Energy Analysis of Biogas Production

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There is an increasing interest in the use of anaerobic digestion and biogas as means for producing a renewable energy carrier and simultaneously achieving multiple environmental advantages. The great variety of raw materials, digestion technologies, and fields of application of the biogas provides many plausible biogas systems, each system having different net energy outputs. The aim of this study is to describe and estimate how the energy performance in various biogas systems is affected by the composition of the biogas system, and by the calculation methods chosen.

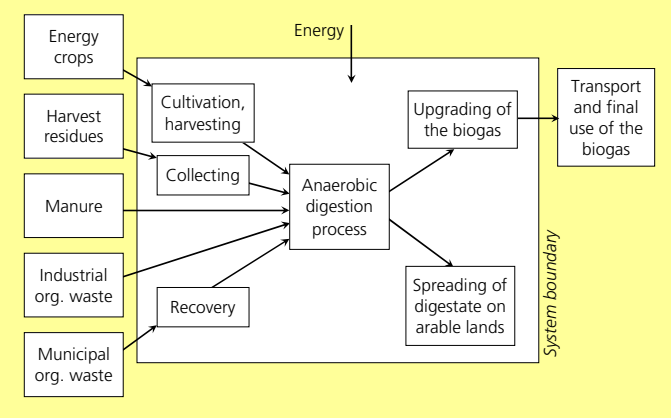

Figure 1. Overview of the biogas systems analysed. The arrows represent material or energy flows in the system.

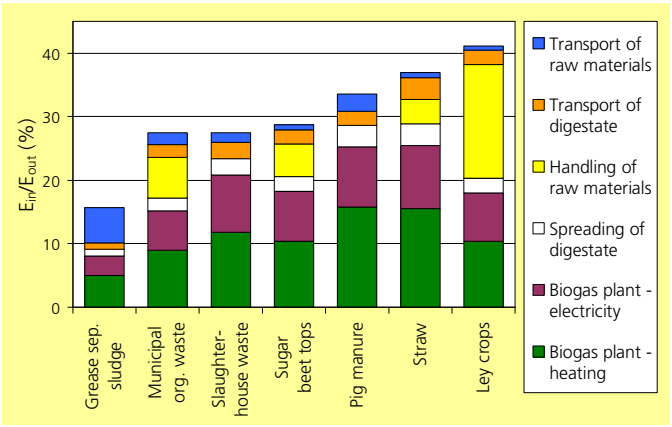

Figure 2. The energy input/output ratio for biogas production systems based on various raw materials.

Methodology

An energy systems analysis using a life-cycle perspective was carried out to evaluate the energy efficiency for biogas production from various raw materials (*Figure 1*). The analysis is based on literature reviews and the results are valid mainly for Swedish conditions.

The analyses and comparisons are made on a primary energy basis. The calculation includes the energy required in the production of energy carriers, vehicles, fertilizers, etc, as well as the energy embodied in these products.

Energy efficiency

To evaluate the energy efficiency, an energy input/output ratio (E_{in}/E_{out}) was defined. The higher the ratio, the less energy efficient the system.

E_{in} = The energy needed to run the biogas system, given as primary energy inputs

E_{out} = The energy content in the biogas produced

Figure 2 shows the calculated energy efficiency for some biogas systems based on different raw materials.

Conclusions

- The energy input typically corresponds to 15–40 % of the energy content in the biogas produced. The results are significantly affected by the raw material studied, but also by the system boundaries and calculation method chosen (e.g. method for allocation of diluting requirements).
- The raw materials can be transported some 200 km (manure) up to 700 km (slaughter waste) before the energy input exceeds the biogas yield.
- Operation of the biogas plant is generally the most energy demanding process in biogas systems, corresponding to some 40–80% of the energy input.
- In cases where production or extensive handling of the raw materials is required, the energy input can increase considerably. For example, ley cropping is estimated to correspond to 40% of the energy inputs in a biogas system based on ley crops.