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Temperature Optimisation for Low Temperature District Heating across Europe

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Fault detection in building installations

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  - Faults in building installations and high return temperatures
  - Fault detection and diagnosis
- Proposed approach
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- Practical guidelines on auditing building installations

One issue

- High return temperatures
- Low temperature difference ΔT

➢Efficiency losses at several levels

➢Obstacle to the integration of renewable heat sources

- Ongoing issue
  - Zinko et al., 2005, Improvement of operational temperature differences in district heating systems. *Report of the IEA R&D Programme on District Heating and Cooling.*
  - Gadd and Werner, 2015, Fault detection in district heating substations. *Applied Energy*.

Multiple possible causes

- Multiple possible origins, e.g.
  - Planning deficiency
  - Defect in installation
  - Equipment degradation
- Affecting individual components or whole subsystems
- Present from the start, happening gradually or suddenly
- With a variety of impacts
  - E.g. on thermal comfort and/or energy use

Multiple possible causes

Substation

- Heat exchanger control issues
- Heat exchanger heat transfer capacity
- Primary control valve issues

Space heating system

- Hydraulic imbalance
- Heating system unsuitability
- Suboptimal heating curve
- Delivery component capacity
- Thermostatic radiator valves

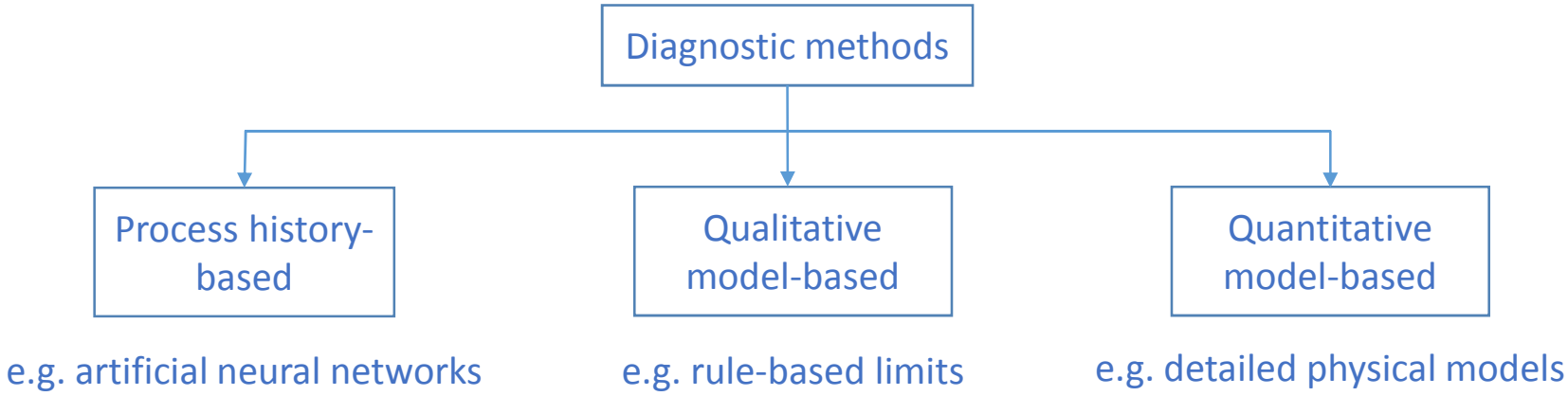
- Sensor faults
- Controller faults
- Pump control

Tap water system

- Excessive recirculation flow
- Tap water bypass
- Storage tank temperature mixing

Fault detection and diagnosis

- Goal: automated fault detection and diagnosis
- Active area of research for many types of systems



