TIMELY RESOLVED NATURAL GAS GRID SIMULATION CONSIDERING HYDROGEN FEED-IN FROM VOLATILE RENEWABLE ENERGY SOURCES

Matthias GREIML[1], Nicolas WOLF WILLIAMS[1], Thomas KIENBERGER[1]

Content

The Austrian government aims to achieve 5 TWh of green gases (hydrogen, biomethane, synthetic gas from renewable electricity) by 2030 [1] . The amount of hydrogen being fed into the natural gas grid must comply with ÖVGW guideline *G B210*, which currently allows for a ten percent hydrogen admixture [2]. Feeding hydrogen from volatile renewable energy sources into the natural gas grid might cause timely fluctuations of the gross caloric value (GCV).

As part of the cooperation with the Large Engines Competence Center (*LEC GmbH*) in Graz, the *Chair of Energy Network Technology* at the University of Leoben aims to determine in cooperation with *E-Netze Steiermark* to what extend volatile green hydrogen injection can cause GCV fluctuations in natural gas grids. A new methodology has to be developed to simulate timely resolved GCV fluctuations. By means of the investigation of various different scenarios, we investigate the impact of an H_2-content of up to 50 % on the natural gas grid operation.

The aim of this paper is to show the developed simulation methodology as well as simulation results, based on the usecase of Styria.

Methodology

Currently, there is no methodology available to track hydrogen feed-in into natural gas pipelines and assess timely and spatially resolved GCV fluctuations. Static steady-state load-flow calculation tools are available, but no dependencies between different timesteps are considered. Rüdiger's [3] approach adopts the node potential analysis for power grids in combination with Darcy's equation (refer to equation 1) to determine gas load-flows [3]. The gas grid is depicted as a node-edge model. An iterative process, using Newton-Raphson solver determines load-flows and pressure levels in the natural gas grid. This approach is extended by a batch-tracking concept, allowing the consideration of spatially and timely resolved distribution of gases fed into the natural gas grid.

$$\Delta \mathrm{p} = \lambda * \frac{8 * \rho * \mathrm{l} * \dot{\mathrm{V}}^2}{\mathrm{d}^5 * \pi^2} \tag{1}$$

The introduced steady-state batch tracking method uses results from Rüdigers' algorithm to determine the distance travelled by sections of gas, being fed into the natural gas grid. The GCV at consumer nodes can be determined based on batches passing by the node within one timestep.

In Figure 1, the high-level natural gas grid of Styria is depicted in a simplified way. Natural gas can be fed into the grid from north (node 2), east (node 15), and south (node 11). Hydrogen can be generated by either photovoltaic in the south near node 11 or by wind in close proximity of node 14. E-Netze Steiermark provided properties of the natural gas grid as well as time-resolved consumer profiles. The hydrogen generation is based on real photovoltaic and wind generation data.

Results

An excerpt of the time and spatially resolved GCV fluctuations can be seen in Figure 2. The displayed results are from January, therefore, photovoltaic generation is rather low (see high GCV at node 11 and 12). In contrast, the wind farm shows strong fluctuation in its generation, resulting in GCV fluctuations at node 14 and surrounding. It can be seen that the GCV fluctuations of node 6 and 8 follow the fluctuations of node 14 within a few timesteps. In comparison node 5 is further away from node 14

[1] University of Leoben, Chair of Energy Network Technology, Franz-Josef-Straße 18, 8700 Leoben, +43 3842 402 5401, evt@unileoben.ac.at, evt.unileoben.ac.at

compared to node 6 and 8. Therefore, it takes several timesteps longer until the hydrogen - natural gas mixture reaches this node and cause GCV fluctuations. Despite a shorter distance to cover, but due to low flow velocity in the pipeline, the GCV of node 13 and 7 fluctuates with a delay of a couple of hours compared to node 14. Due to the gas flows in the grid, certain consumer nodes such as 2,3 and 9 are not affected by GCV fluctuation, since no hydrogen flows to these specific nodes.

