Development of sustainable heat markets for biogas plants in Europe

Project No: IEE/11/025

Overall conclusions, recommendations and good practices

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BiogasHeat website: www.biogasheat.org
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1 Introduction

Biogas production increasingly contributes to meeting energy demands in the European market. It opens new opportunities for farmers, industry and the environment as well as offering sustainable solutions to a variety of challenges we face today in the agricultural, transport and energy sectors. Energy efficiency targets are one of the major priorities and challenges on the European energy policy agenda. The EU set a goal to reach 20% reduction in Europe’s primary energy consumption by 2020, meaning that also the biogas sector is faced with a challenge of reaching higher energy efficiency levels in biogas plants.

Even though in many European countries production and use of biogas is increasingly recognised as a sustainable option to meet 2020 targets, the main focus remains on the optimisation of the electricity production. Most biogas plants produce electricity in CHP biogas plants, providing an opportunity to implement different heat utilisation concepts next to a biogas plant. However, the utilisation of heat from CHP is often not taken into account and is wasted. One of the main reasons for wasting heat from CHP plants is the lacking recognition of renewable heat as valuable source of energy by consumers and energy policy makers in most EU Member States. This leads to slow market development of renewable heating and cooling technologies, including heat recovery from CHP biogas plants.

The BiogasHeat project promotes the efficient utilisation of heat from biogas plants at the European and national level. The project carries out activities in 8 European countries - Austria, Croatia, Czech Republic, Denmark, Germany, Italy, Latvia and Romania - and creates a platform for knowledge exchange and transfer from countries with a developed biogas market.

This summary report was elaborated in the framework of the BiogasHeat project and provides an overview on the status quo from heat utilisation plants in Europe, the current legislative framework and existing bottlenecks, technical solutions for heat utilisation, strategy considerations, business planning and political recommendations and best practice cases. It serves a comprehensive summary of the results achieved over the course of the project.
2 Biogas market in the target countries

The biogas markets in the 8 European project countries (Austria, Croatia, Czech Republic, Denmark, Germany, Italy, Latvia and Romania) are very distinct. In Germany, Denmark and Austria biogas markets are comparatively highly developed. Other countries are in the developing phase without a significant share of biogas in the energy mix from RES.

Whereas Germany is the leading biogas producer in Europe with more than 7,500 installed biogas plants, other countries, such as the Czech Republic and Italy, have also had a considerable market growth in the biogas sector in the last few years. The positive development will not remain stable in the Czech Republic in the coming years due to low support from the policy side. Significant developments were also made in Austria and Denmark where many biogas plants have been installed. However, their markets have remained quite stable in the last years without any substantial establishment of new biogas installations. In Denmark this situation is changing due to the promotion of the biogas sector by the government. Thus, in the next years, a significant increase in the number of biogas plants is expected, some of which are already under development or at the planning stage.

A considerable growth was achieved in Latvia in 2011; however, this development was hindered when new tenders for obtaining the right to receive a feed-in tariff were stopped until the end of 2013 and the moratorium was later prolonged until the end of 2015. Moreover, starting from 2014, biogas plant owners have to pay a subsidised energy tax - 5 or 10% of their income from the sales of electricity. Despite a high potential, biogas activities in Croatia and Romania are still very limited with very few installed plants. The slowest development in agricultural biogas production was observed in Romania. Table 1 (page 6) provides an overview on the primary energy production of biogas and estimation of heat sold to the district heating network or to the industrial units in 2011. Today in 2014, the situation is different but there is no reliable data yet.

The market developments in the different countries are heavily influenced by legal and political framework conditions. In addition, the historical development of the sector as well as other factors such as the general economic welfare of the countries, administrative procedures and access to financing led to uneven developments of the biogas sector in Europe. One of the most important factors that considerably contribute to a fast development and market growth of biogas production in general is the obtainment of feed-in tariffs for the sale of green electricity generated by biogas.
Table 1: Overview on the primary energy production of biogas and estimation of heat sold to the district heating network or to the industrial units in 2011 (EurObserv'ER 2012; Ministry of Economy, Republic of Croatia 2012)

<table>
<thead>
<tr>
<th>Country</th>
<th>Primary energy production of biogas (ktoe)</th>
<th>Heat from biogas plants sold to the district heating network or to the industrial units (ktoe)</th>
<th>Share of the primary energy produced from biogas provided to the district heating network (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>5067.6</td>
<td>58</td>
<td>0.98%</td>
</tr>
<tr>
<td>Italy</td>
<td>1095.7</td>
<td>29.7</td>
<td>2.71%</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>249.6</td>
<td>7.2</td>
<td>2.88%</td>
</tr>
<tr>
<td>Austria</td>
<td>159.5</td>
<td>10.4</td>
<td>6.52%</td>
</tr>
<tr>
<td>Denmark</td>
<td>98.1</td>
<td>28.9</td>
<td>29.45%</td>
</tr>
<tr>
<td>Latvia</td>
<td>22</td>
<td>4</td>
<td>18.18%</td>
</tr>
<tr>
<td>Croatia</td>
<td>3.07</td>
<td>0.8 (estimation)</td>
<td>26.05%</td>
</tr>
<tr>
<td>Romania</td>
<td>5.59</td>
<td>3.15</td>
<td>56.35%</td>
</tr>
</tbody>
</table>

Table 2: Overview on the main heat utilisation ways of the biogas plants in BiogasHeat project countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Utilised for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>72% use parts of the heat on-farm, 50% use parts of heat as process heat, 35% use parts of heat for DH, 1% does not use heat at all. (Sample size in 2008: 151 out of 341 plants)</td>
</tr>
<tr>
<td>Croatia</td>
<td>66% on-farm</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>On-farm, process</td>
</tr>
<tr>
<td>Denmark</td>
<td>On-farm, process, DH(!)</td>
</tr>
<tr>
<td>Germany</td>
<td>On-farm use for heating, DH, drying of woodchips and cereals</td>
</tr>
<tr>
<td>Italy</td>
<td>Process (around 30%)</td>
</tr>
<tr>
<td>Latvia</td>
<td>On-farm, process, DH, drying of wood products and heating greenhouses</td>
</tr>
<tr>
<td>Romania</td>
<td>Use heat as process heat (2 out of 4 plants), new projected facilities to have 100% use of heat in different processes</td>
</tr>
</tbody>
</table>
3 Heat markets in the target countries

It has proven to be difficult to describe the current situation as reliable data on heat use is limited. Nevertheless, it can be concluded that the actual status of heat utilisation from biogas plants in the target countries could be increased through application of different heat use options. Questionnaires and data analysis have shown that there is a vast potential for heat utilisation in all target countries. However, the share of heat utilisation and the used options vary substantially between the countries.

Looking at the numbers for heat that was sold to district heating grids or industrial units (Table 1 page 6), they show that of the produced heat between around 1% (in Germany) and nearly 30% (in Denmark) is utilised in this way. Standing on its own those numbers would present a devastating picture. However, heat sales to district heating and industry depend significantly on the location of a plant and on the national framework and traditions.

When broadening the picture and looking at other utilisation possibilities (Table 2 page 6) one can see that the a substantial number of plant operators uses an unknown share of the produced heat either on-farm, for example for drying purposes, or in the biogas production process itself. The data for Austria (BMVIT 2008), which sketch the most detailed picture, show a high percentage of operators that utilise heat in various ways. However, Austria is one of the most advanced countries when it comes to heat utilisation, so this clearly does not allow the drawing of conclusions about the other countries.

It is important to keep in mind that even based on those numbers one cannot assume that most of the heat is utilised. For example, heat utilisation within the process typically only accounts for 25% of the available surplus heat. At the same time, the fact that an unknown share of the heat is utilised does not allow for any conclusions on the efficiency. Unfortunately, there are many examples for very inefficient utilisation solutions, mainly when it comes to drying.
4 Barriers

The reasons for this shortcoming in heat utilisation are manifold. In table 3 (page 9) there is an overview of the various reasons that were identified or put forward by operators, planners and other experts in the field. The information was obtained through questionnaires prepared within the project and distributed to relevant target groups.