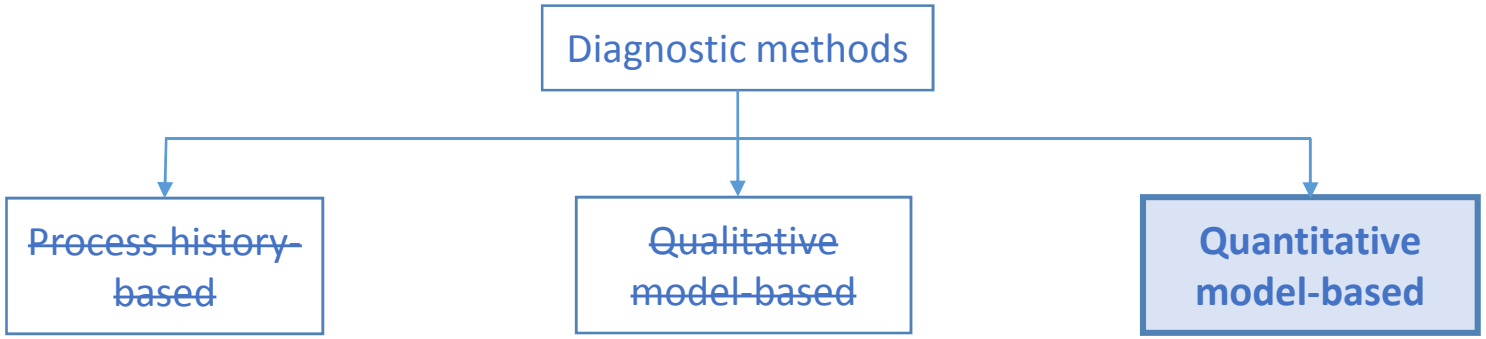
Adapted from Kim and Katipamula, 2018, A review of fault detection and diagnostics methods for building systems. *Science and Technology for the Built Environment*

Fault detection and diagnosis

- Available data
  - Hourly or even subhourly measurements increasingly available
  - but with limitations (usually primary side only)
  - Little information on quality of substation behavior or faults
  - ➢Challenge for process history-based methods

- Variability
  - Each building/installation is unique
  - ➢Rule-based limits and alarms hardly applicable

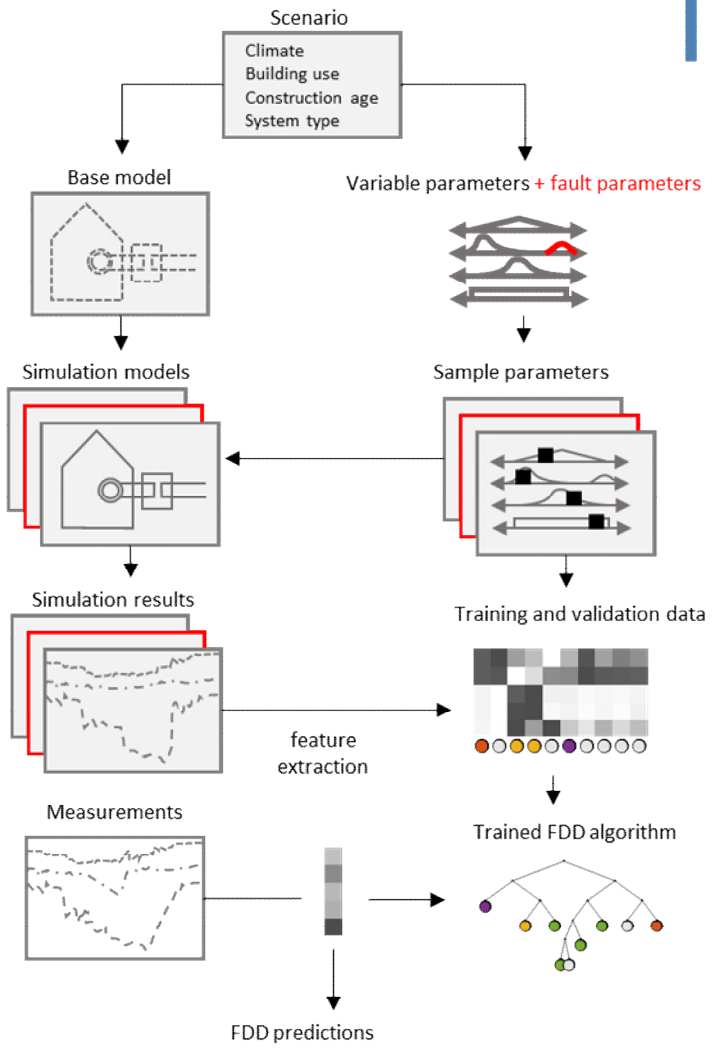
Fault detection and diagnosis



- Detailed physical models of building and installation
  - "Building performance simulation"
  - Allows issues at different levels to be modelled
  - And quantifies their impact
  - Drawback: model preparation and tuning of parameters

Proposed approach

- Building and system simulations
  - With and without faults
  - Accounting for variability
- Synthetic data
- Feature extraction
- Training and validation of classification algorithms



