Section 8

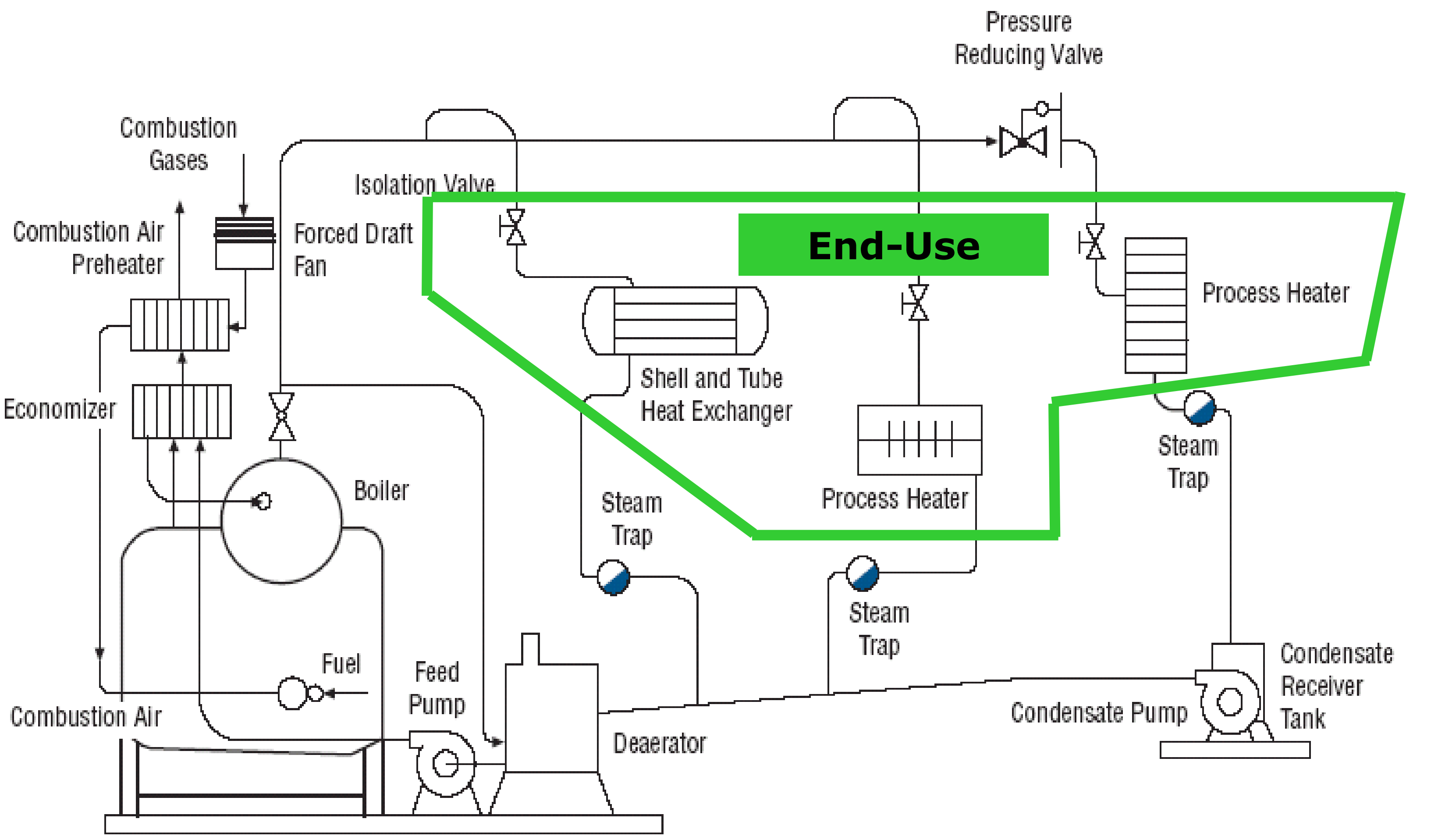
Steam System Optimization - Steam Demand (End Use)

Steam Generation Condition Impacts

Steam Demand (End Use)

