Module 5
ADVANCED DISTRICT HEATING SYSTEMS

Professional Intensive Training Course Version

Detection of malfunctions

SHaKE – Sharing Heat and Knowledge on Energy Communities
Erasmus+ KA220-HED Cooperation Partnerships in Higher Education
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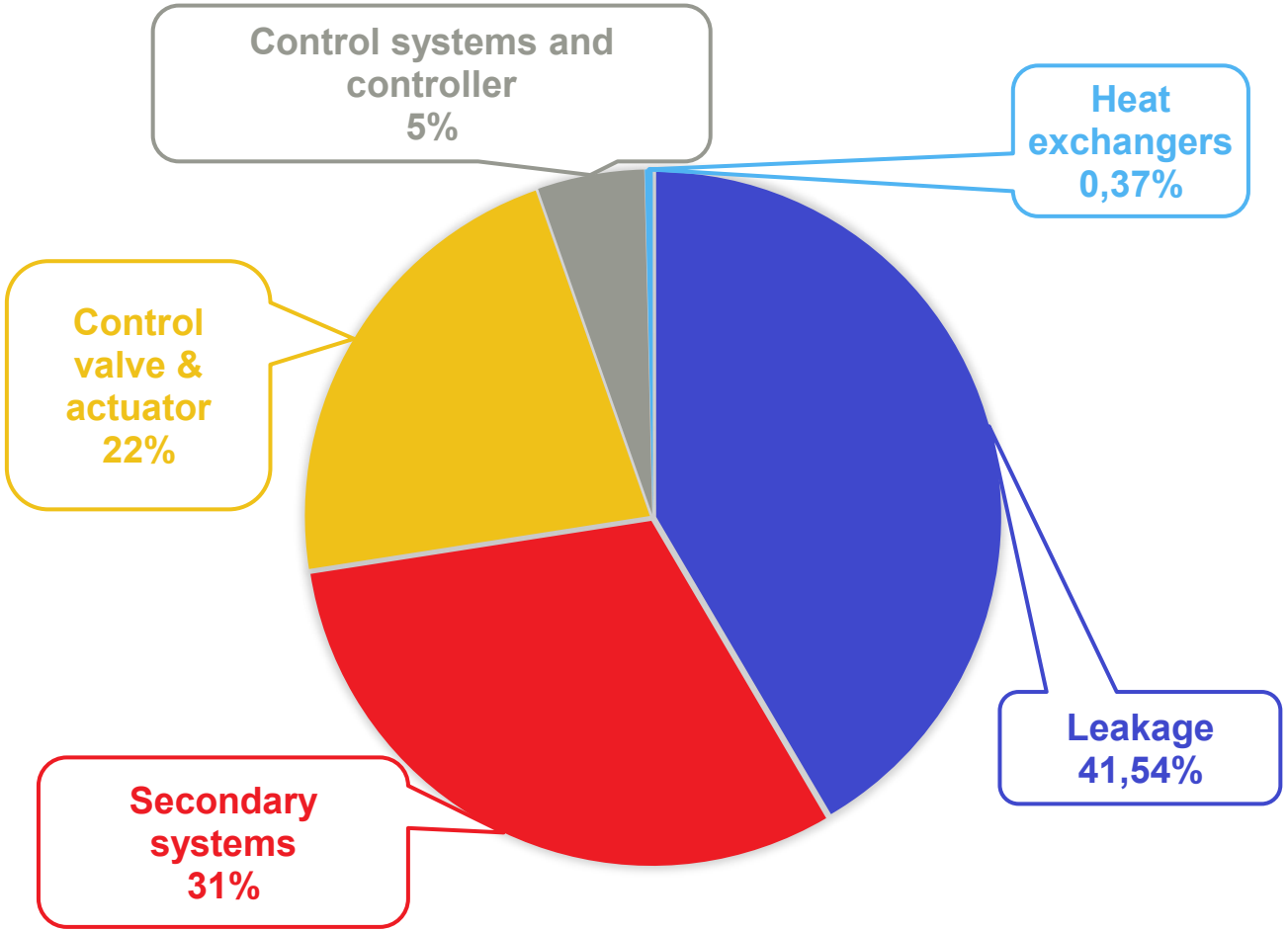
SHaKE
Sharing Knowledge on Energy Communities

