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Moving CO_2 from a liability to an asset: Integrating Electricity and Natural Gas in a sustainable micro-grid

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In a smart system, able to integrate the production, distribution and use of different energy sources and related generation and storage systems, becomes crucial the role of a process able to transform a fluctuating form of energy - i.e. the electricity generated from renewable sources - in an energy carrier that could be continuously integrated in an infrastructured storage and distribution system (e.g. natural gas) [1]. Nowadays the concept of *Smart Grid* is mainly related to electrical grids where a variety of operational and energy measures contributes to integrate smart appliances, renewable energy resources, and energy efficient resources in a smart environment [2]. Recently, a number of innovative technologies (Power to Liquid, PtG) for the production of sustainable synthetic fuels have emerged and currently are at different stages of industrial maturity [3]. On the other hand, the possibility to use avoided CO_2 derived from waste and/or residuals of local economic chain, coupled with H_2 obtained from high efficient electrolysis process of intermittent RES-E to synthetize BioSNG through a biological methanation process will allow to create an *integrated* smart energy system. The possibility to use carbon sources derived from waste and/or residuals, further increases the flexibility and sustainability of this kind of technologies: once unwanted - and sometimes costly – residuals and waste of the local economy are identified as matching carbon sources, they can be associated with local RES-E production in order to shorten the production chain, increase the lifetime and value of raw materials and localize the energetic production and consumption under a circular economy approach. This flexibility in coupling with local economical chain – and related residuals/waste - and local energy demand, such as liquid or gaseous fuels, allows designing a pinpointed process able to satisfy localized requirements of energy supply.

Through biological methanation the production of methane directly from CO_2 and H_2 is possible in a sustainable and efficient way by methanogenic microorganisms (i.e. archaea), which obtain the energy for growth by anaerobically metabolising H_2 and CO_2 [4]. The aim of this paper is to report the activities of he Complex Project denominated *Smart Networks for Efficient Energy Management* running at the Renewable Energy Platform (*Piattaforma Energie rinnovabili - PER*) driven by Sardinian Regional agency for R&D and innovation, *Sardegna Ricerche* in collaboration with *Cagliari University* and *CRS4*. In particular the focus is on those research activities of the Project dealing with the biological methanation process of locally intermittent RES-E and biogas coming from local anaerobic digester (AD) and the integration of the produced bio-methane in the local micro-grid in a Power and Waste to bio Methane (PWtM) sustainable cycle.

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