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Biogas and EU's 2020 targets: Evidence from a regional case study in Italy

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ABSTRACT

The provision of renewable energy by agriculture—so-called agroenergy—is a key element of the Europe 2020 Strategy and has sparked public and research debates on the bio-based economy. Hot topics involve direct and indirect land use change and the ability of agroenergy to foster or hinder food and energy security. Worldwide research has dealt with these and other issues associated with the sustainability of the diffusion of agroenergy generation systems, but the subject is still open.

This paper contributes to the ongoing debate on the sustainability of agroenergy. We propose an empirical model to simulate the diffusion of farm biogas installations and estimate a set of indicators covering the economic, environmental, and social dimensions of sustainability at the regional level. Model results show that the current incentive mechanism does not allow to meet EU's energy targets at the local level. To do so, the policy mix needs an improved design accounting for regional peculiarities across the EU.

Model results show that agroenergy production can help farmers stabilise their income and keep viable rural areas, despite some trade-offs among socioeconomic and environmental indicators. Major drawbacks are environmental risks associated with farming intensification.

1. Introduction

The European energy strategy towards 2020 builds on a set of binding Union-wide targets aiming to reduce the European Union's (EU) dependence on imported fossil fuels and boosting new energy technologies (Renewables Directive 2009/28/EC). In the EU, the share of renewable energy among overall energy consumption should reach 20% by 2020; each member state is called to contribute with at least 5.5%: Italy, for example, is committed with 17%. The Renewables Directive recommends EU nations to increase the use of biogas as a fuel for energy plants and for transports to avoid uncontrolled greenhouse gas emissions. Biogas is generated through the bacterial processing (digestion) of biomass in oxygen-free containers (anaerobic digesters). In addition to the useful output (biogas), the digestion delivers a by-product (i.e., the digestate, a sludge with application as fertiliser). Biomass includes residues, by-products, and waste from forestry, fishery, aquaculture, crop and livestock farming, food processing, management of urban green, the timber processing industry, energy crops and the biodegradable fraction of municipal solid waste.

The agricultural sector may help the EU meet the energy target by providing agroenergy from biogas.

In Italy, the number of farm-based biogas installations has recently increased tremendously. Three interdependent global crises at the energy, environmental and agricultural level may have contributed to biogas success (Carrosio, 2013). Geopolitical trends, with rising political and social instability in fossil-fuel-producing countries and the emergence of state-owned energy champions, contributed to the global increase of traditional fuel prices until 2008 (Umbach, 2010). This upward trend of fuel prices, which raised production costs at the farm level, and adverse meteorological conditions linked to climate change had pushed up agricultural commodity prices globally (FAO-HLPE, 2013). In addition, farmers are more and more committed to climate change mitigation requirements (Nelson et al., 2009). Biogas is a viable solution to contribute to climate-change mitigation and to provide farmers with a new stream of income (Ausilion et al., 2009). Given their decentralised nature and the regional investment structure, biogas plants can also contribute significantly to rural development (Carrosio, 2013).

Two major interdependent determinants of on-farm biogas diffusion in Italy are the public support system and the prospect that production diversification may help income stabilisation by preventing farmers' reliance on the commodity market. Small on-farm biogas plants (up to 999 kWh rated power) have benefited from feed-in tariffs since 2009 (DM 18-12-2008): each unit of electricity plugged into the national grid was remunerated with €0.28/kWh for 20 years. Tariff eligibility involved two major constraints: (i) self-supply constraint (i.e., the farmer needed produce at least 51% biomass on farm) and (ii) out-sourcing constraint (i.e., purchased biomass had to come from

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within 70 km from the plant). The former constraint aims at ensuring that biogas depends on a farm's agricultural activities, while the latter is meant for limiting greenhouse emissions from transports, in compliance with EU's Renewables Directive.

Against this background, this paper aims to answer the following research questions: "To what extent can the diffusion of farm biogas help meet EU's 2020 energy targets at the regional scale?" and "What are the potential socioeconomic and environmental impacts of that diffusion on the region under study?" To answer these questions, we take the Italian province of Pisa as a case study. The province of Pisa is an administrative division of the region Tuscany, one of the 20 regions of Italy. The European Nomenclature of Territorial Units for Statistics (NUTS) classifies Italian regions as level-2 units (NUTS 2) and provinces as level-3 units (NUTS 3). The agricultural sector of Pisa is a heterogeneous set of small and medium farms, which jointly contribute to rural development, local diversity, and cultural heritage and have a prominent role in ensuring food nutrition security. Pisa is in the northern Mediterranean area, and agricultural systems are rather extensive and the agri-food industry is weak. Abandonment of rural areas and farm exit are current issues: in the last decade, utilised agricultural areas and farm numbers have decreased by 10% and 50%, respectively. In terms of 2020 energy targets, the province of Pisa is committed with 7056 MWh energy from biogas by 2020 (Provincia di Pisa, 2012). In Italy, on-farm biogas has followed regional patterns of diffusion, based on the prevailing farming systems. That heterogeneity makes estimating the impacts at the national level tricky; instead, scaling modelling approaches down to the regional level delivers more accurate estimates, although results would not be generalisable. The regional approach to sustainability assessment may allow greater planning efficiency in agriculture and related activities towards 2020 targets. Those assessments may help policy makers and environmental planners focus on key dependencies and processes with local relevance rather than scattering their efforts to face phenomena with unmanageable scopes (Vermeulen et al., 2012). Trainers in biogas technology should also know more about biogas impact at the regional level to adjust their courses to address local needs.

