Industrial Steam Systems
Virtual INPLT Training & Assessment

Session 7

Tuesday – May 18, 2021

10 am – 12:30 pm

Agenda – Session SEVEN

- Safety and Housekeeping
- Today's Content:
  - Discussion of Homework
  - Review of Session 6
  - Distribution – Energy Efficiency & Savings Opportunities
    - Steam leaks
    - Insulation
  - End Use – Energy Efficiency & Savings Opportunities
  - Steam Traps Management
  - Condensate Recovery - Energy Efficiency & Savings Opportunities
- Kahoot Quiz Game
- Q&A

U.S. DEPARTMENT OF ENERGY
Better Buildings is an initiative of the U.S. Department of Energy

Safety and Housekeeping

- Safety Moment
  - Do not touch anything with your bare hands – always wear proper PPE (gloves) – while walking/working in your plant – especially, as you investigate steam end-use areas
- Break points after each sub-section where you can ask questions
- When you are not asking a question, please MUTE your mic and this will provide the best sound quality for all participants
- We will be recording all these webinars and by staying on-line and attending the meeting you are giving your consent to be recorded
  - A link to the recorded webinars will be provided, afterwards

Steam Virtual INPLT Agenda

- **Week 1 (April 6) – Industrial Steam Systems Fundamentals and Introduction to SSST**
- **Week 2 (April 13) – Focus on Steam System Generation and Introduction to DOE's MEASUR Tool**
- **Week 3 (April 20) – Steam System Generation & Cogeneration (CHP)**
- **Week 4 (April 27) – Steam System Distribution, End-Use & Condensate Recovery**
- **Week 5 (May 4) – Energy Efficiency Opportunities in the Generation Area**
- **Week 6 (May 11) – Energy Efficiency Opportunities in Generation & Cogeneration (CHP) Areas**
- **Week 7 (May 18) – Energy Efficiency Opportunities in Distribution, End-use and Condensate Recovery**
- **Week 8 (May 25) – Industrial Steam System VINPLT Wrap-up Presentations**

Homework 6 Discussion

U.S. DEPARTMENT OF ENERGY

Homework #6

- Evaluate the opportunities we talked about in the VINPLT today
- Pick one (or more) applicable scenarios and apply it to your plant by modeling it in your MEASUR plant model
- Save the file w/different scenarios on your computer and send us the .json file
- As you undertake your energy assessment, provide me with one project that you would want to present on May 25 in the group discussion

Session 6 – Review

U.S. DEPARTMENT OF
ENERGY

Better Plants Diagnostic Equipment Program (DEP)

Better Plants® U.S. DEPARTMENT OF ENERGY

Diagnostic Equipment Program (DEP)

The Better Plants **Diagnostic Equipment Program (DEP)** allows partners to borrow over 22 different kinds of tools to collect energy data and improve equipment performance in their facilities.

Through this program, partners have the opportunity to test tools firsthand before deciding to purchase a piece of equipment on their own. This not only allows for the improved testing and collection of energy data, but also helps to demonstrate the value of certain tools in different applications throughout a facility.

FULL SUITE OF DIAGNOSTIC TOOLS

- Anemometer
- Combustion Analyzer
- Conductivity Meter
- Current Transformer
- Digital Manometer
- Digital Thermometer
- Infrared Camera
- Infrared Thermometer
- Laser Distance Meter
- Light Meter
- Pitot Tube
- Power Logger
- Pressure Transducer
- Pyrometer
- Sonic Imager
- Strobe Tachometer
- Temp/RH logger
- Thermocouple
- Thermocouple Logger
- Time of Use Logger
- Ultrasonic Flow Meter
- Ultrasonic Leak Detector

EXPLORE SOME OF THE TOOLS THAT YOU CAN BORROW THROUGH BETTER PLANTS:

POWER LOGGER

This device helps you directly measure energy consumption, which can be converted into costs. It also logs data to provide electric consumption trends.

CURRENT TRANSFORMER

Use this device with a data logger to quantify the electric current flowing to a component or system and identify wasted energy.

COMBUSTION ANALYZER

This analyzer quantifies excess oxygen in boilers and combustion process exhausts, helping you save fuel and heat energy.

LEAK DETECTOR

This device helps you identify leaks in compressed air or steam systems using high frequencies that are undetectable to the human ear.

betterbuildingssolutioncenter.energy.gov/better-plants/diagnostic-tools @BetterPlantsDOE linkedin.com/showcase/better-plants

EXPLORE THE FULL SUITE OF DIAGNOSTIC EQUIPMENT AND SUBMIT AN APPLICATION:

Scan the QR Code above, or click here to download the DEP rental application.

Send this completed form to the Better Plants Diagnostic Equipment Program Manager, Daryl Cox at coxdf@ornl.gov.

HAVE QUESTIONS ABOUT BORROWING EQUIPMENT?

Scan the QR code above, or click here to email Daryl Cox, DEP Program Manager.

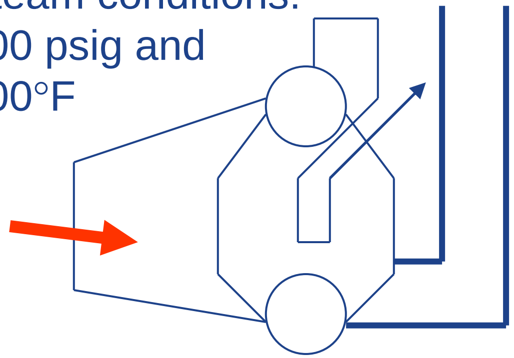
Daryl Cox has over 20 years of experience managing industrial technology and equipment and can help you find the right tool for your energy needs.

Shell Loss Reduction - Summary

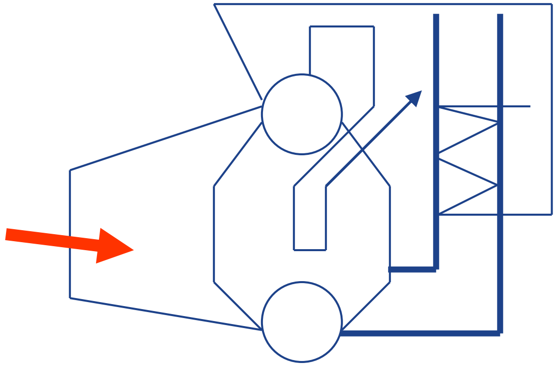
- Search for “hot spots”
- Measure boiler surface temperatures
  - Infrared
- Typical surface temperature should range between 120°F and 140°F
  - Personnel safety
- Repair refractory
- Monitor surface cladding integrity
- Reduced boiler load can present an opportunity

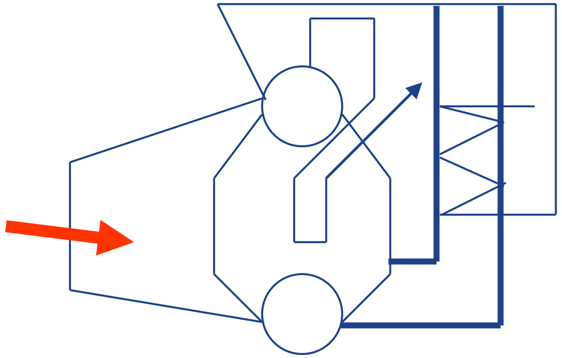
Fuel Selection – Example System – Pulp & Paper Mill

Steam conditions:
400 psig and
700°F



The Example Boiler
(equipped with an economizer)





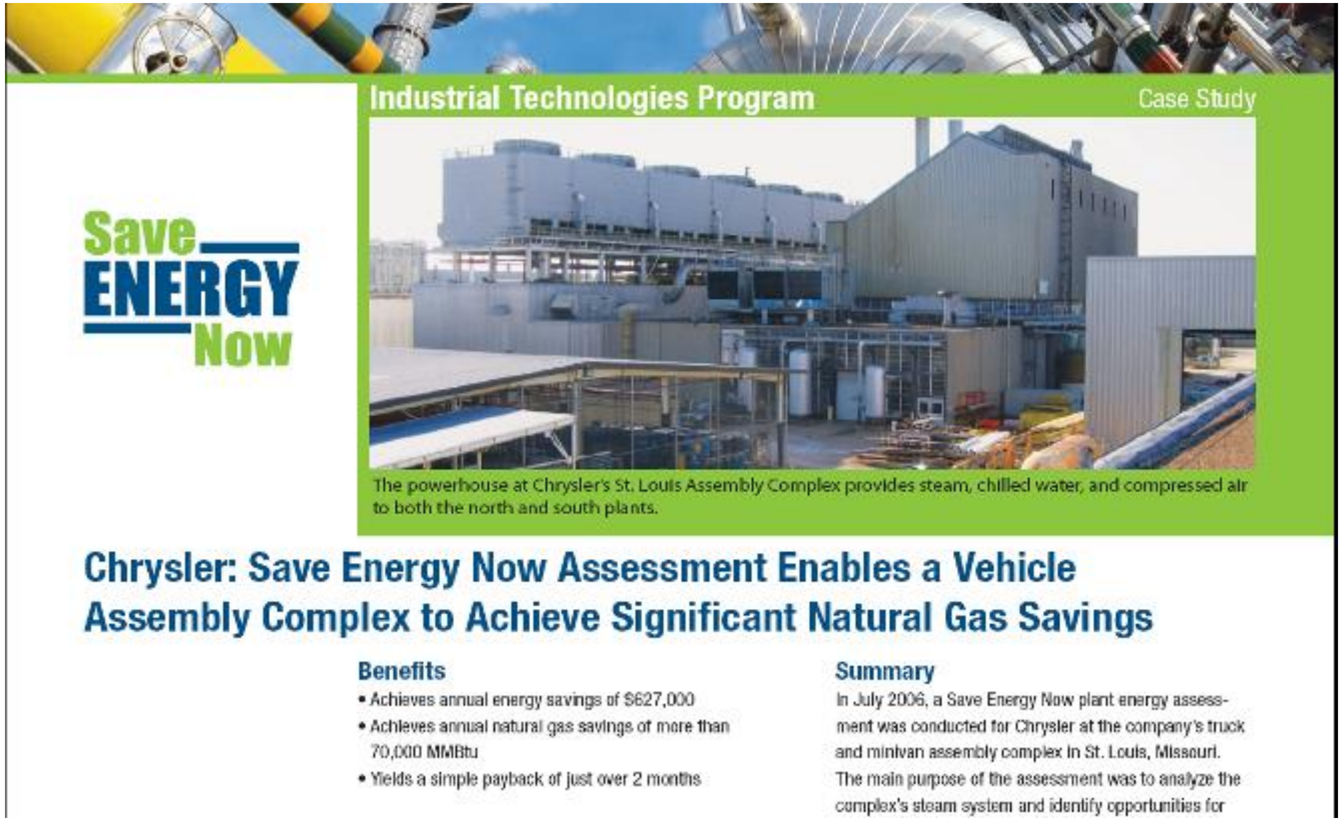
Fuel: Green Wood
Fuel cost: $\$2.00/10^6$Btu
Steam production:
80,000 lbm/hr
Efficiency: ~71.3%

Fuel: Natural gas
Fuel cost: $\$5/10^6$Btu
Steam production:
100,000 lbm/hr
Efficiency: ~84.2%

Fuel: Number 6 oil *HS*
Fuel cost: $\$5/10^6$Btu
Steam production:
80,000 lbm/hr
Efficiency: ~87.4%

- Modifications should be investigated to increase steam production from the wood boiler

Case Study – Success Story



Save ENERGY Now

Industrial Technologies Program

Case Study

The powerhouse at Chrysler's St. Louis Assembly Complex provides steam, chilled water, and compressed air to both the north and south plants.

Chrysler: Save Energy Now Assessment Enables a Vehicle Assembly Complex to Achieve Significant Natural Gas Savings

Benefits

- Achieves annual energy savings of $627,000
- Achieves annual natural gas savings of more than 70,000 MMBtu
- Yields a simple payback of just over 2 months

Summary

In July 2006, a Save Energy Now plant energy assessment was conducted for Chrysler at the company's truck and minivan assembly complex in St. Louis, Missouri. The main purpose of the assessment was to analyze the complex's steam system and identify opportunities for

Plant Energy Champion: Ken Peebles

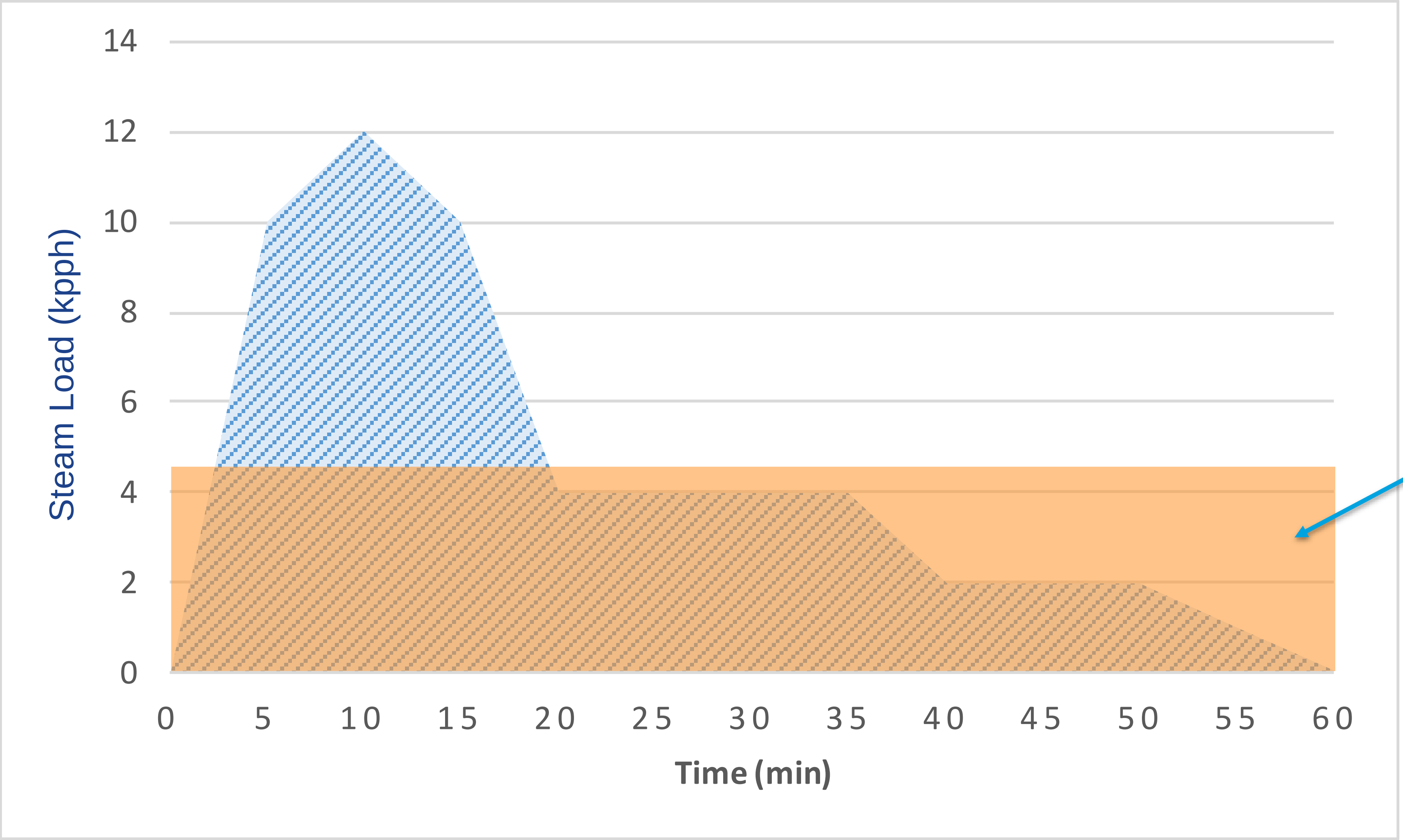
Steam Accumulators

- Primary purpose - Thermal Energy Storage

- Significant impact on operations
  - Boiler plant capacity
  - Energy efficiency
  - Water savings
  - Environmental issues

- Classic applications
  - Batch operations
  - Intermittent high and low steam demands
  - Periods of very small high peaks of steam demand

Steam Accumulators



Fixed Boiler Operation

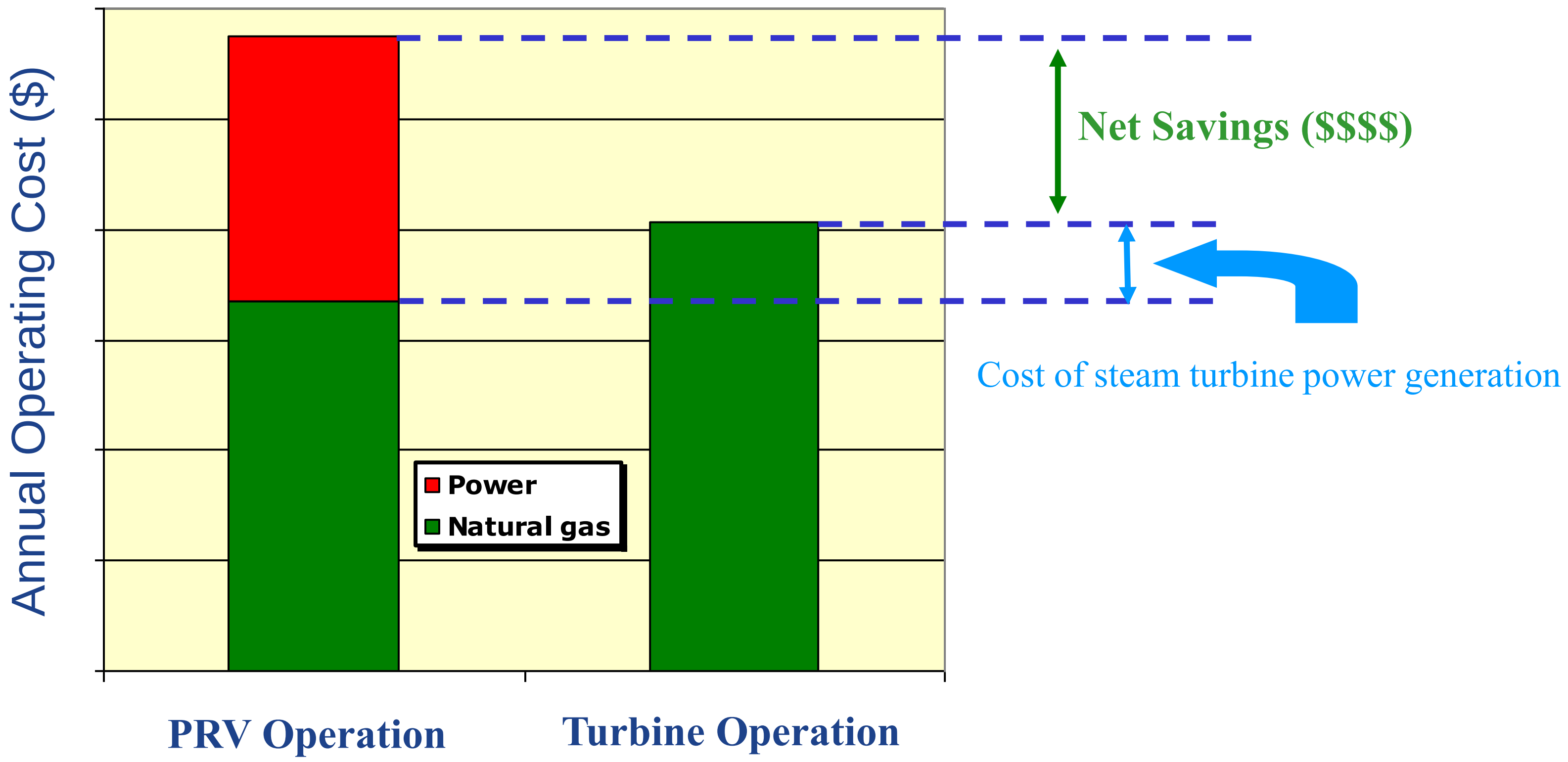
Backpressure Turbine Economics

- Most industrial systems require **<u>thermal energy</u>** (not mass flow of steam)