SSAT Steam Demand Savings Projects

Generic Steam System



Source: US DOE ITP Steam BestPractices Program

SSAT Project 6 – Steam Generation Conditions

Project 6 - Change Steam Generation Conditions Existing Conditions : 25 barg. Superheated steam at 375°C

Do you wish to change the HP steam generation conditions?	Option 3 - No change

Option 1 - Enter temperature	320 °C	

Note: Saturation temperature at specified HP pressure (25 barg) is 226°C

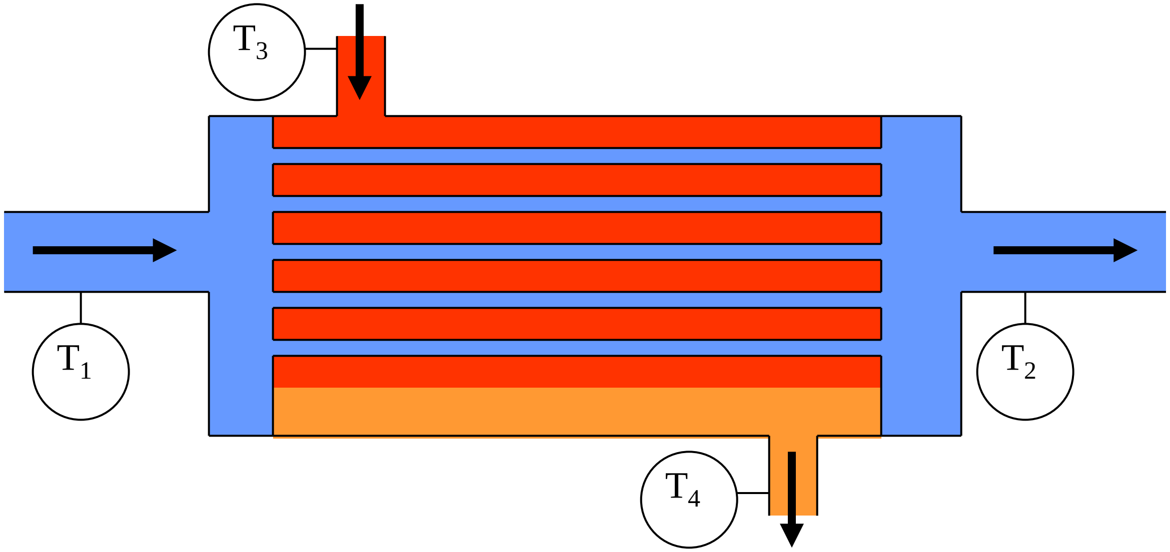
Option 2 - Enter thermodynamic quality	99.9 % dry	

$$Quality = x = \frac{\dot{m}_{vapor}}{\dot{m}_{vapor} + \dot{m}_{liquid}}$$

SSAT Project 6 – Steam Generation Conditions

- SSAT Project 6 allows steam generation conditions to be changed
- The primary emphasis of this project is to investigate the operation of a boiler discharging reduced quality steam
  - Quality referred to in this instance is thermodynamic quality
    - Mass fraction of vapor in the boiler discharge
- Another impact may be changing superheat of an existing system to see the economic impact on fuel and power generation
  - Some turbine performance characteristics maybe required
- The thermal load of the steam demands remain constant

- ✓ Saturated liquid discharged from the boiler does not transfer energy to the process loads
- ✓ Saturated liquid discharged from the boiler passes through the steam turbines and PRV’s
- ✓ The primary loss is realized in the condensate system
  - Additional mass passes through the condensate system
    - Increased heat transfer loss
    - Increased makeup water demands due to lost condensate



