Popular summary

District heating is a common way of heating houses in Sweden today, which is both reliable and easy to use. However, the heating may not always work correctly, resulting in the house getting cold and not getting hot water in the tap when washing your hands. This type of problem is often due to something going wrong in the house's heating system. These faults not only affect those who live in the house but can also have a negative impact on the district heating system. Therefore, it is common for district heating companies to offer help to the customers who experience that something is wrong with the heating system in their buildings. There may also be faults in the houses that customers do not notice, and the district heating companies must find those faults as well. In this dissertation, I have investigated why district heating companies want to find and remove faults in the buildings, why faults occur in the buildings, and how district heating companies can work to find and correct more faults in the buildings.

So, why do district heating companies want to find more faults? I have investigated this by interviewing several district heating companies. They say that the biggest reason why they want to find faults is that the building's return temperature is affected. The return temperature is the water temperature that leaves the building after the heat from the district heating system has been delivered. Suppose the return temperature from the building is high. In that case, it means that the building has not been able to utilize the heat in the water in an efficient manner. Thus, the high return temperature has a negative impact on the entire district heating system, as the heat is not used efficiently in the system. If high return temperatures can be avoided, heat can also be produced more efficiently in several types of heat production plants. A more efficient heat production leads to reduced use of resources and more environmentally friendly heat production. Therefore, district heating companies need to find faults in buildings that lead to increased return temperatures.

The faults in the buildings can be due to many different things. I have investigated this in my dissertation by asking many Swedish district heating companies what the most common faults in their systems are. In a building connected to district heating, a district heating substation transfers the heat from the district heating system to the building's heating system. The substation consists of many different components such as valves, various meters, and a heat exchanger. These components may break or stop working correctly,

for example, if a temperature sensor has stopped working or if a mouse has gnawed off an electrical cord. Sometimes the error can also be due to the human factor. For example, suppose someone changes the settings in the substation's regulator, which determines how much heat is to be delivered to the building. In that case, the changed settings may cause an unnecessarily high energy consumption in the building.

To get more structured information about the faults in the buildings, I have developed a way to name the different faults. This way of naming faults makes it easier if the district heating companies would like to collaborate on how they handle faults and, for example, compare which errors are the most common ones in the industry. The naming is based on several different levels, where you must first describe where in the building the fault has appeared. Then you must explain which component it is that is faulty, what the fault is, if the fault has been corrected, and if so, what was done to correct the fault. By filling in this information every time you find a fault in a building, the district heating companies will know more about the faults that occur in their district heating system. They will also be able to help their customers even more by utilizing this knowledge.

The district heating substation also has a meter, which measures four different measurement values: the water temperature that enters the building, the return temperature from the building, how water passes through the building, and how much energy is used in the building. The measured values can be used to find faults in the buildings by analyzing the measurements with the help of computers. Faults may be detected in this way since a fault will create changes in the measured values, for example, if the fault causes the return temperature to increase. Because there are so many buildings in a district heating system, the data analysis must be fast. In this dissertation, I have examined two different data analysis methods, which show that this type of data analysis is possible. However, we need to know more about the customer data to create even better methods for fault detection. More information would make it possible to investigate whether the data analysis tools find faults in buildings that have had faults in them in reality.

Last but not least, it is also important that the district heating companies work with the faults systematically. Therefore, they may need to adjust the way they work today and, above all, look more actively for faults in the buildings. Some district heating companies do this today, and if they detect faults, they contact their customers to help them correct the faults. To further develop this work, I have developed a proposal on how a district heating company can work to find more faults in its district heating system. The workflow contains several sub-steps, where customer data analysis is one of the essential parts. To ensure that the workflow is possible to introduce in reality, I have conducted a workshop where several Swedish district heating companies participated and helped me evaluate the working method. In this way, we have developed a workflow that contains several smart solutions, which can help solve many of the problems related to fault detection and fault handling in the buildings.