Summary

In the framework of the energy transition towards a decarbonized energy system, the role of natural gas sector is controversial but appears to be crucial for the successful achievement of the future environmental goals, in terms of sustainability, affordability and security.

The renewable gases inclusion within the gas infrastructure appears to be a promising option. Renewable gases are a range of low net-carbon-emissions fuel gases such as biomethane and hydrogen. The most influent institutions in the framework of future energy scenarios studies have lately considered them as a viable option for the decarbonisation of energy intensive sectors and as a way to add flexibility and diversification to the energy system.

However, the impact of their injection within the current gas infrastructure needs to be evaluated by means of suitable simulation tools. This work is devoted to the development of a versatile gas network model and its application on a number of sample cases regarding biomethane and hydrogen grid injection.

A fluid-dynamic transient and multi-component modelling tool of the gas network has been developed for the purpose. It may be easily applied either to high-pressure transmission networks or local distribution ones thanks to the choice of a wide-range equation of state for natural gas mixtures (GERG-2008). Not only the model is sensitive to the gas chemical composition, but it can also perform quality tracking.

A number of case studies addressing the injection of biomethane and hydrogen within the current infrastructure have been performed focusing in particular on the local distribution gas networks. The aim was both to show the capabilities of the model and to address some common issues of distributed injection practices.

As for the biomethane injection case, a local medium-pressure distribution infrastructure has been considered for the evaluation of the impacts and the criticalities of the practice. The strong mismatch between biomethane production and times of low gas consumption may induce to the curtailment of the injections. Innovative strategies of network management such as modulating pressure and linepack storage have been simulated to enhance the biomethane receiving potential, taking advantage of the transient feature of the newly developed model.

As for hydrogen, the impacts on the gas quality perturbation and its distribution throughout the network has been evaluated thanks to the multi-gas and quality tracking features of the model. Furthermore, multiple injections of hydrogen have been tested. Critical operating conditions have been obtained and time-dependent hydrogen acceptability maps have been produced on the basis of gas network operational constraints, so to provide hydrogen acceptability profiles to be matched with possible future productions.

At last, a sample case study of power and gas sector coupling by means of power-to-hydrogen and grid injection pathway has also been addressed, with the aim to evaluate whether and how much the gas network is available to receive power from the electricity infrastructure surplus on-demand, in order to relax its critical operations. The results shows that the seasonal variations of natural gas consumptions and seasonal production form renewable such as solar may anyway limit the potentialities of the sector coupling. However, hydrogen acceptability limits have also an important role in determining the viability of similar integration strategies.

As a general result, the work aims at underline both potentialities and criticalities which the gas sector (with special focus on the local, distribution level) will have to address in the near future by offering suitable tools and innovative methodologies to analyse future scenarios based on a multi-gas system.

Marco Cavana
Turin, April 30th, 2020