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Centre for IT Intelligent Energy Systems

DTU Electrical Engineering
Department of Electrical Engineering

Use cases for integrated electrical and thermal energy systems operation and control with a view on simulation tools.

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WP4.1 Develop methodologies for aggregated simulation, based on detailed models from WP1 and WP2. Investigate methods for classification and aggregation of such components, including the network and associated constraints, and express the technologies at more generic, statistical and scalable levels.

Problem statement

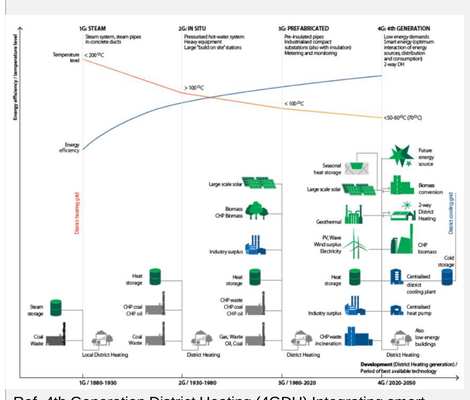
There is a general lack of knowledge regarding energy systems coupling and few well-defined use cases (UCs) that properly describe the operation of such set-up. Domains integration increases complexity due to additional operational, physical, temporal and spatial constraints making it challenging for analysis and simulation but also for designing operational strategies (i.e. control).

Research question

What use cases are the most representative of integrated electro-thermal energy systems, why are they challenging and how to simulate/analyze them?

Background

The Uses Cases (Ucs) presented are designed with respect to the 4th Generation of District Heating (4GDH) and the smart grid which are the next important step for the heating and electrical domains respectively.



Ref. 4th Generation District Heating (4GDH) Integrating smart thermal grids into future sustainable energy systems – Lund et all

Why integrated electro-thermal systems?

- Integration of the DH network and the electrical grid at distribution level (local)
- Use electricity to access low temperature heat source and convert it to useful heat (i.e Heat pumps)
- Support fluctuating renewables penetration into the electric grid
- Enable flexibility from high inertia in the DH network
- Proliferation of power to heat technologies
- Distributed energy resources
- Support DH network operation and control
- Support DSO on operation and control of electrical distribution grid
- Emergence of new markets (i.e Enthalpy pricing for heat)
- Increase consumer comfort
- Decrease operational cost
- Novel way of dimensioning networks

