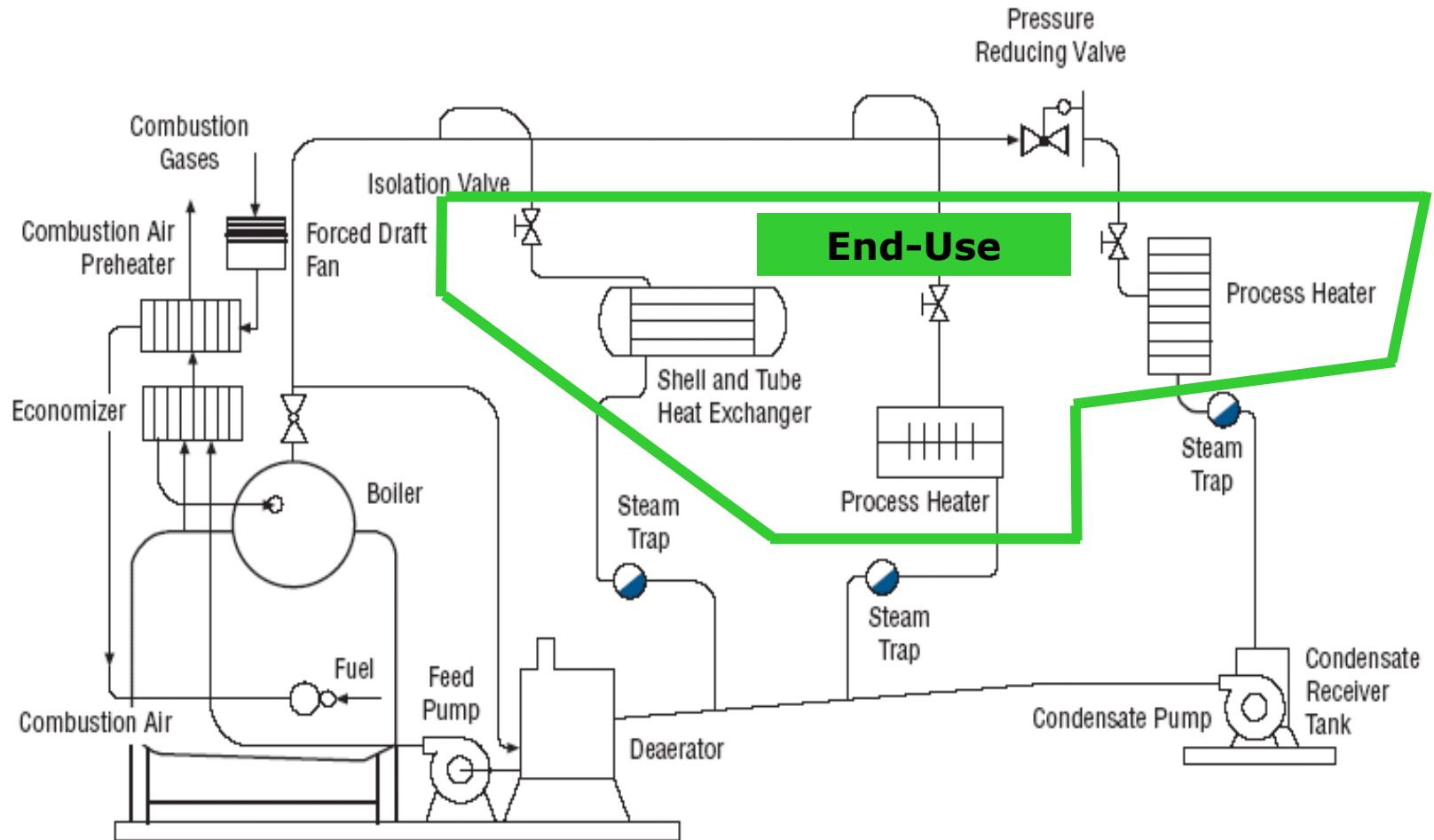




Section 8: Steam System Optimization - Steam Demand (End Use)

