

Image: © Entsorgungsverband Saar (EVS). [Waste Association Saar]

Pilot 7. Valorisation of greenery cuttings

Location: **Saarland (Germany)**
Contact: **Katja Weiler** (weiler@izes.de)

Synopsis: The project aims at the development of a valorisation strategy for landscape material and greenery cuttings in the UNESCO Biosphere Reserve Bliesgau, located in the Southern part of the Federal State of Saarland, Germany. The Biosphere Reserve underlies designated restrictions regarding landscaping and nature conservation. In particular, defined areas need to conserve their ecological functions described in the UNESCO Biosphere Reserve Bliesgau objectives - as e.g. semi-natural grassland formations, orchard lanes. Consequently, an extensive landscaping by extensive agriculture or nature conservation activities is mandatory. The research is dedicated to the question, if this biomass potential is feasible for regional bioenergy supply meeting ecological and socio-economic factors. Given the fact that the energetic use of landscaping material is restricted not only by management (amounts and collection), but also by quality and technical aspects, the study moves the focus on related regional biomasses as e.g. horse straw and manure as co-input for energy conversion.

The purpose of the research is to evaluate sound, regional sustainable closed loop solutions for the acceleration of bioenergy from landscaping materials and greenery cuttings within the specific requirements of the UNESCO. The overall aim is that the investigated scenarios allow better ecological and socio-economical outcomes for the region than the current system.

Outcome(s):

- Development of sustainable value chains for energy recovery, economic and ecological assessment of current situation and proposed scenarios, development of optimised regional material flow management structures (circular economy).
- The developed strategy will be up-scaled for interregional transfer by headlining the key factors (drivers and barriers) for implementation, such as for instance framework conditions, derivations of target countries
- A full report will be produced summarising the outcomes of this pilot.

Involvement: The project does mainly address local stakeholders as farmers, nature conservation institutions as well as municipalities, ministries (Ministry for the Environment and Consumers Protection; Ministry for the Economy, Employment, Energy and Traffic; down-level administrations) and UNESCO reserve administration. The direct public involvement is reached via dissemination activities.

Additional information: This case study is conducted together with ARBOR case study on "Valorisation of organic residues from households and greenery cuttings in Saarland". The Saarland case study is interlinked with the Intelligent Energy Europe project GR3 - Grass as a green resource in terms of landscaping material valorisation.

ENTSORGUNGS VERBAND SAAR EVS

Ministerium für Wirtschaft, Arbeit, Energie und Verkehr SAARLAND

Biosphärenreservat Bliesgau

Pilot 8. Synergy park West-Flanders

Location: **West-Flanders, Belgium**
Contact: **Sophie Tobback** (sophie.tobback@pomwvl.be)
Brecht Vanhecke (brecht.vanhecke@pomwvl.be)

Synopsis: The idea is to focus on industrial estates with their agricultural surroundings to see how these industrial estates could use energy from locally sourced biomass. Concepts where industrial and agricultural activities are combined should allow optimising supply and demand of biomass. Special attention will go to the collection and preparation of the biomass streams with economic return and sustainability being considered.

Outcome(s): An inventory of available organic waste streams in the region surrounding Roeselare was made. It showed that large amounts of biomass from industry are present in this region, mainly in the form of vegetable waste from the vegetable processing industry. These streams are mostly used for animal feed. There were three companies interested in evaluating the financial feasibility of a small-scale anaerobic digester on-site to process their vegetable waste. One feasibility study has been finalised.

Another study on the potential of cross-waste utilization is the usage of wood waste for production of heat and/or electricity in West-Flanders. An inventory of wood combustion installations was made. Based on this inventory the data on the type of wood used (industrial wood waste, wood chips, wood pellets) and the needed volume of wood was gathered.

The air emissions of 2 biomass combustion installations: one of 500 kW and one of 37 kW were sampled. In the first burner a 50/50, and a 65/35 mixture of SRC and Miscanthus was tested as a 83/17 mixture of waste wood and Miscanthus. In the second burner the emissions of a 100% Miscanthus-fuel was tested with and without a dust cyclone. These results are compared with Flemish and Belgian legislation on air emission. The goal of this experiment is to be able to advise companies when burning woody biomass and Miscanthus as to which parameters should be monitored closely. The outcome will be used to make a guideline of good practices when managing a biomass combustion installation.

