FLEXIBILITY IN DISTRICT HEATING SYSTEMS

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A suitable definition and model to describe the temperature and energy flexibility

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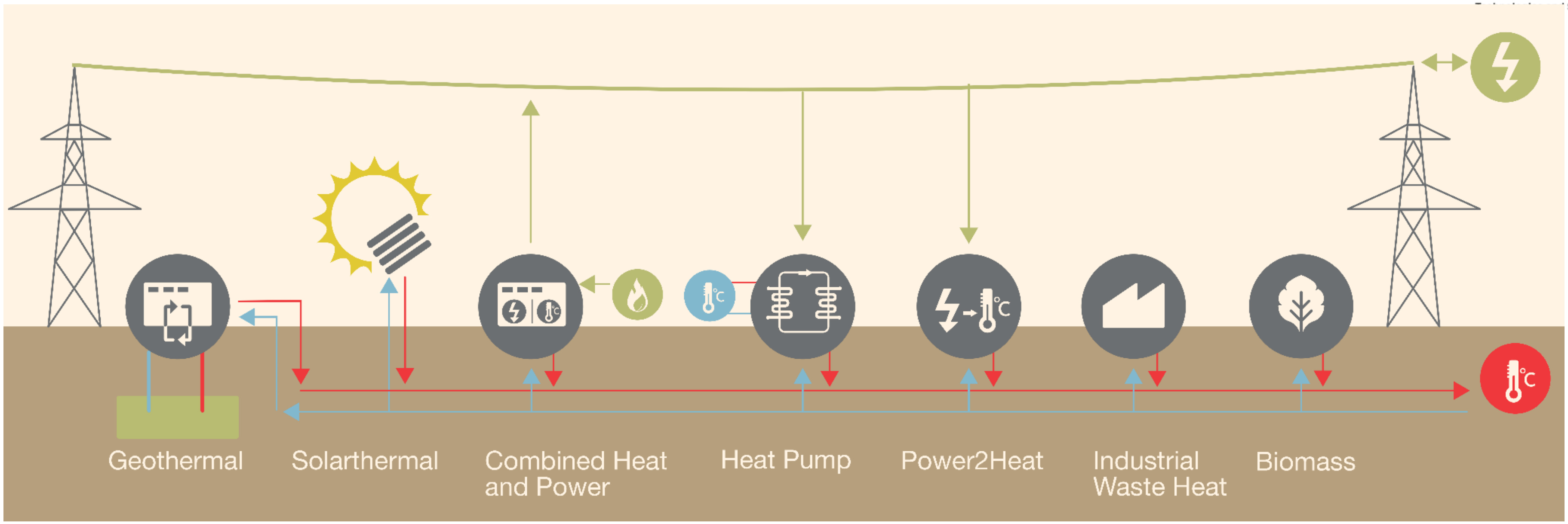
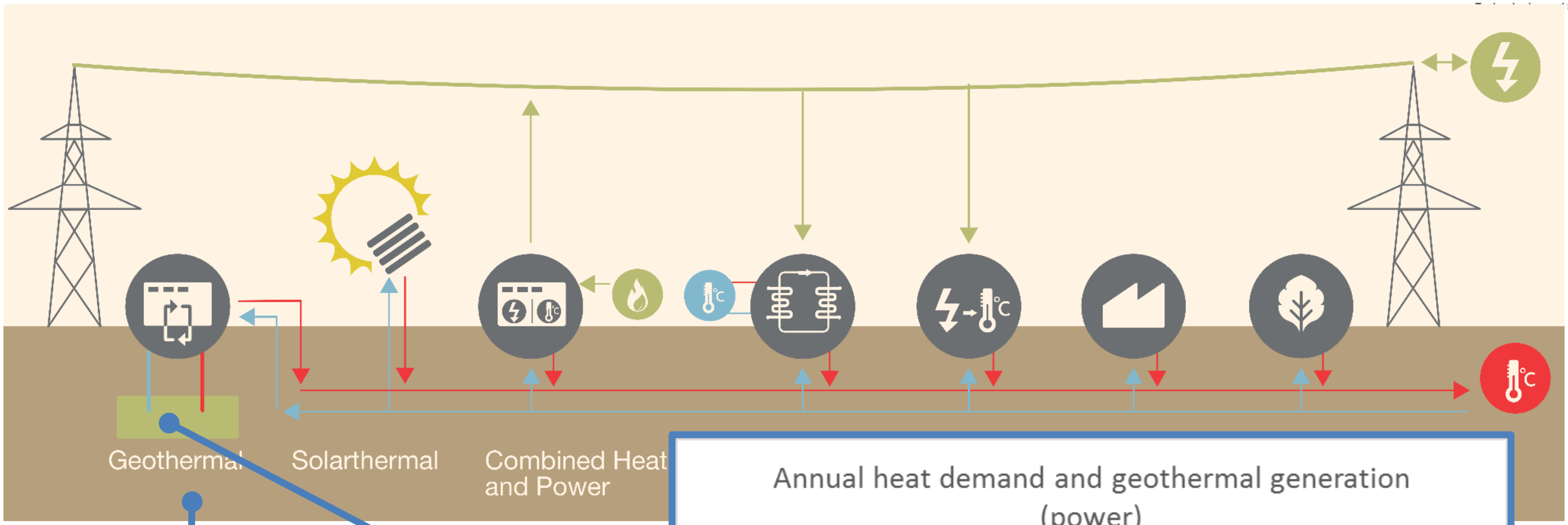
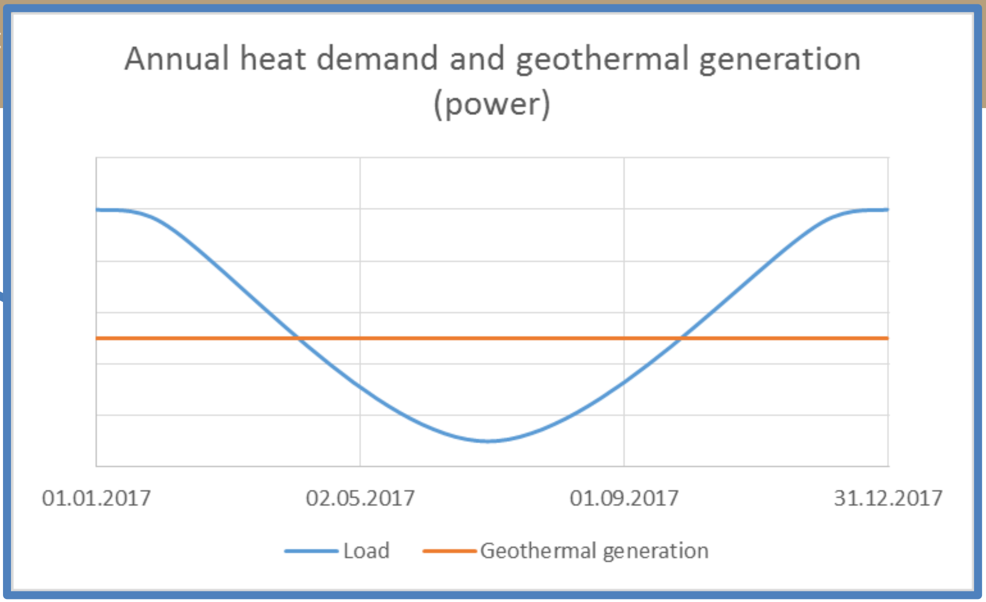
Challenges with renewable generation