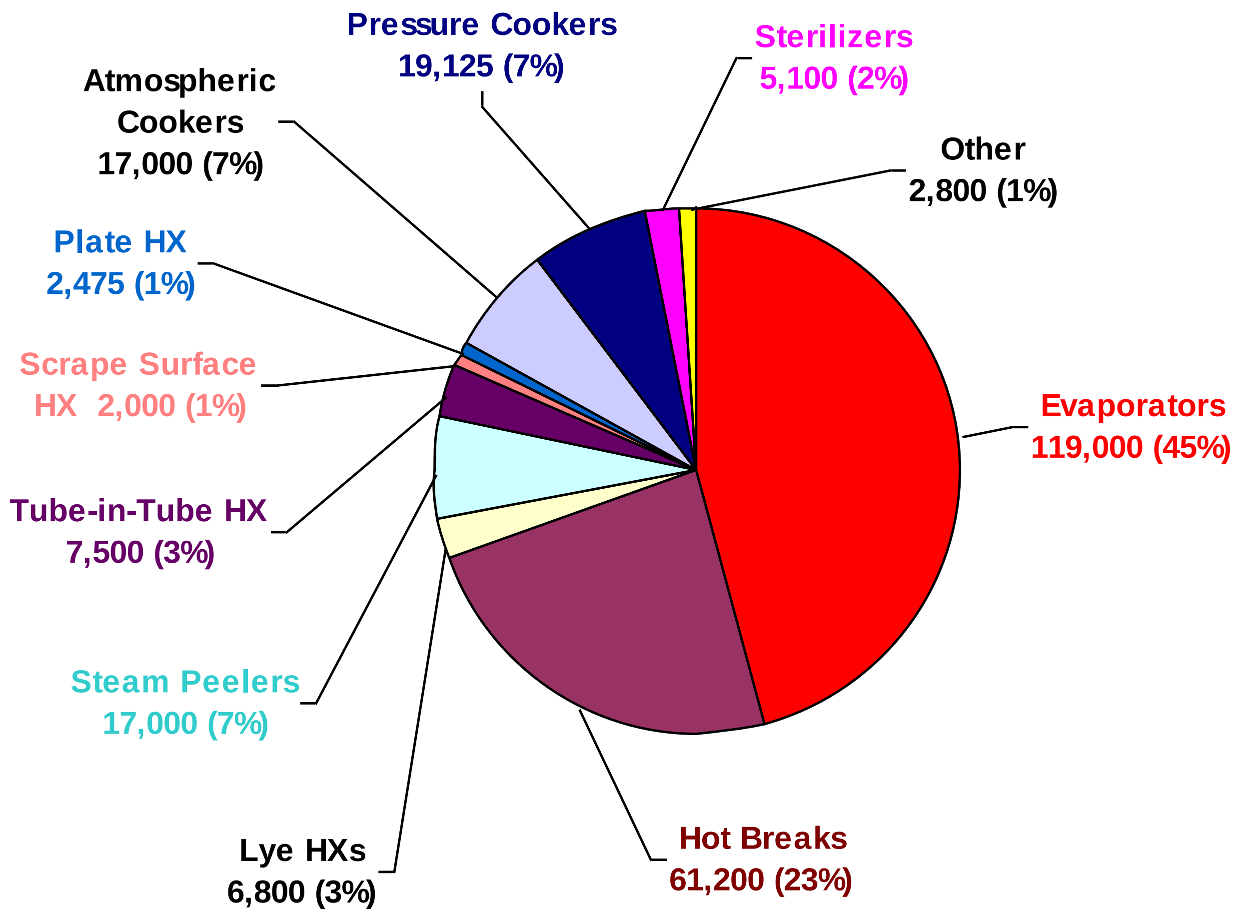
Steam Demand

- Steam demands take on many different forms
- Reducing steam consumption can often result in the most significant energy reduction opportunities
  - Eliminate inappropriate steam use
  - Reduce appropriate steam use
- Nevertheless, it is extremely difficult to cover end-uses that are specific to industrial processes in a general class
  - Hence, general methods will be described and tools provided to capture and quantify steam demand savings

