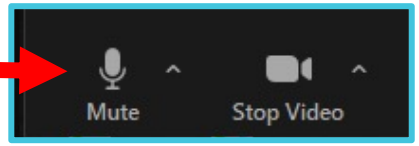
Using Zoom!

Mute yourself! Have a question? Use the chat feature.

Controls accessed at the bottom

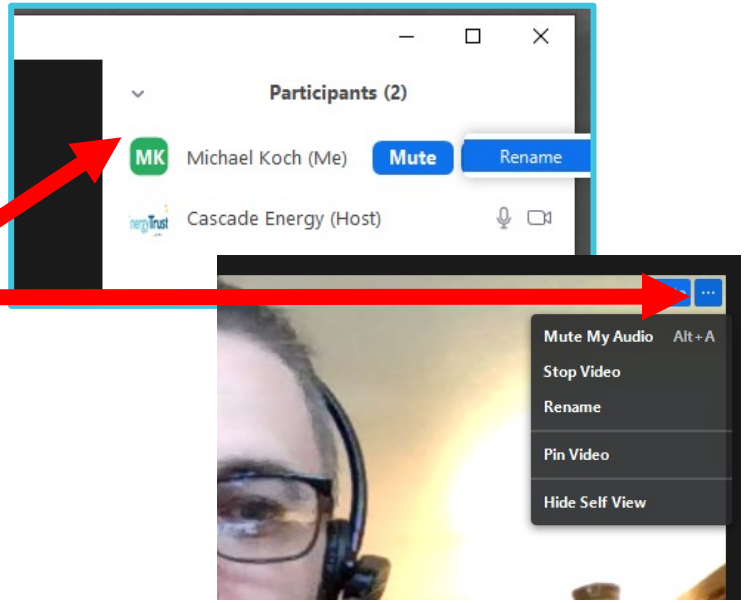


Rename yourself: "Name (Company)"

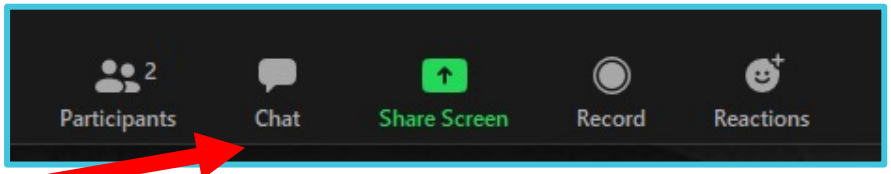
Right click on your picture or 3 dots

OR

Controls accessed at the right after clicking 'Participants' at bottom.



Access Chat at the bottom



This session will be recorded for those not in attendance!

Better Plants
U.S. DEPARTMENT OF ENERGY

REFRIGERATION SYSTEM VIRTUAL IN-PLANT TRAINING

SESSION 1 – JAN 10, 2023

U.S. DEPARTMENT OF ENERGY

Thank You!

Sponsor:

Meet Your Trainers

Steve Koski, PE
Principal Engineer
Cascade Energy, Inc.
steve.koski@cascadeenergy.com

Tom Simenc, PE
Project Engineer
Cascade Energy, Inc.
tom.simenc@cascadeenergy.com

