Partnerships That Deliver Energy and Cost Savings for Manufacturers Through Assessments

Nebraska Industrial Assessment Center

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University of Nebraska Lincoln

University of Nebraska – Industrial Assessment Center

OUR TEAM

- 2 Faculty Members
- 1 Energy Engineer
- 4 Grad Engineering students
- 12 Multi-Disciplinary Undergraduate Engineers
- Funded by a Grant from the Department of Energy

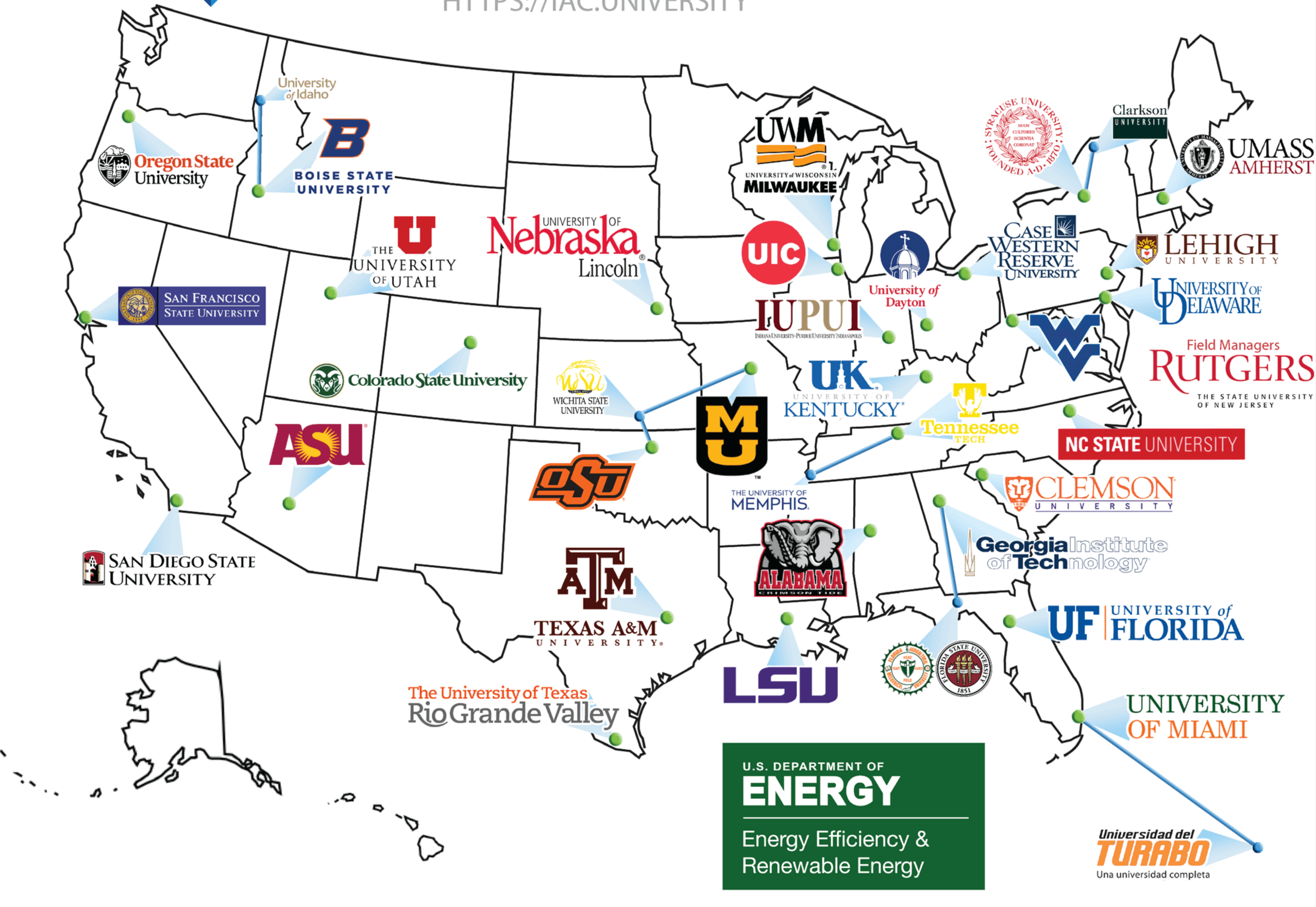
Industrial Assessment Center
U.S. DEPARTMENT OF ENERGY

U.S. Department of Energy (DOE), Industrial Assessment (IAC) Program

- Nebraska Industrial Assessment Center (NIAC) started September 1, 2016 on a 5-year grant
- IAC program has been around for 40 years
- Centers train teams of students to perform no-cost energy, productivity and waste assessments for small to medium-sized manufacturers and wastewater treatment plants

