## 1. Motivation/background on the topic

Biogas plants can contribute to a CO2 - neutral energy supply based on renewable raw materials or organic waste. Especially when using renewable raw materials, an optimal energetic use of raw materials is very important due to the land consumption during cultivation. A biogas plant is to be optimally dimensioned and planned in order to manage the energy supply with electricity and heat on the farm described below. Surplus energy is to be fed into the power grid or marketed via a local heating network.

## 2. Technical task/plant concept

A farm with 100 dairy cows wants to invest in a biogas plant to recover energy from the manure and slurry before it is spread on the fields as fertilizer. The annual electricity demand of the farm is 60 000kWh. The residential house of the family has a living space of 150m² and a heating demand of 50kwh/(m²*a).

In addition, there is an area of 50ha for the cultivation of energy crops (1/3maize, 1/3grain, 1/3clo-ver grass, etc.).
The plant shall consist of a digester and a digestate final storage. After gas purification, consisting of a condenser and an activated carbon filter, the biogas will be converted into electricity and heat in a CHP unit.

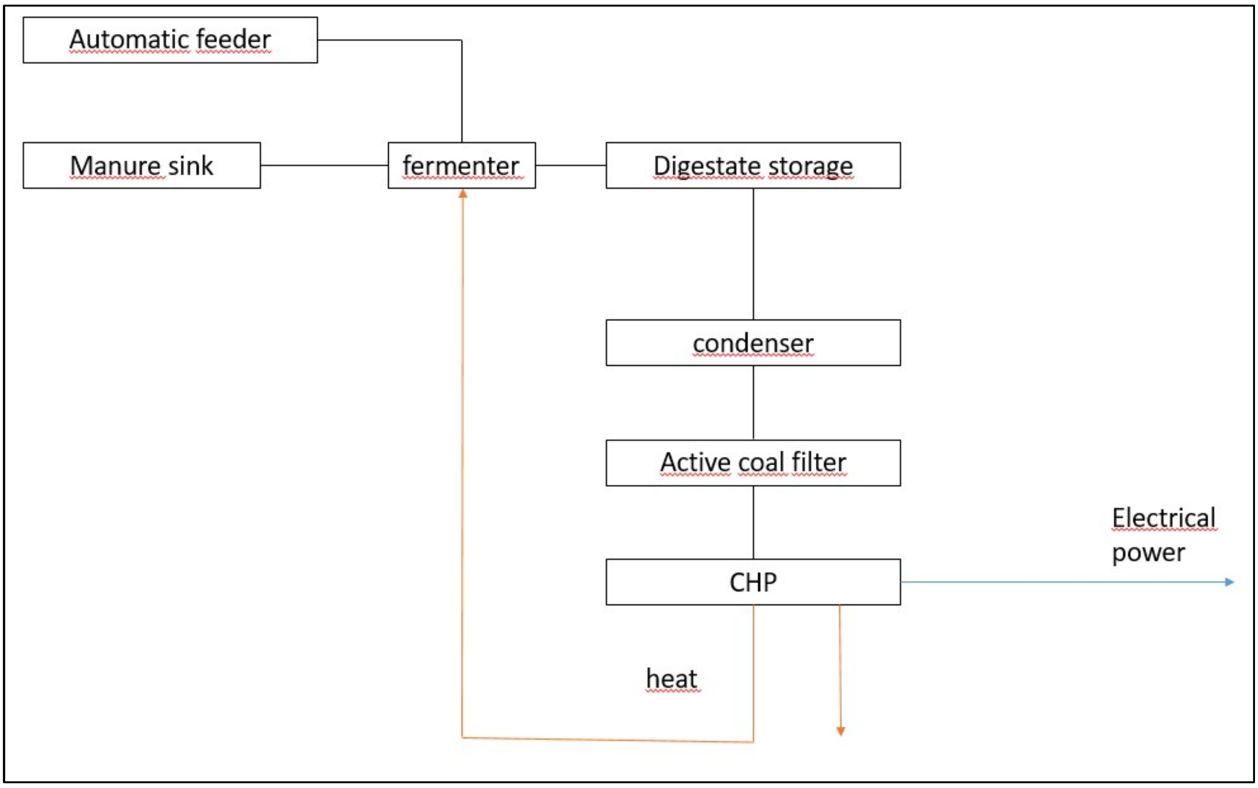


*Figure 1: Scheme of Biogas plant*

**Task:**

1. Design a biogas plant with the above mentioned boundary conditions. Determine the manure and slurry quantities and the annual yield potential on 50 ha of land for the above substrates in tFM/a and convert these quantities into the expected annual gas quantity in Nm³ $CH_4$/a. It is important to pay attention to a suitable retention time and space load in the fermenter.
2. Define work packages, a time schedule with a Gantt chart, which shows the distribution of tasks within the project.
3. The basic engineering is to be prepared for the entire plant. All necessary apparatus shall be specified. Mass and energy balances are to be drawn up for the entire plant as well as for the individual apparatuses, and the composition of the individual streams is to be determined. The result shall be presented in a process flow diagram with basic and additional information according to DIN EN ISO 10628-1. 4.
4. Detail engineering shall be specified for the agitator in the digester, the slurry pump, the condenser and the activated carbon filter. For this purpose, all aspects of the substantive points 14 - 20 are to be taken into account. 5.

   Choose reference models for agitator and slurry pump. Do a technical drawing for the condenser and the active coal filter.
5. In addition to the process engineering features, questions regarding plant safety, material selection, thermal management and legal regulations must be answered, wall thicknesses, sizes, measuring points, valves and other internals must be specified. The pump and the agitator are to be described with regard to material, design, connections and size (if necessary with a reference type). A piping and instrumentation schematic shall be provided for the entire gas cleaning system.