Introduction



[Mansson & al, 2019]

Only 26 % of the substation works correctly

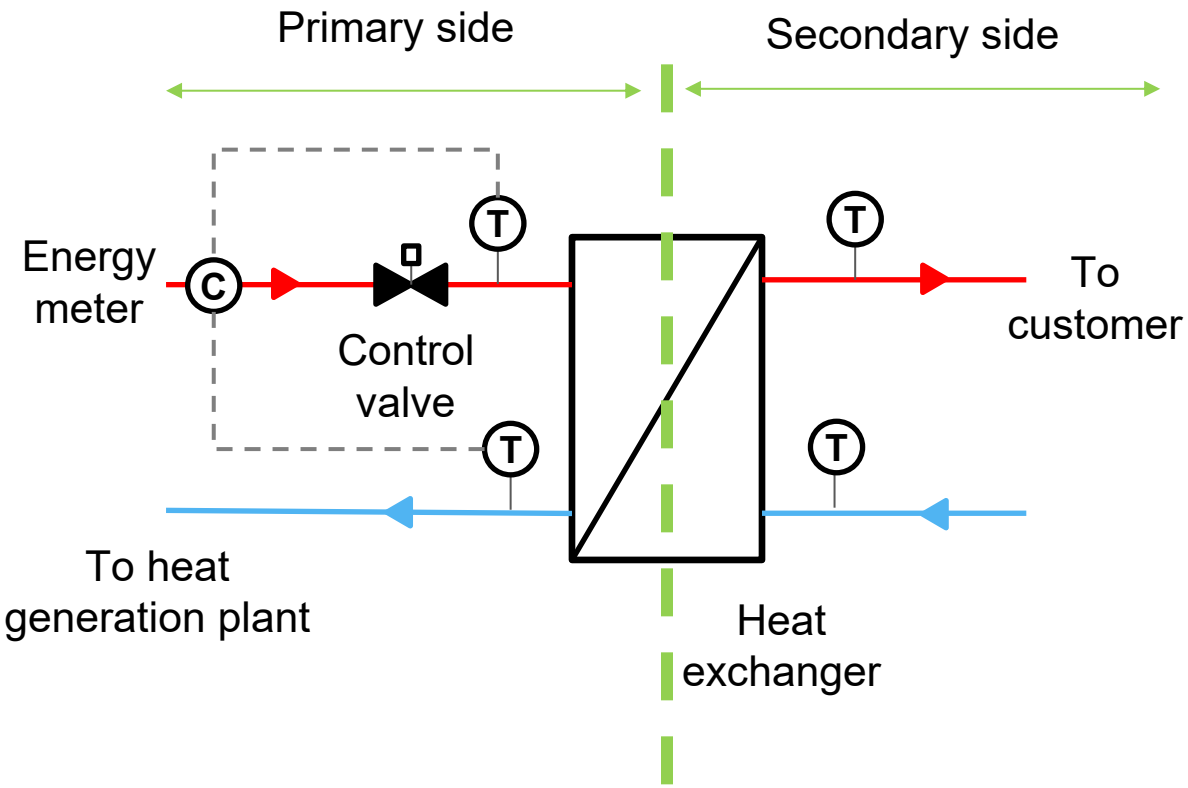
[Gadd et Werner, 2015]

The most impacting malfunctions are:

- Faulty control valves
- Unsuitable secondary network systems
- Unsuitable DHW supply system

[Zinko et Al, 2005]

What is a malfunction?



Available data:

Legal:
- Primary supply and return temperature
- Secondary supply temperature
- Primary mass flow rate
- Exchanged power at the substation

Highly needed:
- Secondary return temperature
- Secondary mass flow rate

Useful:
- Return temperature at each emitter

How to detect if there are malfunctions?

What is a malfunction?