This information will be used in the development of the memorandum on the use of wood for the production of energy in the Province of West-Flanders, a province characterized by the scarcity of locally available wood combined with a high demand for wood as production material.

Involvement: Inagro evaluates the feasibility of drying agricultural residues for bio-energy use. This drying could be performed by industrial waste heat, which creates additional synergy between industry and agriculture. Furthermore, the results they achieve in the pilot on agricultural side-streams will be very useful for the future of synergy parks.

Additional information: Interesting information on energy Conversion Parks gathered in the ECP-project (Interreg): **www.ecp-biomass.eu**

Pilot 9. Synergy Park EcoWerf

Location: **Flemish Brabant, Leuven (Belgium)**
Contact: **Lies Bamelis** (liesbamelis@innovaenergy.be), **Erik Meers** (erik.meers@ugent.be)

Synopsis: The synergy park in the region of Leuven was developed, starting from the intention of the inter-communal company EcoWerf, to valorise the organic waste they collect from households in 27 communities (approx. 400 000 citizens) in an anaerobic digester. Having a guaranteed input-flow from about 40 000 ton / year of VGF-waste this digester could perfectly run within the company limits, though an optimal integration with the region through optimised synergies should result in a win-win situation for all sides. Optimal synergies with neighbouring companies were researched on the following levels:

(i) INPUT (circa 30km)
(ii) DIGESTATE
(iii) BIOGAS (co-firing, upgrading, etc.)

Outcome(s): The conducted inventory for input flows showed that the guaranteed intake they possess now (= 40 000 ton VGF / year) could be easily increased up to 50 000 ton / year. The "add-on" would mainly result from neighbouring communities not yet included in the action radius of EcoWerf at this moment. Hence the type of input would remain unchanged (household VGF). Nevertheless, internal limitations of the company have to be respected as well - for EcoWerf this is the capacity of the down-stream (existing) composting unit. Taking into account this limitation, the maximal input flow was limited to 40 000 ton/year. The next level of synergies that was researched was based on the DIGESTATE flow. In an optimal scenario the liquid fraction of the digestate could be treated in the neighbouring WWTP of Aquafin, but based on juridical restrictions (Aquafin can only treat communal waste water, not industrial waste water) there is no possible synergy on this level. Therefore the complete digestate flow will have to be processed in the existing composting unit. The final synergies researched were on the level of BIOGAS. For now the "standard" option of valorisation of the biogas on the site of EcoWerf itself showed the best economical results, though the other possibilities are not completely rejected yet. In case the policy framework for bio-methane injection would be realised in Flanders, EcoWerf will potentially consider this.

Involvement: The main work of this study was conducted by Innova Enegy and the University of Ghent. Innova Energy took on the part of interaction with possible "synergy-partners" and the profitability study, while University of Ghent provided support with academic information, networking and background information. Furthermore there was a subcontracting to Innolab for the execution of 2-monthly biogas potential analysis on the VGF-flow coming to EcoWerf for 12 months.

Pilot 10. Biomass from contaminated land

Location: **Lommel, Province Limburg (Belgium)**
Contact: **Brecht Annicaert** (brecht.annicaert@ugent.be), **Erik Meers** (erik.meers@ugent.be)

Synopsis: The food versus energy debate has initiated a search for low impact energy crops that can fulfil additional functions besides biomass supply. Biomass production on land that is unfit for agricultural use through contamination is examined. The Campine region in the province of Limburg is a textbook example of an area facing problems with diffuse metal contamination, mainly cadmium and zinc. Phytoextraction is a treatment strategy for diffusely contaminated soils that is based on the use of plants and associated microorganisms to remediate the soil. The big challenge with phytoextraction, however, remains the long remediation time. This could be overcome by valorising the harvested biomass in non-food applications, for example in the production of bio-energy. In this way, an income is generated for the farmer during the remediation period and the long remediation time is no longer a restriction. The aim of this pilot is to investigate the growth potential of different energy crops (maize, winter rye, ryegrass) on these soils and to address the opportunities for their energetic valorisation.

Outcome(s): The pilot has revealed that the growth potential of energy crops on contaminated land will not be a hurdle for the implementation of phytoextraction. In the future, this pilot will allow us to evaluate the year round growth of energy crops in a rotation scheme. There is little known about agronomic rotation schedules other than food crops, so this outcome will have a broader application than contaminated land. Additionally, different crops will accumulate different metal concentrations in their biomass and therefore it is an indispensable condition that safe energetic valorisation of this biomass is investigated. This research is on-going and valorisation strategies will include innovative techniques such as pyrolysis, torrefaction and hydrothermal conversion.

