Fault Handling in DH Substations

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EnergyVille Business Day

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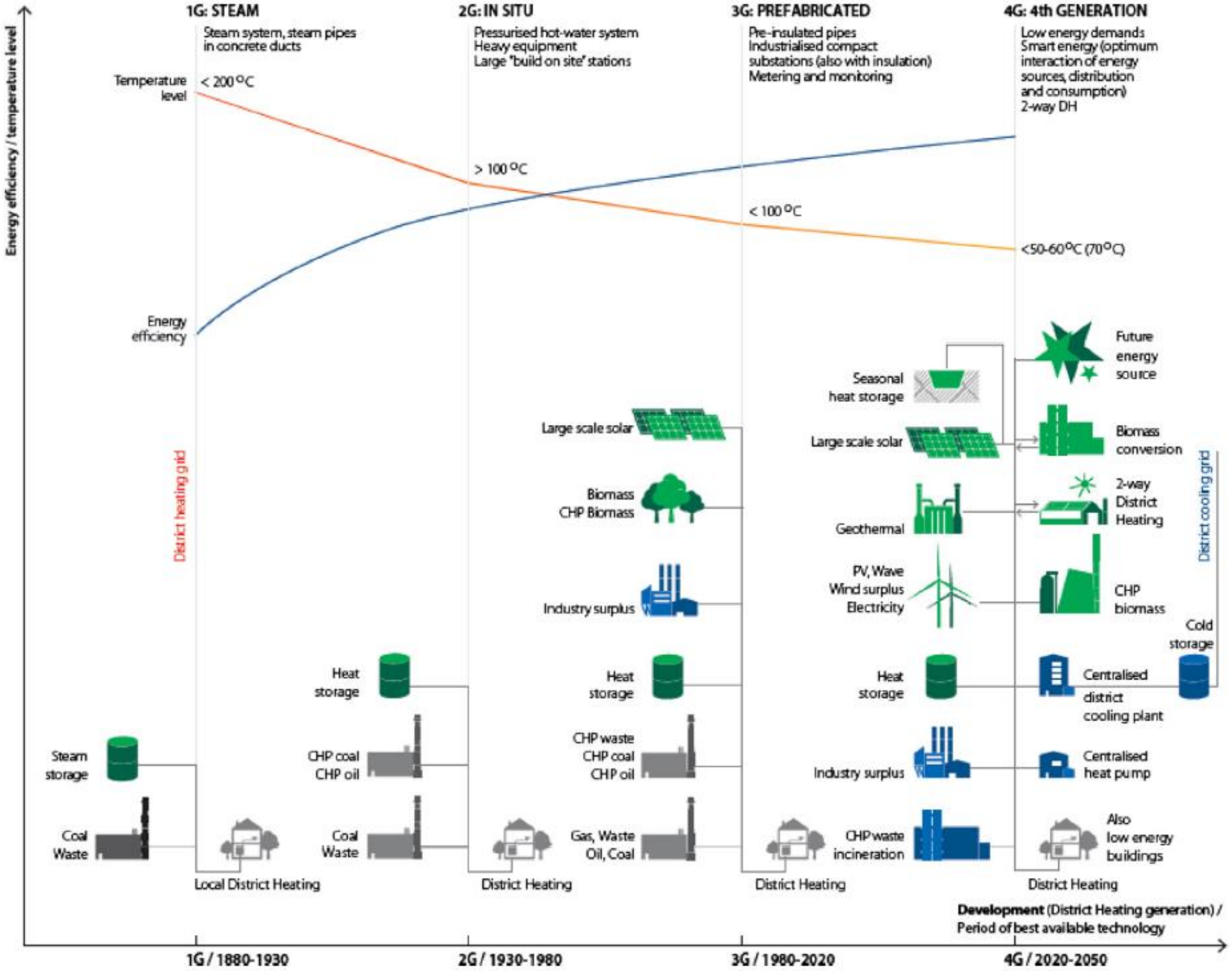
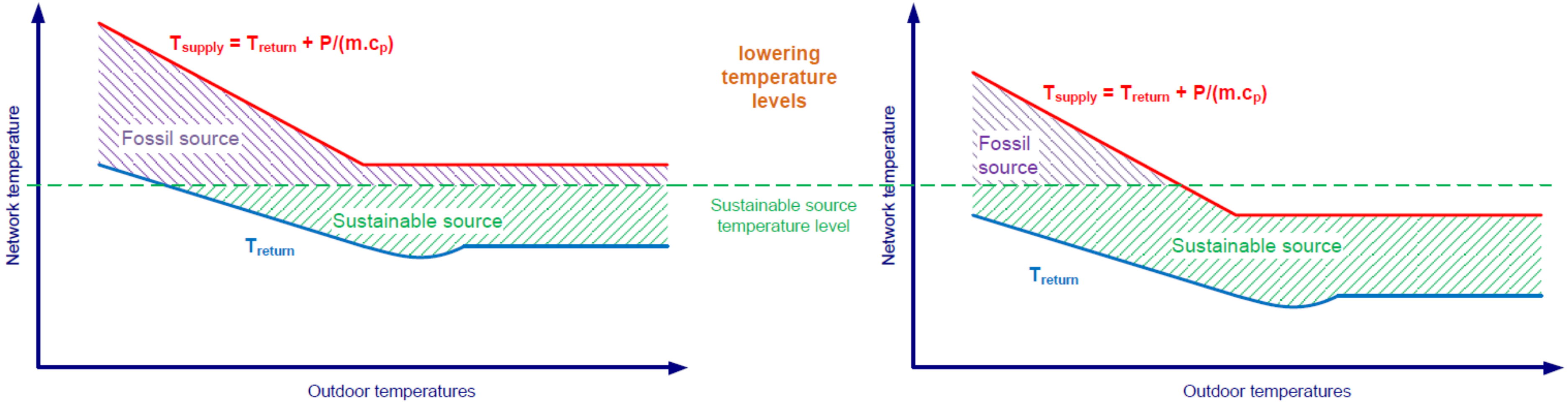