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

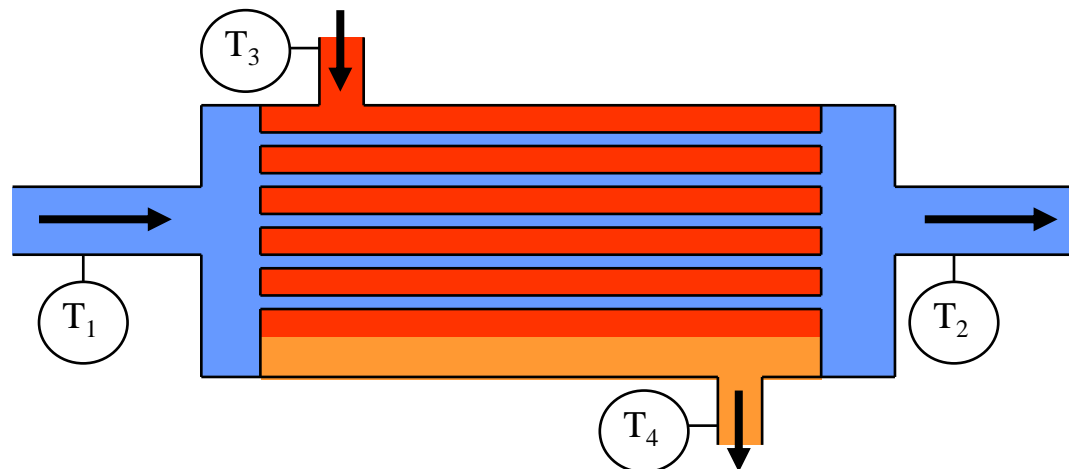
99.9 % dry

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

SSAT Project 6 – Steam Generation Conditions

- ✓ SSAT Project 6 allows steam generation conditions to be changed (lowering generation pressure)
- ✓ 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
 - Lower pressure to end users due to higher pressure drop in distribution headers
- ✓ 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
- ✓ Major impacts could be at the End Users & at the condensate system
 - Poor quality steam supply to end users
 - Additional mass passes through the condensate system
 - Drop in heat exchanger performance
 - Increased handling of condensate quality



