The holistic view of the energy systems promotes the increase of prosumer flexibility by coupling electricity and gas infrastructures

Promoting the new energy system era through a holistic vision

Andrea Ademollo[1(1)], Albana Ilo[(2)], Carlo Carcasci[(1)]

[(1)]Università degli studi di Firenze, [(2)]TU Wien

Motivation and central question

Overall climate commitments require the integration of energy systems belonging to various economic sectors in order to decarbonise them. Cities offer great potential to couple electricity and gas vectors using the available infrastructure, thus protecting the environment.

This paper focuses on the issues related to an extended rooftop PV installations on each Customer Plant (CP) evaluating the exploitation of the electricity surplus through an holistic view in two different ways: injection back into the electricity grid or production of green methane and injection into the Natural Gas (NG) grid. The goal is evaluating if voltage or pressure limits violations occur in the respective grids.

Methodological approach

The analysed area is composed by twenty identical residential CPs in Turin, during a sunny August day, equipped with a PV plant connected to the Low Pressure (LP) gas grid and to the Low Voltage (LV) electricity one.

Once electricity surplus from each CP is found, the distributed electricity injection into the LV electricity grid is simulated analysing if voltage behaviour respects voltage limits ($\pm 7\%$ of nominal value).

Alternatively, it is used in an AEM electrolyser [1-2] to produce hydrogen which is exploited in a methanation reactor [3] to produce Synthetic Natural Gas (SNG) (green methane), whose surplus is injected into the LP gas grid analysing if pressure and velocity behaviours inside the pipeline respect the corresponding limits. Another possibility offered by the gas grid is the exploitation of the linepack effect, i.e., the pipeline storage capacity. It allows covering a part of the thermal load even in the evening without incurring additional costs to buy a storage tank for each CP.

For the entire simulation process, a programme has been written in free software Python, whose output values have been used in private software Sincal to find, through steady-state simulations, voltage and pressure/velocity profiles. The linepack effect has been entirely modelled in Python.

Results and conclusions

Results show that injecting electricity surplus back into the LV grid in unfavourable scenarios leads to violations of the higher voltage limit (Fig. 1).

Instead, injecting methane into the LP gas grid doesn't create neither pressure nor velocity problems for a LP pipeline diameter of 300mm proving that NG grid's technical limitations are much lower. The disadvantage is that compressors must be installed at pressure reduction groups to make them bidirectional.

[1] Via dell'Argin Grosso n.69, Firenze, +39 334 5891455, andrea.ademollo@unifi.it

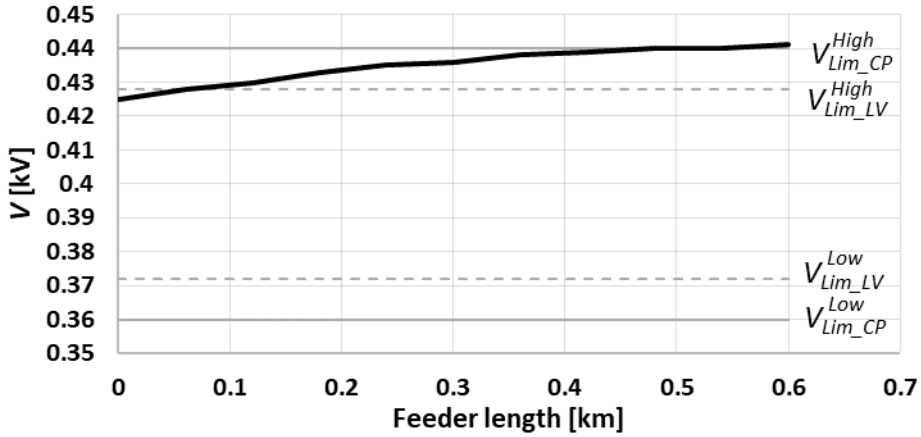

Figure 1: Voltage profile along the LV feeder at 11 p.m., V=106%

The gas prosumer may use another great advantage offered by the gas network, in addition to the absence of pressure problems, which is the possibility of exploiting the linepack effect. At the onset of the electricity surplus, SNG is produced and injected into the low-pressure NG grid by increasing the pressure from the nominal to the maximum allowable value. This process let covering even a part of the night gas load (Fig.2).

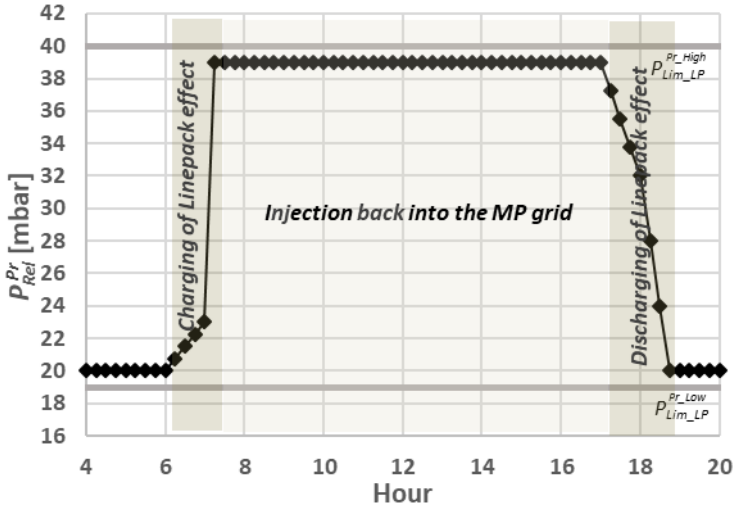

Figure 2: Linepack exploitation in distribution level: daily pressure profile

With this solution, when there is contemporaneity between production and consumption, both electricity and gas loads can be covered, and, thanks to the linepack effect, even a further part of the gas load can be covered. Finally, the distributed gas injections from the LP level, can create the possibility, in summer, to become more independent from foreign countries.

Literature

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