DVGW-Forschungsstelle am Engler-Bunte-Institut
des Karlsruher Instituts für Technologie



# Trial of Basic Control Strategies of Gas Supply and Distribution Networks to Allow Integration of Renewable Gases from Distributed Production

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- Approach – Experimental Section
- Approach – Modelling Section

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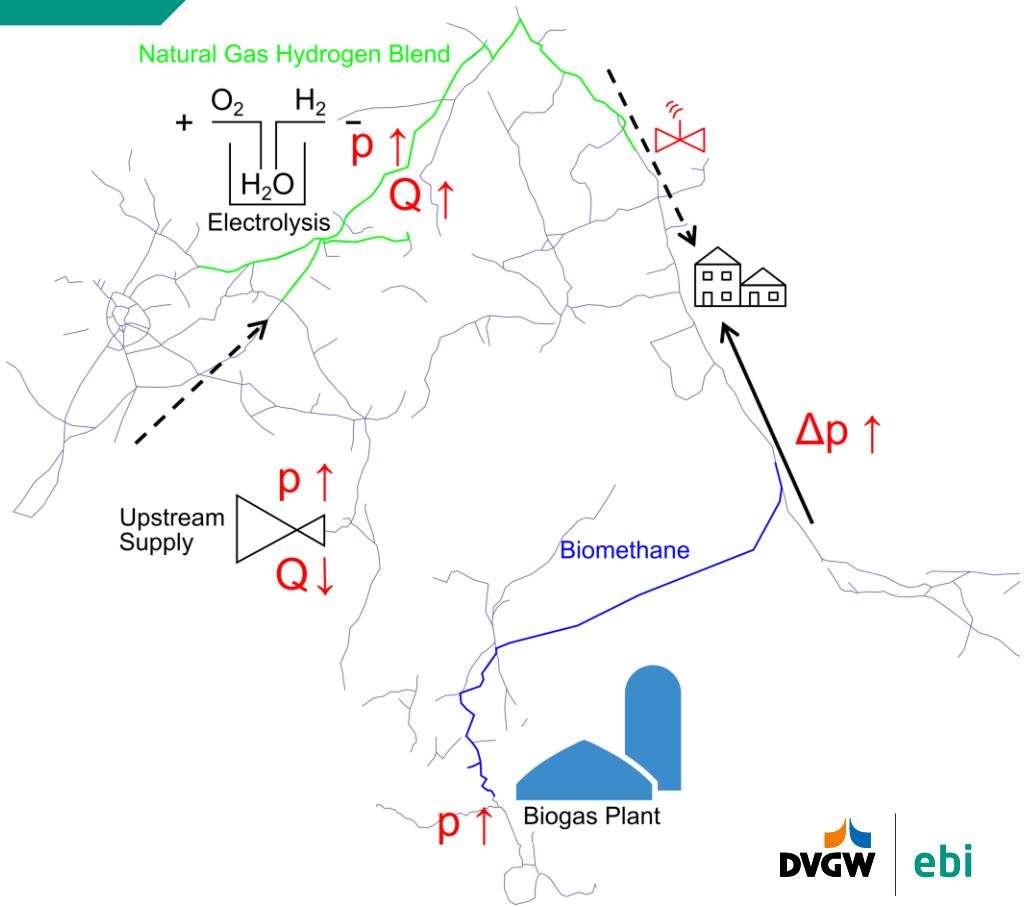
- Outlook and Open Work

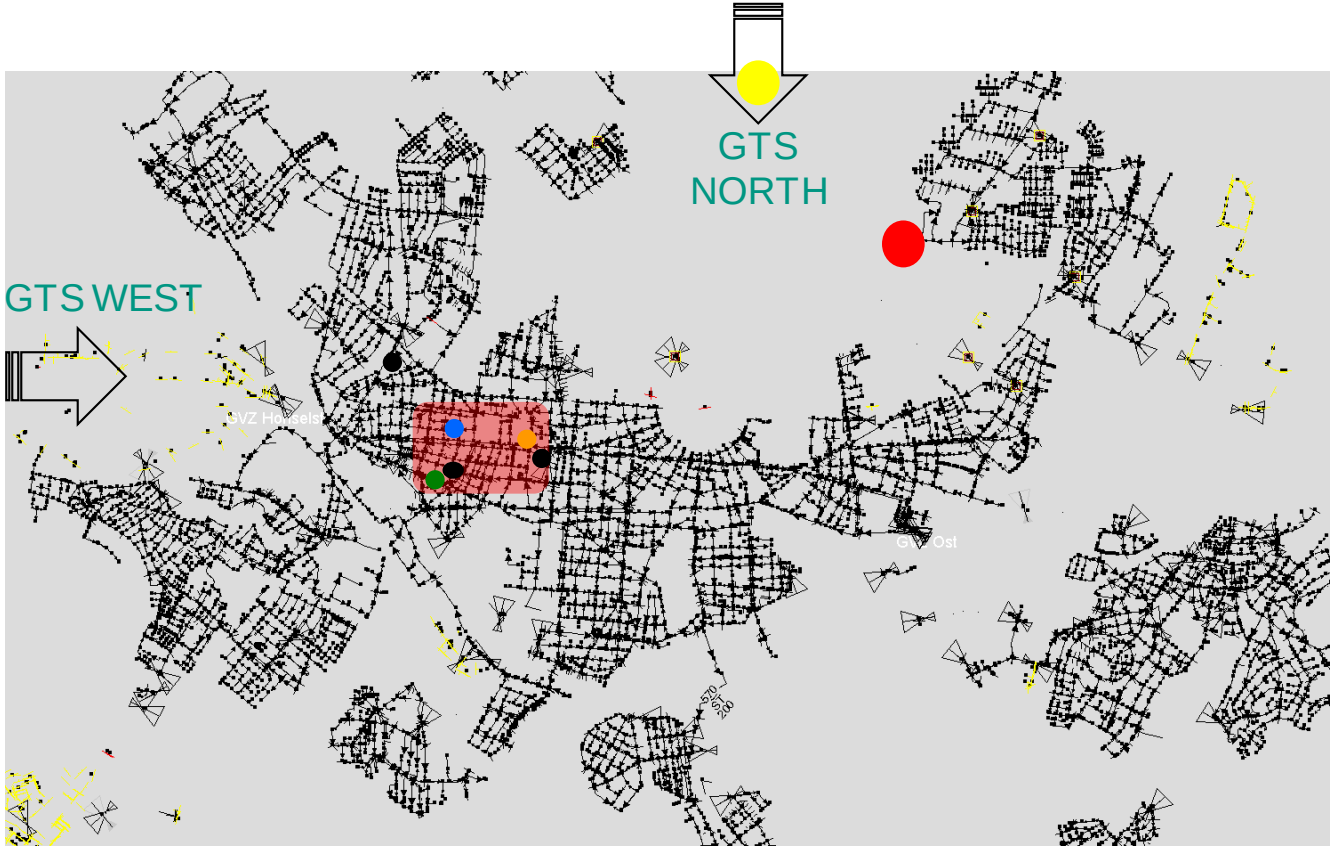
# Introduction and Motivation
# Smart Gas Grids