The barriers can be clustered in four categories:

- awareness,
- capabilities,
- structural issues and
- framework conditions.

The first and essential hurdle is the lack of awareness. Many operators and planners are only aware of the possibility to produce electricity from biogas but not of the opportunity to additionally use the surplus heat. This hurdle must be actively overcome by informing the involved stakeholders about the general possibility to utilise heat.

The second barrier is a lack of capabilities. This includes on the one hand a lack of knowledge, be it technical or business-related. These stakeholders are aware of heat utilisation but do not know which possibilities they have, what would suit their situation best or how to realise the project. Similar to the lack of awareness this can be overcome by information campaigns and trainings. However, stakeholders might also ask for help actively, e.g. at their national associations. On the other hand, lack of capabilities can also mean a lack of financial means. Upfront and development costs for biogas plants and for heat utilisation are higher than for other renewables. Therefore, information on financing mechanisms and business planning is well-needed.

Structural issues are mainly a matter of planning and can therefore – in the case of new plants – be treated similar to a lack of knowledge/capabilities. However, in the case of existing plants this is a barrier on its own. Once a plant is built, the location is fixed and might be a barrier to certain heat utilisation solutions. In this case, the barrier cannot be overcome by capacity building targeting the planning phase. Rather, it needs tailored solutions that need to be developed case-by-case.

Last but not least, the biggest bottleneck and at the same time the hurdle that is the most difficult one to overcome is the legislative framework. In this field, three major categories of issues could be identified. Firstly, certain laws only support the production of electricity or even discriminate against heat production. Secondly, regulations are often unclear or even contradictory. Thirdly, they get changed quite often which leads to a climate of insecurity. What is needed is a legal framework that is clear, long-term and unambiguous. Such a shift cannot be achieved by simple information campaigns but only by concerted advocacy efforts.
Table 3: Main bottlenecks for heat utilisation from biogas plants in BiogasHeat project target countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Bottleneck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Injection of heat into DH network is almost exhausted; Many plants are in rural areas with little local heat markets; Uncertainty for producers with respect to changes in demand</td>
</tr>
<tr>
<td>Croatia</td>
<td>Lack of awareness, lack of knowledge, lack of incentives, lack of transparency of legislation</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Missing specifications of reasonable heat utilisation options, lack of incentives</td>
</tr>
<tr>
<td>Denmark</td>
<td>On-site utilisation creates wasted heat surpluses in summer, local resistance against centralised plants, industrial utilisation unattractive because of Danish legislation</td>
</tr>
<tr>
<td>Germany</td>
<td>Many of the 8,000 biogas plants were installed at locations which did not consider the heat use. They are often in remote areas where there is no heat demand. For new installations (EEG 2012) a 60% heat use obligation was introduced. This is generally positive, but generates risks for the plant operator, in case that the heat demand of the heat consumer suddenly drops. Today, the trend of German biogas plants is towards flexibilisation of power production, in contrast to base-load production. This has impacts on the availability of the heat and requires sophisticated, but non mandatory, heat use concepts.</td>
</tr>
<tr>
<td>Italy</td>
<td>Lacking recognition of heat as primary energy source, heat utilisation not obligatory, Technical difficulty in reaching the standard of high efficiency cogeneration bonus (the use of heat for the process is not considered as &quot;useful heat&quot;)</td>
</tr>
<tr>
<td>Latvia</td>
<td>Most of the biogas plants in Latvia were constructed in remote areas and initially the use of heat was not required by the legislation. As a result, many of existing biogas plants does not have external heat consumers near by the plant. New biogas plants are required to comply with the high-efficiency CHP definition, ensuring generation of a useful heat. According to the regulation, heat is considered useful only in the case if it is sold to external user. Heat use for the self-consumption or for the farm buildings owned by the biogas plant, is not counted as useful. Thus, for biogas plants it is almost impossible to comply with the high-efficiency CHP requirement. Incentives for using heat in DH systems are lacking. DH operators do not benefit from biogas heat use.</td>
</tr>
<tr>
<td>Romania</td>
<td>Lack of clarity in green certificate legislation, lack of measures on the thermal sector, lack of incentives for biogas production in general. Loans difficult to obtain</td>
</tr>
</tbody>
</table>
5 National Policies

Austria

Since 2002 a Green Electricity Bill has been in place in Austria which resulted in a biogas boom. However, an amendment in 2006 cut feed-in tariffs heavily which led to a sudden stop in biogas investments. The 2009 amendment turned the wheel back while introducing minimum efficiency requirements. Current feed-in tariffs for electricity range between 12.93 Ct/kWh (capacity > 750 kW) and 19.5 Ct/kWh (capacity < 250 kW). After the contract periods they are decreased to 9.95 Ct/kWh. Additionally, 2 Ct efficiency bonus for efficiencies above 60% and 4 Ct operating bonus are offered. Last but not least grant subsidies for certain investments are part of the legislative support scheme.

Croatia

Biogas is mentioned in some 40 legal documents that could be arranged in three main categories: energy, agriculture and environmental protection. Within energy policy, biogas is described as one RES while in other policies, biogas is positioned as a tool for achieving some specific goal of agricultural policy (e.g. a rural development measure) and environmental policy (e.g. a GHG emissions saving tool, agriculture pollution prevention measure).

Currently, biogas production has two mutually exclusive incentives: a feed-in tariff for RES-E from biogas (set of laws from energy, since 2007) and 50% grant in investment for building and/or reconstruction of a biogas plant (set of laws from agriculture). A Law on RES-H has been pending since 2008.

Czech Republic

The Act on the support of electricity from RES was adopted in 2005 with the objective of reaching the target for the share of RES-E in 2010, without regard for cost optimisation and with no requirements on energy efficiency. High feed-in tariffs for electricity and investment subsidies resulted in a focus on electricity production.

The 2012 Act on the support of RES sources introduced new requirements on sustainability (at least 30% of biogas should be produced from substrates other than from arable land and permanent pastures) and for energy efficiency (at least 50% of energy in substrates should be utilised).

Feed-in tariffs are determined by the Energy Regulatory Office (ERO). In 2012 the ERO introduced a requirement for the maximum FiT requesting useful heat utilisation of an equivalent of 10% of electric power production. This was changed in 2013: the new tariffs are significantly lower but there is a special CHP bonus. Secondary legislation describing CHP electricity entitled to support is also in preparation. There is, however, no positive list for suitable heat utilisation options.

Denmark

The legislation for the establishing and operation of biogas plants in Denmark is well developed. This also holds for the utilisation of heat from the plants. Furthermore there is a strong desire among Danish politicians to promote biogas, which is reflected in the “Energy Agreement” signed by most parties in the Danish Parliament in March 2012.

Germany

The introduction of the so-called ‘CHP bonus’ in the amendment of the Renewable Energy Act (EEG) in 2004 resulted in a significant increase of heat utilisation of biogas plants. In addition to the basic feed-in tariff, the law had foreseen an additional 2 Ct/kWh in case of heat utilisation. Since the 2012 version, heat utilisation is mandatory. As of 1 January 2012, biogas operators of newly installed biogas plants are required to use at least 25% waste heat during the first year of operation and at least 60% heat in the following years from the CHP plant. 25% thereof counts for heating of the digester. Instead of complying with this heat use...
obligation, a biogas plant operator can also choose alternatively to use at least 60% manure in a biogas plant. In this case, no minimum heat use must be ensured.

**Italy**

In Italy Legislative Decree No. 28 of 3 March 2011 simplified administrative procedures for renewable energy plants and therefore facilitated the start-up of plants. The decree on incentives for renewable electricity (Decree of the Ministry for Economic Development of 6 July 2012) grants feed-in tariffs and additional support for cogeneration. If biogas is made from by-products the tariff is 10 EUR/MWh, if it is used for DHC it is 40 EUR/MWh. However, the decree also sets limits and hampers biogas developments. The maximum amount granted by the government is 5.8 bn EUR/year. To receive the subsidy plants between 100kW and 5MW must be registered and win a tender. Within the register there is a priority system. Plants need to be owned by individuals or farmer cooperatives, fuelled by biomas or biogas composed of agricultural products and by-products or organic waste, and have less than 600MW peak electricity production. Priority is given to smaller plants using specific technologies such as highly-efficient CHP, nitrogen recovery or improved filter solutions.

