# A data-driven approach for fast and accurate dynamic simulation for district heating networks

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#### Content

- Background introduction
- Physical model for district heating system simulation
- Neural networks and LSTM algorithm
- Results



#### Thermal inertia effect in the piping system



Pipe outlet temperature comparison

Pipe: DN50, 100 m

 $\dot{m} = 0.1 \text{ kg/s}$ 



Thermal Inertia Factor =  $\Delta T/T_{ref}$ 

 $\Delta T$ : response time difference

T<sub>ref:</sub> response time without thermal inertia



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#### Physical model for district heating system simulation



$$\frac{\partial T^{c}}{\partial t} = \alpha^{c} \frac{\partial^{2} T^{c}}{\partial x^{2}} + \frac{1}{R_{ic} V_{c} \rho_{c} c_{p_{c}}} (T^{i} - T^{c}) - \frac{1}{R_{cg} V_{c} \rho_{c} c_{p_{c}}} (T^{c} - T^{g})$$

$$\frac{\partial T^{i}}{\partial t} = \alpha^{i} \frac{\partial^{2} T^{i}}{\partial x^{2}} + \frac{1}{R_{si} V_{i} \rho_{i} c_{p_{i}}} (T^{s} - T^{i}) - \frac{1}{R_{ic} V_{i} \rho_{i} c_{p_{i}}} (T^{i} - T^{c})$$

$$\frac{\partial T^{s}}{\partial t} = \alpha^{s} \frac{\partial^{2} T^{s}}{\partial x^{2}} + \frac{1}{R_{ws} V_{s} \rho_{s} c_{p_{s}}} (T^{w} - T^{s}) - \frac{1}{R_{si} V_{s} \rho_{s} c_{p_{s}}} (T^{s} - T^{i})$$

$$\frac{\partial T^{w}}{\partial t} + v \frac{\partial T^{w}}{\partial x} = \alpha^{w} \frac{\partial^{2} T^{w}}{\partial x^{2}} - \frac{1}{R_{ws} V_{w} \rho_{w} c_{p_{w}}} (T^{w} - T^{s})$$

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#### Physical model for district heating system simulation



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- Recurrent neural networks and LSTM algorithm
- Result



### **RNNs and LSTM algorithm**

**Recurrent Neural Network (RNN)** 

Long short-term memory (LSTM)

![](_page_7_Figure_4.jpeg)

#### **Oscillations caused by sudden change**

![](_page_8_Figure_2.jpeg)

#### Hyperparameter tuning

![](_page_9_Figure_2.jpeg)

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## **Study in progress**

- More features need to be captured
- Computationally costly, simpler algorithms need to be tested

![](_page_10_Picture_4.jpeg)

# **Thank you!**

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![](_page_11_Picture_3.jpeg)

![](_page_11_Picture_4.jpeg)

![](_page_11_Picture_5.jpeg)

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![](_page_11_Picture_7.jpeg)

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![](_page_11_Picture_11.jpeg)

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