Involvement: In addition to Ghent University, Inagro is involved for the strategic design of a year round plantation scheme with energy crops. Furthermore, based on the results of this pilot and the data delivered by Ghent University and Inagro, a Life Cycle Assessment is in preparation by CRP Henri Tudor, to estimate the potential environmental gains and impacts of combining phyto remediation with crop cultivation for energy production purposes.

Additional information: Combine **http://www.combine-nwe.eu/** - use of contaminated ryegrass in the IFBB technology for energy production

Pilot 11. Nutrient Recovery

Location: **Flanders (Belgium)**
Contact: **Viooltje Lebuf (Inventory report)** (viooltje.lebuf@vcm-mestverwerking.be), **Ivona Sigurnjak** (ivona.sigurnjak@ugent.be), **Erik Meers** (erik.meers@ugent.be), **Evi Michels (Field trial)** (evi.michels@ugent.be), **Bart Ryckaert** (bart.ryckaert@inagro.be)

Synopsis: Biogas plants depend on different factors to be economically viable depending on their location. One of these factors is another important aspect is the valorisation of the digestate. In some areas with large livestock numbers and an excess of manure, the digestate has to be processed before it can be transported and finally spread out on land. The aim of the pilot was to evaluate several treatment techniques, and most importantly evaluate the valorisation potential of the out-coming products, in agriculture and in industry in both lab and field trials. In this bio-based era, recycling of nutrients and organic material is highly desired, and digestate and its derivatives might have great potential as an (in)organic fertilizer. However, insufficient knowledge about its properties currently limits its use.

Outcome(s): An inventory report was made on the existing nutrient recovery techniques from digestate. Along with digestate, a broad range of end-and side products coming from manure processing have been collected and characterised. To evaluate the agricultural potential and impact of bio-based fertilizer use on soil quality and crop production, lab and field trials were set up using these products instead of conventional fertilization regimes (livestock manure + synthetic fertilizers). The first results have shown no significant difference in soil quality, crop uptake and crop yield as compared to the reference. Hence, the tested products have great potential to be used as a replacement for synthetic fertilizer. This could lead to more optimal nutrient recycling and a reduced use of fossil fuel based fertilizers, allowing farmers to meet crop nutrient requirements by good economic and environmental farming practice. Using the results of the field trials, several meetings with European Commissioners and local governments have been set up, to introduce these bio-based fertilizers in practice.

Involvement: This is a cooperation between University of Ghent, VCM and Inagro. University of Ghent and Inagro focus on the physicochemical composition of the products tested, the experimental design and practical execution of the trials, as well as statistical analysis of the results. VCM was in charge of the inventory report, the legal framework, as well as the market study for the end-products. Additionally in this context, based on the data delivered by the Flemish partners, a Life Cycle Assessment and economic assessment of different digestate treatment/nutrient recovery systems has been prepared by CRP Henri Tudor, to estimate the treatment/recovery costs, potential economic value of the nutrients captured in the products as well as the environmental implications linked to the treatment/recovery step.

Additional information: INEMAD: www.inemad.eu - BioRefine: www.biorefine.eu - Report: Techniques for Nutrient Recovery from Digestate (**http://arbornwe.eu/downloads**).

3. The Investments

Stoke-on-Trent, UK

Investment: 1 **560,000 EUR** 20

Stafford, UK

Investment: 4 **83,000 EUR** 23

West-Flanders, Belgium

Investment: 2 **8,000 EUR** 21

West-Flanders, Belgium

Investment: 5 **8,000 EUR** 24

Province of Utrecht, Netherlands

Investment: 3 **500,000 EUR** 22

Netherlands

Investment: 6 **4,000 EUR** 25

Investment 1.

Closed loop biomass system

Location: **Stoke-on-Trent, United Kingdom**
Contact: **Elliot Jones** (Elliot.Jones@stoke.gov.uk)

Synopsis: In Stoke-on-Trent a closed loop biomass supply chain is being piloted with the intention of turning waste wood from the City Council's tree management works into fuel grade wood chip for use within the City. To provide initial demand, a biomass boiler system has been installed in a City Council public building – St James House. The building is an Enterprise Centre with approximately 30 business units designed to enable start-up and small businesses to develop. Installation of the biomass boiler system took place in October 2013 and work is now focusing on identifying a feasible operating model to deliver the closed loop supply chain.

