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Assessing land efficiency of biomethane industry: A case study of Sicily

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ABSTRACT

Recent estimates show that the potential for biomethane production in Italy for 2030 is about 8 Bn Nm^3/year, initially by upgrading the biogas produced by anaerobic digestion.

We derive the 'Land Efficiency' of Biomethane in accordance with the Biogasdoneright® principles in Sicily (Italy), from the standard formula to determine the 'First Crop Land Requirement'. The results were achieved using large proportions of 'integration biomasses'. The concept of Land Efficiency is verified because the first constituent of the formula (land efficiency) is much higher than the second one (biomethane yield of monocrops).

The outcome of this study indicates clearly that 'integration biomasses' in the Sicilian context are among those which produce advanced biofuels. All by-products and wastes from the agrifood sector are necessary to produce about 562 million Nm^3/year of biomethane in Sicily for 2030 (about 8% of the Italian one), allocating only 28,000 ha for the monocrops for the anaerobic digesters.

1. Background information

Italian Biogas production is the third largest in the world after China and Germany with more than 1400 biogas plants at farm level producing over 2.5Bn Nm^3 [1]/year of Biomethane (BM) thus far equivalent to combined heat and power (CHP) systems and creating 12,000 direct, permanent and qualified jobs in the last five years (Bozzetto et al., 2017). In particular, from 2013 to 2016, Italian biogas sector has grown until to reach an installed capacity of about 1000 MWel, of which 85% in the northern regions and the remaining 15% distributed between the central and southern regions (GSE, 2017). Thanks to feed in tariff (a public subside), all the biogas produced in Italy has been used to produce electricity; recently new incentive policies are encouraging biomethane production from biogas through the so-called "upgrading process" (Carfora et al., 2018).

In Sicily, currently, there are only 4 operative biogas plants at farm level, but there are 3 additional authorized plants (not yet realized) for advanced Biomethane production (not from food crops). Actually, the biogas plants produce electricity for the grids, for a total of 2 MWel every hour.

As regards the production of biomethane, as showed in the next figure (Fig. 1), its production has increased and stabilized since 2013. Instead, the quantity of Natural Gas extracted from national wells was decreased, according to the recent political guidelines. In 2016, Biomethane produced was 44.5% of the national gas wells.

In the same figure, the processed data show a recovery in the trend of gas consumption, after a period of decline (from 2008 to 2014).

In this context, Italian biogas has developed so-called 'Biogasdoneright®' platform technologies (Dale et al., 2016) which have completely restructured farming activities around anaerobic digestion plants and strengthened the ability of farms to produce food and feed as well as renewable energy (Manetto et al., 2016).

These results have been achieved by using large proportions of so-called 'integration biomasses' which are the waste and by-products often considered environmental problems (livestock effluents, agricultural by-products, food processing waste), and crops harvested from agricultural land held bare during the year (double cropping) or annually (set aside 'maggese[2]').

The use of integration biomasses will make it possible to reduce the use of energy crops and, therefore, ensure the supply for food, feed and energy chain.

At the European level, these 'integration biomasses' whether obtained from food, feed crops or other, are the biomasses that should be used in the production of advanced biofuels, since they do not cause

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[1] Nm^3: *Normal cubic metres* is the unit of measure used for the gas in 'normal conditions', i.e. in relation to atmospheric pressure and at a temperature of 0 °C.

[2] *Maggese* is the Italian word to indicate the lands with natural grass cover included in the rotation with principal crops (i.e. durum wheat), a common practice to reduce soil organic matter losses in Mediterranean climates.

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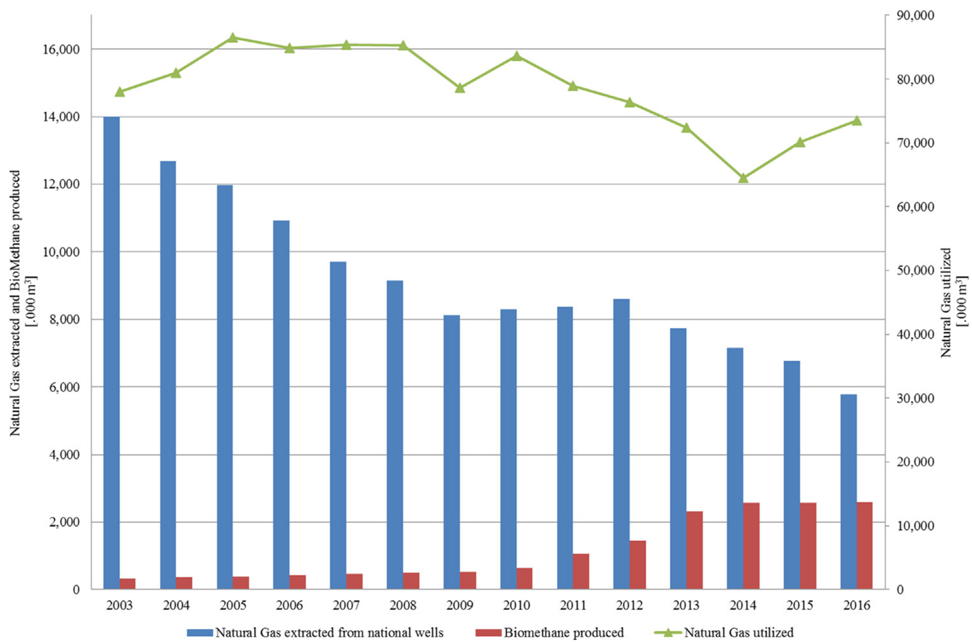

