

# Timely resolved natural gas grid simulation, considering hydrogen feed-in from volatile renewable energy sources

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- Extended Gas LFC
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# Project Overview

## **Project Target**

The presented research is part of the COMET Center LEC EvoLET. The aim of this project is to investigate the effects of fluctuating H<sub>2</sub> concentration in natural gas grids on the operation of gas engines.

## **Contribution Chair of Energy Network Technology and Energienetze Steiermark**

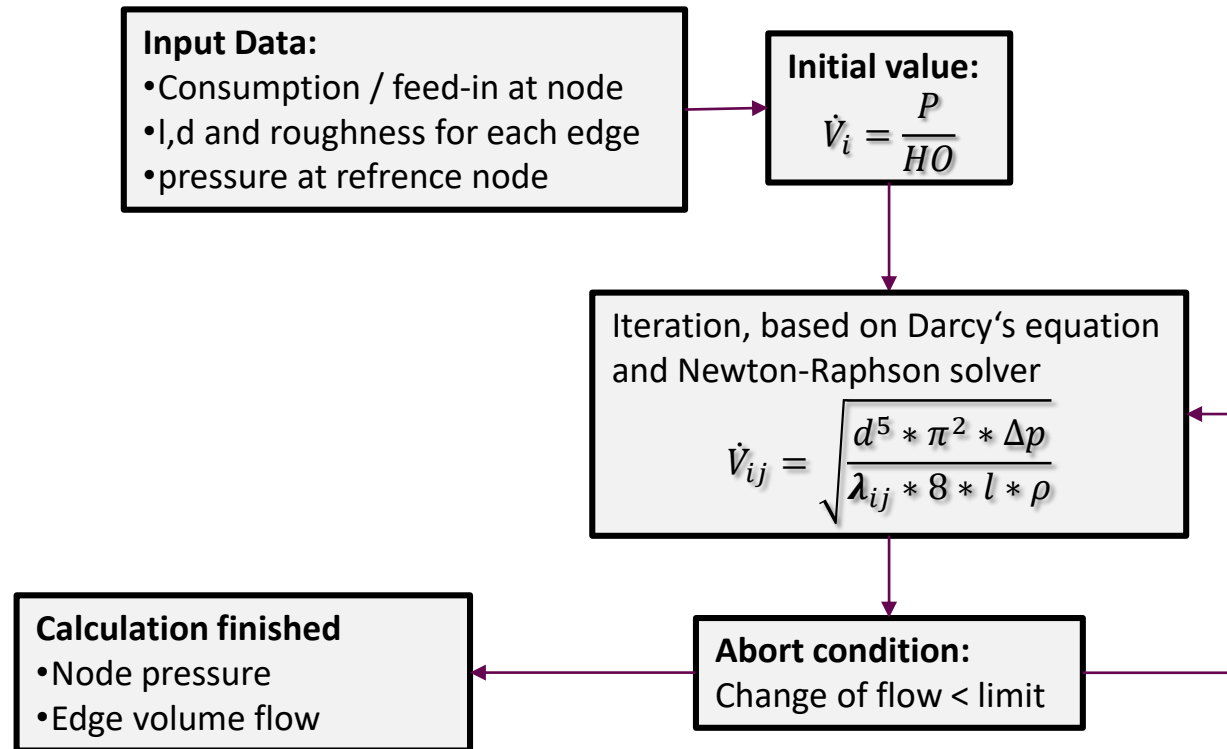
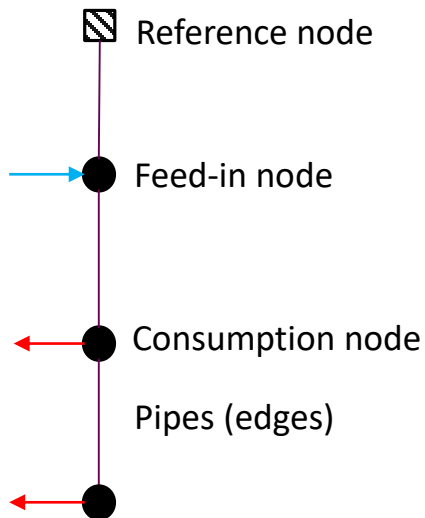
Simulation of hydrogen propagation injected into natural gas grid:

- Development of suitable simulation methodology.
- Simulation of hydrogen propagation, based on current natural gas grid data.