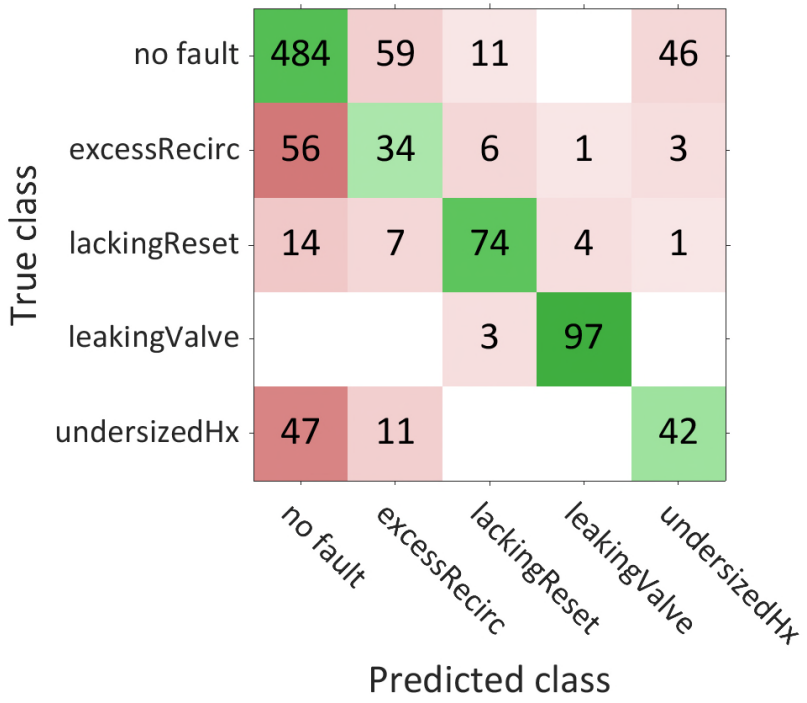
Case study scenario

- Single-family houses built in the 1980/1990's
- Northern Germany
- Indirect parallel connection for space heating and DHW
- Four fault types

Abbreviation	Fault
excessRecirc	excessive hot water recirculation flow
lackingReset	lacking space heating secondary temperature reset
leakingValve	leaking space heating heat exchanger valve
undersizedHx	undersized space heating heat exchanger

