Training example for 3rd training day
Simplified Brewery

Production capacity 1,9 Mio. hl per annum
12 brews/day; 60 brews per week

6 days per week; 52 weeks per year → 312 production days per year
24 hours per day

Energy consumption: 20,000 MWh natural gas á 40 €, electricity price is 100 €/MWh

Heating supply: Steam network (7 bar) supplied by a steam boiler (10 MW, conversion efficiency 0.90), outlet temperature 180 °C, return temperature 90 °C, rate of recirculation 0.80, pipe length 300 m

Cooling supply: glycol network (outlet temperature to distribution: -8 °C, return temperature -2 °C) supplied by a chiller (1,2 MW, temperature of re-cooling 30 °C, COP = 3, temperature of re-cooling 30 °C)

Considered processes:

1) Mashing

Final process temperature 75 °C

Inflows:

- √ Water inflow: 400 hl per brew at 60°C after external heat exchanger
  The water is taken from a storage tank, that is filled with hot water generated over the wort cooler. Fresh water reference temperature is 10°C.
- √ Malt inflow: 10 tons (= 7 m³) at 15°C
  First 10 minutes of each batch

Outflows:

Mash: 470 hl per brew at 75°C

"Startup Heat demand"

Mixing temperature of two inflows = 55,5°C (= start-up temperature of process medium)
overall heated to 75°C in 50 minutes after filling

Process schedule:

Try to enter a detailed schedule for this process.
Starting on Monday at 12:00 a.m., last batch starting Saturday at 10:00 a.m.

1 hour for each batch, 12 batches per day, between each batch 1 hour break
For each batch: first 10 minutes inflow, 50 min heating, 10 minutes outflow

2) Lautering

Final process temperature 75 °C

Inflows:

- √ Water inflow: 300 hl per brew at 75°C after external heat recovery

The water is taken from a storage tank, that is filled with hot water generated over the wort cooler. Fresh water reference temperature is 10°C.

Outflows:

- √ Wort: 640 hl per brew at 75°C
- √ Spent grain: 12 tons at 75°C (not modelled in EINSTEIN as heat from solids can hardly be recovered)

Process schedule:

No input of a detailed schedule in this testcase → instead operation time is entered in a simplified way: 1.8 hours for each batch, 10 batches per day, 6 days per week (=60 batches per week)

3) Wort preheating and boiling

Final process temperature 100 °C

Inflows:

- √ Wort inflow: 640 hl per brew at 75°C

Outflows:

- √ Wort: 615 hl per brew at 98°C, cool-down over external heat exchanger to 8°C
- √ Vapours: 25 hl per brew at 102°C, possible cool-down to 15°C

1 hour for each batch

Maintainance Heat

On average 1550 kW during batch time

Process schedule:

No input of a detailed schedule in this testcase → instead operation time is entered in a simplified way: 1 hours for each batch, 10 batches per day, 6 days per week (=60 batches per week)

4) Fermentation (continuous cooling process)

Final process temperature 12°C

Power requirement of the process during operation 500 kW (constant cooling load assumed for testcase)

Process schedule:

24 hours per day, 365 days a year

5) Maturation (continuous cooling process)

Final process temperature 1°C

Power requirement of the process during operation 100 kW (constant cooling load assumed for testcase)

Inflow
220 kg/h wort, inlet temperature 12°C

Process schedule:
24 hours per day, 365 days a year

Economical data:

Inflation rate	3%
Increase of energy prices	3%
Nominal interest rate	4%
Company specific discount rate	3%
Time frame	20 years