Cascade Energy®

Please direct questions to sarah.moore@cascadeenergy.com

Meet Your Colleagues

Training Schedule

Sessions 1 and 2

- Introduction to Refrigeration Systems
- Compressors

Sessions 3 and 4

- Condensers

Sessions 5 and 6

- Evaporators
- Defrost

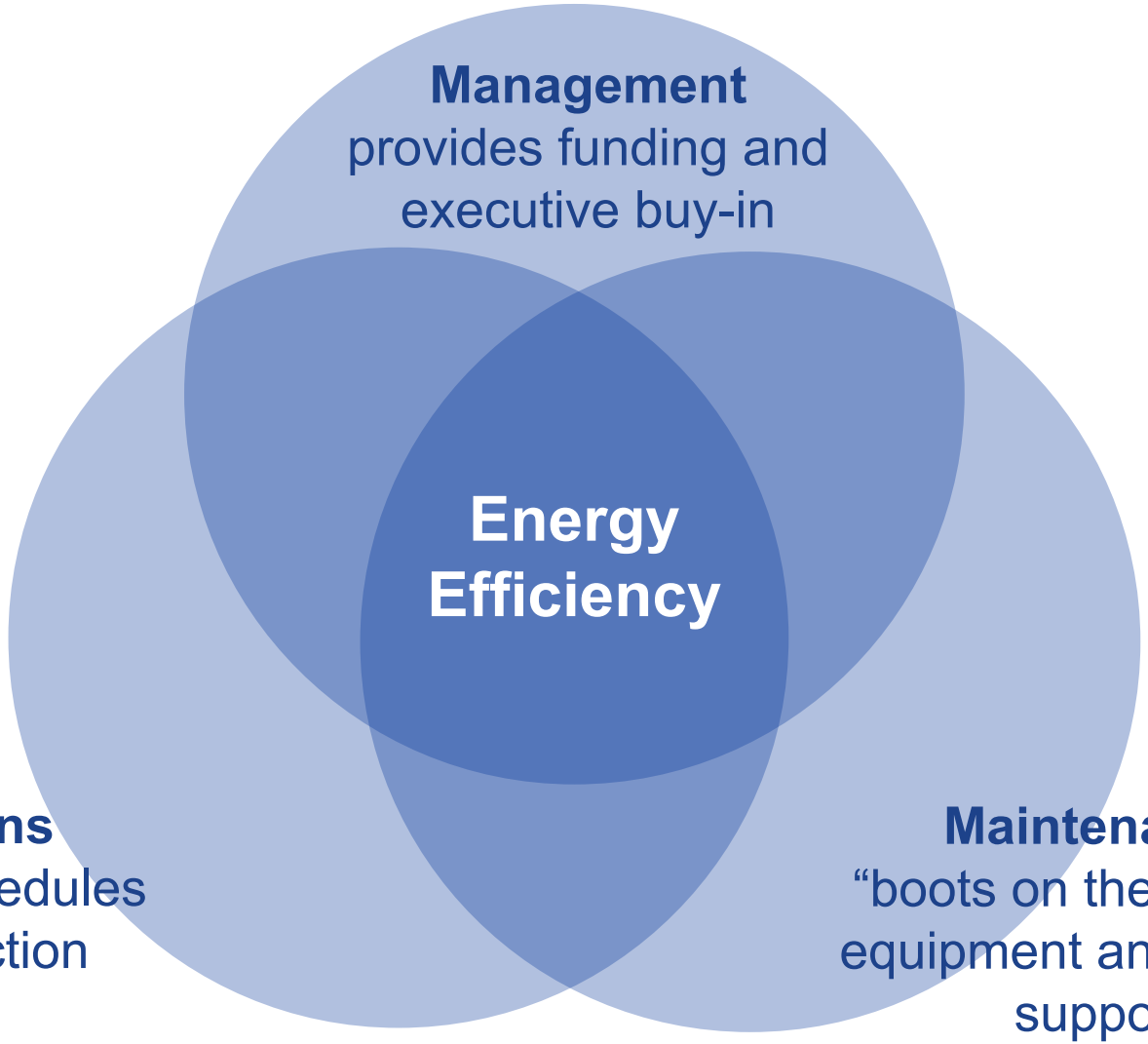
Sessions 7 and 8

- Evaporators/Defrost continued
- Opportunity List Reporting

Today's Agenda – Session 1

- Welcome & intros
- Opportunity tracking
- Energy basics
- Fundamentals of refrigeration
- Compressor basics
- Compressor lift

Everyone Contributes to Energy Efficiency



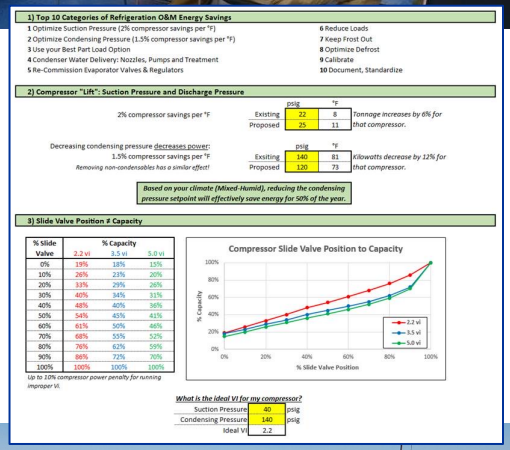
Preconditions for Energy Efficiency Success

Why VINPLT?

- Maximize the energy efficiency of your existing refrigeration system.
- Identify energy saving projects.

VINPLT Objectives

1. Knowledge
2. Tools
3. Action



1) Top 10 Categories of Refrigeration O&M Energy Savings

1 Optimize Suction Pressure (2% compressor savings per °F)
2 Optimize Condensing Pressure (1.5% compressor savings per °F)
3 Use your Best Part Load Option
4 Condenser Water Delivery: Nozzles, Pumps and Treatment
5 Re-Commission Evaporator Valves & Regulators
6 Reduce Loads
7 Keep Frost Out
8 Optimize Defrost
9 Calibrate
10 Document, Standardize

2) Compressor "Lift": Suction Pressure and Discharge Pressure

		psig	°F	
2% compressor savings per °F	Existing	22	8	Tonnage increases by 6% for
	Proposed	25	11	that compressor.

		psig	°F	
Decreasing condensing pressure decreases power: 1.5% compressor savings per °F	Exsiting	140	81	Kilowatts decrease by 12% for
Removing non-condensables has a similar effect!	Proposed	120	73	that compressor.

Based on your climate (Mixed-Humid), reducing the condensing pressure setpoint will effectively save energy for 50% of the year.

3) Slide Valve Position ≠ Capacity

% Slide Valve	% Capacity 2.2 vi	3.5 vi	5.0 vi
0%	19%	18%	15%
10%	26%	23%	20%
20%	33%	29%	26%
30%	40%	34%	31%
40%	48%	40%	36%
50%	54%	45%	41%
60%	61%	50%	46%
70%	68%	55%	52%
80%	76%	62%	59%
90%	86%	72%	70%
100%	100%	100%	100%

Up to 10% compressor power penalty for running improper Vi.

What is the ideal Vi for my compressor?

Suction Pressure	40	psig
Condensing Pressure	140	psig
Ideal Vi	2.2	

Energy Savings

Benefits of Energy Efficiency

- Lower your energy costs
- Reduce maintenance costs
- Increase employee satisfaction
- Improve customer satisfaction
- Decrease greenhouse gas emissions

Let's Get our Priorities Straight …

1. Safety
2. Production
3. Quality
4. Energy

Opportunity Ideas

- Note opportunity ideas as we go
- Use the Opportunities sheet in the Excel Tool
- We'll flesh these out later
  - Type in an idea now, or a place holder

Opportunity Ideas (Brainstorming Area)

Idea place holder

Energy Opportunities

#	Name	Description	Energy Savings kWh	Cost Savings $
1				
2				
3				
4				

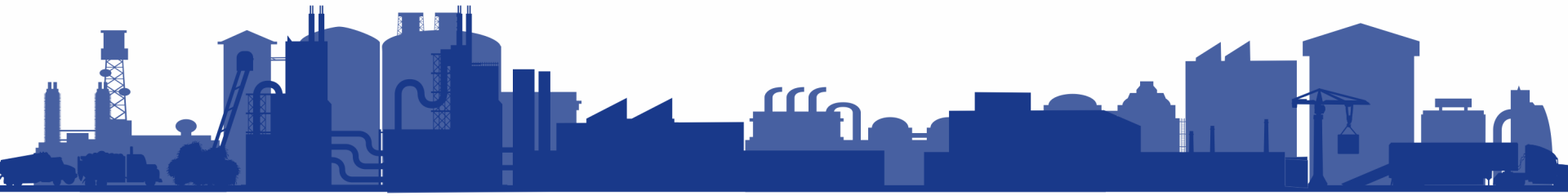
Energy Opportunities

- We'll refine the brainstorming ideas
- Goal: develop several real opportunities for your site
- Report out at final session

Energy Opportunities

#	Name	Description	Energy Savings kWh	Cost Savings $
1	Decrease condensing pressure	Historically the condensing setpoint is 130 psig, but could be lower in cool weather, perhaps 100 psig	350,000	$ 28,000
2				
3				
4				
5				

Introduction to Utility Bills



Why Understand your Utility Bill?

