

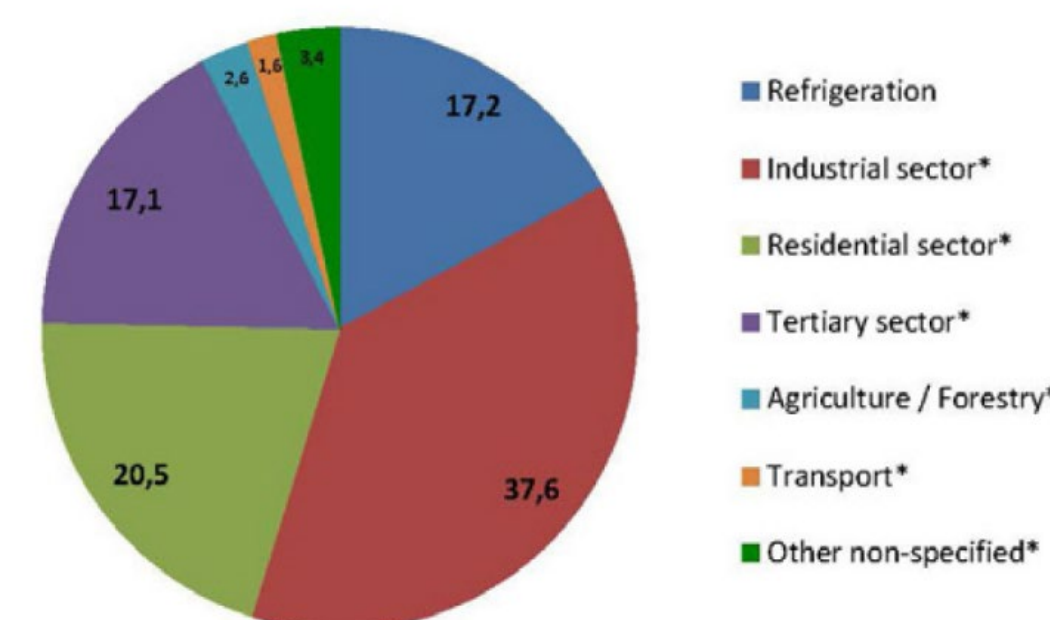
Fault Detection and Diagnosis for Chiller

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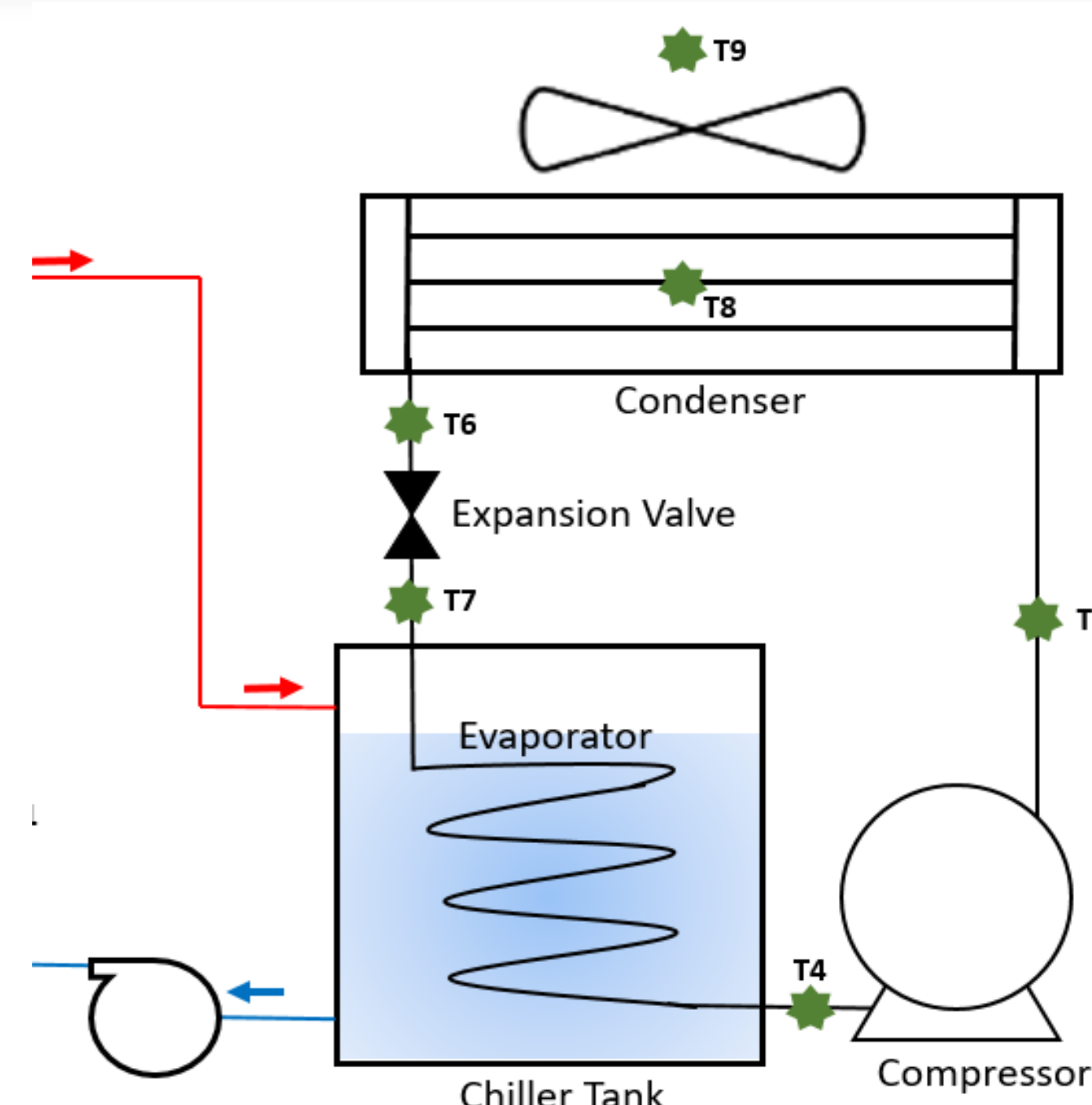
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Motivation

