Beyond Energy Action Strategies

BEAST

D.3.1. P4-3-1 – Farm scale biogas

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Location: The County of Møre and Romsdal

Møre and Romsdal County Authority

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Contents

1 Summary of the Project/Project at a Glance .... **Error! Bookmark not defined.**

2 Details of the Proposed Project .... **Error! Bookmark not defined.**

3 Internal aspects.. **Error! Bookmark not defined.**

4 External environment .... **Error! Bookmark not defined.**

5 Market Potential .... **Error! Bookmark not defined.**

6 Risk analysis 7

7 Financial Analysis .... **Error! Bookmark not defined.**

7.1 Cost .... **Error! Bookmark not defined.**

7.2 Income .... **Error! Bookmark not defined.**

7.3 Feasibility assessment .... **Error! Bookmark not defined.**

7.4 Sensitivity analysis .... **Error! Bookmark not defined.**

7.5 Social benefits and Public support... **Error! Bookmark not defined.**

8 Implementation roadmap.. 10

9 Conclusion.. 10

1 Summary of the Project/Project at a Glance

In Norway, the climate gas emissions from the agriculture sector amount to 8,5 % of the total emissions. Treatment of animal manure from farms in biogas-plants is considered a possibility both to provide energy, reduce GHG-emissions and to improve manure handling and nutrient utilisation in farming systems. The Norwegian government has identified treatment of livestock manure in farm-scale and community-sized biogas plants as one important measure to lower the GHG-emissions.

In course of the project, several initiatives have been investigated. The one initiative that has been investigated in more detail is a pig farm in Eidsdal, Møre og Romsdal, Norway. The other is a larger biogas plant either utilising substrates from only or both Eisdal or Kleivasida joint operation dairy farms which are located 1 km from each other. The main challenges are the low energy content in animal manure and therefore the limited range within one can transport this substrate and the digestate as well as the limited need for the heat production at the farms and the distance from the farms to other potential heat demand customers. The prospect of utilising food waste in these plants in the ratio 1:3 compared to cow manure from the nearby tourist location Geirangerfjorden will certainly increase the energy production and the value of the digestate as nutrients from the food waste are recovered in the digestate. One however still and even more so will have the issue with utilising the surplus heat. Currently, many Norwegian farms are facing a challenging economic situation. Some farms expand with the concomitant termination of other farms. The average size of a Norwegian farm is significantly smaller than the average size of farms in countries where biogas-plants have become widespread. This has left the biogas plants in e.g. Denmark and Germany non-suitable for implementation as farm-sized biogas plants in Norway. The few plants that exist have been subject to a large degree of technology and competence development and as of today, there are few success-stories and few to none farm-scale plants being built. Both immature technology and relatively high capital costs have hampered the development.

In the end, we have chosen to frame the biogas plant as to utilizing only the manure originating from the farm. The subsidiary action has been doubled from 30 NOK/tonne manure to 60 NOK/tonne manure from 2014 to 2015. However the subsidiary action is still no established and there is a large degree of uncertainty to what the future level of subsidy will be. If subsidies is held at the present level a “only substrates from the farm”-solution may be economically viable. This may be balanced by changes in the price of electricity. The “income” consists of a reduction in the electricity bill as well as subsidies from the government for handling manure that otherwise would give GHG-emissions.

2 Details of the Proposed Project

There is a strong focus on improved digester-design for reduced capital costs in Norway. Traditional or modified continuous flow stirred tank reactor (CSTR) systems are the most likely solutions. The plant will most probably be operated at mesophilic conditions - 37 °C. In CSTR-systems, the typical residence time is 15-30 days and a corresponding volume of substrate is fed to and taken out of the digester daily. The technology is proven, but the capital costs will most probably drop with widespread utilisation. The current capital cost ranges from 330-440 000 Euro. A capital cost of 390 000 Euro has been used in the calculations. The utilization of the gas will most probably be made through proven burner and gas engine (CHP) technology to provide heat or heat and electricity. As mentioned, one of the key issues in order to make a farm-scale biogas plant economically viable is the complete utilisation of the heat in the farm or nearby buildings/activities.

