Methods for Identifying Critical Temperature for Control of Low-Temperature DH Systems

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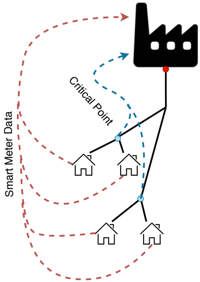
Outline

- Digitalization in District Heating
- Load Forecasting in District Heating
- Temperature Optimization in District Heating
- Usage of digitalization in District Heating

Digitalization in District Heating

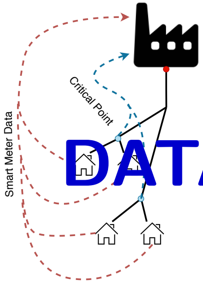


Data rich DH system:

- Large amount of available data from the production, end-users and critical points in the network.
- Measurements of supply temp., return temp., flow, pressure, etc.
- Smart meter at the end-user are usually just used to charge the customer.
- Critical points are usually used to control pressure difference between supply and return for hydraulic modeling.

How can DH create value for the company and customers by utilizing all of the available data?

Digitalization in District Heating



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DATA DRIVEN MODELS

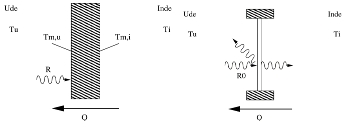
How can DH create value for the company and customers by utilizing all of the available data?

Methodologies for Data-Driven Models

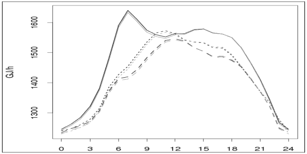
- Statistical Modeling
- Artifical Intelligence
- Physical Modeling
- Big Data Analytics tools

By using these methodologies, we can create value from the district heating data by formulating new grey-box models based on the data and physical intelligence of the network. Thus, **Data-Driven Models** enables to increase the savings and the efficiency of the DH network.

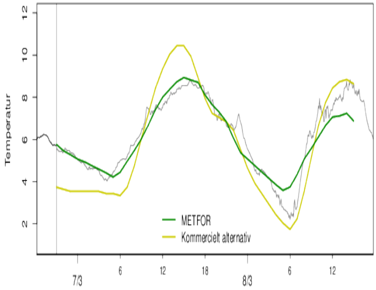
Physical Modeling



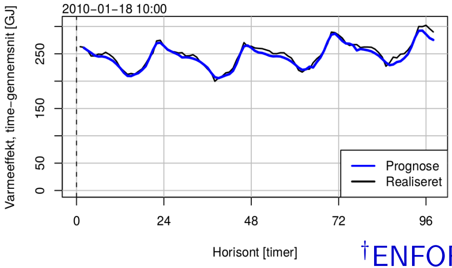
Statistical Modeling



Weather Forecast†

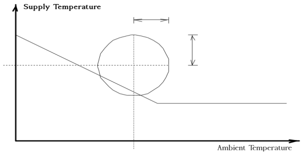


Heat Load Forecast†

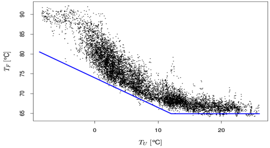


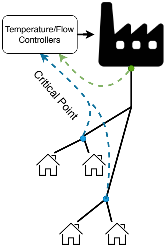
†ENFOR

Uncertainty



Real data





- Listen to the grid, by **identify** few of the lowest temperature (critical) in the grid and optimize based on the *grid feedback*
- Using controllers to **control** the *flow* and *supply* temperature from the production
- **Increase** the flow, $[m_t]$ before increasing the temperature to produce the requried heat load, $Q_t = m_t c_p \Delta T_t$
- Regulating the flow first will increase the **savings** of the production

Savings by using Temperature Optimization

- The objective of utilizing the data and create data-driven models is to increase the savings for the district heating company.
- A new report shows there is a potential of saving about 240-790 Million DKK yearly by reducing the temperature of about 3-10 degrees using data-driven temperature optimization*.
- More savings using intelligent heat control as the supply temperature is lowered

*Potentialet ved dynamisk datadrevet temperaturregulering i fjernvarmesektoren, DANVAD Analytics & Dansk Fjernvarme, 2019-02

Usage Case of creating value from end-user data

How to use the end-user data to identify and create an artificial critical temperature.

Data - Kraftringen

The data was supplied by Kraftringen in realtion to the Smart Cities Accelerator project.