- **17%** of global electricity is consumed by refrigeration sector
 - Improper maintenance of these systems cause **15-30%** loss of energy
- Detect and Diagnose commonly occurring faults in vapour compression chillers
- AI based classification for fault and normal conditions using measurement data



Chiller System



- A chiller consists of 5 main components: evaporator, condenser the two heat exchangers, compressor.
- The pressure and temperature of these components are indicator of the health of the system.

Types of Faults

- 7 faults are identified which have the highest frequency of occurring in a chiller as well as most cost intensive to repair.

| Sr No. | Faults |
|--------|---------------------------------|
| 1 | Refrigerant Leak |
| 2 | Condenser fouling |
| 3 | Reduced Condenser Water Flow |
| 4 | Reduced Evaporator Water Flow |
| 5 | Non-Condensables in Refrigerant |
| 6 | Refrigerant Overcharge |
| 7 | Excess Oil |

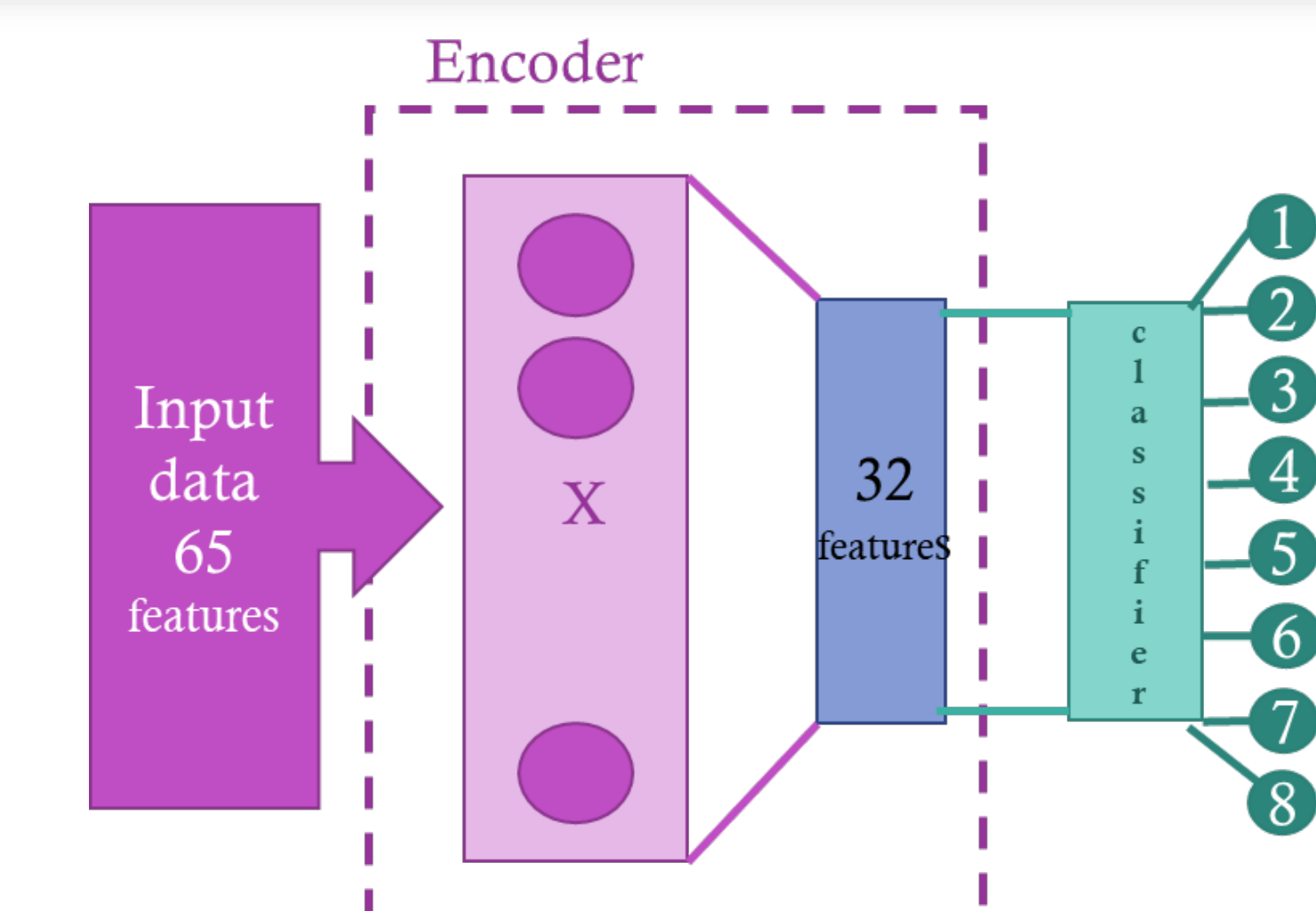
- Each fault displays a unique pattern of rise and fall of the measured parameters such as temperatures and pressures at different locations on chiller system

| | kW | PRE | PRC | TRC_sub | Tsh_suc | Tsh_dis | TEA | TCA | TEI-TEO | TCO-TCI | kW/ton | TO_sump | TO_feed |
|---------------------------------|----|-----|-----|---------|---------|---------|-----|-----|---------|---------|--------|---------|---------|
| Reduced Condenser Water Flow | ▲ | ▲ | ▲ | ▲ | ▼ | · | ▼ | ▲ | · | ▲ | ▲ | ▲ | ▲ |