- The turbine will extract energy from the steam and convert it into shaft energy
  - The steam will exit the turbine with a reduced temperature

- The result will be an increased mass flow of steam required to satisfy the thermal demand

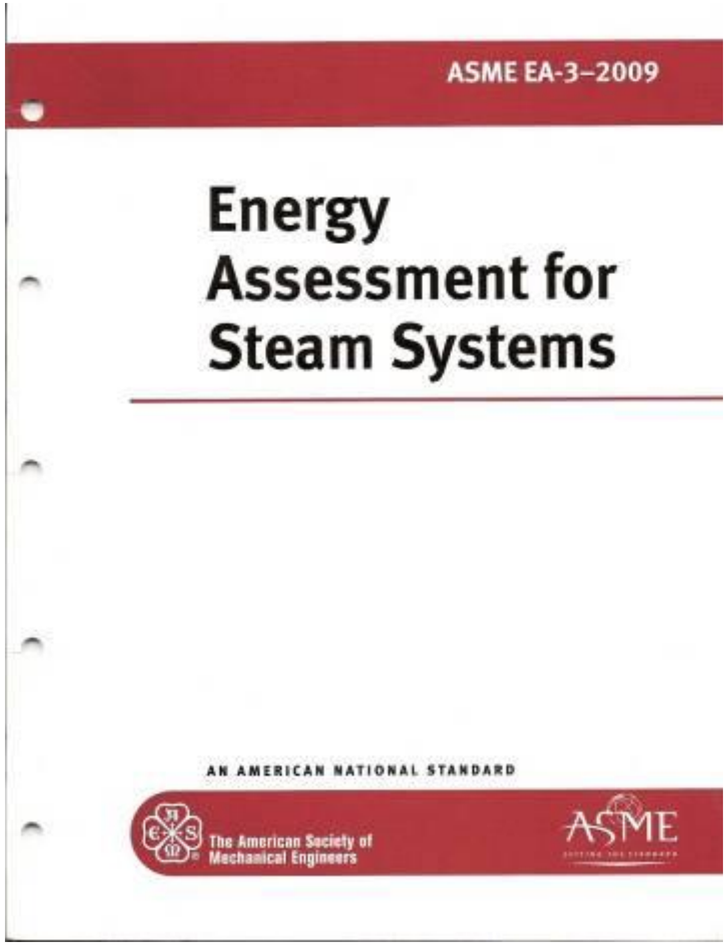
Backpressure Turbine Economics

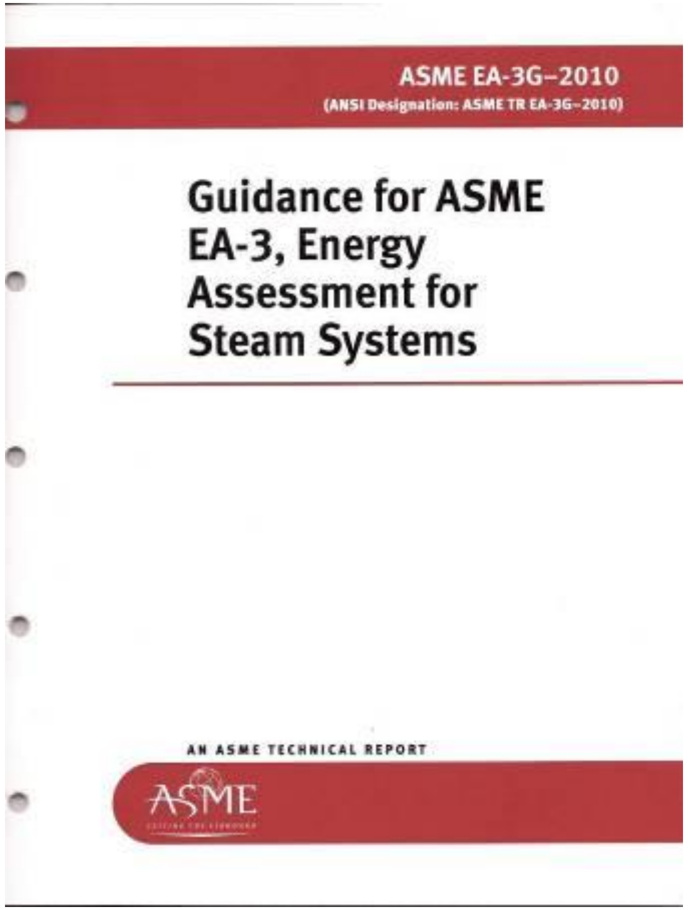


Variables for Industrial Applications

- Constant steam flow
- High pressure supply steam
- Existing Pressure Reducing Valve (PRV)
- Multiple steam header system
- Simultaneous steam and electric (power) demand
- High run hours

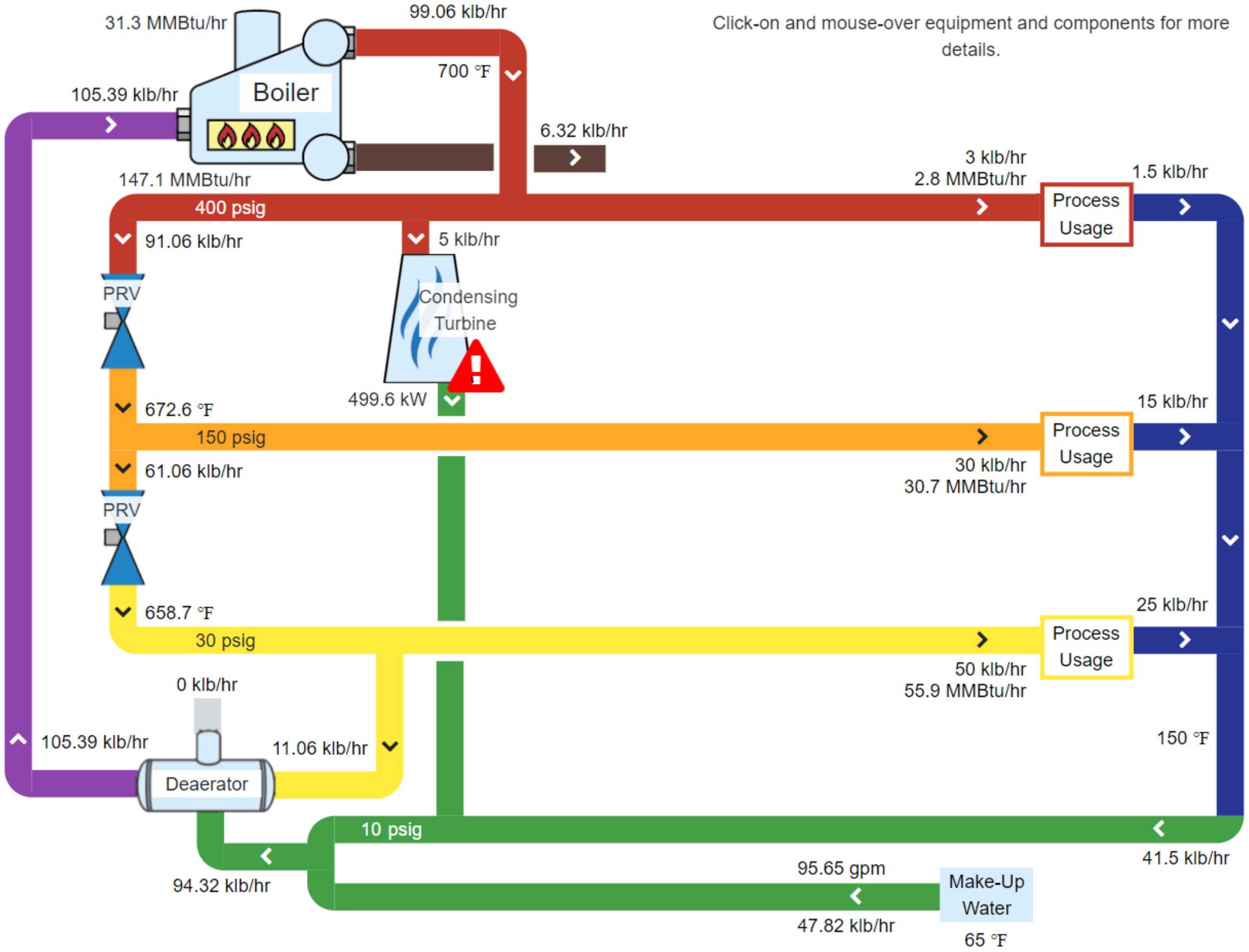
Energy Assessment Standard for Steam Systems





http://www.asme.org/products/codes---standards/energy-assessment-for-steam-systems

MEASUR – Pulp & Paper Mill Model



MEASUR – Pulp & Paper Mill Model

COST SUMMARY

Power Balance	
Generation	499.6 kW
Demand	5,499.6 kW
Import	5,000 kW
Unit Cost	$0.05 /kWh
Total $/yr	$2,190,000

Fuel Balance	
Boiler	147.05 MMBtu/hr
Unit Cost	$5.00 /MMBtu
Total $/yr	$6,440,979

Make-Up Water	
Flow	95.65 gpm 50,272,661.49 gal
Unit Cost	$0.01 /gal
Total $/yr	$502,727

Total Operating Cost
$9,133,705

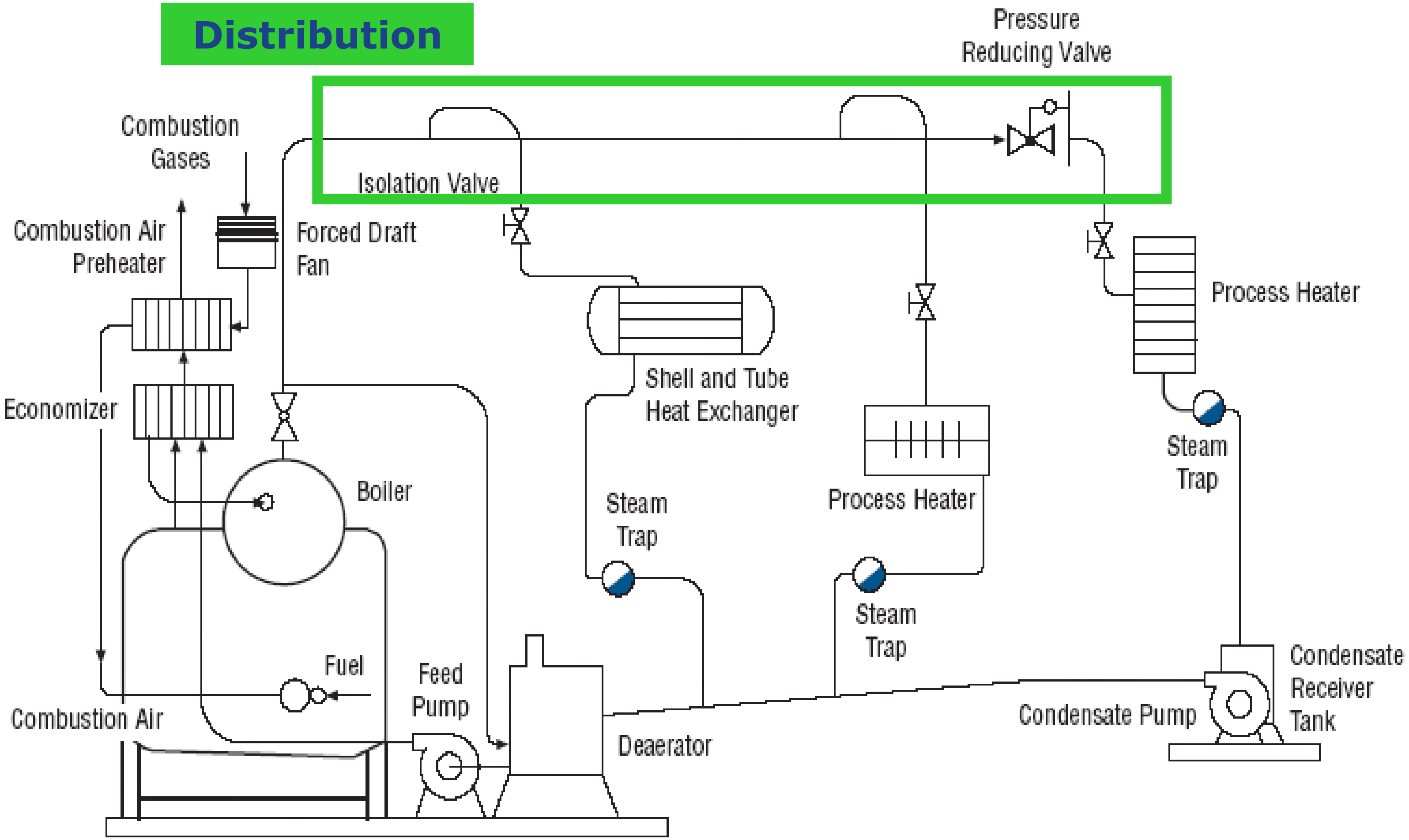
MARGINAL STEAM COST

High Pressure	$9.04 /klb
Medium Pressure	$9.04 /klb
Low Pressure	$9.04 /klb

Energy Efficiency Opportunities (Distribution)

- Steam Leaks

Generic Steam System

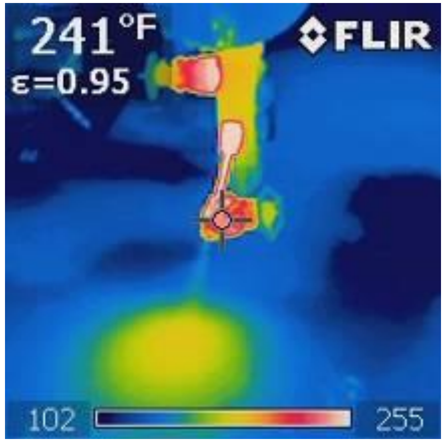


Steam Leaks

- End-user quote – *"Steam leaks are an essential component of my system, if I don't hear or see them, I can't tell if my steam system is operating!"*

Steam Leaks

- Steam leaks occur everywhere but most common places are:
  - Flanges and gasketed joints
  - Pipe fittings
  - Valves, Stems and packings
  - Steam traps
  - Relief valves
  - Pipe failures, etc.



- An “order of magnitude” steam loss estimate can provide enough information to determine if the repair must be made immediately, during a future shutdown, or online

- Pipe failures (steam leaks) often present a “safety issue” that demands immediate attention

Steam Leaks

- Methods to determine economic impact of steam leaks
  - Using MEASUR steam system based model
  - Empirical and observation based – plume height
  - Measurement and calculation based via choked flow equation – Napier's equation
  - Field measurement with a pitot tube
  - Ultrasonic technique, specific manufacturers' instrument and protocol (standard) based
  - Other system or equipment balance methodologies

- Condensate leakage can be measured by stop watch and bucket methodology

Steam Leaks

Orifice Diameter [inch]	Leak Rate [lb/hr]						
	Steam Supply Pressure [psig]						
	20	**50**	**100**	**150**	**300**	**400**	**500**
1/16	3	6	11	16	30	39	49
1/8	13	25	43	62	119	157	195
3/16	30	55	98	140	268	353	439
1/4	53	98	174	249	477	628	780
5/16	82	153	271	390	745	981	1,218
3/8	118	221	391	561	1,073	1,413	1,754
7/16	161	300	532	764	1,460	1,924	2,388
1/2	210	392	695	998	1,907	2,513	3,118
	3	**18**	**43**	**68**	**143**	**193**	**243**
	Discharge Pressure [psig]						
Discharge coefficient		0.6	dimensionless				

Steam Leaks

Orifice Diameter [inch]	Leak Rate [$/yr]						
	Steam Supply Pressure [psig]						
	20	50	100	150	300	400	500
1/16	200	400	800	1,100	2,100	2,800	3,400
1/8	900	1,700	3,100	4,400	8,400	11,100	13,700
3/16	2,100	3,900	6,900	9,900	18,900	24,900	30,900
1/4	3,700	6,900	12,300	17,600	33,600	44,300	55,000
5/16	5,800	10,800	19,100	27,500	52,500	69,200	85,900
3/8	8,300	15,500	27,600	39,600	75,600	99,700	123,700
7/16	11,400	21,200	37,500	53,900	102,900	135,700	168,400
1/2	14,800	27,600	49,000	70,400	134,500	177,200	219,900
	3	18	43	68	143	193	243
	Discharge Pressure [psig]						
Discharge coefficient	0.6	dimensionless					
Steam cost	8.05	$/klb					

Pipe Failures

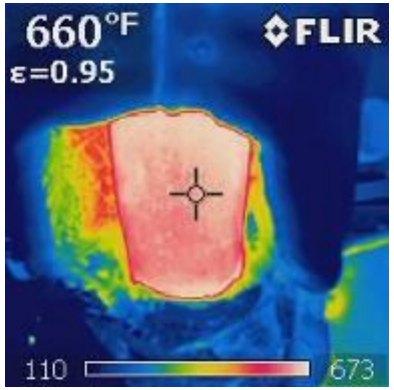
- Steam leaks occur in all plants and a continuous improvement type steam leak management program should be implemented in industrial plants
- An “order of magnitude” steam loss estimate can provide enough information to determine if the repair must be made immediately, during a future shutdown, or online
- Pipe failures (steam leaks) often present a “safety issue” that demands immediate attention

Energy Efficiency Opportunities (Distribution)

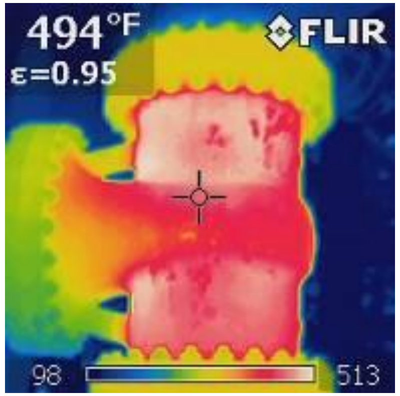
- Insulation

Steam System Insulation

- Why is insulation necessary on steam systems?
  - Personnel safety – high temperatures
  - Minimize energy losses
  - Protection from ambient conditions
  - Preserve system integrity



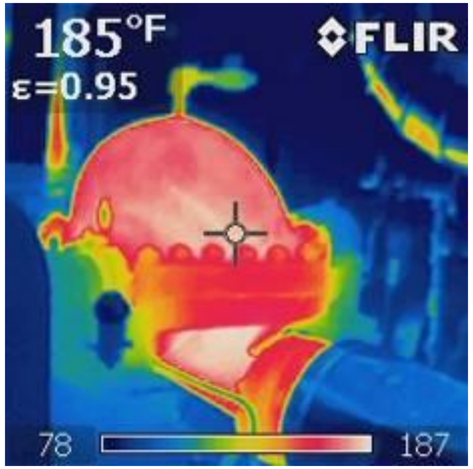
- Typical areas of insulation improvement opportunities
  - Distribution headers
  - Inspection man-ways
  - Valves
  - Condensate return lines
  - End-use equipment
  - Storage tanks, vessels, etc.