Controllable network areas with distributed renewable gas feed-in could allow for

- increasing renewable gas receptivity of different origins,
- a limited temporal decoupling of feed-in and feed-out, and
- practical and legally secure billing in non-stationary gas quality areas.



# Approach: Field Test
# Experimental Setup - Overview




Investigation Area

Gas Pressure Regulation Station

THT injection

THT measurement

Continuous THT measurement

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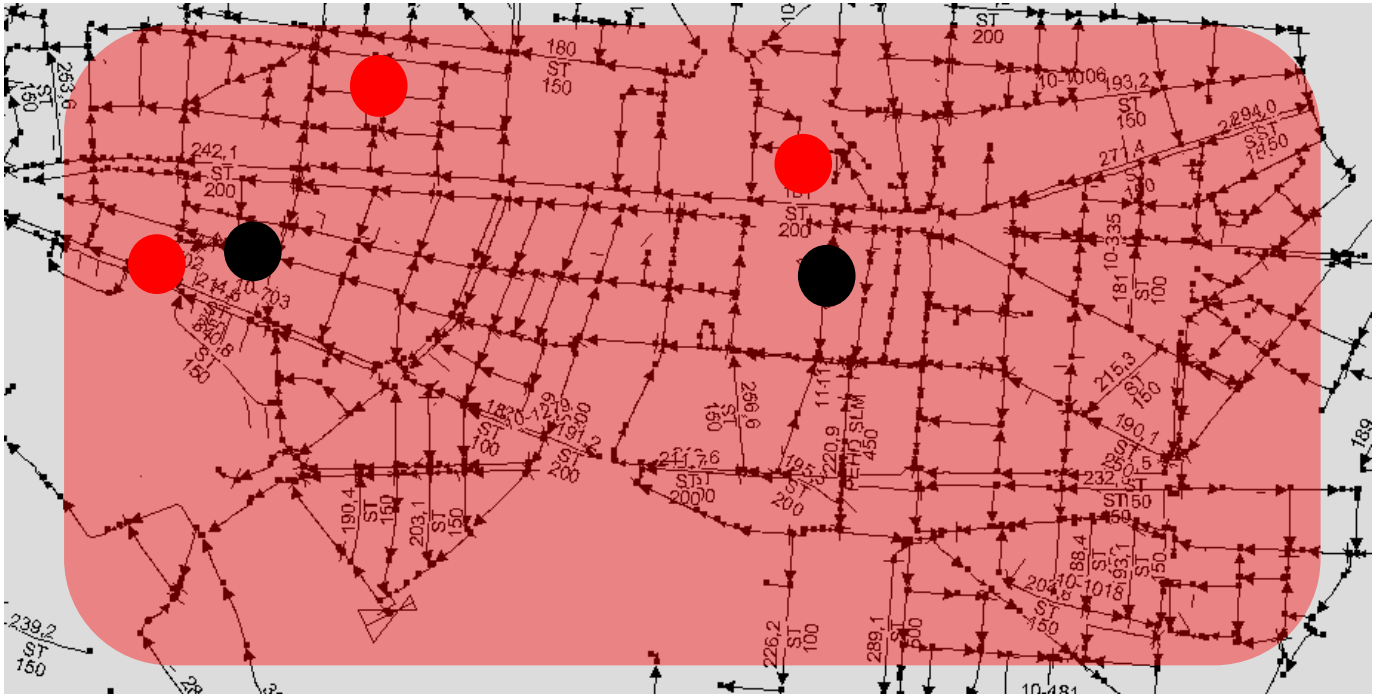
# Approach: Field Test
# Experimental Setup – 0



