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Programme Storage and Cross-linked Infrastructures (SCI)

Topic 6: Superconductivity, Networks and System Integration

Graph-theoretic Model for Observability in Multi-carrier Energy Distribution Networks (MEDNs)

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Multi-carrier Networks

Energy networks: electrictiy (`el`), heat (`h`), natural gas (`g`)

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Decentralized energy converters (e.g. CHP, P2X)

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Multi-carrier **E**nergy **D**istribution **N**etwork (MEDN) [1]

Observability

An energy network is *observable* if all operational variables are determinable, based on the topology of the network, and the types and locations of the measurement points [2].

Monitoring

Monitoring of operational variables is essential as network constraints have to be met by the MEDN control

- `el`: voltage and current limits
- `h`: pressure, temperature and volume flow limits
- `g`: pressure and volume flow limits

Key Questions

Q1. How can we include the network topology and the operational variables in a unified MEDN model?

Q2. Based on that model, how can we determine *observability* in MEDNs?

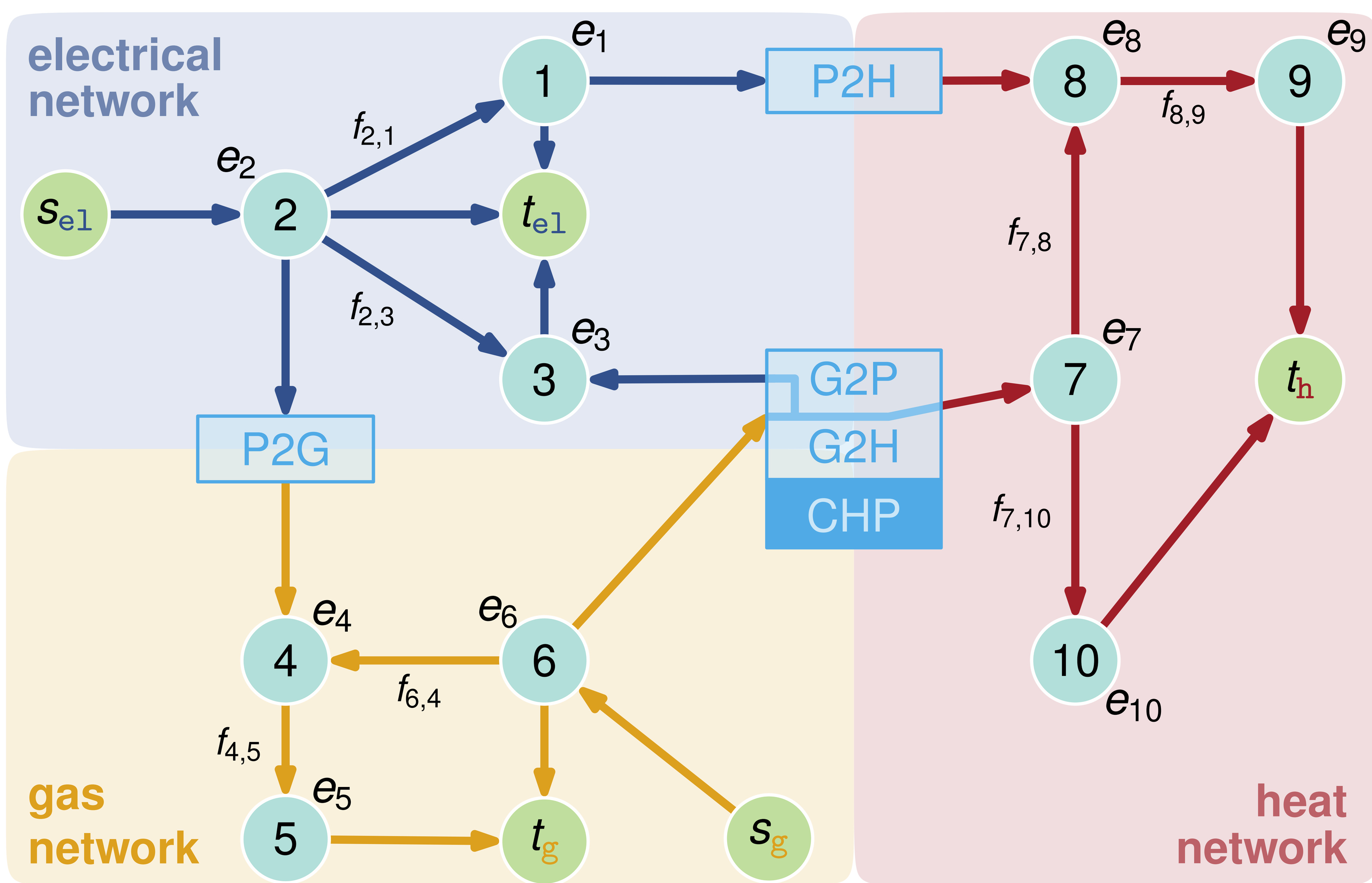
Model

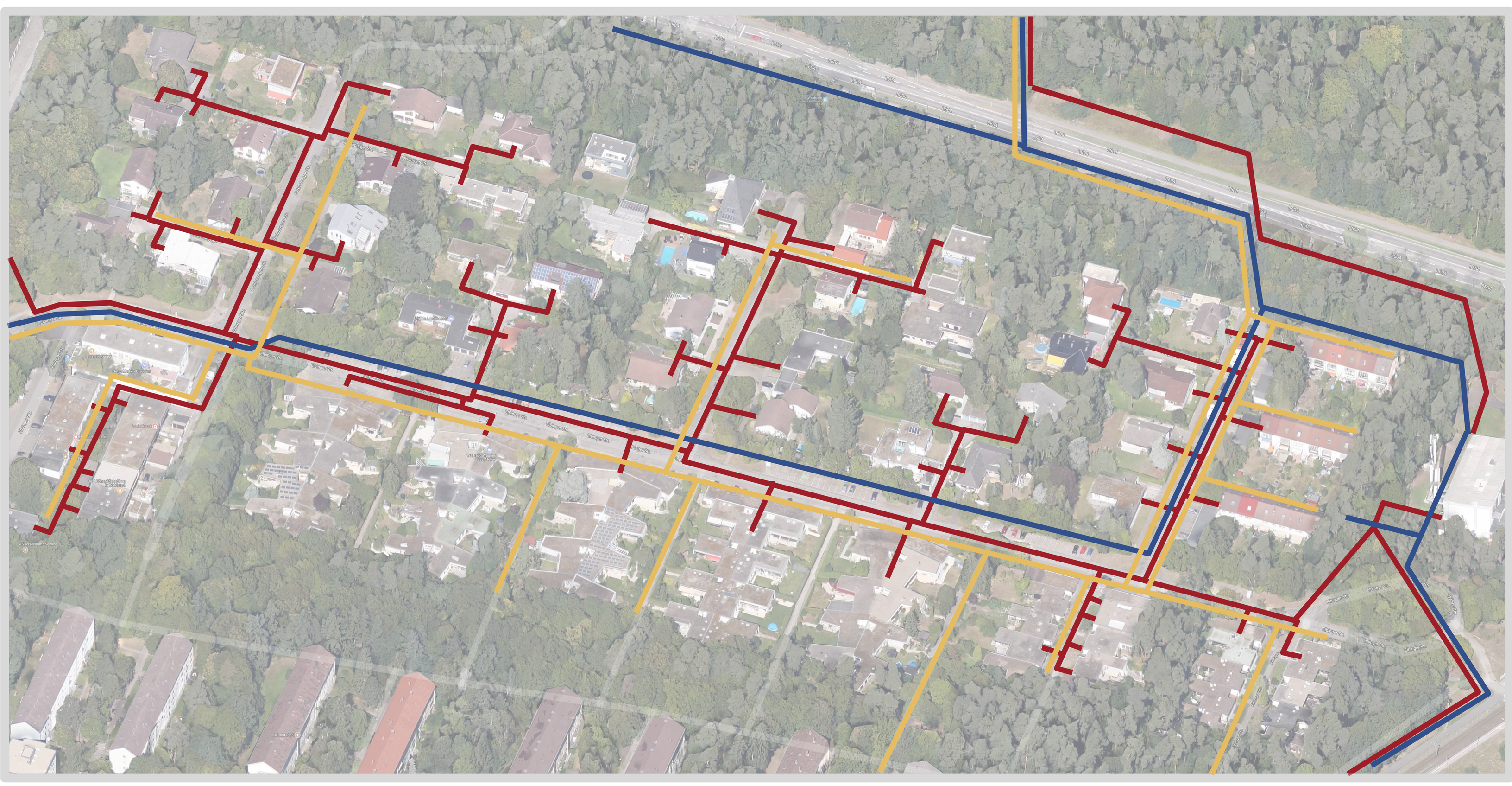
Steady state modeling as a graph $M = (V, A)$

