Off-Grid biomethane mobile solution - Investigation on upgrading & storage mobile units and centralized injection facility

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1. Introduction

Research shows that the majority of biogas sources are remote from the gas grid (i.e. 36% off-grid farms and 21% off-grid landfill in Ireland), and thus represents both a challenge and an opportunity in getting to market/grid. To overcome these issues and to sustainably produce, capture and utilize this gas, a centralized biomethane grid injection facility with third party access has been proposed and further investigated.

A centralized grid injection and a virtual pipeline transport solution (cleaning, upgrading and storage mobile units) are critical to the development of the wider green gas industry in countries where the physical or economic conditions deems the installation of a real pipeline unfeasible. In this paper technical and economical challenges of an aggregator and centralized biomethane grid injection model are identified and discussed.

2. Technology description

The following technical elements were evaluated: a centralized injection point, where the biomethane transported from each cluster is injected, and a mobile solution including cleaning/upgrading technology and storage units.

The mobile units consist of a cleaning and upgrading technology to remove mainly CO_2 and H_2S and other impurities which also has a negative effect on equipment [1]. Membrane and pressure swing adsorption (PSA) for small scale were evaluated for this purpose. The membrane plant has a capacity for raw biogas flow up to 300 m^3/h [2] and PSA from 50 - 200 m^3/h [3]. Such technologies are mounted on a trailer in a 20 ft container. Upgraded biogas is then compressed to a maximum of 250 bars and stored in gas vessels on the second truck within a container. The standard gas storage containers are available in steel or in composite tanks. The standard steel vessels have a total storage capacity of 2500 Nm^3 whereby the composite vessels have a total storage volume of 5200 Nm^3 [4]. Such trucks would ideally run on biomethane, which could reduce fuel cost up to 40% [5]. Trucks deliver biomethane to centralized gas injection facilities where the gas is then odourised and quality controlled before being injected into the gas grid.

3. Economical analysis

The collected data has been used to perform economical analysis for different off-grid biomethane scenarios in an Irish context, focusing only on cleaning, storage mobile units and gas injection.

Assumptions & Scenarios

The grid injection facility is provided by the gas network operator; however producers are responsible for gas conditioning and an injection fee. Biomethane is injected into the high pressure pipeline, therefore propane addition is not required.

Key variables for sensitivity analysis are distances, consumption, compliance with the transport, environmental and security norms in addition to the biogas cost, investment and capacity factor.

Baseline scenario has a total raw biogas capacity of 275 m^3/h – 16 GWh (5 small scale biogas plants), CH_4 53-62%, low pressure biogas storage capacity 30-48 hours/site, distance between plants 30-60 km, transportation and setting-up time 2 hours. Such scenario was studied while varying the number of biogas plants from 3 to 5, the upgrading technology (membrane/PSA) and transport capacity (2500 m^3/5200 m^3). Furthermore, it was compared with a decentralized plant (8 GWh).

4. Results

The study of the baseline scenario and its alternatives shows that a centralized system is required to make the business case for small scale producers.

Table 1 shows a comparison of the capital (CAPEX) and operational cost (OPEX) [6] of the most representative scenarios.

Table 1. Economic analysis.

	Decentralized	Mobile Sol'n	Mobile Sol'n
	1 plant	5 plants	3 plants
Capacity - kWh	*8,000,000*	*16,000,000*	*10,000,000*
Capital	**€**	**€**	**€**
Storage raw biogas	40,000	360,000	275,000
Cleaning & Upgrading	520,000	1,005,000	520,000
Gas Conditioning - compression	252,000	405,000	308,000
Storage biomethane	220,000	220,000	220,000
Trucks	110,000	220,000	220,000
Grid Connection Contrib'	342,000	342,000	342,000
Total Capital Investment	**1,484,000**	**2,552,000**	**1,885,000**
Capital Investment/Site	**1,484,000**	**510,400**	**628,333**
Operating Cost / annum	**€**	**€**	**€**
Cleaning & Upgrading	20,000	30,000	30,000
Injection/Pressurization	50,000	50,000	50,000
Electricity	100,000	150,000	120,000
Labour	70,000	140,000	120,000
Insurance	100,000	120,000	110,000
Mobile - Transport	24,100	41,800	41,800
Total Annual Opex	**364,100**	**531,800**	**471,800**
Annual Opex /Site	**364,100**	**106,360**	**157,267**

Membrane technology was chosen due to its higher upgrading capacity, since PSA would be a limiting factor in the 5 plants scenario. However, the higher investment of such technology could affect the economical viability for clusters with capacity bellow 150 m^3/h, therefore, PSA may be the most feasible technology for low capacity clusters. Regarding the storage, composite vessels were found to be the most cost-effective option. Although it requires a higher CAPEX, the OPEX and availability for higher transported volume makes a difference in the producers' revenue and NPV analysis.

Technical limitations regarding the storage and pressure requirements might impact the investment; alternatively delivering the biomethane into a filling station instead of centralized injection could reduce operational cost avoiding additional compression and storage. The economics of virtual pipeline are significantly influenced by the distance and the biogas production and storage capacity. Incentives may be necessary for economic justification.

5. Conclusions

Clustering farms, landfills and wastewater treatment plants to facilitate use of a mobile upgrading and storage system is imperative for achieving economies of scale and make biogas market accessible for small scale producers. However, biomethane quality requirements for end use applications, technically demanding mobile units, restrictive guidelines and high cost for grid injection are among the prevailing challenges.

6. References

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