Dairy Energy Symposium

43rd Annual Rural Energy Conference

Energy Efficiency in Food Processing Plants

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Agenda

- Introductions
- A Perspective on Energy Efficiency
- Some Basic Tips
- Awareness
- Project Rate Example
- Evaluating the Opportunities
- Opportunities – Electric
- Opportunities - Thermal/Fuel Based

A Resource Perspective on Energy Efficiency

- Energy Versus "Availability"
- Developing Countries Will Have a Major Impact on Resource Utilization
- Improving Conversion "Efficiency" Will Become Even More Important

A Resource Perspective on Energy Efficiency

- Understand How Literature Reports "Efficiency"
- Boiler example: What Does a Combustion Test Reveal?

Some Basic Tips

- Get to Know the Facility Staff and Management
- Understand What you are Trying to Accomplish
- Consider the Whole Energy Picture – Avoid the "Shell Game"

Some Basic Tips

- Consider Low / No Cost Opportunities
- Know Your ***Project*** Energy Rate

Low / No Cost Opportunities

- Staff Know A Lot About Their Plant – Talk to Them and Learn to Guide the Conversation
- Work Practices Relate to Operations, Maintenance *and* House Keeping

Low / No Cost Opportunities

- Example Work Practices Are:
  - Use of Startup / Shut down Procedures
  - Maintenance Activities for Major Energy Using Systems
  - Bypassing Automatic Controls
  - Use of a Process / Procedure for Everyday Maintenance Activities

Awareness

- ***Employees*** Should Know the ***Energy Cost*** of Utilities and Ancillary Systems such as:
  - Compressed Air, Gas and Electric
  - Heating & Cooling (process and comfort)
  - Lighting, Water and Others

Project Rate Example

- Total kWh: 1,286,225 kWh
- On-peak kWh: 542,403 kWh
- Off-peak kWh: 743,822 kWh
- Peak Demand: 2,608 kW (monthly)
- Customer Demand: 2,492 kW

Project Rate Example (utility rates)

- On-peak Charge : $0.033/kWh
- Off-peak Charge: $0.021/kWh
- Peak Demand Charge: $8.36/kW
- Customer Demand: $0.76/kW
- Tax Rate: 5.5%

Project Rate Example (monthly charges)

- Peak Demand: $21,802 (2,608 kW)
- Customer Demand: $1,869 (2,492 kW)
- Peak kWh: $17,899 (542,403 kWh)
- Off-peak kWh: $15,620 (743,822 kWh)
- Tax: $3,147
- Total Cost: $60,360

Project Rate Example ("blended" utility charges)

- On-peak Average Cost: $0.077/kWh
- Off-peak Average Cost: $0.025/kWh
- Average Rate: $60,360 ÷ 1,286,225 = $0.047/kWh (overall average)

(all include tax of 5.5%)

Rate Structure Example (project)

- Project will Save 50 kW from 8 am to 6 pm, or 10 Total Hours per Day
- Peak Time: 10 am to 6 pm: 8 Hours
- Off-peak Time: 8 am to 10 am: 2 Hours
- kWh per Year: 10 hrs/d x 5 d/wk x 50 wk/yr = 2,500 hrs/year

Rate Structure Example (project)

- Electricity Savings:

50 kW x 2,500 hrs/yr = 125,000 kWh/yr

- The Electricity Savings is Known: How do We Estimate ***Cost*** Savings?

Rate Structure Example (savings estimate)

- Based on average rate:

125,000 kWh/yr x $0.047/kWh = $5,875 /yr

- Considering Peak & Off-peak Time:

125,000 x 0.078/kWh x (8 ÷ 12) +
125,000 x 0.022/kWh x (2 ÷ 12) = $6,925 /yr

- The Difference is ~20%

Opportunities – Electric

- Lighting
- Compressed Air
- Premium Efficiency Motors
- Variable Frequency Drives
- "Free" Cooling
- Water Reclaim

Lighting

- High Output T8 Lighting will Replace 400-watt Metal Halide Lighting
- ~50% Energy Cost Reduction
- Coated Tubes are Required (GE Star Coat)
- Typical T8 Installed Cost ~ $200/fixture
- Replace Incandescent Lights with CFLs (~4 to 1 energy benefit)

Compressed Air

- Air Compressors Are ***~15%*** Efficient!
- Over a Ten Year Life, 15% is Capital, 15% is Maintenance & 70% is Energy
- Duct Air Intakes to the Outside
- 1% Savings per 5ºF Reduction in Inlet Temperature
- ~ ½ % Savings per PSI Reduction

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Premium Efficiency Motors

- Many F & D Plants Operate Long Hours
- Many F & D Plants Use Old Motors
- Metering Shows That Motors Tend to be Loaded Either Less than 50% or More Than 90%

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Premium Efficiency Motors

3600 RPM

Size	100%	75%	50%	25%
2	86.5	87.1	85.5	79.1
3	89.5	90.2	89.7	84.7
5	89.5	89.9	89.0	84.2
7.5	91.0	90.4	88.8	83.7
10	91.7	92.2	92.3	87.9
15	91.7	92.3	91.7	87.5
20	92.4	92.6	92.0	88.1
25	93.2	94.4	93.0	89.9
30	93.1	93.0	93.2	90.2
40	93.6	94.6	93.1	82.4
50	94.5	94.8	94.0	91.8