Anomaly detection

Patterns in data that do not conform to a previously defined notion of expected and « normal » behavior

- Outliers
- Deviations
- Atypical behavior
- Abnormal patterns

Fault detection

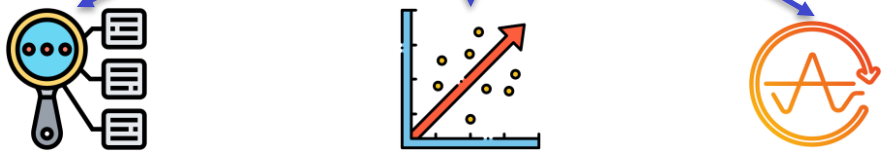
Change in a system so that it can no longer operates satisfactorily and meet the requirements of its user

- Need of corrective action
- Finding of the causes

Faults? Inefficient usage? Change in user behavior?

What is a malfunction?

Anomaly detection



Classification Regression Thresholds

Fault detection

Visualization Clustering

These methods of anomaly or fault detections can be used separately or in combination

Anomaly detection

All these methods are based on the same concept: comparing measured data with reference to a normal operation data to find deviations

What are the data quality?

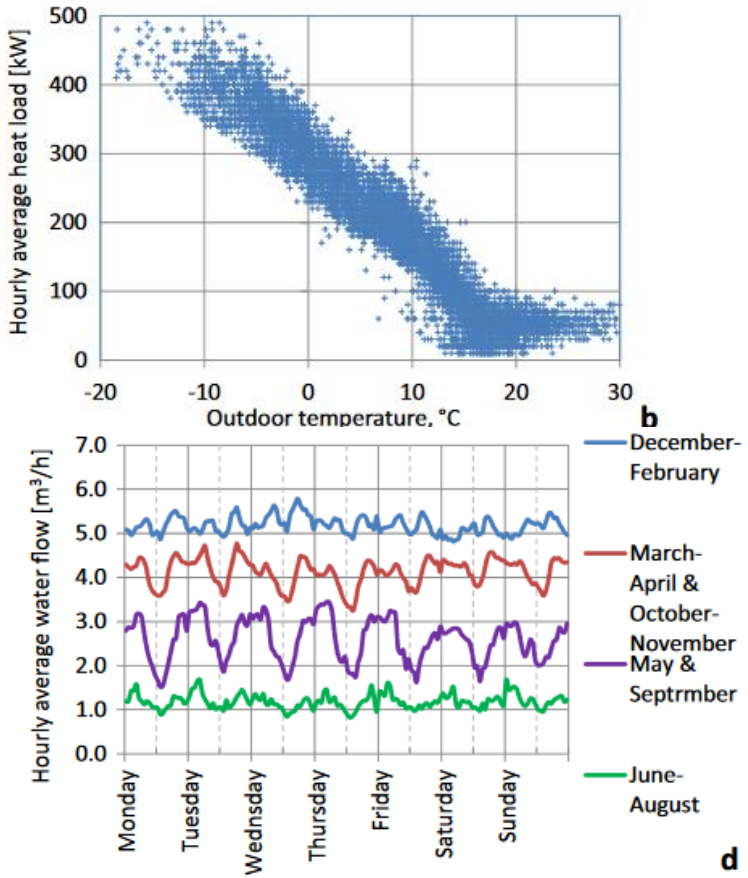
What is a normal behaviour?

What is the fault causes?

What is the detection threshold?