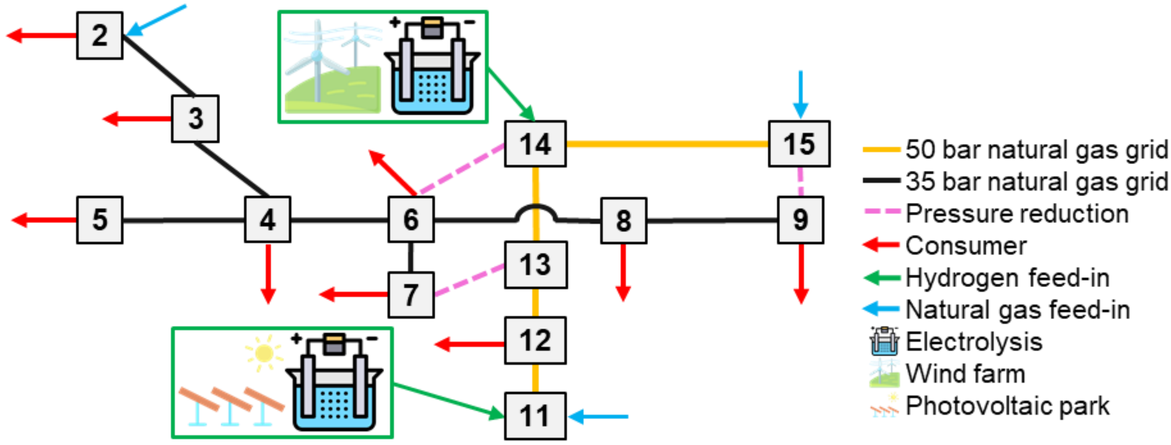

Figure 1: Depiction of considered grid section for simulation

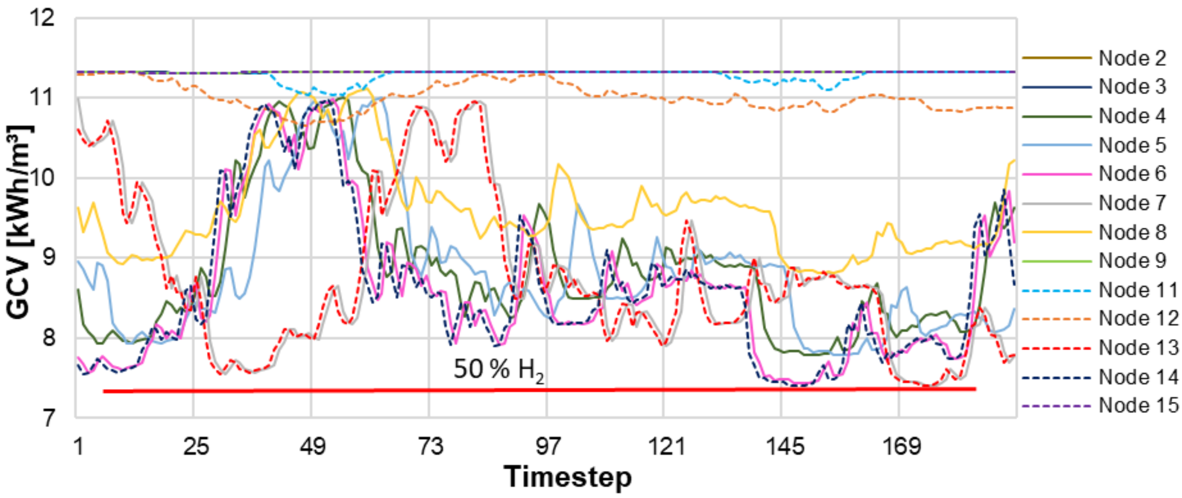

Figure 2: Example of spatial and time resolved GCV

References

[1] Bundeskanzleramt, Ed., “Aus Verantwortung für Österreich: Regierungsprogramm 2020 - 2024,” Bundeskanzleramt, Wien, 2020. Accessed: Nov. 11 2021. [Online]. Available: https://www.bundeskanzleramt.gv.at/dam/jcr:7b9e6755-2115-440c-b2ec-cbf64a931aa8/RegProgramm-lang.pdf

[2] ÖVGW, Mehr Grünes Gas im Gasnetz. [Online]. Available: https://www.ovgw.at/aktuell/

[3] J. Rüdiger, “Enhancements of the numerical simulation algorithm for natural gas networks based on node potential analysis,” IFAC-PapersOnLine, vol. 53, no. 2, pp. 13119–13124, 2020, doi: 10.1016/j.ifacol.2020.12.2282.