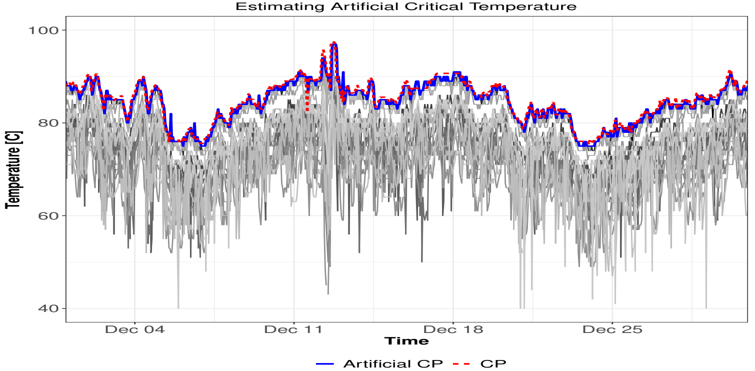
- Around 60 houses located in Lund.
- Three different set of houses behind a physical measurement.
- The smart data set include: Supply Temperature, Return Temperature, Flow, Total Energy.
- Hourly resolution over the period 01/10/2017 until 31/03/2018.
- The data were anonymized and the location of the houses is unknown.

The Smart Cities Accelerator (SCA)

- EU funded project through the regional programme Interreg-ÖKS
- A research and innovation partnership working with optimizing energy-systems away from fossile fuels towards a more sustainable future
- SCA involves 12 partners from universities, cities and companies in the Greater Copenhagen area and Skåne region who have ambitious agendas on becoming CO2 free in a close future
  - Copenhagen aims to be CO2 free by 2025
  - Malmö aims to be CO2 free by 2030
- Budget: 6.468.035 Euro / 50
- Period: 1. September 2016 – 28. February 2020
- Projectleader: DTU Compute

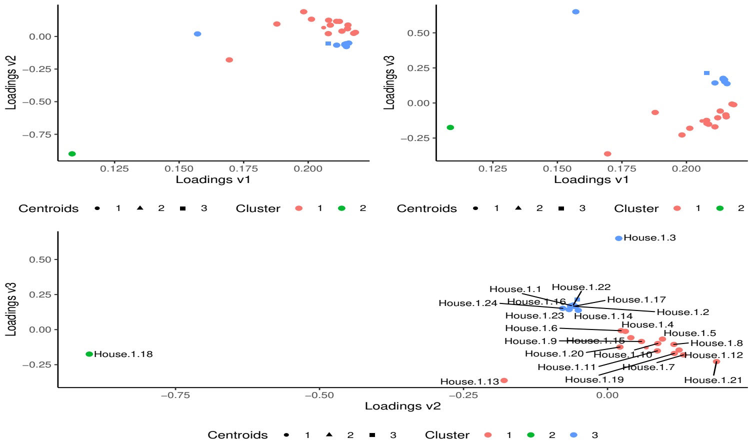
Interreg
Öresund-Kattegat-Skagerrak
European Regional Development Fund
EUROPEAN UNION

Artifical Critical Temperature



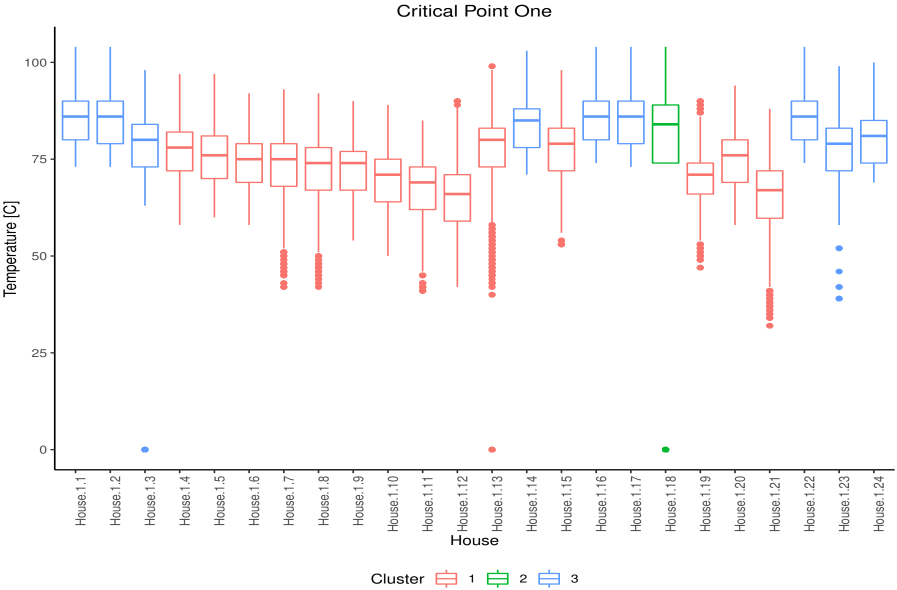
- By using the end-user smart meter measurements to estimate critical temperature or *Artifical Critical Temperature*.
- Utilizing the data from the end-users gives value to district heating company
  - Making the physical critical points redundant
  - More flexibility as the critical points can be moved in the grid with no effort