In the Mediterranean area, agriculture is facing environmental (e.g., global change), economic (e.g., market fluctuations, maintenance of agricultural income) and social (e.g., abandonment of rural areas, job and labour creation) challenges. The diffusion of local agroenergy chains may help sustain those rural areas.

The following section overviews the literature on the impacts of farm biogas on the economy, society and the environment. The next one provides the theoretical framework of this study. Then, we detail the steps we followed for delivering this analysis and discuss the results of the model we proposed. We conclude by summarising our findings and delivering policy recommendations. We also discuss the strengths and weaknesses of this study.

2. Sustainability issues associated with the diffusion of farm biogas

The sustainability of biogas is still debated within the scientific community (see Kirkels, 2012, for a review). Here, we propose a brief review of the academic literature that points out the hot topics concerning the sustainability of farm biogas. Far from depicting the complete picture, we aim at framing relevant opportunities and threats to the environment, economy and society associated with the adoption and diffusion of farm biogas-to-energy plants.

Biogas offers agricultural systems the opportunity to mitigate some of their externalities on the environment (Ausilion et al., 2009), particularly in terms of climate change potential, contamination of underground water, and fertiliser use intensity. For example, replacing natural gas with biogas for fuelling electricity plants saves around 90% greenhouse gas emissions (Bachmaier, 2010). In addition, using biogas for processing manure and slurry in animal farming abates climate-altering emission (Clemens et al., 2006), nitrogen leaching into underground water, which help farmers in the EU to comply with the Nitrates Directive (91/676/EEC), as well as pathogen and odour spreading (Yiridoe et al., 2009) from livestock waste compared with other treatment processes. Particularly, odour reduction may facilitate the coexistence of livestock farms with residential areas in the countryside (Massé et al., 2011), thereby contributing locally to economic and social stability, thanks to job creation Faaij and Domac (2006). In addition, the diffusion of biogas-to-energy plants in rural areas helps the distributed generation and allows host farms reach energy security (see Chicco and Mancarella, 2009; Sovacool and Mukherjee, 2011 for an overview), which is particularly important for remote communities (Faaij and Domac, 2006). However, the NIMBY (not in my back yard) syndrome has slowed down the diffusion of farm plants (Capodaglio et al., 2016), as has the high start-up costs and daily management costs (Massé et al., 2011), at least in the EU, including Italy. The allocation of Common Agricultural Policy (CAP) funds to farm plant building and member states' support of electricity production from renewable sources boosted the adoption rate (Wilkinson, 2011). The CAP is structured towards two pillars. Pillar I entails direct payments to farmers and is entirely covered by EU funds. Direct payments are a lump sum payment per hectare (ha) of utilised agricultural area (including energy crops), and farmers received around €174/ha of farmland (Frascarelli, 2014). Pillar II is the rural development policy and is cofounded by member states. Member states deliver their Rural Development Programmes (RDPs) at either the national or subnational level. RDPs follow EU regulation, but might differ in terms of funding priorities and activated measures. Italian RDPs are delivered at the regional level (NUTS 2). Both pillars could contribute to the diffusion of agroenergy production systems by ensuring liquidity, raising the incentive to invest in agriculture (Pillar 1), and by co-funding investment costs (Pillar 2). See, for example, Bartolini and Viaggi (2012), Bartolini et al. (2015), Bartoli et al. (2016) for a discussion of policy measures that may affect propensity to adopt renewables.

Capital-risk investors have driven the diffusion of farm biogas plants in Italy, following the release of the first feed-in tariff scheme (e.g., Cannemi et al., 2014). The recent literature, however, suggests that the profitability of biogas plants is so dependent on states' incentives (e.g., Capodaglio et al., 2016) that changing the tariff could hinder further investments (Chinese et al., 2014). In Italy, the incentive scheme has driven a process of structural isomorphism, with entrepreneurial agroenergy farms hosting plants with over 900 kWh rated power being the dominant model (Carrosio, 2013).

Concerning landscape, biogas installations have a visual impact. Such plants are not necessarily associated with livestock farming; in that case, odours increase, especially during digestate spreading. Basically, biogas adopters prefer the digestate to a purchased fertiliser for economic reasons. For example, in Demark, digestate spreading saves 100% phosphorus and up to 80% nitrogen fertilisers (Holm-Nielsen et al., 2009). Digestate spreading may also reduce farm reliance on chemicals, such as herbicides and phytopharmaceuticals (Sapp et al., 2015).

Biogas plants hardly rely on a single type of biomass, as co-digesting different animal- and plant-based substrates improves the processing conditions and allows year-long production. Although the use of by-products from the agri-food industry is rising, energy crops are widespread biomasses, particularly where arable farming systems prevail and where the food-processing industry is not well developed. Silage corn is the most widespread cultivated biomass, given the high yield of high-quality biogas (Walla and Schneeberger, 2008). Corn cropping for energy purpose is generally nutrient-intensive and rarely entails crop rotation, thus bringing environmental pressures such as reduced fertility, water retention potential of soils (May, 1975) and loss of biodiversity on farmland (e.g. Sauerbrei et al., 2014). However, double-cropping systems (e.g., the rotation corn-triticale) are more suitable for areas where yields are suboptimal; those rotations are less