ENVIRONMENTAL ASSESSMENT FRAMEWORK FOR BIO-BASED METHANE PRODUCTION VIA ANAEROBIC DIGESTION, GASIFICATION, AND GAS UPGRADING

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In the endeavor of supporting the transition towards a low fossil carbon energy sector, it is necessary to exploit the potentials of waste and bioresources available within a country or region. It is important to combine the best ways of energy conversion based on physico-chemical properties of waste and bioresources, and technology conversion pathways, in vision of the energy supply-demand and environmental targets. While replacement of natural gas with bio-based methane from waste and bioresources is a promising solution, several challenges may exist: i) the local availability of waste and bioresources, ii) their physico-chemical heterogeneity, which may affect the technological performance of bio-based methane production, iii) the consequences of diverting waste and bioresources from their current uses, iv) the fulfillment of regional gas demands, and v) the need for systemic environmental benefits associated with the changes.

With this study, we provide an environmental assessment framework supporting decisions at regional and national scales associated with production of methane from waste and bioresources for use in local gas grid infrastructures. While the assessment framework may be applicable for a variety of gas supply-demand situations, we implemented it on a French region, Occitania (72,700 km^2, 5.8 M inhabitants), with concrete ambitions of local energy transitions and climate savings. The three selected technology conversion pathways were: i) anaerobic digestion with hydrogen upgrading, ii) anaerobic digestion with water scrubbing upgrading, and iii) gasification with C-to-CH_4 upgrading. The environmental performance was evaluated through a process-oriented life cycle assessment (LCA) with results interpretations at two levels: technology level (tier 1), and system level (tier 2). In tier 1 results, the three conversion pathways were evaluated individually relative to the production of 1 Nm^3 of bio-based methane with given characteristics of injection and network distribution. Here, we quantified and identified the environmental benefits, the process hotspots, and the technology-by-technology comparison. While, in tier 2 results, we evaluated combinations of waste and bioresources with technology conversion pathways reflecting the supply of methane demand and overall climate change impacts.

The results showed that Occitania has the potential for fulfilling and exceeding the annual gas demand of 17.5 TWh, seeing export of bio-based methane as a further possible strategy in vision of promoting local bioeconomy. In addition, for manure, green waste, and sludge, the production of bio-based methane in anaerobic digestion resulted in more climate benefits than their current uses. Gasification was found as a promising technology for bio-based methane production, generating about five times more methane than anaerobic digestion for some bioresources.