Anomaly detection

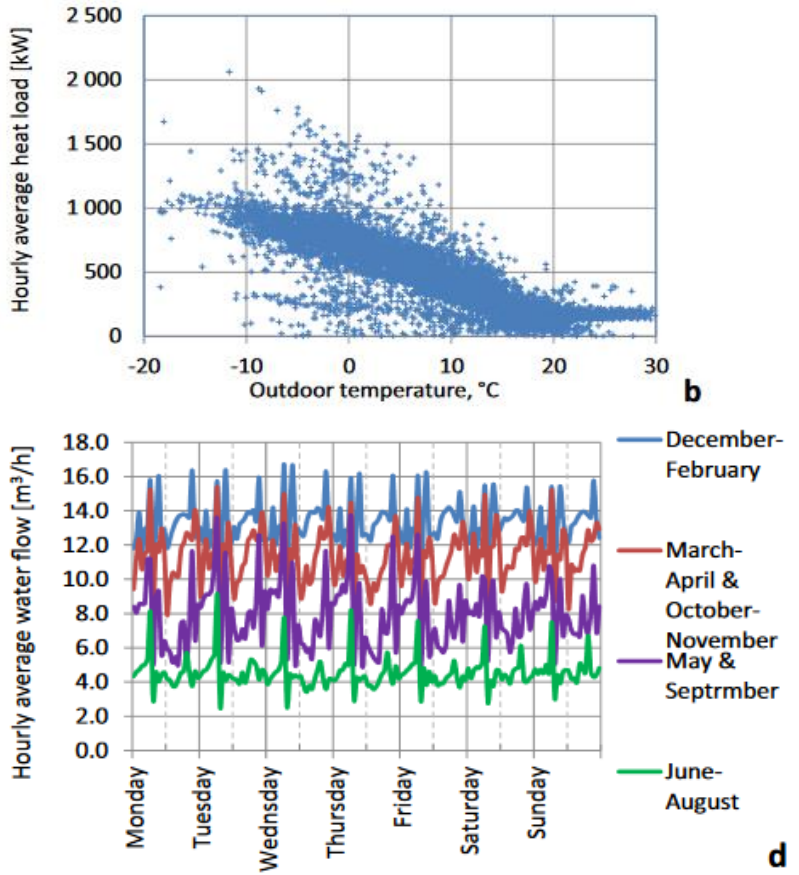
Correct behavior



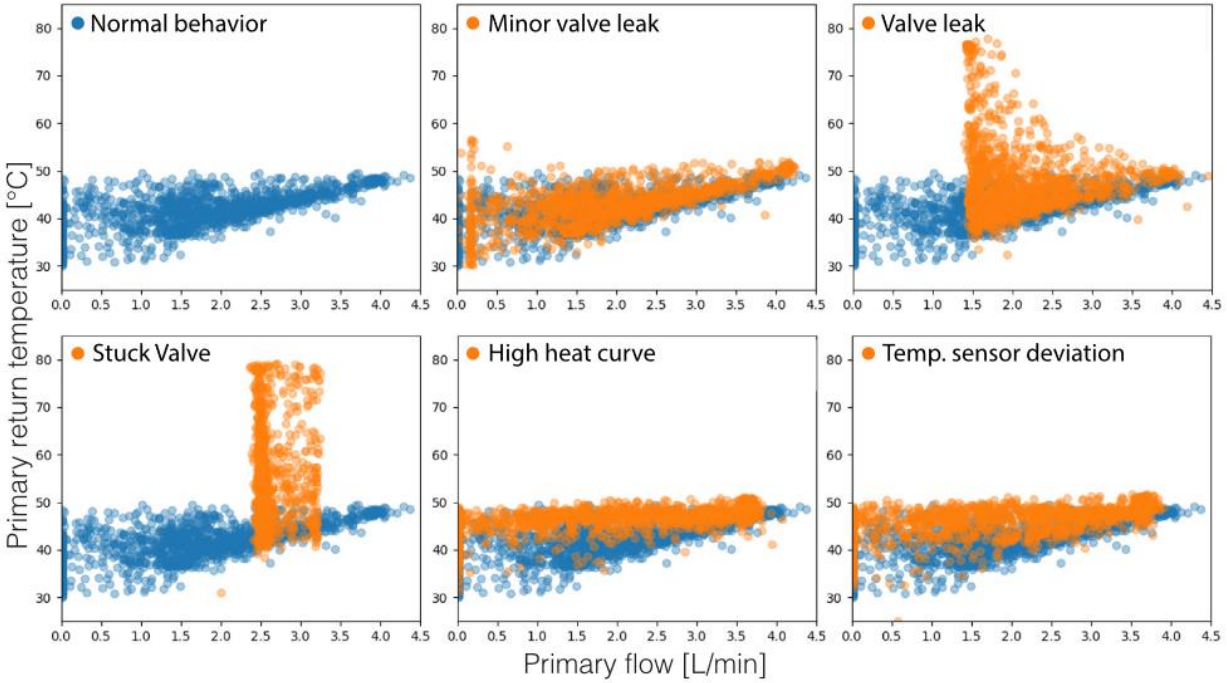
Different behaviors of the substation compared to a reference one

[Gadd & Werner, 2015]

Incorrect behavior



Fault detection



A ML algorithm is used to:

