Embedding commodity price variation in the economic evaluation of biofuels projects: the example of a Power-to-Gas biomass-to-biomethane process under the Italian biomethane subsidy scheme

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Techno-economic modelling and evaluation is essential in identifying the potential, barriers and optimization needs of any process for biomass and waste conversion to renewable energy carriers. Most assessments of the economic feasibility of bioenergy processes rely on discounted cash flow methodologies that estimate the minimum selling price (MSP) of the core product (Albrecht *et al.*, 2017), the expected net present value (NPV) of the project, or its return on investment (ROI) (Heinzle, Biwer and Cooney, 2006). One inherent limitation of these methodologies resides in the hypothesis of constant product pricing conditions, hardly attainable over typical project lifetimes of 15 – 20 years (Brown and Brown, 2014). Such downside generates the potential for considerable inaccuracies in the projection of financial performance, with the consequent risk to mislead the appraisal of investment and policy support mechanisms, which has stimulated efforts to define normalized techno-economic indices for renewable energy systems (Guo, Liu and Liao, 2021). In instances where biofuels feed-in tariffs are calculated based on prices traded on regional commodities markets, the effect of the variability of external commodities prices on biofuels projects feasibility can be particularly substantial.

In this study we draw on a previously published detailed techno-economic model of a Power-to-Gas biomass-to-biomethane process (Menin *et al.*, 2021) (Fig. 1) and we take the example of Italian biomethane feed-in tariffs (FITs) as a price-based subsidy scheme (Cucchiella, D'Adamo and Gastaldi, 2019) to demonstrate the influence of natural gas price variability on process feasibility.

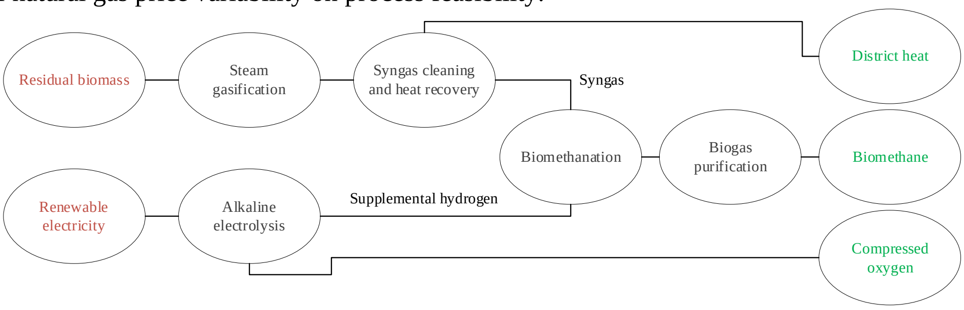

Fig.1. Schematic representation of the biomass-to-biomethane process considered in Menin *et al.* (2021).

The specific objectives of the work were to estimate the difference in NPVs and in ROIs obtained over the project lifetime when applying a constant feed-in tariff value and a tariff value inclusive of gas price variation ($P_{NG,spot}$) according to the national biomethane scheme (Eq. 1).

Eq. 1

$$FIT_{biomethane}[€/MWh] = 95\% \left(P_{NG,spot}\right) + 64.26$$

In the evaluation of the process economic performance, we make use of the estimated performance and cost parameters from our previous study, and we retrieve spot-market natural gas prices ($P_{NG,spot}$) from the national market database (GME, 2021) and supplement it with a simple exponential smoothing forecast time series estimated in Microsoft Excel (Fig.2). We consider a single matrix of cost conditions applicable to an energy system with high penetration of wind and solar (electricity cost: 40 €/MWh) (Lorenczik and Keppler, 2020) and a biomass fuel derived from residual wood and waste biomass (cost: 30 €/t as received) (Thunman *et al.*, 2019). We then estimate the NPV and ROI of the project by applying monthly variations in the consequent FIT value according to Eq. 1 rather than a constant biomethane price.

Preliminary results indicate that the calculated monthly FIT values are higher than the previously estimated MSP for 91 months over the considered project lifetime (44.6% of monthly data, Fig. 1).

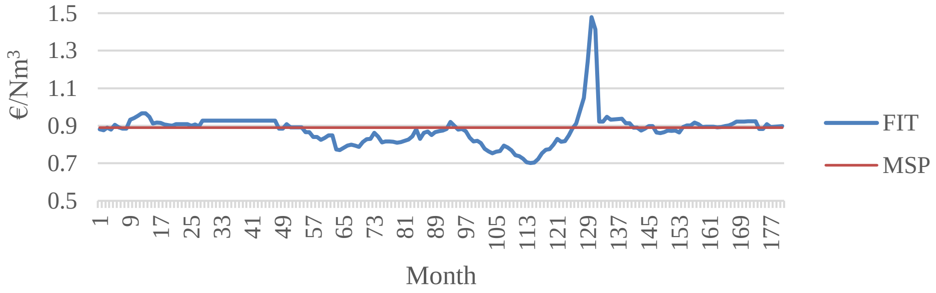

Fig.2. Time series of estimated feed-in tariffs (FIT) from January 2011 to September 2025 against the minimum selling price (MSP) previously estimated for the cost conditions considered (Menin *et al.*, 2021).