What if the gas station treated you like the electric utility does?

Common Utility-Bill Line Items

CURRENT CHARGES

Electric Charges

RATE PLAN
024 - Large General Svc Tou

METER READING
Electric Meter read on 02/28/13 at 12:00 am
(Next scheduled read date 4/3/13)

METER NUMBER	BILLING PERIOD	DAYS
MULTIPLE	1/31/13 - 2/28/13	28

TIME OF USE PERIOD	KWH	KW DEMAND	KVA DEMAND
On-peak - Non-summer	106,204	732	933
Off-peak	248,966	778	969

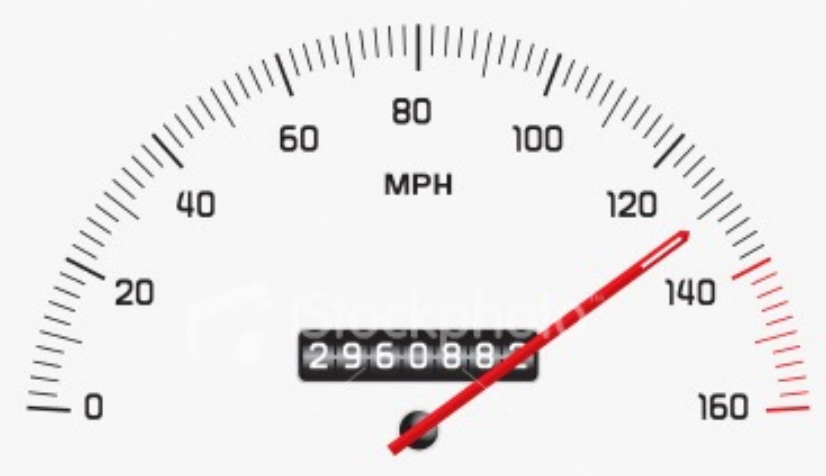
On-Peak Bill Demand is 830 kW which is 80.0% of 1,038 kW from 07/12.
Off-peak Bill Demand of 170 kW is contract demand of 1,000 less On-Peak Demand.
Power factor is 80.00%.

Basic Facilities Charge	1,925.00
On-Peak Non-Summer 106,204 kWh X $ 0.060110	6,383.92
Off-Peak 248,966 kWh X $ 0.046080	11,472.35
On-Peak Non-Summer 830 kW X $ 12.420000	10,308.60
Off-Peak 170 kW X $ 5.380000	914.60
Meterlink Charge	35.00
Overhead Floodlighting	52.91
Overhead Floodlighting	137.97
State Sales Tax at 7.00 %	2,183.67
Total Electric Charges	**$33,414.02**

Energy vs. Power

Demand or power is …

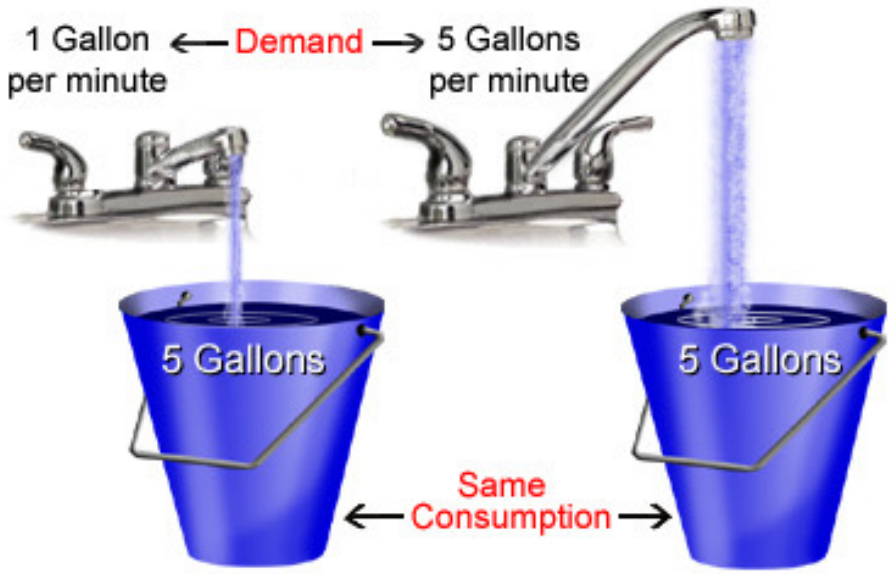
- Measured in Watts, kilowatts, or kW
- Rate of energy use, “flow”
- Like a speedometer or water flow rate



Energy vs. Power

Energy is …

- Measured in kilowatt hours, or kWh
- A total quantity used
- Analogous to miles traveled, or water in a bucket



What is Energy?

