Benchmark gas distribution network for cross-sectoral applications

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IESC

New York, USA

cire
Cologne Institute for Renewable Energy

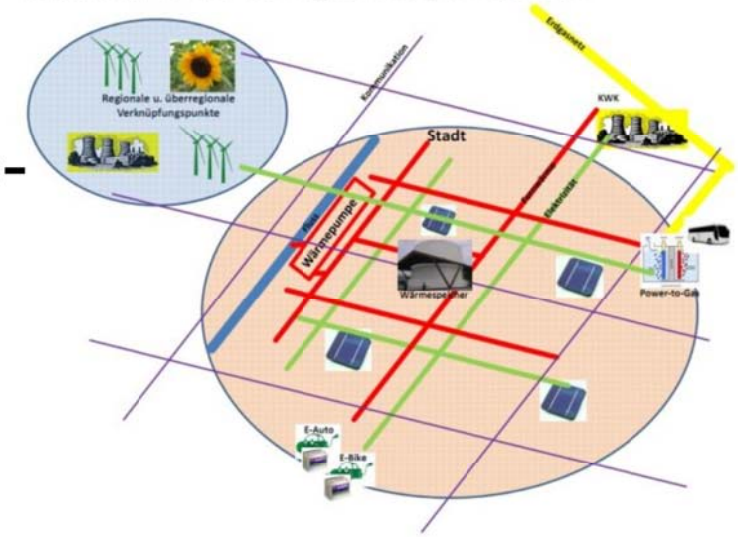
ES-FLEX-INFRA [1]

Project objective:

- software prototype
- optimized application of cross-sectoral technologies

es×flex×infra

Modellierung und Optimierung der Kopplung von Energiesektoren zur Flexibilisierung der Energieinfrastruktur



Consortium:

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Fraunhofer SCAI

WERUSYS INDUSTRIEINFORMATIK

RNG Rheinische NETZGesellschaft

SWB Stadtwerke Bonn

Benchmark systems

- General validity for investigations
- Comparable and verifiable results
- Anonymous, synthesized data for easier publishing
- Simple network structures for easy verification and clear overview

The CIGRE benchmark system

- Electricity networks for
  - HV, MV, LV, applications
- For integration of renewable and distributed energy resources
- Connections to the gas network:
  - CHPs
  - Fuel cells