Steam System Insulation

- The piping energy loss impacts the energy delivered to the process units
  - The mass flows to the process demands remain as specified but the energy content of the steam is diminished

- There are several reasons for damaged or missing insulation and hence, energy savings opportunities in the insulation area
  - Missing insulation due to maintenance activities
  - Missing / damaged insulation due to abuse
  - Damaged insulation due to accidents
  - Normal wear and tear of insulation due to ambient conditions
  - Valves and other components not insulated



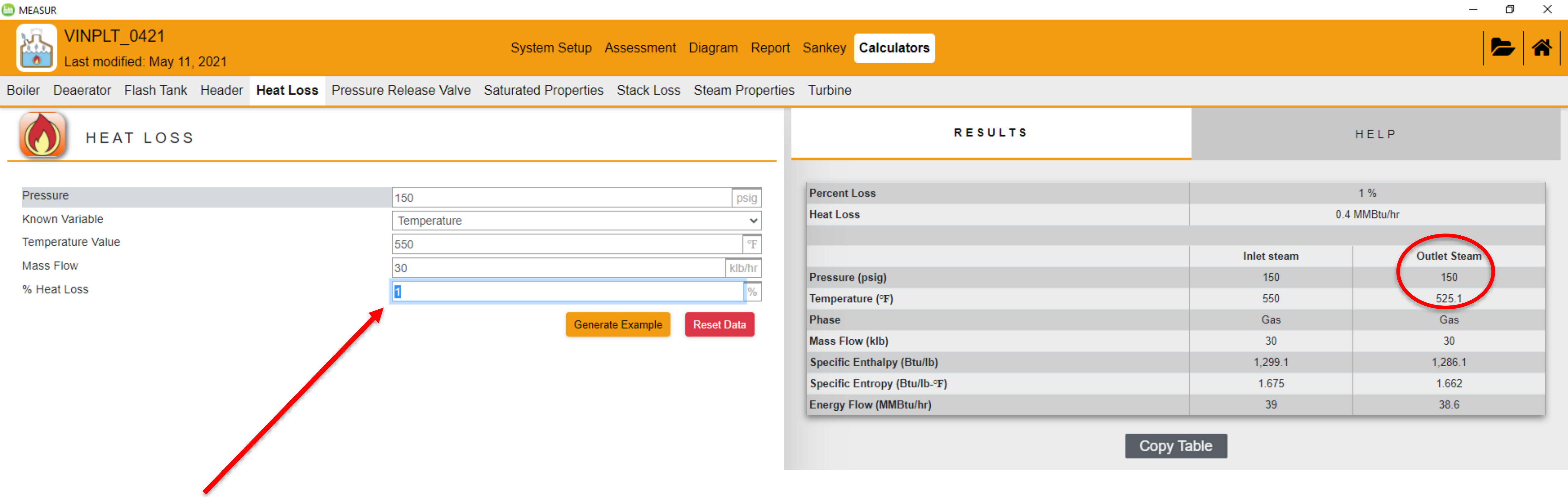
Steam System Insulation

- Some basic instruments, software and basic data required to quantify the economic impact of insulation
  - Infra-red thermography camera
  - Infra-red temperature gun
  - Measuring tape
  - 3E Plus insulation evaluation software
  - Operating information
    - Hours per year
  - Ambient conditions
    - Temperature
    - Wind

Missing Insulation

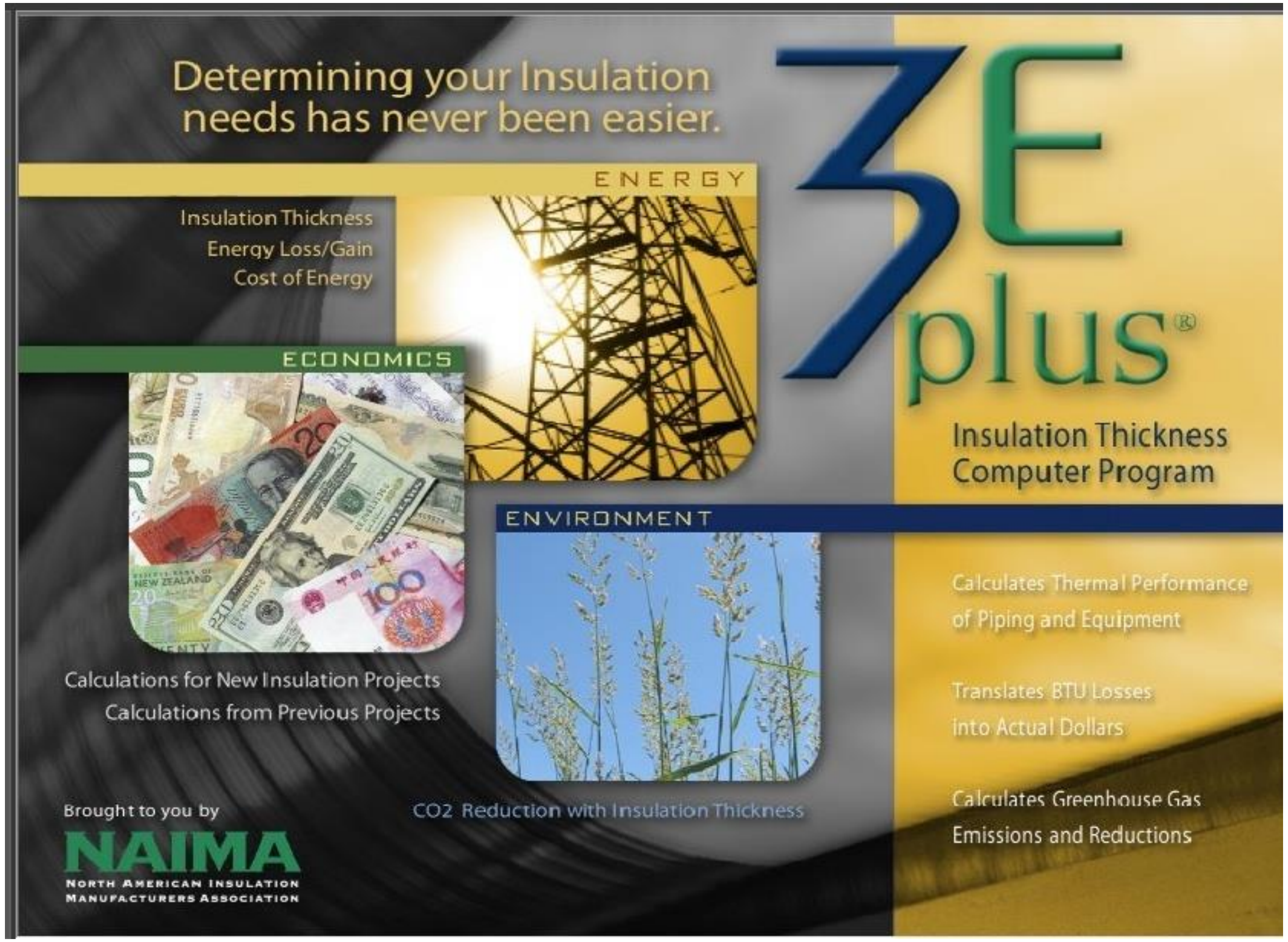
- A 20 foot long section of 150 psig header is observed to be un-insulated
  - 10 inch nominal diameter
  - Steam temperature is approximately 550°F

Header Loss Evaluation (MEASUR)



Percent Loss	1 %	
Heat Loss	0.4 MMBtu/hr	
	Inlet steam	Outlet Steam
Pressure (psig)	150	150
Temperature (°F)	550	525.1
Phase	Gas	Gas
Mass Flow (klb)	30	30
Specific Enthalpy (Btu/lb)	1,299.1	1,286.1
Specific Entropy (Btu/lb-°F)	1.675	1.662
Energy Flow (MMBtu/hr)	39	38.6

Insulation Evaluation Software



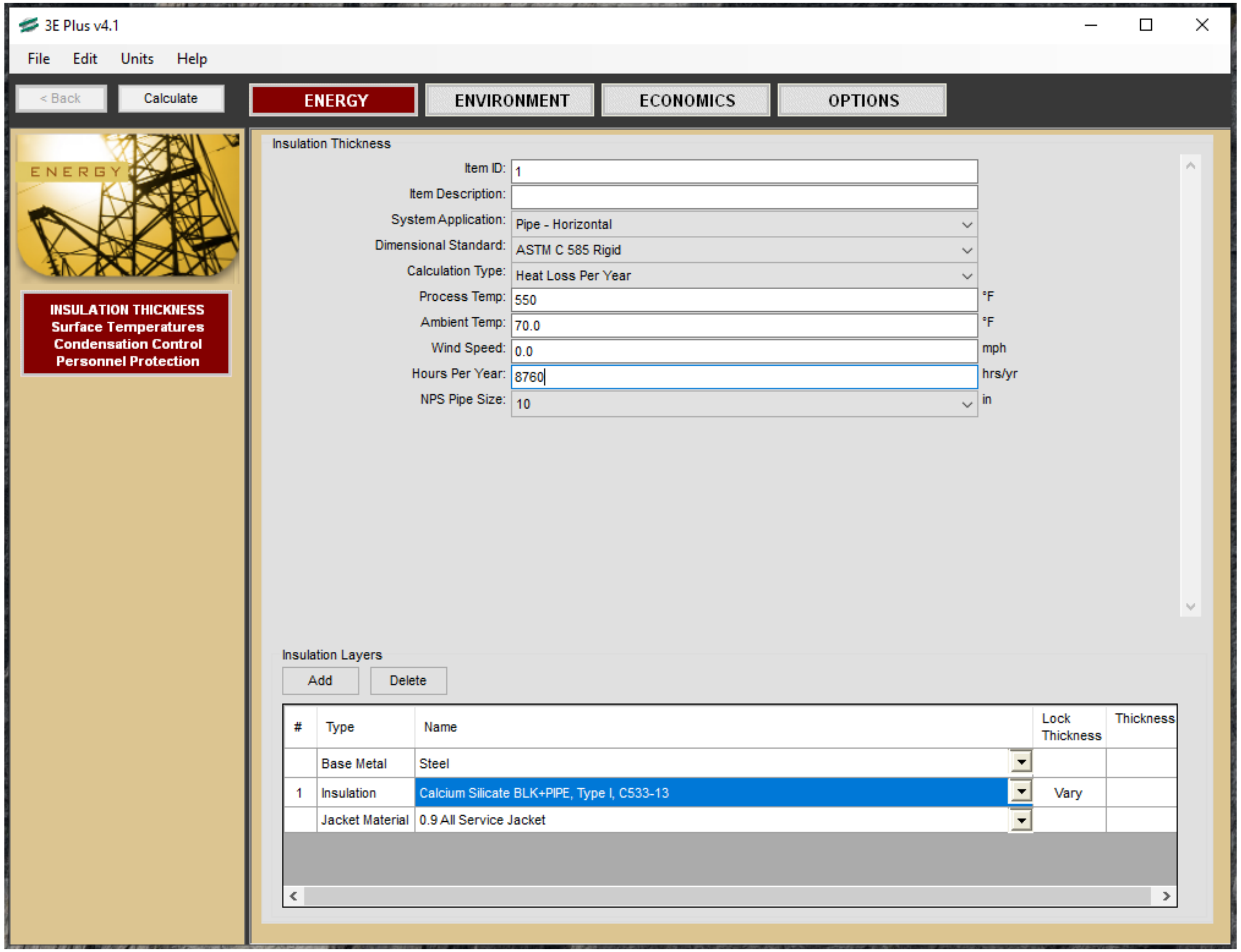
- Pipe Insulation | Calculate Thickness | 3E Plus Software (insulationinstitute.org)

- Software outputs include:
  - Surface heat transfer loss
  - Insulation surface temperature
  - Simple payback, Life Cycle Cost of an insulating project

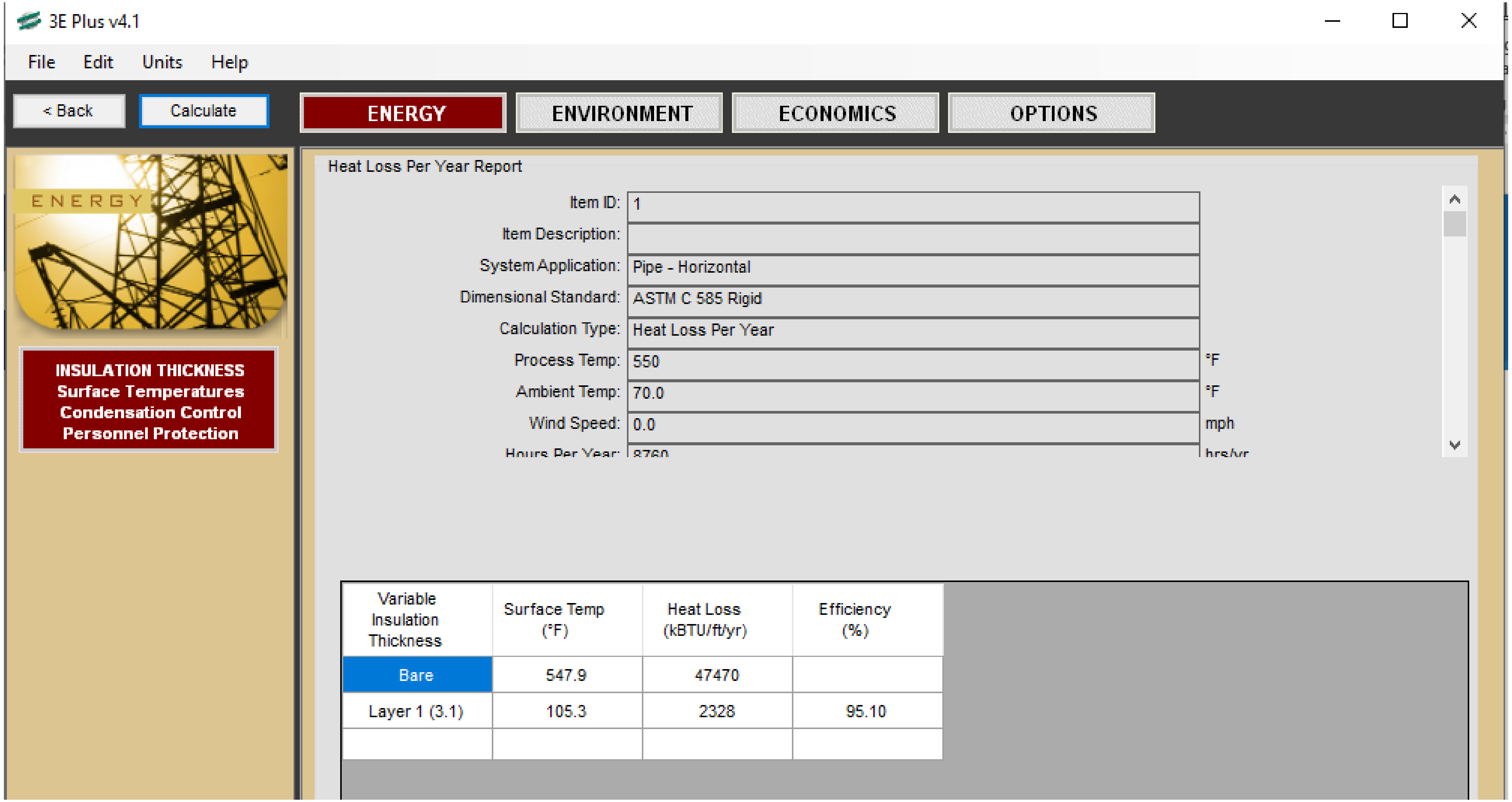
Insulation Evaluation

- A 20-foot long section of 150 psig header is observed to be un-insulated
  - 10 inch nominal diameter
  - Located outside on a pipe bridge
  - Steam temperature is approximately 550°F
  - Remainder of the system is covered with a 3-inch thick layer of calcium silicate insulation
    - All service jacket as well
  - Fuel cost: $5 per MMBtu

Insulation Evaluation



Insulation Savings



Insulation Savings

- If the energy impact is realized “at fuel cost”:

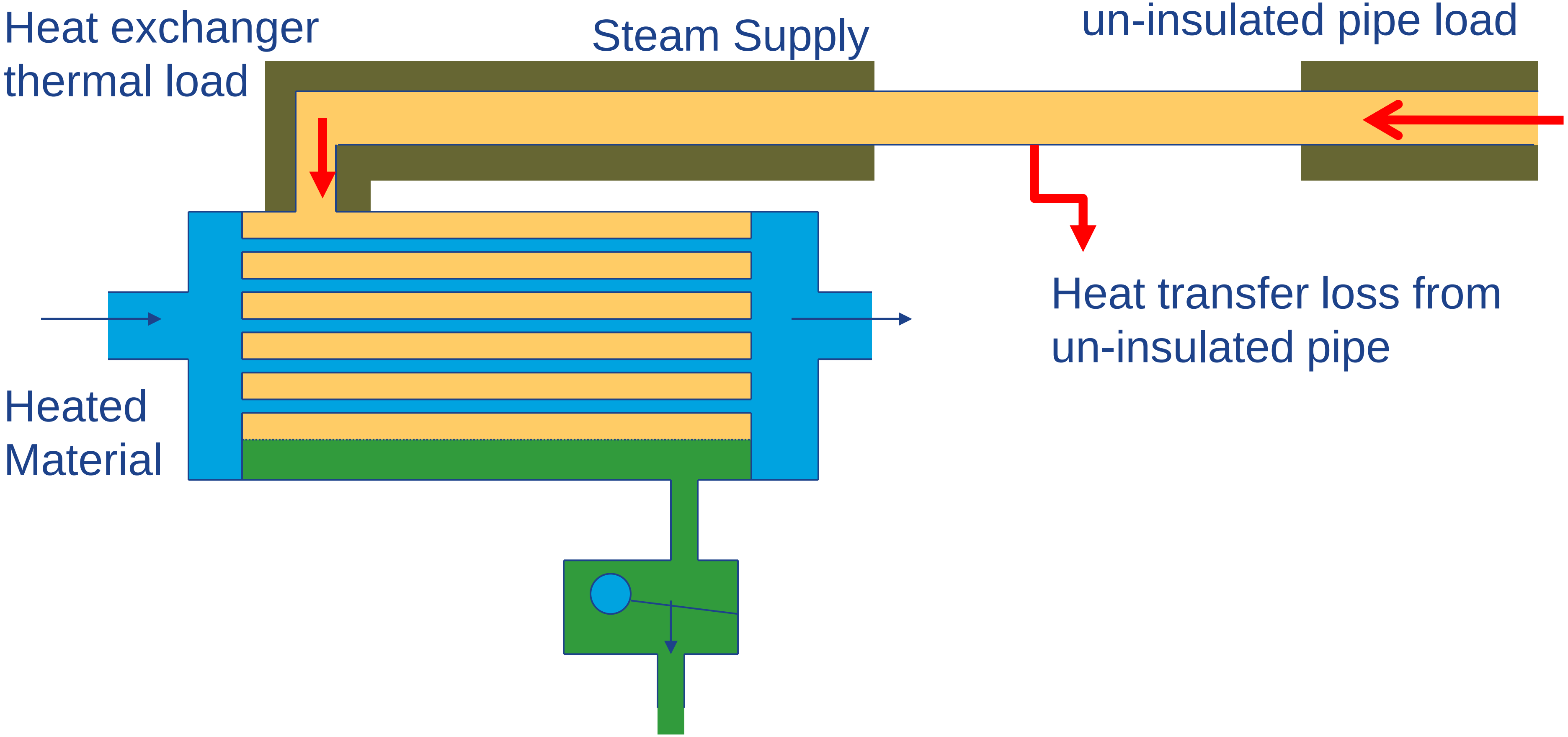
Energy savings = (47,470 – 2,328) = 45,142 kBtu/ft/yr

Energy cost savings = 45,142 * 1,000 * 20 * 5 / 1,000,000

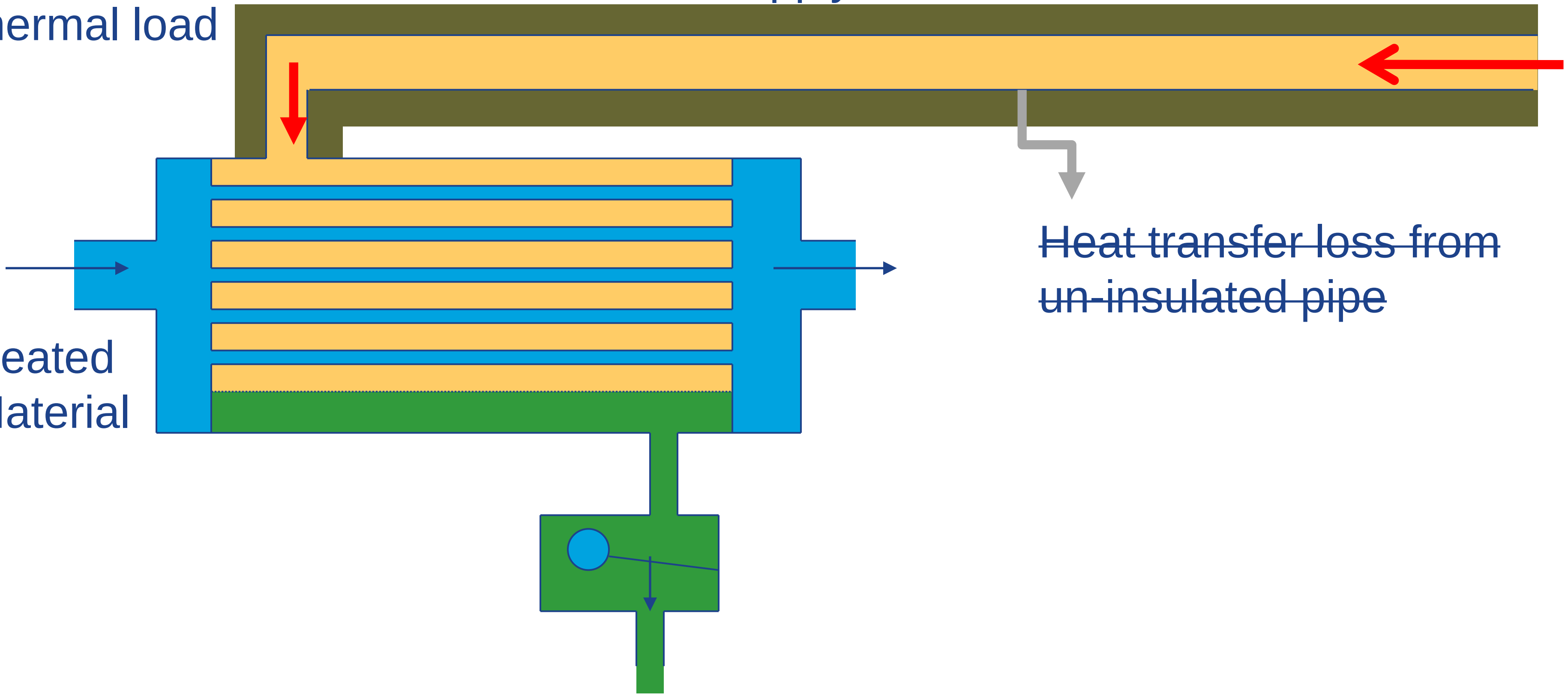
Energy cost savings = 4,514 $/yr

Equivalent Steam Demand

The total thermal energy supply includes the heat exchanger load and the un-insulated pipe load



Equivalent Steam Demand



Energy Loss Converted to Steam Loss

- If the energy impact is realized "at steam cost":

Energy savings = (47,470 – 2,328) * 20 = 902,840 kBtu/yr

Properties							
Location	**Temp [°F]**	**P [psia]**	**Specific Volume [ft³/lbm]**	**Enthalpy [Btu/lbm]**	**Entropy [Btu/lbm°R]**	**Quality [%]**	**P [psig]**
Medium Pressure	550	164.7	3.54075	1,298.86	1.67502	****	150
Saturated vapor	366	164.7	2.75693	1,195.57	1.56726	100.0	150
Saturated liquid	366	164.7	0.01818	338.36	0.52323	0.0	150

Steam savings = 902,840 * 1,000 / (1,298.86 – 338.36)

Steam savings = 940,000 lb/yr = 940 klb/yr

Energy Loss Converted to Steam Loss

MARGINAL STEAM COST

High Pressure	$9.04 /klb
Medium Pressure	$9.04 /klb
Low Pressure	$9.04 /klb

If the cost of steam is known

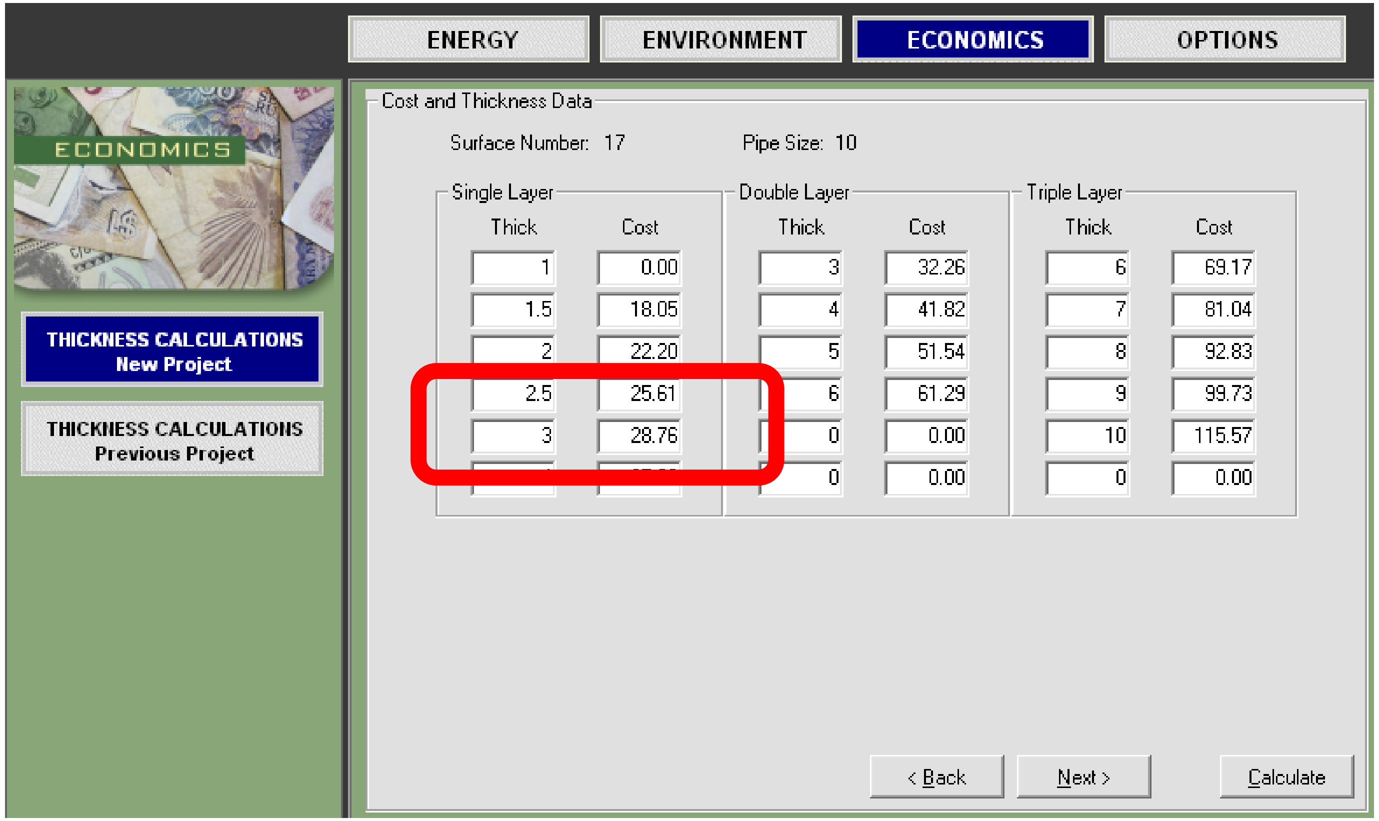
Energy cost savings = 940 * 9.04

Energy cost savings = 8,500 $/yr

- The MEASUR steam demand savings project can also be utilized

Project Cost Estimate

- 3E Plus can be used to estimate the cost of installing insulation
  - Undertake a life cycle costing analysis, if needed



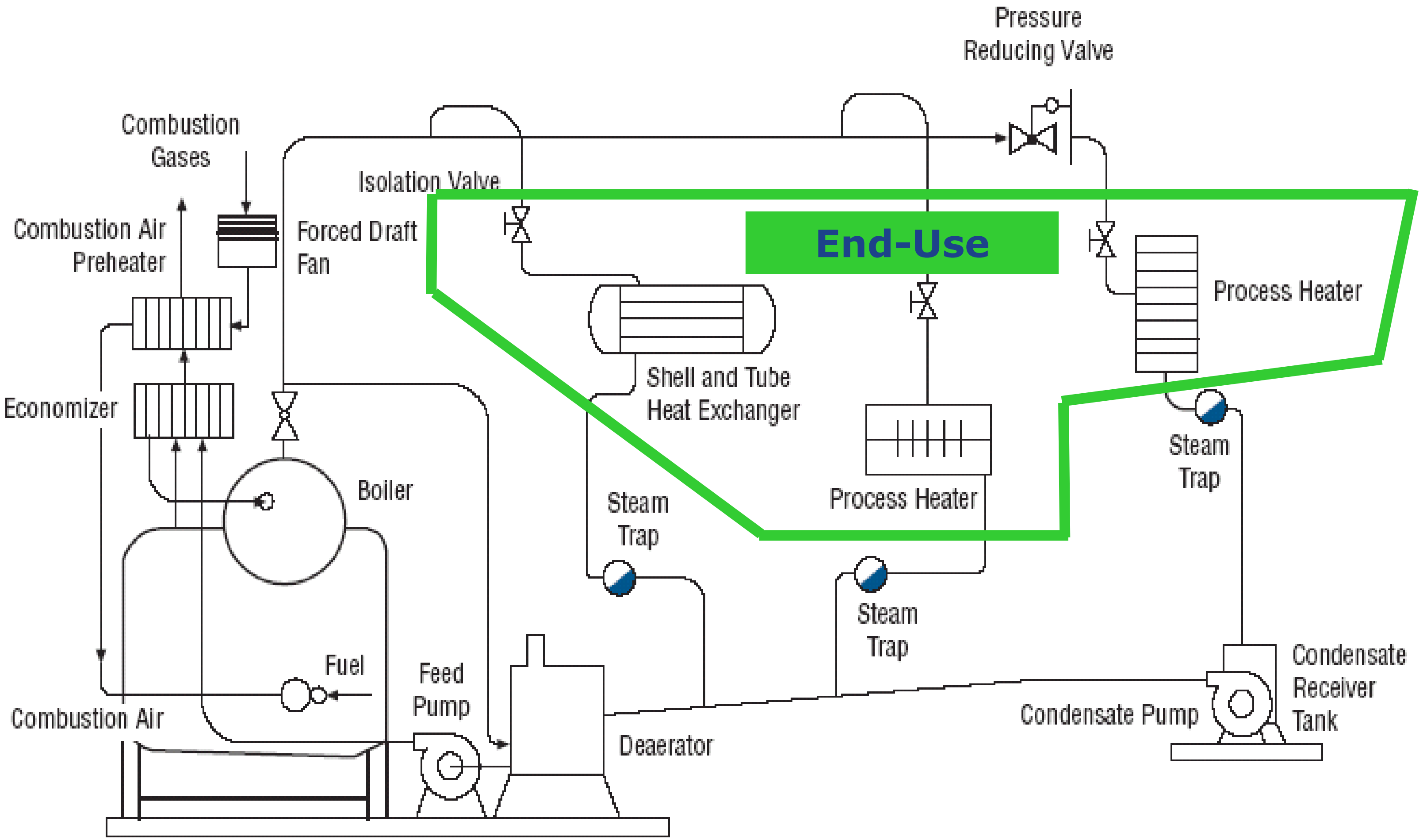
Common BestPractices - Distribution

- Repair steam leaks
- Minimize vented steam
- Ensure that steam system piping, valves, fittings and vessels are well insulated
- Isolate steam from unused lines
- Minimize flows through pressure reducing stations
- Reduce pressure drop in headers
- Drain condensate from steam headers

Energy Efficiency Opportunities (End-Use)