- Energy = Power x Time
- kWh = kW x hours

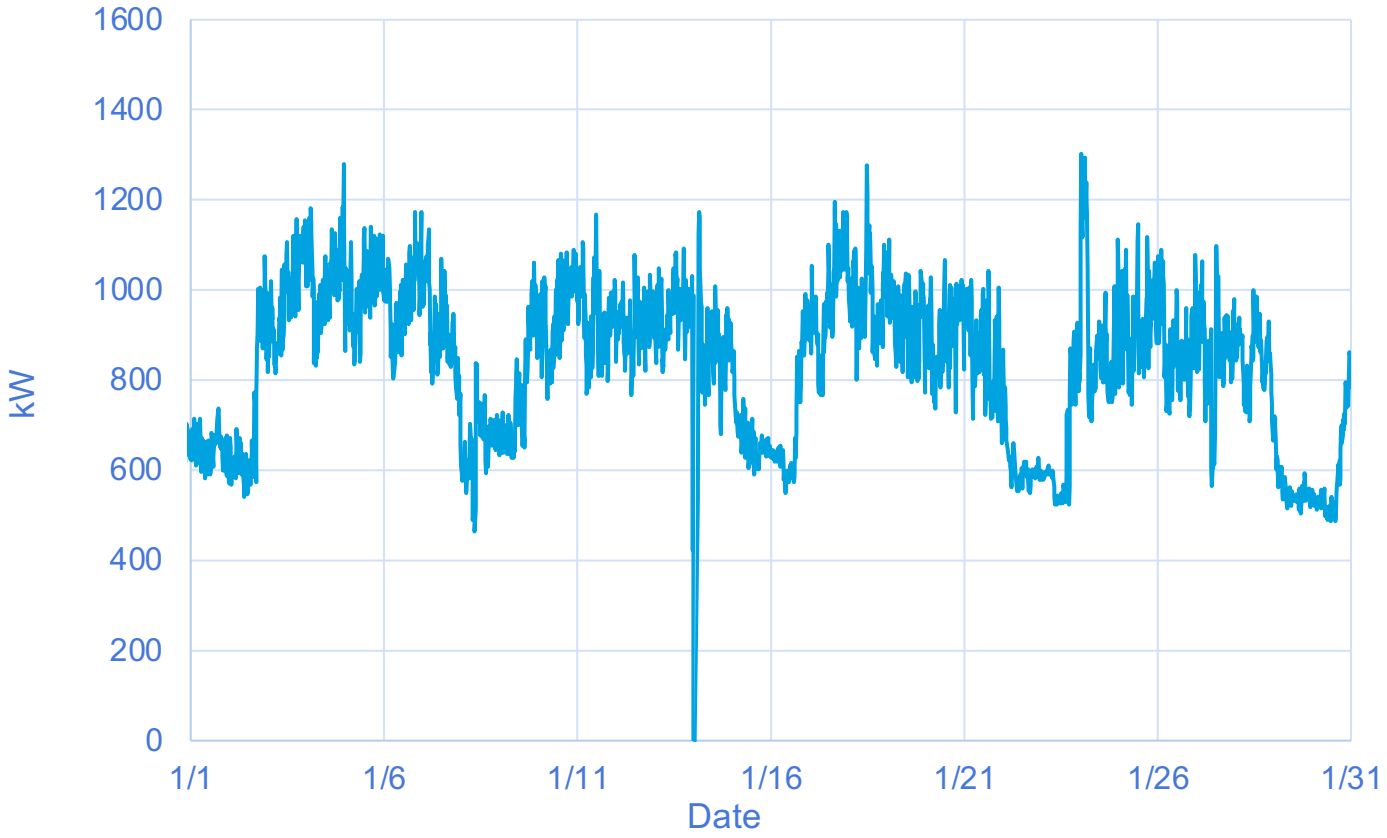
How is Energy Calculated?

Space heater example

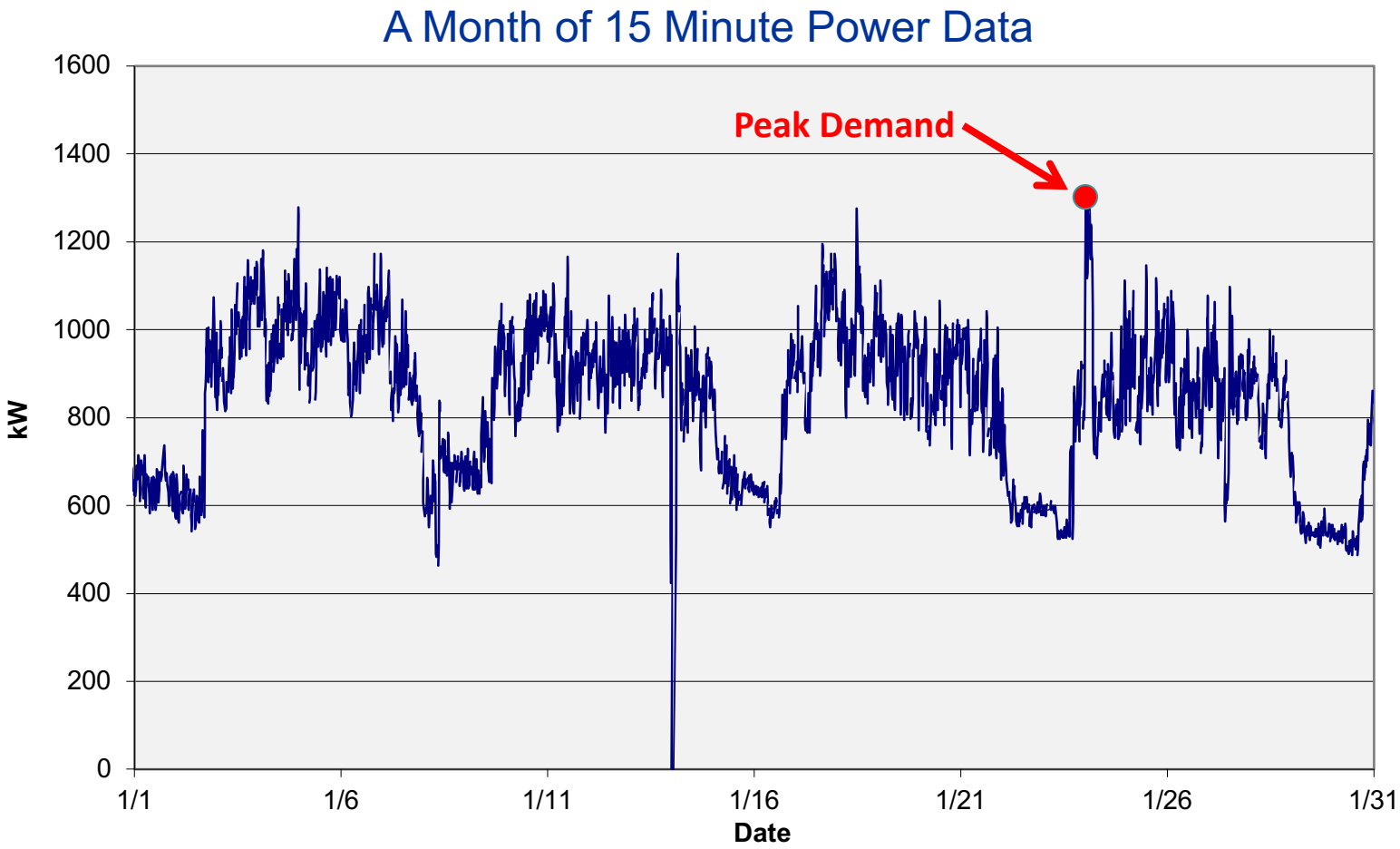
- Power = 1500 Watts or 1.5 kW
- Total Annual Energy = 1.5 kW x 100 hr/yr = 300 kWh/yr
- Cost = 300 kWh/yr x $0.10/kWh = $15/yr

What is Energy?