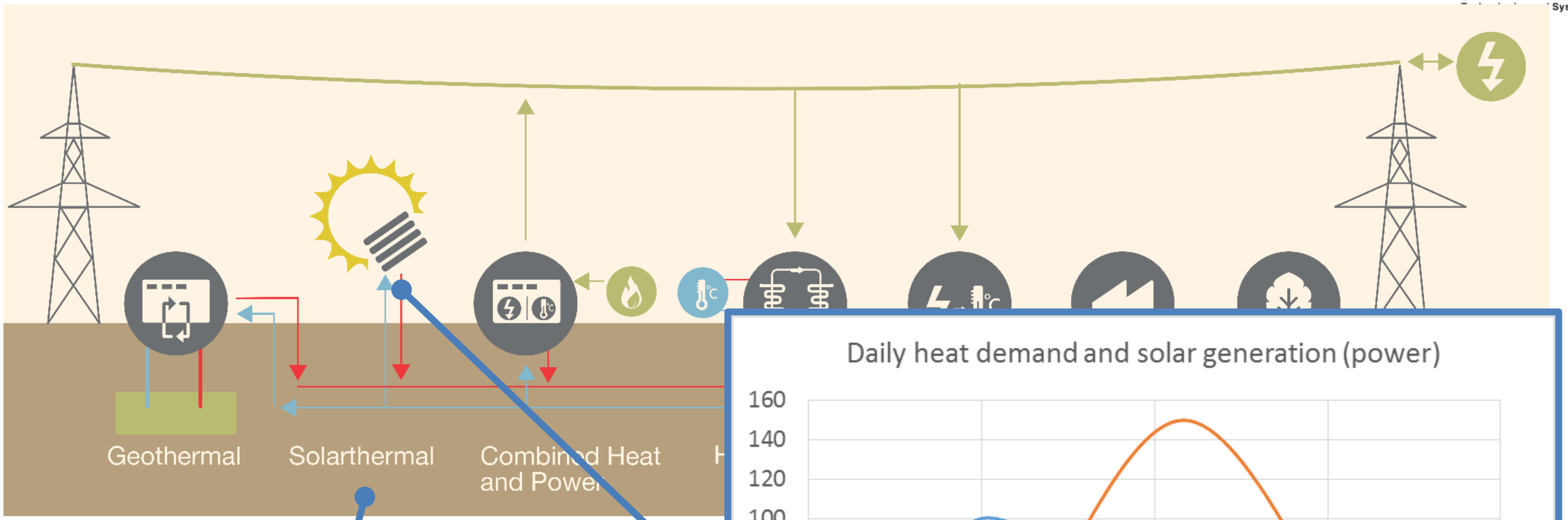
Challenges with renewable generation

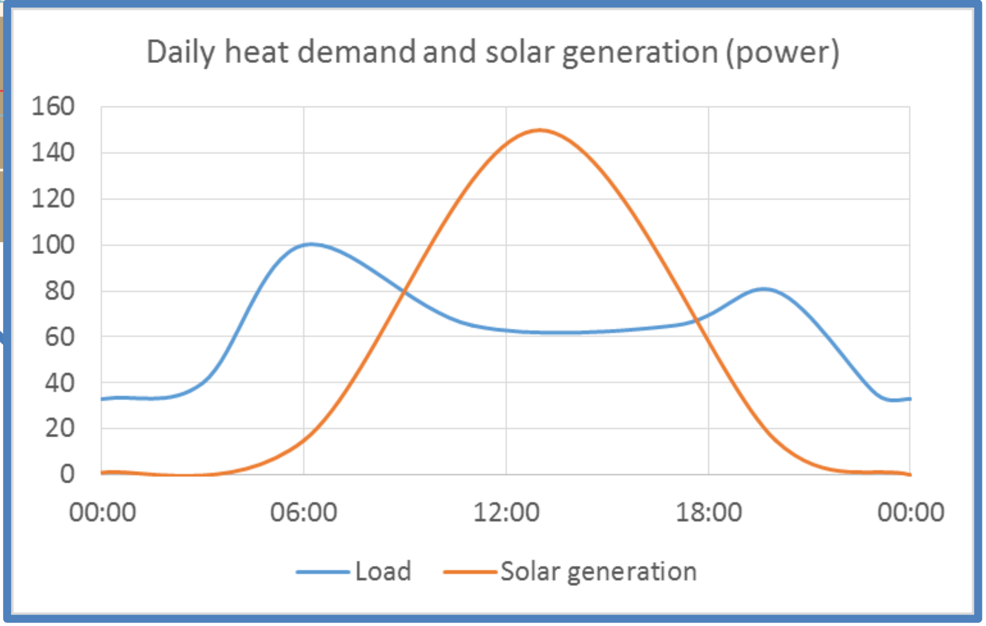




Base load generator

Challenges with renewable generation





Availability not synchronous with demand

Definition of flexibility

Flexibility: "Easily changed to suit new conditions"

(Oxford Dictionary)

Flexibility is not fixed to a physical quantity.