source: Lund H. Werner S. et al. 4th Generation District Heating (4GDH) Integrating smart thermal grids into future sustainable energy systems. Energy 68 (2014) 1-11

Aspects of network temperature level reduction

1. Supply and return temperature reduction
   - Reduction of heat losses

     e.g. 70-40C instead of 90-60C reduces heat losses by ~15%
   - Maximization of share of sustainable sources (renewable, excess heat) / maximization of the efficiency of fossil sources



Conclusion 1: lower network temperature levels lead to more sustainable DH networks

Aspects of network temperature level reduction

2. Maximization of temperature difference

$$P = \dot{m}.c_p.\Delta T$$

$$P = cte, \dot{m} \sim {}^{1}/_{\Delta T}$$

$\dot{m}$ limited to $\dot{m}_{max}$
(pump capacity, network resistance)

So ΔT ↗, network capacity ↗

$P_{pump} \sim \dot{m}^3$
$\Delta T \times 2$ means $\dot{m} \div 2$
means $P_{pump} \div 8$

Conclusion 2: larger ΔT's lead to more efficient networks

Conclusion 1+2:

Supply temperature should decrease, but return temperature should decrease even further

⬇

Priority is reduction of the network return temperature

The problem

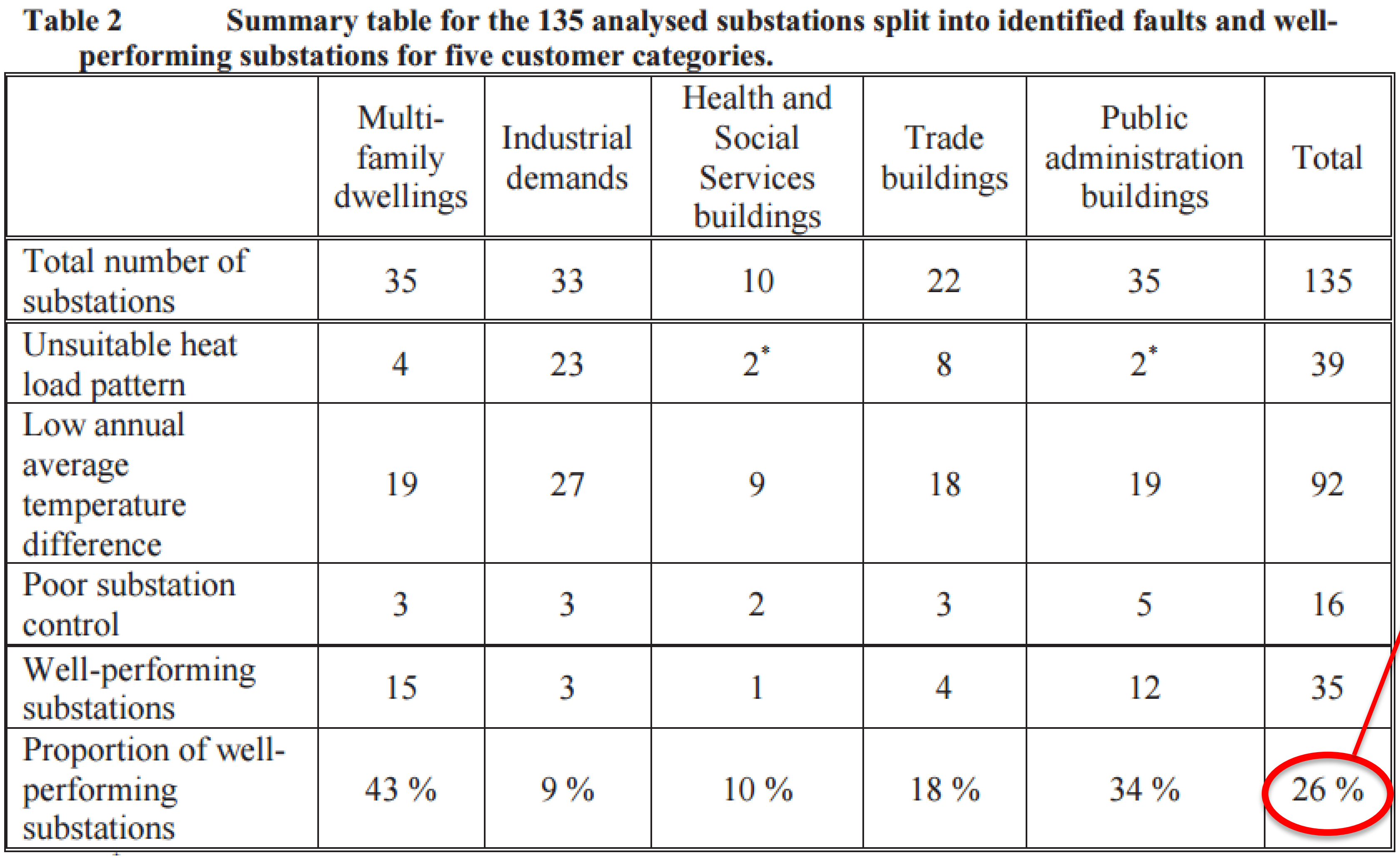


Table 2 Summary table for the 135 analysed substations split into identified faults and well-performing substations for five customer categories.

	Multi-family dwellings	Industrial demands	Health and Social Services buildings	Trade buildings	Public administration buildings	Total
Total number of substations	35	33	10	22	35	135
Unsuitable heat load pattern	4	23	2^*	8	2^*	39
Low annual average temperature difference	19	27	9	18	19	92
Poor substation control	3	3	2	3	5	16
Well-performing substations	15	3	1	4	12	35
Proportion of well-performing substations	43 %	9 %	10 %	18 %	34 %	26 %

source: Gadd, H. (2014). To analyse measurements is to know! (Doctoral dissertation, Lund University).

only 26% of DH substations perform well!

Insufficient cooling. The return temperature is on average 20C higher than necessary[1]

Development of an automated on-line hard- and software platform to detect, diagnose and correct faults in DHC networks, with the objective to reduce the return temperature by ~15C.

