Redox flow batteries instead of biogas plants

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Abstract – As the first biogas plants fall out of the German Renewable Energies Act (EEG) subsidy, a new possibility for further use is being explored. The conversion of an old biogas plant into a redox flow battery is investigated. The technical potential is determined and a utilisation concept for the redox flow battery and the resulting waste heat is presented.

1. Biogas plant

- Different types of biogas plants, with different system components [1]
- Fermenters can be up to 8,000 m³ in size and are usually made of steel reinforced concrete [1]
- The biogas produced can be used to provide heat, electricity or fuel [1]
- In Germany most biogas plants have a combined heat and power plant [1] with an electrical output between 75 kW and 500 kW [2]

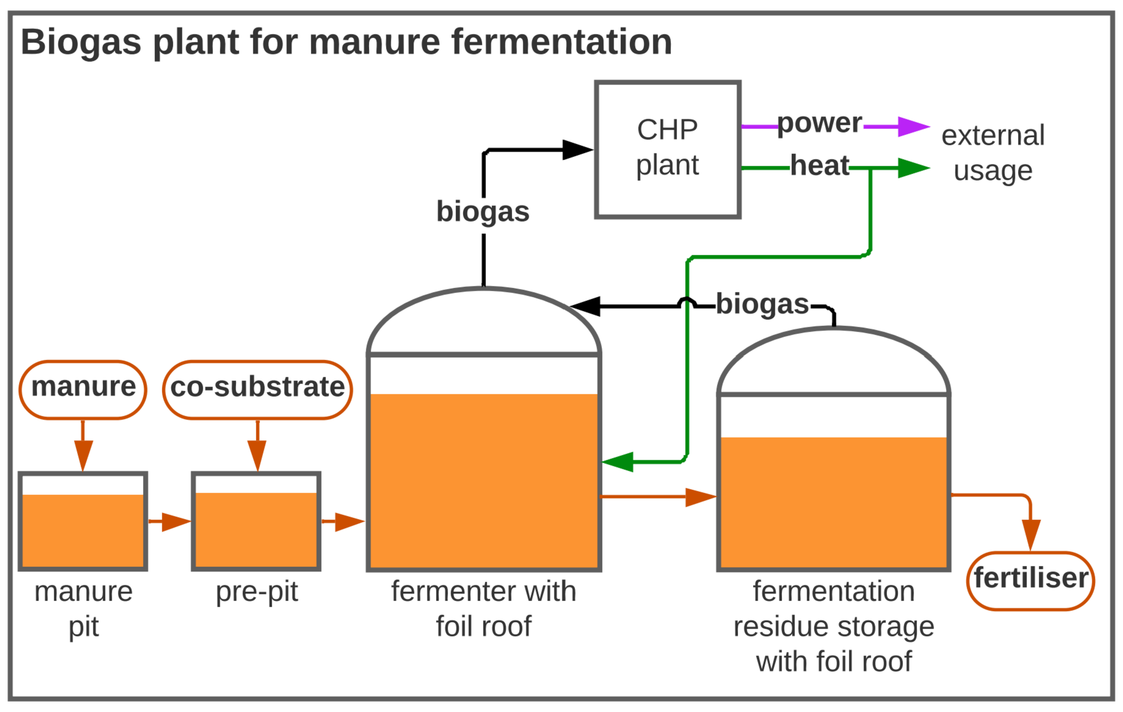

Fig. 1: Schematic layout of a biogas plant for manure fermentation according to [1]

2. Redox flow battery

- Redox flow batteries use redox reactions to store energy chemically [3]
- Dimensioning of power and capacity is independent of each other [3]
- The liquid energy-storing electrolytes are stored outside the cell [3]
- Electrolytes consist of redox-active material in a liquid solvent [4]
- Metal-based redox partners are most used (e.g. pure vanadium) [4]
- Organic materials are also possible, but are not yet fully developed [4]

