



Aalto University

From partial optimization to overall system management

– Analysis of district heating consumption data after consumers implementing demand response actions

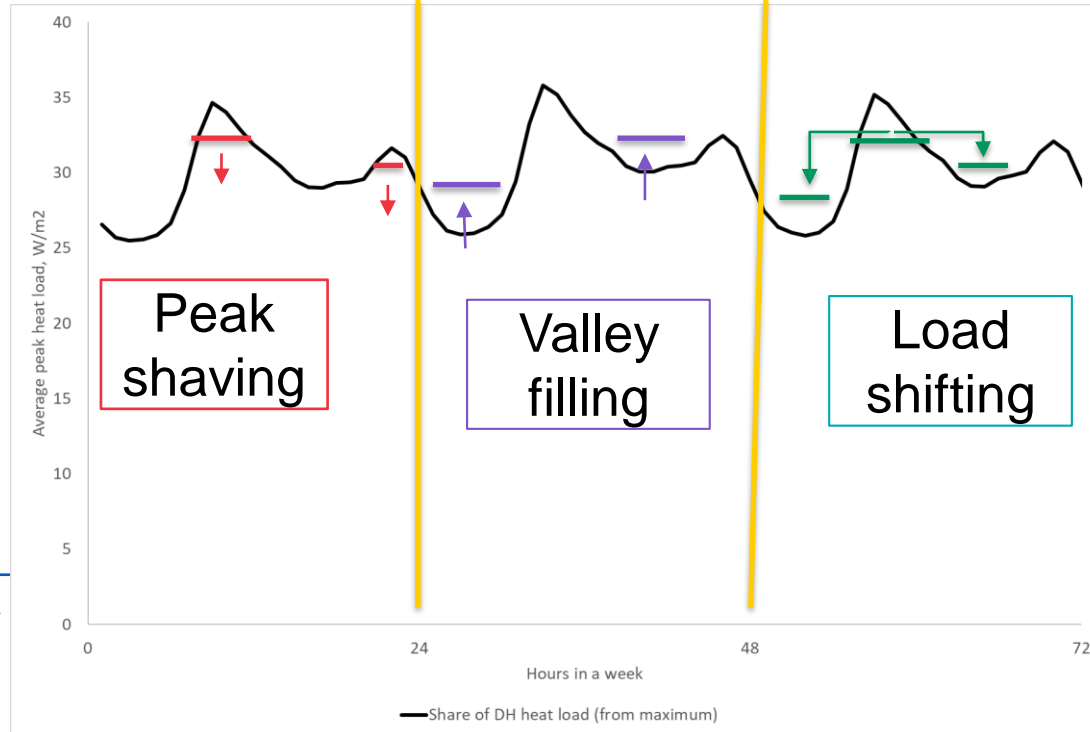
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Demand side management (DSM)

– what is it?

