THE ROLE OF BIOGAS IN ENERGY SUPPLY - FOCUS ON AFFORDABILITY, SUSTAINABILITY AND SECURITY OF SUPPLY

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In the recent past we considered energy supply as a centrally managed, inexhaustible, cheep source of power, gas, water, heat. Nowadays, in the era of economic crises, growing number of warlike conflicts, vulnerable global supply chains, climate change - this is not that obvious anymore. As an aftermath of all recent changes, it common to talk about decentralised generation, energy communities, microgrids, demand management. The energy industry is still one of the biggest emitters in its never-ending contest to cope with steadily growing energy hunger of the world. In this context energy industry does its best to behave on a responsible manner and exploits all possible non-fossil, non or reduced emitting, renewable primer energy resources to decrease – or keep the level at least – of the emission of greenhouse gases. In this study our aim is to demonstrate the possible positive impact of an energy source, not yet utilised to its full potential, the biogas. We analyse under what economic, social, regulatory environment can grow up to its potential and what are the preconditions of feasibility.

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1 Introduction

A sustainable energy transition will transform the energy sector (De-León Almaraz et al. 2023). Today, companies, including energy companies, are facing major challenges: global crises such as pandemic COVID-19 and the Russian invasion of Ukraine have highlighted the need for affordable, secure and local energy supplies (Csiba – Szigeti, 2023). At the same time, climate change mitigation requires a rethink. While the challenges may seem daunting, energy companies can draw on the experience of others in the sector and beyond who are finding solutions and scanning the horizon for new opportunities (Fantaguzzi et al., 2022).

It is the shared responsibility of all institutions, businesses and consumers to share best practices, knowledge and experience on how to reduce and rationalise their energy consumption.

One way to do this is to use industrial, agricultural or municipal waste for energy production, in line with European Union (EU) waste management principles.

Rapid demographic growth is putting great pressure on the consumption of biological resources, and is forcing governments, organisations and society to work on the reproduction of these resources. The Circular Economy Business Model (CEBM) is described and defined as such an organisational ecosystem that creates and fixes value by extending the lifetime of products, remanufacturing, repairing or simply designing products with a long lifetime from the outset (Hina et al., 2022).

The basic difference between Circular Economy (CE) and CEBM can be formulated as CE is an economic model and CBM is a way of creating value.

CE focuses on the remanufacture and reuse of materials, as well as refurbishment, maintenance and repair to keep products in use for a long time. CEBM, on the other hand, is an approach whereby organisations create value by adhering to CE principles (Csiba – Szigeti, 2023).

The theoretical background of the study is based on the guidelines of Webster and Watson (2002) and Brocke et al. (2009).

In addition to the literature search, 12 interviews were conducted with company executives/senior managers who play an important role as decision makers and market players in the energy and financial sector.

The results of the qualitative research are presented along three main themes, highlighting the most important findings due to space limitations:

a) Renewables versus conventional energy, business models
b) Economic and environmental impact
c) Future perspectives and strategies

Our research suggests that technological progress and the evolution of the regulatory environment need to be in harmony. The production of biogas, biomethane (also a non-electric renewable energy) in a supportive regulatory environment is growing significantly, not only as an energy supplier but also as a waste management element, and is yielding good financial, environmental and social results in micro and medium scale plants.

Subsequently, those who succeed in operating in new business models, such as digital utilities, or in local supply, such as biogas producers, or who master the scheduling of weather-dependent renewables, will achieve measurable and excellent financial results and environmental benefits.

2 Theoretical background / Literature review

The study is based on a literature review following the guidelines of Webster and Watson (2002) and Brocke et al. (2009).

The Circular Economy model is a valid alternative to the linear economy model that has been widely used until now (Bocken et al., 2022). There are many examples of business model formulation in the economic literature (Velandia et al. 2024). The most common approach is that a business model (BM) is a conceptual tool that helps to explain how a company operates. Central to the concept of a BM is how a company differentiates itself from other companies, how it determines the price of its products and its competitive strategy through the design of its product or service. (Bocken et al., 2014). Linear business models (LBMs) have existed since the early

days of industrialisation. In LBM, products are made from virgin materials, then the products are sold, used, and finally disposed of after use. The result is today's polluted environment. This traditional model does not consider the social and environmental impacts of this process.

Sustainable business models (SBMs) put environmental and social objectives at the heart of business operations. SBMs can address social and environmental problems in new and more profitable ways by creating competitive advantage and value for society (Alonso-Martinez et al., 2021). Several research groups are studying SBMs and the changes that occur under the influence of COVID19 (Csutora et al., 2022). Enterprises are very important actors in the circular economy, as they can develop and implement circular business models and thus contribute to changing the basic conditions of production. Companies are experimenting with new CBMs, launching a business model in one country (sometimes in parallel) and then introducing it in other countries. An important role for companies is that they do not necessarily have to close resource loops within their own internal system boundaries, but there can be business relationships in which participants collaborate to achieve a 'circular' goal (Das et al., 2022).