Some Common Steam End-Uses

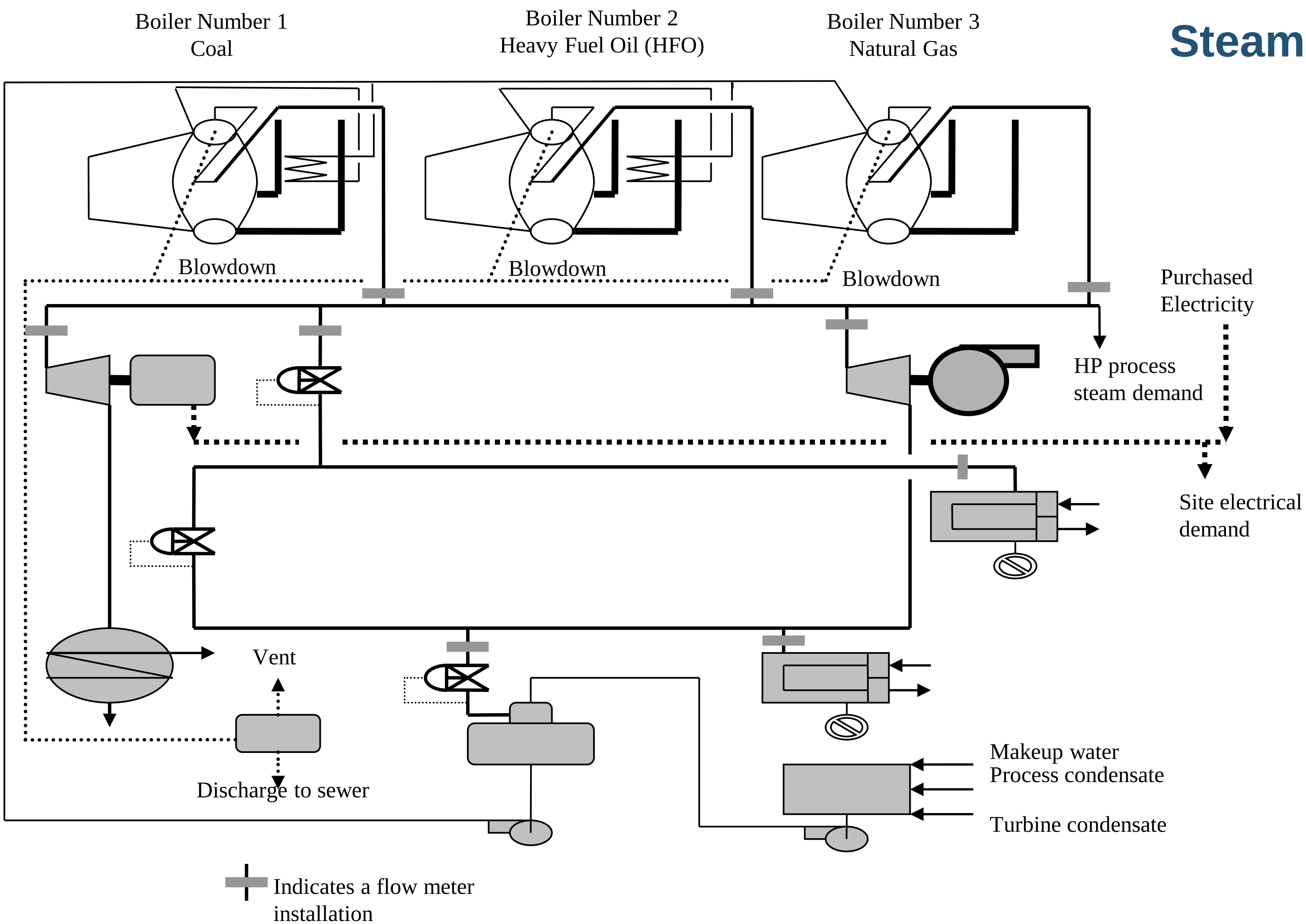
- ✓ Distillation towers
- ✓ Dryers
- ✓ Evaporators
- ✓ Heat Exchangers
- ✓ Reboilers
- ✓ Reformers
- ✓ Steam ejectors / injectors
- ✓ Strippers
- ✓ Thermocompressors
- ✓ Absorption chillers
- ✓ Humidifiers
- ✓ Preheat / Reheat Air Handling Coils