Industrial Assessment Centers 2019-2021

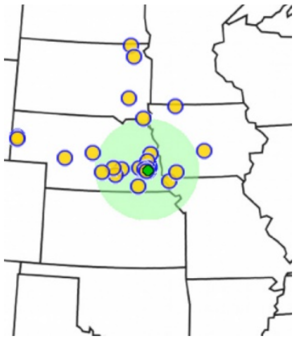
HTTPS://IAC.UNIVERSITY



Center Goals

- Provide current, relevant technical assessments to SMEs in the region
- Enhance energy education and student experience
- Help network students into summer and full-time positions in the energy engineering field
- Work with partners to leverage resources and improve outreach to constituents
  - Joint assessments
  - Answering billing and energy use data questions concerning clients

Target Demographics of Center Clients



- Located within 120-150 miles of Lincoln normally (trips that would require an overnight stay would typically be scheduled over the summer or on semester breaks)
- Gross annual sales below $100 million*
- Fewer than 500 employees at the plant site*
- Annual utility bills (electricity, gas, water, etc.) more than $100k and less than $2.5 million*

* can obtain exceptions for all but the $100K min. in annual total utilities

Topics of Current Competence

- Lighting
- Compressed Air
- VFD’s
- Demand management and power factor correction
- Boilers
- Smart manufacturing/process improvements
- Water conservation and wastewater surcharge reduction (deduct meters)
- Insulation
- Cooling towers
- Data loggers of various types (temperature, light, pressure, vibration, etc.)

NIAC Partners and Collaborators:

1. **Utilities**
   - Lincoln Electric System (LES), Nebraska Public Power District (NPPD), Municipal Energy Agency of Nebraska (MEAN)

2. **Government or University Entities and Agencies**
   - Nebraska Manufacturing Extension Partnership (MEP), Nebraska Department of Environment and Energy (NDEE)

3. **Energy Service Providers**
   - IC Energy Solutions, Asset Environments, Rasmussen Mechanical Services

Some of our partners may already be working with you (eg. Rasmussen Mechanical Services from Council Bluffs)

Assessment Cycle

Pre-Assessment Work

- Client Research
- Utility Collection and Analysis
- Gathering Facility Specific Information

Assessment Day

Post-Assessment and Follow-Up Survey

Preassessment Work

<u>Client Research</u>

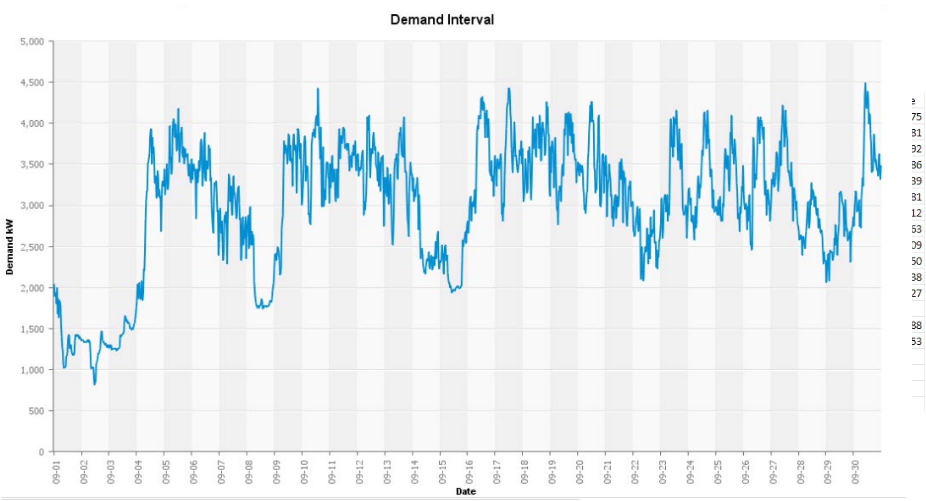
- Who are you?
- Scope of Company
- Number of Facilities
- Main Products and Consumers

Preassessment Work

Utility Collection and Analysis

- Provide 1+ year of continuous utility data
  - Electricity
  - Water
  - Gas
  - Others
- Obtain directly from utility providers?
- Ensure completeness
- Ensure company fits DOE metrics

Preassessment Work



<u>Utility Collection and Analysis</u>

- Enter data into a spreadsheet
- Verify billing structure
- Graph data and look for trends or irregularities

Preassessment Work

Potential Recommendations

- Incorrect billing structure
- Inconsistent water values
- Investigating peak demand
- Reduce fees