Consequently, by applying the historical price series the NPV estimated for the project is 8 % higher than can be estimated based on a constant FIT (0.78 €/Nm^3) available at the time of the previous investigation (Fig. 2a). Similarly, under a ROI approach, considering variable natural gas prices allows estimating a return 12 % higher than for a constant FIT (Fig. 2b).

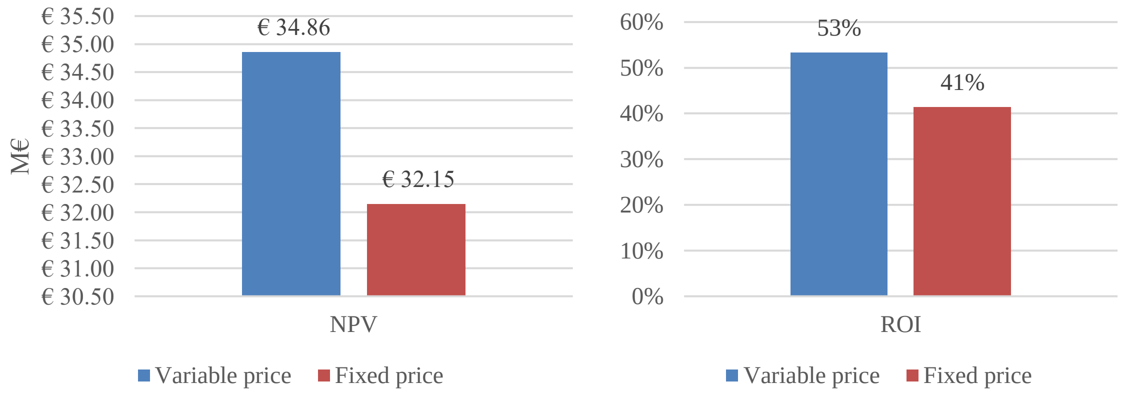

Fig. 2. Differences in estimated project net present values (a, left) and returns on investment (b, right).

The results of the study indicate that embedding a variation in external price factors that affect biofuel remuneration in FIT schemes is essential in assessing their techno-economic competitiveness comprehensively. The methodology applied and the example assessment undertaken also points to the need to include such variability projections through historical series and forecast techniques in the evaluation of the effectiveness of biofuels fiscal support schemes.

References

Albrecht, F. G. *et al.* (2017) 'A standardized methodology for the techno-economic evaluation of alternative fuels – A case study', *Fuel*, 194, pp. 511–526. doi: 10.1016/j.fuel.2016.12.003.

Brown, R. C. and Brown, T. R. (2014) 'Economics of Biorenewable Resources', in *Biorenewable Resources*. Hoboken, NJ, USA: John Wiley & Sons, Inc., pp. 287–326. doi: 10.1002/9781118524985.ch12.

Cucchiella, F., D'Adamo, I. and Gastaldi, M. (2019) 'An economic analysis of biogas-biomethane chain from animal residues in Italy', *Journal of Cleaner Production*, 230, pp. 888–897. doi: 10.1016/j.jclepro.2019.05.116.

Guo, M., Liu, G. and Liao, S. (2021) 'Normalized techno-economic index for renewable energy system assessment', *International Journal of Electrical Power & Energy Systems*, 133, p. 107262. doi: 10.1016/J.IJEPES.2021.107262.

Heinzle, E., Biwer, A. P. and Cooney, C. L. (2006) 'Sustainability Assessment', in *Development of Sustainable Bioprocesses*. Chichester, UK: John Wiley & Sons, Ltd, pp. 81–117. doi: 10.1002/9780470058916.ch4.

Lorenczik, S. and Keppler, J. H. (2020) *Projected Costs of Generating Electricity*, *International Energy Agency*. Paris. Available at: https://ncdc.gov.ng/themes/common/docs/protocols/111_1579986179.pdf.

Menin, L. *et al.* (2021) 'Competitiveness of syngas biomethanation within the bioenergy with carbon capture and storage and power-to-gas concepts: techno-economic modeling and evaluation of the level of incentives required at different scales', in *29th European Biomass Conference and Exhibition*.

Thunman, H. *et al.* (2019) 'Economic assessment of advanced biofuel production via gasification using cost data from the GoBiGas plant', *Energy Science & Engineering*, 7(1), pp. 217–229. doi: 10.1002/ese3.271