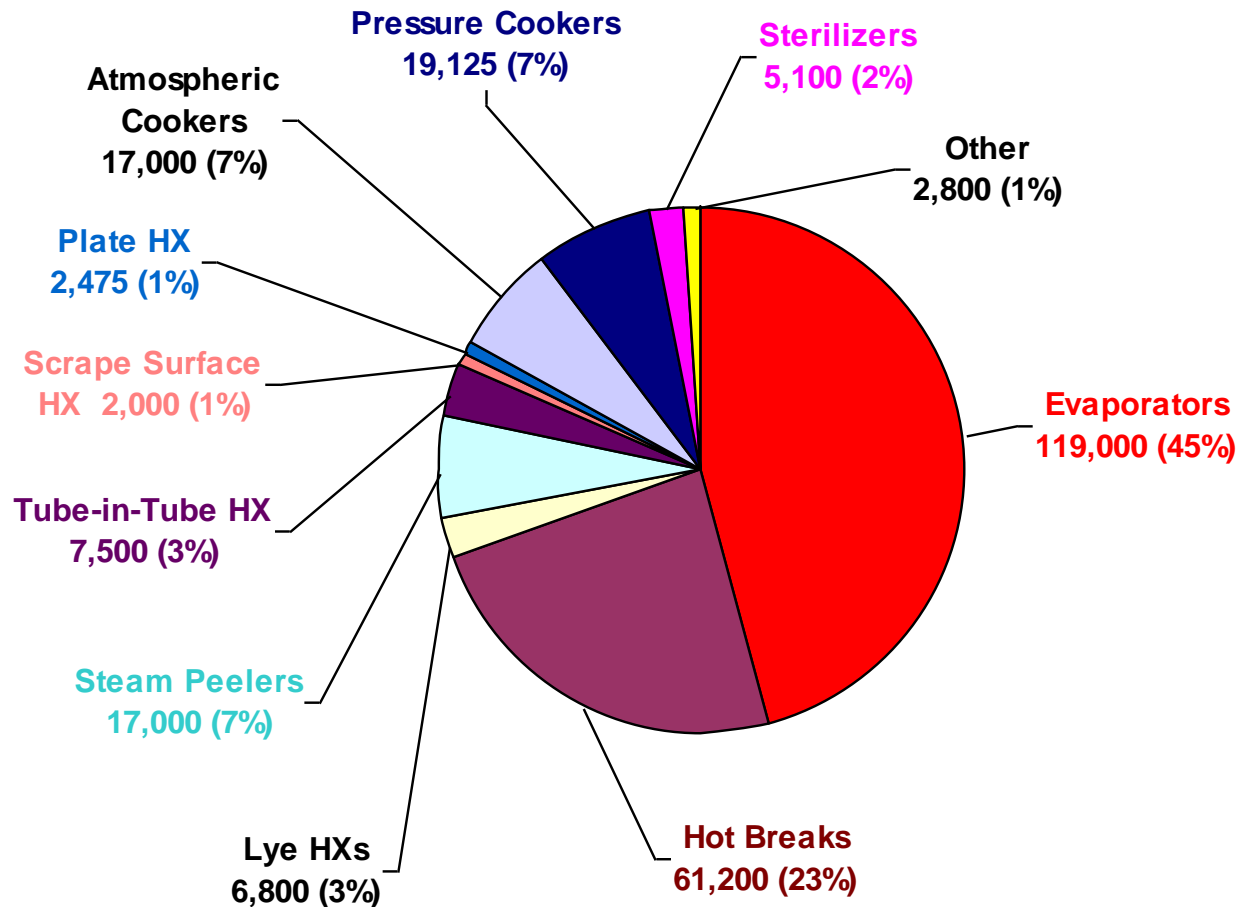
Steam Demand

- ✓ 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

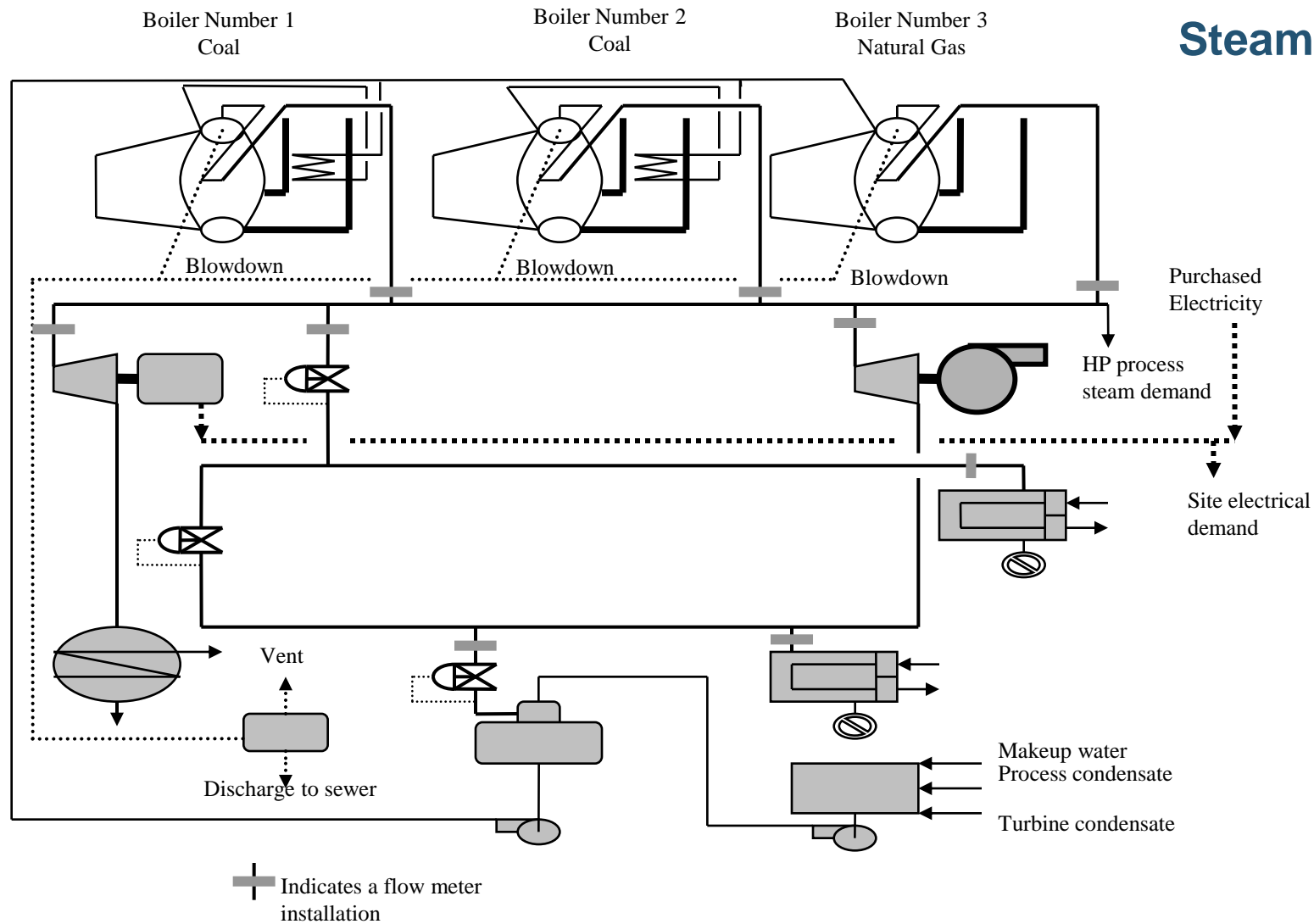
Some Common Steam End-Uses