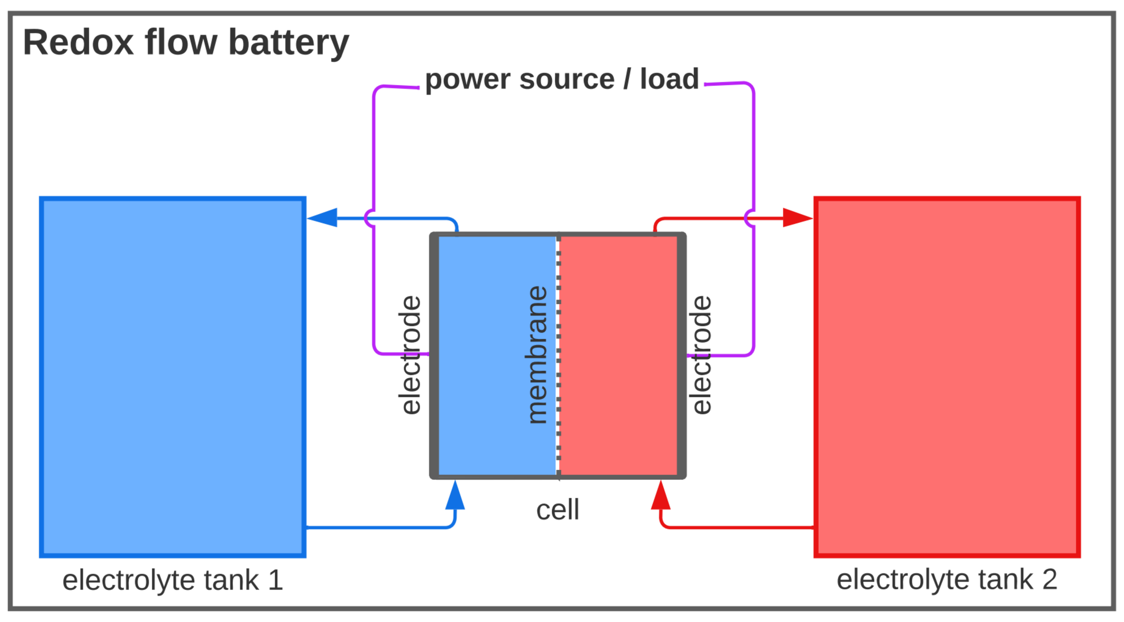

Fig. 2: Schematic layout of a redox flow battery according to [3]

3. Technical concept

- Former fermenter and fermentation residue storage are used as electrolyte tanks but need a coating with an acid-resistant material [5]
- Foil roofs of the fermenter and fermentation residue storage must be replaced with solid building roofs
- Existing openings in the tanks can be used for the feed and discharge of the electrolytes and excess or unsuitable openings must be sealed
- Stacks of the redox flow batterie can be installed in the former building of the combined heat and power plant
- Existing grid connection can still be used and extended if needed
- The investigated model plant can have a storage capacity of 51 MWh and a power output of 8.9 MW