**Latvia**

Latvia grants FiT for electricity from RES (Cabinet Regulation No.262) and from high efficiency CHP (Cabinet Regulation No.221). Biogas plant operators could choose under which regulation to fall. Most of the plants are operating under regulation No.262 where efficient heat use is not required. In Regulation No.221 the efficient heat use is defined as obligation to sell heat to the end user. Heat used for self-consumption (e.g. for heating the digesters) is not considered as efficient heat use. So far there are no real control mechanisms in place.

**Romania**

Renewable energy policies are favourable for RES providing advantages for electricity generation and CHP. The emphasis is put on high efficiency CHP with additional Green Certificate or high efficiency cogeneration bonuses. There are a number of legal inconsistencies that protract or even block the implementation of biogas projects and therefore integrated concepts related to it, with increased and more efficient use of biogas energy potential. There is no specific legislation dedicated to biogas.

A hindrance to the development of heat recovery and use systems from biogas plants is a demarcation between biogas on the one hand and landfill gas and sewage sludge fermentation gas, on the other hand. This has an impact on the granted GC number (2 versus 1), although they represent the same type of renewable energy.

**General**

In general, the heating market still lacks legislative improvements in most of the countries. For example, heat utilisation concepts have to be considered only in new biogas plants, whereas older biogas plants are not obliged to utilise their heat. Older biogas plants also have a potential for optimisation and could consider heat utilisation concepts. Therefore the focus should also be given to combined heat and power production in existing biogas plants. A political push for the heat market is still missing in most of the countries. For example, stronger incentives for the development of new heating networks are still missing.

A lack of knowledge in different useful energy forms that biogas could provide among decision-, policy-, strategy- and legal framework-makers is a bottleneck as well. Therefore heat utilisation is often not taken into account. In addition, currently only Germany has a ‘positive list’ for heat utilisation from biogas CHP plants that is defined in the Renewable Energy Law. The definition of a ‘positive list’ for heat utilisation could help to clearly define which concepts should be supported and promoted.

The lack of incentives for utilisation of renewable heat in general, including biogas, also hinder broader implementation of heat utilisation concepts from biogas plants. The
Implementation of heat utilisation concepts requires additional investments from biogas plant operators and is related to additional risks if heat consumers are suddenly lost.
6 EU Policies

Although the European Union has no direct competence when it comes to heat utilisation from biogas, there are several dossiers with an impact on biogas and heat.

Energy and Environmental State aid Guidelines (2014/C 200/01)

In April 2014 the European Commission endorsed new guidelines for state aid for environmental protection and energy. The new guidelines have an extended scope as they now also cover aid to energy infrastructure projects, generation adequacy measures and energy intensive users. The European Commission aims to replace feed-in tariffs by competitive bidding processes in order to increase cost-effectiveness and to limit market distortions. However, small installations below 1MW can ask for an exemption from these bidding systems and installations below 500kW can still get support through feed-in tariffs. Since July 2014 the European Commission has assessed new and pending state aid measures and as of 28 June 2014 the Member States have one year to bring existing schemes in line with the new rules. Schemes for renewables and cogeneration are explicitly excluded and will only be subject to the guidelines when adapted or extended. However, from 2016 on aid towards renewables will have to be adjusted gradually.

Energy roadmap 2050 (COM2011/885)

The Roadmap seeks to develop a long-term European framework in which national policies could be more effective. It recognises that renewable heating and cooling are vital to decarbonisation by stating that 'A shift in energy consumption towards low carbon and locally produced energy sources and renewable energy (e.g. solar heating, geothermal, biogas, biomass), including through district heating systems, is needed.' However the Roadmap does not include any further guidelines on how to enable the shift towards increased heating and cooling utilisation from RES.

Energy Efficiency Directive (DIR 2012/27/EU)

The Directive promotes energy efficiency and will in particular aim at delivering energy savings on the heating and cooling market with district heating and cooling.

According to the Directive member states will carry out a Comprehensive Assessment (CA) of the potential for high-efficiency cogeneration and district heating and cooling. As part of the CA, Member States will develop Cost-Benefits Analysis on CHP/DHC at national level. Cost-Benefits Analysis will also be done at installation level to analyse the possible use of waste heat. Where a potential has been identified, 'Member States shall take adequate measures for efficient district heating and cooling infrastructures to be developed and/or to accommodate the development of high-efficiency cogeneration and the use of heating and cooling from waste heat and renewable energy sources'. It is important to note that the comprehensive assessment will also deal with the use of Renewable Energy Sources. This assessment should be finalised by Member States by December 2015.

The Directive does not set any minimal national efficiency targets for cogeneration.

The Renewable Energy Directive 2009/28/EC (RED) established a European framework for the promotion of renewable energy, including biogas. The Directive recognises that ‘the use of agricultural material such as manure, slurry and other animal and organic waste for biogas production has, in view of the high greenhouse gas emission saving potential, significant environmental advantages in terms of heat and power production and its use as biofuel. Biogas installations can, as a result of their decentralised nature and the regional investment structure, contribute significantly to sustainable development in rural areas and offer farmers new income opportunities’. It also indicates that Member States should consider mechanisms for the promotion of district heating and cooling from energy from renewable sources.

However, heat utilisation from biogas CHP plants is not mentioned and promoted in the Directive. This means that Member States are not obliged to implement any changes in the national policy in order to develop RES production closely linked to increased energy efficiency.

In the framework of this directive, Member States defined clear goals for biogas production in a renewable energy mix by 2020 which primarily focus on electricity production. Member States also estimated a total contribution (final energy consumption) expected from biogas technology to meet the binding 2020 targets in the heating and cooling sector. Out of 7 analysed EU countries (Denmark, Czech Republic, Italy, Latvia, Romania, Germany and Austria) Germany and Italy will contribute most to the electricity production from biogas, followed by Denmark.

However, the implementation of the biogas 2020 goals faces challenges. In the Czech Republic the target was set too low, which creates a risk for the further development of biogas in this country as at the moment no targets beyond 2020 are defined. In the Czech Republic, the biogas market experienced a rapid development during 2010 and 2012. At the end of 2012, the electricity production from biogas (incl. landfill gas and sewage gas) amounted to 1.4 TWh and it was expected that in 2013 it might reach 1.6-1.7 TWh. This would outpace the biogas target set in the National Renewable Energy Action Plan by 60-70%. As of 2015 the Czech Republic has no further biogas targets and it is a rather negative signal for the entire biogas industry in the country.

According to the Danish Energy Statistics in 2011 the electricity and heat generation from biogas were, respectively, 343 GWh (1.24 PJ) and 29 ktoe (1.22 PJ) (Energistatistik 2012). Since then production has been stable. Electricity production is therefore a bit higher than the estimated in the interim trajectory in the Danish NREAP, but the heat production is around half. The rate of biogas production increase in the last years is far from fast enough to meet the 2020 objectives (from the actual biogas production of around 4 PJ to about 24 PJ). According to Danish Biogas Association some 40 to 50 large biogas plants should be constructed in order to reach this target. To impulse the biogas production and to reach the 2020 objectives, the new Danish Energy Agreement 2012-2020 includes several support mechanisms. The most important mechanisms are an increase in the feed-in tariff, the introduction of a subsidy when biogas is sold to the natural gas grid, a start-up aid of 30% instead of 20% and the establishment of a task force to study and support specific biogas projects. If there is not enough development of new biogas project until the end of 2013 the parties behind the Energy Agreement will discuss further options.

In Austria due to the new ÖSG 2012 (Ökostromgesetz - Green Electricity Bill) public support has become more attractive once again. Due to the long term guarantee of feed-in tariffs, CHP bonuses and premiums it is expected that new biogas plants will be developed in upcoming years. Until 2020 the ÖSG 2012 aims at the development of an additional 1.300 GWh from biomass and biogas. This figure is realistic only if banks are willing to grant loans to potential investors. If more biogas plant operators quit their business the biogas 2020 targets will be at risk.