**Initial Situation**

low THT concentration

THT measurement

GPRS

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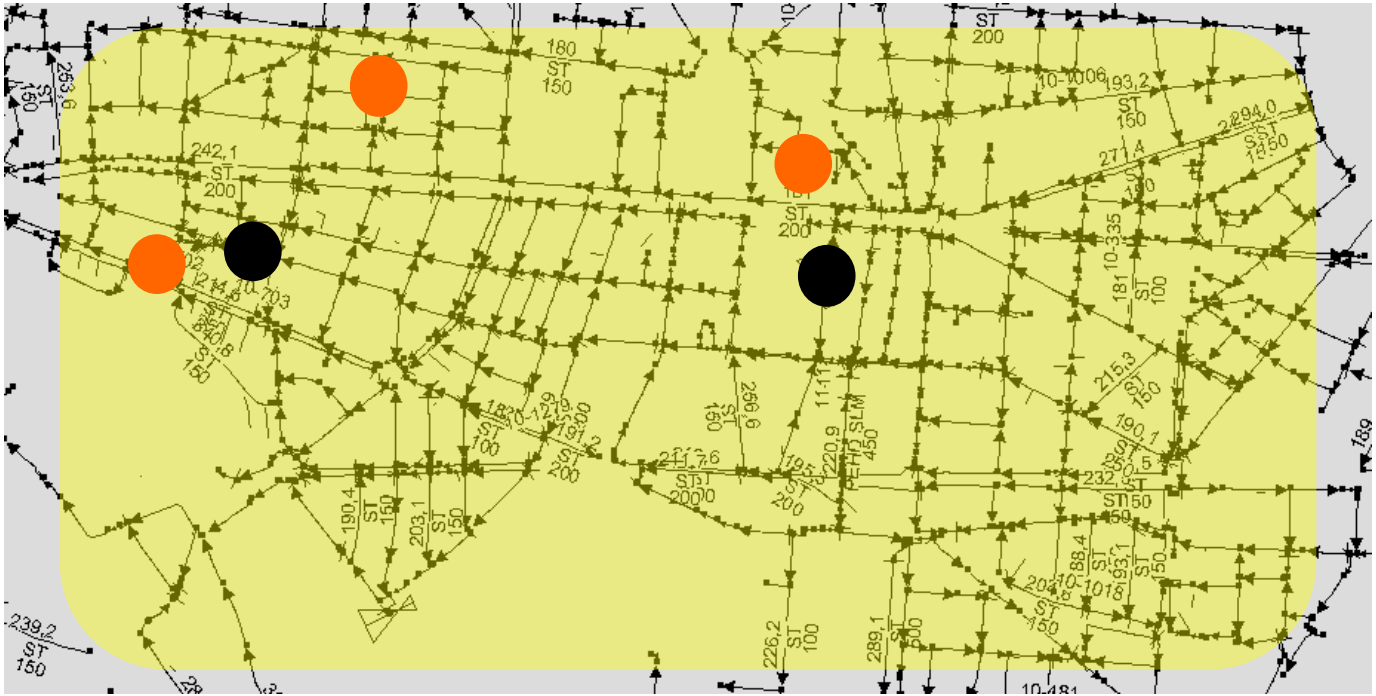
# Approach: Field Test
# Experimental Setup – 1