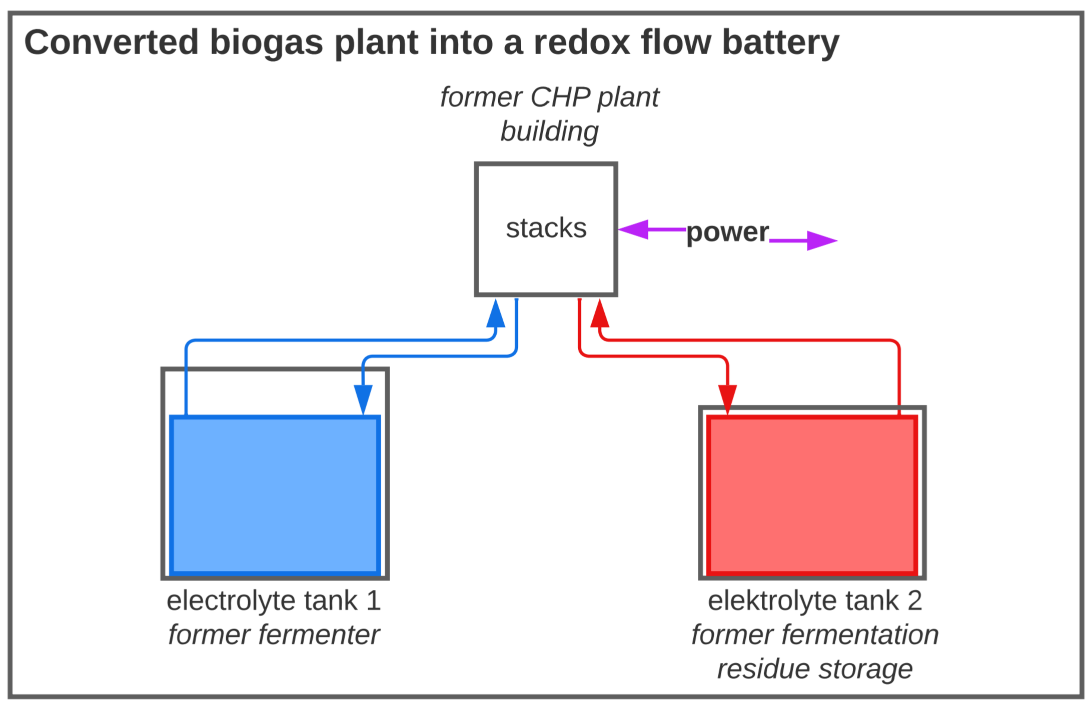

Fig. 3: Schematic layout of the biogas plant converted into a redox flow battery

4. Potential in Germany

- Under the assumption that half of the biogas plants that will lose EEG subsidies in the next five years will be converted to redox flow batteries, a total storage capacity of 53.8 GWh and power output of 9.4 GW can be provided