Energy is the area under the curve



What is Peak Demand?



Simplification: Bulk Rate

Used to simplify cost saving estimates

- 12 month total cost: $1,839,000
- 12 month total energy: 22,982,000 kWh

$1,839,000 / 22,982,000 kWh = $.080/kWh

Bulk Rate: $.080/kWh

Simplified Savings Estimate

Shorthand Cost Savings Estimate

Use about 85% of bulk rate: $.080 x .85 = $.060

If you expected 10,000 kWh savings, this would be about

$600 savings on your bill.

Utility Bill Exercises

ACME ELECTRIC

February, 2015

Account ID	0004 1234-56789 8
Billing Dates	1/27/2015- 2/28/2015 33 days of service
Usage	490,793 kWh

Invoice Number	**123456789**
Current Charges	**$29,760.80**
Due By	**3/15/15**

Meter # ABC123456, Schedule 81 Secondary

Service Descriptions

Basic Charge	560.00
System Charge	593.85
Off-Peak Usage of 195,446 kWh x $0.0335	6,547.44
On-Peak Usage of 295,347 kWh x $0.0504	14,885.49
Demand Charge of 932 kW x $1.9500	1,817.40
Transmission Charge of 932 kW x$0.910	848.12
Distribution Facility Capacity Charge of 1,017 kW x $2.0600	2,095.02
	$27,347.32

Taxes and Adjustments

City Tax (1.5%)	410.21
Public Purpose Charge (3%)	820.42
108 Regulatory Adjustments	29.47
115 Energy Efficiency Funding	1,153.38
	$2,413.48

Period Ending	Avg. Daily Temp °F	Avg. kWh Per Day	Avg. Cost Per Day
This Year	45.6	14,872.5	$901.84
Last Year	46.2	15,020.9	$910.84

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	$27,347.32

How many kWh of energy did they use this billing cycle?

$2,413.48

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	$27,347.32

How much cheaper is their off-peak vs. on-peak energy price?

$2,413.48

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	$27,347.32

The plant runs a 400 hp compressor at full capacity all year, drawing 250 kW. How many kWh energy does this use per day?

This Year	45.6	14,872.5	$901.84
Last Year	46.2	15,020.9	$910.84

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	$27,347.32

What % of the demand charge does the compressor make up?

$2,413.48

Period Ending	Avg. Daily Temp °F	Avg. kWh Per Day	Avg. Cost Per Day
This Year	45.6	14,872.5	$901.84
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	$27,347.32

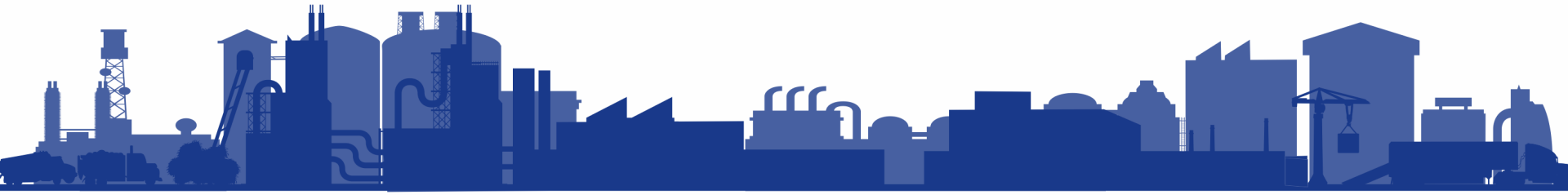
Taxes and Adjustments

City Tax (1.5%)	410.21
	$2,413.48

What is the bulk rate energy price for this bill?

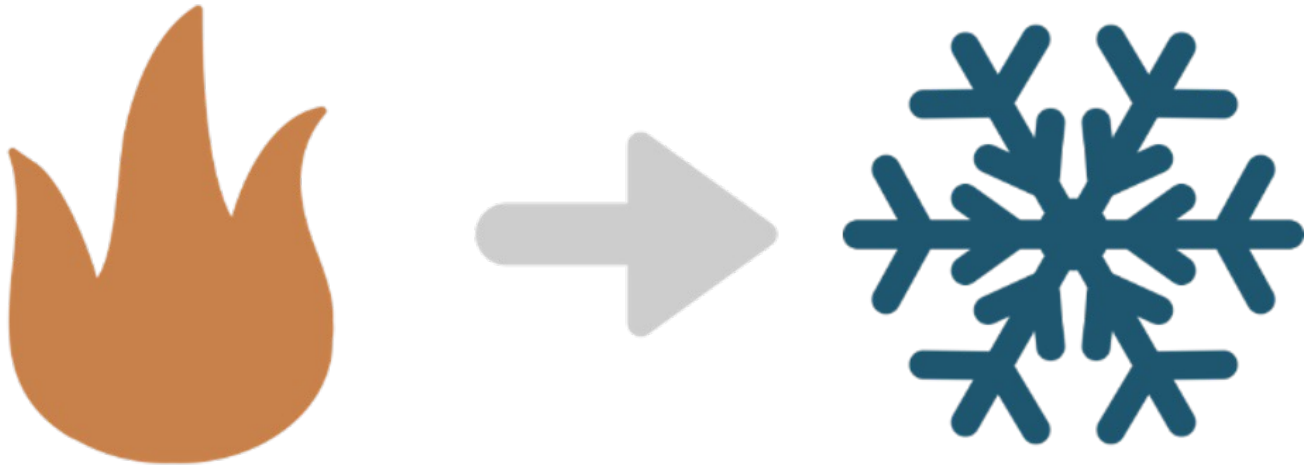
Period Ending	Avg. Daily Temp °F	Avg. kWh Per Day	Avg. Cost Per Day
This Year	45.6	14,872.5	$901.84
Last Year	46.2	15,020.9	$910.84

