Cumulative Energy and Exergy Demand of Agricultural Anaerobic Plants

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**Abstract.** Renewable energy production was rapidly increased in the last decades thanks to favorable public subsidies frameworks, and it is expected to continue to grow due to high price of fossil fuels as well as political instability. In this context, in Italy, renewable electricity production from agricultural anaerobic plants (AAP) plays a role. Despite a contribution from 1.5% to 2% of the total electric consumption, this renewable electricity sources involve also environmental benefits and has a positive economic impact on the agricultural sectors.

Over the years, several studies focused on the environmental performances of AAP. Most of these studies, carried out with the Life Cycle Assessment approach, highlighted how electric energy from AAP presents a lower impact on climate change respect to the same energy produced from fossil fuel. Moreover, when the plants are fed mainly with animal slurry and agricultural by-products the environmental results are interesting also for other environmental impact such as particulate matter formation, acidification, and eutrophication.

However, despite a huge interest on the environmental performances of AAP, little attention was paid on their energetic results. This study, using two indicators such as the Cumulative Energy Demand (CED) and the Cumulative Exergy Demand (CExD), deals with the energy performance of 10 AAP located in Northern Italy. CExD depicts total exergy removal from nature to provide a product, summing up the exergy of all resources required. CExD assesses the quality of energy demand and includes the exergy of energy carriers as well as of non-energetic materials. In CExD exergy is used as a measure of the potential loss of “useful” energy resources. Due to the consideration of the quality of the energy and the integration of non-energetic resources CExD is a more comprehensive indicator than CED.

The 10 AAP are in Lombardy and Piedmont, they are dedicated to the production of electricity while the surplus heat is not valorised. The electrical power of the Combine Heat and Power unit fed with the biogas ranges from 100 to 999 kW while, regarding the feedstock utilisation, 7 plants are fed with a mix of cereal silages and animal slurries, 2 only with cereal silage while the last one uses only animal slurries.

Both for CED and CExD, the AAP fed with waste shows best performance than the one fed with cereal silage. Despite this, for some impact categories of CExD and, in particular for, “non renewable, metals” and “non renewable, minerals” the small plants fed mainly with slurry show the worst performances (due to the higher specific volume of digesters per unit of power installed).