A Steam End-Use* Distribution Pie-Chart

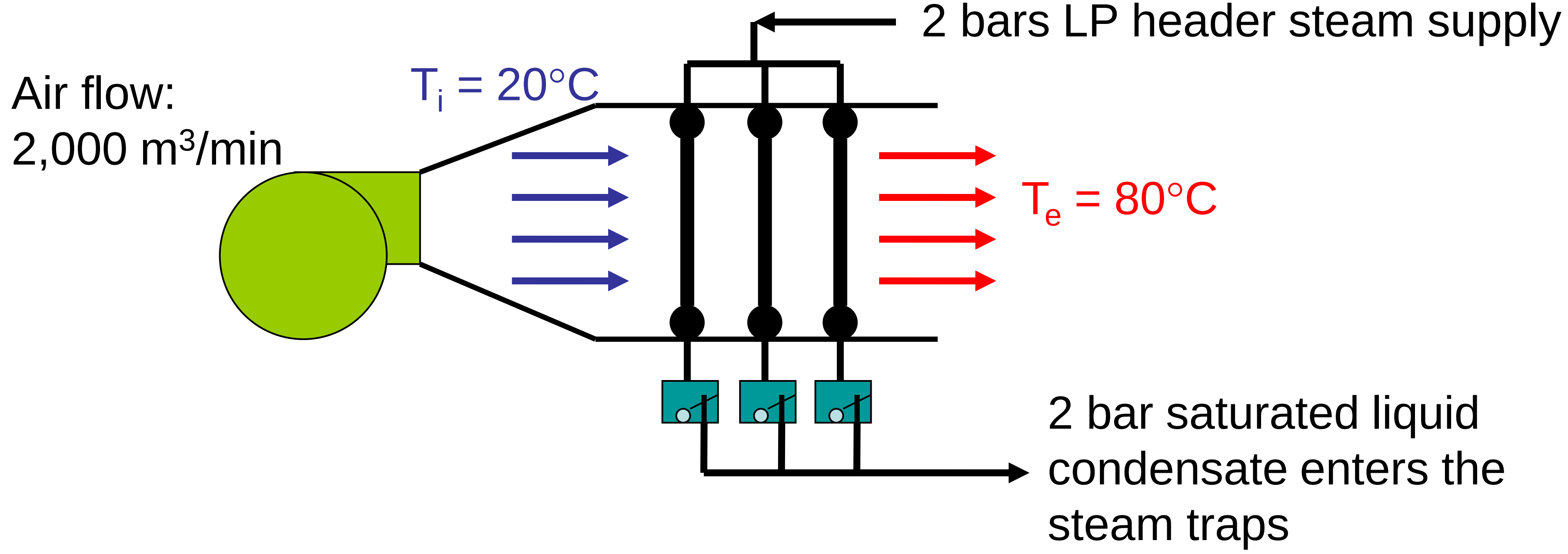


*** Food & Beverage – Vegetable & Fruit Juices**

Steam System



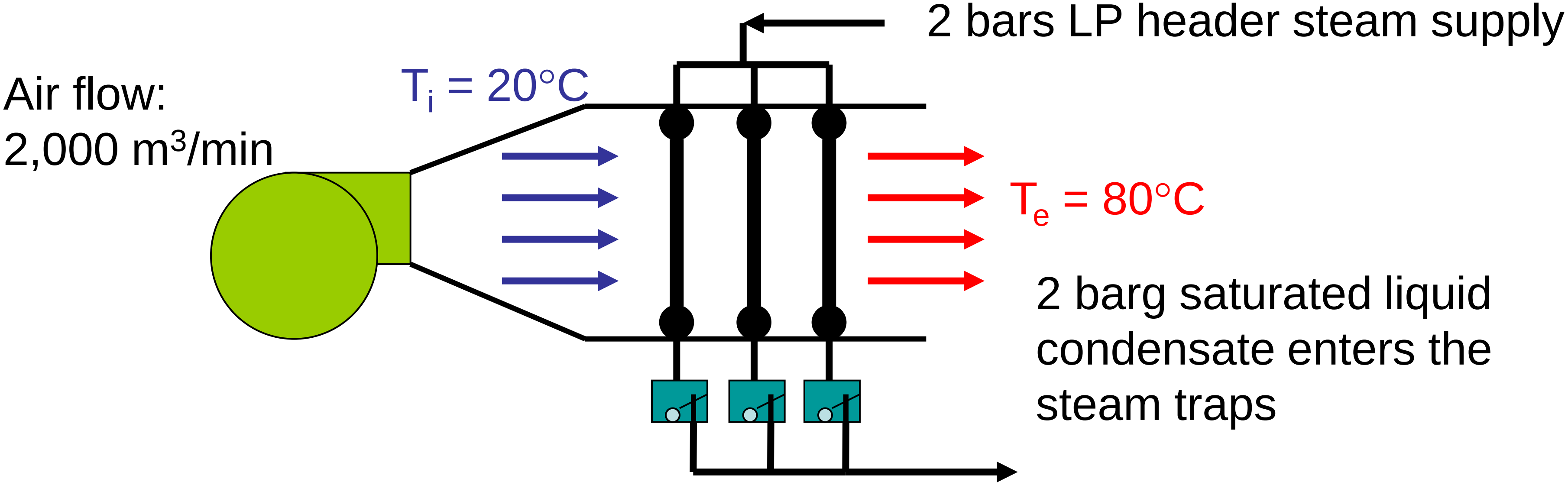
Example Steam Demand (Pre-heat air)



- ✓ A process requires air to be heated to 80°C
- ✓ Outside air is currently being supplied to the process oven

Source: US DOE ITP Steam BestPractices Program

Example Steam Demand (Pre-heat air)