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

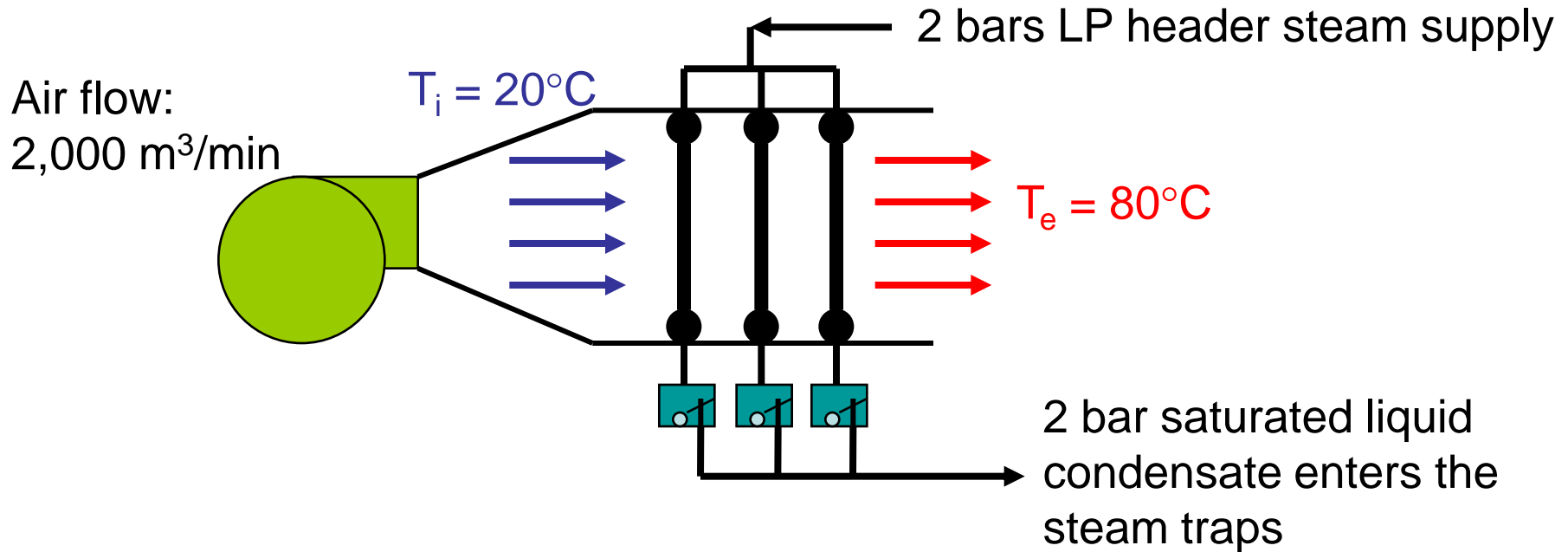
A Steam End-Use* Distribution Pie-Chart



* Food & Beverage – Vegetable & Fruit Juices