**Displacement of Original Gas**

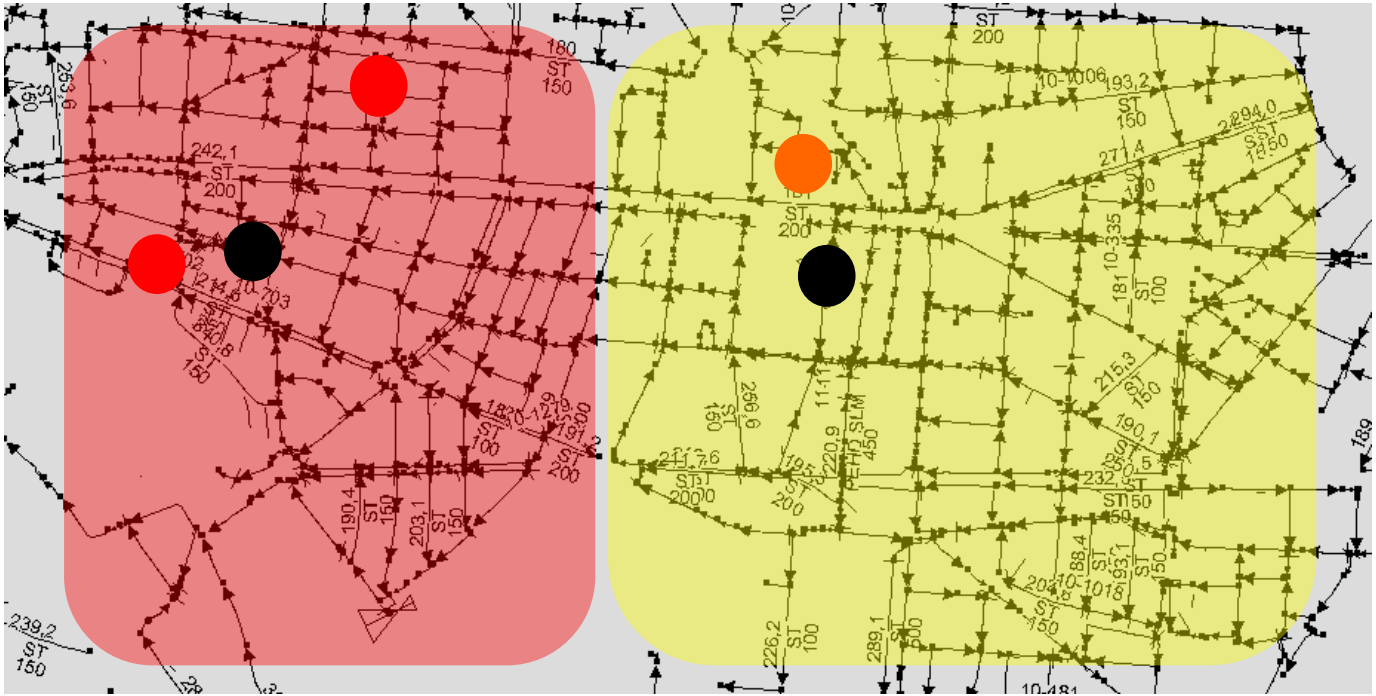
low THT concentration

high THT concentration

THT measurement

GPRS

# Approach: Field Test
# Experimental Setup – 2



**Manipulations of Gas Propagation**

low THT concentration

high THT concentration

THT measurement

GPRS

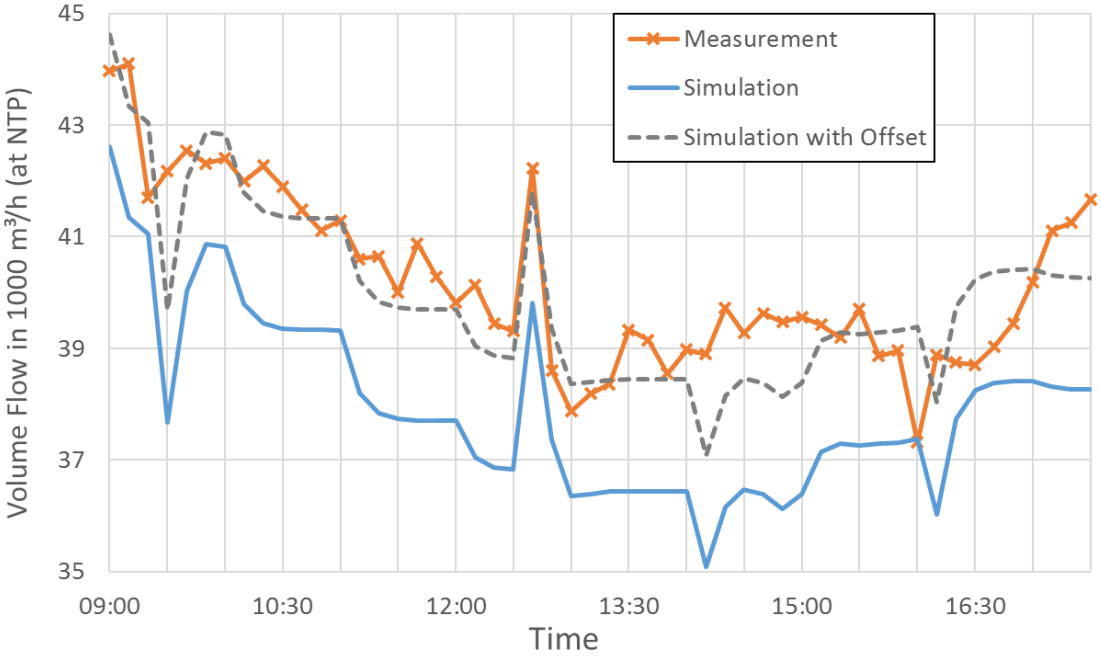
# Approach: Modelling Characterization and Validation

Gas network modelling with STANET

Natural gas network of Karlsruhe [1]

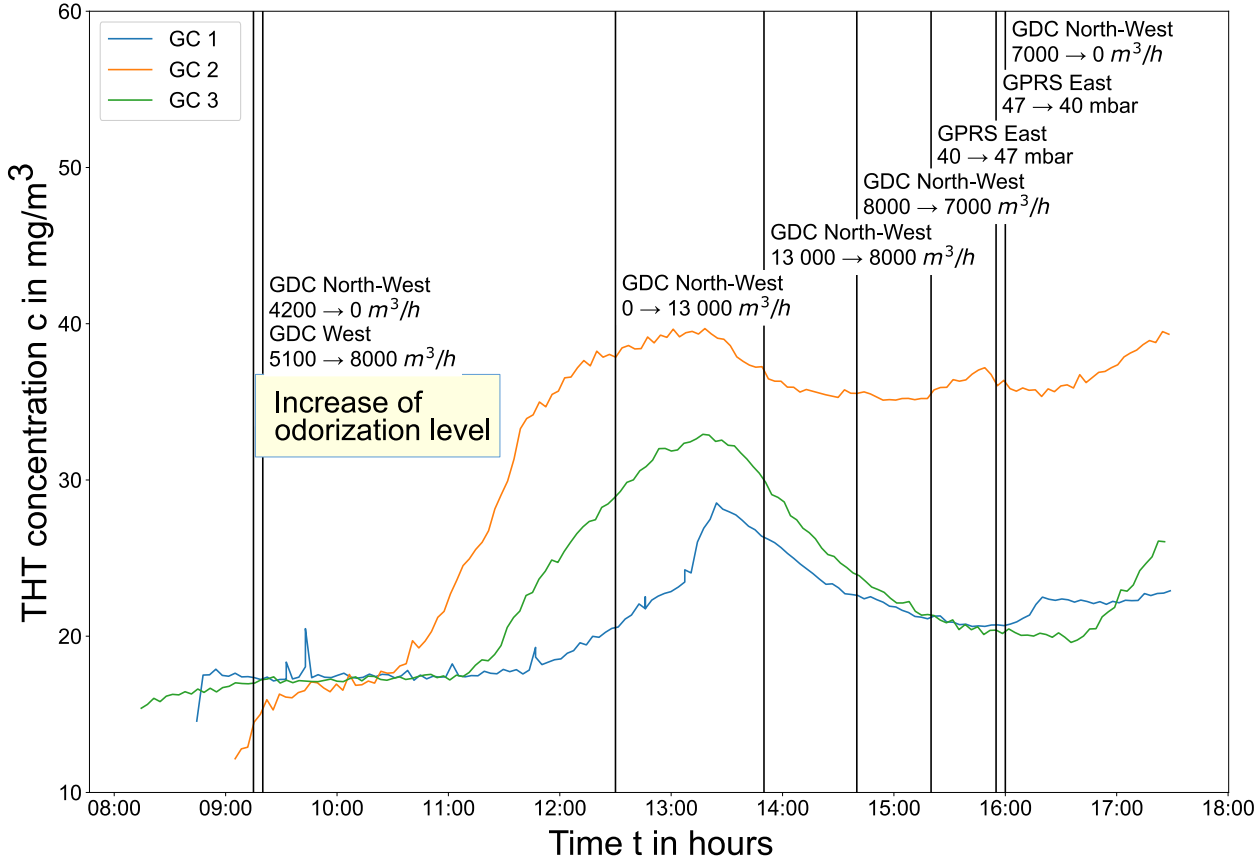
- annual demand 1821 TWh
- annual peak load 665 MW
- delivery points ~ 68 000