➡ **Fault detection platform**

[1] Frederiksen, S. & Werner, S. (2013). District Heating and Cooling (1ed.). Lund: Studentlitteratur

The impact

Rough calculation for a fossil CHP or boiler fired network

- Decreasing the return temp. by 15C would increase the network efficiency by 8-9%:
  - 1.5% (increase gas/oil boiler efficiency)
  - +1% (decrease heat losses)
  - + 1% (pumping power reduction)
  - + 5% (flue gas condensation)

The impact

- For Europe, ecological savings add up to a:
  - Fuel savings represent a primary energy reduction of ~ 150 PJ
  - Reduced electricity use for pumping of ~ 25 PJ, i.e. primary energy reduction of ~ 62 PJ
  - 12 Mton CO2 emission reduction
  - A significant (~10-20%) increase of renewable and excess heat in networks

The impact

- Financial figures for EU:
  - Service visits: M€150 cost elimination
    - €100/substation * M2 substation * ¾ elemination by the platform
  - Savings by system temperature reduction: M€1500
    - €45/C.TJ * 2500 PJ * 15C

      Frederiksen, S. & Werner, S. (2013). District Heating and Cooling (1ed.). Lund: Studentlitteratur

➡ **+M € 1500 ANNUAL SAVING POTENTIAL**

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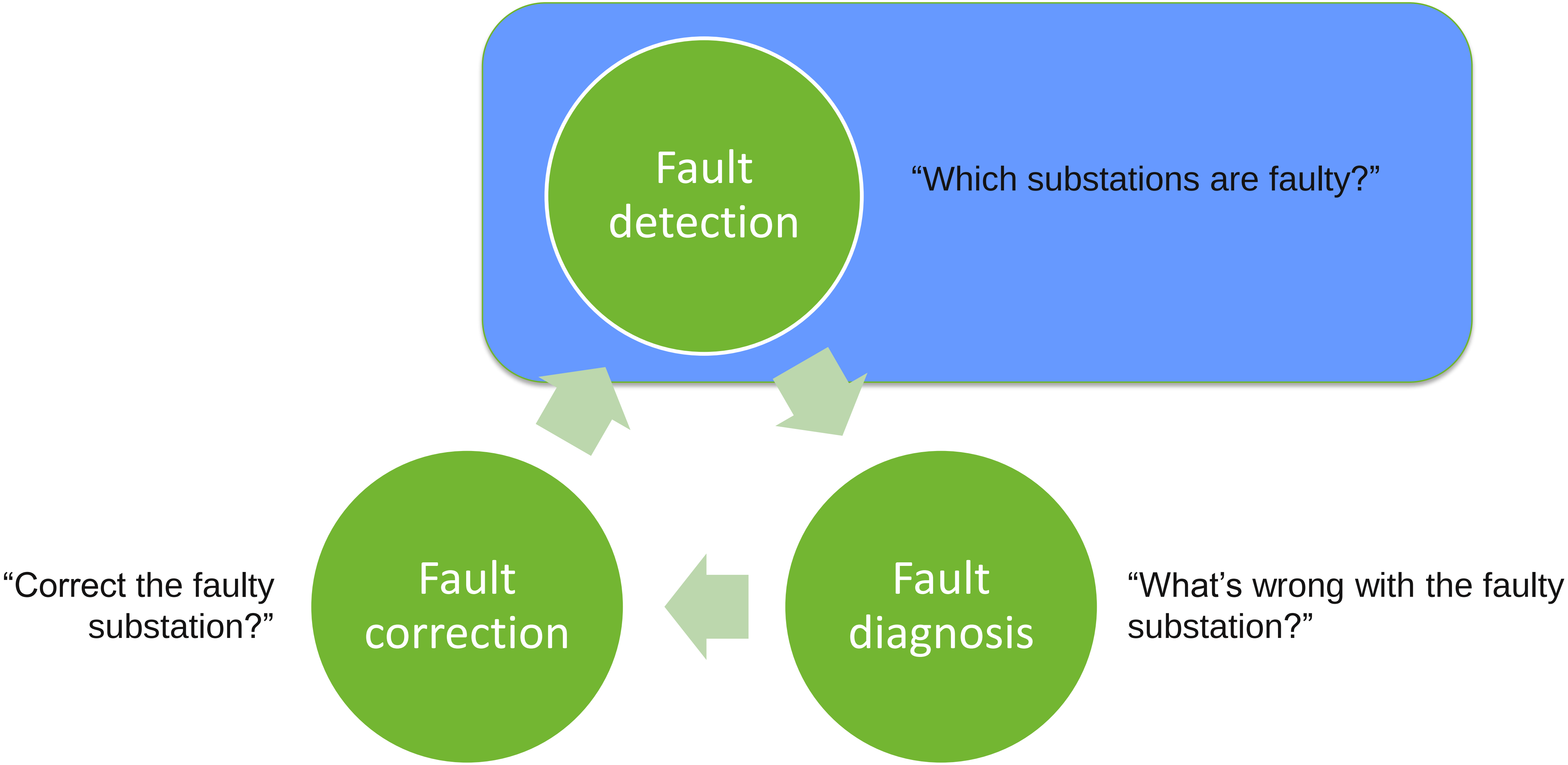
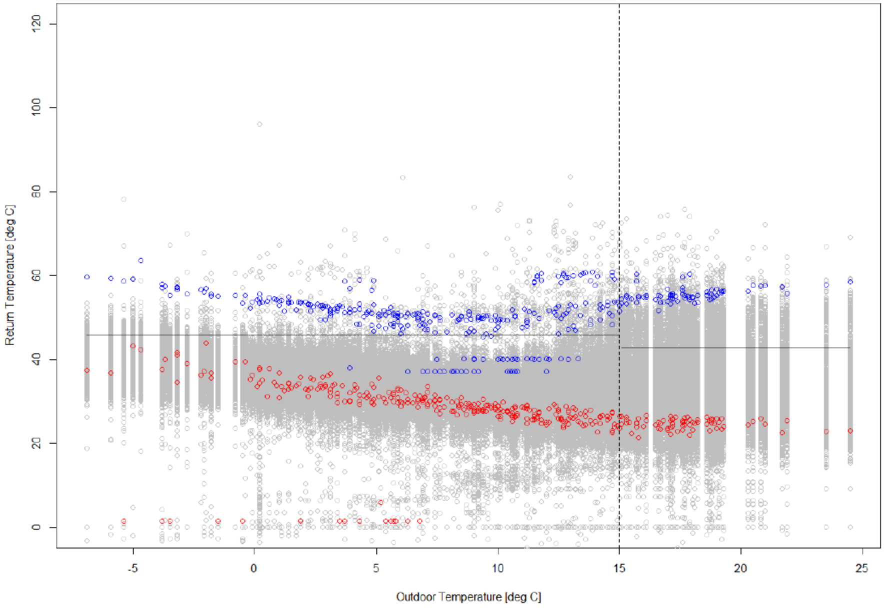
How? The fault handling cycle