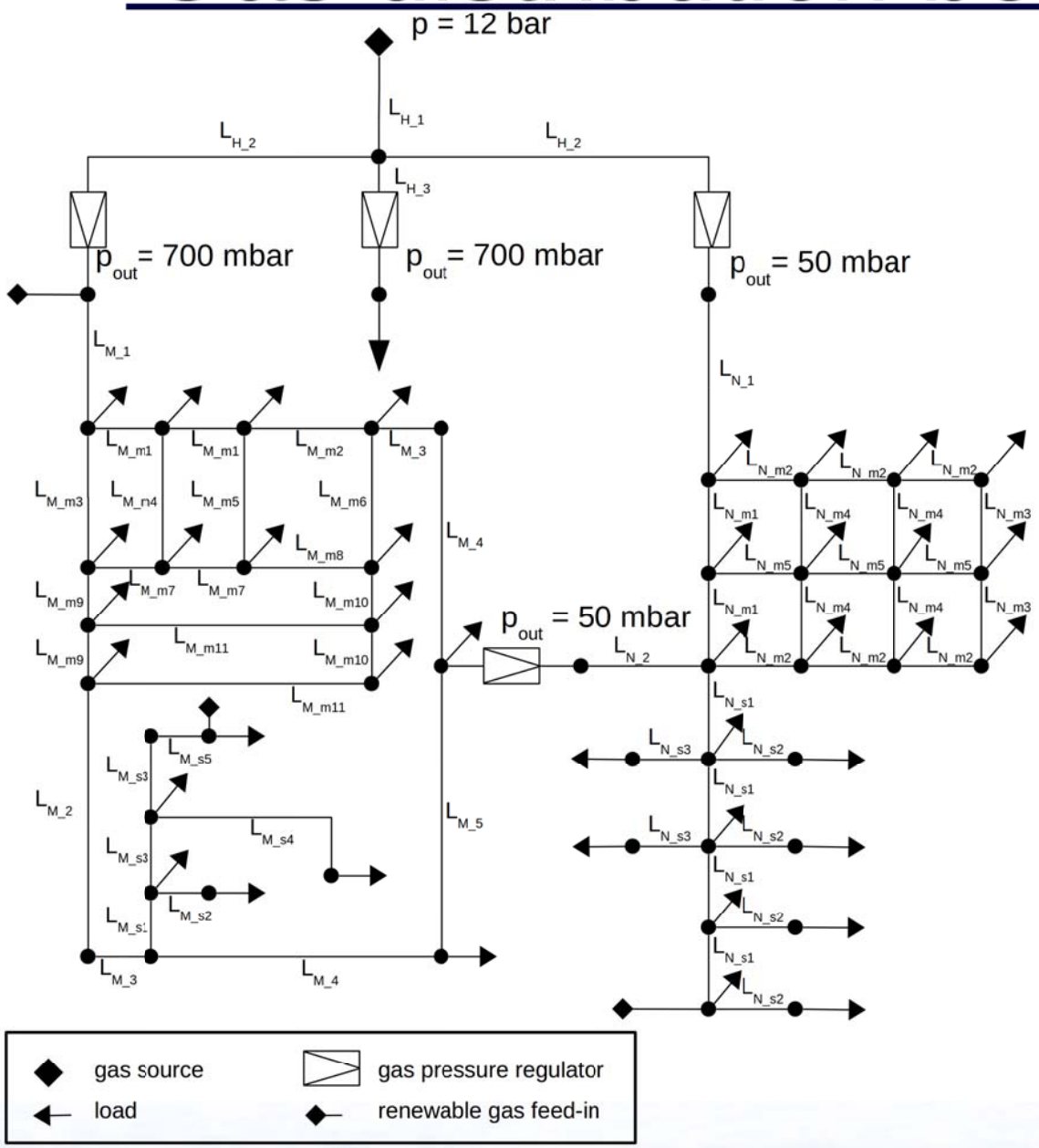
no gas benchmark network available yet

[2]