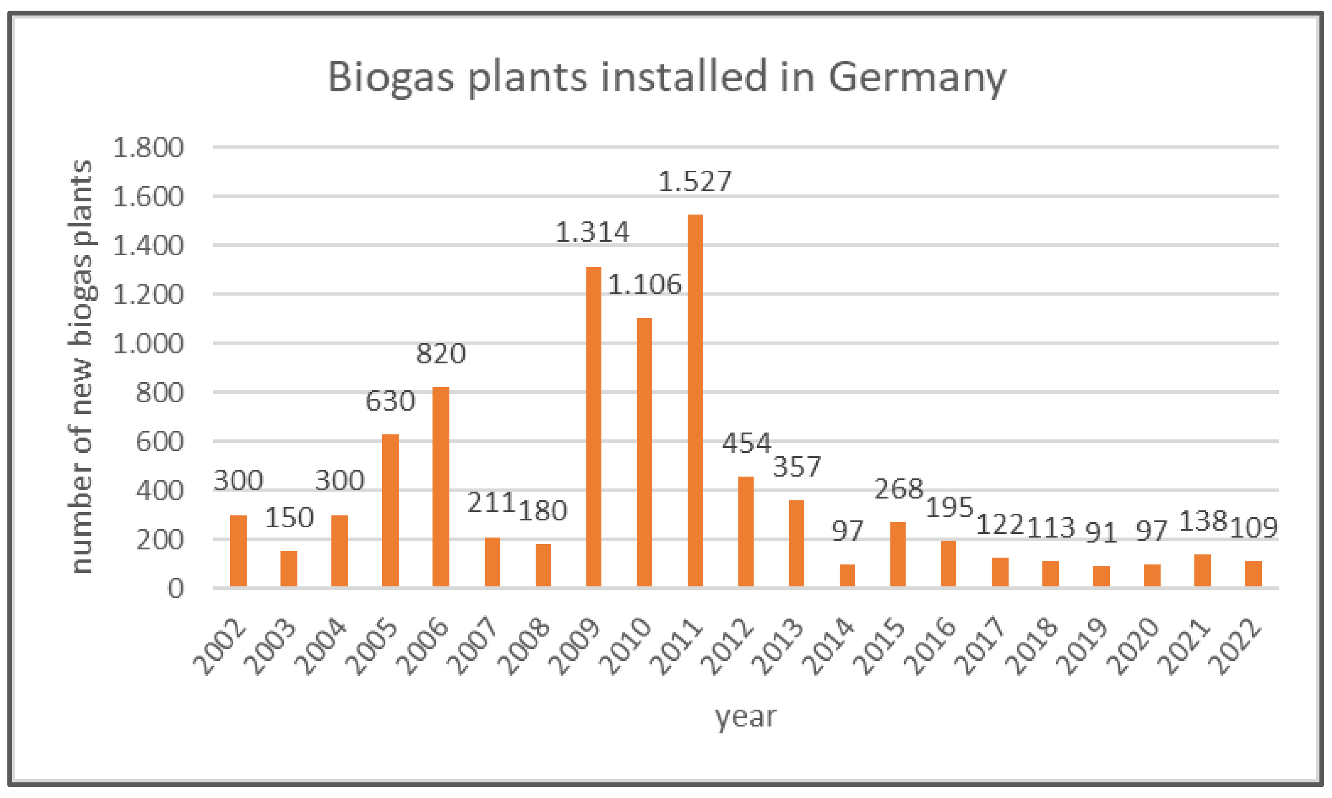

Fig. 4: Biogas plants installed in Germany between 2002 and 2022 according to [6]

5. Utilization concept

- Redox flow batteries can be used for all types of control energy [3]
- Automatic frequency restauration reserve is economically very attractive due to the high performance price [7]