Table 4-4 : Overall Water and Sewer Information

Meter #	Annual Water Usage (gallon)	Annual Sewer Usage (gallon)
1584201	109,000	-
1584301	23,713,820	26,296,478
1584401	158,891	-
1584801	1,883,000	-
Total	**25,864,711**	**26,296,478**

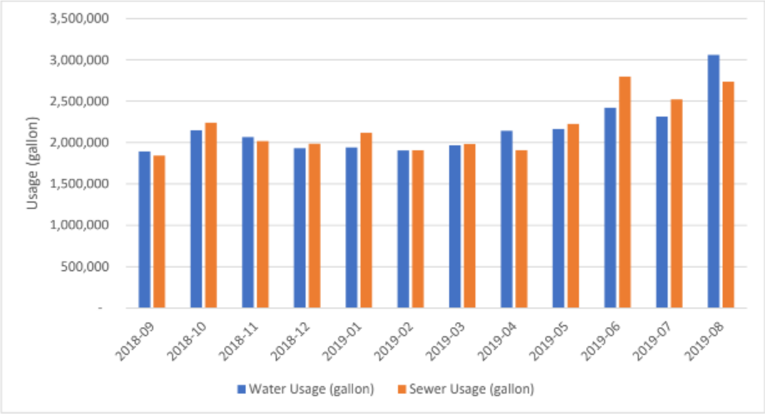


Figure 4-5: Water and Sewer Usage Trend

OUR TOOLS

- Thermal Imaging Camera
- Flue Gas Combustion Analyzer
- Laser Tachometer
- Light Meter
- Anemometer
- Ultrasonic Air Leak Detector
- Vibration Logger
- Temperature/Humidity Logger
- Current Logger
- Power Logger
- Dissolved Oxygen Meter

Assessment Day

- Team of 6-8 Students and Staff Conduct Comprehensive 1-day No-cost Energy Assessment

- Interaction with plant staff
  - Intake Meeting (~8:00 a.m.)
  - Exit Interview (~3:00 p.m.)
  - Plant tour and gathering data

- Logistics
  - Parking, badges, specialized PPE
  - COVID-19 Adjustments
  - Dedicated “home base” for the day
  - Wi-fi
  - Lunch

Post-Assessment and Follow-Up Survey

After Assessment

- Follow-up questions
- Report delivery within 60 days

Table 1-1: Overall Summary of Assessment Recommendations

$$P_i = Load * hp * \frac{0.746\ kW}{\eta_{pl}}$$

$$P_i = 0.75 * 40 * \frac{0.746\ kW}{0.942} = 23.8\ kW$$

Now that the input power of the replacement motor has been calculated for a partial load of 75%, the annual cost to operate the motor is calculated as follows:

$$E_{Motor} = 23.8\ kW * \frac{6{,}000\ hours}{year} = \frac{142{,}548\ kWh}{year}$$

$$C_{Motor} = 142{,}548\ kWh * \frac{\$0.027}{kWh} + 23.8\ kW * \frac{\$21.478}{kW * month} * 12\ months = \frac{\$9{,}983}{year}$$

These equations are applicable to all motors in your facility. To avoid redundancy, Table 5.4-5 shows the resulting cost for all the motors being analyzed. Table 5.4-6 shows the estimated savings of downsizing these motors.

Table 5.4-5: Summary of Replacement Motors

Replacement Motor	Hours in Operation (hours/year)	Input Power/Demand (kW)	Energy Usage (kWh/year)	Annual Cost ($/year)
40-hp Banbury Motor	6,000	23.8	142,548	$9,983
25-hp Calender motor	6,000	14.9	89,282	$6,251
30-hp Vacuum motor	6,000	18.3	109,706	$7,679
Totals	-	**57.0**	**341,536**	**$23,913**

Table 5.4-6: Estimated Savings of Downsizing Motors

Current Motor	Replacement Motor	Monthly Demand Savings (kW/month)	Energy Savings (kWh/year)	Annual Cost Savings
250-hp Banbury Motor	40-hp Banbury Motor	3.8	22,964	$1,599
200-hp Calender motor	25-hp Calender motor	3.1	18,773	$1,306
50-hp Vacuum motor	30-hp Vacuum motor	1.0	6,302	$428
	Total	**7.9**	**48,040**	**$3,333**

