Environmental assessment of electricity produced in biogas plants using alternative feedstocks

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1. INTRODUCTION

Anaerobic Digestion (AD) has been recognized as an effective process to produce **renewable energy** while contributing to **reduce the greenhouse gases (GHG) emissions**.

AD can use different feeding mix, chosen primarily in function of maximization of profit according to technical and economical feasibility of process.

The rapid **expansion of biogas production in Europe** is largely due to the **feed-in-tariffs (FiT) schemes**, in which **cereal silages** are the **most used feedstock.**

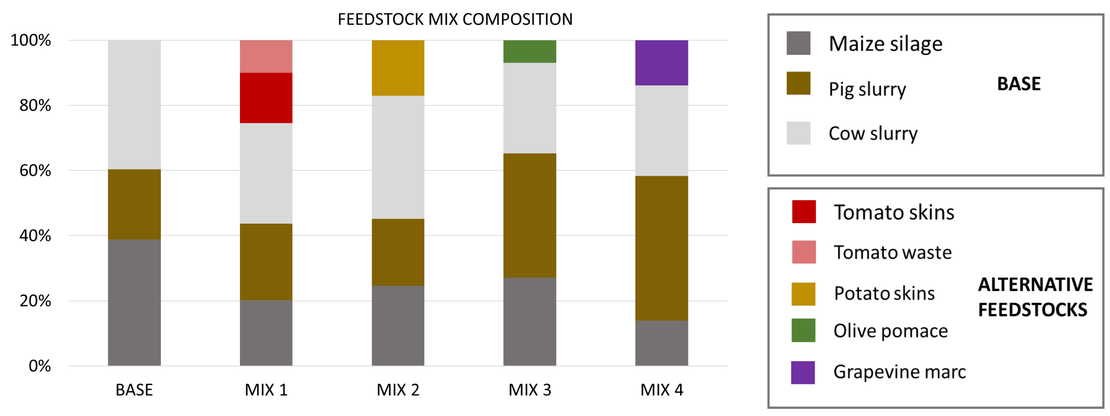
Incentives have been largely reduced for the case where more than **30% (mass) of energy crops**. The **higher subsidies** are granted for plants with an electrical power < 300 kW fed mainly with **by-products and waste.**

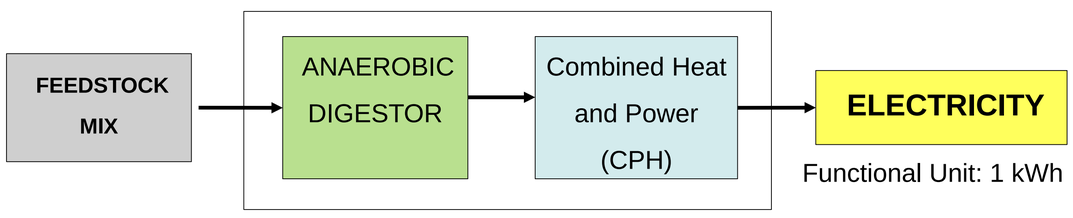
Alternative feedstocks such as **crop residues**, **livestock manure [1]** and **agro-industrial wastes**, may be environmentally favorable.

The present study aims at **comparing different mix of feedstocks** to **unveil environmental burdens and benefits** associated to their anaerobic digestion.

2. METHODOLOGY

Life Cycle Assessment has been applied to compare the **environmental profiles of electricity production** through **anaerobic digestion**, using **alternative mix of feedstocks**. The scenarios are built taking **Italy as case study**. Results are shown using the **ILCD life cycle impact assessment method**.