Deriving a gas benchmark network

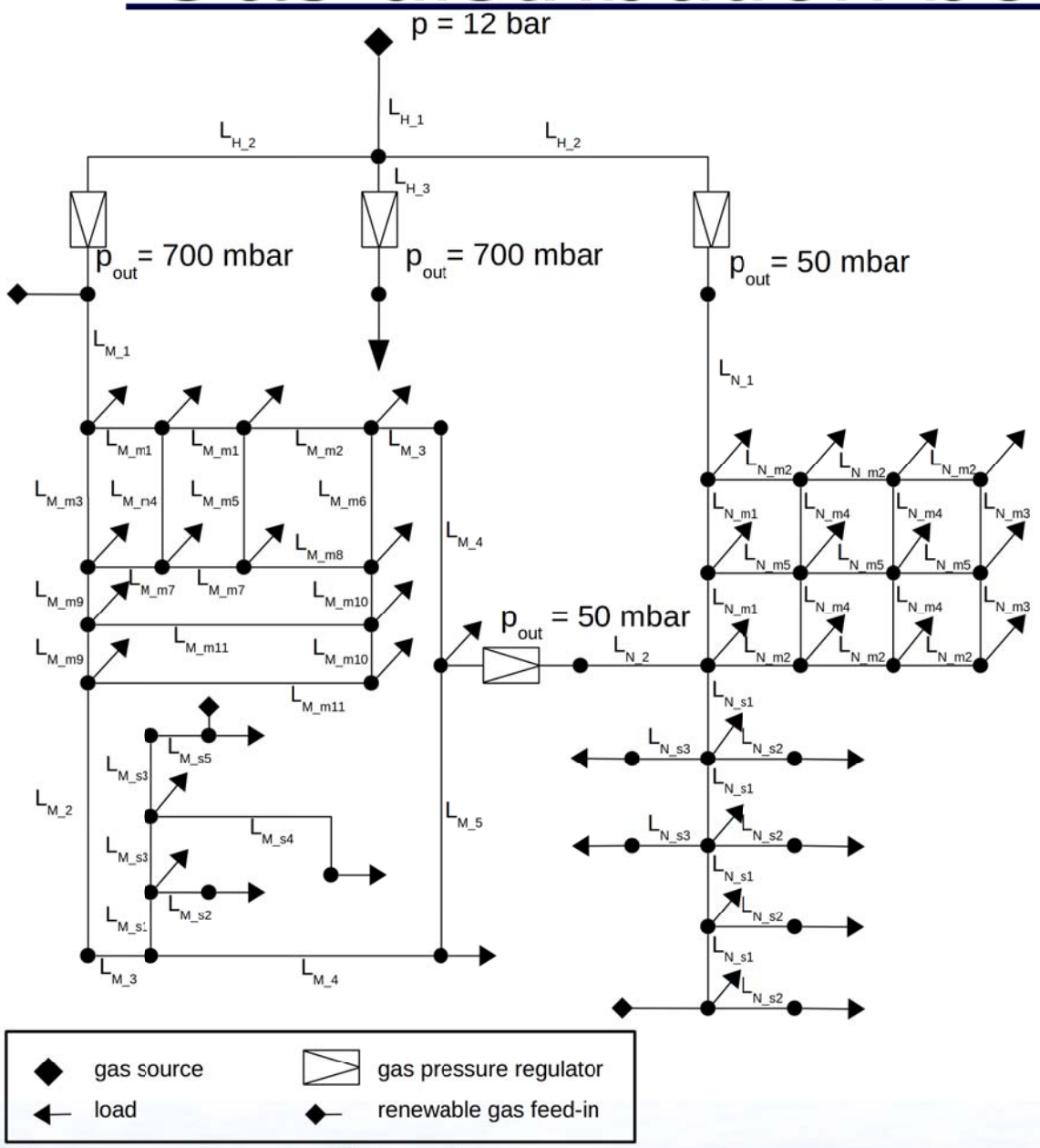
- Based on CIGRE MV network
- Synthesized from present RNG distribution network
  - Medium pressure: 3 meshed / 3 radial grids
  - Low pressure: 3 meshed / 3 radial grids
  - Parameters considered:
    - Pipe diameters, materials, lengths
    - Building structure/usage within topologies
    - Longest pipe length from superordinate network

Gas distribution benchmark network



- High pressure supply:
  - 12 bar
- Medium pressure (MP):
  - 650-750 mbar
- Low pressure (LP):
  - 40 – 45 mbar
- Household pressure:
  - 22 mbar