Clustering the supply temperature

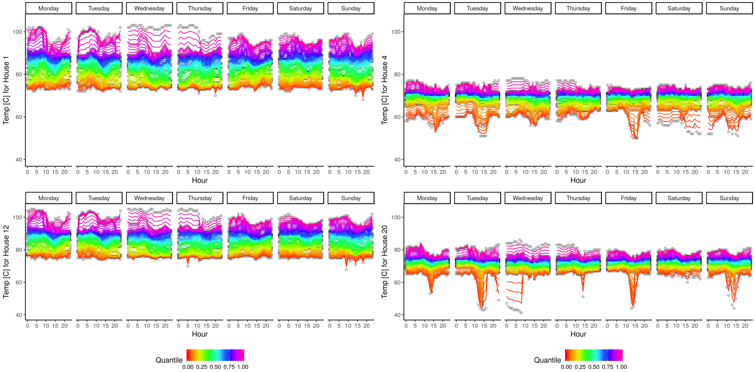


- Using *Principal Component Analysis* to cluster the houses together by using the eigenvector values as inputs for the *Kmeans*

Clustering the supply temperature

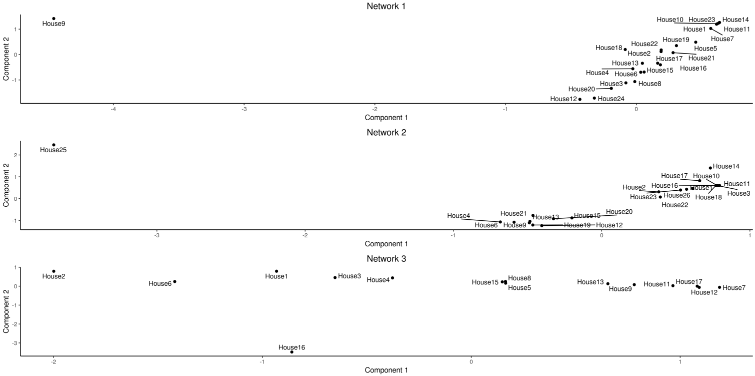


Time of the week distribution



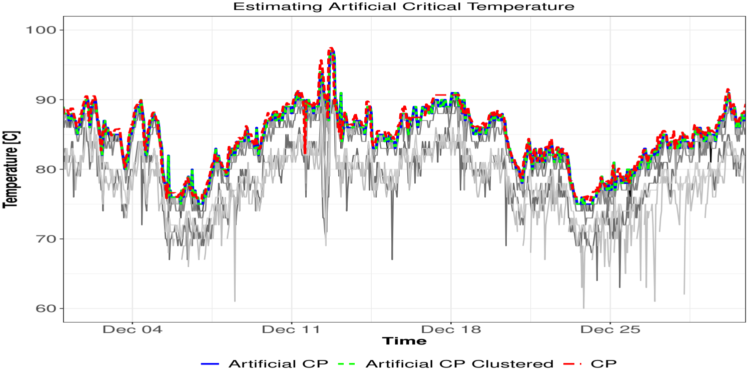
- Two different temperature zones behind one of the critical points
- Faulty pipe?, two different house types?, leakage?

Clustering



- Possible to cluster houses together based on the time-of-the-week distribution of their supply temperature using Jensen-Shannon probability distance metric. Then using Laplacian eigenmaps to cluster the houses together.
- Identify houses with problems, different temperature zones in the network, etc.

Artifical Critical Temperature using Clusters



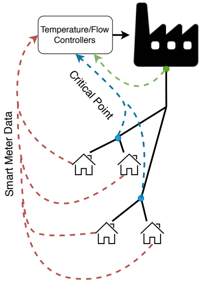
- Cluster houses together then taking the cluster with the highest median and create an artificial critical temperature based on them.

Multiple Temperature Zones inside a City

- Combining the current temperature optimization, HEATTO† and smart-meter data to control several different temperature zones inside a city
- Removing pre-selected critical points from the network using the meter data
- Controlling areas with new sustainable buildings with lower supply temperature and large old inefficient buildings with higher temperature
- Using temperature mixing and pressure pumps in the network

†ENFOR

Digitalization gives the opportunity of getting the end-users measurement in real-time which can be used for information, monitoring and control purposes.



Example of Value Creation from Digitalization in DH:

- **Identify** critical points in the network and creating artifical critical point, i.e. making the physical critical point *redundant*
- **Temperature optimization** using controllers with the *feedback* from the *end-users* in the grid.
- **Hierarchical** Temporal/Spatial Load Demand Forecast.
- Utilizing **local** weather stations to improve heat load demand forecast.
- **Clustering** to create multilevel temperature

Thanks

Thank you

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