- Very Industry Specific but some commonalities exist and will be covered here

Generic Steam System



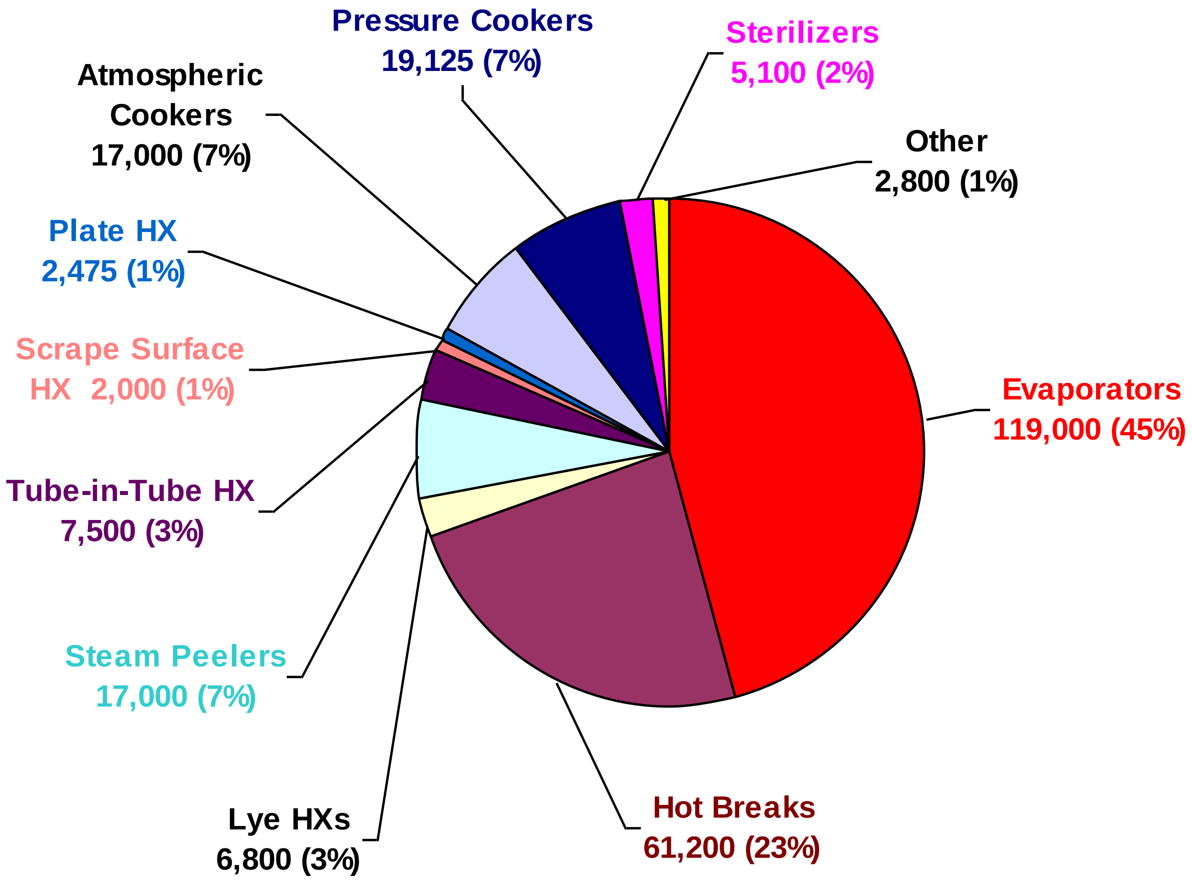
Steam Demand

- 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

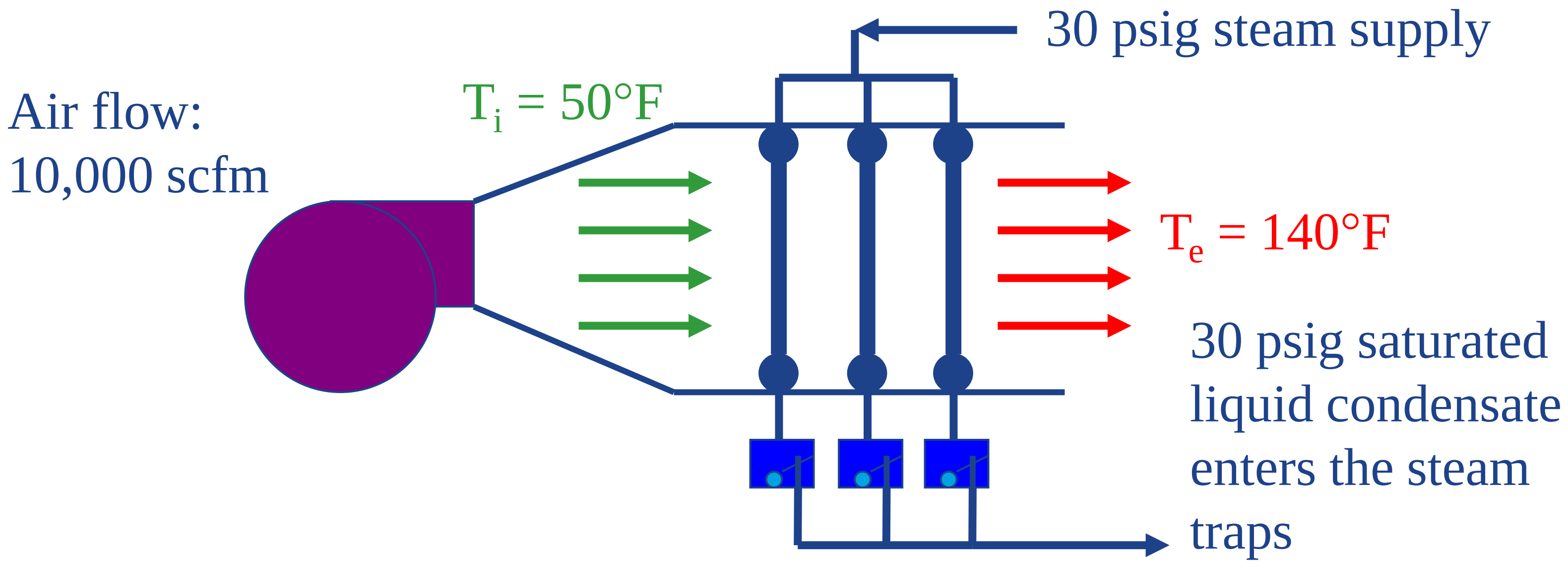
- Distillation towers
- Dryers
- Evaporators
- Heat Exchangers
- Reboilers
- Reformers
- Steam ejectors / injectors
- Strippers
- Thermocompressors
- Absorption chillers
- Humidifiers
- Preheat / Reheat Air Handling Coils

A Steam End-Use* Distribution Pie-Chart



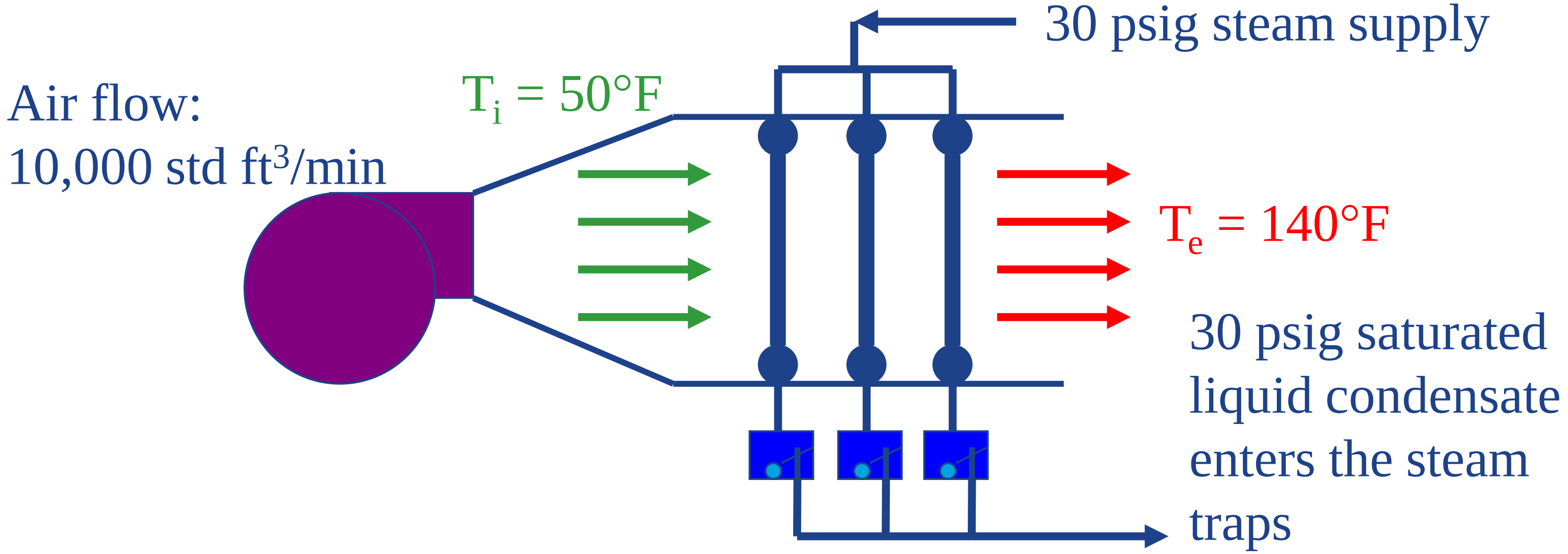
* Food & Beverage – Vegetable & Fruit Juices

Steam Demand



$$\dot{Q}_{air} = \dot{m}_{air}\left(C_p\right)_{air}\left(T_e - T_i\right)_{air}$$

Steam Demand



$$\dot{Q}_{air} = \dot{m}_{air}(C_p)_{air}(T_e - T_i)_{air}$$

$$\dot{Q}_{air} = 10{,}000\,\frac{std\ ft^3}{min}\left(0.0742\,\frac{lbm}{std\ ft^3}\right)\left(0.24\,\frac{Btu}{lbm^\circ R}\right)(140^\circ F - 50^\circ F)\left(\frac{60\,min}{1\,hr}\right)$$

$$\dot{Q}_{air} = 961{,}000\,\frac{Btu}{hr}$$

Steam Properties

STEAM PROPERTIES

Pressure	30 psig
Known Variable	Temperature
Temperature	650 °F

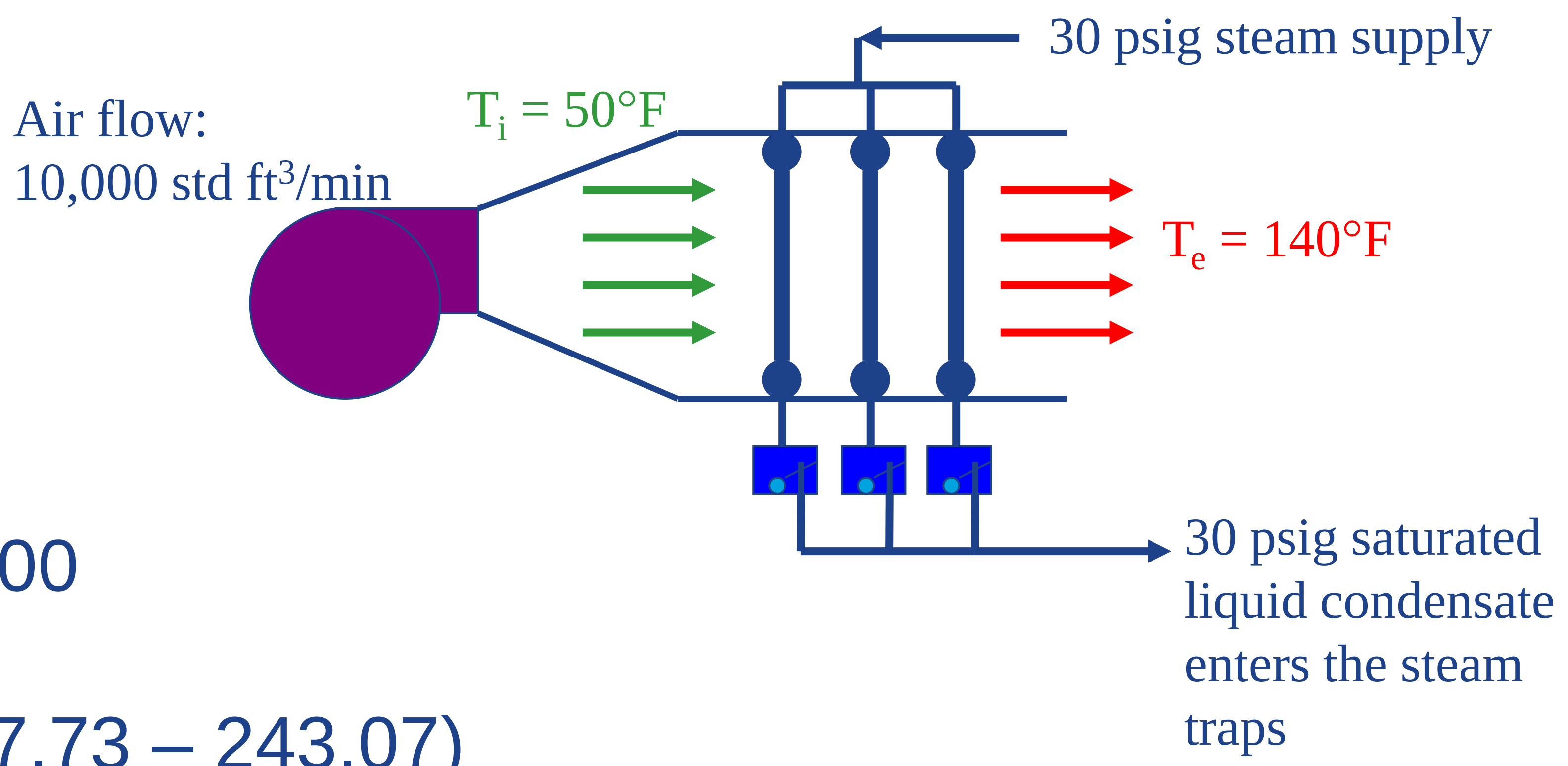
Pressure	**30 psig**
Temperature	**650 °F**
Specific Enthalpy	**1,357.73 Btu/lb**
Specific Entropy	**1.8726 Btu/lb-°F**
Quality	**Gas**
Specific Volume	**14.7061 ft³/lb**

STEAM PROPERTIES

Pressure	30 psig
Known Variable	Saturated Quality
Quality	0

Pressure	**30 psig**
Temperature	**274 °F**
Specific Enthalpy	**243.07 Btu/lb**
Specific Entropy	**0.4016 Btu/lb-°F**
Quality	**Liquid**
Specific Volume	**0.0172 ft³/lb**

Steam Demand



Q_{steam} = 961,000 Btu/hr

$M_{steam} * (h_i – h_e) = 961,000$

$M_{steam} = 961,000 / (1,357.73 – 243.07)$

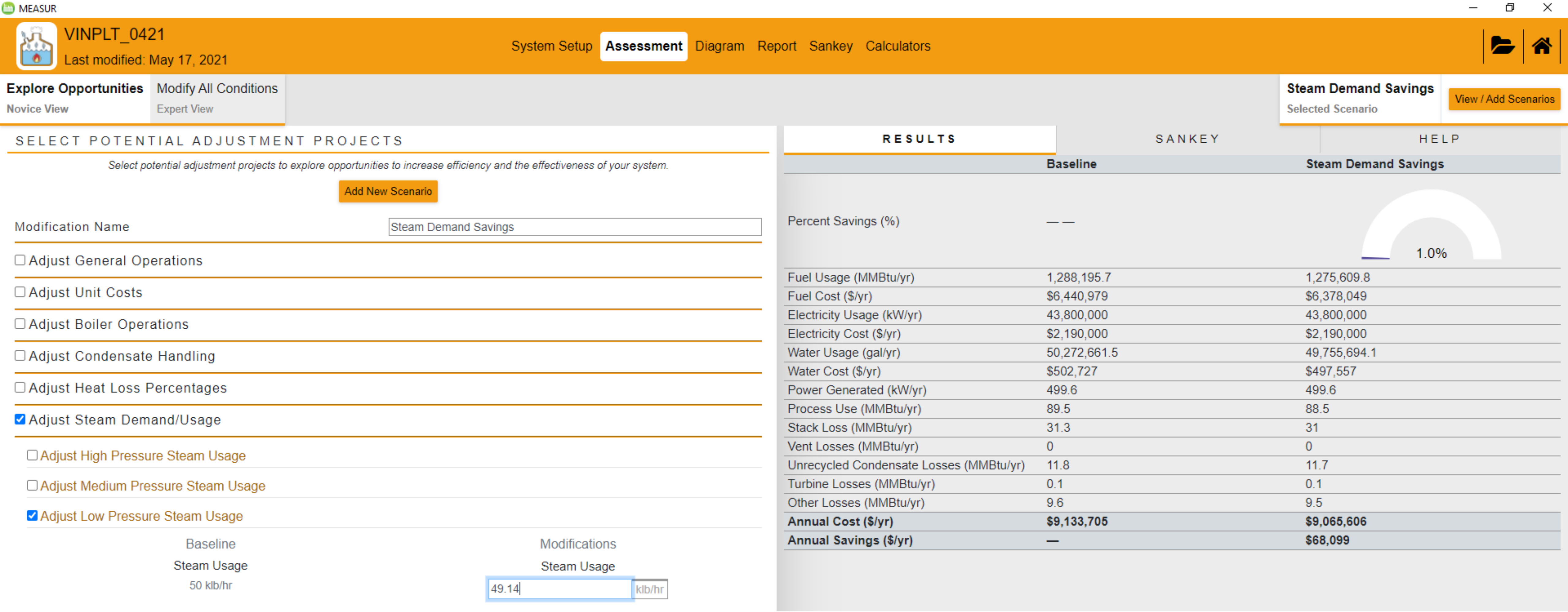
M_{steam} = 862.1 lb/hr

End-Use Energy Efficiency Analysis

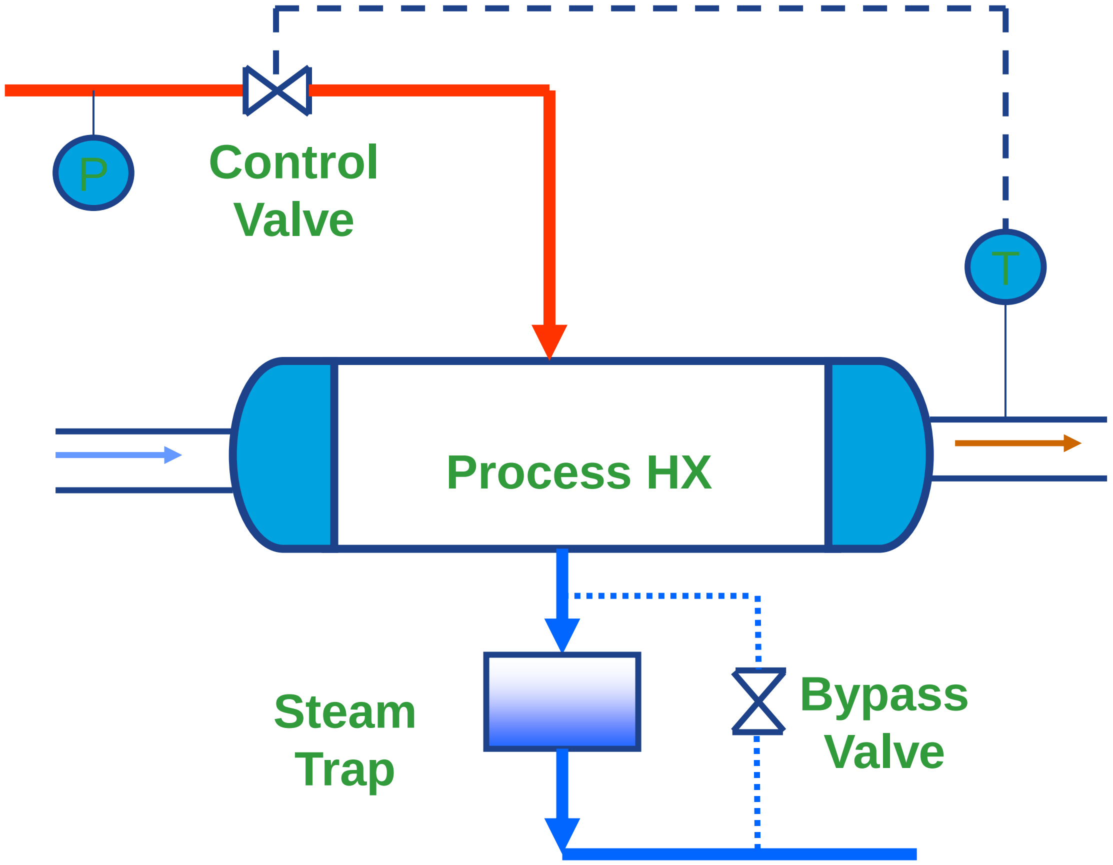
- A source of waste heat has been identified which can heat this process air and meet the needs