Introduction to Refrigeration Systems and Compressors



Refrigeration Basics: Two Key Principles

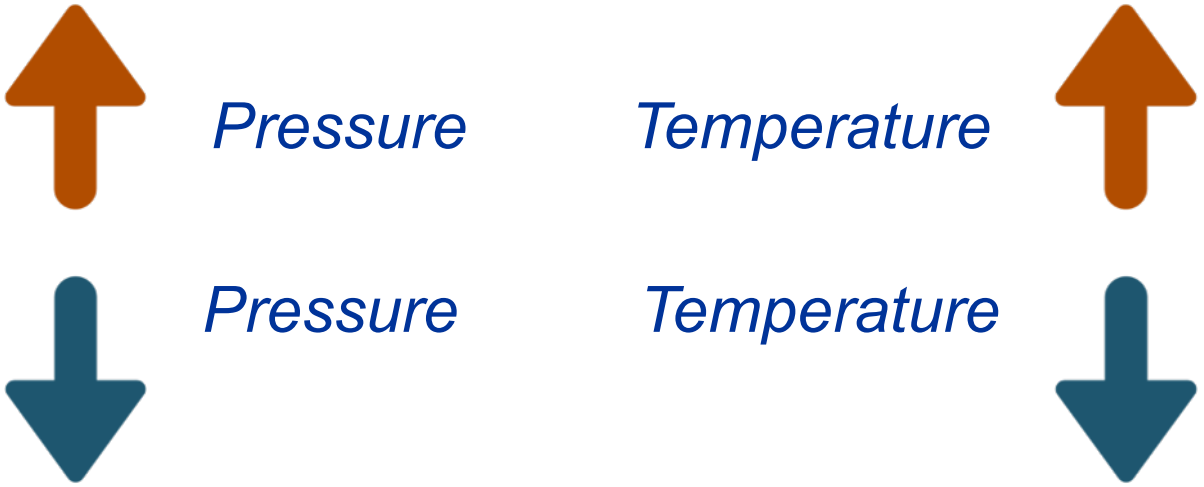
No.1: Heat flows from hot to cold



Refrigeration Basics: Two Key Principles

No.2: For a saturated refrigerant

(mix of liquid and gas)



Four Major Processes

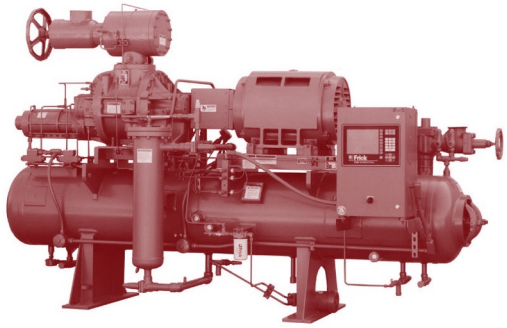
Liquid Gas (Vapor)