6. On the basis of the basic and detail engineering, the investment and operating costs are to be determined and a profitability analysis is to be prepared in accordance with VDI 2067.

## 7. Content of the task

Submission of a detailed project report, which includes the following points depending on the assignment
included. These can be adapted to the requirements of the project if necessary.

1. Title page with title, course of study, group members, matriculation number, start, submission date, supervisor, professorship
2. Summary/Management Summary
3. Table of contents
4. Task and objective
5. Group structure, division of tasks, procedure
6. Timetable for the creation of the work
7. State of the art
8. Description of the plant or apparatus to be planned, plant structure
9. Prepared plant diagram/process flow diagram of the plant according to DIN EN ISO 10628 with designation of the essential apparatus, machines and media.
10. Description of the plant function
11. Brief description of the plant group, apparatus, machine within the plant
12. Prepared mass and energy balance for the plant and/or apparatus and machinery according to the task using the chemical, biological, reaction, thermodynamic, fluidic, thermal and mass transfer aspects required for the task.
13. Execution of experiments, analysis, results (optional if required)
14. Technical design and scale-up of the apparatus or machines according to the technical requirements, such as turnover, volume/dwell time, pressure, temperature, pH value, ...
15. Technical design according to safety aspects such as material selection, corrosion, wall thickness according to e.g. AD 2000, gasket selection for flanges, bearing types of agitator shafts, insulation requirements, requirements for explosion protection zones, air exchange, ...
16. Technical design according to licensing aspects such as pollutant emissions in exhaust gases and exhaust air, noise emission, wastewater pollution, ...
17. Overview of the created safety concept (HAZOP) with treatment of the essential safety aspects (machine directive, pressure, explosion, machine) and solutions (according to product safety), indication of the method of safety consideration
18. Prepared technical equipment specifications with regard to technical design parameters, material specifications and other e.g. production-related special features and requirements such as welds and tests
19. Derivation and presentation of a control concept with essential system and safety-related control loops in a piping and instrument flow diagram
20. Prepared media specifications of essential input materials, products and wastes with reference to the plant scheme, properties and safety
21. Capex and opex calculation and economic evaluation by means of a profitability calculation according to VDI 2067 or cash flow consideration.
22. Bibliography with indication of the essential literature, references in the chapters
23. Appendix with list of figures and tables, ...