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Premium Efficiency Motors

1800 RPM

Size	100%	75%	50%	25%
2	88.1	88.5	87.4	82.2
3	90.2	89.5	88.5	82.5
5	90.2	90.2	90.2	85.5
7.5	92.1	91.9	90.5	85.0
10	91.8	91.9	91.0	86.6
15	92.4	93.8	93.7	91.2
20	93.0	93.4	92.8	89.7
25	93.6	93.6	92.4	88.6
30	94.1	94.0	93.2	88.9
40	94.5	94.6	93.9	90.6
50	94.5	95.1	95.1	93.2

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Premium Efficiency Motors

Recent Motor Projects (1800 RPM)

- 20-hp

-87.5% to 93% Efficiency: Cost ~$739

- 25-hp

-91.7% to 93.6% Efficiency: Cost ~$856

- 30-hp

-92.4% to 94.1% Efficiency: Cost ~$1,013

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Premium Efficiency Motors

Recent Motor Projects (3600 RPM)

- 60-hp

-90% to 94.1% Efficiency

Cost ~$1,656

(And actually use the existing drive!!)

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Variable Frequency Drives

- There Always Seem to be Opportunities for VFDs
- The Cost of VFDs Has Come Down Considerably
- Metering, Pump Curves and Affinity Laws Can help Evaluate the Potential for VFDs
- For Power: $P_2=P_1 \times (Q_2/Q_1)^3$

Variable Frequency Drives

- Reducing flow by 30% Reduces Power by up to 66%!
- The Above Rule is Based on an Exponent of 3; Recommend use of 2 or 2.5 if no Other Information is Available
- Typical DRIVE Costs (not installed)
  - 10 hp to 50 hp: $100 to $130/hp
  - ->50 hp: $80 to $110/hp

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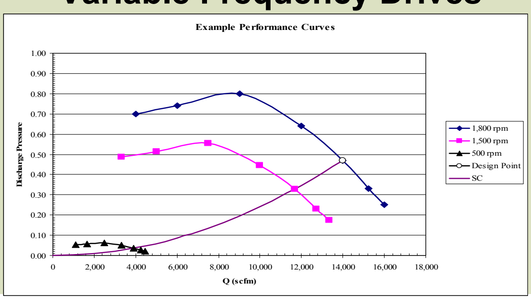
Variable Frequency Drives



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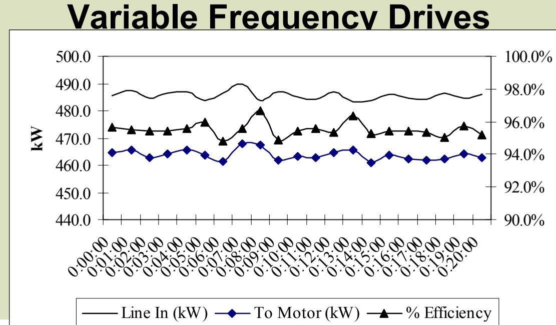
Variable Frequency Drives



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"Free" Cooling

- Most Facility Personnel Do Not Know or Have a Misunderstanding About Free Cooling
- Free Cooling Killers:
  - Low Temperature Requirement
  - Low Electricity Rate
  - Low Use Hours
  - Small Load

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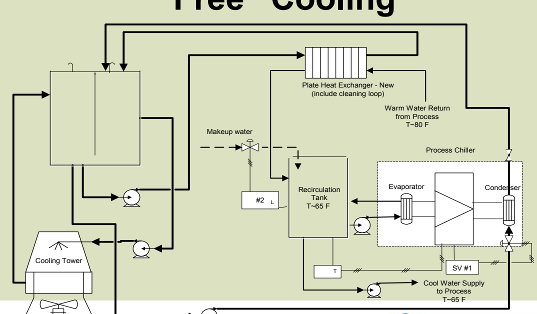
"Free" Cooling



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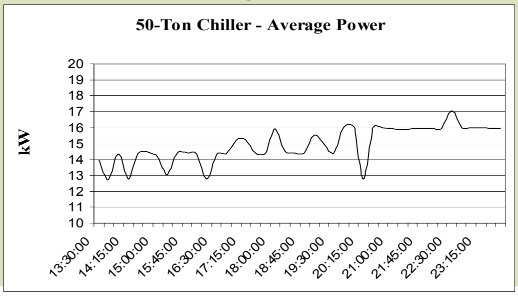
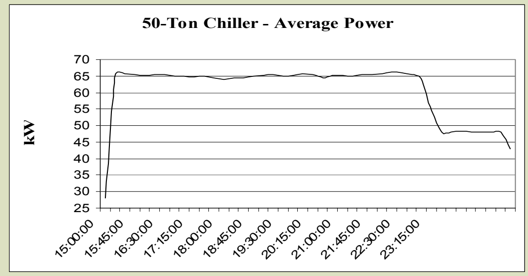
“Free” Cooling – Load Profile