# Current Natural Gas LFC

based on Rüdiger's approach [1]

## Grid depiction – Node-Edge-Model

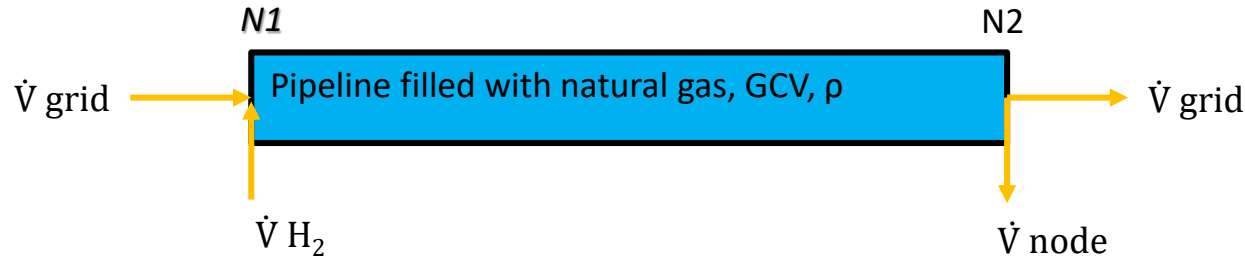


**What LFC can do:** determine static load flows

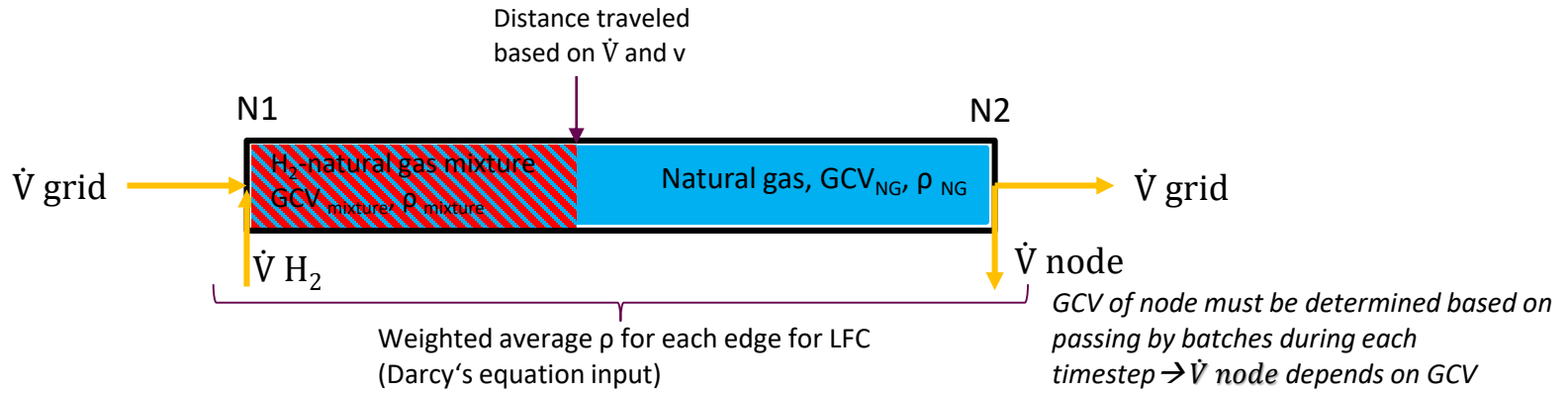
**What LFC can't do:** consider variable gas mixtures and taking previous timesteps for current calculation into account

# „Batch Tracking / Tracing“ Concept

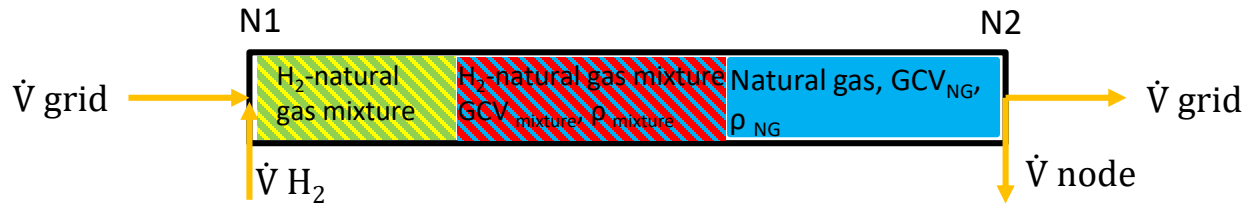
**t=0**



**t=1**



**t=2**



# Extended Gas LFC

## Existing Gas LFC concept

### Input Data:

- Consumption / feed-in at node
- $l, d$  and roughness for each edge
- pressure at reference node