The total installed electric capacity of biogas plants in Germany in 2013 reached 3,543 MW. The number of biogas plants reached 7,850 in 2013 (Fachverband Biogas e.V. 2011). The
expected installed capacity of biogas plants in 2014 was estimated to be around 3,804 MW meaning that Germany implemented the NREAP target for 2018 already.

According to a survey conducted by CRPA (Centro di Ricerca Produzioni Animali), the number of biogas plants operating in Italy was 587 at the end of 2011 and 937 at the end of 2012 (estimation based on the data of 87% of plants, Informatore Agrario, 2013). The total amount of power from all kinds of biomass to be supported during the next years will be as follows: 170 MW in 2013, 160 MW in 2014 and 160 MW in 2015.

At the moment there is no regulation for the period from 2015 to 2020, what creates a huge uncertainty among investors.

According to the 2009/28/EC Directive, the share of renewable energy sources in final energy consumption in Latvia should be increased from 32.6% in 2005 to 40% in 2020. In order to reach this target, Latvia has developed a National Renewable Energy Action Plan (NREAP) where different measures for RES support have been provided. Support measures mostly address the electricity (RES-E) sector. It is expected that biogas will significantly contribute to reaching the RES 2020 target in the electricity sector. According to NREAP, the biogas capacities will gradually increase, reaching capacity of 92 MW_el and providing 584 GWh of electricity from biogas in 2020. The total electricity generation from biogas in 2013 was 275 GWh from 52 operating biogas plants (installed capacity 54.42 MW_el). The progress of the Latvian biogas market in the future will depend from the national RES support policy that is currently under revision by the Ministry of Economics of Latvia.

More information about national policies related to the heat use from biogas could be found in the report on national policy enforcement for heat use from biogas (Mergner, 2013).

7 Policy recommendations

It is clear that biogas can significantly contribute to renewable energy production by 2020 and beyond. It can be converted to electricity, heat and upgraded to biomethane. In addition, digestate from biogas plants can be used as biofertiliser. However, the potential of biogas is not yet fully exploited in many Member States despite its high potential in terms of available agricultural resources. Therefore, changes in the legislative framework are necessary to foster heat utilisation from biogas.

In general, RES support in the Member States is focused on electricity production whereas efficient use of heat is hardly taken into account. According to NREAPs, more than 1/5 of the EU’s heating consumption in 2020 is expected to come from renewable sources. It is expected that the share of RES in heating and cooling will increase from 10.2% in 2005 to 21.3% in 2020. In 2020 biomass should represent 17.2% of heating and cooling consumption (EREC 2011). Sustainable heat utilisation from biogas CHP plants can significantly contribute to the share of RES in heating and cooling. However this requires a clear direction from the Member States towards the efficient use of primary energy from biogas. More focus on releasing the potential of RES, including biogas, in the heating and cooling sector is missing in the European and national policies.
Recommendations

Following the bottlenecks identified on the national level and the needs declared by the national stakeholders there are a number of recommendations for the European level:

On the use and utilisation of biogas in general

- National 2020 targets for the development of the biogas sector have proven to be unambitious or unsustainable in various countries. It would be helpful if the European Commission would push for an ambitious but realistic revision of the national targets.

- Currently, there are no clear biogas targets for the time after 2020 but in order to foster the sustainable development it is crucial to define them. Therefore, the European Commission should include corresponding paragraphs in the relevant dossiers that urge the Member States to define binding biogas targets for 2030 and 2050. One way to avoid unambitious targets as for 2020 could be the definition of target corridors or development criteria.

- To ensure that these targets are reached Member States need to implement sustainable and predictable support measures. In the short-term the European Commission could urge the Member States to create stable framework conditions. In the long-term the definition of future binding biogas targets could be linked to the development of a corresponding and binding support scheme.

On the utilisation of heat from biogas

- Generally, the utilisation of heat from CHP as well as in the form of waste heat must be promoted more. Therefore, the European Commission should adjust its strategies and consider the whole potential of heat utilisation for energy efficiency, energy security and phasing-in of RES. Future binding biogas targets should include realistic but ambitious heat utilisation targets, too.

- Accordingly, a comprehensive assessment under the Energy Efficiency Directive 2012/27/EU should also consider the use of biogas as a strategic source for District Heating and Cooling and look into the use of heat from biogas.

- Additionally, the development of a fair positive/negative list for ‘useful heat utilisation’ from CHP plants which includes various possibilities such as DHC and on-site utilisation should be started.

- With view to the Member States it would be helpful if the European Commission pushed for harmonised efficiency targets for heat utilisation from (biogas) CHP plants outside the field of highly efficient CHP.

- Also with regard to the utilisation in heat support schemes must be sustainable and predictable. Therefore, the binding support schemes should include clear rules on support measures, i.e. feed-in tariffs linked to efficiency, and documentation needs, i.e. utilisation plans, but also safety nets for operators in case of changing demands.

- The European Commission is asked to push for heat utilisation plans for future CHP plants as well as for existing ones.

- In addition to supporting schemes for the development of biogas CHP plants it is also necessary to support the development and construction of corresponding distribution networks. Therefore, the European Commission should revise its energy network development plans and take the potential of heat distribution into account. Accordingly, the European Commission could urge Member States to revise their network strategies and consider heat distribution as a sustainable alternative to other heating options.

For more information regarding policy recommendations please see the European Strategy Paper on Heat Use from Biogas Plants (Mergner 2013).
8 Heat utilisation concepts

Heat as an energy source can be utilised in manifold ways. All those different ways can be split in two types. Heat can be either utilised in a way that uses the actual warmth or in a way that uses the energy content otherwise. The first category includes processes such as heating and drying, the second cooling and electricity production. Formulated differently, the heat is used as end-product in the first case and as means to produce a different product (energy form) in the second case.

Which utilisation category and option is the right one for a plant depends on a variety of factors. On the one side there are personal preferences and capabilities. On the others side, there are many external and technical factors, such as location of a biogas plant, location of the potential consumers and heat demand.

Table 4 provides an overview on the main heat utilisation options which can be implemented to increase the overall efficiency and to improve the economic performance of the biogas plant. The table again shows that there are two kinds of options. Heat can be utilised on-site, e.g. for additional electricity production, drying in own facilities or heating stables owned by the operator. But heat can also be exported, e.g. for District Heating or Cooling, transported in containers, or used for heating or cooling of more distant facilities.

Table 4: Heat utilisation options (Rutz 2013)

<table>
<thead>
<tr>
<th>Heating</th>
<th>Drying</th>
<th>Cooling</th>
<th>Electricity production</th>
</tr>
</thead>
<tbody>
<tr>
<td>District heating</td>
<td>Drying wood, woodchips, and pellets</td>
<td>District cooling</td>
<td>Additional electricity production with CRC, ORC</td>
</tr>
<tr>
<td>Heating of stables</td>
<td>Drying agricultural products</td>
<td>Cooling of buildings</td>
<td>or Kalina technologies</td>
</tr>
<tr>
<td>Heating of greenhouses</td>
<td>Drying digestate and sewage sludge</td>
<td>Cooling of stables</td>
<td></td>
</tr>
<tr>
<td>Heating for aquaculture</td>
<td></td>
<td>Acclimatisation of food storage buildings</td>
<td></td>
</tr>
<tr>
<td>Heat transport in containers</td>
<td></td>
<td>Process cooling</td>
<td></td>
</tr>
<tr>
<td>Other heating options</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9 Good practice examples

Due to the broad variety of heat utilisation options and because no biogas plant is like the other, it is not possible to provide a one-size-fits-all solution. For this reason, it is important to provide all involved stakeholders with positive examples of how heat utilisation can be realised in practice. In the course of BiogasHeat project, the partners collected many good practice examples and twenty of them were summarised in a Good Practice Examples for Efficient Use of Heat from Biogas Plants (Mergner 2013). The following few examples were selected in order to give a first overview of different options in reality.