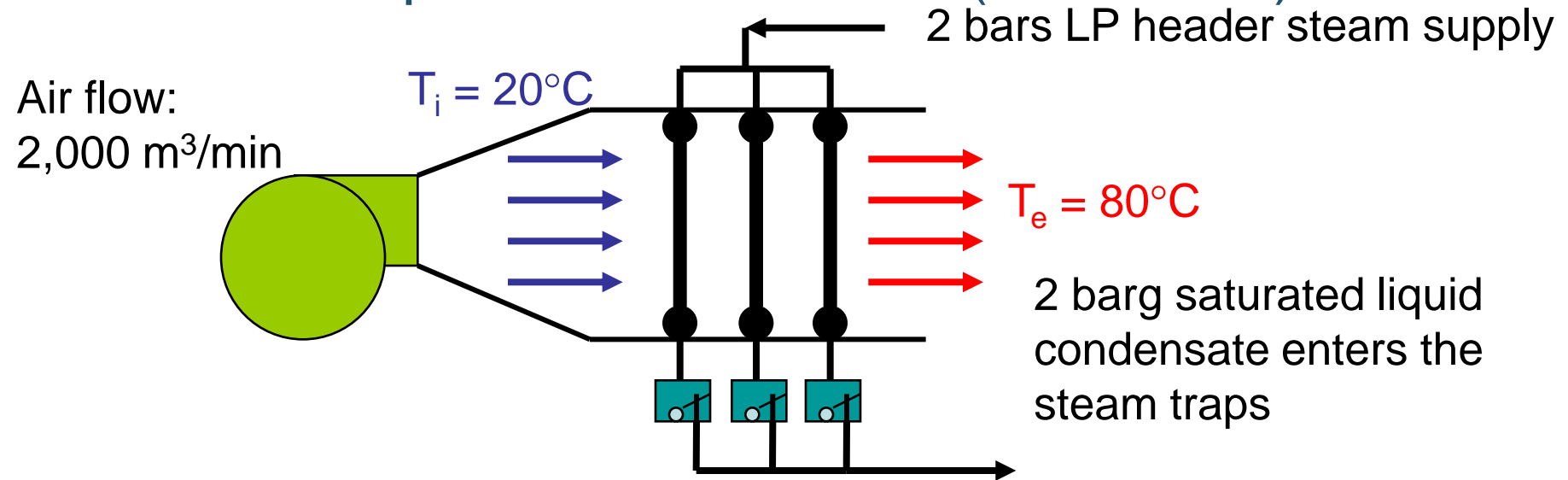


Example Steam Demand (Pre-heat air)



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

Example Steam Demand (Pre-heat air)