- Complete the analysis utilizing the MEASUR three header model
  - Note:
    - Solution method
      - Modifications to the Impact Model
      - Projects executed
        - Project input data
    - Total economic impact
    - Electrical impact
    - Fuel impact
    - Makeup water impact

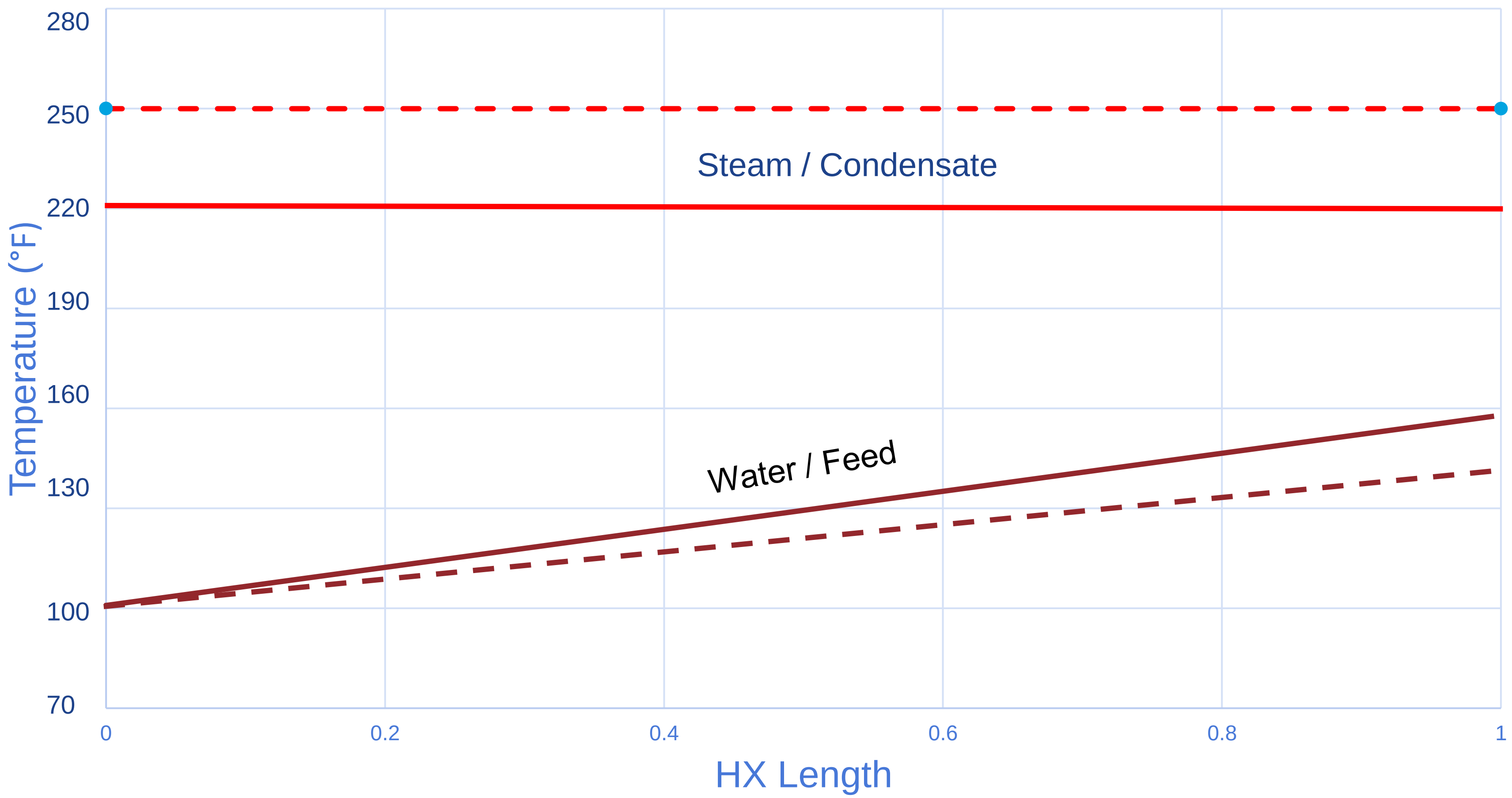
End-Use Energy Efficiency Analysis



Heat Exchanger Operation



Heat Exchanger Performance



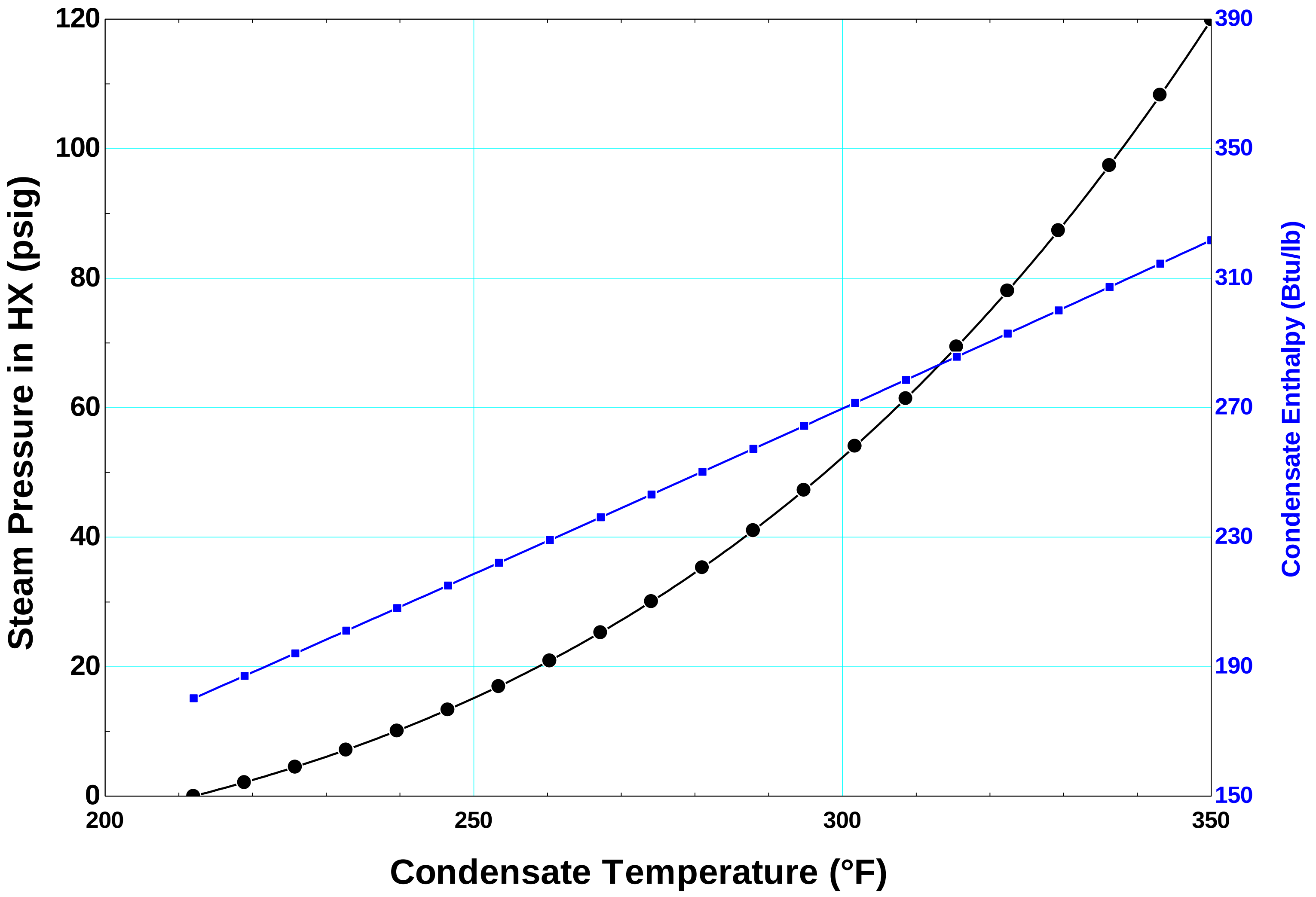
Heat Exchanger Performance

$$Q = m_{steam} * \left(h_{steam} - h_{cond}\right)$$

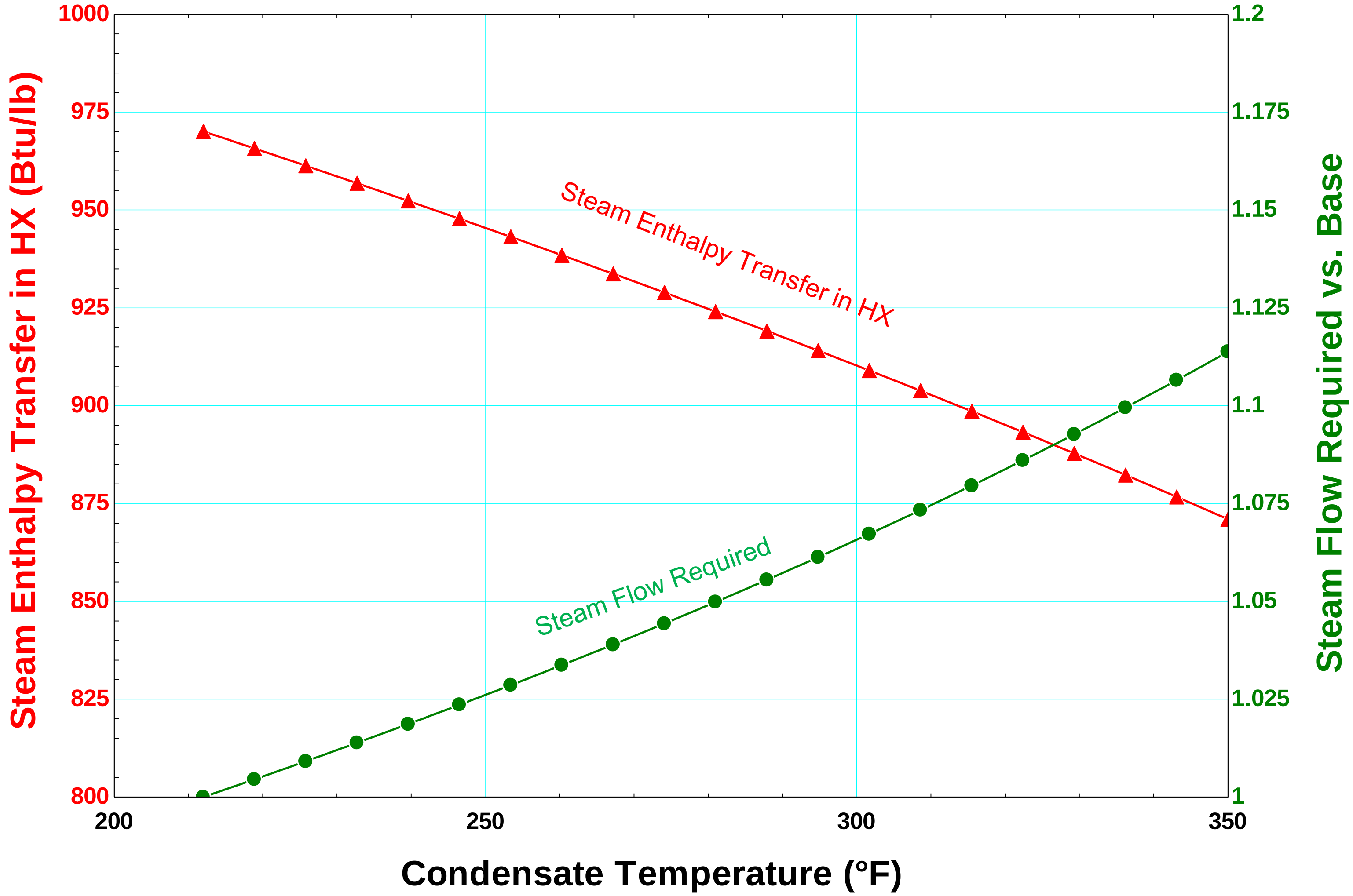
Heat Exchanger fouling results in the following

- Driving temperature (steam) increases
- Steam pressure increases
- Condensate enthalpy increases
- Enthalpy difference (steam and condensate) reduces
- For the same heat duty, more mass flow of steam is required
- If condensate is not collected – leads to additional penalty
- If condensate goes to atmospheric flash – energy loss occurs due to more flashing

Heat Exchanger Performance



Heat Exchanger Performance



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

Energy Efficiency Opportunities (Condensate Recovery)

- Steam Traps
- Condensate Recovery

Steam Traps

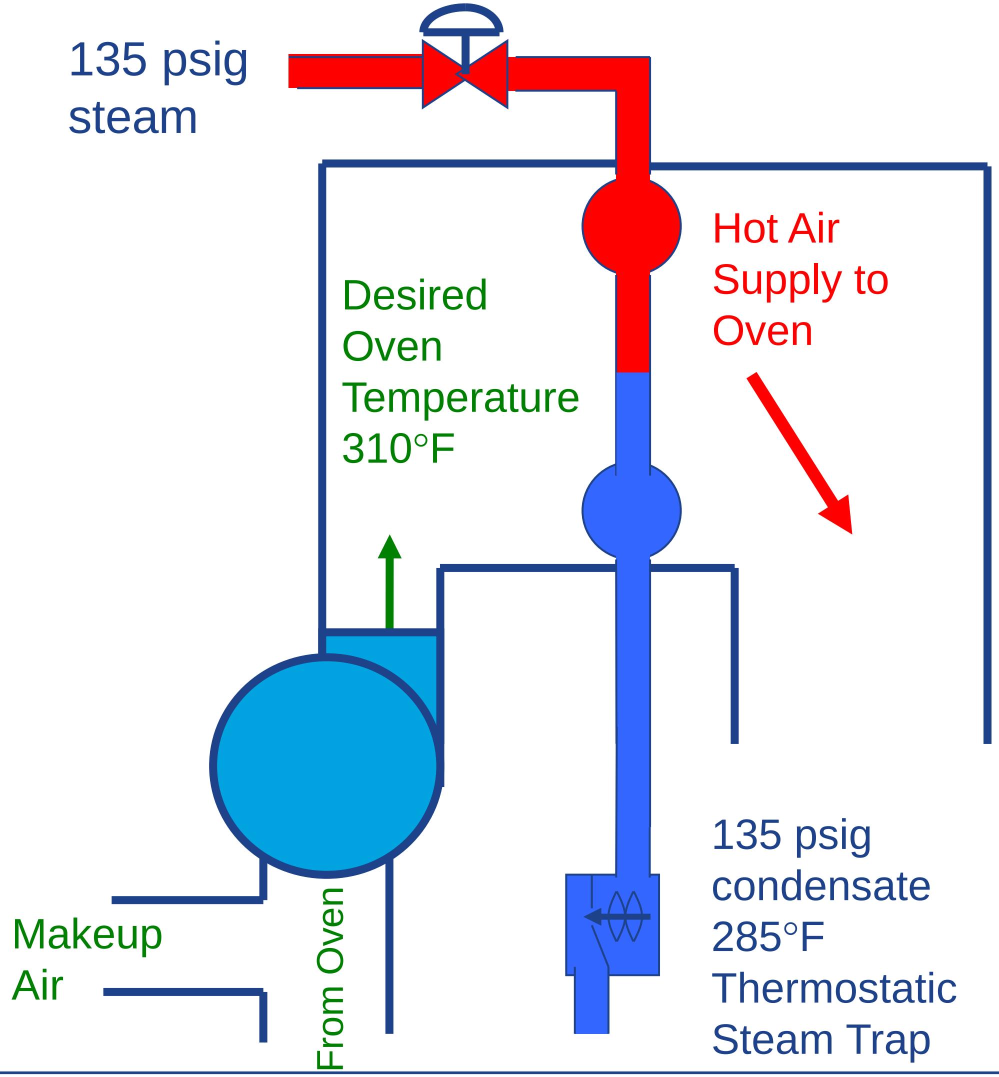
- Thermostatic
- Closed Float
- Open Float
- Thermodynamic
- Orifice
- Float and Thermostatic

Steam Trap Management

- In many facilities steam traps present a significant loss potential
  - Industrial facilities may have steam trap populations numbering in the hundreds and even thousands
- Steam traps must be investigated to determine if they are functioning properly
- The operating principles of steam traps must be understood to properly manage the equipment

Steam Trap Selection

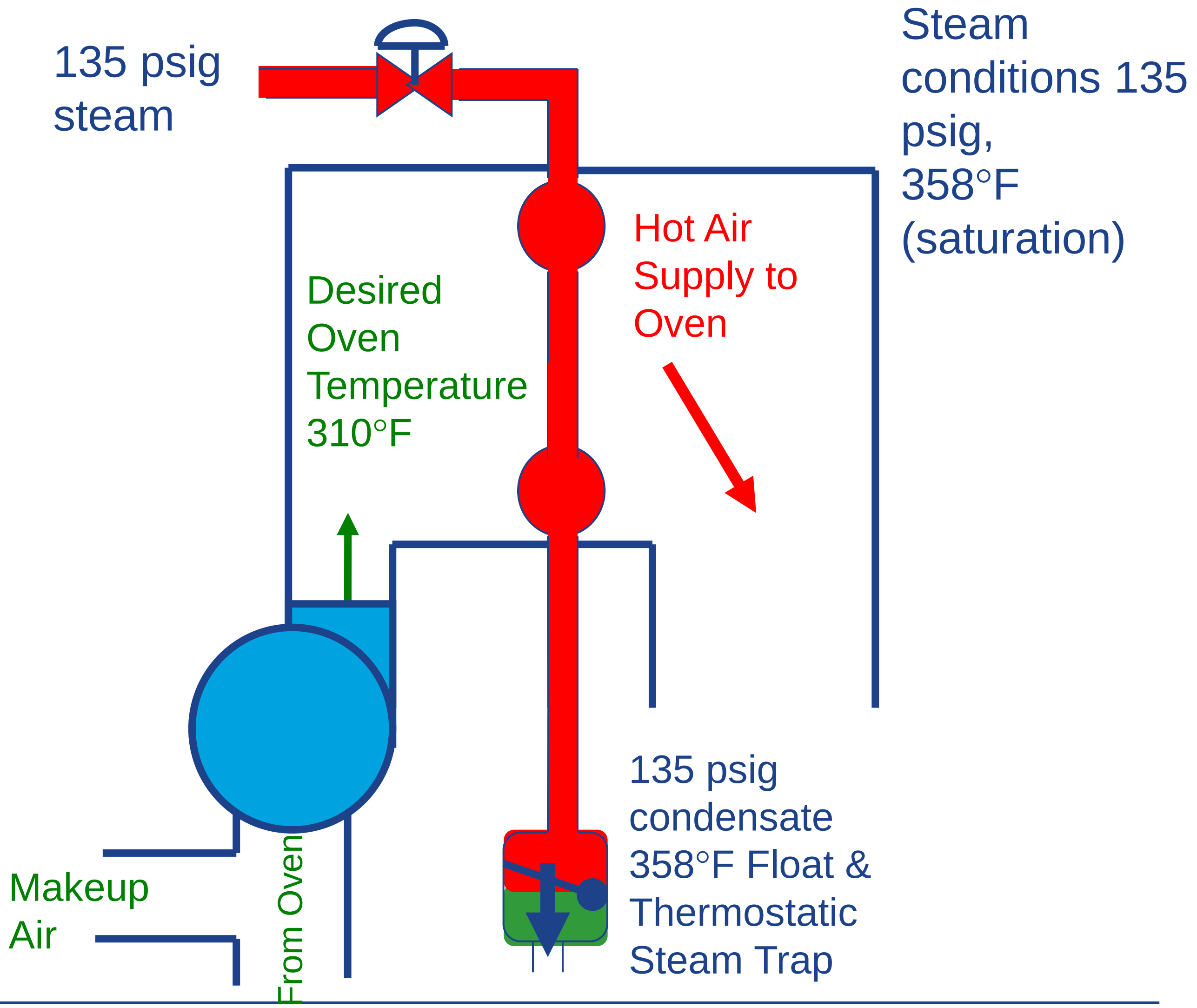
- Steam heated ovens were scheduled for replacement because of <u>*insufficient capacity*</u>