Follow-Up Survey

- 9-10 months after assessment day
- 10-15 minutes on phone to complete

Case Study Examples

- Boiler
- Steam Traps
- Water Reduction

Boiler

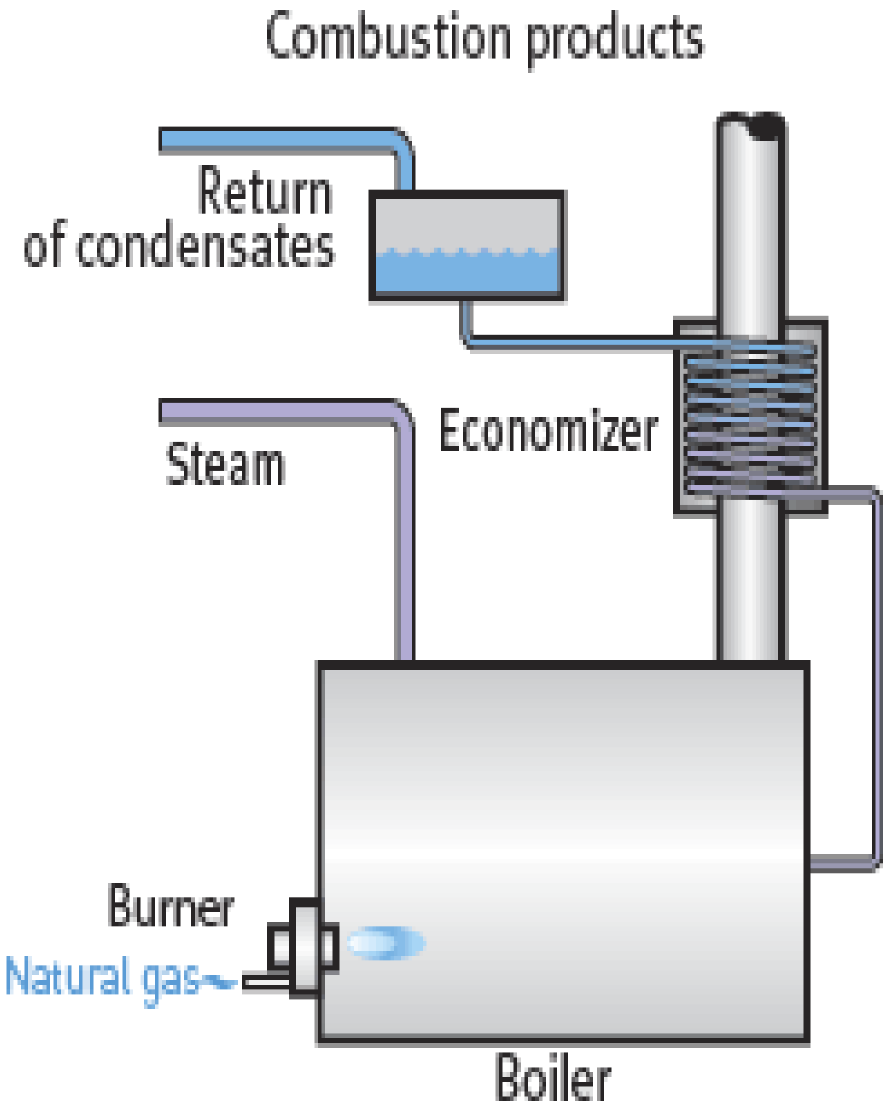
- “A boiler is only efficient when turned off” (Rasmussen)
- An Ethanol plant had a boiler that was running without an economizer
- An economizer is a special heat exchanger used to transfer heat from flue gas to the water entering the boiler

Boiler

- Every 40°F taken off flue gas results in 1% savings on gas usage by boiler

- Using a flue gas analyzer, we can determine the temperature

$$\% \, Reduction = \frac{\Delta T_{flue\ gas}}{40F}$$



Boiler Case Study: Economizer

- Temperature flue gas 242°F
- % Reduction = 242°F/40°F
- % Reduction = 6%
- Boiler ran at 90% load
- Natural Gas Savings = % Reduction * Ng_{annual}
- Natural Gas Savings = 5.4% * 23,600 MMBtu/year
- Annual Savings = $64,400 on natural gas
- Plant spent = $1.1 million on natural gas
- Payback Period =1.4 years

Steam Traps

- Filter out condensate within the pipes
- Lifespan of 5-7 years
- Fail in two ways
  - Open (lose steam)
  - Closed (reduce heat transfer)
- From DOE tip sheet 30% of steam tra checked and maintained within 3-5 ye
- Temperature, sound, and visually
- Should be performed once a year
- FLIR imaging cameras used to detect t

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
ADVANCED MANUFACTURING OFFICE
Energy Tips: STEAM
Steam Tip Sheet #1

Inspect and Repair Steam Traps

In steam systems that have not been maintained for 3 to 5 years, between 15% to 30% of the installed steam traps may have failed—thus allowing live steam to escape into the condensate return system. In systems with a regularly scheduled maintenance program, leaking traps should account for less than 5% of the trap population. If your steam distribution system includes more than 500 traps, a steam trap survey will probably reveal significant steam losses.