Fig. 1. Trend of biomethane produced and natural gas extracted and utilized. (Source: C.R.P.A. elaboration on TERNA data, 2018)

any indirect land use change impacts (ILUC), but allow farms to improve their sustainability performance regarding greenhouse gas (GHG) emissions and biodiversity compared to conventional farming, and ultimately they strengthen the economic competitiveness of the farms (Gibbins and Chalmers, 2008; ECOFYS, 2016; IPCC, 2014).

The agronomic practices of Biogasdoneright® require substantial modification of current farming practices:

- It requires a greater recycling of livestock effluents and by-products;
- It increase the cultivation of energy crops for the production of silage, even when there is no local requirement from livestock industry by maintaining all year ground cover and thereby greatly reducing farmland GHG emissions and improving photosynthesis;
- It increases the number of crop rotations thereby increasing biodiversity;
- It improves soil fertility by increasing soil biomass (roots, plant parts) and restoring organic fertilization via biogas digestate or biofertilizer;
- It reduces the cost of chemical fertilizers, the cost input for production and diversifies output markets.

In a nutshell, the application of the Biogasdoneright® concept improve farm sustainability from an environmental and economic point of view, but also reduce the cultivation of lands for energy use. Moreover, this approach of production increase the economic profitability of biomass produced by farms and agro-industrial systems (Valli et al., 2017; Valenti et al., 2017c; Chinnici et al., 2018).

From these simple concepts, five years ago the Italian Biogas sector developed a roadmap targeting 8Bn Nm^3/year of BM by steadily increasing their use (Bozzetto et al., 2017). Sicily is one of the Italian regions falling short of the target, but due to its strong agriculture sector and its geography (Mediterranean climate, desertification of the farmland, agro food productions, etc.) it holds about 8% of the national potential for 2030 corresponding to about 562 M Nm^3/year which includes about 40 M Nm^3/year of biomethane from Municipal Organic Waste (MOW).

This target can be achieved with:

- 20% of BM obtained from monocrops cultivated in areas that are becoming economically marginalized in today's market conditions;
- 80% via so-called integration biomass like livestock effluents, agro-waste and ground-cover crops which without the additional demand created by anaerobic digestion plants would not be produced.

This study, from our perspective, clearly concludes that ‘integration biomass’ is to all intents and purposes among those allowed for the production of advanced biofuels as clarified in Annex IX of the new Renewable Energy Directive, RED 2015/1513. Specifically, for the Mediterranean area and Sicily, the ground-cover crops highlighted in our Plan (i.e. Italian sainfoin, *Sorghum spp*, cereals and pulse mixtures) can be classified as advanced biofuel biomass[3], when inserted in a rotation before or after a cash crop for the market or stable (i.e. durum wheat) (Selvaggi et al., 2018).

With clear legislation on the biomass suitable for advanced biofuels, Italy with more than 1 billion Nm^3/year as compressed natural gas (CNG) or liquid natural gas (LNG) fuel (8 billion Nm^3/year forecasts for 2030) and more than 1200 outlets already has a consolidated market for utilising biomethane as road transportation fuel. It must be noted that in this case BM can not only reduce exhaust emissions compared to petrol and diesel, but according to Biogasdoneright® principles its production will also lead to a stark reduction in agricultural and agroindustrial GHG emissions, will improve biodiversity and farm economies thereby contributing to securing food safety for the EU (Rana et al., 2016).

Last but not least, fostering advanced biomass biofuels and avoiding mono-cultures will trigger investments for €1.2–1.5Bn and create 3000–3500 directly qualified jobs in Sicily until 2030 (Althesys, 2015). Such a development plan, along with other potential species for biomass utilization (e.g. Giant Reed), can contribute to reversing the tide and make Sicilian agriculture the root of economic development in rural areas with new markets for farms (Chinnici et al., 2015b; Sgroi

[3] In Annex IX 'non-food cellulosic material' means feedstocks mainly composed of cellulose and hemicellulose, and having a lower lignin-content than ligno-cellulosic material; it includes food and feed crop residues (such as straw, stover, husks and shells), grassy energy crops with a low starch content (such as *ryegrass*, switchgrass, *miscanthus*, *giant cane* and ***cover crops before and after main crops***), industrial residues (including from food and feed crops after vegetal oils, sugars, starches and protein have been extracted), and material from biowaste.