Gas distribution benchmark network

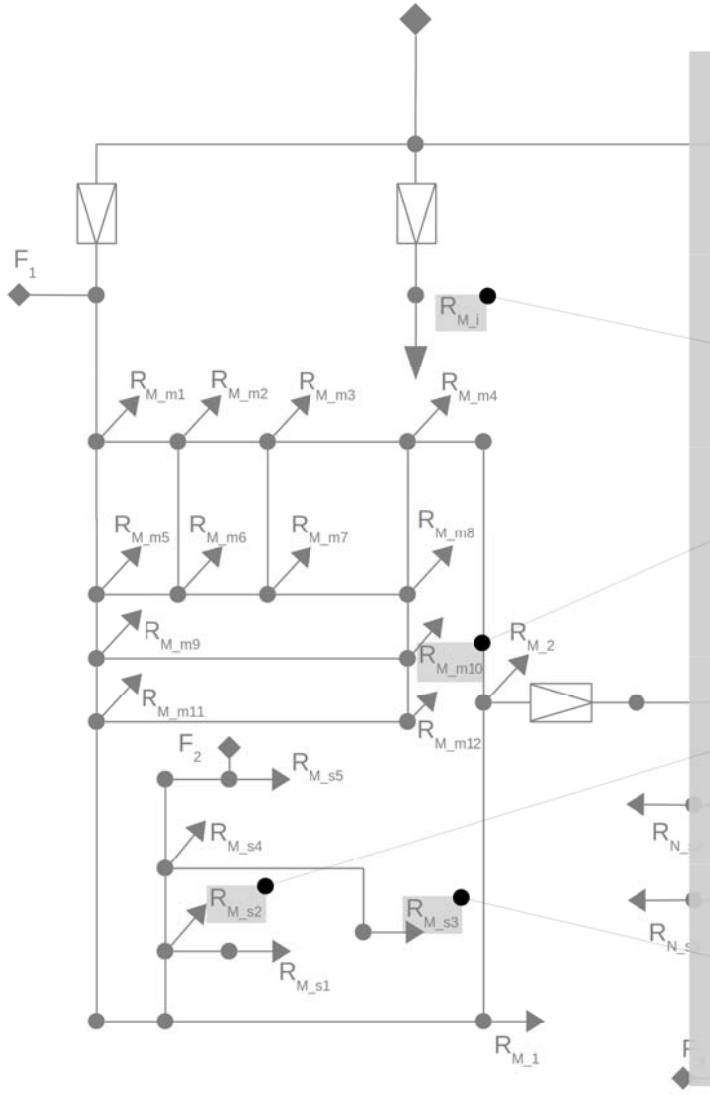


- Total demand:
  - 11,64 MW
- Elements:
  - 4 regulators
  - 42 loads
  - 110 pipes
  - 1 main supply
  - 3 gas feed-ins

Assumptions and simplifications

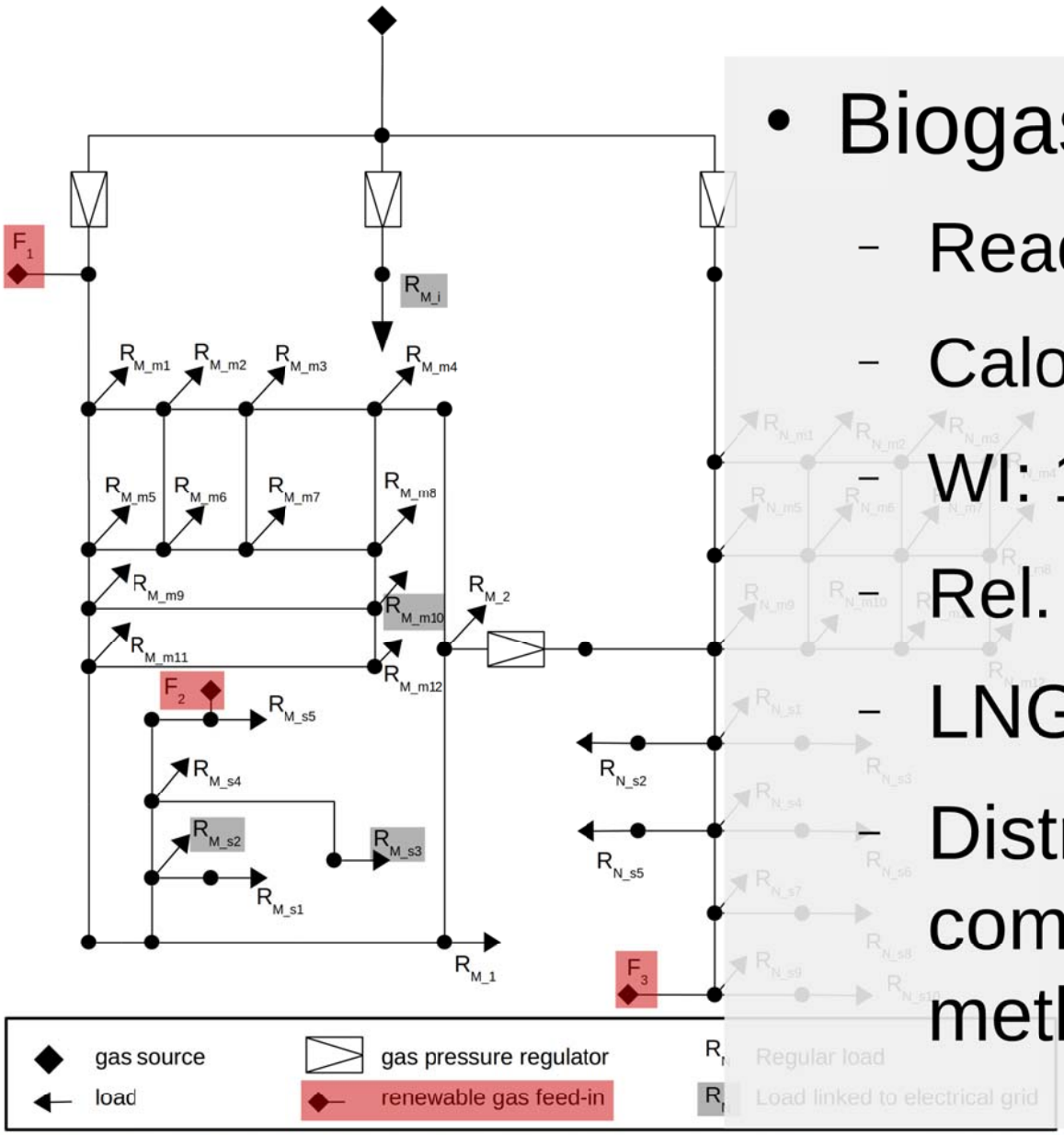
- German low calorific gasmix [3]
  - Calorific value: 9.8 kWh/m³
  - Wobbe-Index (WI): 12.4 kWh/m³
  - Relative density: 0.626
- 70 % of households with gas supply
- Simultaneity factor: 0.7
- Households aggregated block-wise
  - 50 m pipe length to block of households