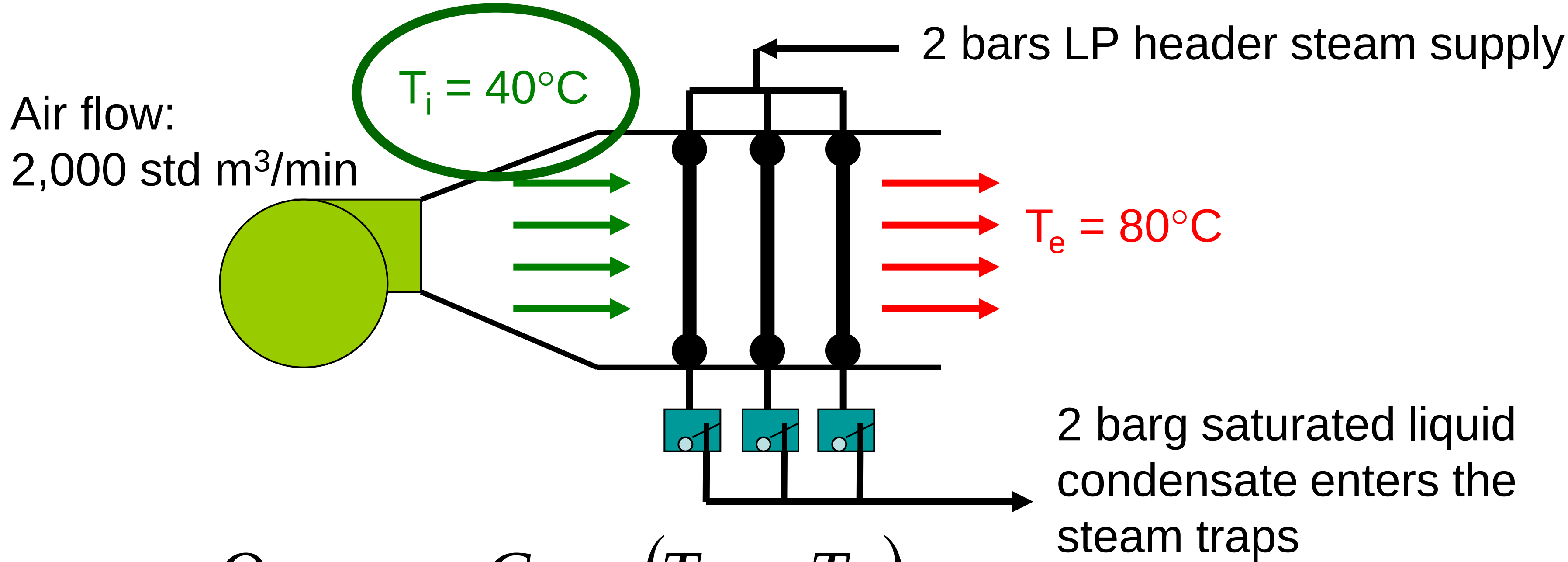


$$Q_{air} = m_{air} C_{p\_air} \left(T_{out} - T_{in}\right)_{air}$$

$$Q_{air} = 2{,}000 \times 1.188 \times 1.006 \times (80 - 20) \times \frac{1}{60}$$

$$Q_{air} = 2{,}391\, kW$$

Example Steam Demand (Pre-heat air)



$$Q_{air} = m_{air} C_{p\_air} \left(T_{out} - T_{in} \right)_{air}$$

$$Q_{air} = 2{,}000 \times 1.188 \times 1.006 \times (80 - 40) \times \frac{1}{60}$$

$$Q_{air} = 1{,}594\ kW$$

Example Steam Demand (Pre-heat air)

- ✓ Energy Savings = 2,391 – 1,594 ≈ 796 kW

$$m_{steamsaved} = \frac{EnergySavings}{\left(h_{steam} - h_{condensate}\right)}$$

$$m_{steamsaved} = \frac{796}{\left(3{,}181 - 561.5\right)} \times 3{,}600$$

$$m_{steamsaved} = 1{,}094 \frac{kg}{\text{hr}}$$

- ✓ Steam saved = 1.094 * 8,760 = 9,582 tonnes/yr
- ✓ Unit cost of LP steam generation: $46.64 per tonne
- ✓ Annual cost savings = $447,000
- ✓ This same analysis can be done using Project 1 – Steam Demand Savings in SSAT

SSAT Project 1 - Steam Demand Savings

Project 1 - Steam Demand Savings (Changing the process steam requirements) Current use - HP: 20 t/h (12273 kW) MP: 40 t/h (26660 kW) LP: 76 t/h (54448 kW)	
Do you wish to specify steam demand savings?	Yes

If yes, enter HP steam saving	0 t/h	
If yes, enter MP steam saving	0 t/h	
If yes, enter LP steam saving	1.094 t/h	

Note: A negative saving can be entered to model an increase in steam demand

Note: The savings have been converted to heat duties of 0 kW (HP), 0 kW (MP) and 784 kW (LP) based on current header enthalpies