Example

In a plant where the value of steam is $10.00 per thousand pounds ($10.00/1,000 lb), an inspection program indicates that a trap on a 150-pound-per-square-inch-gauge (psig) steam line is stuck open. The trap orifice is 1/8th inch in diameter. The table shows the estimated steam loss as 75.8 pounds per hour (lb/hr). After the failed trap is repaired, annual savings are:

Annual Savings = 75.8 lb/hr x 8,760 hr/yr x $10.00/1,000 lb
= $6,640

Leaking Steam Trap Discharge Rate*

Trap Orifice Diameter, inches	Steam Loss, lb/hr			
	Steam Pressure, psig			
	15	100	150	300
1/32	0.85	3.3	4.8	-
1/16	3.4	13.2	18.9	36.2
1/8	13.7	52.8	75.8	145
3/16	30.7	119	170	326
1/4	54.7	211	303	579
3/8	123	475	682	1,303

*From the Boiler Efficiency Institute. Steam is discharging to atmospheric pressure through a re-entrant orifice with a coefficient of discharge equal to 0.72.

Suggested Actions

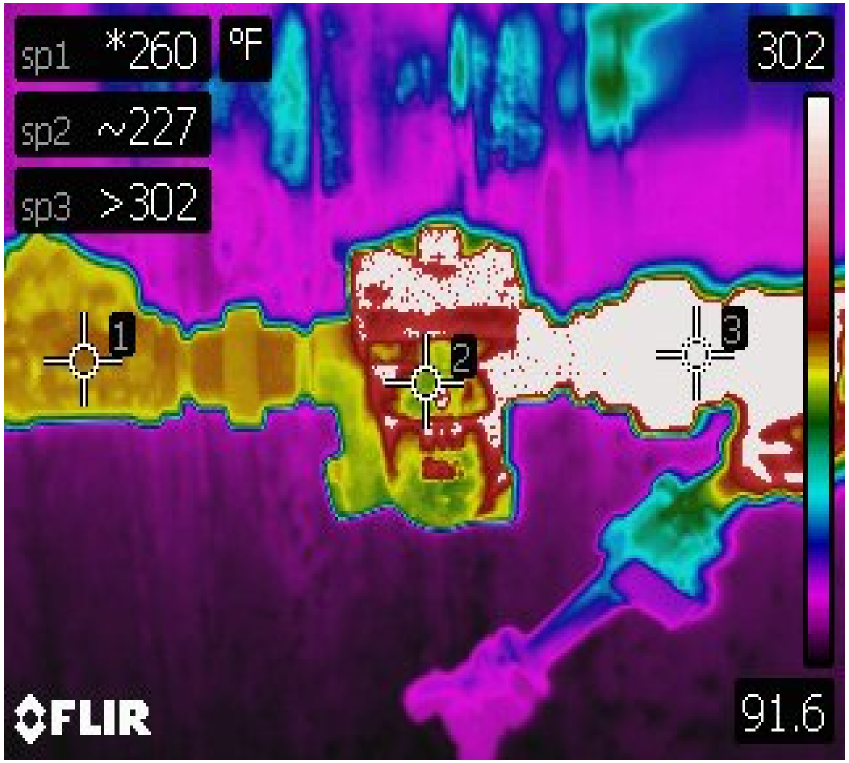
Steam traps are tested primarily to determine whether they are functioning properly and not allowing live steam to blow through.

- Establish a program for the regular systematic inspection, testing, and repair of steam traps.
- Include a reporting mechanism to ensure thoroughness and to provide a means of documenting energy and dollar savings.
- Consider online monitoring of the most important steam traps or those associated with your most important processes to quickly identify steam loss trends.