### Initial value:

$$\dot{V}_i = \frac{P}{GCV}$$

Iteration, based on Darcy's equation and Newton-Raphson solver

$$\dot{V}_{ij} = \sqrt{\frac{d^5 * \pi^2 * \Delta p}{\lambda_{ij} * 8 * l * \rho}}$$

**Abort condition:**  
Change of flow < limit

Yes

### Calculation finished

- Node pressure
- Edge volume flow

## Addition to existing gas LFC

Time dependent  $\rightarrow$  initial GCV guess necessary (e.g. previous timestep)

### If above limit

Initial GCV guess insufficient, recalculation with updated GCV

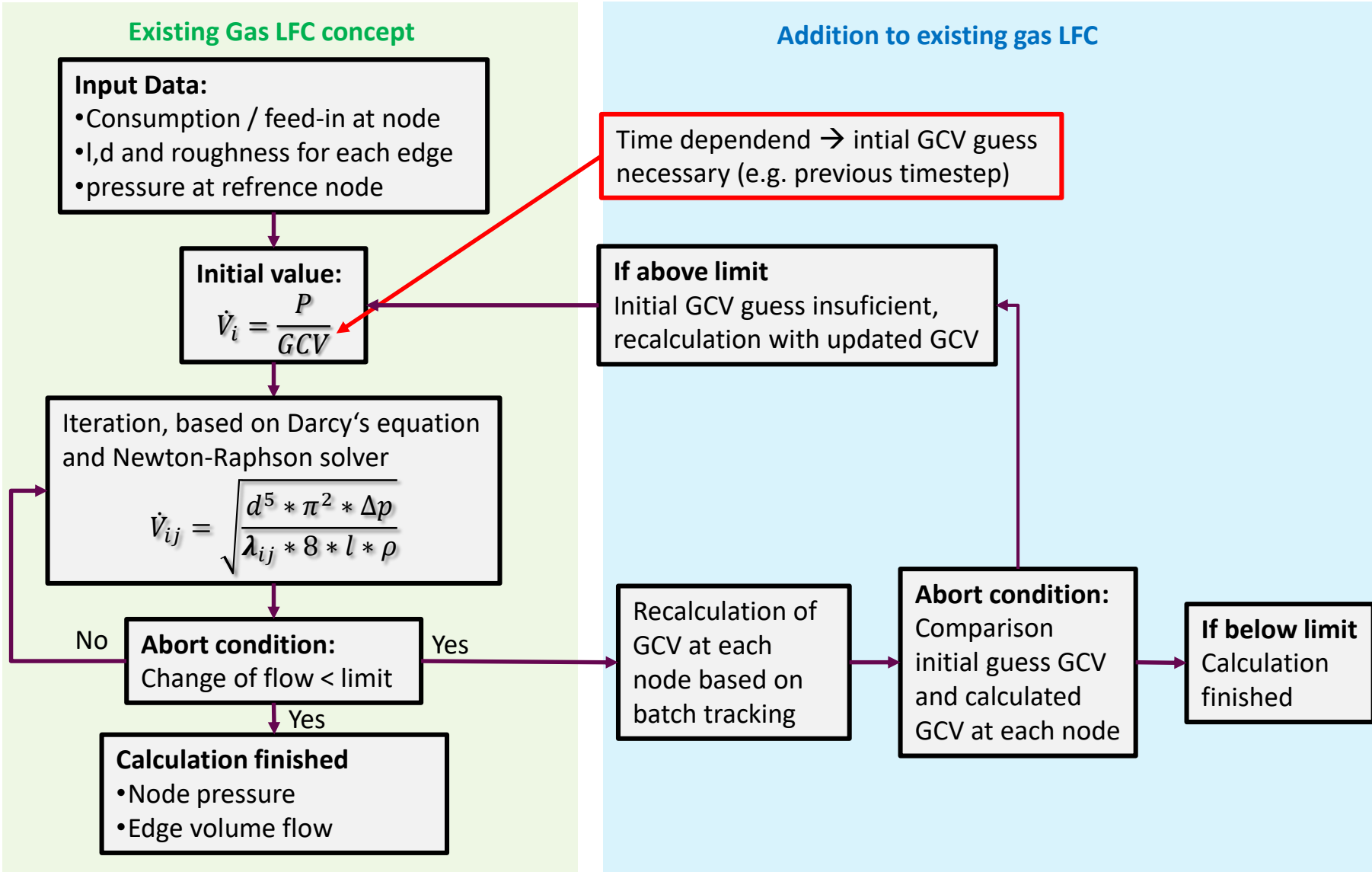
Recalculation of GCV at each node based on batch tracking