District heating for residential purposes in Odense, Denmark

Fangel Bioenergi is one of the first Danish biogas centralised plants. It was built by Bigadan A/S in 1988/1989 on the initiative of local farmers in order to find a solution for the environmental problems related to the slurry from the intensive animal production of the area. The plant underwent major reconstruction in 1999 and since 2001 is has been owned and operated by Bigadan. From 2002 to 2005 an enlargement and a renovation was carried out including a centrifuge to dewater the digestate. In 2008-2009 equipment for drying and pelletising the recovered fiber fraction from the centrifuge was installed.

The Fangel biogas plant produces around 10-12,000 Nm3 biogas/day, with a productivity of around 50 Nm3 biogas/ton biomass. The biogas is introduced in a co-generation engine of 1.4 MWel, after previous desulfurisation in a biological filter. Moreover, the plant has a back-up second engine of 0.8 MWel and a biogas storage tank of 1,500 m3.

The engine generates 10-12 million kWhel/year that is sold to the electrical network (consumed in around 2,000 one family houses) and 14 million kWhth/year of thermal energy. Of this thermal energy around 10% is used for heating the digesters and the pasteurisation of the feedstock. About 15-25% heat is used in the process of drying and pelletising of the digestate. The rest of the heat is sold in the form of hot water to the Odense Municipal District Heating and used in the heating network of a nearby city (ca. 600 single family houses).

![Aerial photograph of the Fangel biogas plant](www.bigadan.dk)
The plant collects around 65,700 ton/year of slurry from 18 to 20 nearby farms (max. 15 km), from which around 65.5% is pig manure, 8.2% cow and 8.2% poultry. In addition, around 14,600 ton/year organic waste is treated mainly from food industries close to the installation (50 km). This includes about 60% dairy waste, 25% intestinal content and flotation sludge from an abattoir and 14% waste from a spring roll industry.

The different waste fractions are homogenised and preheated in 3 heat exchangers before being pasteurised at 70°C for 1 hour in two parallel tanks. Then the feedstock is fed into 3 parallel digesters working in mesophilic conditions. The digestate is stored in a post-digester until its separation in a solid and liquid fraction in a centrifuge.

The liquid fraction is transported to decentralised storage tanks close to the fields. The solid fraction with a humidity of 65-75% is treated in a drying plant, which uses the heat from the co-generation engine and reduces its humidity to 10%. Afterwards the digestate is pelletised.

The optimisation of the energy efficiency in the drying plant is an important part of the overall process feasibility. The plant produces 2,000 ton/year of pellets that are sold to farmers.

Table 5: Main characteristics of Bigadan biogas plant

<table>
<thead>
<tr>
<th>Commissioning date</th>
<th>1988, major renovation 1999, 2002-2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input substrate</td>
<td>Around 220 ton/day (82% manure and 18% industrial waste)</td>
</tr>
<tr>
<td>Biogas production</td>
<td>About 3.6-4.4 million Nm³/year</td>
</tr>
<tr>
<td>Process</td>
<td>3 digesters with a total capacity of 4,500 m³ Total retention time of 18-23 days and 37-38°C</td>
</tr>
<tr>
<td>Installed power</td>
<td>1.4 MWel</td>
</tr>
<tr>
<td>Heat utilisation</td>
<td>Heating of 600 residential houses</td>
</tr>
<tr>
<td></td>
<td>Heating of the digesters and pasteurisation</td>
</tr>
<tr>
<td></td>
<td>Drying-pelletising (2,000 ton pellets/year)</td>
</tr>
<tr>
<td>Investment</td>
<td>Project cost in 1888: 3.4 million EUR (1.3 million EUR subsidies). Cost of the drying plant in 2008: 1 million EUR</td>
</tr>
</tbody>
</table>

Contact details
Fangel Bioenergi ApS, Oestermarksvej 70, DK - 5260 Odense S
+ 45 65963420 mail@bigadan.dk http://www.bigadan.com/

**ORC plant in Valovice, Czech Republic**

The biogas plant in Valovice has a total installed electrical capacity of 1,163 kW and has been in operation since 2008. All electricity is delivered into the ČEZ distribution network. In this case the ORC technology is used to generate electricity out of the waste heat which is produced by the CHP plant. With the help of ORC equipment with a capacity of 100 kW, an additional electricity generation of around 740,000 kWh/year is reached.

The facility is designed as a classical agricultural biogas plant which processes input raw materials in the following composition:

- pig liquid manure: 12,000 t/year
- maize silage: 14,802 t/year
- beet slices: 4,000 t/year
Special technologies for the mixing of input materials before dispensing them into fermentation tanks and including the co-generation unit are installed. The beet slices are treated before they are fed into the mixing unit where all the input materials are mixed. A new lagoon for the storage of digestate with a capacity of 7,000 m$^3$ is also part of the biogas plant.

![Biogas plant in Valovice](Source: EnviTec)

**Table 6: Main characteristics of Valovice biogas plant**

<table>
<thead>
<tr>
<th>Location</th>
<th>Valovice, Czech Republic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed power</td>
<td>1,163 kW$_{el}$ + 100 kW of ORC</td>
</tr>
<tr>
<td>In operation since</td>
<td>January 2008</td>
</tr>
<tr>
<td>Input materials</td>
<td>Liquid manure of pigs, maize silage, beet slices</td>
</tr>
<tr>
<td>Features</td>
<td>ORC technique is used to generate electricity out of the waste heat which is produced by the CHP</td>
</tr>
</tbody>
</table>

**Contact details**

EnviTec Biogas Central Europe s.r.o.
Průmyslová 2051
594 01 Velké Meziříčí, Czech Republic
+420 56 66 88 430 info@envitec-biogas.com
Heat for public buildings from a satellite CHP in Steinfurt, Germany

In Steinfurt the local government and farmers organised a joint initiative and since 2005 local administration buildings, a school center, a health center, an outdoor pool and retirement home are heated with district heating from a biogas plant.

As building a biogas plant directly in the city was not possible, another solution had to be found. It was decided to build a biogas plant outside the city and to install a CHP of 347 kW_{el} capacity. The biogas plant was connected through 3.6 km biogas pipeline to a second CHP plant of 536 kW_{el} capacity. The heat is fed into the district heating system. This model allows optimal biogas utilisation. If both CHP units would be at the location of the biogas plant, considerable heat losses would occur. About 4 million kWh of heat are generated by the CHP unit.

Forty-six farmers and 23 investors established the company named Bioenergy Steinfurt GmbH & Co. KG. In addition, the project received a state grant from Nordrhein-Westfalen and a loan from KfW Bank. Additional support was gained through Renewable Energy Sources Act (EEG) as the plant used substrates such as manure and renewable raw materials (NawaRo). The biogas plant can cover up to 80% of the heat demand of the local administration building. In order to optimise heat utilisation in summer, the heat is used for an outdoor pool.

The biogas plant was extended in 2007. In 2009 a third satellite CHP was commissioned. In 2010 planning and implementation of the extension of the gas line to a micro gas network was carried out. Finally, in April 2010, a fourth satellite CHP started its operation. Since the adoption of EEG 2012 the biogas plant participates in the ‘direct marketing’ scheme with its 3 CHPs. Since February 2012 the biogas plant operator applies a market premium model and plans to receive a flexibility premium.
Figure 4: Biogas plant in Steinfurt (Source: www.n-e-st.de/)

Table 7: Main characteristics of Steinfurt biogas plant

<table>
<thead>
<tr>
<th>Commissioning date</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Biogas plant and 2 CHPs (one CHP at the administration building and one next to the biogas plant)</td>
</tr>
</tbody>
</table>
| Installed power    | 1. CHP: 347 kW_{el} and 390 kW_{th}  
                      2. CHP: 536 kW_{el} and 505 kW_{th}  
                      3. CHP: 380 kW_{el} and 390 kW_{th}  
                      4. CHP: 380 kW_{el} and 390 kW_{th} |
| Substrate          | Per day: ca. 30 tons of maize/day grown on abandoned areas, 10-30 tons of manure and 10 tons of agricultural by-products. Biomass comes from the region and the digestate is used as fertiliser |
| Investment costs   | 3.5 million EUR |
| Support            | Loan from KfW Bank (90,000 EUR), state grant |
| Annual savings     | 35,000 EUR heat cost for natural gas |
| CO₂ savings        | 5,000 tons |
| Heat utilisation   | Ca. 20,000 m² public building, school center, health center, outdoor pool and retirement home |

Contact details
Bioenergie Steinfurt GmbH & Co. KG  
Hollich 79, 48565 Steinfurt, Germany  
+49 2551 701746
Digestate drying in Azienda Agricola Andretta farm in Marcon, Italy

The Andretta is a farm around 86 ha with 700 cattle located in Marcon, in the Venice Province. Since 2005 the farm is running a biogas plant with an installed capacity of 800 kW\textsubscript{el}. The farm has a drying plant next to the biogas plant, complemented by a removal system for the nitrogen contained in the digestate. The drying plant, exploiting the heat coming from the generator, has 2 fundamental outputs: organic matter with 92% of dry matter and liquid ammonium sulfate produced by air cleaning through a stripping process. The heating pipeline is around 50 meters as the whole process is applied internally at the farm.