Note: These heat duties are then used to determine the actual flow change in the Projects Model based on the calculated header enthalpies

✓ Steam demand change is based on the enthalpy flow of the steam with the **initial model properties**.

- Steam properties change as the projects are initiated
- The process enthalpy flow is reduced by the demand change enthalpy flow

SSAT Project 1 - Steam Demand Savings

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Results Summary

SSAT Default 3 Header Metric Model Moldova Ex 5

Model Status : OK

Cost Summary ($ '000s/yr)	Current Operation	After Projects	Reduction	
Power Cost	6,132	6,132	0	0.0%
Fuel Cost	57,726	57,287	438	0.8%
Make-Up Water Cost	1,136	1,127	9	0.8%
Total Cost (in $ '000s/yr)	**64,993**	**64,546**	**447**	**0.7%**

Key Points / Action Items

1. There are several end-uses of steam in industrial plants
2. Do a steam end-use balance in an industrial plant and identify the largest steam end-users in a plant
3. Reduce steam end-use by
   - Improving the efficiency of the process
   - Shifting steam demand to a waste heat source or lower pressure steam available in the plant

Common BestPractices – End-Use

- ✓ Reduce steam usage by a process
  - Improving the efficiency of the process
  - Shifting steam demand to a waste heat source
- ✓ Reduce the steam pressure needed by process, especially in cogeneration systems
- ✓ Upgrade low pressure (or waste) steam to supply process demands
- ✓ Process integration leading to overall energy optimization of the plant

Source: US DOE BestPractices Steam System Sourcebook