Outcome(s): Following an initial feasibility study, it was determined that the most appropriate location for a boiler to stimulate demand for biomass within the City was St James House, a former Victorian school that was renovated in the 1990s and turned into a Business Enterprise Centre. The building currently has nearly 30 individual business units of different sizes that are occupied by small start-up businesses. This same study determined that the most appropriate system to be installed was a direct combustion boiler rather than a pyrolysis based unit due to both the scale required and the technology available.

Since installation, the boiler has created a demand for approximately 65 tonnes of woodchip per annum. Whilst wood fuel is currently being supplied from local virgin timber by an established biomass supplier, work is well under way to create the closed loop supply chain to feed the boiler from the City Council's own wood waste going forward.

With assistance from local biomass partners, several options have been explored to determine the most effective and economically sustainable model for delivering the closed loop supply chain. After examining the available solutions it has been concluded that utilising a third party biomass supplier to store, season and chip the waste wood on an existing site will produce the only viable operating model. This will allow the viability of the closed loop supply chain to be proven whilst providing a sustainable solution which retains the ability to be scaled up when biomass demand within the City grows.

Involvement: This investment is being led by Stoke-on-Trent City Council with support from the National Task Force and local biomass partners.

Funding: 560,000 EUR

Investment 2.

Multi-functional Short Rotation Coppice (SRC)

Location: **West-Flanders, Belgium**
Contact: **Pieter Verdonckt** (pieter.verdonckt@inagro.be)

Synopsis: Bio-energy production from energy crops is a very controversial subject (cf. food vs fuel discussion). In ARBOR we do not want to be dragged into this discussion that is why we focus on low-impact energy crops, that do not interfere with food production and that combine different functions. A good example of a low-impact energy crop is short rotation coppice (SRC). Willows and poplars are grown and harvested in cycles of 2-5 years using very few pesticides and no fertilizers. The harvested wood chips can be used for energy production.

Outcome(s): Inagro planted three pilots with short rotation coppice in 2012. Two of these pilots were situated on agricultural land in the province of West-Flanders. Besides their function for biomass production, these pilots were adapted to optimise their value for biodiversity. In total around 2.5 hectares were planted. Another hectare was also planted in combination with free range chickens. At this moment the free range is mostly pure grassland and is as a consequence not used by the chickens. Since they are naturally forest animals, by planting SRC the benefits of the free range method are improved. As a result, the chickens spread better over the whole area which improves their well-being. A demonstration day, calculation tool and billboards were developed in order to trigger other farmers to plant SRC for multifunctional purposes. In 2014 new pilots have been planted, both by Inagro and POM.

Involvement: Inagro worked very closely with POM (cf. Investment 5) for the planting design, the planting material and the planting machinery. Additionally, based on the data delivered by Inagro and POM, a Life Cycle Assessment and economic assessment of the SRC pilots have been prepared by CRP Henri Tudor, to estimate the investment costs, understand the economic risks as well as the environmental implications linked to the cultivation of SRC.

Funding: 8,000 EUR

Additional information: POPFULL: **http://www.afbini.gov.uk/willowbestpractice.pdf**

Investment 3.

Biogas hub

Location: **Province of Utrecht, Netherlands**
Contact: **Sieta de Vries** (sieta.de.vries@provincie-utrecht.nl)

Synopsis: The Province of Utrecht facilitates the realisation of a biogas hub. This is a pipeline in which the biogas from different producers is collected and transported. At a well-chosen location, the biogas will be upgraded to green gas, which has the same properties as natural gas. The green gas will be injected into the gas grid or will be used to produce bio-LNG (bio Liquid Natural Gas). Several digesters will be connected by a pipeline (biogashub).

Outcome(s): A study has revealed two potential regions in the Province of Utrecht where a profitable biogas hub can be developed. Only one of them can be realised in the timeframe of the Arbor project. This is the region around Woudenberg. A digester and a gasification plant will be connected to a collective pipeline. The biogas produced will be upgraded to green gas and injected into the gas grid. A nearby factory will also connect to the hub and use a part of the produced green gas. Several other entrepreneurs who are interested in digestion or gasification are expected to join the hub in the near future. After its implementation this will make a good case study to investigate the transferability to other regions in North West Europe.

Involvement: This investment will be realised in co-operation with local biogas producers.

