ECONOMIES OF SCALE IN BIOGAS PRODUCTION AND HOW TO ORGANIZE REGULATION

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Overview

We examine the biogas production chain from the farmer, to the biogas plant and through to the use in a combined heat and power plant or alternatively as upgraded biogas supplied to a natural gas grid.

The main objective is to clarify the net effect of opposing scale effects for the economic profitability of the operation. Collection of resources (which composition is regulated) requires transport over longer and longer distances depending on the scale of operation. This drives up unit costs of inputs. Unit costs on the other hand declines as scale is increased and economies of scale for capital expenditures are realised. Based on a case study for an area in Denmark we compare these two opposing effects and finds that the cost decreasing scale effect is nearly outweighed by the cost increase from collection costs.

Secondarily we investigate if the regulation in place in Denmark, namely the constraints on inputs and the large (and diversified) subsidies provided at the end use level of the biogas output is affecting the choice of scale. We find in a first examined case, that the subsidies provided at end-use level are favorising the upgrade to natural gas grid since the element of risk for supplying to the gas grid is less than the implied risk of basing the operation and sales on a combined heat and power plant using the biogas.

The regulatory choices made by authorities both concerning level of support to environmentally friendly technologies as biogas and other renewables are crucial for profitability of biogas production and also for providing incentives for choosing the most efficient scale and technology for operation. This analyses highlights the effect of these choices.

Methods

We use a small model to calculate costs of input collection, biogas production and upgrade to natural gas grid. Revenues from the operation is then based on the various choices for supplying the biogas output to a local combined heat and power unit (CHP) or to the natural gas grid based on the gas prices + subsidies that can be obtained. The approach is focusing entirely on the private profitability of operation. The objective is to examine private incentives for scale and input composition with the effect from public support and regulatory incentives provided.

The model first calculates input costs based on required amounts for each scale of operation. For a case with the input mix of manure and sugar beet we use the local resource constraints for a region in Denmark. Transport distances, type of vehicles, loading costs etc are taken into account. Increasing the scale of operation results in longer distances driven to collect, but it varies dependend on the type of input. All operational and capital expenditures of the biogas plant itself is added dependend on the three different scales. For scale effects there is a choice between using the output from biogas plant directly in a combined heat and power plant or upgrading the biogas output to the standard of the natural gas grid and connecting to this grid. The larger the scale, the more relevant the final upgrade of biogas output become and this again involves additional capital and operational expenditures.

With the model we examine the effect of the provided public support incentives as the size of support correspond to 50-70% of the revenue from the operation of the biogas plant. Also the support is differently provided as a production based support to electricity output from the CHP unit or as support to the supply of upgraded biogas to the natural gas grid. For sensitivity we examine the effect on profitability and scale choice of varying both the absolute and the relative support level.

Results

We find that economies of scale can be found in biogas plant operation, but that the two decreasing and increasing unit costs tend to balance each other.

Scale effect results:

- A unit cost reducing effect from scaling biogas plant size from 110,000 tonnes of annual inputs to 500,000 tonnes (capex per unit is reduced 35%)
- A unit cost increasing effect from scaling on transport costs (increase 45% for manure input and 96% for sugarbeet input)
- The net effect (trade-off) result in equal costs per unit of the 320,000 tonnes case and the 500,000 tonnes case. The benefit of scaling to 500,000 tonnes (biogas plant + upgrade capex) is outweighed by the increase in transport costs for both inputs and outputs.

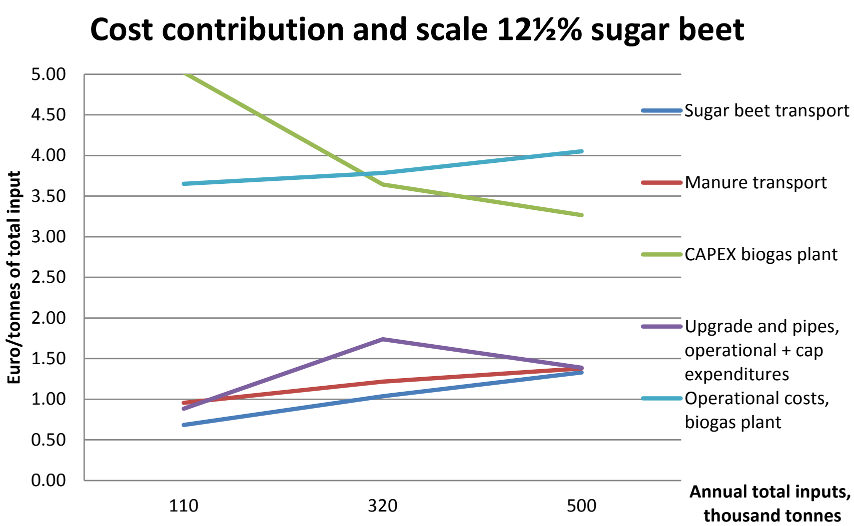

Figure 1 Trade off between rising operational costs (including transport) and reduced capital costs in a case of mixed manure and sugar beet input and three different scales of operation

The drop in costs for upgrade and pipes etc. in figure 1 is a result of positive scale effects in the upgrading facility. The 110,000 tonnes case does not involve upgrading and therefore costs are lower here. The unit costs associated with transport do increase, and most for the sugar beet, but this is not severe enough to capture the capital cost benefits of increasing size. With the increasing operational unit costs of the plant the entire scale benefit disappears

Critical assumptions and main uncertainty identified are related to:

1. Sugarbeet price (relative to manure)
2. Biogas yield (relatively between cases)
3. Support levels and difference between biogas used for CHP electricity generation and upgraded biogas for natural gas grid

Conclusions

The balance between increased operational costs and the reduced capital costs results in similar total unit costs for our different scales of operation. As seen from the figure this is caused by counteracting effects balancing out each other. As such the operational costs at the plant can be identified as an important factor in achieving profitability of increasing the scale.

Additionally the assumption about all subsidy from biogas used in the CHP plant accruing to the biogas plant is questionable for alternative ownership structures. We assume that either the CHP owns and builds the biogas plant as an additional activity or that the negotiating power of the biogas plant is sufficiently strong to secure the full subsidy. Alternative assumptions could change the attractiveness of upgrading relative to the CHP solution further.

Authorities have to carefully consider both the level of support provided but also differences in support for different end uses of biogas.