https://www.energy.gov/eere/amo/tip-sheets-system

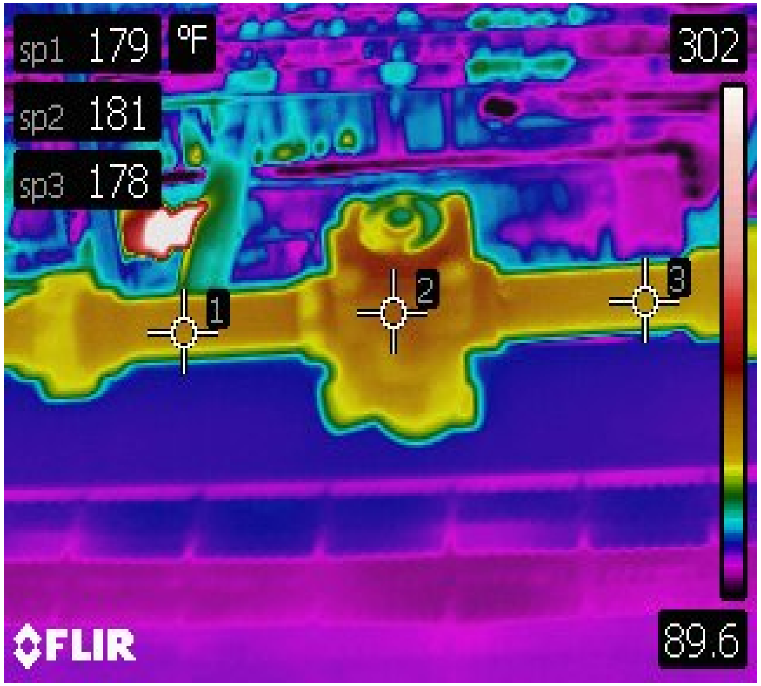
Functioning Steam Trap

- Inlet Temp >302°F (Steam)
- Outlet Temp 260°F (Condensate)



Failed Steam Trap

- Inlet Temp 179°F (Condensate)
- Outlet Temp 178°F (Condensate)
- Corrosion, reduced heat transfer



Estimated Savings

- Two ways to lose money: lost steam and lost heat transfer
- $Cost\ of\ Steam\ Loss = Hourly\ Steam\ Loss * Annual\ Operation\ Hour * Baseline\ Cost$
- $5 per 1,000 lbs of steam

National Board of Boiler and Pressure Vessel Inspectors

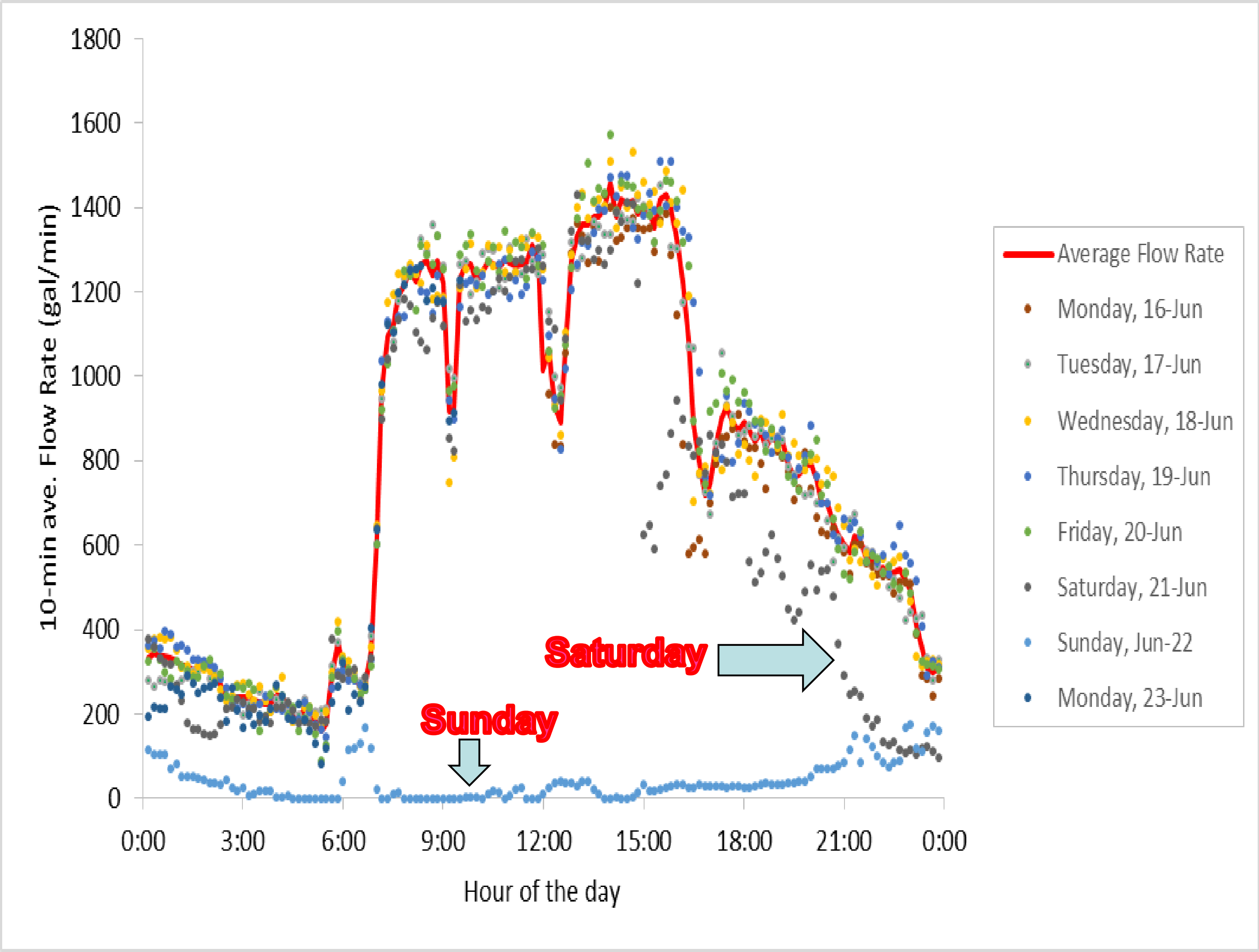
Size of orifice (in.)	Lbs. steam wasted per month	Total cost per month	Total cost per year
1/2	835,000	$4,175	$50,100
7/16	637,000	3,185	38,220
3/8	470,000	2,350	28,200
5/16	325,000	1,625	19,500
1/4	210,000	1,050	12,600
3/16	117,000	585	7,020
1/8	52,500	262	3,150