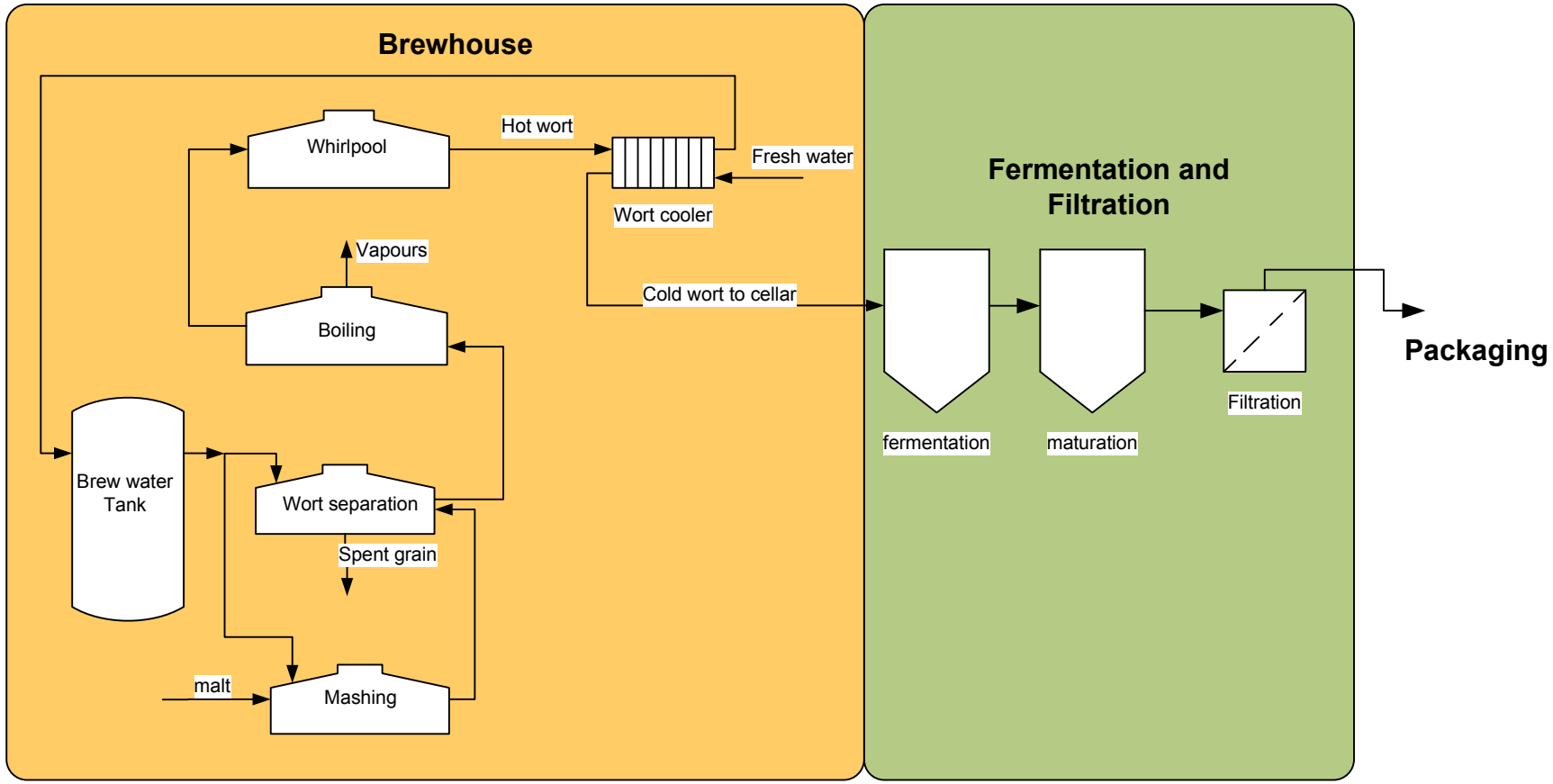

Figure 1: general brewery flowsheet

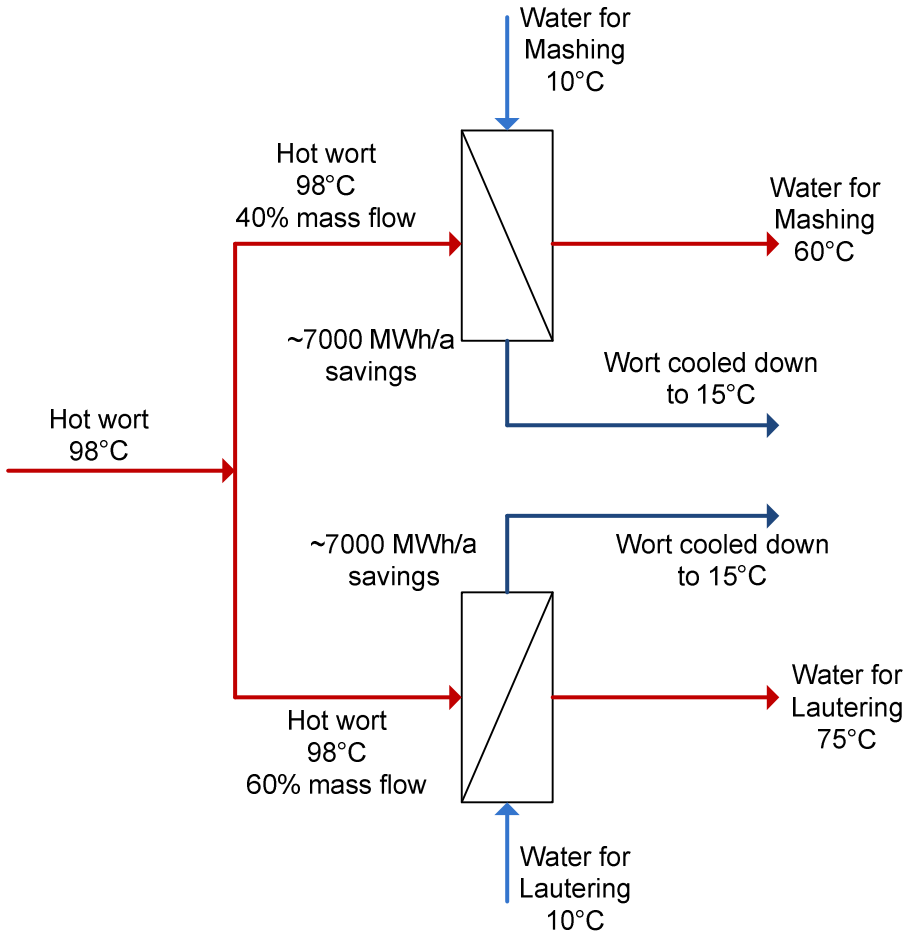

Figure 2: Modelling the preheating of water for the mashing and lautering process in EINSTEIN