ANAEROBIC DIGESTION AND DIGESTATE UTILIZATION IN EUROPE

Körner I., Amon B., Bade O., Balsari P., Bioteau T., Dabert P., Dach J., Deipser A., Kupper T., Fabbri C., Martinez Ferreira L.J., Moller H.B., Schnürer A., Soldano, M., Ward A.J.
Hamburg University of Technology, Institute of Environmental Technology and Energy Economics, Harburger Schlossstr. 36, 21079 Hamburg, Germany, ++49 40 42878 3154, i.koerner@tuhh.de

1 INTRODUCTION

Today, there is no disputing that the use of renewable energy has to increase in order to reduce the CO_2 net emission and the dependence on fossil fuels. In 2008 the EU consequently passed a directive with the given objective to enhance the contribution of renewable energies to 20% of the total energy needs by 2020. Additionally a 10% use of green fuels in transport is also included within the overall EU objective (EC, 2008). Currently energy production from renewable resources is mainly based on wind power, solar energy and hydropower. Another important source is biomass, which may be converted by thermal or biological processes. The most promising technology of biological basis is anaerobic digestion (AD), where substrates such as energy crops, agricultural waste or urban waste may be converted into a methane rich biogas, suitable for heat and electricity production but also other purposes such as natural gas substitution. Furthermore, during the process a digestate remains, which may be used for fertilization and soil improvement purposes, but under certain circumstances it may cause environmental and disposal problems.

In 2008 the RAMIRAN task group on “Anaerobic digestion (AD) and utilization of digestate” was established. It includes voluntary members from several European Countries that proposed to collect data about AD of waste and other biomass in Europe. The purpose was to produce a picture of AD development and utilisation in Europe.

2 MATERIALS AND METHODS

2.1 Preparation of the questionnaire content

A questionnaire was elaborated containing statistical inquiries of present AD facilities regarding substrates; biogas production, processing and utilization; digestate production, utilization, treatment or disposal; the legal framework and other driving forces of AD development. The content preparations were based on the aspects considered as major factors to evaluate the background situation, the technologies, the product and by products used based on the experiences of the authors. To allow international application of the questionnaire, during preparation scientists from 9 countries were involved. Its principal practicability for the different regional situations was verified by the group members before the final distribution for data collection.

2.2. Transformation into on web-base tool

The central challenge to any questionnaire is to get recipients to respond. In most cases, one can expect an indifferent reaction from people who have their own work pressures. Once the structure and the key questions were validated by the scientists involved, the questionnaire was then transferred to an internet available form using the on-line survey designer tool: http://www.surveymonkey.com. Consequently, the proposed questionnaire had several features to encourage participation: (1) online format for ease of completion; (2) simplicity in layout both pleasing in appearance and easy to complete; (3) avoidance of ambiguity; (4) clear instruction; (5) use of devices to aid completion: (drop down menus, tick boxes, comment boxes, etc.). Part of the questionnaire is shown in Figure 1.

The online questionnaire is also useful for collecting the results directly in the form of a spreadsheet format. The spreadsheet can be transferred into a database to allow further analysis.

2.3 Data collection

The data collection was carried out by the group members based on their own surveys or on nationally available survey literature. The data collection and input into the on-line questionnaire is still going on. For this paper following data sets were used: 1) Data input into the on-line tool for 5 countries - Denmark, France, Italy, Sweden, and Switzerland; for Denmark data sets of 2 authors were available; 2) Written summaries of the state of AD from 5 countries - Denmark, Germany, Italy, Portugal, and Switzerland; for Italy 2 data sets were available.

3 RESULTS AND DISCUSSION

3.1 General Aspects

This questionnaire is a complement of the one performed in the EU project Agrobiogas (www.agrobiogas.eu), which was related to specific European plants. In contrast data of the RAMIRAN questionnaire cover entire countries. Using a similar methodology, a study coordinated by The European Joint Research Centre and in relation with the GGELS project (Greenhouse Gas from the European Livestock Sector) was conducted to augment the regional production descriptions with quantitative information on manure management (i.e. processing, storage and land application) per farm animal species across the EU 27.

Comparing the initial entries into the questionnaire, the following findings can be stated: 1) Questions regarding personal evaluations regarding general importance, trends, goals and driving forces were answered easily by all authors; 2) Questions demanding data and more detailed evaluations (e.g. percentage in increments of ten; verbal descriptions) needed considerable research time. No author could fill out the whole data set, but was able to put in a considerable amount of data at least for one of the sectors of agriculture, agro-food industries or urban wastes. These questions covered topics regarding numbers of plants, amounts and types of substrates treated, transport topics, types of fermentation and fermenters, energy production, biogas treatment and utilization, digestates, digestate treatment and application, laws and general problems.