Hot,
High Pressure

Condenser

Expansion Valve

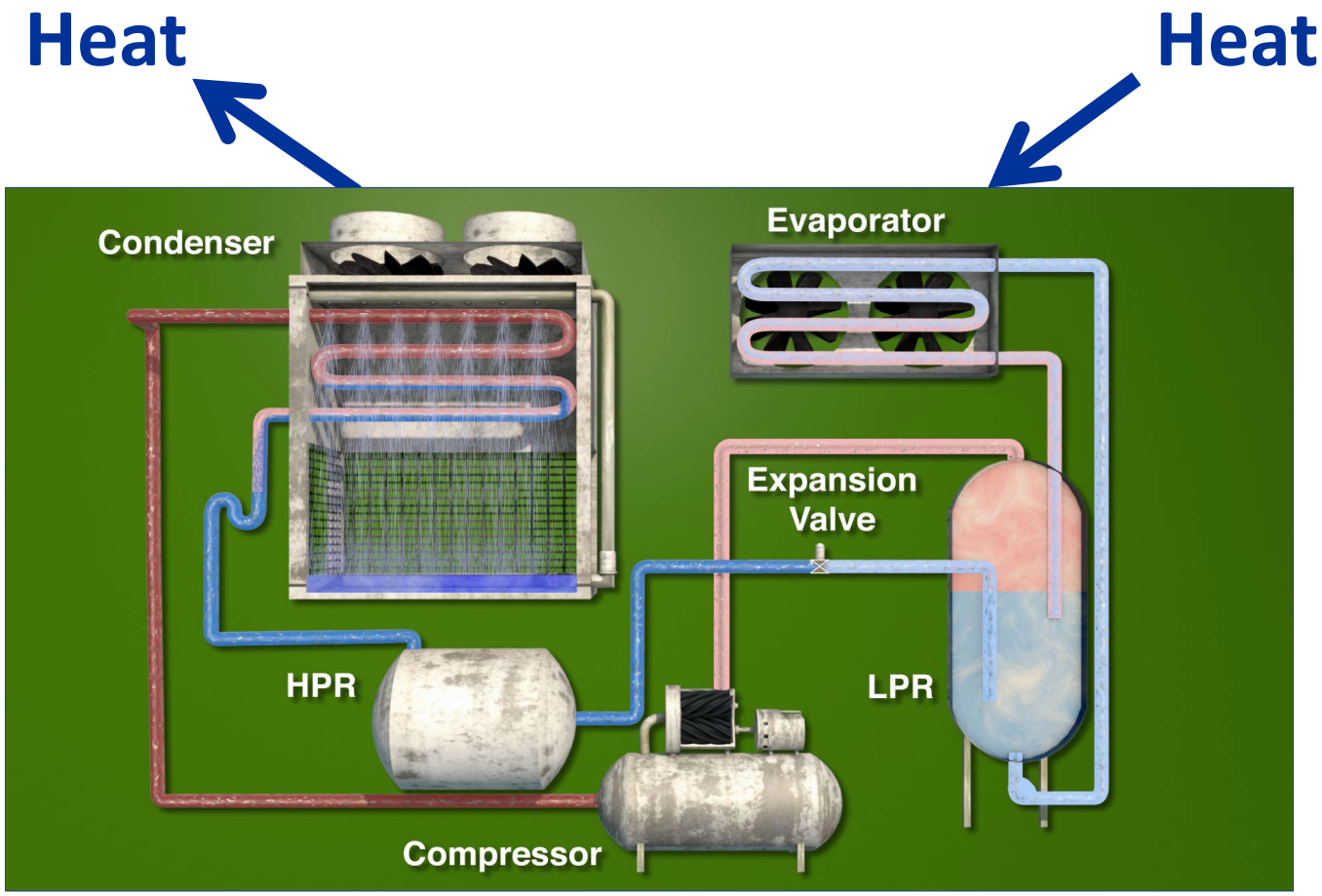
Compressor



Evaporator

Cold, Low Pressure

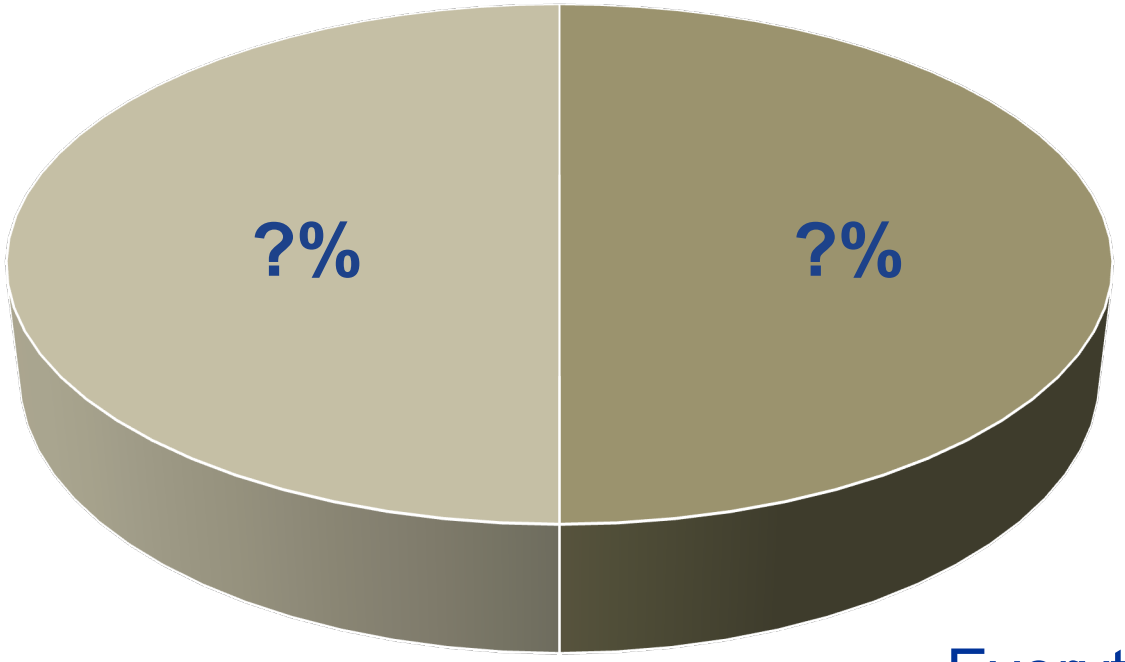
Refrigeration Cycle



What percent energy is used by each system component?