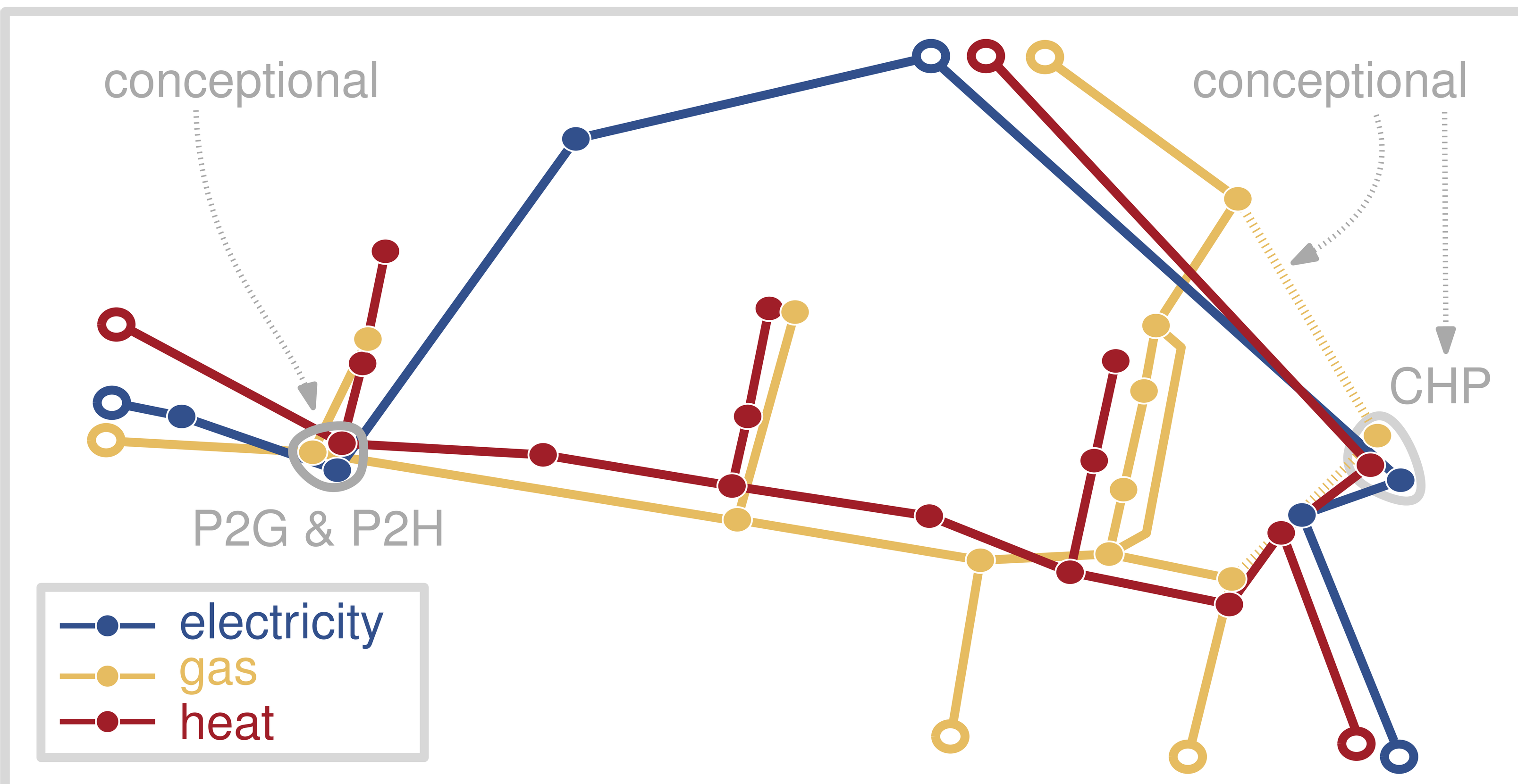
- V: set of vertices
- $V_i \subseteq V$: set of transfer vertices of carrier $i \in [1, k]$
- $V_C \subseteq V$: set of converters (e.g. CHP, P2X)
- $V_T \subseteq V$ set of disturbances
- $A \subseteq \binom{V}{2}$: set of edges

Vertices and edges are related to *effort* and *flow variables*:

	Electricity	Natural Gas	Heat
effort e	voltage U	pressure p	pressure p
flow f	current I	flow Q	flow Q







Future Work

- Derivation of an observability criterion for MEDNs
- Determination of a cost-optimal sensor placement

Literature

[1] Geidl and Andersson: A modeling and optimization approach for multiple energy carrier power flow. In: IEEE Power Tech, Russia (2005)

[2] Baldwin et al.: Power system observability with minimal phasor measurement placement. IEEE Transactions on Power Systems 8(2), 707–715 (1993)