Simulation-based assessment of energy flexibility offered by the thermal capacity in district heating network pipes

Annelies Vandermeulen
Tijs Van Oevelen
Bram van der Heijde
Lieve Helsen
Context
Network flexibility:
To use the thermal inertia of the water contained in the pipes to shift the plant heat load in time.

1 Charge period
2 Discharge period
3 Rebound period
Research goal

How sensitive is the available network flexibility to the control parameters?

Control parameters:

- $t_{\text{pulse}}$
- $\Delta T_{\text{sup}}$
Network model: Modelica

- Aggregated model of Waterschei (Belgium) – 1500 buildings
  - Single building (Aggregated heat demand profile) [1]
  - Extensive substation model

- Pipe: validated plug flow model [2]
- Plant: no ramping and power output constraints


Simulated cases

Seasons:
- Winter
- Spring
- Summer

Scales:
- 1500 buildings
- 150 buildings
- 15 buildings

Control parameters:
- $t_{\text{pulse}}$
- $\Delta T_{\text{sup}}$
Methodology

Quantification of network flexibility:
By simulating two cases:

1) No flexibility: constant temperature
2) Flexibility: pulse temperature

1 Charge period
2 Discharge period
3 Rebound period
Variations of $t_{\text{pulse}}$

- Short Charge
  - $\Delta T_{\text{sup}} = 9^\circ \text{C}$
  - $t_{\text{charge}} = 5 \text{ min}$

1 Charge period
2 Discharge period
3 Rebound period

Plant

- Temperature [°C]
- Heat flow rate [kW]

Building

- Temperature [°C]
- Mass flow rate [kg/s]
- Heat flow rate [kW]
Variations of $t_{\text{pulse}}$

1. Charge period
2. Discharge period
3. Rebound period

Optimal Charge

$\Delta T_{\text{sup}} = 9^\circ\text{C}$
$t_{\text{charge}} = 35\ \text{min}$
Variations of $t_{\text{pulse}}$

1. Charge period
2. Early discharge period
3. Discharge period
4. Rebound period

Long Charge

$\Delta T_{\text{sup}} = 9^\circ\text{C}$
$t_{\text{charge}} = 60 \text{ min}$

Plant

Building

Temperature [°C]

$T_{\text{sup}}$

$\Delta T_{\text{sup}}$

$t_{\text{up}}$

$t_{\text{down}}$

Time [h]
Variations of $t_{\text{pulse}}$

![Diagram showing variations of $t_{\text{pulse}}$ with time and temperature parameters.]

- $t_{\text{up}}$ and $t_{\text{down}}$ represent the time periods for the pulse.
- $T_{\text{sup}}$ is the supply temperature.
- $\Delta T_{\text{sup}}$ is the temperature change.

![Bar chart showing discharged energy for different pulse durations.]

- Discharge period vs. Early discharge period.
- Short, Optimal, and Long durations are shown.

---

5th International Conference on Smart Energy Systems
Copenhagen, 10-11 September 2019
#SESAAU2019
Conclusions

Characterization of supply temperature pulse response:
- **Charge period**
- **Discharge period**
- **Rebound period**

To activate network flexibility: Limited charge duration is important to prevent early discharging
Questions?
Variations of $\Delta T_{sup}$

1 Charge period
2 Discharge period
3 Rebound period

$t_{charge} = 15\text{ min}$
Variations of $\Delta T_{\text{sup}}$
Variations of $t_{charge}$

- $t_{up}$
- $t_{down}$
- $T_{sup}$
- $\Delta T_{sup}$

Discharge period
Early discharge period

Discharged energy [kWh]

Heat flow rate [kW]

Short | Optimal | Long