Connections to electricity grid



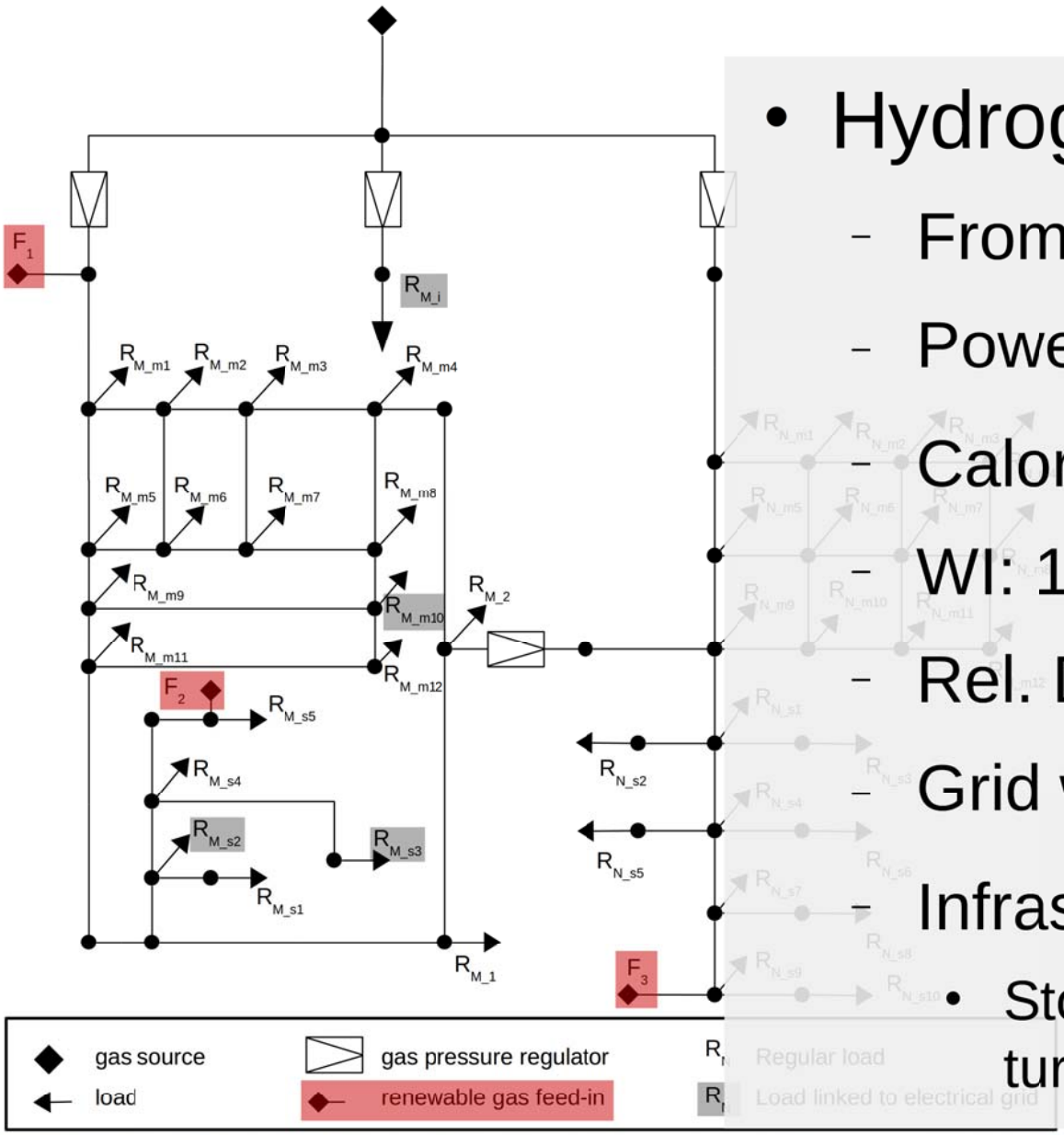
Load	Type	P_{gas} [kW]	$\eta_{el.}$ [%]	$\eta_{tot.}$ [%]
R_{M_i}	CHP	721	43	86
R_{M_m10}	FC	471	45	85
R_{M_s2}	FC	82,5	40	90
R_{M_s3}	FC	28	50	90

