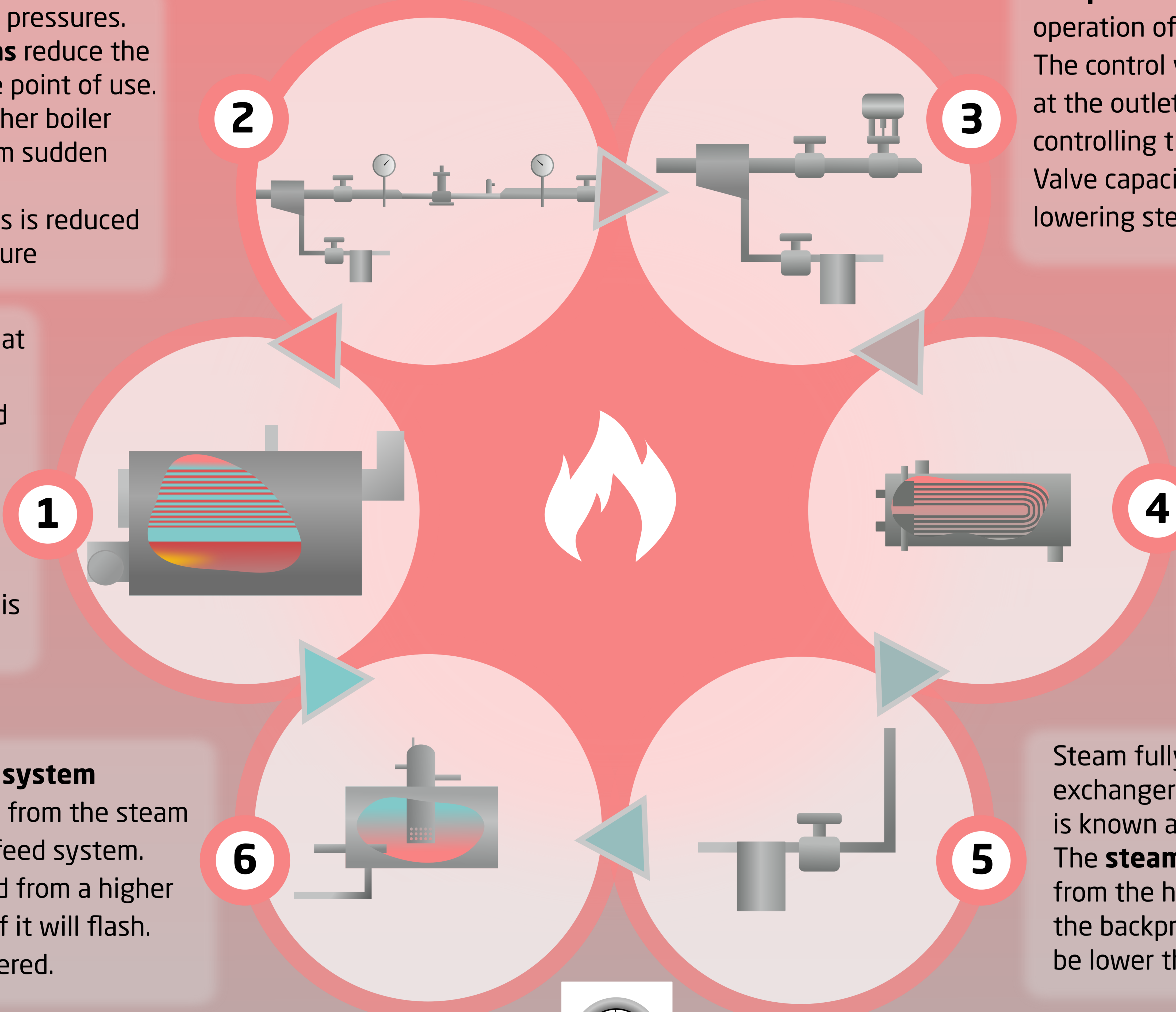
From boiler-based to Heat-Pump-based Industrial Steam Systems

Replacement of gas-fired boilers with High Temperature Heat Pumps in existing steam systems may be an economically attractive option to achieve electrification of industrial processes. In order to do so, it may be desirable to reduce the pressure of steam. This infographic presents the limitations and constraints that are necessary to consider in order to effectively replace the boiler with a Heat Pump by lowering the steam pressure of the system.



1. The **boiler** produces steam at high pressure.
The water level is controlled to avoid overheating of the tubes.
It is possible to lower the pressure of the steam by working at part load, which is controlled by the burner.