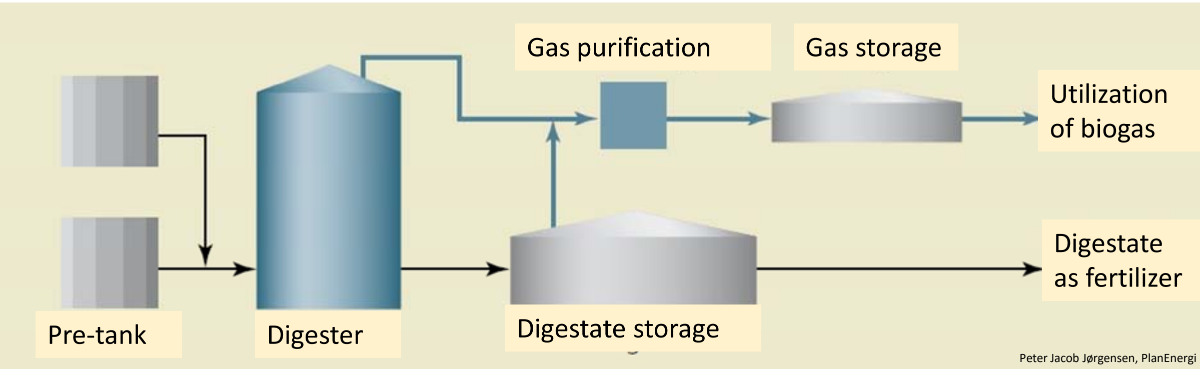


Figure 1. Schematic of biogas plant.

The process steps and parts in a biogas plant are typically as shown in figure 1.

1. Pre-tank(s) for storing and pre-treating (hygienisation) of substrates.
2. Digester. Here is where the anaerobic degradation of organic matter and formation of biogas happens. The CSTR is typically a mixed vertical tank that is fed semi-continuously.
3. The part that is not digested, the digestate is transported to a storage unit. The digestate is used as a fertilizer.
4. The biogas I purified, e.g. water and hydrogen sulphide is taken out of the gas. The gas is typically stored before utilisation in a gas boiler or gas-engine (CHP).

The dairy farms in Eidsdal are similar in size with about 70 milking cows and have a heat and power demand of about 100 000 kWh/year (heat and power). The manure availability constitutes about

3000 tonnes/year. The methane-potential of cow manure used in the calculations is 170 Nm3 methane/ton volatile solids.

The government funding body Innovation Norway is supporting biogas plants with a possible 45 % of the capital costs. The remaining is funded by equity and loans.

3 Internal aspects

Strengths

1. Human resources
   The human resources located in Norddal/Eidsdal are considerable. There is a wealth of activities and initiatives in this region, largely affected by its proximity to one of the most touristic places in Norway, the Geiranger Fjord.
2. Energy self-sufficiency
   The prospect of being able to produce energy from own or local resources gives motivation to the farmer(s) and the local community.
3. GHG-reduction potential
   The GHG-emissions from manure handling and use can be reduced considerably if biogas production is realized. The socioeconomic benefits are considered significant. Consequently, the government has established a subsidy system that could help realize a financial gain for the farmer.

Weaknesses

1. Few farms with heat demand corresponding to the production
   Dairy farms typically have low heat demand and it is necessary to have other on-farm heat demand or local heat demand costumers to utilize the full heat production from a biogas plant.
2. Biogas substrate availability
   Typically, the size of a Norwegian farm makes it challenging to establish biogas production on the manure from one's own livestock. Co-substrates are available and may give gate-fee income, but there is competition to get hold of the substrate from other centralized plants, even in neighboring countries. As a consequence of this and other issues stated above co-substrates have been not calculated into the business plan

4 External environment

Opportunities

1. Improved advisory services
   The competence level on biogas is relatively low and there is a clear need to improve advisory services.
2. Biogas subsidy system
   The subsidy system is as mentioned above based on the prospect of reductions in GHG-emissions. There is a clear prospect of establishing the subsidies at a level that can help to realize the building of more plants based on cow manure only.
3. Technology development
   There are several R&D-institutions and companies working on solutions for farm-scale biogas. There is clear potential in improved technology and thereby a reduction in capital costs.