Model validation for measurement day with average deviation **< -8 %**
(no explanation for assumed offset)




[1] in 2020

# Results
# Field Test: Overview of Interventions



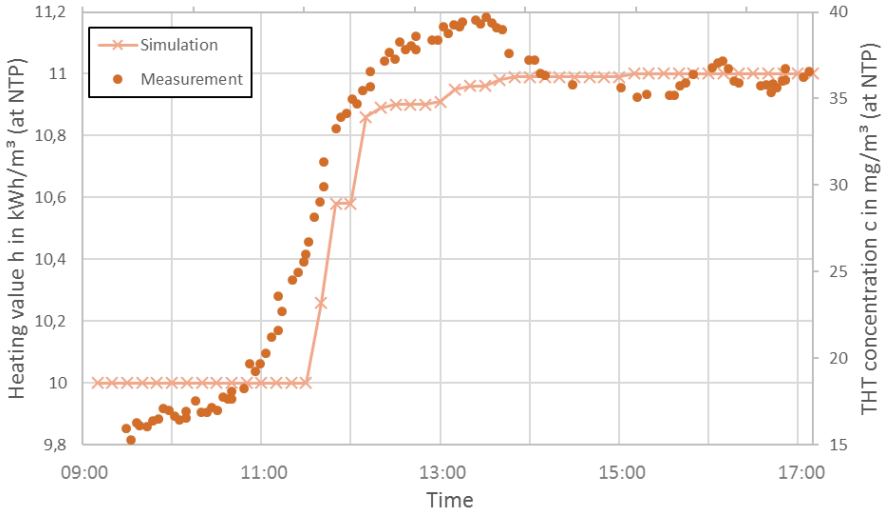

Discontinuous measurement of THT concentration

Regulating interventions in network operation

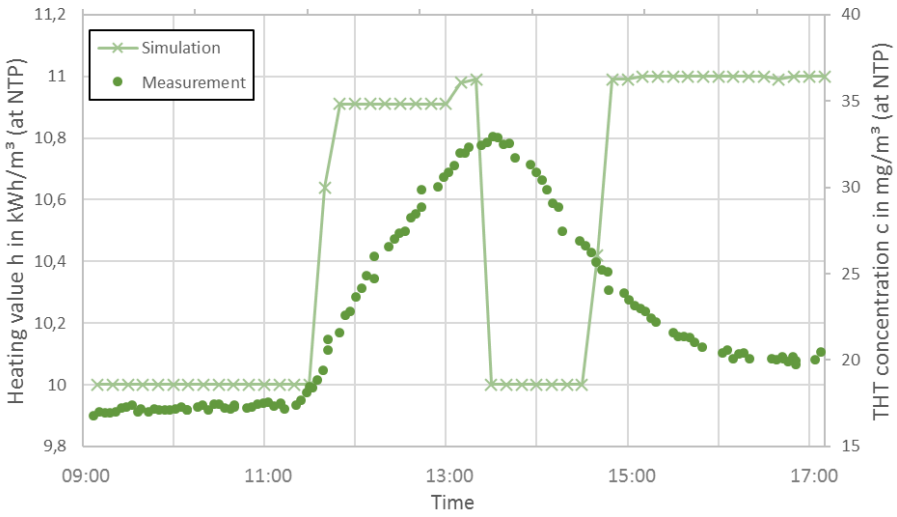
- Gas flow set values (HP)
- Pressure set values (LP)

# Results
# Simulation: Flow Variations – 1

GC 2




GC 3




Measurement stations at locations close to GPRS

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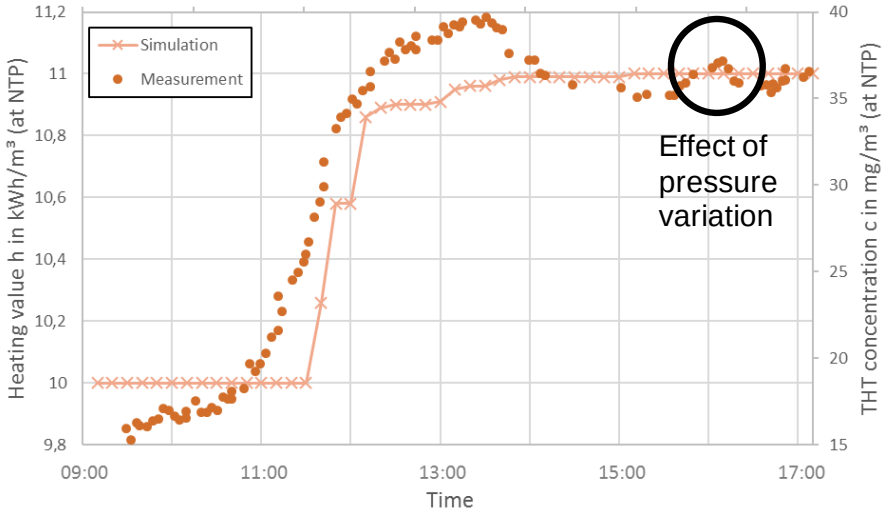
# Simulation: Flow Variations – 1