Funding: 500,000 EUR
The digester will use roadside grass from the collecting structure (Pilot 4).

Investment 4.

Centre of Excellence for Biomass

Location: **Stafford, United Kingdom**
Contact: **Professor Tarik Al-Shemmeri** (t.t.al-shemmeri@staffs.ac.uk)

Synopsis: The establishment of this centre has become a major step in bringing a closer focus on the role of biomass as a key source of renewable energy. The Centre is being used for demonstrating the different biomass into energy conversion technologies currently available, as well as the fuel quality assessments carried out for biomass samples supplied by our partners. The Centre is also being used for demonstration and seminar purposes, and provides a platform for students to carry out projects as part of their academic development in the general area of energy and environment, which are the core subjects in Engineering and Sciences degree courses at Staffordshire University.

Outcome(s): A 45kW BioWin XL Windhager unit was installed along with a daily hopper and an 825 litre buffer tank. A portion of the existing radiator panels were decoupled from the existing central heating system. This proved a major improvement as the existing pipe system is approximately 40 years old and all the valves were no longer operational. An existing water tank was modified to provide storage for 6m^3 of pellets. The installation provides heating for approximately 150m^2. An absorption refrigeration unit was installed in line with the biomass hot water heating system with a capacity of 10kW of cooling.

In addition, ARBOR Centre of Excellence has the following units to demonstrate further capabilities of biomass energy:

(a) A wood gasification unit will be used to generate a gas mixture to be injected into an IC engine to generate power from biomass. Besides being used for demonstration purposes the University will organise a number of workshops and integrate the Centre of Excellence in its teaching curricula.
(b) A Stirling engine driven by the waste energy from the biomass combustion unit to produce electricity.
(c) A Thermo-electric Peltier device driven by the waste heat from the biomass combustion unit, powering a strip of LED lights
(d) An electrostatic precipitation unit to capture the particulate matter generated from the combustion of biomass. This unit has been tested and results are exceeding expectations with efficiency over 95%.

Involvement: Fuel samples from all interested partners are investigated as well as fuel samples obtained through other projects. Engineering students on the undergraduate course have been using the facilities to conduct fuel sample tests as part of their assignment on energy. In addition, one module on the MSc programme has offered the facility for research on biomass, and currently there are 6 doctorate students engaged in research related to different aspects of biomass.

Funding: 83,000 EUR

Additional information: The centre is used for demonstrations, delivery of short courses and training for biomass heating, cooling and electricity generation.

Investment 5.

Multi-functional Short Rotation Coppice

Location: **West-Flanders, Belgium**
Contact: **Sophie Tobback** (sophie.tobback@pomwvl.be),
Brecht Vanhecke (brecht.vanhecke@pomwvl.be)

Synopsis: This investment is as in the above-mentioned investment 2 also on the topic of Short Rotation Coppice (SRC) as an example of a low-impact energy crop. The difference is to be found in the used parcels: instead of using agricultural land the focus is on unused industrial land. The goal of these pilots is to provide an extra income for the company-owner of the land, to create a natural buffer for odour, particulate matter or other emissions, to support biodiversity on industrial estates and to integrate the company in its landscape.

Outcome(s): POM planted six pilots with short rotation coppice, all situated on previously unused industrial areas in the province of West-Flanders. In total around 5 hectares were planted. The used cycles are respectively 3 and 5 years. A demonstration day and billboards should trigger other industrial companies to valorise their unused terrains in a similar way. Additional prospecting for extra pilots in 2015 will be executed.

The goal of the pilots is to provide an extra income for the company-owner of the land, to create a natural buffer for odour, particulate matter or other emissions, to support biodiversity on industrial estates and to integrate the company in its landscape. In winter 2014-2015 POM will coordinate the first harvest of 3 willow pilots, in close collaboration with Inagro. Practical and economical experiences of the harvest will be disseminated to other industrial companies. Several methods of drying the harvested wood chips will be investigated. In addition, hypothetical cases of short rotation coppice in buffer zones surrounding industrial areas will be studied, comparing the classical way of planting a buffer zone (indigenous species, maximal visual buffer,...) with a buffer zone that consists of short rotation coppice.

A calculation tool was developed that offers companies and farmers the possibility to have a better insight in the parameters that define the profitability of an SRC pilot (**www.korteomloophout.be**).