### Abort condition:

Comparison initial guess GCV and calculated GCV at each node

### If below limit

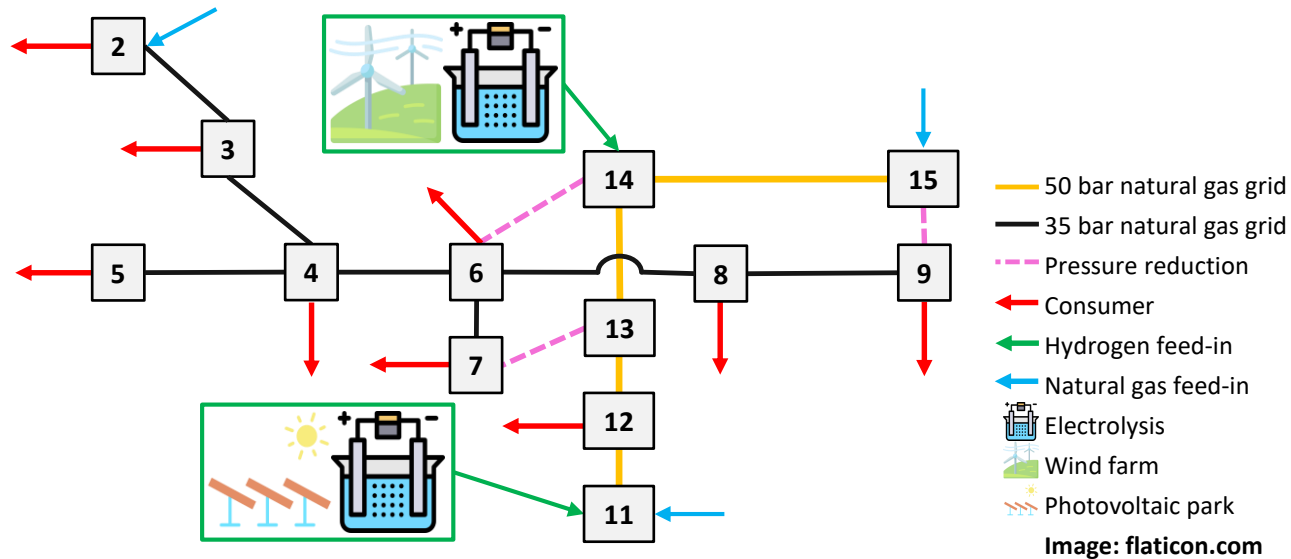
Calculation finished



# Scenario

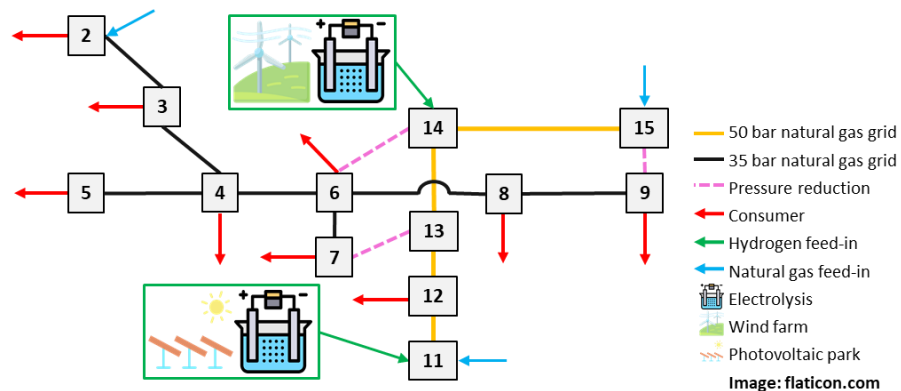