Threats

1. Cost of technology
   There lies possibilities within technology development, but still major breakthroughs are needed to reduce costs to a level as to make biogas production economically viable and realize widespread utilization of biogas treatment of manure.
2. Agricultural policy/Large biogas plants/waste handling
   From the government there is a clear tendency towards agricultural policies supporting the establishment of larger farms. Waste handling policy also draws on local and regional government to realize the building of larger plants. This raises pressure on the availability of co-substrates.

5 Market Potential

There is considerable interest in the concept of farm-scale biogas, both among farmers and regional and central government. If proven at a reasonable cost, the concept of farm-scale biogas will become widespread. At present, the subsidy action is picking up, but the total subsidy and the subsidy action per ton manure will be limited, will vary and will drop if several plants are realized. The potential is heavily dependent on the electricity price which has been low for several years. At present the electricity price is about 5,5 eurocents/kWh. The effort to develop farm-scale biogas production is largely driven by R&D-institutions and the government funding body Innovation Norway. The concept will have to compete with the increasing number of large-scale plants being projected and built all over Norway.

6 Risk analysis

The risk in investing at present is that the subsidies mentioned above may be reduced on short notice. The level of the subsidy is negotiated each year. Also, the technology solutions for farm-scale biogas are relatively costly. The R&D-activity both for improving digester solutions and reducing costs as well as realising purification of biogas to fuel quality are ongoing and there is a clear possibility that within some years there will be breakthroughs in technology.

7 Financial analysis

7.1 Cost

The capital cost is estimated to be 390 000 Euro. Innovation Norway, the governmental funding body, covers 45 %. The depreciation time is set to 20 years and the annual interest rate is set to 5 %.

7.2 Income

The income is based on the energy produced and regarding this energy as saved energy. E.g. the energy production is given a value based on estimated energy prices. At the moment the energy price in Norway is low and we have used 5,5 euro-cents/kWh in the calculation. The energy value of the production after losses is calculated to be 5600 Euro and 5900 Euro for power and heat respectively. The subsidy of 60 kr/ton manure or 6,6 Euro/ton manure is used in the calculation.

7.3 Feasibility assessment

Based on the numbers above, the IRR is calculated to be 8,85 % and the payback time about 10 years. The numbers are dependent on the full utilisation of the heat and power production.

7.4 Sensitivity analysis

The main parameters influencing the economy of the plant are:

- The capital cost

There are several cost estimates available based on the few plants of the CSTR-type that have been built. There is a degree of uncertainty in these numbers An increase in the capital cost by 25 % keeping all other numbers equal, the IRR and payback time would be 5,56 % and 12,5 years respectively.

- The subsidy system

The subsidy of 60 kr/ton manure is relatively high. If it was reduced by 50 % the IRR and payback time would be 0,58 % and 19 years respectively.

- The energy needed to run the process

The energy demand for running the process is typically 15-30 % when it comes to heat and 2-4 % when it comes to electricity. The numbers used in the calculation are in the higher range of these numbers although some studies have shown that in the case of manure based biogas plants the energy demand may be even higher than 30 %. If the calculation has used 50 % energy demand, the IRR and payback time would be 4,84 % and 13 years respectively.

- The operational and maintenance costs

The calculations are based on the farmers joint operation including the running of the biogas plant in the daily routines, thereby the operation hourly costs are set to zero. If the operational costs are included based on the operator needing about half an hour a day to operate the plant and with a hourly cost of 33 Euro, the IRR and payback time would be 4,07 % and 14 years respectively