This kind of plant is the first one installed in Italy, and it utilises BTS BIOdry conservative technology. The biogas plant has an input of 5,000 t/day of sewage sludge and 34.20 t/day of biomass; the drying plant has as input of 12.6 t/day while the remaining digestate goes to storage. The output of the drying plant is: 1.17 t/day of dry digestate and 0.30 t/day of ammonium sulphate (solution 35%), reducing the mass of around 90%.

The main driver of the plant is to reduce the content of nitrogen in the digestate, being the farm is in a nitrogen pollution sensitive area (drainage basin of the Venice Lagoon).

Table 8: Main characteristics of Andretta biogas plant

<table>
<thead>
<tr>
<th>Commissioning date</th>
<th>2005 for the biogas plant, 2010 for the heating system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed power</td>
<td>800 kW\textsubscript{el}</td>
</tr>
<tr>
<td>Heat utilisation</td>
<td>Digestate drying</td>
</tr>
<tr>
<td>Input/output</td>
<td>Sludge and biomass; organic dry matter and ammonium sulfate</td>
</tr>
</tbody>
</table>

Contact details

Andretta Ivano
Via Poianon, Marcon (Venezia)
+39 0414569369 info@agricolaandretta.com
10 Feasibility checks

The BiogasHeat project aims at an "economic and sustainable utilisation of heat from existing and future biogas plants, which currently is wasted" (Dzene et al. 2012) as well as an increase of heat use capabilities in European countries. For this reason promising strategies and business models for heat use from biogas plants were developed (Amann et al. 2014).

In accordance with most European support schemes, biogas plants usually focused on the production of green electricity, generated mainly in CHP units. In many cases the heat is not used, but wasted, at least to a certain extent. Besides political commitment and stable legal conditions there are urgent economical needs. The biggest economical need is that the biogas plant runs economically. Economic efficiency is crucial for long term development of the biogas sector. Economic performance of biogas plants is quite critical in some European countries as most of the plants have a poor overall efficiency. Heat use can help to increase the efficiency and can also lead to additional earnings.

Therefore 80 feasibility checks in 8 different partner countries were carried out. A feasibility check can be seen as an initial feasibility study. Hence a feasibility check collects and presents basic data about the plant and incorporates plant specific challenges. Such a check does not replace an entire full feasibility study (or business case development). However, it provides the owner, investor or plant operator with an additional informational source in order to obtain further information on site specific heat use options. It aims at lowering initial barriers to heat utilisation from biogas plants. These checks i) show the initial situation of the respective plant, ii) try to identify technical solutions, iii) analyse the economic situation and iv) propose a heat use business model which is likely to be successful. The information provides a first basis for setting up a concrete heat use project (see chapter 13).

In a first step all 8 feasibility check partner countries have approached potential interest groups. Each country followed its own approach in order to come up with ten reasonable cooperation partners. In order to ensure neutrality the lists were developed in cooperation with national and regional stakeholders (e.g. biogas associations). Hence, selection of cooperation partners was carried out in a fair and transparent manner and does not distort the respective market.
<table>
<thead>
<tr>
<th>Country</th>
<th>Type of third party</th>
<th>Average electrical capacity (kW)</th>
<th>Average thermal capacity (kWh)</th>
<th>Average annual heat production (MWh)</th>
<th>Status of the project: in planning; in construction; in operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>10 plant operators</td>
<td>373</td>
<td>438</td>
<td>3,285</td>
<td>10 x operational</td>
</tr>
<tr>
<td>Croatia</td>
<td>9 x plan operator 1 x project developer</td>
<td>781</td>
<td>857</td>
<td>6,909</td>
<td>3 x operational 7 x planning</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>10 plant operators</td>
<td>1,094</td>
<td>1,062</td>
<td>6,830</td>
<td>8 operational 2 in planning</td>
</tr>
<tr>
<td>Denmark</td>
<td>3 plant owners/operators 1 plant manufacturer/owner/operator</td>
<td>905</td>
<td>1,143</td>
<td>7,680</td>
<td>4 in planning</td>
</tr>
<tr>
<td>Germany</td>
<td>10 plant operators</td>
<td>281</td>
<td>327</td>
<td>2,533</td>
<td>10 operational</td>
</tr>
<tr>
<td>Italy</td>
<td>6 plant operators 3 municipalities 1 Water management Utility</td>
<td>439</td>
<td>521</td>
<td>4,166</td>
<td>5 operational 1 in construction 4 in planning</td>
</tr>
<tr>
<td>Latvia</td>
<td>6 plant operators 1 installer 3 project developers</td>
<td>1,348</td>
<td>1,620</td>
<td>13,039</td>
<td>7 operational 3 in planning</td>
</tr>
<tr>
<td>Romania</td>
<td>4 plant operators 6 investors</td>
<td>1,307</td>
<td>1,633</td>
<td>526</td>
<td>4 x operational 6 x planning</td>
</tr>
</tbody>
</table>
11 Country specific conclusions

Austria

For the case of Austria drying of agricultural commodities was the most investigated heat use option. The Austrian biogas market with agricultural feedstock follows more a small scale biogas production. All Austrian CHP plants have an average installed capacity of approximately 250 kW\textsubscript{el} per biogas plant. In the year 2011 the total heat use potential was about 530 GWh\textsubscript{th}.

The potential of connecting existing agricultural biogas plants to a district heating network is almost depleted. Austrian farmers push towards heat utilisation on site as many plants are located in rural areas. Heating of family houses nearby, heating of stables and drying of various agricultural commodities (e.g. grain or wood chips) with little investment costs are the favoured options. Heat prices are about a tenth compared with subsidised green electricity tariffs. Promising future options are seen with the combustion of raw biogas in a satellite CHP and upgrading to biomethane.

Croatia

For the case of Croatia additional power production (ORC) and drying of digestate were the two most investigated heat use options. While the exploitation of heat energy from biogas plants in Republic of Croatia is not subsidised, the production of electricity is supported by favourable feed in tariffs. From the results of the feasibility check studies it is possible to conclude that additional investment in further useful heat energy utilisation is beneficial and feasible, and as well beneficial for total energy efficiency of biogas plant.

However, the options for heat use utilisation are encountering mostly economic barriers. Considering the present economic situation in Croatia it is not likely that potential biogas plant investors will realise some of the venture possibilities for heat utilisation analysed and proposed in these feasibility checks, because investing in heat usage is not seen as additional profit, but rather additional investment that is hard to finance. Furthermore, due to high investment even the realisation of biogas plants seems unlikely.

Czech Republic

It can be stated that the most demanding projects are those with heat supply to heat consumers located at a distance to the biogas plant (beyond the owners’ grounds). The problems are in finding an optimal route for the pipeline considering the land owners property rights and the legal aspects and complicated negotiation conditions of heat supplying. Unfavourable business or personal relationships between the partners can often be a serious problem in reaching an agreement.