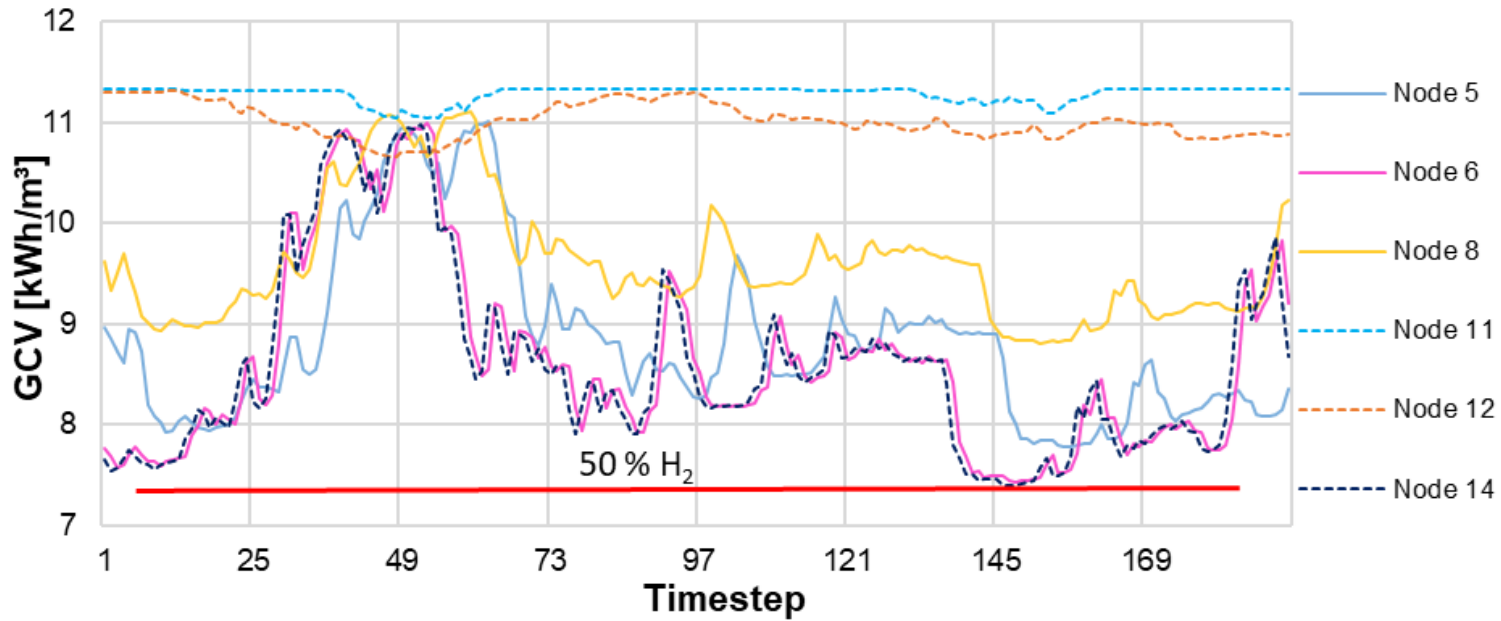
## Investigated Use Case Styria

- An H<sub>2</sub> content of up to 50 percent is considered.
- Consumption and natural gas grid properties were provided from Energienetze Steiermark.
- Model of use case Styria:



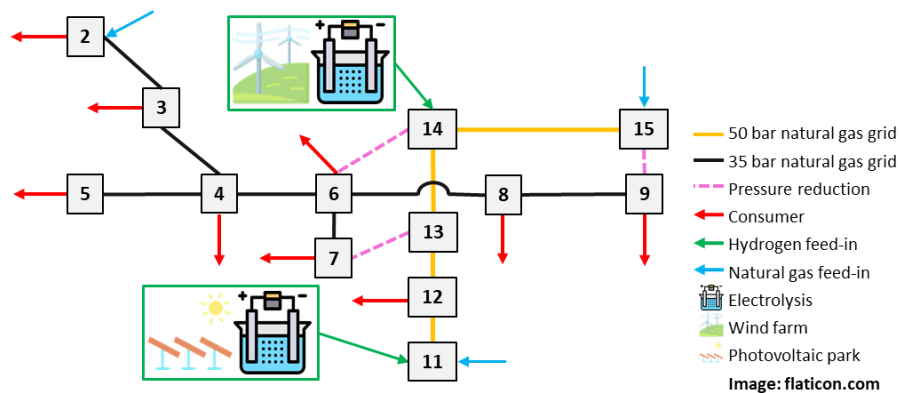
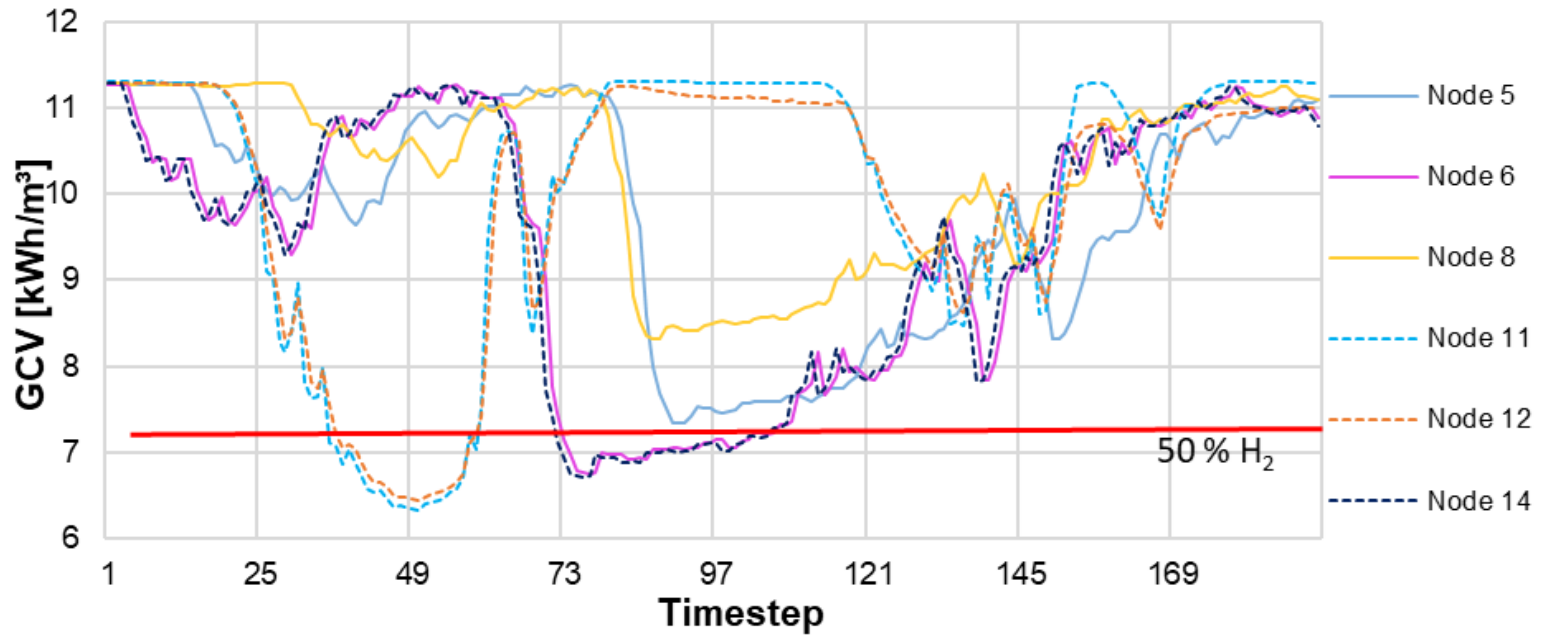
- H<sub>2</sub> feed-in is based on wind (node 14) and photovoltaic (11) generation profiles.

# Results – GCV in Winter





# Results – GCV in Summer



# Conclusion

- An existing steady-state natural gas LFC was extended with quasi-dynamic batch tracking / tracing concept to investigate time and spatial resolved GCV fluctuations in an existing natural gas grid.
- Based on use case Styria, GCV fluctuations in the gas grid, caused by H<sub>2</sub> feed-in from generated from photovoltaic and wind are simulated.
- Different areas of Styria are affected by GCV fluctuations to a different degree.
- Depending on the distance between H<sub>2</sub> feed-in and consumption, it may take several hours until H<sub>2</sub> feed-in affects a node's GCV.

# Thank you for your interest in this topic!



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# Literature / References

- [1] 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.