→ *It is a property of a chosen physical quantity.*

Energy Flexibility is "the ability to modify energy generation or consumption of a system in response to external […]" [conditions]

(Fischer et al.: "Model-based flexibility assessment of a residential heat pump pool", Elsevier Energy, 2016)

Typical flexibility model in thermal systems

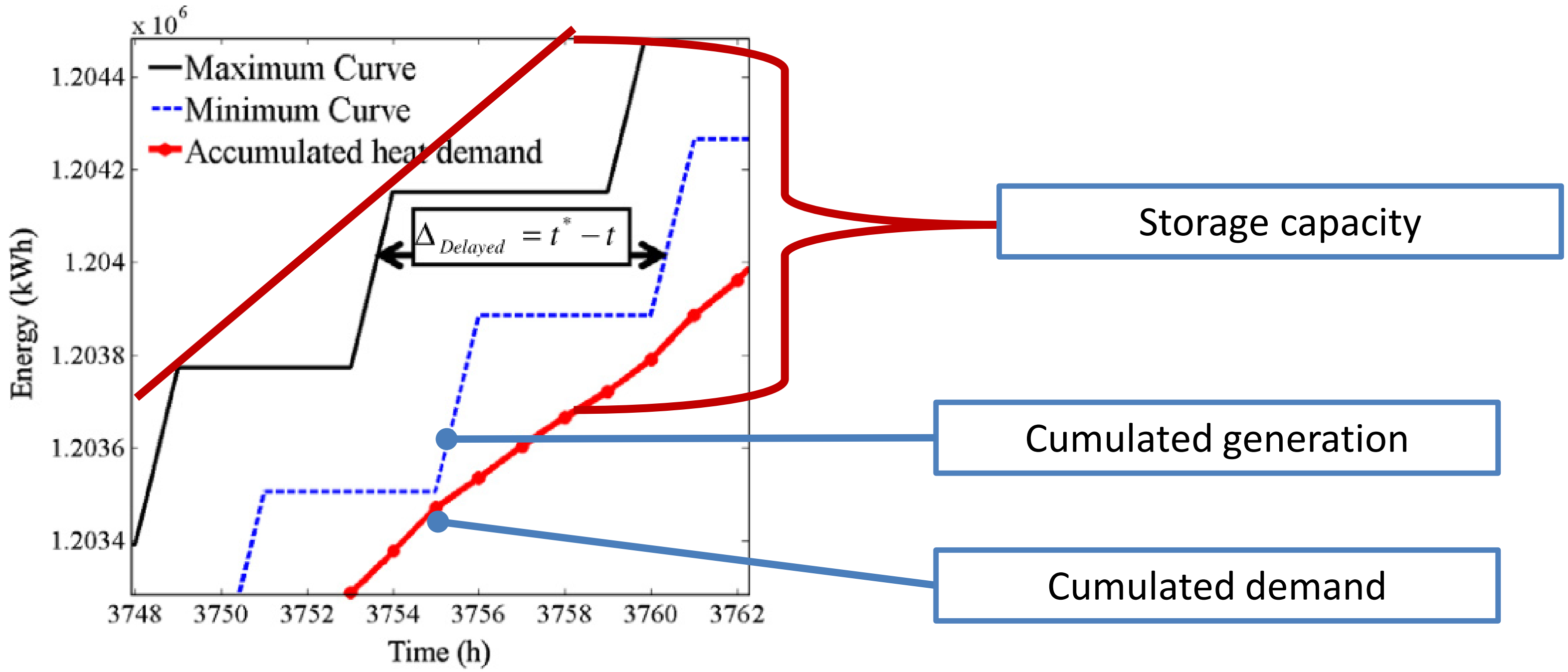


Fig. 1. Definition of the (left) delayed and (right) forced operation flexibility Δ.