Gas feed-in



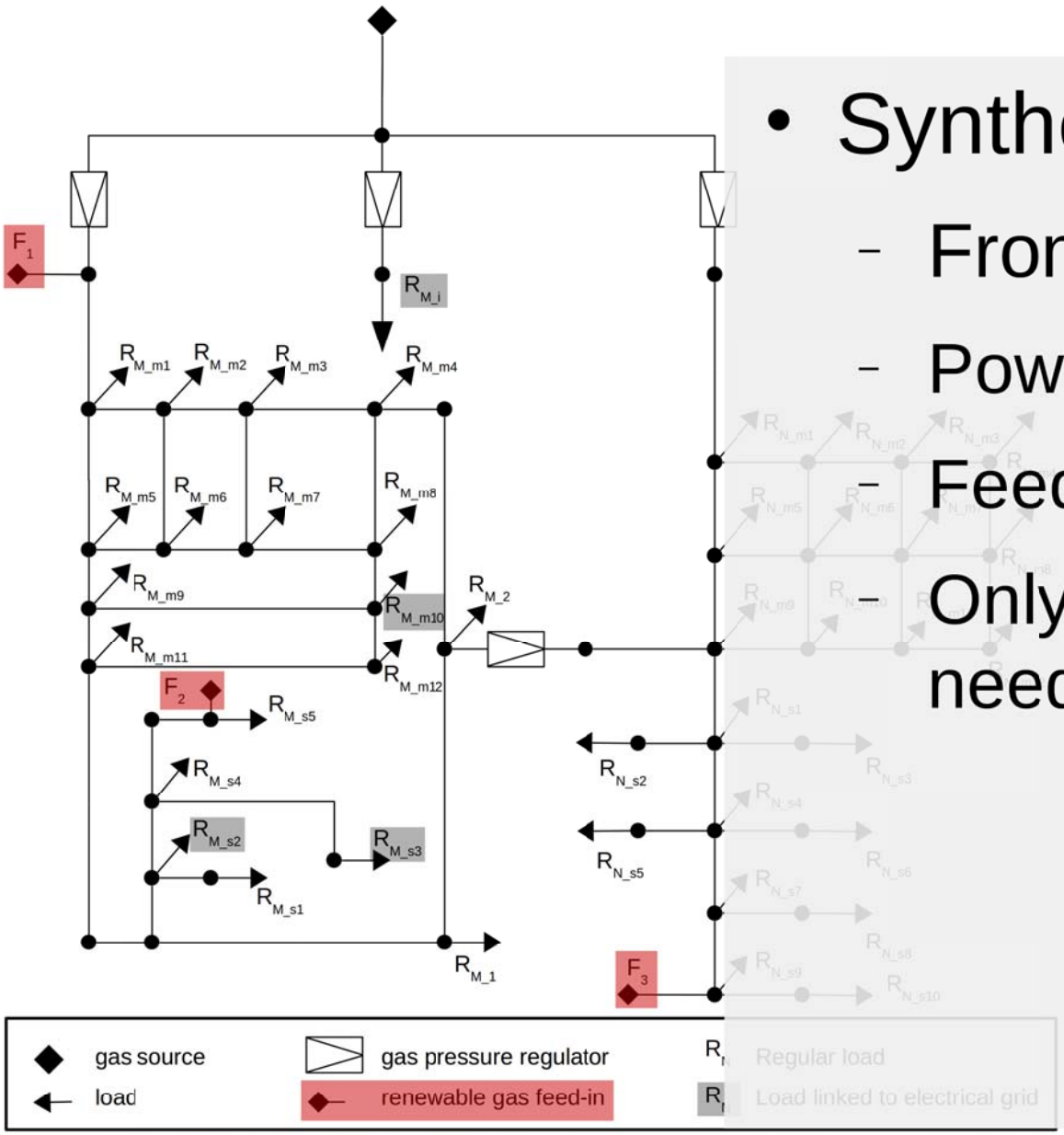
- Biogas
  - Readily processed
  - Calorific value: 10.6 kWh/m³
  - WI: 13.9 kWh/m³
  - Rel. Density: 0.5877
  - LNG added in some cases
  - Distribution grid level is common to feed-in bio-methane

Gas feed-in



- Hydrogen
  - From electrolyzer
  - Power to H_2 → η = 70 % [4]
  - Calorific value: 3.54 kWh/m³ ↓
  - WI: 13.43 kWh/m³ ↑
  - Rel. Density: 0.07 ↓
  - Grid withstands up to 50 % H_2 [5]
  - Infrastructure susceptible:
    - Storage tanks (CNG cars), and gas turbines → 2-5 % H_2