| Reduced Evaporator Water Flow | ▲ | ▼ | · | ▲ | ▼ | ▲ | ▼ | · | ▲ | · | ▲ | · | · |
| Refrigerant Leak | ▼ | · | ▼ | ▼ | · | · | · | ▼ | · | · | ▼ | · | · |
| Refrigerant Overcharge | ▲ | ▼ | ▲ | ▲ | · | ▲ | · | ▲ | · | ▲ | ▲ | ▲ | ▲ |
| Excess Oil | ▲ | · | · | ▲ | · | · | · | ▲ | · | · | ▲ | ▲ | ▲ |
| Condenser Fouling | ▲ | · | ▲ | · | · | · | · | ▲ | · | ▲ | ▲ | · | · |
| Non-condensables in Refrigerant | ▲ | ▲ | ▲ | ▲ | · | ▲ | ▼ | ▲ | · | ▲ | ▲ | ▲ | ▲ |
| Defective Pilot Valve | ▲ | ▲ | · | ▲ | ▼ | ▼ | ▼ | ▼ | · | · | ▲ | · | · |

AI based FDD

- The unique pattern which each fault presents makes application of AI more prudent.
- The dataset used is publicly available by ASHRAE. The experimental data was collected by inducing faults in a chiller at various severity fault levels in different operating conditions.
- A hybrid approach which combines AI feature extraction with machine learning classifier was developed due to the high dimensionality of the data set.

Hybrid Model



- High dimensional data set is compressed by autoencoder which is trained using unlabelled data
- The compressed data is used as input in the classifier to diagnose normal or fault condition
- Different classifiers such as neural network and SVM are implemented
- The Hybrid model was able to classify all the classes with above 93% of accuracy.
- The machine learning classifier (SVM) performed better than the neural network classifier