- Various approaches affecting the customer's traditional consumption profile



Benefits of DSM for different parties

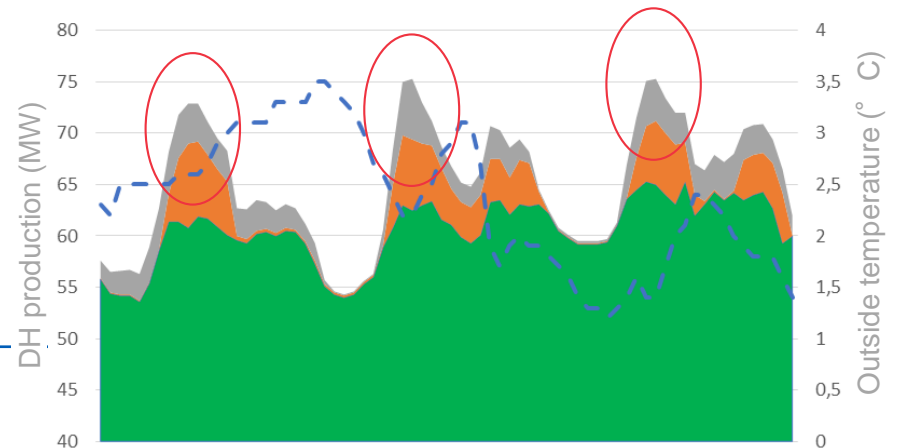
For customer and building owner

- Energy saving
- Lower energy costs
- Better indoor climate



DH Company / Energy system

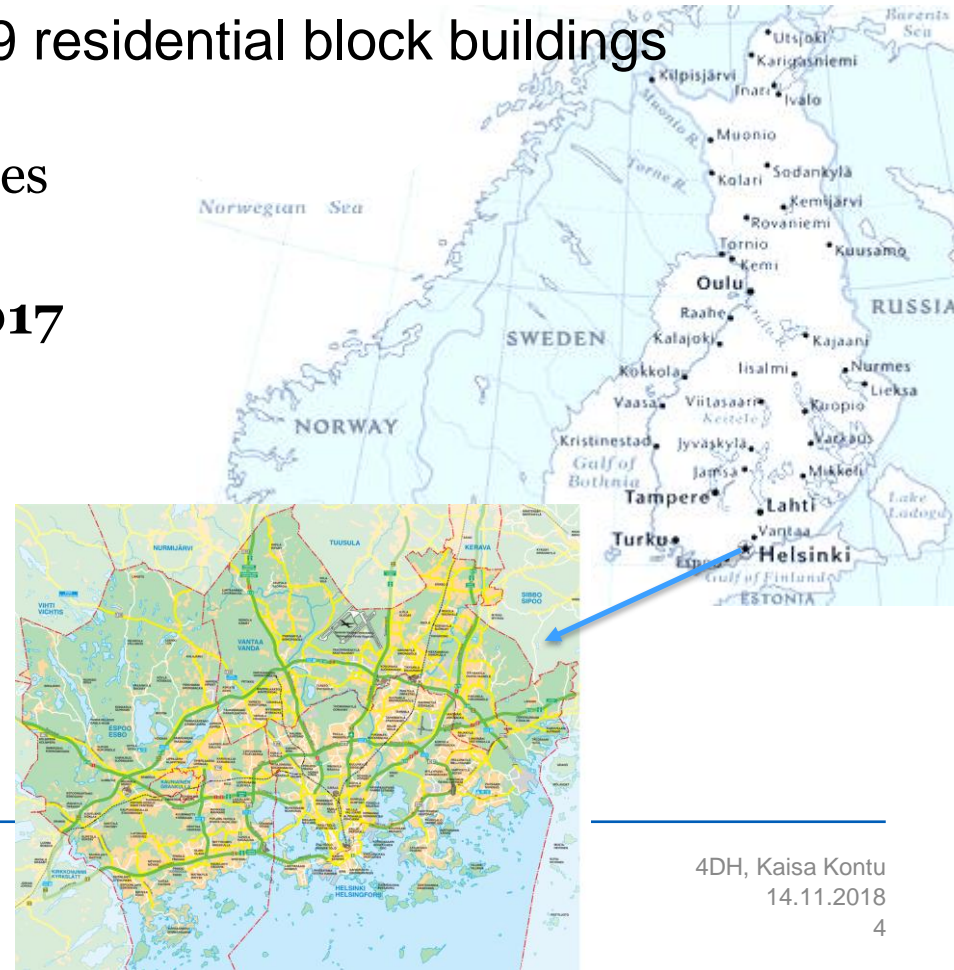
- Optimal production
- Cut peak load
- Eliminate bottlenecks in the district heating network



Data

Hourly consumption data from 109 residential block buildings

- located in neighbouring two cities in capital area of Finland
- data from **1.1.2014 – 31.12.2017**
- 31 had DSM implementations started in 2016
- other 78 were for comparison



Target of the study

- To analyze how DSM implementation affects the consumption profile of a customer