GC 2

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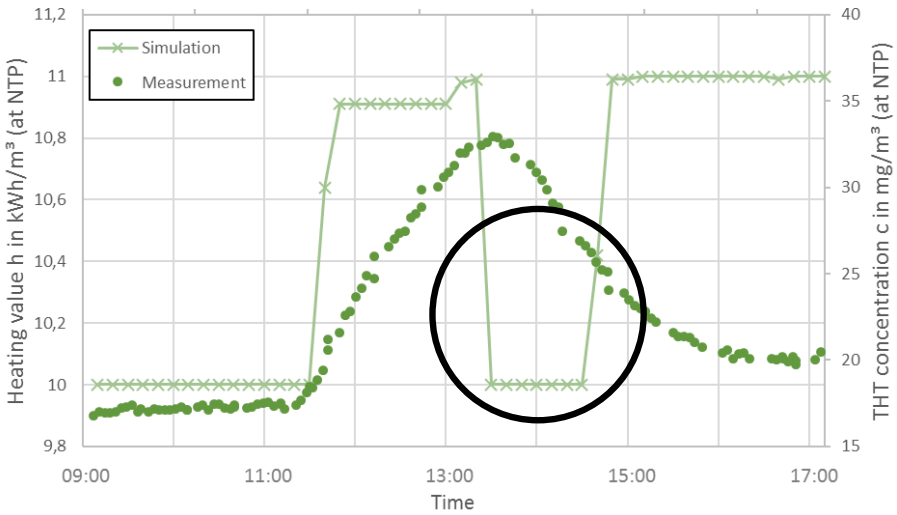
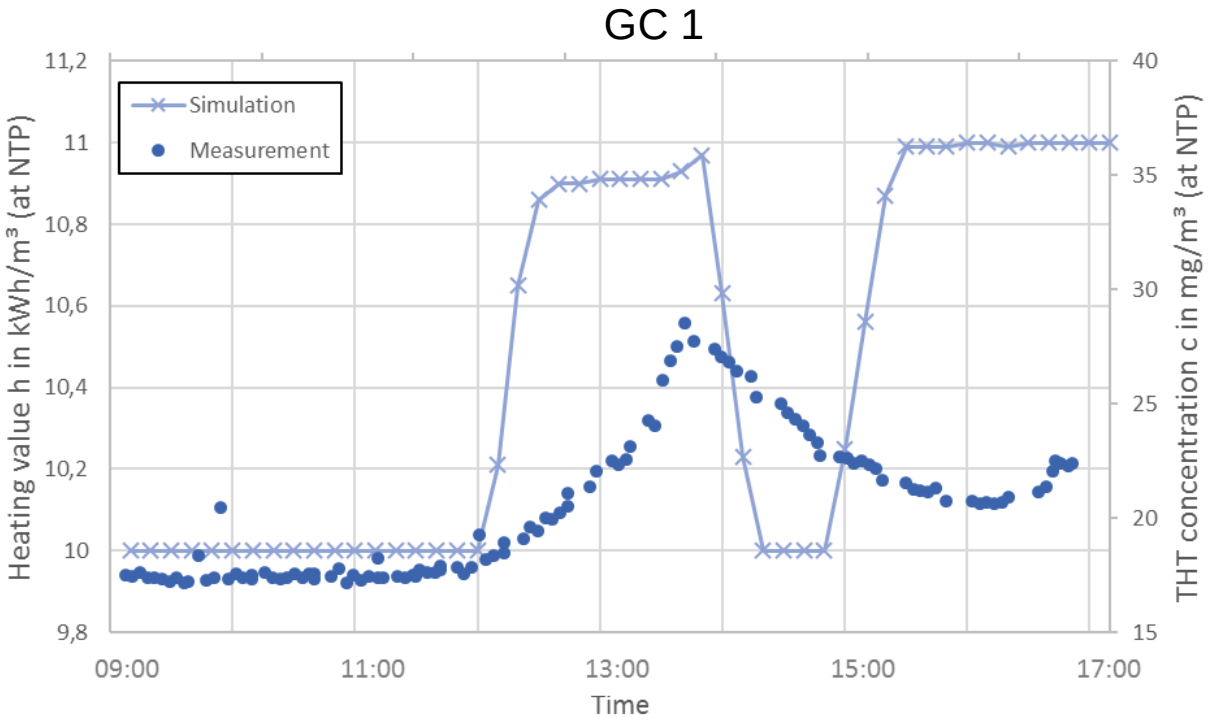



Measurement stations at locations close to GPRS

- Satisfying simulation results
- Model shows systems‘ expected response to interventions
- Real systems‘ inertia and blending effects significantly higher than in the model