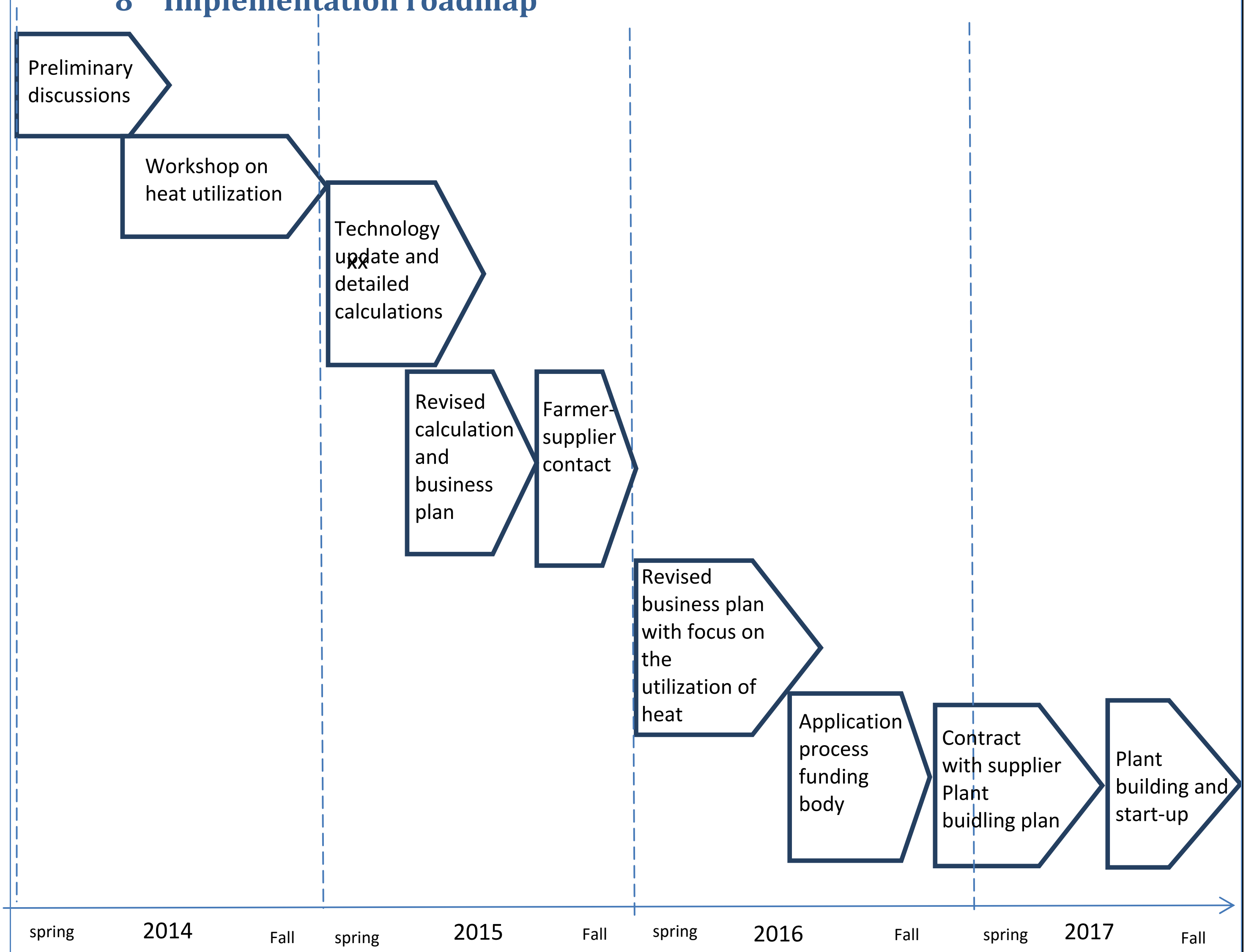
- Electricity price

If the electricity price should increase it would have a big impact on the feasibility of the plant. An increase from 5,5 to 7,8 Euro-cents/kWh would result in an IRR and payback time of 17,33 % and 6 years respectively. It is however very likely that the subsidy action would be reduced if the electricity prices would increase.

7.5 Social benefits and Public support

If provided at a reasonable cost, biogas production based on fish sludge will provide the farmers with energy production based on their own resources and if managed properly the treatment of manure in the biogas plants would result in a considerable reduction in GHG-emissions from farming.

8 Implementation roadmap



9 Conclusion

The low energy density of manure makes transport to larger plants challenging concerning both the scale of transport and the cost. Utilising co-substrates in farm-scale biogas plants based on cow manure is equally challenging, as dairy farms typically are low energy demand productions. The present subsidy level may makes it possible to support farm-scale biogas plants that utilises only their own substrate.