In principle the priority should be given to biogas CHP where the additional cost of heat or gas pipelines and other technological and related investments would often be lower compared to a newly installed natural gas CHP, for the same amount of heat supplied, and moreover considering that the natural gas has to be imported to the country.

Denmark

For Denmark, the upgrading of biogas to biomethane with subsequent injection into the natural gas grid will gather much focus in future biogas development. This is because utilisation of heat from co-generation of biogas is very well developed, especially from larger (centralised) biogas plants.
For many farm biogas plants there is a substantial heat surplus in the summer months. However, biogas plant owners show little or no interest in optimising this, mostly because this has been considered already in the planning phase, and also it is of minor importance to the overall farm (and biogas) economy.

The feasibility checks are not expected to be multiplied to other Danish projects as most of the existing plants already have a decent heat use ongoing. And new projects consider these issues already in the planning phase, so no feasibility checks are necessary.

So the lessons learned from the Danish feasibility checks can be concluded as follows:

- The use of heat from co-generation of biogas is well developed in Denmark;
- For existing (farm) biogas plants, it seems often too costly to establish transmission pipelines (gas or heat) to nearest district heating grid;
- As a result, upgrading and alternative use of biogas seems to gather most interest among many Danish biogas plants and other actors.

Germany

Most plant operators wanted to know if a small district heating grid is economically feasible, followed by information on heat use options for drying, the option of the installation of a raw biogas pipeline to a satellite combined heat and power unit (CHP), and other options.

The following lessons learned can be summarised from the feasibility checks:

- The use of waste heat from biogas plants in Germany for supplying micro heating grids is usually only economically feasible with public support (KfW or BAFA support).
- Some fraction of the heat is usually already used for heating of the farmer’s buildings, stables or for wood drying.

Knowledge, capacity and skills vary significantly among biogas plant operators. For some operators, additional heat use would not be considered without external ideas / expertise.

After completing all pre-feasibility studies it can be stated that all investigated biogas plants use already heat for heating of the farmer’s buildings, stables or for wood drying. However, most of the plants still do not use the main fraction of heat. For most biogas plants the main investigations were related to the set-up of small heating networks that supply households in the vicinity. Thereby, the remoteness of the biogas plant is one barrier, but also social constraints, where personal relationships between the partners can often be a serious problem in reaching an agreement.

Italy

In Italy due to the incentives that took place from 2008 to 2012, a lot of large biogas plants were planned and built in isolated places only for electricity production from dedicated agriculture production. That is the reason why three out of ten feasibility checks were conducted on these typical plants and the studied option was the decrease of the CHP installed capacity and the installmment of an ORC in order to keep the overall installed capacity (<1MW in order to maintain the feed in tariff) and the electricity production constant, which has an economic benefit from the decrease of feedstock needed and an environmental benefit from less GHG production and less soil consumption. Unfortunately the electricity production of the ORC is not considered renewable and does not keep the feed in tariff and does not get white certificates (that cannot be accumulated with the feed in tariff). The lesson learned in this case is that there is the need of a political operation for recognising the power produced by the ORC as renewable or the white certificates together with the feed in tariff.

Three FCs were conducted on the possible biogas production from small plants (>100kW) for organic waste AD in urban areas, with digestate drying in order to decrease costs of waste management through the decrease of weight of the digestate to be sent to composting
plants. The result is that technology is still not ready for AD of such small plants and drying facilities are too expensive.

**Latvia**

For the case of Latvia drying is the most favourable heat use option (either drying of wood products or drying of agricultural products).

Historically biogas plants in Latvia were constructed when the existing legislative framework did not require certain efficiency of the CHP plant. Requirements of complying with the highly efficient cogeneration definition were introduced only later. Consequently most of the existing and planned biogas plants in Latvia for whom the initial feasibility checks were performed did not use the main part of the generated heat efficiently.

Heat is either used only for fermenters heating, or in some cases part of the heat is delivered to the district heating system or local heat consumer (e.g. nearby farm). In particular it is difficult to ensure heat demand in summer months. Every biogas plant is different, but remote locations and lack of heat consumers in the vicinity mostly leads to one preferable option – installation of dryers. This alternative is promising because of comparatively low investment costs and flexibility. The risks related to this solution are lack of demand for drying services, lack of market for dried products and commodities and the need for a buffer storage for the dried products that would require additional investment costs.

From the ten feasibility checks two projects (Ecozeta and Piejura Energy) were selected for the field testing of suggested heat use solutions.

**Romania**

Many of the biogas facilities in Romania are in the development phase. Only very few plants have been implemented up until now. Usually the biogas facilities are developed using structural funds that have high requirements in terms of economic performance. This is leading to 100% heat utilisation solutions. For different projects that means: transport of biogas through a pipeline to a satellite combined heat and power unit (CHP), use of the heat in process (the biogas facility in Filipestii de Padure, Prahova county), use of heat for drying, use of heat for greenhouses and other options.

The lessons learned can be summarised from the feasibility checks:

- The use of waste heat from biogas plants in Romania to micro heating grids is usually not economically feasible and there are not governmental support schemes for this
- Most of the biogas projects are, from the drawings, developed with heat utilisation/recovery options on site (drying, use in the industrial process, use for greenhouses etc).

At the moment, the renewable energy market in general, and the one for biogas in particular are still confronted with a lack of dynamics and new developments. After a two years lag in the RES law elaboration, since March 2013 the Government decided to postpone payments for a number of green certificates (especially in photovoltaics and wind) for the period 2017-2020. There was a reduction of the green certificates support scheme, including for existing facilities.

The biogas and biomass energy support schemes were not modified. Nevertheless, the implemented measures negatively affected the market for biogas too, due to the legislation framework volatility. Many projects in advanced state were cancelled during 2013 and 2014.

A good trend that could be seen in the market is the increased awareness of farmers about the opportunities offered by biogas. Both energy crops and agricultural leftovers are clearly identified now as business opportunities, even if the concrete market conditions are not totally favourable to new investments.
One project (the WWTP from Buzau County) was selected for the field testing for sludge drying. This in fact means that a development of a business model will be envisaged.

12 Overall conclusions from feasibility checks

The range of heat utilisation from biogas plants varies tremendously among investigated partner countries. Clearly Denmark, Germany and the Czech Republic can be described as leading countries even if their legislative framework conditions and its incentive schemes are quite different. Generally it can be said that many existing biogas plants were constructed in order to maximise the output of green electricity and heat use was of minor interest.

The 80 feasibility checks turned out to be a very helpful tool in order to get a first idea about the basic problems, challenges and future developments. The feasibility checks proved to be a good help to the biogas plant operators as it served as an additional information source during their decision making phase. With such a check two or three basic heat use options can be identified quickly, however, they do not replace an in-depth development of an individual heat use concept. Such a heat use concept has to be considered already during the very early planning phase of the plant. Ex-post solutions are more challenging to implement and need more effort.

The following general lessons learned from the feasibility checks can be summarised:

- The decision of the location of the biogas plant and the CHP unit is the most important element for successful heat use (feedstock market and heat use market);
- An unstable legislative framework is seen as the main barrier. Stable framework conditions are required which allow long-term planning and investments;
- Incentives (e.g. grants, CHP-bonus, taxes) may boost the utilisation of heat;
- A positive list of efficient heat use concepts (like in Germany) may provide a solid orientation to biogas plant operators;
- Know-how about heat use varies significantly among plant operators;
- Investments in heat use are sometimes seen as additional costs and not as potential source of further income;
- The heat use business is a long-term business (for feedstock contracts and heat supply contracts);
- The three most favoured biogas utilisation options in future are very likely to be:
  - Upgrading of biogas to biomethane and subsequent injection into the natural gas grid;
  - Direct supply of raw biogas and combustion in a satellite CHP unit for heat supply;
  - Additional power production.
13 Business cases

The most promising/suitable heat use options identified for each target country in preceding work packages were subject to further development into concrete business cases.

The aim was to verify in more detail the feasibility of selected heat use strategies respecting the capabilities and requirements of local cooperation partners which were selected by the project consortium members for this phase.

If the business case for a given cooperation partner was found as achievable from all relevant point of views, then, both parties (national project consortium member and local cooperation partner) agreed on coordinated action to its realisation, so-called field testing.