(Nuytten et al.: "Flexibility of a combined heat and power system with thermal energy storage for district heating", Elsevier Applied Energy, 2013)

Example model in electrical systems

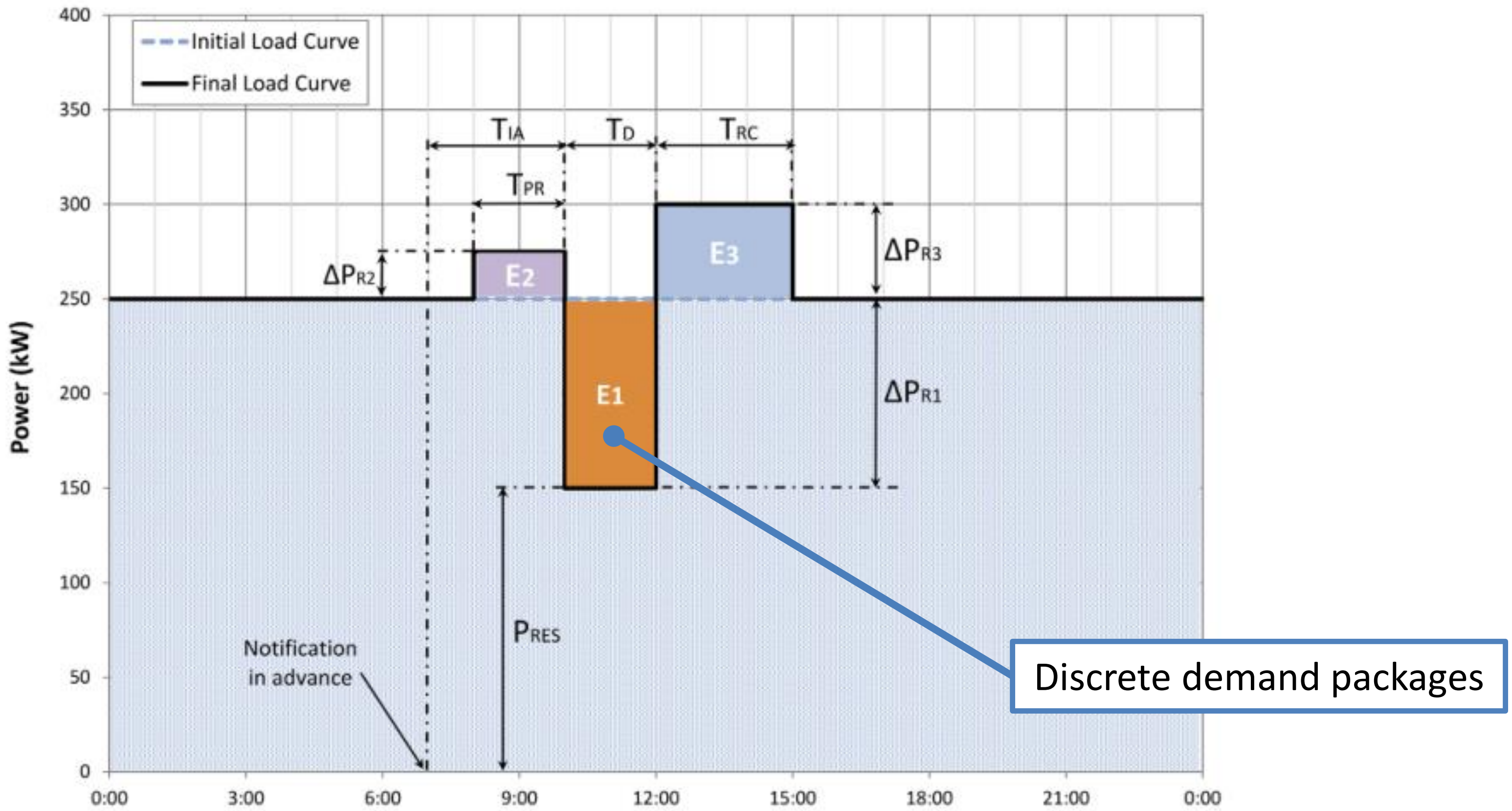
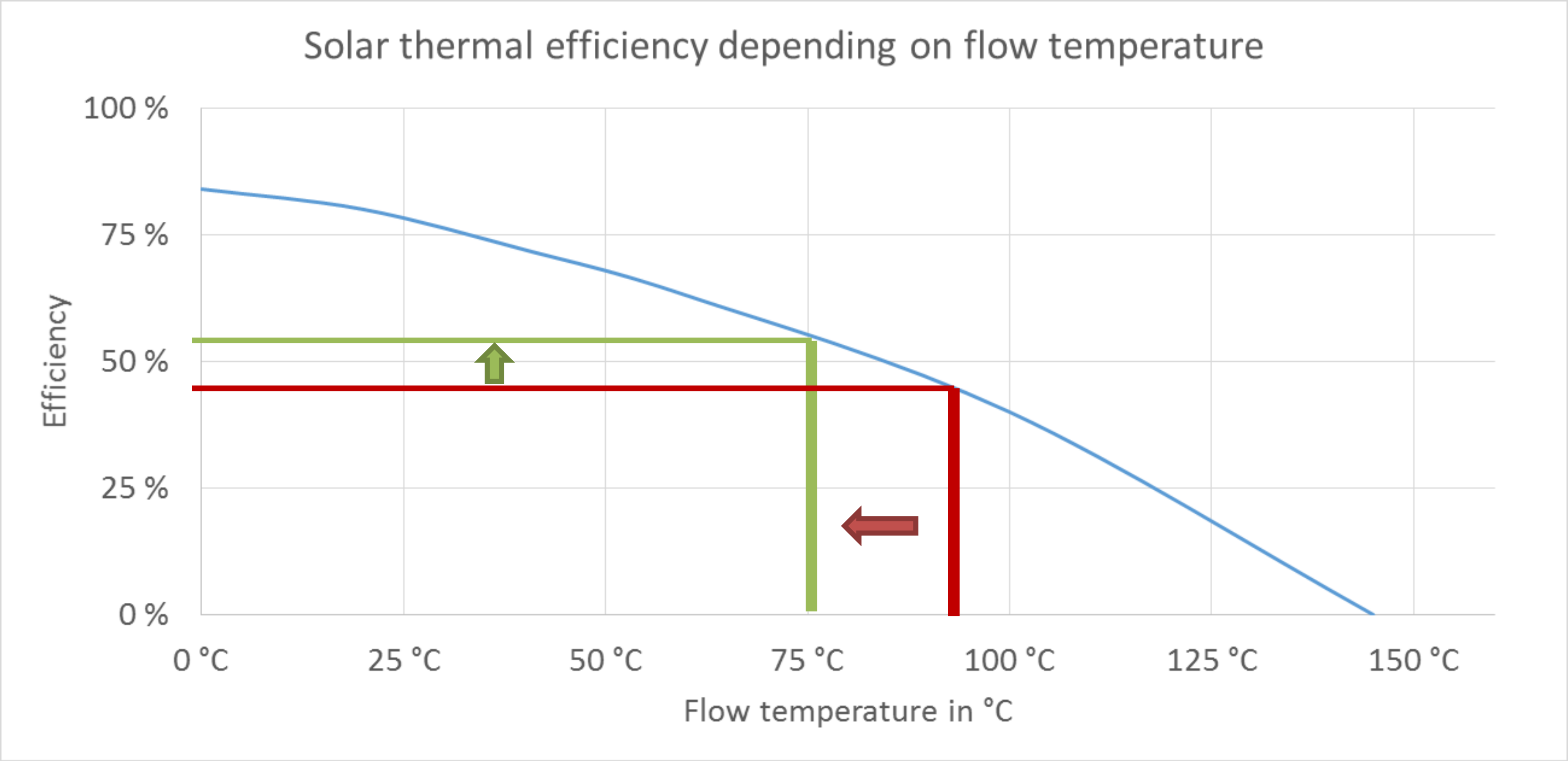