Steam conditions 135 psig, 358°F (saturation)

Steam Trap Selection

- The steam trap was changed to a float-thermostatic type trap
  - Dramatic increase in condensate temperature and heat transfer



Steam Loss Reduction

- Steam loss through trap failures and leaks is generally reduced through increased maintenance activities
  - Investigate each trap and the piping system at least one time each year
    - Trap performance
      - Testing equipment is required
    - Trap type
    - Trap installation
    - Condensate return
    - Order of magnitude leak rate
      - Orifice calculations set the maximum
  - Training is essential
  - Maintain a steam trap database
  - Set an investigation route
  - Daily monitor receiver vents

Steam Trap Failure Modes

- Steam traps can fail in several conditions
  - Fully blocked
    - This failure mode is easy to determine
    - This failure mode is the most expensive in terms of production costs
  - Open blowing
    - This failure mode is easy to determine
    - This failure mode is the most expensive in terms of steam energy costs
  - Partially leaking
    - Difficult to identify

- There have been numerous studies in the industry and one of the more statistically accepted “rules of thumb” is that 10% of traps fail every year
  - This depends on several factors and can be very industry specific also

Steam Trap Investigation for Performance

- There are several methods for investigating steam trap performance
  - Visual
  - Acoustic
  - Thermal
- Most times, using only one method maybe inconclusive – so the following is recommended
  - Combination of methods
  - Additional process or system information, is required
- New state-of-the-art in-trap (real-time) monitoring is available for some steam traps

Visual Steam Trap Investigation

- Limited in applicability
  - Most condensate systems are closed
  - Safety and practicality limit the use of this method
- Individual trap operation and application must be understood
  - Intermittent
  - Continuous
- Several traps can return condensate via a cascaded condensate return system – condensate receiver vent becomes the point of visual inspection

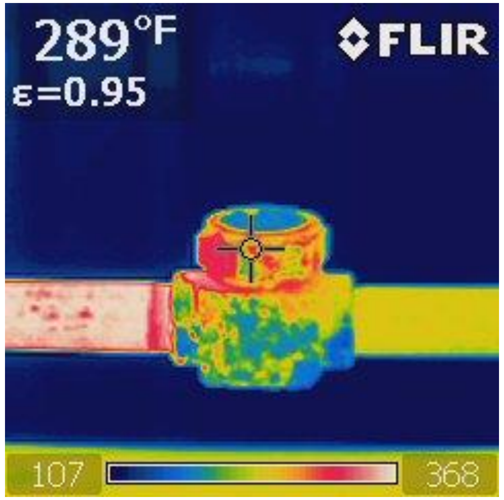
Acoustic Steam Trap Investigation

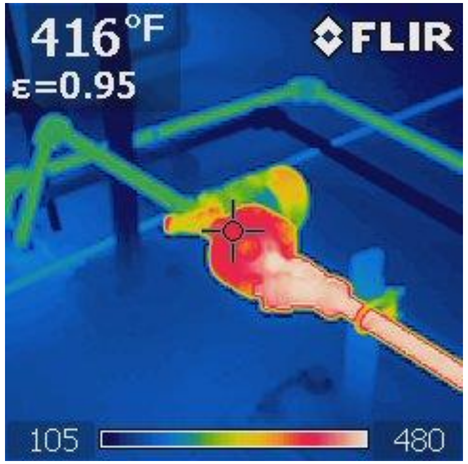
- Many instruments are available
  - Screw driver
  - Stethoscope
  - Ultrasonic devices
- Individual trap operation and application must be understood
- Ultrasonic sensing is typically the most practical
- Some manufacturers have tools that can take the acoustic signature of steam flow through the trap and use that information to detect failure

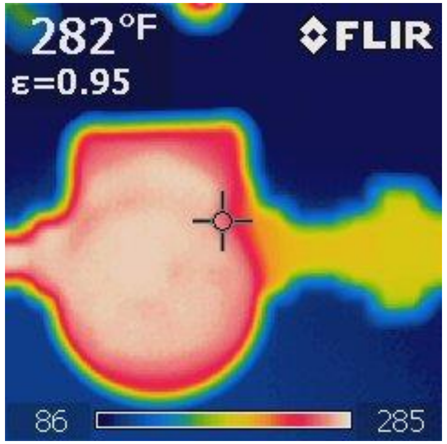
Thermal Steam Trap Investigation

- Many instruments are available
  - Temperature stick
  - Infra-red temperature gun
  - Infra-red thermography camera
- Individual trap operation and application must be understood
- Data can be inconclusive
  - Condensate and steam will take a temperature drop while going through an orifice – hence, difficult to say if trap is failed open!

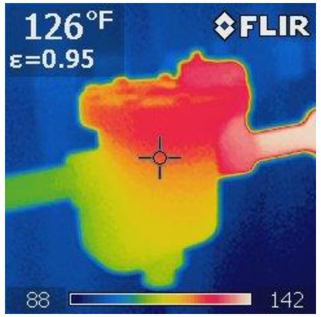
Steam Traps in the Field

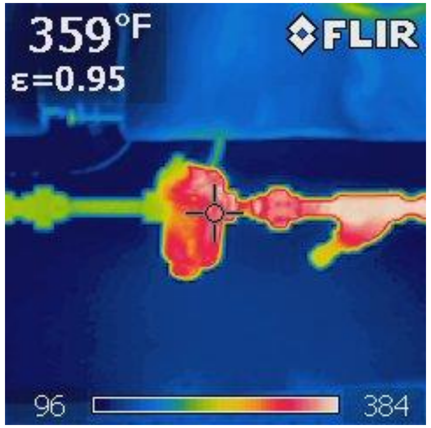


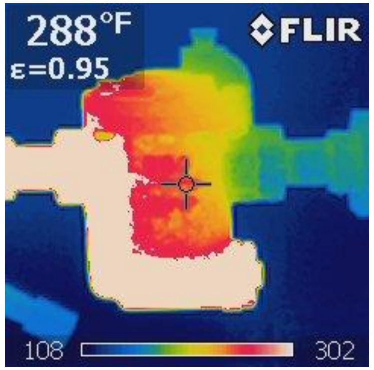


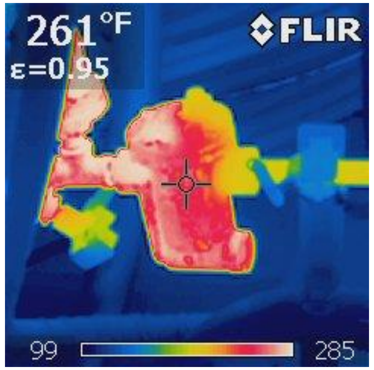


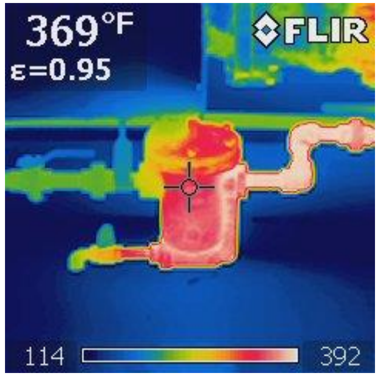
Steam Traps in the Field

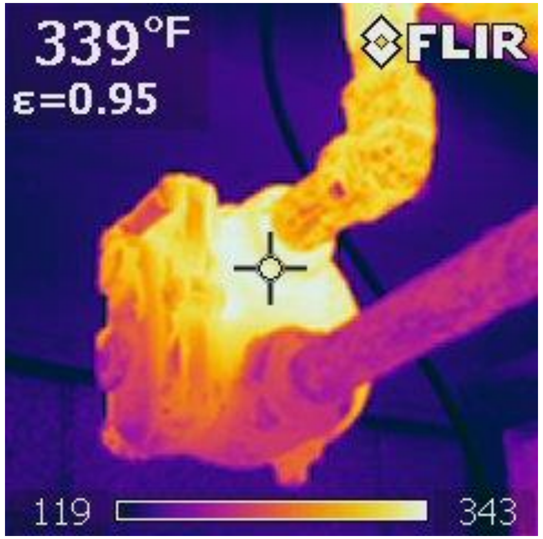


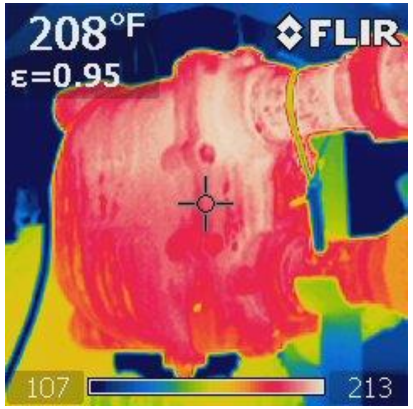












Combined Method Steam Trap Investigation

- Combining visual, acoustic, and thermal investigation methods is recommended
  - Individual instruments can be employed in this service
- Inline and in-trap sensing is also available

Steam Trap Installation

- Each trap must be installed properly
- Non-condensable gas and startup considerations must be targeted
- The condensate collection system must be considered
  - Backpressure considerations
  - Lift considerations
  - Two-phase flow considerations

Effective Steam Trap Management Program

- Maintain a steam trap database
  - Type of trap, model number, size, etc
  - Application
  - Energy loss if failed open
  - Problems if failed closed
  - When was the last recorded failure, repair
- Prioritize repairs based on loss estimates and criticality of steam system and production operations
- Daily monitor receiver vents
- Inspect all traps at least once a year
- Trap maintenance training is essential

<u>*World Class*</u> Steam Trap Maintenance Program

- Investigate each trap at least one time each year (problem and high-pressure areas should be more frequent)
  - Performance
    - Testing equipment is required
    - An order of magnitude leak rate should be determined for failed traps
      - Orifice calculations set the maximum steam flow
  - Trap type
    - Trap selection should match the application
    - Universal mounts can be a good option
  - Installation
  - Establish an investigation route
  - Condensate return
  - Outsourcing can be a good option

Energy Efficiency Opportunities (Condensate Recovery)

- **Condensate Recovery**

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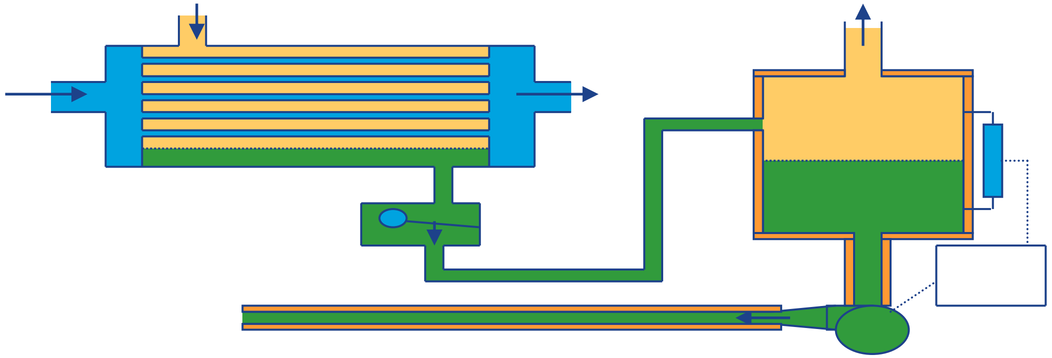
Steam Trap Survey - Condensate Recovery Investigation

- Is condensate being recovered?
- Is the condensate recovered *to the boilers* with the greatest practical thermal energy?
- Does the condensate recovery system place excessive backpressure on the traps?
- Is flash steam recovery applicable?
- Design the condensate recovery system for the greatest effectiveness



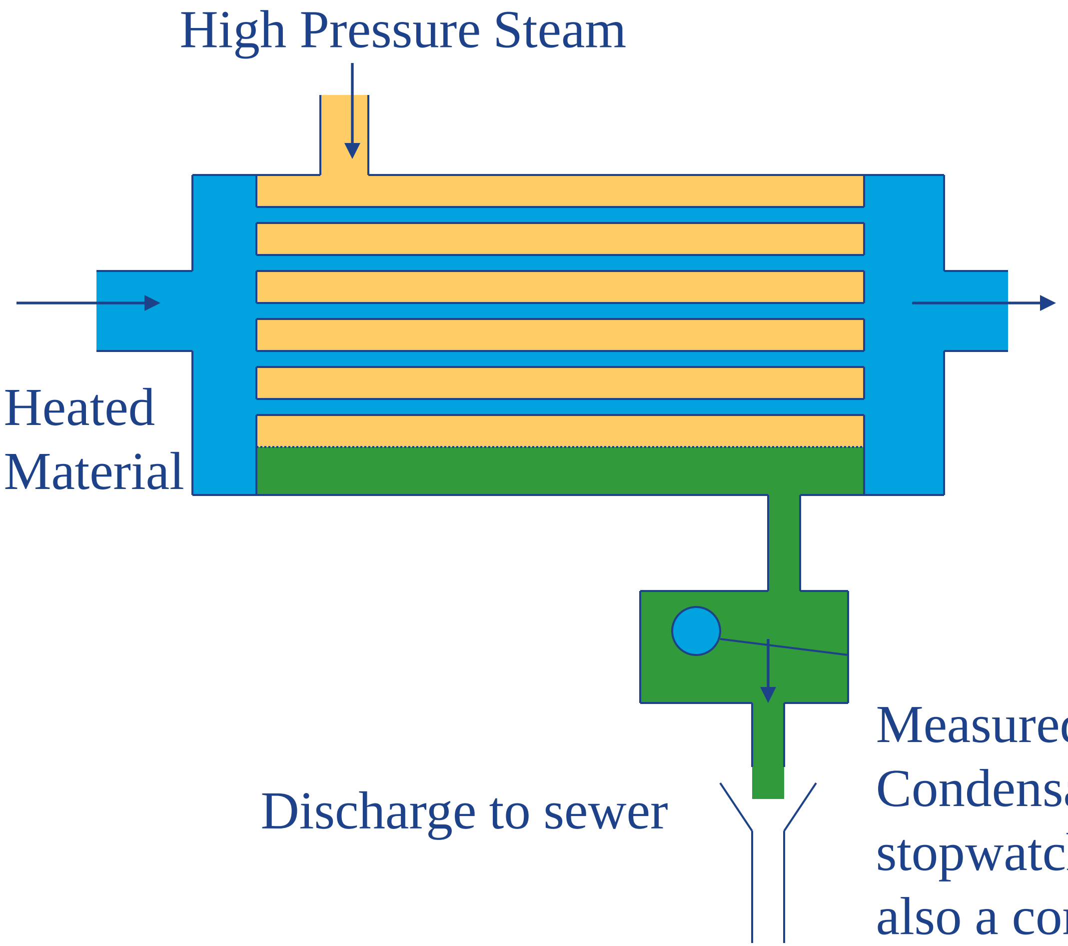
Condensate Recovery

- Condensate is produced after steam has transferred all its thermal energy and condensed into water
- Nevertheless, there is significant thermal energy in condensate
- Every unit of condensate returned implies one less unit of make-up required
- Returning condensate
  - Reduces energy (steam required) in deaerator
  - Reduces make-up water
  - Reduces chemicals for water treatment
  - Reduces quenching water
  - May reduce blowdown