Customer and building owner

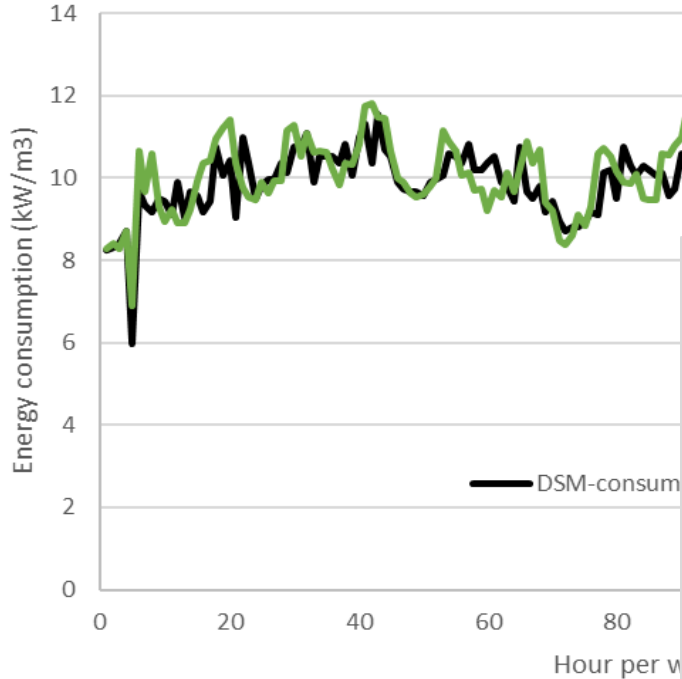
- Energy consumption
- Peak heat load

DH company / energy system

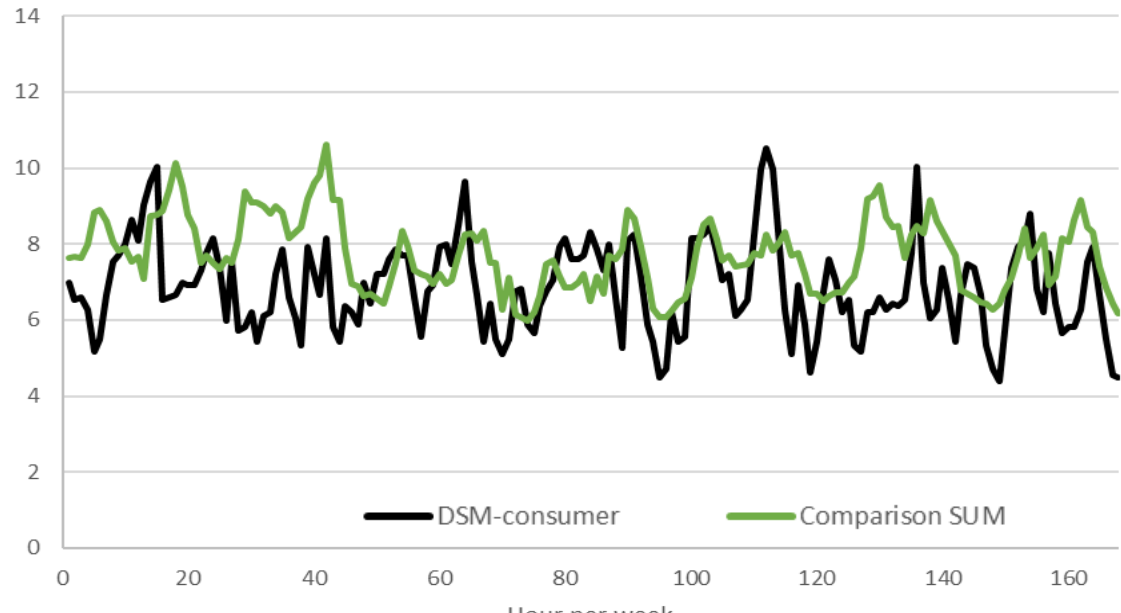
- Peak heat load
- Short-term heat load variation

Comparison – preliminary results

Winter week **before** DSM actions



Winter week **after** DSM actions



Parameters – Customer

- Normalized yearly heat consumption
- Yearly peak heat load, three hour average

To explain if customers with DSM have saved energy and costs compared to customers without any DSM implementation

Parameters – DH Company

- Annual relative seasonal variation
 - Consequence of annual large variations in outdoor temperatures between different seasons
- Annual relative short-term variation (4 and 24 hours)
 - Consequence of social component of the heat load

To explain how customers with DSM affect the operation of DH system

Parameters – DH Company

- Annual relative seasonal variation

$$W = \frac{24 \cdot \frac{1}{2} \sum_{j=1}^{365} |P_{d,j} - P_a|}{P_a \cdot 8760} \cdot 100[\%]$$