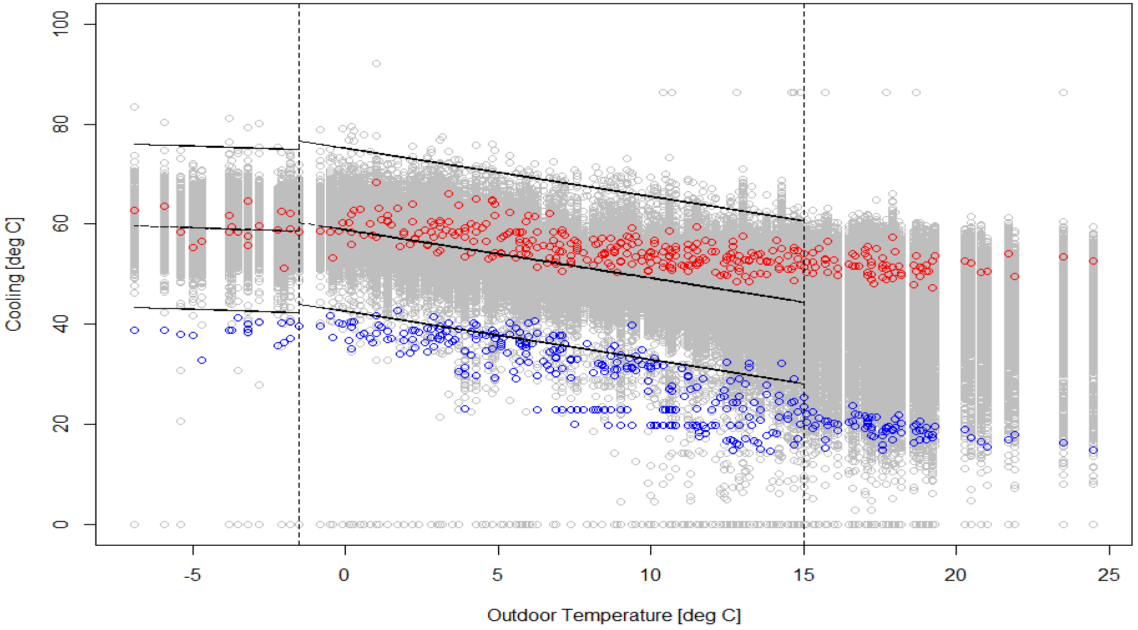
Part of EFRO SALK GeoWatt



1. Fault detection

- Using only primary side data (i.e. supply + return temperature and flow rate)
- Numerous statistical algorithms available, but not on-line
- Example: Malmö DH (12.000 connections)



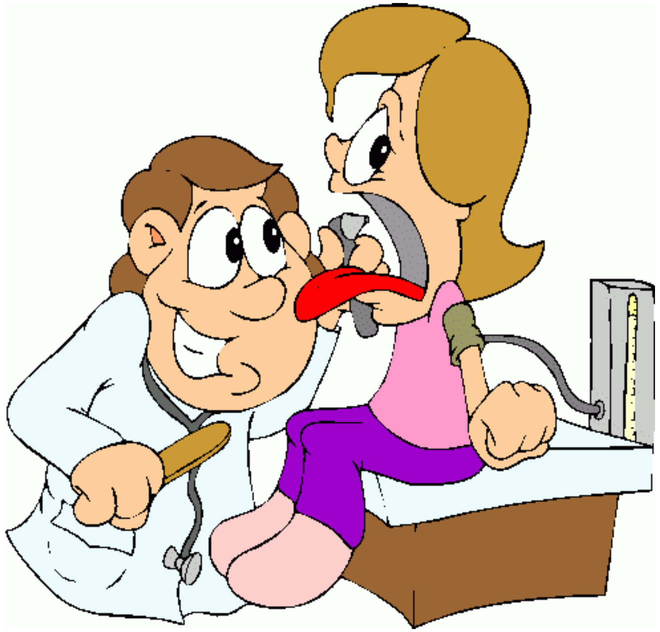


1. Fault detection

- Next steps (in GeoWatt):
  - Automize the algorithms: DIGITALISE !!
  - Big data handling: machine learning techniques
  - Integrate it in a hard-/software platform to make it online
  - Demonstrate fault detection

2. Fault diagnosis (not part of GeoWatt)

- By means of machine learning classification algorithms, coupling symptoms to faults
- Started up a joint PhD with Lund University (Sweden) on this topic
- Looking for district heating network operators willing to share data!



3. Fault correction (not part of GeoWatt)

- Cure the pain!
- First objective: automize it as much as possible
- If not possible, provide interactive action plans for technicians

Project side steps (not part of GeoWatt)

- Consumer interaction
  - Giving insight in energy consumption
  - Provide suggestions to improve their energy use
  - Pass information about imperfect functioning of substations/building installations to consumers

Conclusions

- Imperfections in DH substations and building installations are widespread.
- They cause insufficient cooling in the substations, and too high return temperatures as a consequence.
- In 3GDH networks it only causes loss of efficiency and increased operational costs, in 4GDH it is simply inacceptable.
- EnergyVille develops and demonstrates a platform for detection, diagnosis and correction of faults.