Involvement: Inagro worked in partnership with POM (cf. Investment 2) for the planting design, the planting material and the planting machinery and the calculation tool. Additionally, based on the data delivered by Inagro & POM, a Life Cycle Assessment and economic assessment of the SRC pilots have been prepared by CRP Henri Tudor, to estimate the investment costs, understand the economic risks as well as the environmental implications linked to the cultivation of SRC.

Funding: 8,000 EUR

Additional information: POPFULL: (International Re-integration Grant (IRG) with grant agreement n° 268257 / A Marie Curie Action under the European Commission's Seventh Framework Programme (FP7/2007-2013): **http://webh01.ua.ac.be/popfull/index.php?lang=en**

Investment 6.

Multi-functional buffer strips

Location: **Netherlands**
Contact: **Cor van Oers** (c.vanoers@dlvplant.nl)

Synopsis: In Holland, as in the rest of Western Europe, the use of buffer strips is commonly used for protecting surface water from pollution of minerals and chemicals from agriculture. These buffer strips are paid for by the EU and are highly dependent on subsidies. If the price of food rises or the compensation for buffer strips drops, the farmers will plough the buffer strips. In this action DLV Plant is looking for new possible uses of the crops used as buffer strips e.g. for the production of low impact energy crops.

Outcome(s): DLV Plant will develop pilots of different types of strips and usage.

- 'Pannekeet' measuring 9m by 493m
- 'Waesberghe' measuring 9m x 658m
- 'Schaapstal' measuring 9m x 518m
- 'Colijnsplaat' with 3 areas measuring 3m x 200m

This means almost 1.7ha in total. Different sorts of cereals (e.g. wheat, barley and rye) as well as mix of grasses were planted. All crops were harvested by a combination of manpower and machines. Additionally a demonstration of sorghum, sunflower and flowers were trialled. As the onset of spring in 2013 was rather late, with temperatures only rising in June, the growth was impeded by a drought period. As a result the pilots were not so well developed as in 2012. In line with the definition of being a buffer area for the water body (an important canal/ ditch), spot samples are harvested in August and September. After this the pilots were ploughed. They will be sown again in 2014 and in addition there will be pilots with different crops. There are plans for demonstrating the bufferstrip system at a research station.

Involvement: Based on the data delivered by DLV Plant, a Life Cycle Assessment and economic assessment of the buffer strip pilots is in preparation by CRP Henri Tudor, to estimate the potential environmental gains and impacts of combining function of water protection with low-impact crop cultivation for energy production purposes.

Funding: 4,000 EUR

4. Partners

Partners and url

Staffordshire University
www.staffs.ac.uk

Provincie Utrecht
www.provincie-utrecht.nl

Stoke-on-Trent City Council
www.stoke.gov.uk

Inagro
www.inagro.be

VCM
www.vcm-mestverwerking.be

Ghent University
www.ughent.be

IZES gGmbH
www.izes.de

UCD
www.ucd.ie

Innovwa Energy
(sub-partner)

Wageningen University
www.wur.nl

DLV Plant
www.dlvplant.nl

Public Research Centre
Henri Tudor
www.tudor.lu

FlandersBio
www.flandersbio.be

POM
www.pomwvl.be

ARBOR works closely with the following projects:

Enalgae	www.enalgae.eu
BioenNW	www.bioenergy-nw.eu
Biorefine cluster	www.biorefine.eu/cluster
Combine	www.combine-nwe.eu
Inemad	www.inemad.eu
BioRefine	www.biorefine.eu

Co-finance land url:

ERDF (Interreg IVB)	www.nweurope.eu
Ministerium für Wirtschaft, Arbeit, Energie und Verkehr Saarland	http://www.saarland.de/ministerium_wirtschaft_arbeit_energie_verkehr.htm
Entsorgungsverband Saar	http://www.entsorgungsverband.de
Flemish Government, Hermes	
Ministère de l'enseignement supérieur et de la recherche du Luxembourg	http://www.mesr.public.lu
Flemish Energy Agency	http://www.energiesparen.be
Province East Flanders	http://www.oost-vlaanderen.be
Province West Flanders	http://www.west-vlaanderen.be
Province Flemish Brabant	http://www.vlaamsbrabant.be
Province of Gelderland	http://www.gelderland.nl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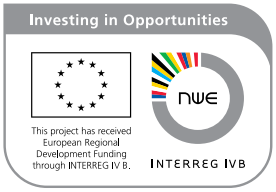
Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B.
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