Research on circular models of biogas plants is typically carried out in a national context. This is due to the different geographical circumstances. By this we mean not only the dominant 'fuel' for biogas production, but also the energy mix of the country - and the regulatory environment. In recent years, a number of studies on circular models of biogas plants have been published in Italy (Sica, 2023), Finland (Valve et al., 2021, Akerman et al., 2020), Sweden (Karlsson, 2019, Karlsson et al., 2018, Hendriks 2024), Switzerland (Bowman et al., 2022), Brazil (Oliviera et al. 2024), India (Kapoor et al., 2020) and Mexico (Sadhukhan et al. 2024).

When evaluating biogas plant models, it is necessary to consider the MWh-equivalent produced, the added value, the role in the ecosystem and the critical institutional factors (+) and barriers (-). It should be considered whether this classification is general or country-specific. Another dimension of biogas production to be examined is whether and according to what criteria biogas production makes sense in each country/region and what instruments are available to increase efficiency, e.g. through strategic partnerships (De Jesus et al, Although biogas production is country-specific due to the geographical (in the broad sense described

above) and regulatory context, the possibility of internationalising the country-specific circular economy (CE) model and developing its methodology (Castilla-Polo et al., 2022) is the subject of further studies.

3 Methodology

The study will use a mixed-methods approach.

The literature review is based on relevant sources in Scopus, Web of Science, Google Scholar, Science Direct databases.

Secondary sources are used to combine qualitative analysis of regulatory frameworks, economic modelling, quantitative assessment of environmental impacts and economic benefits. By examining case studies in different geographical and regulatory contexts, the research aims to identify key factors for the successful implementation and scaling up of biogas projects. The expected outcome is a comprehensive understanding of the role and potential of biogas in CEBMs, together with a detailed business model framework that can be adapted and applied in different contexts.

In addition to the literature review, 12 interviews were conducted with company executives / senior managers who play an important role as decision makers and market players in the energy and financial sector. Our qualitative research is based on a semi-structured interview. The managers were interviewed in person. The interviews lasted 1-1.5 hours.

4 Results and discussion

The main findings of our primary research are presented, summarised along the main subjects of the interview.

A. Renewables versus traditional energy, business models

Apparently, renewables provide proper solution to the challenge of climate change, but majority of them are weather dependant, therefore requires huge, badly utilised fossil fuel fired capacities to manage system balance. Ever growing investment into

weather dependent renewables increases the volume of curtailed energy thereby significantly decrease return on investment. Non-electric renewables are getting into forefront now, especially hydrogen but the financial stability of hydrogen economy is not proven yet. Biogas, biomethane (non-electric renewable as well) production is growing significantly under supportive regulatory environment, not only as an energy provider but as waste management element as well and it generates good financial, environmental, and social results in micro and in mid-sized operation. such ventures are typical and good examples of implementation circular business model in energy business. Circular business model considered as a much more business-like model compared to no-growth business model to manage overall sustainability. Demand management – which can be considered as a partnership based circular approach – can induce fundamental changes in energy supply, that is what digital utilities are dealing with.

B. Economic and environmental impact

There is no doubt, that energy business is one of the biggest when it comes to environmental impact. It must comply with the imbalance of securely, affordably, and sustainably supply the ever-growing energy while continuously kept under pressure to reduce emissions and CO^2 footprint. Unfortunately, many deals with dark export, placing high-emission activities to less regulated locations. But those who managed either to operate in a new business model, like digital utilities or doing local supply, like biogas producers or those are mastering to schedule of weather dependant renewables are reaching measurable and excellent financial results and environmental benefits at the same time.

C. Future perspectives and strategies

Major development in technology were the commercial availability of 4th generation nuclear reactor or of the fusion reactor. Until then there is a very fast development can be witnessed because of many smaller elements like high efficiency wind turbines, high output photovoltaic cells, low resistant power grid, AI and Machine Learning aided systems, just to mention a few. The trend is that energy supply systems (power, gas, oil) get more and more complex, not only in technical means, but when it comes to regulation, financing, stakeholders as well. The same valid for other utilities. like water, sewage, telecom systems.

The central generation and distribution model develops toward distributed generation model. The market uptake of weather dependent renewables is unstoppable. This phenomena challenges not only the power system balance but return on investment as well.

Production of non-electric renewables can accelerate energy transition (e.g., hydrogen economy), but it requires strong governmental support. Local solutions, like biogas production, can efficiently support local communities, not only when it comes to energy supply, but as solution of waste management and local social issues as well.

Major issue to protect environment by significantly reduce emission of greenhouse gases meanwhile maintain competitiveness of European economy.

Major development required to drastically improve the pace of energy transition when it comes to power generation, distribution, and demand management.

6 Conclusions

To fulfil the three major requirement of energy supply – affordability, sustainability, security of supply – presume much more coordinated approach in the future. The literature clearly demonstrates that technological developments and the evolution of the regulatory environment need to be consistent with each other. Regional – i.e., European at least – coordination of technology and grid development, proper global and harmonized country specific regulation, which actively promote energy transition without harming competitiveness and the development of local solutions like biogas production, microgrids and consumer communities.

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