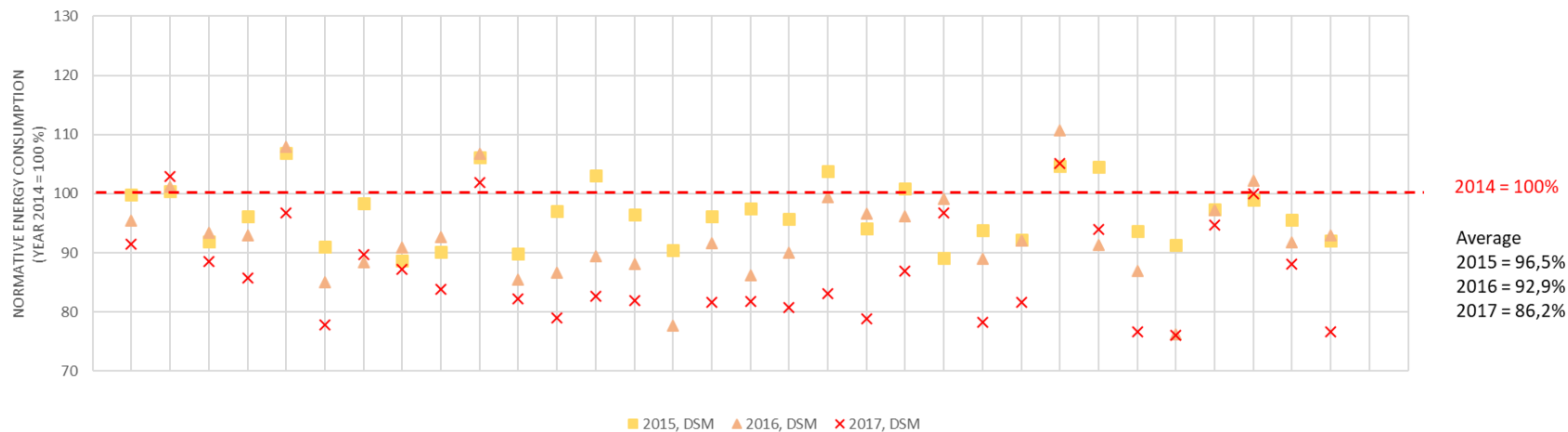
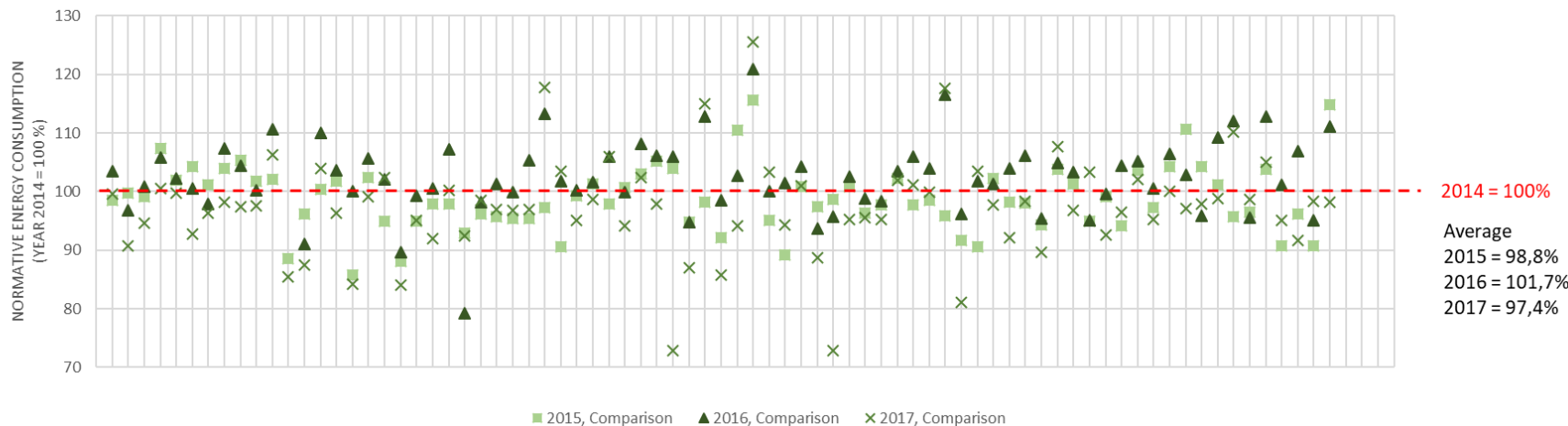
- Annual relative short-term variation (4 and 24 hours)

$$G_{ST} = \frac{\frac{1}{2} \sum_{i=1, j=1}^{8760, 365} |P_{h,i} - P_{ST,j}|}{P_a \cdot 8760} \cdot 100[\%]$$