In total the eleven following business cases were ultimately selected and developed into the field-testing phase:

- Heat supply outside farms (Czech Republic (2 projects), Germany, Italy, Latvia and Romania)
- Heat use for drying of wood chips (Austria and Latvia)
- ORC installation (Croatia and Italy)
- Lowering own heat consumption at biogas plant for possible supplies to external customers (Denmark)

Table 10: Overview of the business cases

<table>
<thead>
<tr>
<th>Country</th>
<th>Business Case</th>
<th>Amount of heat to be newly utilised [MWh/y]</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Wood chips drying</td>
<td>up to ~ 300</td>
<td>P</td>
</tr>
<tr>
<td>Croatia</td>
<td>ORC installation</td>
<td>Not yet specified</td>
<td>TBA</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Heat supply to external customers (health-care facility)</td>
<td>up to ~ 1,500</td>
<td>UPP</td>
</tr>
<tr>
<td></td>
<td>Heat supply to external customers (DH system)</td>
<td>up to ~ 4,700</td>
<td>TBA</td>
</tr>
<tr>
<td>Denmark</td>
<td>Lowering heat demand of fermenters (for possible heat supply to external customers)</td>
<td>up to ~ 660</td>
<td>TBA</td>
</tr>
<tr>
<td>Germany</td>
<td>Heat supply to external customers</td>
<td>up to ~ 1,100</td>
<td>R</td>
</tr>
<tr>
<td>Italy</td>
<td>ORC installation</td>
<td>up to 5100 x 3</td>
<td>TBA</td>
</tr>
<tr>
<td></td>
<td>DH completion</td>
<td>1000</td>
<td>UPP</td>
</tr>
<tr>
<td>Latvia</td>
<td>Heat supply to external customers</td>
<td>up to ~ 9,220</td>
<td>TBA</td>
</tr>
<tr>
<td></td>
<td>Wood chips drying</td>
<td>up to ~ 9,500</td>
<td>R</td>
</tr>
<tr>
<td>Romania</td>
<td>Heat supply to external customers</td>
<td>Not yet specified</td>
<td>TBA</td>
</tr>
</tbody>
</table>
14 Lessons learnt from business cases

The various heat utilisation options come with numerous unique features that are mirrored in the variety of lessons learnt.

Heat supply to external customers

A business offer to supply heat from a biogas plant to a nearby external customer must be first of all competitive. Thus, the price of heat originating from a biogas plant must be inevitably lower than current costs for the end customer compared to whichever system is operational (mostly only variable i.e. fuel).

Since heat for a biogas plant operator is very often a by-product (as biogas plant are very often designed as primary power production facilities), investments in the necessary infrastructure are the main cost-driver (that is either an interconnecting pipeline or biogas pipeline with a satellite CHP unit closer to the heat demand) that have to be compared to potential heat sales.

The level of total investment costs to interconnect a biogas plant with external heat customers increases with distance and heat transfer capacity. In the case of existing biogas plants, the local conditions typically determine the viability of such projects. Often financial incentives (i.e. an investment subsidy or operational subsidy in the form of e.g. CHP bonus) secure the feasibility in these cases.

The bigger the heat demand, the better the prospects for project viability. Hence, the most promising customers are large ones, such as municipalities, public entities, and industrial plants.

Any investment into establishing the pipelines for the transfer of biogas or heat to the external heat customers require long-term stability which must be secured by concluding long-term agreements on heat supplies. This might prove to be difficult.

Another aspect of these projects is that the longer the interconnecting infrastructure is, the more demanding project preparation usually is, too. The primary challenge is to find a suitable route via land of owners that do not misuse this opportunity to try to solicit unreasonable price for getting affirmative easement.

Last but not least, a very important factor for the development of the plans to a real business case is mutual trust and a close relationship between contractual partners, i.e. the heat supplier and consumers. Furthermore, intensive networking is recommendable. Being in regular communication helps and allows for the solving any unexpected problems which may slow down or threaten the preparation process. Partnerships that result in the sharing of understanding, innovative knowledge, skills, and other forms of support are invaluable to the successful development and realisation of the plan.

Drying processes

Utilisation of heat for drying is an activity typically performed by the operator of the plant or entities closely linked.

Drying wood chips to be used as fuel

Dried chips have a better quality and price, however, trading biomass fuel has to be a developed business itself and drying can only enhance it – the availability of free heat is not sufficient for starting such a business. The installation of drying technology is also costly and payback of the respective investment based on higher revenues from wood sales could be long. An important aspect could be additional revenue if wood drying is eligible for a CHP bonus.
**Drying of timber**

Similar comments as above apply also to this activity.

**Drying of digestate**

Dried digestate at a biogas plant using crops can be sold as substrate for gardens and pot flowers, but the chances of placing it on the market are rather low due to competition from other sources.

Drying digestate which is returned to the field does not make much sense, it just lowers the transportation volumes and costs, but causes some additional emissions (such as ammonia).

Drying digestate from waste water treatment plants can be justifiable. Savings thanks to the reduced transportation costs and especially reduced fees for land-filing can make this business case economically feasible.

**Supplementary power generation by means of ORC module**

An additional power generation unit utilising the waste heat from the standard motor-generator can increase the electric efficiency of the biogas plant by several percentage points. Whether or not this solution is economically feasible very much depends on the support schemes in place at the time of the commissioning of the unit. Installation of an ORC unit has a reasonable payback when the RE-electricity was supported by feed-in tariff. Another support mechanism might be a technological bonus or CHP bonus, however, for example Czech legislation does not recognise ORC as CHP electricity.

**Reducing the self consumption of heat at the biogas plant**

Additional investment measures to lower the own heat consumption of the biogas plant have to be evaluated with respect to the cost of heat from competitive sources. This business case can be considered if heat demand is greater than the current net biogas plant capacity and the additional supply of heat from biogas plant will eliminate significant costs for fossil fuels and possibly also investment costs for peaking sources of heat in winter. While the heat supplied in off-peak times (transition periods and summer) can be regarded as free, heat demanded in winter peaks can have a high market price. The evaluation has to be based on an annual profile of the heat supply and its coverage by sources of different types (i.e. biogas plant as base load and other sources operated for peaking).
15 Overall conclusions

This summary document shows the extent of field research conducted during the project life time. As shown the partners were able to collect a vast number and large spread of valuable insights. Overall the following conclusions can be made:

Markets
- Biogas markets in the project countries differ widely
- Heat markets in the project countries differ widely

Bottlenecks
- The main reasons for underdeveloped heat utilisation are:
  - A lack of awareness that heat can be utilised
  - A lack of knowledge of how heat could be utilised
  - Unfavourable legal/political conditions

Legal framework
- The most successful support schemes for biogas builds on feed-in tariffs
- To foster heat utilisation additional legal requirements for heat use or efficiency are necessary paired with a positive list on heat utilisation options
- Support schemes must be long-term, reliable and sustainable

Heat utilisation options
- Biogas plants differ largely in size and capacity
- Other factors such as location and feedstock supply play a major role
- There is a vast number of heat utilisation options
- The ‘right’ option for every plants needs to be picked on a case-by-case basis – there is no one-size-fits-all solution

Feasibility checks / Business cases
- The location plays the most crucial role for the development of biogas and heat utilisation
- Instable legal conditions are the biggest obstacle for operators
- Long-term planning and contracts are necessary for a successful business case
- The main three heat utilisation options for the future are:
  - Upgrading of biogas for grid injection or transport
  - Supply of biogas to a satellite CHP unit with subsequent heat supply
  - Additional power production

Overall it can be said that there are enough heat utilisation possibilities to find an economical and ecologically feasible solution for the majority of biogas plants. The main problem is a lack of appreciation for heat which results in unfavourable legal framework conditions. Changing this and making stakeholders and policy-makers aware of the value of heat is the first step towards sustainable heat markets in Europe. Subsequently, better framework conditions, financial support and the use of existing knowledge on the issue can have a major impact on energy efficiency and energy security in Europe as well as on the income of plant operators and farmers.
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