Fig. 4. Technical parameters proposed to define DR actions (source: project DRIP).

(Rodríguez-García et al.: "A novel tool for the evaluation and assessment of demand response activities in the industrial sector", Elsevier Applied Energy, 2013)

Problem of existing thermal models



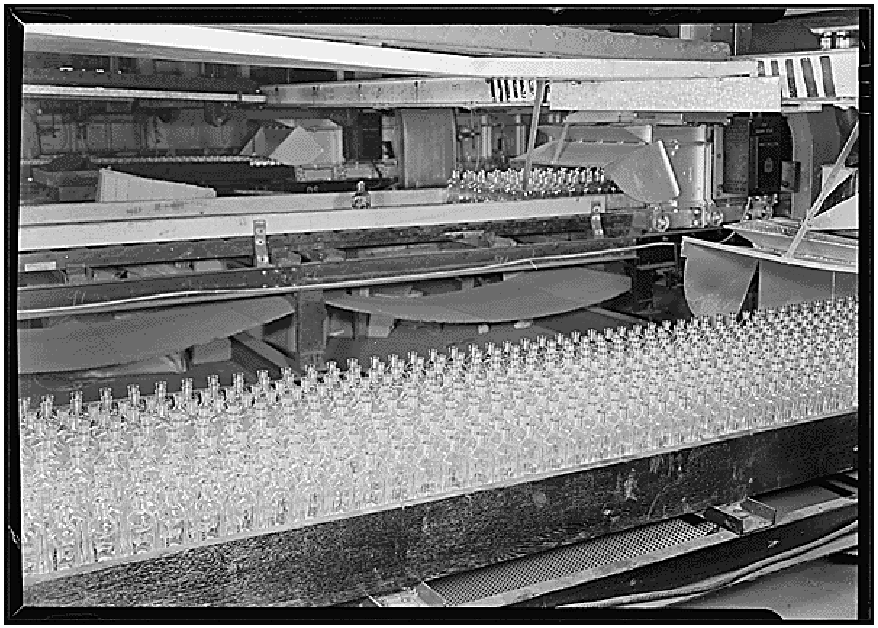
→ Flexibility in thermal systems should include **quantity AND quality** of energy
= energy and temperature

Flexibility definition in production systems

Flexibility theory is used in production systems for more than 40 years.

Definition: ***"Adaptability of production systems to changing responsibilities"***
(Hans Corsten: „Produktionswirtschaft"; Oldenbourg; Munich 1996)

Flexibility in quantity of products



(Lewis Wickes Hine: "Millville, New Jersey - Glass bottles"; research.archives.gov/description/518673, 12/11/2018)

Flexibility in quality (state) of products

(Steve Jurvetson: "Tesla Autobots"; CC BY 2.0 Licence; https://www.flickr.com/photos/44124348109@N01/6219463656, 12/11/2018)

Opportunistic coordination in production systems

Principle of opportunism

- Consider all degrees of freedom
- Detecting all alternatives
- Resource-capacity

→ „Smart“ system: knowledge of subsystem‘s potential

→ No early data aggregation: separated planning of temperature and energy

Principle of least commitment

- Point of time to decide
  - Time based: latest point of time with least loss of flexibility
  - Content: most flexible alternative

→ Use the most economical flexibility

(Hans Corsten: „Produktionswirtschaft“; Oldenbourg; Munich 1996)