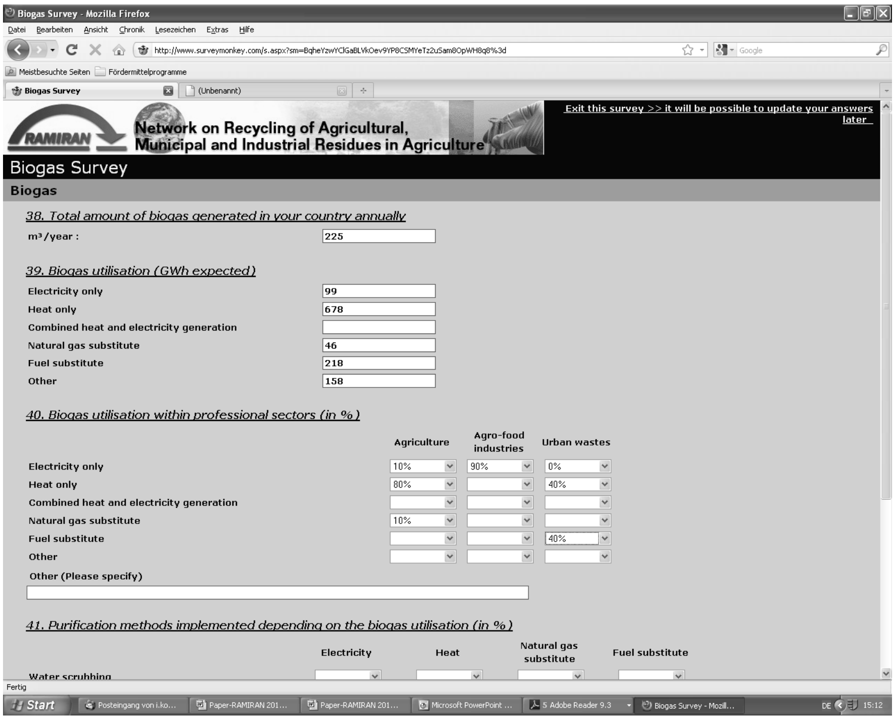

FIGURE 1 **Part of the on-line questionnaire with data for Sweden (entry No. 38 to 41)**

3.2 Countries Profiles

In the following some country-specific summaries on AD are given as an excerpt of the on-line questionnaires and the written summaries.

Italy: In 2009, 333 biogas plants were operating or in construction using mainly livestock effluent, agricultural waste, energy crops, organic residues, discharges from the agro-industrial sector, but also the organic fraction of municipal solid waste as feedstock. The areas most affected are those with the highest concentration of livestock farms, almost all located in the northern regions. Some of the plants using livestock were constructed at the beginning of the 1990s with a plastic cover fitted to a slurry storage tank and/or lagoon. Subsequently there has been increased interest in the co-digestion of livestock slurries mixed with other biomass. With reference to the type of reactor, the most common by far is that of the stirred and insulated tank with vertical walls (CSTR) in the majority of cases constructed in reinforced concrete followed by plug flow technology and simplified plants such as covered lagoons. Several plants have an installed power higher than 0.5 kWel, but most of them are farm scale plants with <0.1 MWel installed power. Process temperatures are in the range of 40-42°C in most of the plants. Only a few run under thermophilic conditions. Hydraulic retention time varies according to plant and feeding typology, nevertheless farm scale plant usually are characterized by HRT <40 days. In many cases, plants fed with energy crops and animal manures have HRT as long as 120 days. Digestate is generally used in agricultural under the rules of Action Programmes (Nitrate Directive).

Portugal: The realistic potential of the biomass suitable for biogas production (from the animal production sector, wastewater treatment industry, municipal solid waste (MSW) management) represents approx. 150 – 200 MWel. The three key sources of this potential are around twenty industrial AD facilities which in 2007 produced electricity using biogas, but only fifteen of these continued production during 2008. From these, two are farm scale plants (total 0.7 MWel installed), four are wastewater treatment plants (sewage sludge digesters), seven are systems which collect biogas from MSW landfills, one is a dedicated plant for organic fraction of MSW (these represent in summary almost 16 MWel installed) and one is an industrial wastewater plant of a dairy factory (0.6 MWel installed). Seven other AD plants using urban wastes are at the moment in different implementation phases. There are farm scale digesters from the mid nineteen eighties, operating in poor condition and exclusively as a pre-treatment of animal slurries/manure. The direct use of digestate by crop farmers is not common practice. With regards to manure AD systems, digested manure is post-treated in lagoon systems and afterwards lagoon wastewater is discharged to the natural environment or used in agriculture. Digestates from urban wastes in most cases after a solid-liquid separation are used in agriculture or composted. Biogas production in Portugal is likely to be developed in the near future by the water and MSW industry, to comply with EU regulations for these sectors.