Steam Trap Case Study (Ethanol Plant)

- Four failed traps
- 48 lb/hr
- $Cost\ of\ Steam\ Loss = \ 48\ lb/hr * \frac{8{,}664\ hours}{year} * \frac{\$2.770}{1{,}000\ lbs}$
- $Cost\ of\ Steam\ Loss = \frac{\$1{,}152}{year*trap}$
- $Total\ Cost\ of\ Steam\ Loss = \frac{\$1{,}152}{year*trap} * 4\ traps$
- $Total\ Cost\ of\ Steam\ Loss = \frac{\$4{,}608}{year}$
- Payback Period = 0.3 years

Water Reduction

- Energy is 60-80% of water cost (sanitation)
- Leads to reduction in product loss (food manufacturing)
- Reduce wastewater and water bills
- Ultrasonic flow meters for collecting data and verifying sensors are working properly



1800
1600
1400
1200
1000
800
600
400
200
0
10-min ave. Flow Rate (gal/min)
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00
0:00
Hour of the day
Saturday
Sunday
Average Flow Rate
Monday, 16-Jun
Tuesday, 17-Jun
Wednesday, 18-Jun
Thursday, 19-Jun
Friday, 20-Jun
Saturday, 21-Jun
Sunday, Jun-22
Monday, 23-Jun

Example Water Reduction Recommendations

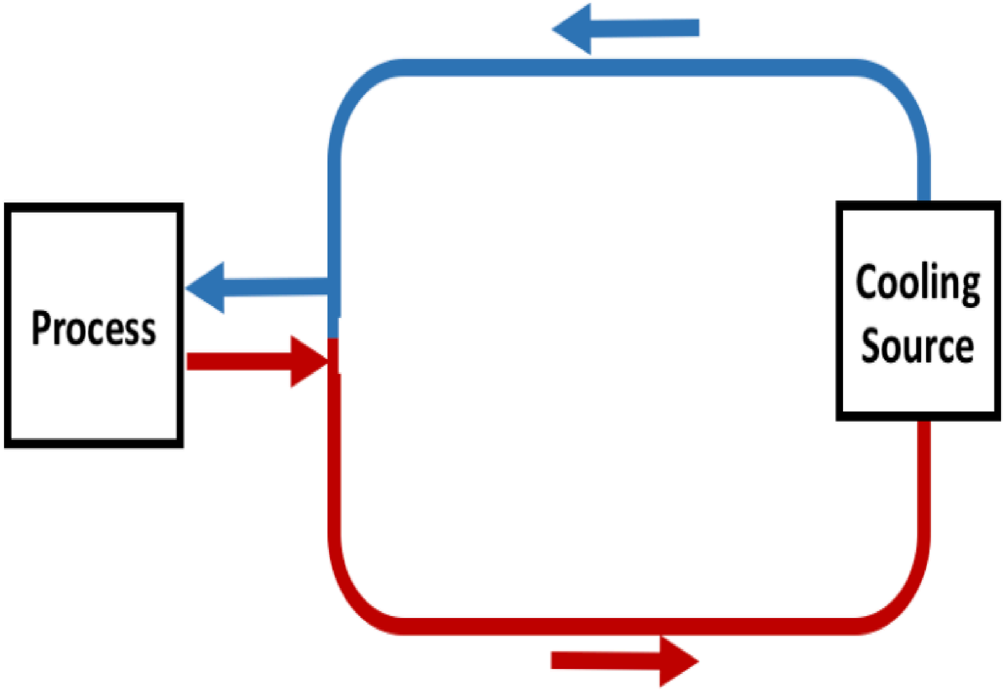
- Squeeze Nozzles
- Flow constrictors
- Level Sensor
- Deduct Meters
- Closed-loop chiller