Results - Customer

- Normalized yearly heat consumption

Results – Normalized yearly heat consumption

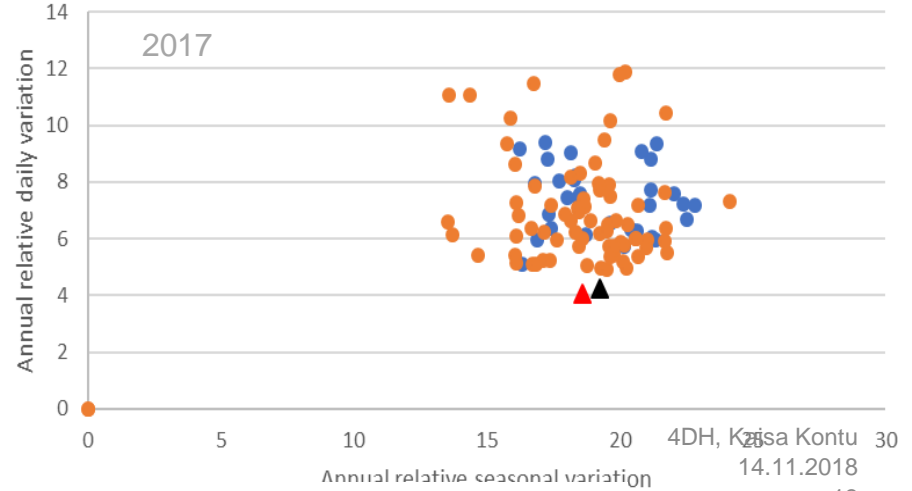
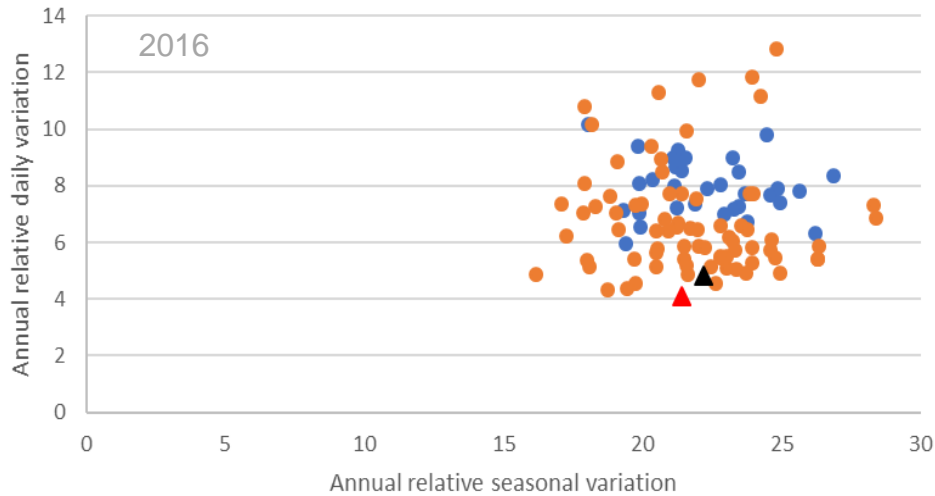
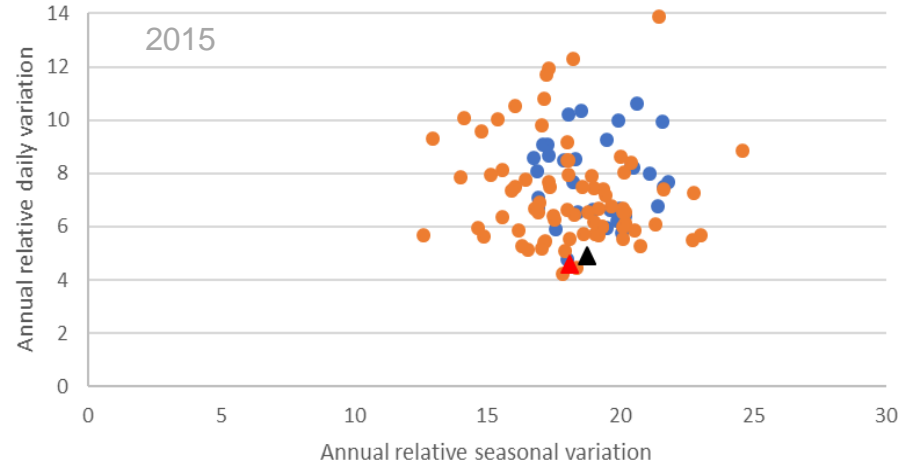
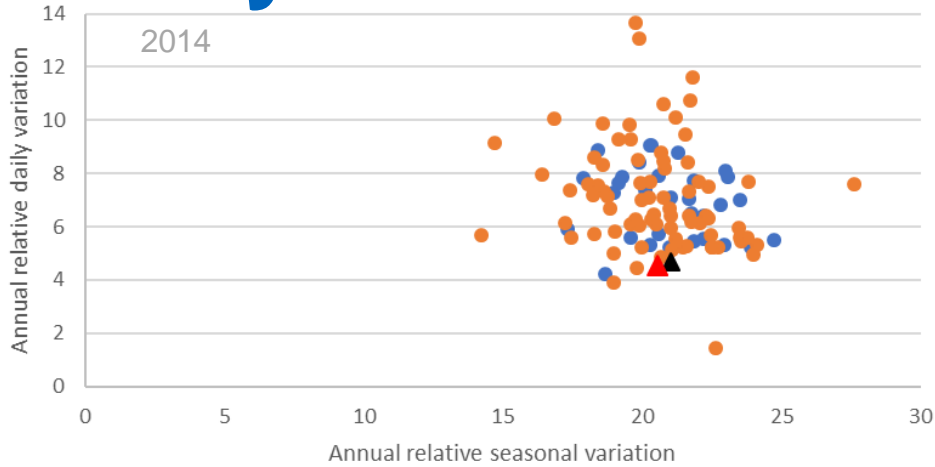