- Learn the normal operation behavior (laboratory experimental data)
- Learn the specific signature of several fault (Pattern and statistical value)

[Van Dreven & al, 2024]

Fast anomaly detection

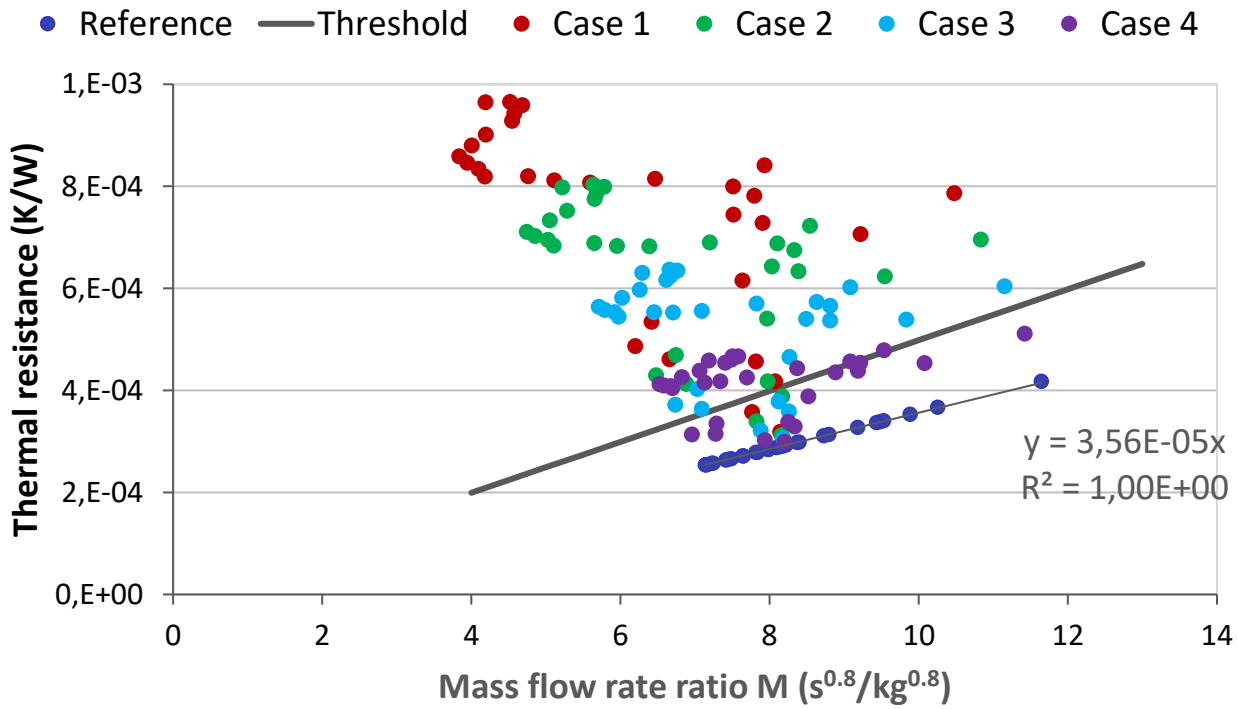
Diagnostic of the anomaly

Need of quality data

Need of a labelled data about fault

Fault detection

Fouling of the heat exchanger



Observation: An increase of the thermal resistance according to a mass flow rate ratio

Calculation of the thermal resistance after a cleaning:

$$R_{HEX,without\ fouling} = DTLM/\dot{Q}$$

$$R_{HEX,without\ fouling} = \mathrm{A}\,\dot{M} + \mathrm{B}$$

$$\dot{M} = \frac{\dot{m}_p^{0,8} + \dot{m}_s^{0,8}}{\dot{m}_p^{0,8}\dot{m}_s^{0,8}}$$

Criteria: for a given $\dot{M}$ if

$$R_{HEX} > 1{,}4\ R_{HEX,without\ fouling}$$

[Fabre, 2020]

Conclusion

1

Improve and fix the hydronic element of the secondary side

2

Improve and fix the hydronic element of the primary side

3

Optimize the DHC operation

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Thank you!

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https://www.shakeproject-dhc.eu/

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