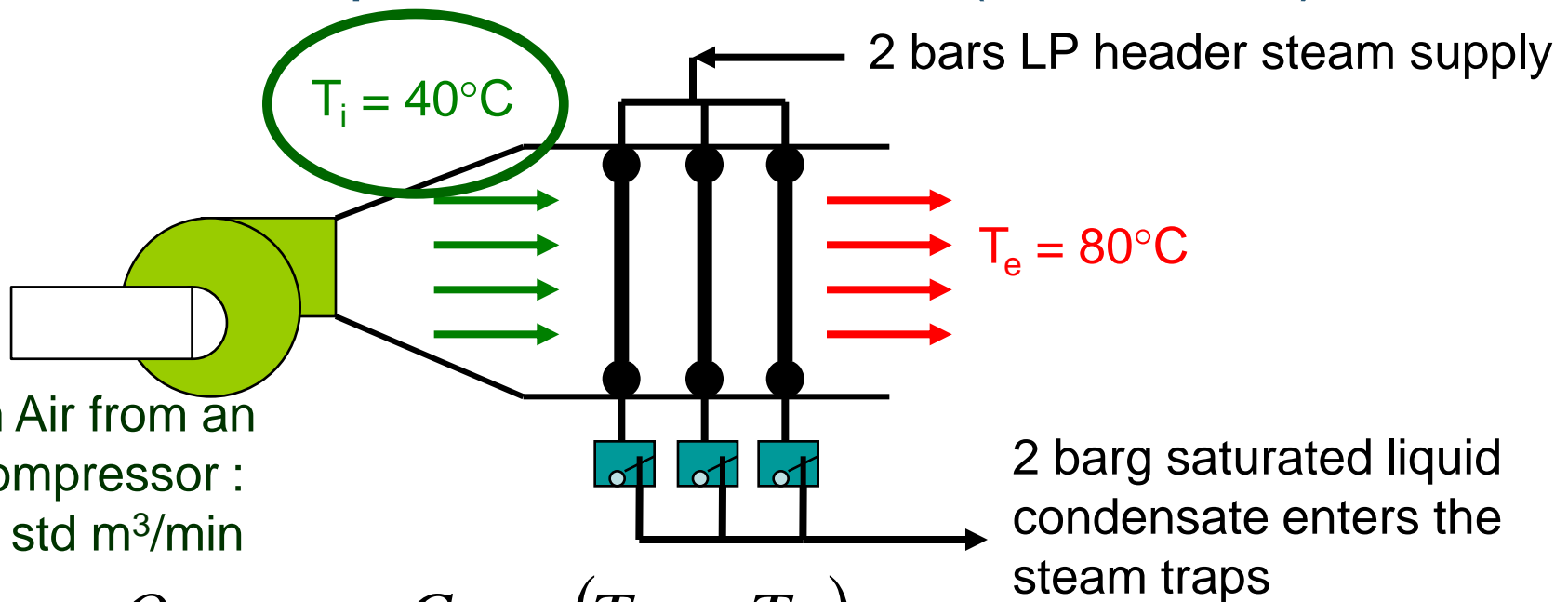


$$Q_{air} = m_{air} C_{p_air} (T_{out} - T_{in})_{air}$$

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

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

Example Steam Demand (Pre-heat air)



$$Q_{air} = m_{air} C_{p_air} (T_{out} - T_{in})_{air}$$

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

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

Example Steam Demand (Pre-heat air)

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

$$m_{steamsaved} = \frac{EnergySavings}{(h_{steam} - h_{condensate})}$$
$$m_{steamsaved} = \frac{796}{(3,181 - 561.5)} \times 3,600$$
$$m_{steamsaved} = 1,094 \frac{kg}{hr}$$

- ✓ Steam saved = 1.094 * 8,760 = 9,582 tonnes/yr
- ✓ Unit cost of steam generation: EGP 197.42 per tonne
- ✓ Annual cost savings = **EGP 1,892,000**
- ✓ 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 (55285 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 796 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

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 (55285 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 796 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

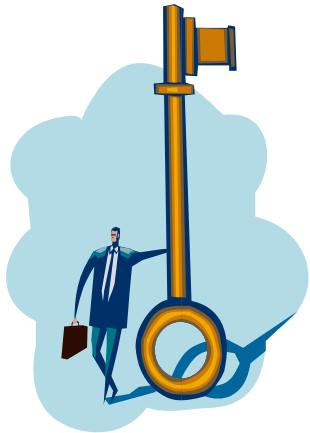
Results Summary

SSAT 3 Header Metric Model for User Training Egypt

Model Status : OK

| Cost Summary (\$ '000s/yr) | Current Operation | After Projects | Reduction | |
|------------------------------------|-------------------|----------------|--------------|-------------|
| Power Cost | 33,726 | 33,726 | 0 | 0.0% |
| Fuel Cost | 231,305 | 229,444 | 1,861 | 0.8% |
| Make-Up Water Cost | 3,897 | 3,865 | 31 | 0.8% |
| Total Cost (in \$ '000s/yr) | 268,928 | 267,036 | 1,892 | 0.7% |

Annual cost savings = EGP 1,892,000



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