Results

- DH Company

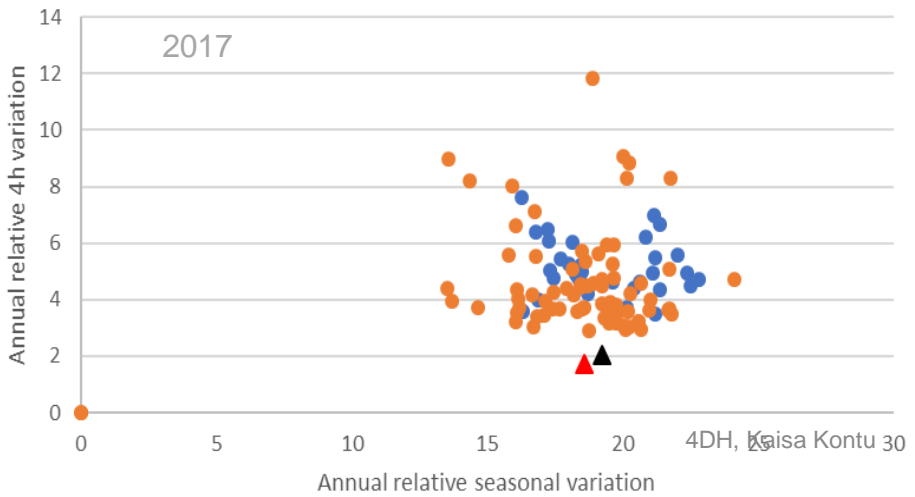
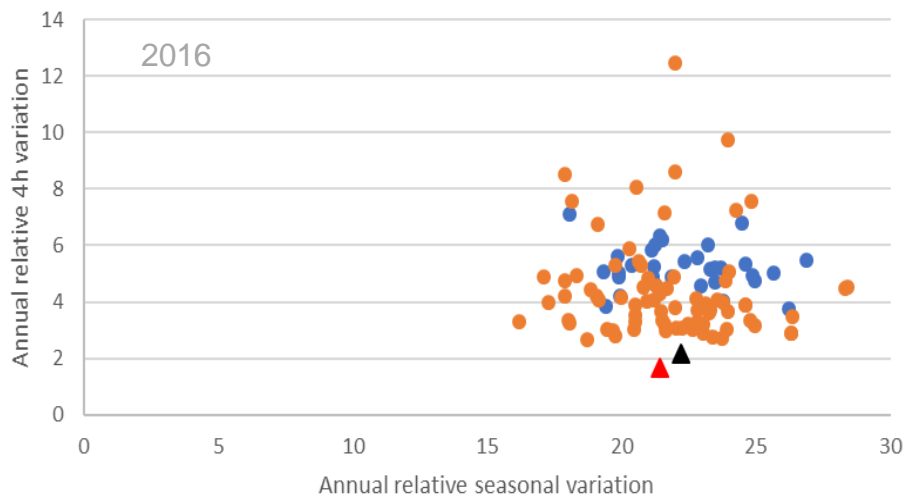
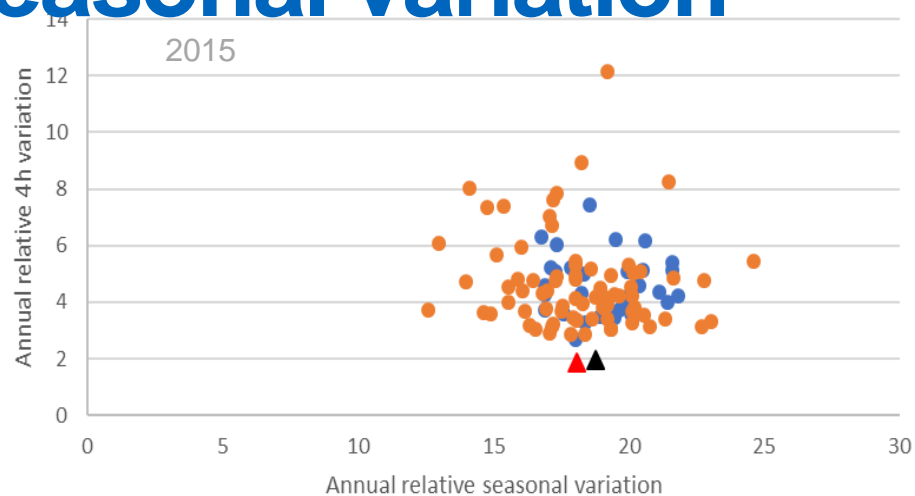
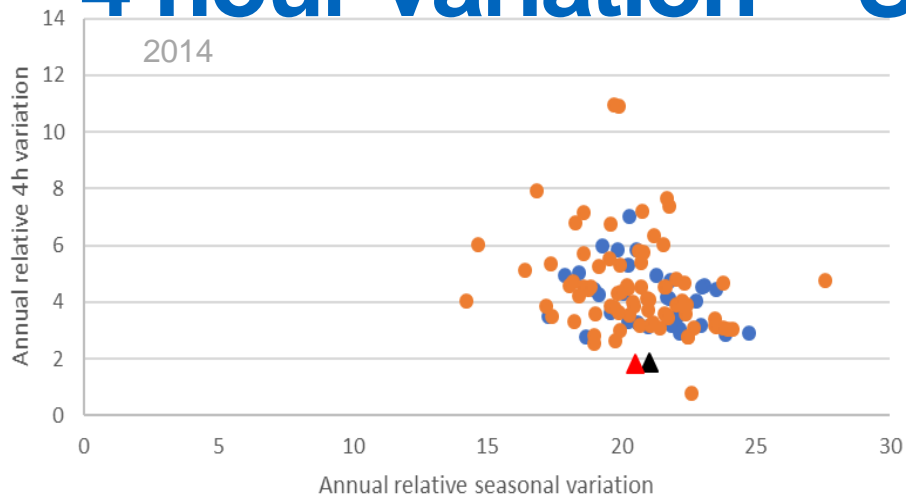
- Annual relative seasonal variation
- Annual relative short-term variation (4 and 24 hours)

Daily variation – Seasonal variation



● DSM ● Comparison ▲ Sum of DSM ▲ Sum of comparison

4 hour variation – Seasonal variation



● DSM ● Comparison ▲ Sum of DSM ▲ Sum of comparison

Conclusions

Customer

- **Lower yearly heat consumption** for DSM customers (consumption in 2017 86% compared to 2014)
- **Higher** yearly average three hour **peak heat loads**

DH company / Energy system

- **Higher** yearly average three hour **peak heat loads**
- Heat load variation increased slightly with customers with DSM, especially in short-term

Questions?

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