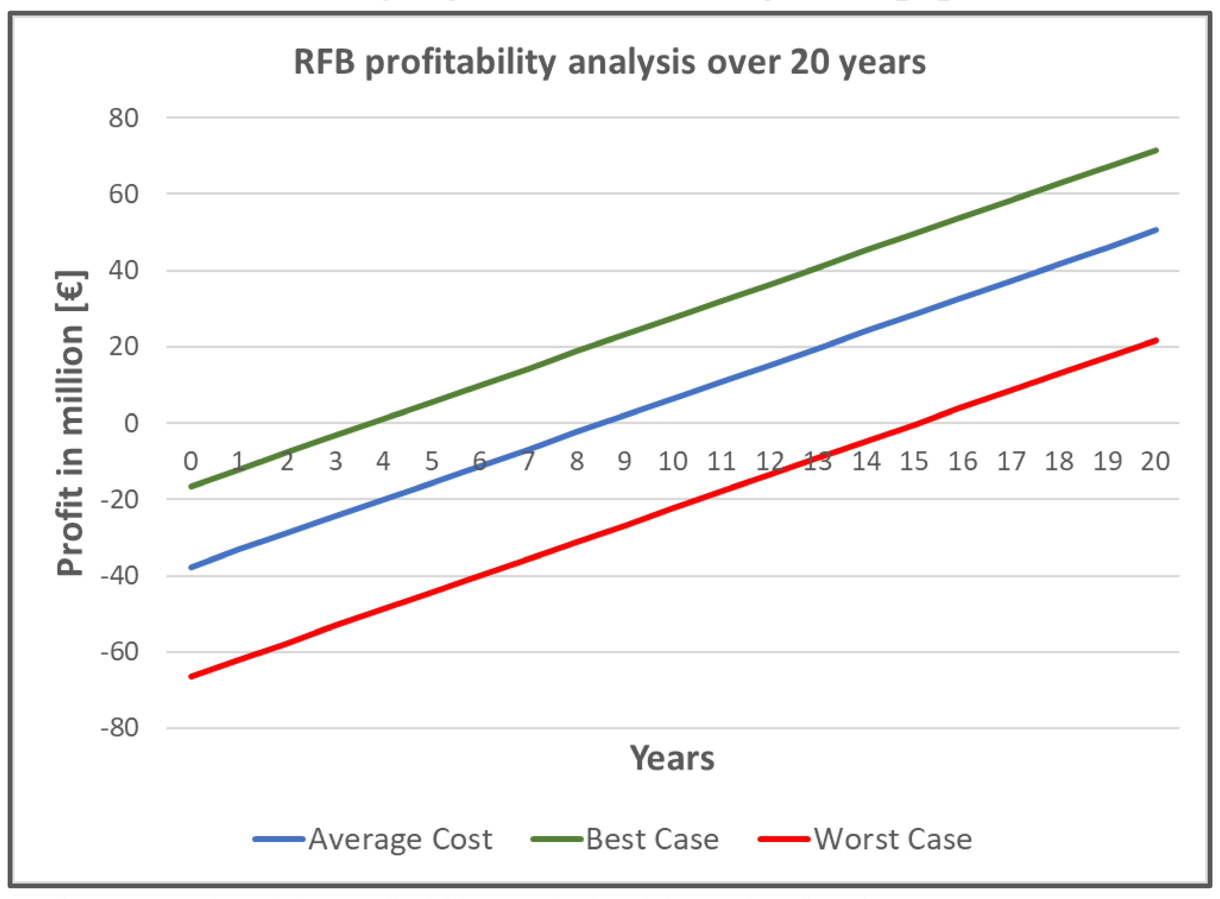

Fig. 5: Results of the profitability analysis of the redox flow battery over 20 years

- The generated waste heat has a low temperature level
- Possible to use a cold local heating network [8]
- Waste heat can be used directly on the farm (e.g., breeding and agriculture) [8]

6. Conclusions

- Possible to convert old biogas plants into redox flow batteries
- Only fermenter and fermentation residue storage are useful for further applications and require additional costly processing and conversion
- All-in-one systems are much more reasonable, leaving space as the only resource used
- Currently very high investment costs for redox flow batteries
- Investments in other utilisation concepts for the old biogas plants may be more attractive at this point of time

References

[1] M. Kaltschmitt, H. Hartmann, and H. Hofbauer, Eds. *Energie aus Biomasse: Grundlagen, Techniken und Verfahren,* 3rd ed. Berlin Heidelberg, Germany: Springer Vieweg, 2016
[2] J. Daniel-Gromke, N. Rensberg, and V. Denysenko, "Biogas – Status quo und Anlagenentwicklung," in *Biogasfachgespräche Leipzig „Neues für Biogas- und Biomethananlagen – Was bringt das Jahr 2021?".* Accessed: Aug. 27, 2023. [Online]. Available: https://www.dbfz.de/fileadmin/user_upload/Fachgespraeche/Biogas-Fachgespraeche/Vortraege/2021-02_BGFG_Vortraege.pdf
[3] M. Sterner and I. Stadler, Eds. *Energiespeicher: Bedarf, Technologien, Integration,* 2nd ed. Berlin, Germany: Springer Vieweg, 2017
[4] J. Winsberg, T. Hagemann, T. Janoschka, M. D. Hager, and U. S. Schubert, "Redox-Flow-Batterien: von metallbasierten zu organischen Aktivmaterialien," *Angewandte Chemie*, vol. 129, no. 3, pp. 702–729, Jan. 2017, doi: 10.1002/ange.201604925
[5] A. Taffe, M. Pohl, W. Roeser, and B. Schwamborn, "Betonkorrosion durch Schwefelsäure an Abwasserbauwerken: Innovative Schadensdiagnose," *Beton- und Stahlbetonbau*, vol. 102, no. 10, pp. 691–698, Oct. 2007, doi: 10.1002/best.200700574
[6] Fachverband Biogas e.V., Ed., "Branchenzahlen 2021 und Prognose der Branchenentwicklung 2022," Accessed: Aug. 30, 2023. [Online]. Available: https://www.biogas.org/edcom/webfvb.nsf/id/DE_Branchenzahlen/$file/22-10-06_Biogas_Branchenzahlen-2021_Prognose-2022.pdf
[7] C. Schäfer. "Leistungspreise." Regelleistung Online. https://www.regelleistung-online.de/srl/leistungspreise/ (accessed Aug. 21, 2023).
[8] G. Pertiller, "Nutzungsmöglichkeiten für Niedertemeratur-Abwärme der energieintensiven Industrie, am Beispiel einer Garnelenfarm," M.S. thesis, Lehrstuhl Wirtschafts- und Betriebswissenschaften, Montanuniversität Leoben, Loeben, Austria, 2018.

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