Flexibility definition in DHS

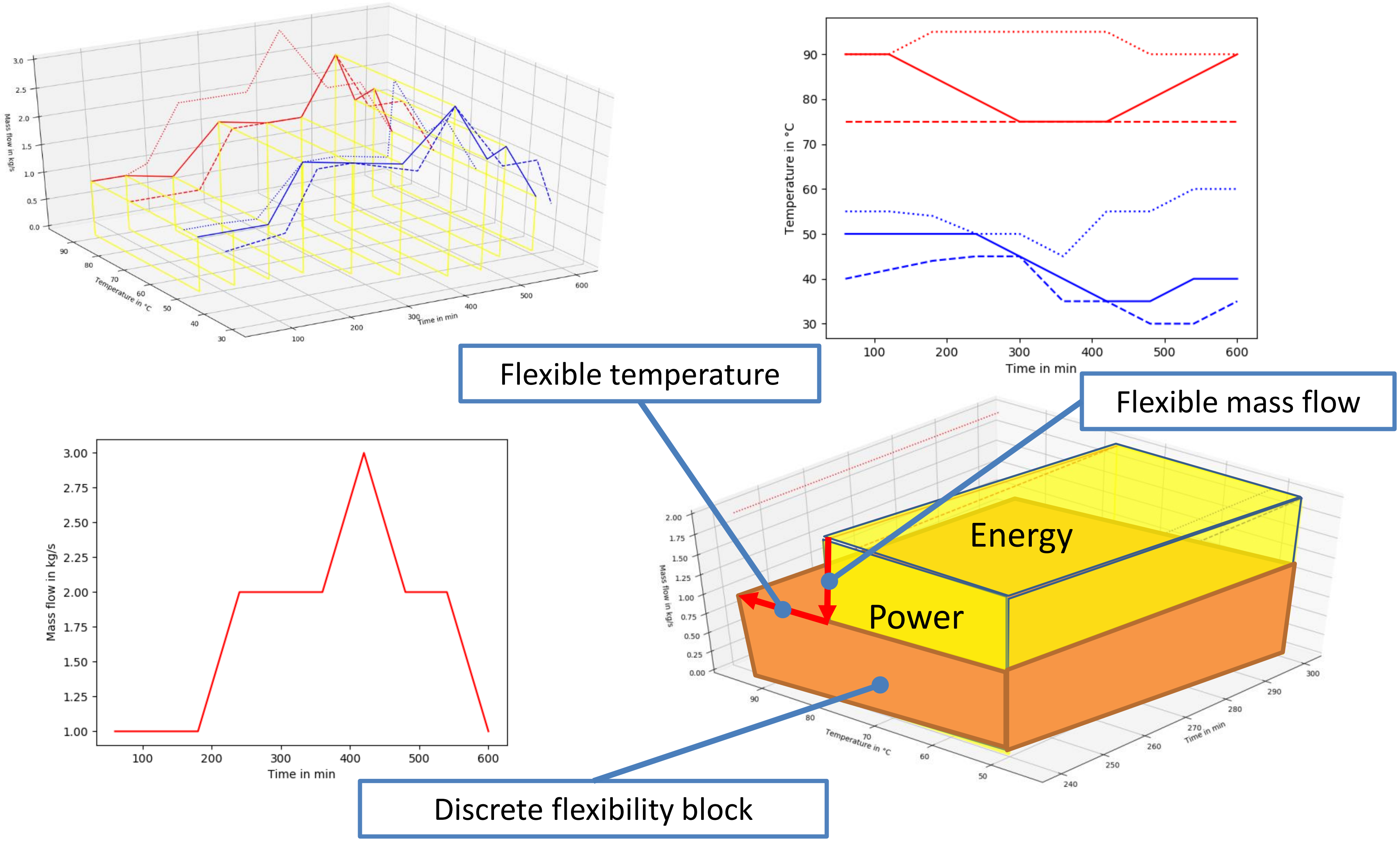
The Energy and Temperature Flexibility of District Heating Systems

is the ability to modify

energy and temperature level of generation or consumption

in response to external conditions.

Flexibility model



Categories of flexibility

	Seasonal flexibility	Mid-term flexibility	Short-term flexibility
Water storages	Buffers • Aquifer • Surface basin	Buffers • Central tanks	Infrastructure • Pipes of the grid • Consumer: Hot domestic water tanks
Sector coupling	Shifting to gas grid • Boiler • CHP	Shifting to gas / electrical grid • Boiler • CHP • Heat pumps	Shifting to gas / electrical grid • Boiler • CHP • Heat pumps
Other media storages	Chemical / biomass (primary energy) • Biomass boiler		Air and building mass (demand side) • Intelligent HVAC • Digital radiator valves
	Different volumes	→	**Different temperatures**

Time horizons in district heating systems

Long term planning
- → **Average system temperatures**
- → Frequency: 1 a
- → Scope: >10 a
- → Interval: 1 d

Day ahead planning
- → **Forecasted temp.**
- → Frequency: 1 d
- → Scope: 14 d
- → Interval: 1 h

Intraday planning
- → **Interaction of temperatures**
- → Frequency: ¼ h
- → Scope: 1 d
- → Interval: ¼ h

>10 a | 1 a | 1 d | ¼ h

>10 a
- Investments
- Customer contracts

1 a
- Seasonal storages
- Raw material trading
- Ecologic KPIs

1 d
- Interaction with electrical markets
- High forecast accuracy

¼ h
- **Integration of temperature flexibility**
- Integration of customer-plant
- Prices for temperature levels

Requirements to Smart Thermal Grids

- Flexible quantity and quality of energy: Energy and Temperature
- Energy flexibility has 3 dimensions: mass flow, temperature and time
- Principle of opportunism: Smart thermal grid (measurement & actors)
- Principle of last commitment: Use the most economical flexibility
- Different planning horizons for energy and temperature

→ Detailed optimization and trading becomes possible

Thank you for your attention!

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→ Find "Smart Heat Grid Hamburg" on **youtube**!

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