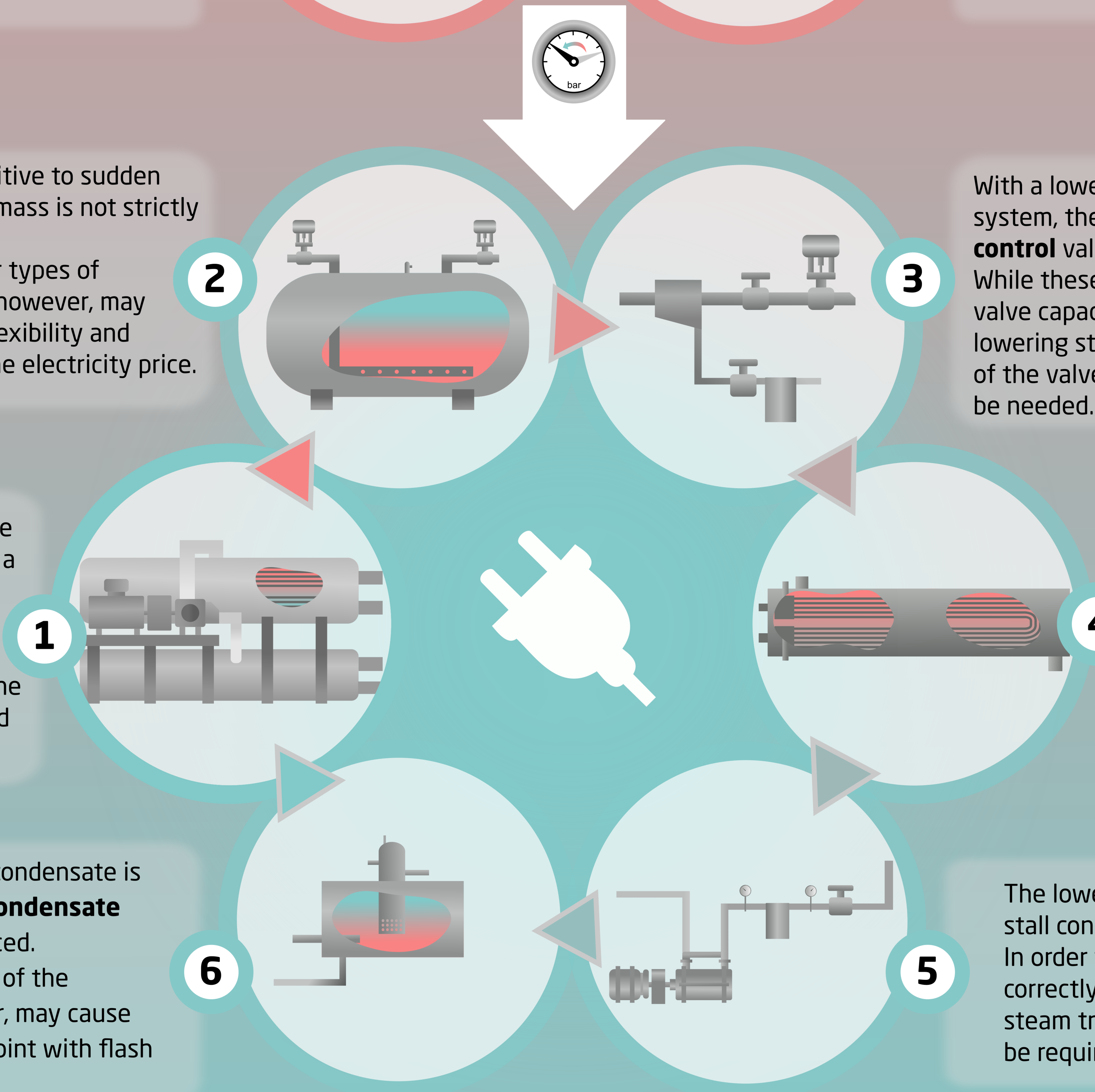
2. Steam is distributed at high pressures. **Pressure Reduction Stations** reduce the correct pressure level at the point of use. These valves allow a smoother boiler operation and protect it from sudden changes on the load.
The capacity of these valves is reduced when lowering steam pressure

3. **Temperature control** is key to the operation of the system.
The control valve controls the temperature at the outlet of the heat exchanger by controlling the mass flow of the steam.
Valve capacity must be checked when lowering steam temperature.

4. Heat is transferred from the steam to the process in the **Heat Exchanger**.
The heat exchanger can be sized by the pressure drop at the process side or by the heat exchange area. Lowering steam pressure would lower the capacity of the heat exchanger.

5. Steam fully condenses in the heat exchanger, and if subcooling takes place, it is known as "stall conditions".
The **steam trap** drains the condensate from the heat exchanger. In order to do so, the backpressure of the condensate must be lower than steam pressure.

6. The **condensate recovery system** collects the hot condensate from the steam and returns it to the boiler feed system.
As condensate is discharged from a higher to a lower pressure, some of it will flash.
This steam should be recovered.



1. The steam is produced at the lowest possible pressure by a **High Temperature Heat Pump**.
The COP and therefore the electricity consumption of the Heat Pump is directly related to the temperature lift.

2. The operation is not as sensitive to sudden changes in load, so thermal mass is not strictly required.
Steam accumulators or other types of **thermal energy storages**, however, may become attractive to offer flexibility and exploit the fluctuations in the electricity price.

3. With a lower pressure on the steam system, the capacity of the **temperature control** valve is reduced.
While these valves are usually ovesized, valve capacity must be checked when lowering steam pressure as replacement of the valve seat or complete valve might be needed.

4. The **Heat Exchanger** may have to be replaced with a bigger heat exchanger due to a smaller temperature difference. A minimum temperature difference with the process will probably be the lower limit for lowering the pressure.

5. The lower steam pressure will cause stall conditions more often.
In order for the steam condensate to be correctly discharged, replacing the steam trap with a **vacuum pump** may be required.

6. As the temperature of the condensate is lower, flash losses on the **condensate recovery system** are reduced.
High degrees of subcooling of the condensate return, however, may cause hammering at the mixing point with flash steam.

When lowering the pressure of steam all of the different elements of the system have to be studied in detail. A comprehensive description of the system and data on all of the components have to be gathered in order to study the economic viability and the lower limits on steam pressure. This study is key to effectively and efficiently integrate a High Temperature Heat Pumps into existing systems.

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