Process Condensate

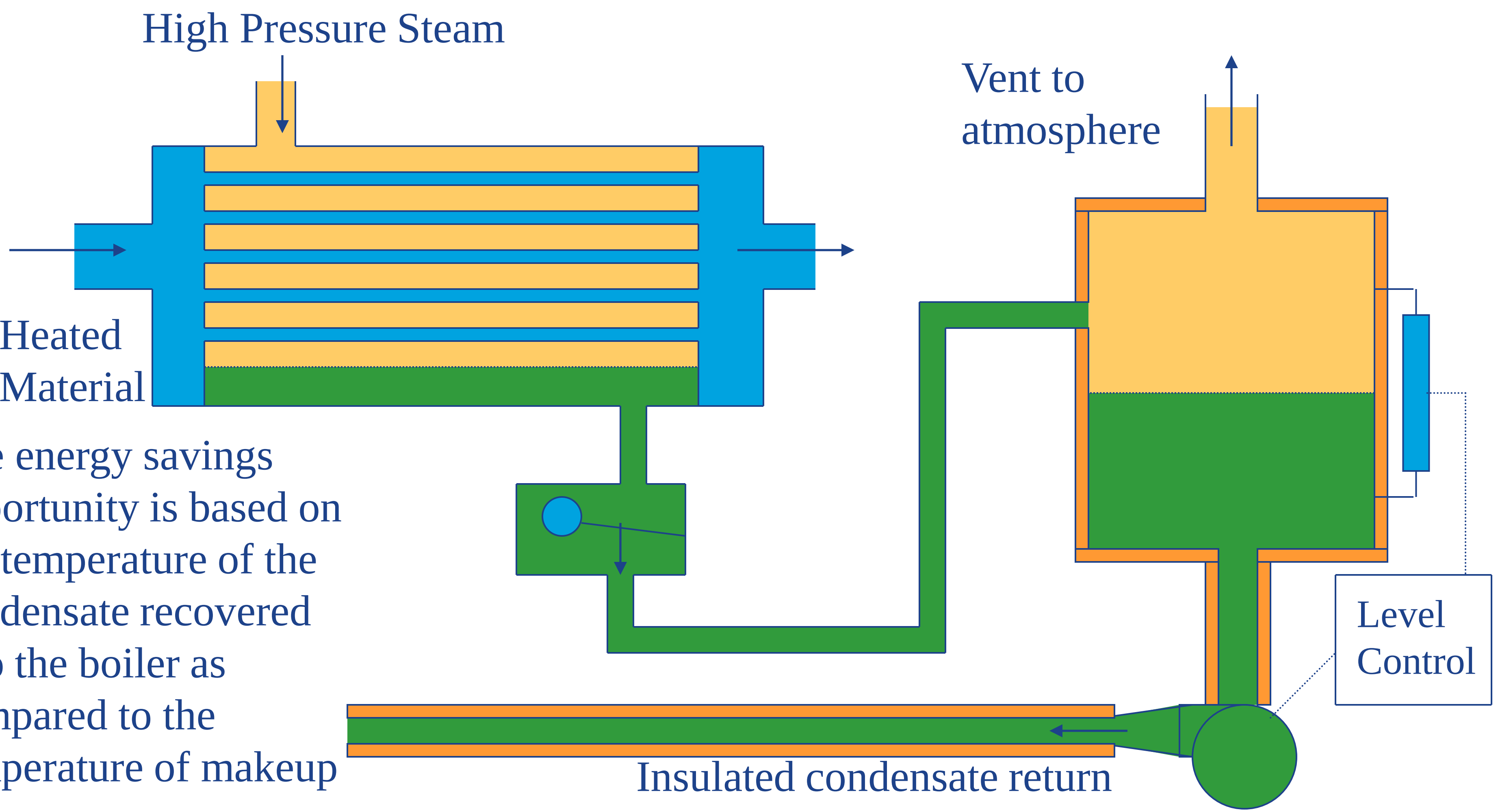
- Condensate receiver operates at atmospheric pressure
- The condensate return temperature provides an indication of the energy loss associated with the condensate return system
  - Condensate exits a process heat exchanger as a saturated liquid at the pressure of the heat exchanger
- Condensate recovery percentage describes the amount of *process steam* recovered in the condensate system
- Flash steam recovery systems allow recovered condensate to flash steam into lower-pressure steam systems
- Makeup water temperature impacts condensate related projects

Condensate Return Example



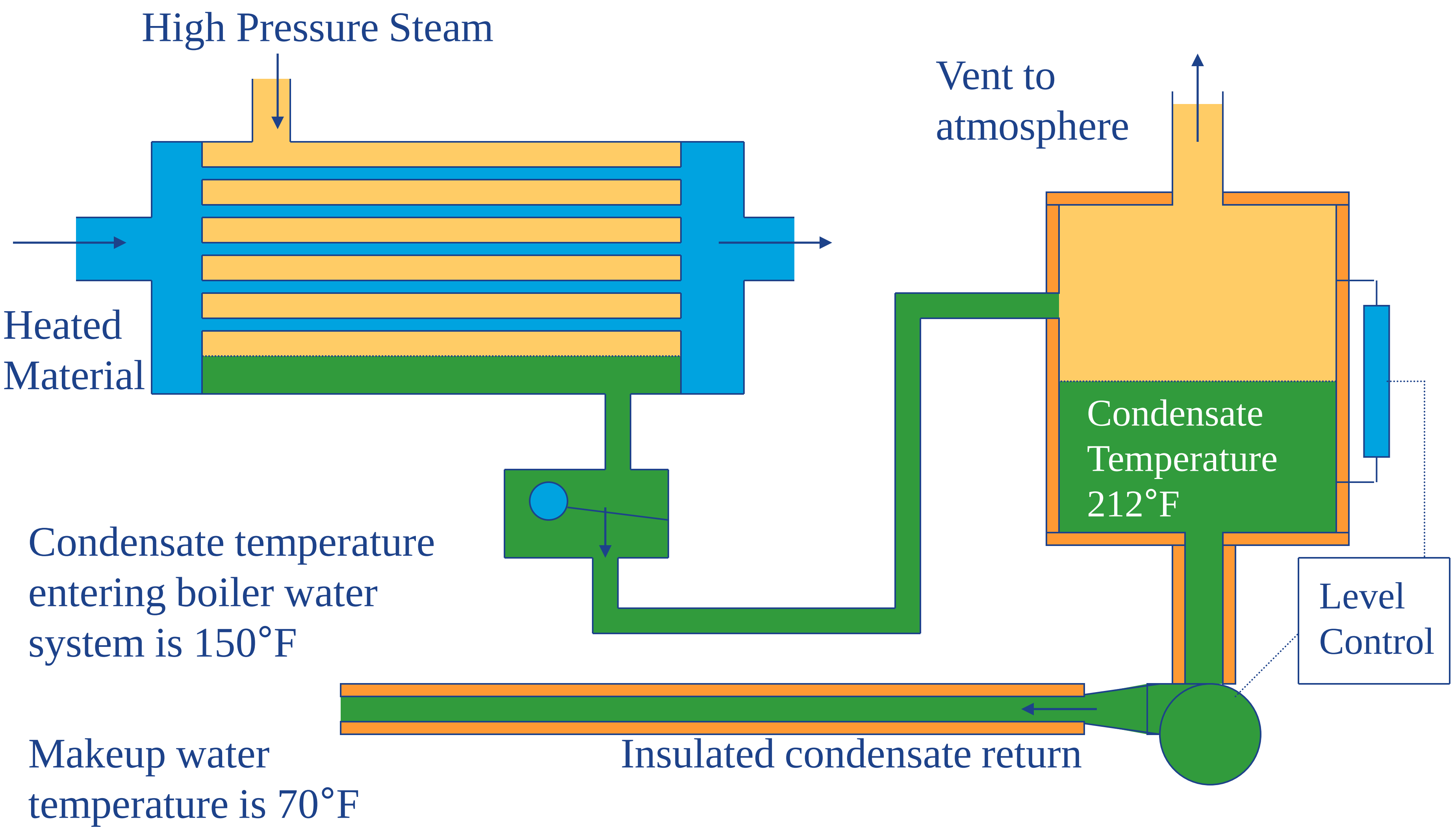
Measured condensate temperature 212°F
Condensate flow measured by bucket and stopwatch (mass and energy balance is also a common method) to be 10 gallons/minute (5,000 lbm/hr)

Condensate Return Example

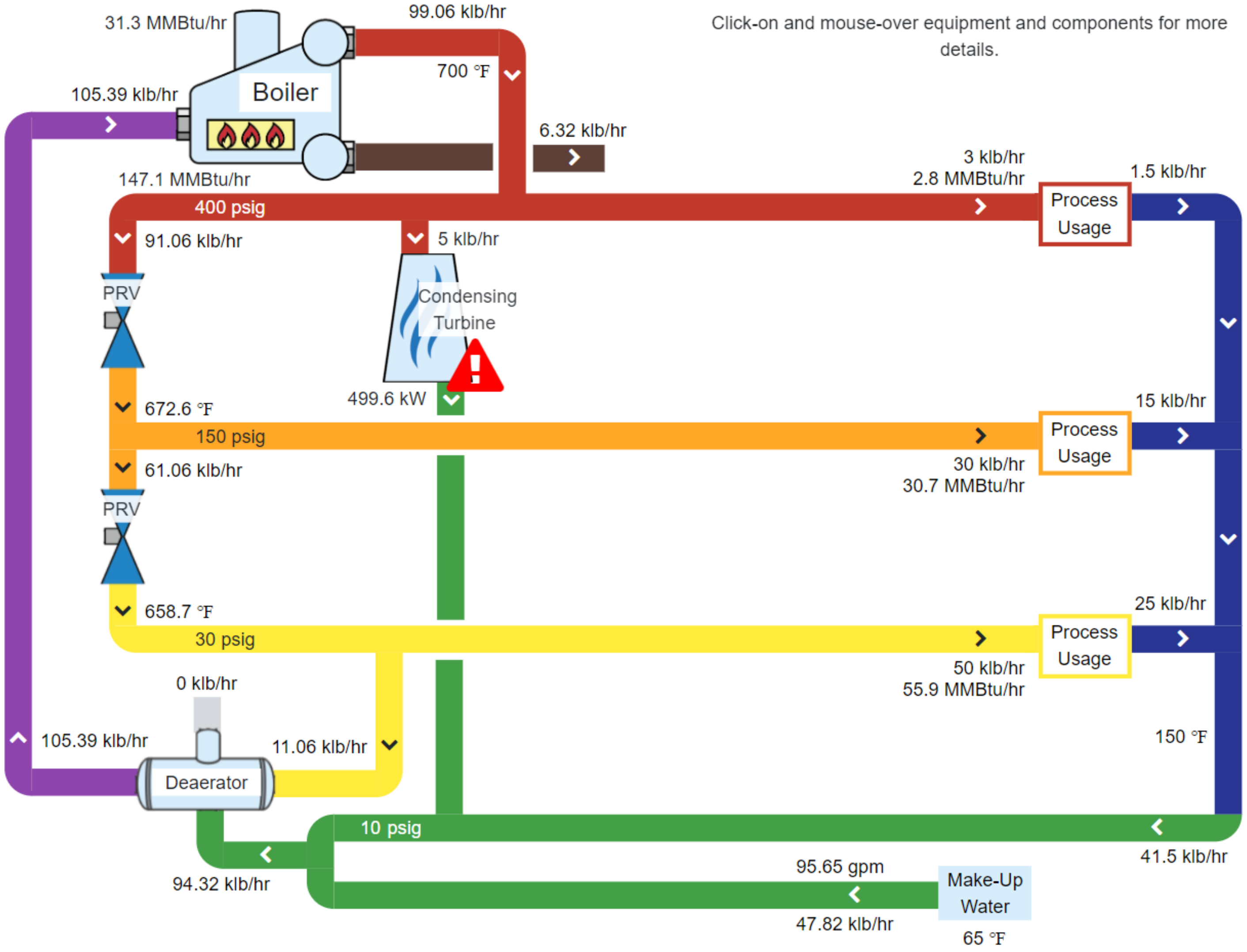


The energy savings opportunity is based on the temperature of the condensate recovered into the boiler as compared to the temperature of makeup water

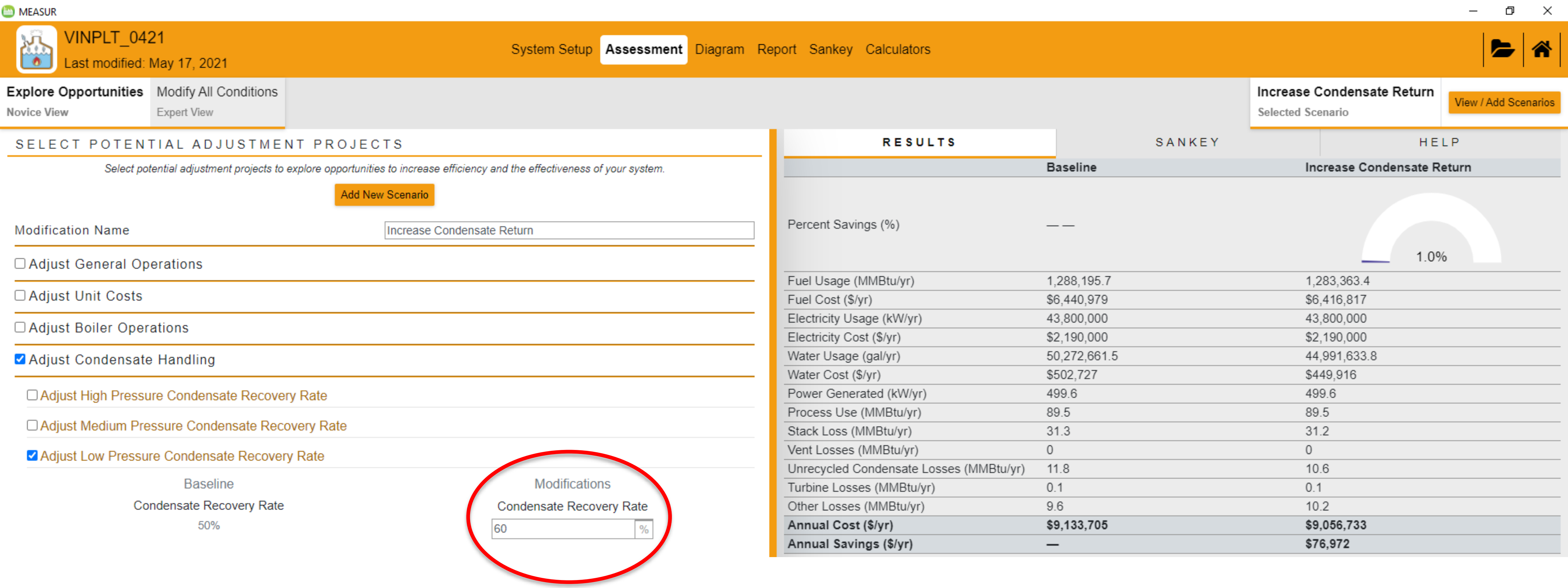
Condensate Return Example



MEASUR – Pulp & Paper Mill Model



Condensate Return Example (in MEASUR)

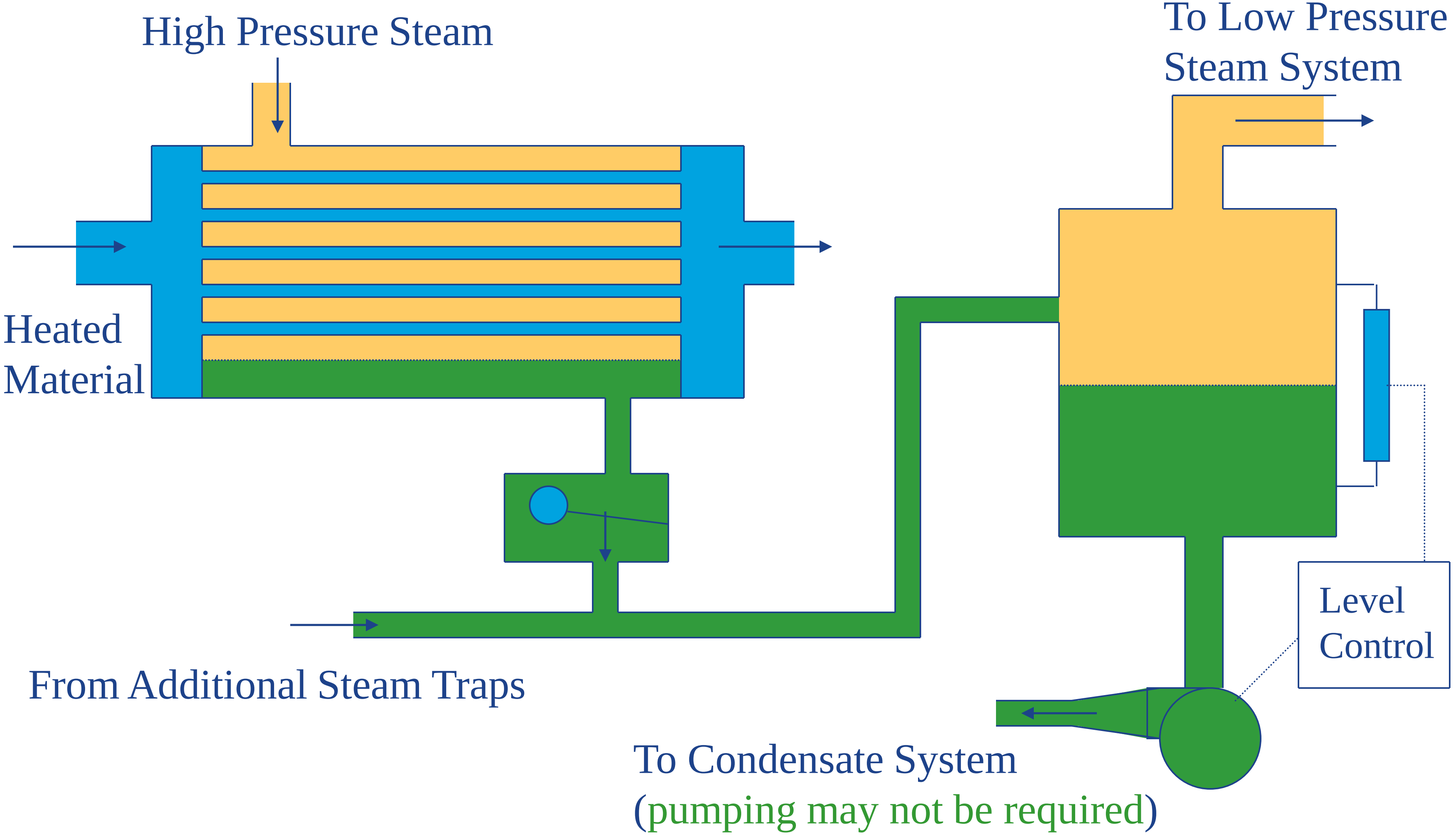


Condensate Recovery Rate = (25 + 5) / 50 = 60%

Condensate Recovery

- Condensate receivers serving “areas” can reduce project costs
- Condensate receivers and flash tanks serve to reduce the amount of steam entering the condensate return piping reducing flow restriction problems
- Receiver vents are indicative of trap failures
- Pump NPSH issues must be investigated

Cascade Condensate Systems



Condensate Recovery

- Condensate typically has worth
  - Energy
  - Make-up water reduction
    - This generally improves feedwater quality
      - Resulting in a reduction in boiler blowdown
  - Chemicals

- Condensate recovery costs generally center on the recovery system piping
  - Recovery equipment
  - Return piping

VINPLT Final Session (May 25)

- Specific Topics & Applications
- Planning for Group Discussion

Specific Topics & Applications

- Steam system pressure reduction - implications
- Condensate flash steam heat recovery
- Desuperheaters
- MEASUR overall assessment summary
- Ultrasonic data for steam trap operations
- Absorption chillers
- Steam coil air preheaters
- Thermocompressors
- ……

Thank You all for attending today's webinar.

See you all on next Tuesday – May 25, 2021 – 10 am ET

If you have specific questions, please stay online and we will try and answer them.

Alternately, you can email questions to me at rapapar@c2asustainable.com

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