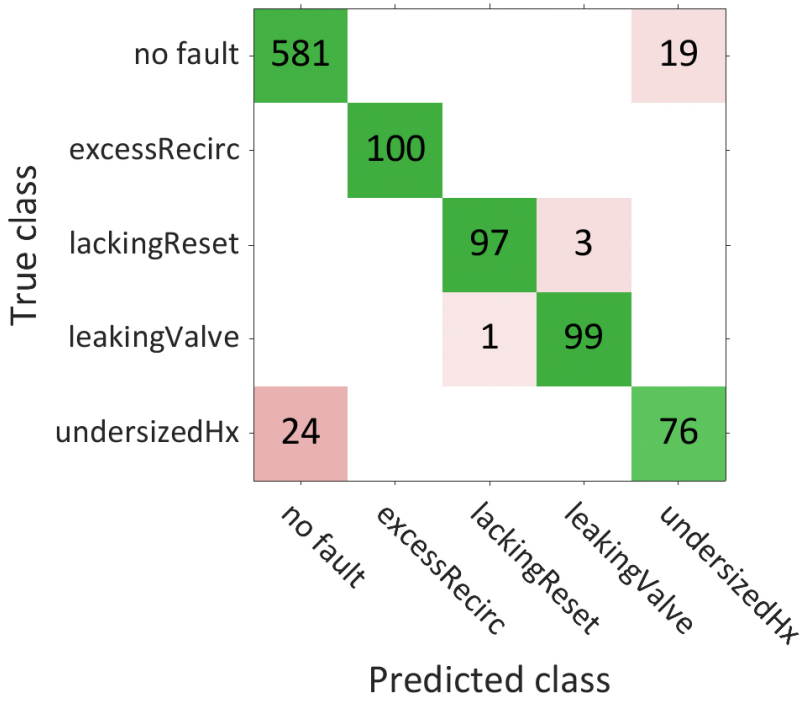
Results

- Overall prediction accuracy
  - **without secondary measurements: 78%**



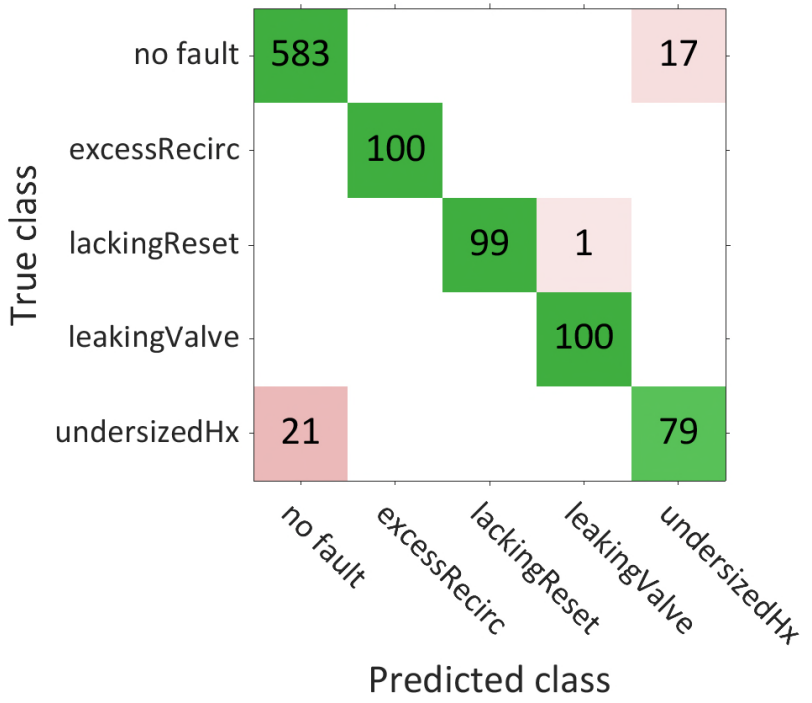
Results

- Overall prediction accuracy
  - without secondary measurements: 78%
  - **with secondary temperature measurements: 96%**



Results

- Overall prediction accuracy
  - without secondary measurements: 78%
  - with secondary temperature measurements: 96%
  - **with secondary temperature and flow rate measurements: 96%**



Discussion

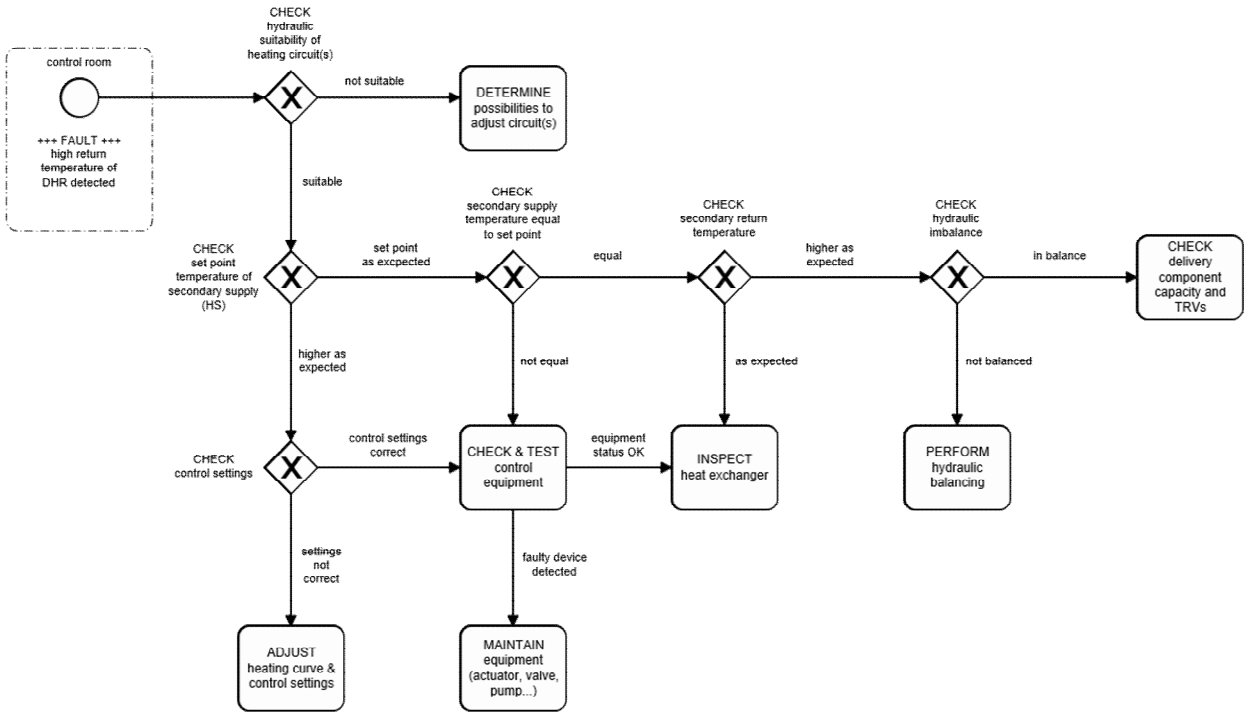
- Measurements of secondary temperatures allow predictions to be significantly more accurate.
- Measurements of secondary flow rates do not lead to significant improvements.
- Some faults (undersized heat exchanger) are more difficult to diagnose than others
- Promising, but should be applied to real data

Practical guidelines on auditing building installations

- A complementary approach
- What to do when a building installation is suspected to behave suboptimally?
- Preparing, executing, documenting and following up on an audit
- Flowcharts to support diagnosis
- Fault profiles

Practical guidelines on auditing building installations

- Example of flowchart



Future work

- Extension to additional types of systems and faults
- Simulation calibration
- Empirical validation
- Deployment in real networks
- Refinement of the practical guidelines

Thank you!