“Free” Cooling – Load Profile



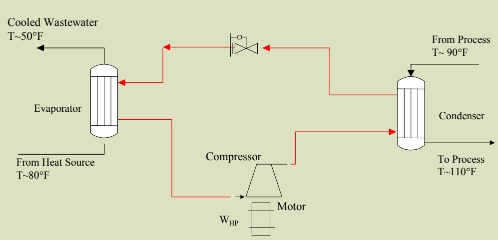
“Free” Cooling

- ***Rough*** Cost: $300 to $350 per Ton Refrigeration for COMPLETE System
- Existing Cooling Towers Can Potentially Be Used to Reduce Cost
- Remember That if a Chiller is in a Free Cooling Mode, Condenser Water is not Needed

Heat Pumps

- Common Heat Pumps are Mechanical & Thermal Vapor Recompressors (MVR & TVR)
- Closed Cycle Heat Pumps (CCHP) are an Option for ***Water*** Heat Recovery
- CCHPs Have an Upper Limit of ~215°F, with a Max Rise per Stage of ~50°F
- Efficiency Suffers as Rise Increases

Closed Cycle Heat Pump



Heat Pumps – Cost of Heat

Electricity Cost ($/kWh)	Cost of Delivered Heat ($/10^6 Btu)					
	Heat Pump Coefficient of Performance (COP)					
	3	5	8	10	20	30
$0.02	$1.95	$1.17	$0.73	$0.59	$0.29	$0.20
$0.03	$2.93	$1.76	$1.10	$0.88	$0.44	$0.30
$0.04	$3.91	$2.35	$1.47	$1.17	$0.59	$0.40
$0.05	$4.89	$2.93	$1.83	$1.47	$0.73	$0.50
$0.06	$5.86	$3.52	$2.20	$1.76	$0.88	$0.60

Water Reclaim

- Typically, Much Water is Used and Discarded
- Cold Water Results from Single Use Cooling (~55 °F)
- Conduct a Survey to Identify Water/Heat Reclaim Opportunities

Fuel Based / Thermal Opportunities

- Boiler Heat Recovery
- Steam Vacuum Pumps
- Reverse Osmosis Concentration
- Heat Exchangers
- Heat Pumps
- Water Reclaim

Boiler Heat Recovery

- Underutilized Opportunities!!
- Boiler Exhaust Economizers
- Continuous Blowdown Recovery
- Vent Condensers
- Boiler Tube Maintenance

Boiler Heat Recovery

- **Example:** Economizer to Recover Exhaust Heat to Preheat Return Condensate.
- Existing Conditions:

  -Stack Temperature: 510ºF
  -Return Condensate Temperature:130ºF
  -Boiler Efficiency: 75%
  -Operating Hours: 4,000/yr
  -Fuel: Natural Gas at $7.00/MMBtu

Boiler Heat Recovery

- **Economizer Benefits**

  -New Exhaust Temperature: 250ºF
  -New Condensate Temperature: 186ºF
  -Installed Cost:~$16,000
  -Fuel Savings: 2,990 MMBtu/yr
  -Cost Savings: $20,900/yr
  -Simple Return: 9 months

Steam Vacuum Pumps

- Found on Flash Condensers
- Basic Operation: Use Steam Jet Pump to Create Vacuum
- Steam Jet Pumps are 10%-15% Efficient - Usually
- Alternative: Electric Motor Driven Liquid Ring Pump (Last one evaluated: ~2.5 yr simple return @ ~$5.00 gas)

Reverse Osmosis Concentration

- Good for Concentration of Whey and Other Streams from ~6% to ~22%
- Theoretically Less Energy Intensive than Evaporation-Why?
- Study Underway to Evaluate/Compare RO Systems to MVR and TVR Based on Energy AND Operating Cost
- Stay Tuned!

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Heat Exchangers

- Usually Shell & Tube Exchangers can be Upgraded to Plate and Frame
- Plate and Frame Exchangers can have Approach Temperature as Low as 2°F
- Low Approach Temperature Can Make a Big Difference
- Vendors Will NOT Typically Offer the Best Exchanger Unless Asked-They Cost More

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Heat Exchangers

- Example: HTST Pasteurizer
  - Historically Used 190°F Water
  - Options Were to Replace Worn Plates, Replace Entire Exchanger with New Version of the same or to Optimize the Exchanger Performance
  - Option Being Pursued is Optimization Via Reduction in Temperature to 185°F

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Heat Exchangers

- Example: HTST Pasteurizer – Benefits

  -Lower Heating Utility Requirement

  -Savings Will Pay for ENTIRE Exchanger in ~2.5 years!!

  -Don't Forget Environmental Impacts-

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Water Reclaim

- Much Water is "Wasted" in Dairy Facilities.
- The Majority of This Water Contains Useable Heat.
- Both Heat Pumps and Plate Exchangers Can be Used.
- Water Costs are Also on the Rise.

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For More Information

For More on Energy Cost Reduction Contact Tom Tucker at

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OR

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