Water Reduction Case Study: Chiller

- Facility used 62 gal/min to cool two mixers
- Water sent directly to sewer drain
- Led to large water & wastewater bill

Chiller Analysis

- Recommendation, closed-loop chiller
- Find heating load
- $Q = m * c * \Delta T$
- Q = 30 ton

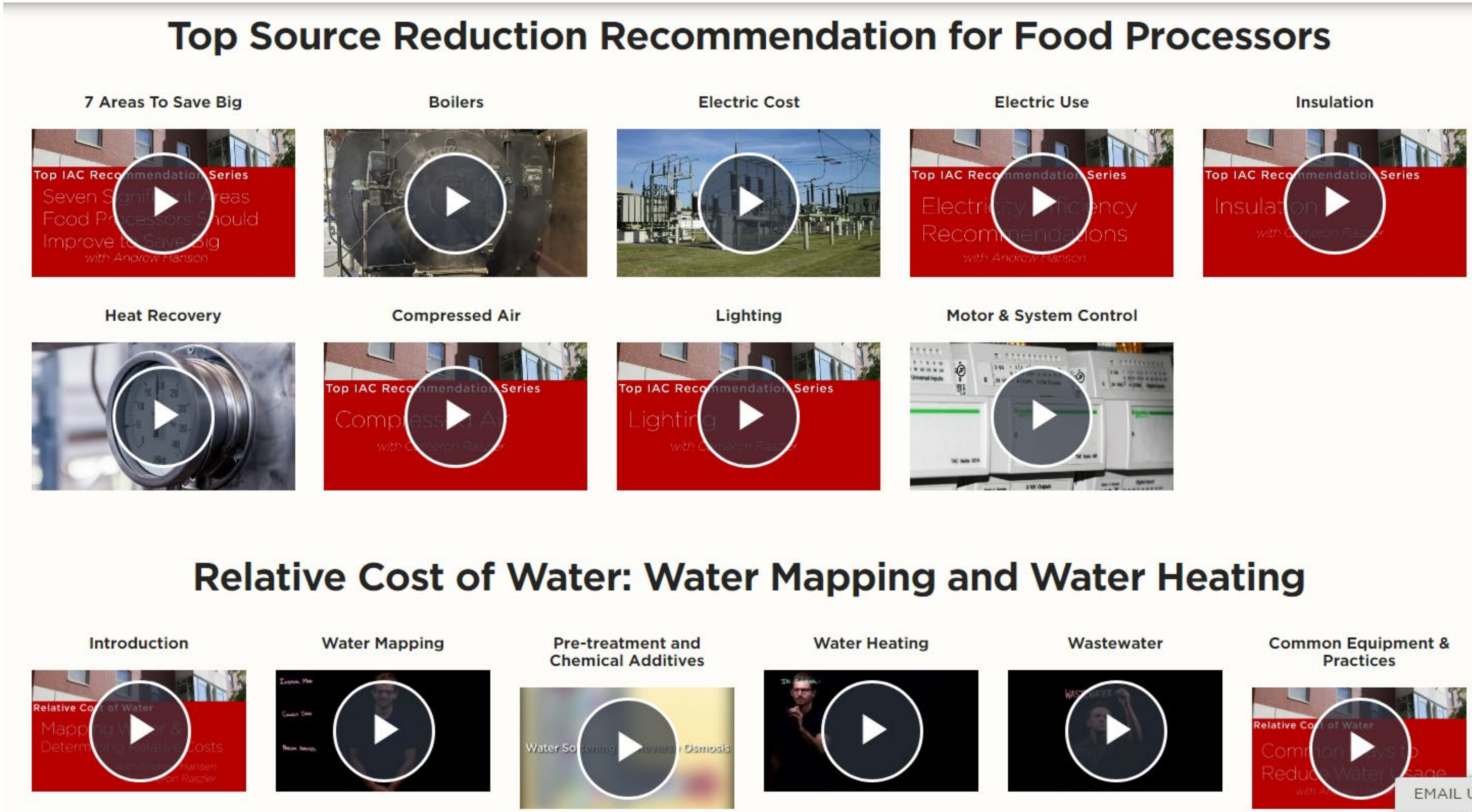


Chiller Recommendation

- Annual Water Usage – 4,650,000 gal/year (using 62 gpm and hours of operation)
- Chiller recycles the water
- Water Cost savings = $10,035/ year
- Wastewater Cost savings = $16,084/year
- Chiller Electricity cost = $2,240/year
- Total Savings = $23,879/ year
- Payback Period = 1.9 years

Self-Help Videos: Common E2/P2 Suggestions

https://engineering.unl.edu/iac/niac-webinar-videos/



For more information related to assessments, contact:

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or visit:

https://engineering.unl.edu/iac/