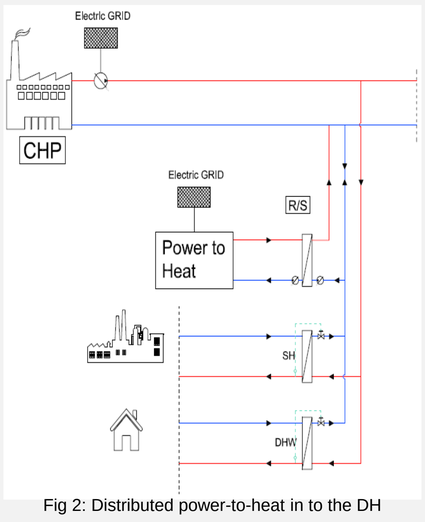


Fig 2: Distributed power-to-heat in to the DH

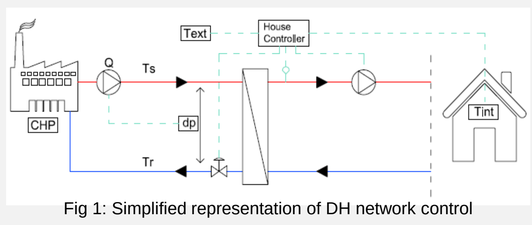


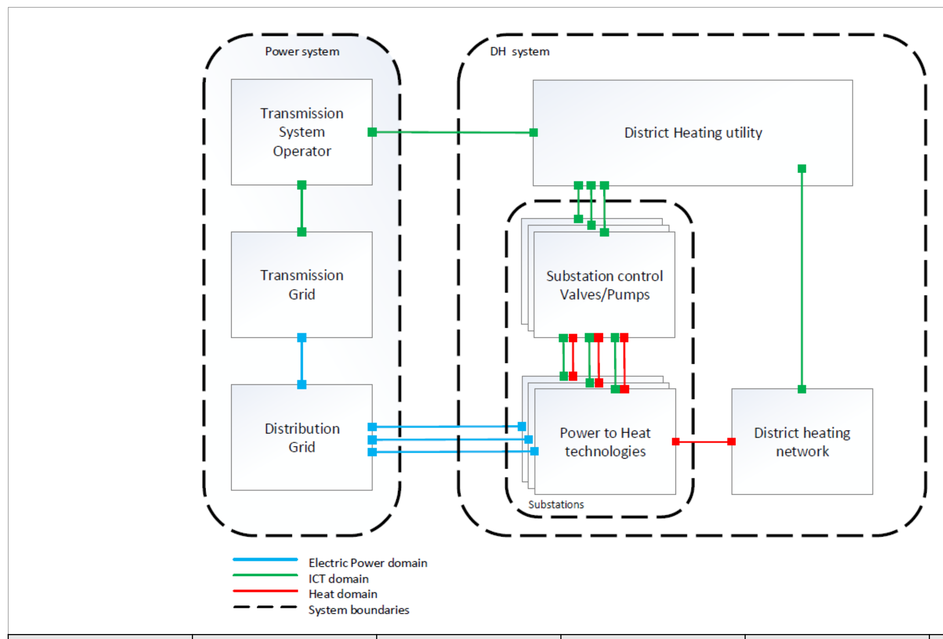
Fig 1: Simplified representation of DH network control

Challenges?

- Gap in operational time scale
- Correlation of different uncertainties
- Consumers in DH network have some control capabilities (***Figure 1***)
- Coupling energy components are given many control strategies
- Multi-level repercussions from one domain into another

Use Cases

- Decentralized feed-in (waste heat from supermarket refrigeration) – **UC1**
- District heating providing ancillary services to the electrical grid (e.g regulating power by dumping electricity as heat) – **UC2**
- Electrical system providing services to the heat distribution network (e.g electrical booster heaters covering peak demand) – **UC3**



Name	Electrical network	Thernmal network	Simulation	Focus	Commercial
ESP-r	Detailed	Simplified	Yes	Building performance	No
Polysun	Simplified	Detailed	Yes	Solar panels	Yes
TRNSYS	Simplified	Detailed	Yes	Multi-domains	Yes
IDEAS lib	Detailed	Simplified	Yes	Transient of thermal and electrical system	No
LBNL lib	Detailed	Simplified	Yes	Building library	No
EnergyPRO	Detailed	Detailed	No	Techno-economic design, analysis and optimization	Yes
Neplan	Detailed	Detailed	Yes	Network	Yes
SynCity	Simplified	Simplified	No	Optimal building placement, activity locations, transport	No
EPIC-HUB	Simplified	Simplified	No	Energy flow based on energy hubs	-
MEU	Simplified	Simplified	No	Web platform scenario based demand/supply	No
SimRen	Detailed	Detailed	Yes	Independent detailed models for energy demand and management	Fee
HOMER	-	-	Yes	Micro power design tool	No/Yes

There is no existing tool that would be suitable for a holistic analysis of the different Use Cases . A single tool might not be desirable after all since some part of the energy system can/should be simplified/abstracted when analyzing its different functions. Multi-domain modelling environments, such as Modelica based platforms are interesting and flexible candidates. Additionally, co-simulation through FMI would be an interesting track since it allows different modelling environments to interact and run at the same time (FMI for co-simulation not model exchange).

MODELICA fmi FUNCTIONAL MOCK-UP INTERFACE

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