# Results
# Simulation: Flow Variations – 2

Measurement station with greatest distance to GPRS



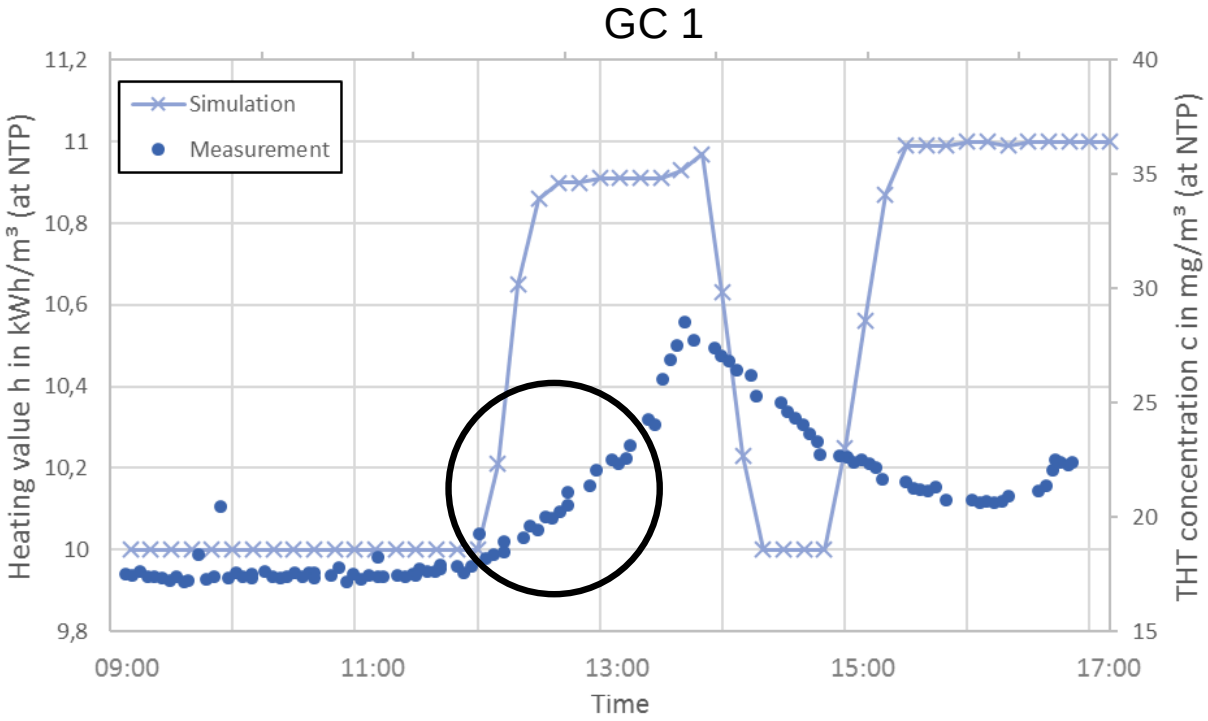
# Results
# Simulation: Flow Variations – 2

Measurement station with <u>greatest distance</u> to GPRS

Poor simulation quality of pulse rate of rise

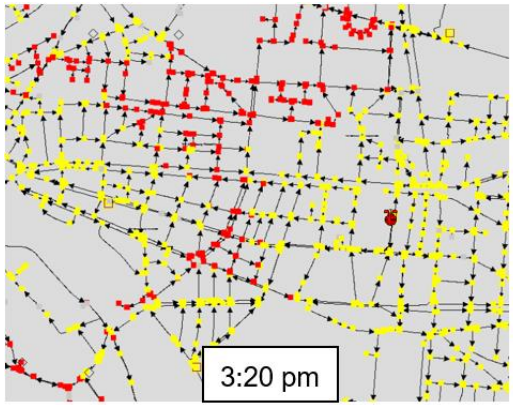
Possible causes:

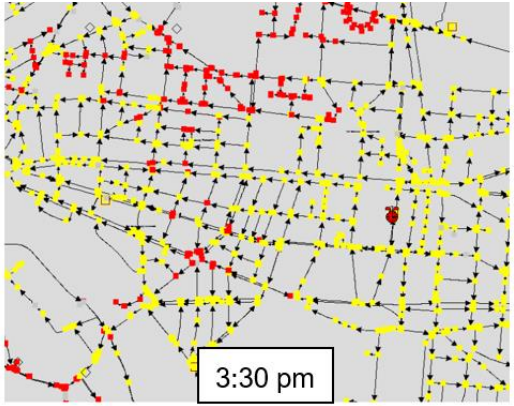
1. Limitations of correlations for laminar flow regime („Gasstangenmodell“) [1]
2. Program error (currently under revision)
3. Modelling inaccuracy (currently under revision)

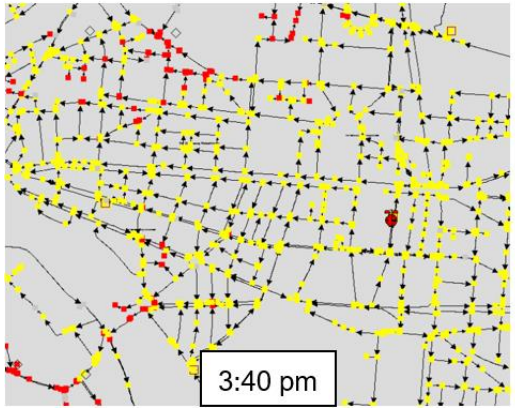


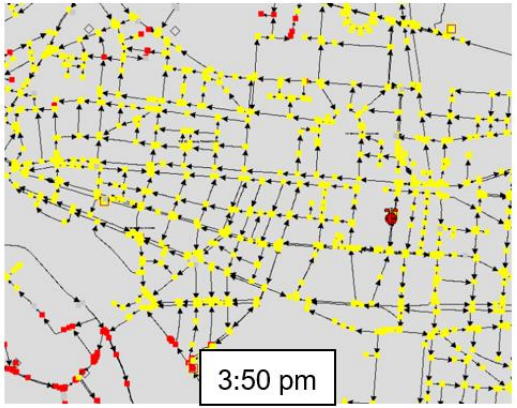

[1] Interpretation of the gas flow as a series of non-overlapping segments of gas that fills each link of the network according to the epanet model for water. https://epanet22.readthedocs.io/en/latest/3_network_model.html

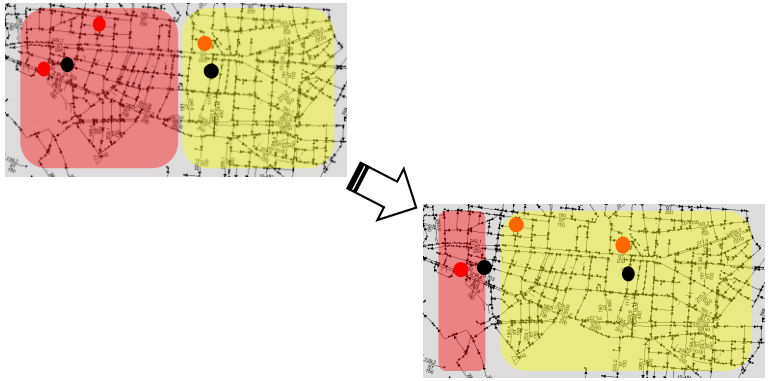
# Results
# Simulation: Pressure Variation (LP)