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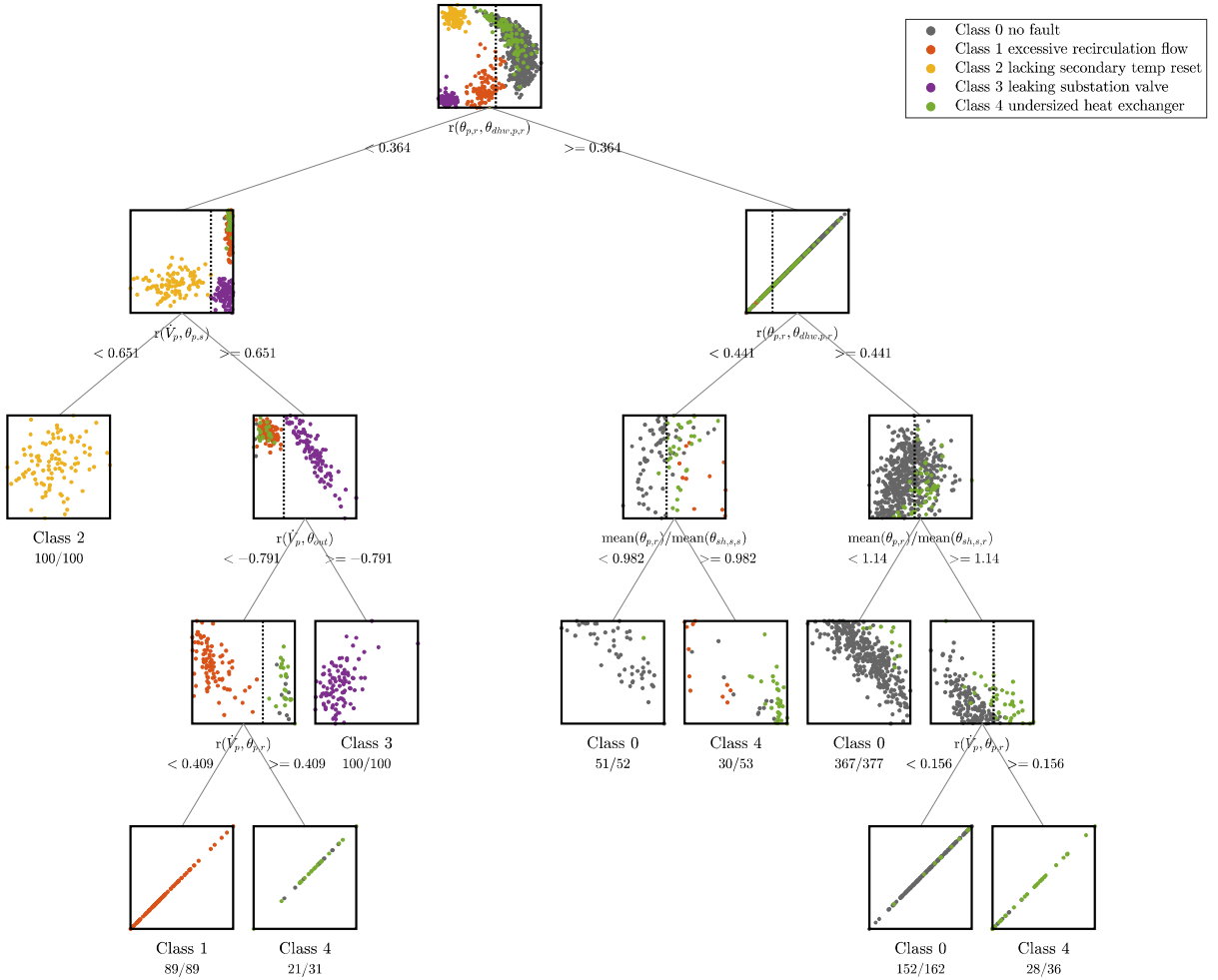
Example of classification tree