Gas feed-in

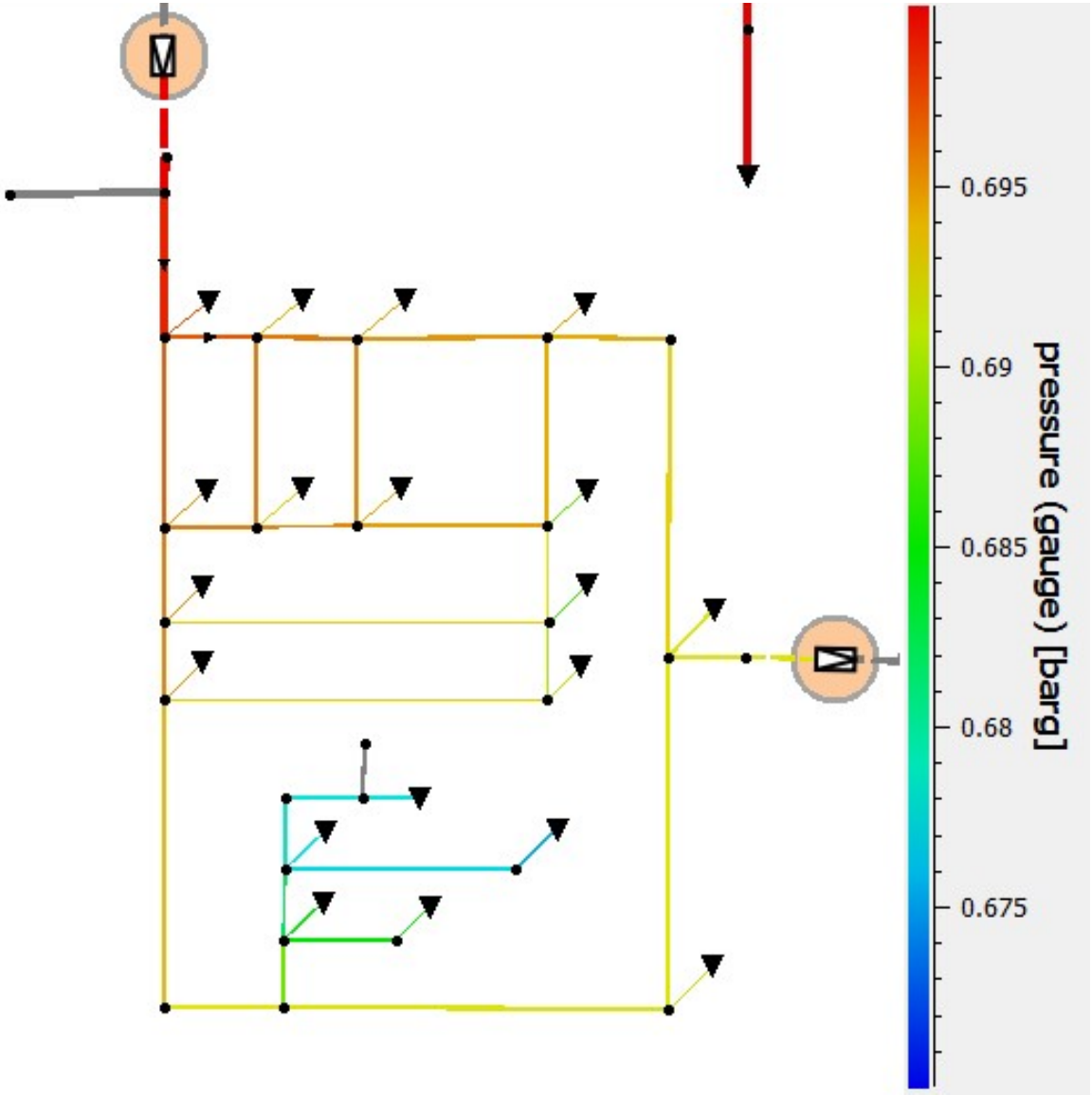


- Synthetical methane
  - From methanation
  - Power to gas → η = 58 % [4]
  - Feed-in after drying
  - Only small quantities of air need to be added [6]

First simulation results

- Multiphysical Network Simulator [7]
- Includes models for:
  - All relevant network elements
  - gas laws
  - Gas composition, molar composition and temperature propagation over the network
  - Joule-Thomson effect

First simulation results



- Medium pressure
- Pressure drop:
  - 23 mbar
- G2P loads:

  → no problem.
- Low pressure:
  - 2 mbar drop

Conclusion

- Gas distribution benchmark network developed from:
  - CIGRE electricity benchmark system
  - RNG network data from Cologne area
- Pressure drops of 0.02 (LP) to 0.23 mbar (MP) in the network
- Additional loads in gas network → no problem
- Gas feed-in limited to coverage of demand

Outlook

- Analysis of interdependent impacts (power and gas network)
- District heating network benchmark
- Integral energy system benchmark

Thank you!
Questions?

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References

[1] TH Köln. (2017, Aug. 25). *Forschungsprojekt ES-FLEX-INFRA* [Online]. Available: www.th-koeln.de/informations-medien-und-elektrotechnik/forschungsprojekt-es-flex-infra_37260.php

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