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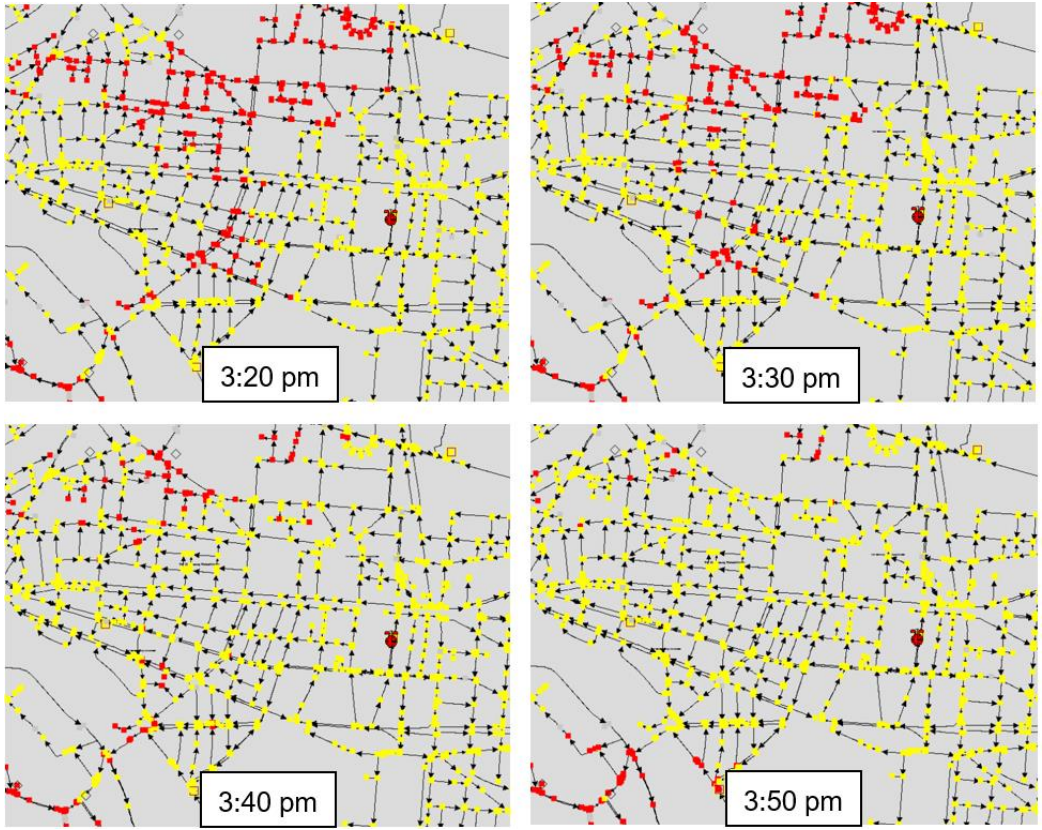


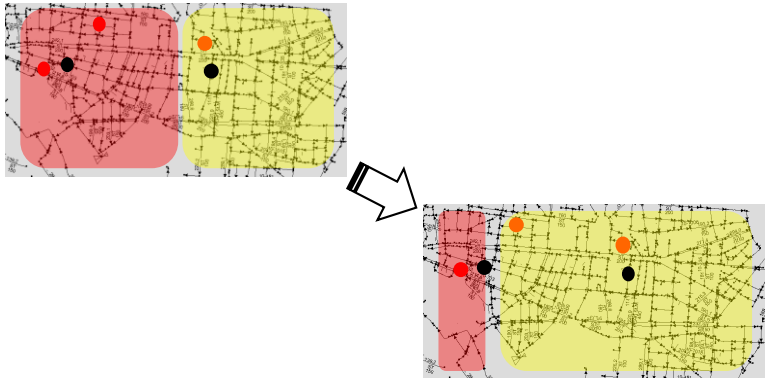

Effect of pressure variation

- Visible in model visualization
- Not visible in modeled signal at all measurement points
- Visible at only 1 measurement point in experiment

**DoE limitation**

# Conclusions

## Approach and Modelling

1. **Successful proof** of the gas grid model's ability to simulate interventions in network operation (PoC)
2. Development of model, toolkit, and workflow as **basis for more detailed investigations**
3. Model or software **shows limitations for gas quality tracking** in low-pressure laminar flow regime (improvement in prospect).

## Transformation of Gas Infrastructure

# Conclusions

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## Transformation of Gas Infrastructure

1. Verification of gas quality tracking is **key to reduce the need for measurement and control technology** and ICT (which are related to higher cost).
2. Interventions in the examined network at high-pressure levels are **possible with today's equipment**, interventions on low-pressure seem **little promising**.
3. The **higher the degree of meshing** of the respective network level, the higher the complexity and cost of interventions.

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# Outlook and Open Work

- More use cases: Investigations of hydrogen feed-in points with reversal of flow direction depending on network management and load scenario **to identify maximum hydrogen integration capacities**

- Parameter studies: input parameter time resolution (e.g. temperature series) and computing parameter selection **to increase accuracy of simulation**

- Discussion of results with stakeholders (e.g. system operators) **to disseminate results and integrate stakeholders' perspective**

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… stay tuned for further insights and results

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# Q&A

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