Switzerland: 76, 22 and 20 AD facilities processing waste originating from of agriculture, agro-food industry and from households (respectively) are operated. The total amount of substrates digested is approx. 320 000 Mg per year of which 30%, 20% and 50% are processed by agricultural, agro-food industrial and urban plants, respectively. They produce 49 GWh of heat, 58 GWh of electrical power, 10 GWh of natural gas substitute and 7 GWh of fuel, respectively. All classes of plants produce electrical power in combination with heat except for urban plants producing electrical power combined natural gas substitute. Agricultural plants use 80 % of biogas for generation of electricity while agro-food industrial facilities focus on production of heat (70 % of biogas output). The main goals of AD are production of energy and use of resources. The main driving factors are national regulations, energy production and remuneration from feed-in tariffs. Agricultural and urban plants are emerging. Thus, competition for substrates occurs which might entail economical constraints for operators and conflict with quality improvement of digestates. 63 % of all digesters have a volume of < 500 m^3, the maximum digester size is below 3000 m^3. Agriculture and agro-food industry plants process liquid substrate at mesophilic process temperatures while urban plants treat a solid substrate under thermophilic conditions. Almost all residues end up as fertilizers on soils, with the major part being used in agriculture. About 30 % of digestate is composted prior to spreading.

Denmark: There are 60 agricultural biogas plants, 30 treating municipal wastewater, 21 centralised co-digestion plants and 2 plants treating municipal solid waste. Most of these plants are in the medium size range, with 30 plants of 0.6 – 0.75 MWel, 30 plant of 0.75 - 1 MWel. Only 2 plants are below 0.6 MWel and 20 plants are greater than 1 MWel. Approximately 85% of plants operate in the thermophilic temperature range and consequently hydraulic retention times are relatively short with more than 60% of plants operating below 20 days HRT. The number of Danish agricultural biogas plants is expecting a substantial increase in the future as a result of government plans to use 50% of animal manure for energy production by 2020, compared to the 3% of manure currently used. Danish manure production is about 1,000,000 Mg per year of which about half is pig manure. Energy crops and crop residues have a much smaller role in Danish biogas production with 90% of crop feedstocks produced on site.

Germany: At the end of 2008, about 4000 biogas plants were in use (installed capacity: 1.4 MWel). 650 were biowaste digesters and 99 of them were certified with the quality assurance for digestion residuals. The main driving force of AD plant installation was the Renewable Energies Act (EEG). The installed capacity of plants using energy crops was about 1.04 MWel. Agricultural biogas plants are small to medium size with an installed capacity of 0.35 MWel on average. Electricity generation from biogas was 9,200,000 MWhel. Moreover, landfill gas plants provided about 1,000,000 MWh per annum. At present approximately 700 sewage gas plants with an installed electric capacity of about 160 MW are in use. The electricity generation from sewage gas plants was approx. 1,000,000 MWh. Biogas is used to generate electricity alone as well as for combined heat and power (CHP) generation. Furthermore, 15 plants feeding biogas into the natural gas distribution system were in use (installed capacity in total: approx. 80 MWh). The realised feed-in from biomethane into the gas distribution system is estimated to an amount of approx. 420,000 MWh. The estimated future installed capacity for biogas production is 3635 MWel, the possible future heat utilization from biogas will be roughly between 9,000,000 and 13,000,000 MWh per annum. Assuming that the number of new biogas plants will increase as a result of the amendment of the Renewable Energies Act 2009, a moderate growth of the number of biogas plants for the future energy use of biogas can be projected.

4 CONCLUSIONS

The on-line tool and set-up of the questionnaire allows a direct comparison of the data from different countries and is easy to actualize. Later questionnaire versions have to be improved. Problems found were regarding the clarity of definition. E.g. it was not clear if sewage sludge is included in urban waste or not. Since the on-line questionnaire is of easy access an update of data should be carried out at regular intervals as long as the developments on anaerobic digestion in the member's home countries are continuing. The questionnaire results and the international networking will help in learning from each other and in the integration of AD into regional systems in the most suitable and beneficial way.

At this stage of elaboration it can be stated that the intentions regarding the introduction, the substrates, the procedures and the driving forces for the establishment of this technology are very different from one country to another. The increasing amount and diversity of substrates and processes result in a variety of digestate qualities. The distribution and characteristics of the digestates will become an important topic in the future.

For the RAMIRAN conference the data sets will be improved and evaluated in detail regarding the similarities, differences, problems and benefits. Complete data sets will be available by then for Austria, Denmark, France, Germany, Italy, Poland, Portugal, Sweden, and Switzerland.

In perspective, given that quantified data is requested in the questionnaire, it might be possible to use the results of the questionnaire in existing decision support tools to assess the impacts of anaerobic digestion on GHG emissions. In addition, these data could also be useful to consider anaerobic digestion as a reduction in the making of GHG inventories built by the official institutions of each country.

ACKNOWLEDGEMENTS

We would like to thank Pekka Raukola from Finland and Tina Koeppke from Canada which helped us in the frame of their student’s work at the Hamburg University of Technology to prepare the first versions of the questionnaire. Furthermore we thank Jose Martinez for the suggestion and the possibility to transform the questionnaire into an on-line tool.

REFERENCES

European Commission 2008. *Directive on the promotion of the use of energy from renewable sources. C*OD/2008/0016.