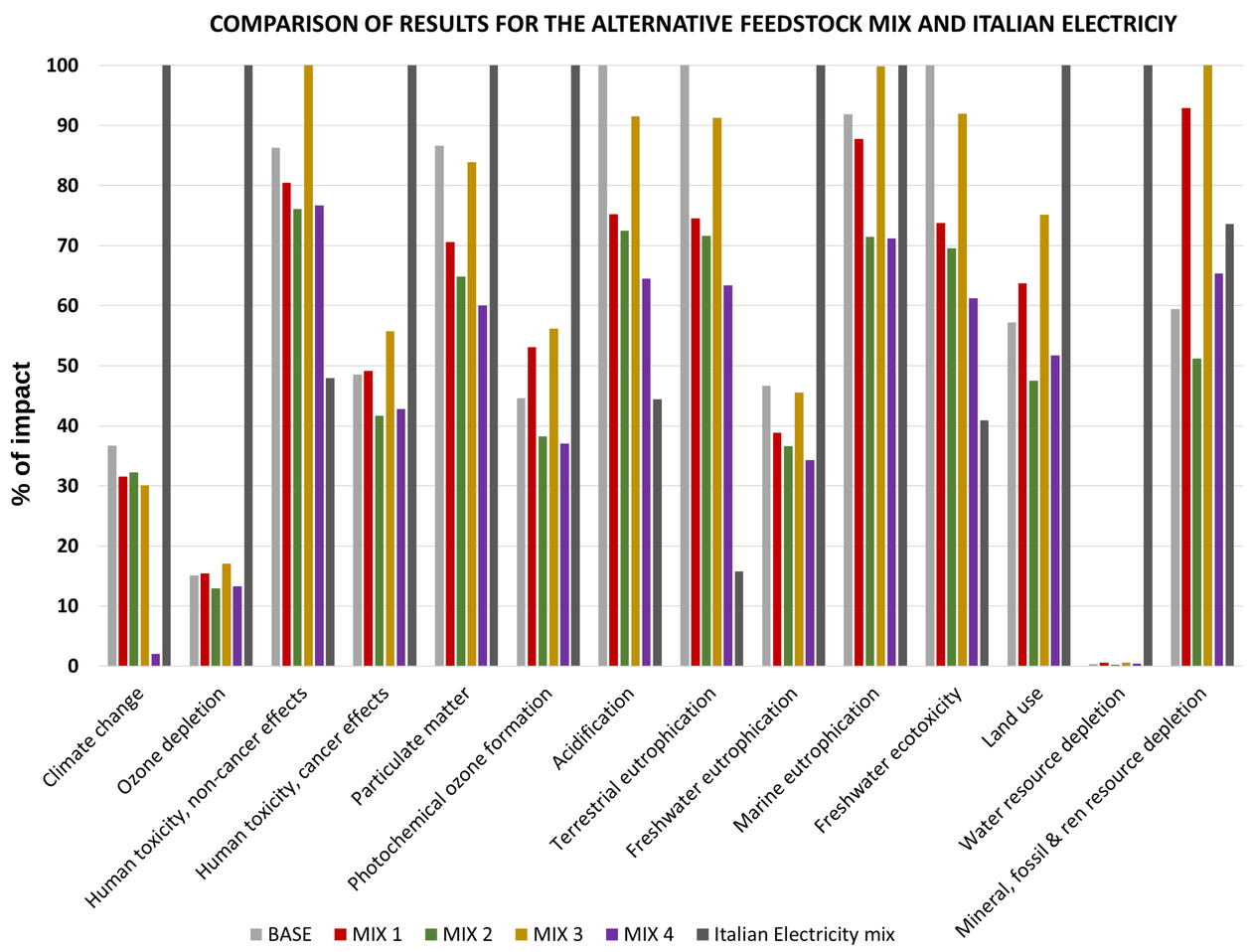


Functional Unit: 1 kWh

Assumptions highlights

- Transportation of the feedstock from the production location to the AD plant located in Casalvolone was included.
- Animal slurry and wastes from the agro-food industry were considered as zero burden.
- 2% fugitive methane losses from digester and from CHP engine were considered [2].
- Emissions of methane and ammonia from digestate storage in open tanks were assessed in accordance with the values reported by Edelmann et al. [3].
- Emissions from the avoided conventional management of animal slurry (methane, ammonia and nitrous oxide) as well as the emission from digestate were calculated with the factors provided by Amon et al. [4] for cattle slurry and Wang et al. [5] for pig slurry

3. RESULTS



4. DISCUSSION AND CONCLUSIONS

- The **type of feedstock mix** used in the anaerobic digester **influences the environmental profile of the electricity** produced.
- The **feeding MIX 4 is environmentally beneficial** as it reduces the environmental impacts in several impact categories, specially Climate Change. This **reduction is due to the credits related of the digestion of animal slurry**. In fact, in this scenario, an increased amount of slurry (above all pig slurry) is digested to keep the dry matter content inside the digesters below 9%.
- Also **MIX 1 (contain about 25% of tomato wastes) presents advantages comparatively to the base scenario for all the impact categories**. Nevertheless, the **methane production is lower than with MIX 4**.
- The feeding **MIX 3**, containing olive pomace, **performs worse or very similar than the base scenario** in several impact categories because the **transport distance is considerable**, being the olive mainly produced in central-south Italy and the AD plant is located in the north.
- The **replacement of maize silage by the tested agro-industrial wastes** is advantageous to **reduce GHG emissions of electricity**.
- **Comparatively to the Italian electricity mix, all the feedstock mix** analyzed present **better performance for 9 impacts categories**, including **Climate Change**, but **worse for Human Toxicity non-cancer, Acidification, Terrestrial Eutrophication and Freshwater Toxicity**.
- Beside the feedstock mix, **other factors** could be considered, such as **particular fugitive (or accidental) methane emissions and plant design (open or closed digestate, flare or venting etc.)** as it is known that they **influence the environmental performance**, specifically GHG emissions [6].
- Other aspects to be considered are the investigation of possible **indirect effects of using waste feedstocks** for AD as they can be used for other purposes, and a **sensitivity analysis** on the **credits** considered for **animal slurry** using the **values reported in the RED II.**

References

[1] Agostini et al. (2015) Environmentally sustainable biogas? The key role of manure co-digestion with energy crops. Energies 2015, 8(6), 5234-5265; [2] Dressler et al. (2012). Life cycle assessment of the supply and use of bioenergy: impact of regional factors on biogas production. The International Journal of Life Cycle Assessment, 17(9), 1104–1115. doi:10.1007/s11367-012-0424-9; [3] Edelmann et al.. (2011) Ökobilanz der Stromgewinnung aus landwirtschaftlichem Biogas; [4] Amon et al. (2006). Methane, nitrous oxide and ammonia emissions during storage and after application of dairy cattle slurry and influence of slurry treatment. Agric. Ecosyst. Environ. 112 (2–3), 153-162. doi:10.1016/j.agee.2005.08.030. [5] Wang e al. (2014). Comparison of air emissions from raw liquid pig manure and biogas digester effluent storages. Transactions of the ASABE. 57(2), 635-645. doi:10.13031/trans.57.1029; [6] Giuntoli J, Agostini A, Edwards R, Marelli L, Solid and gaseous bioenergy pathways: input values and GHG emissions. Calculated according to the methodology set in COM(2016) 767, EUR 27215 EN, doi:10.2790/27486

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