Activity: Refrigeration vs. Total-plant Energy

Refrigeration



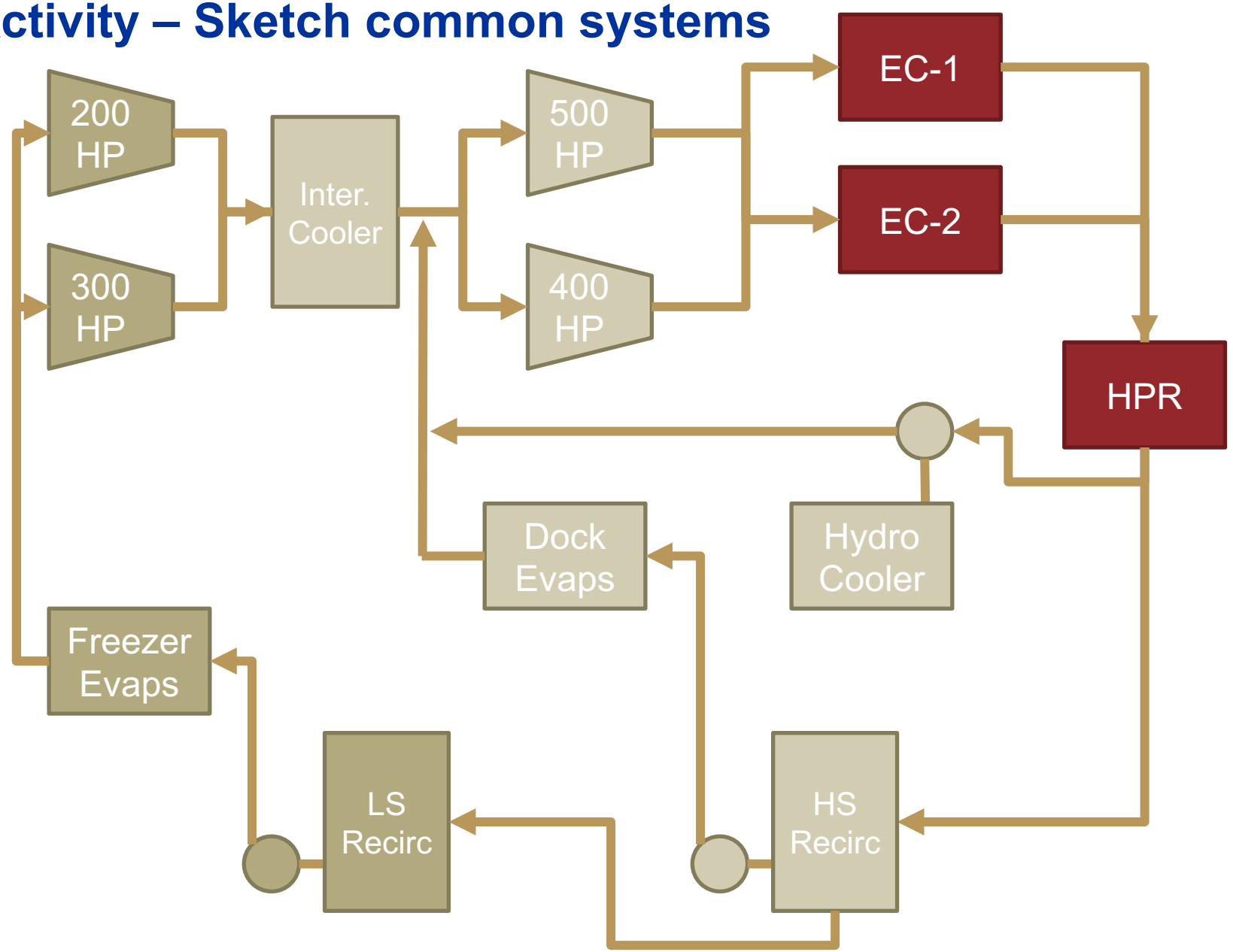
Everything else

Activity: Annual Energy Cost

What is the annual energy cost to run a 250 hp compressor fully loaded 24/7?

1. $10,000/year
2. $25,000/year
3. $40,000/year
4. $90,000/year

Activity – Sketch common systems



Sketch an ammonia system

Assignment – Sketch Your System

1. Suction vessels
2. Loads
3. Compressors
4. Condensers
5. Liquid path

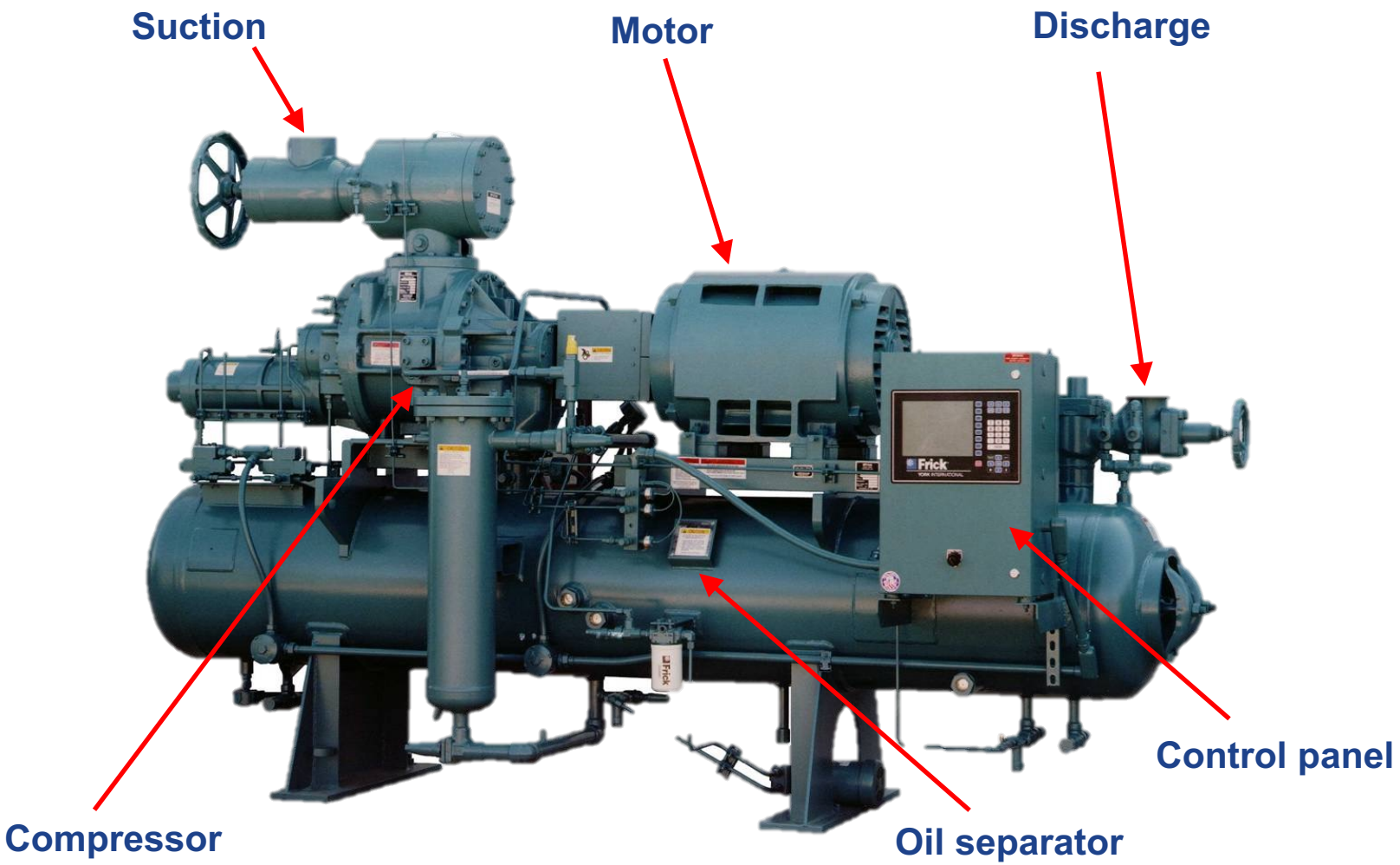
Email a picture, screen snap, etc. to
steve.koski@cascadeenergy.com

Compressors

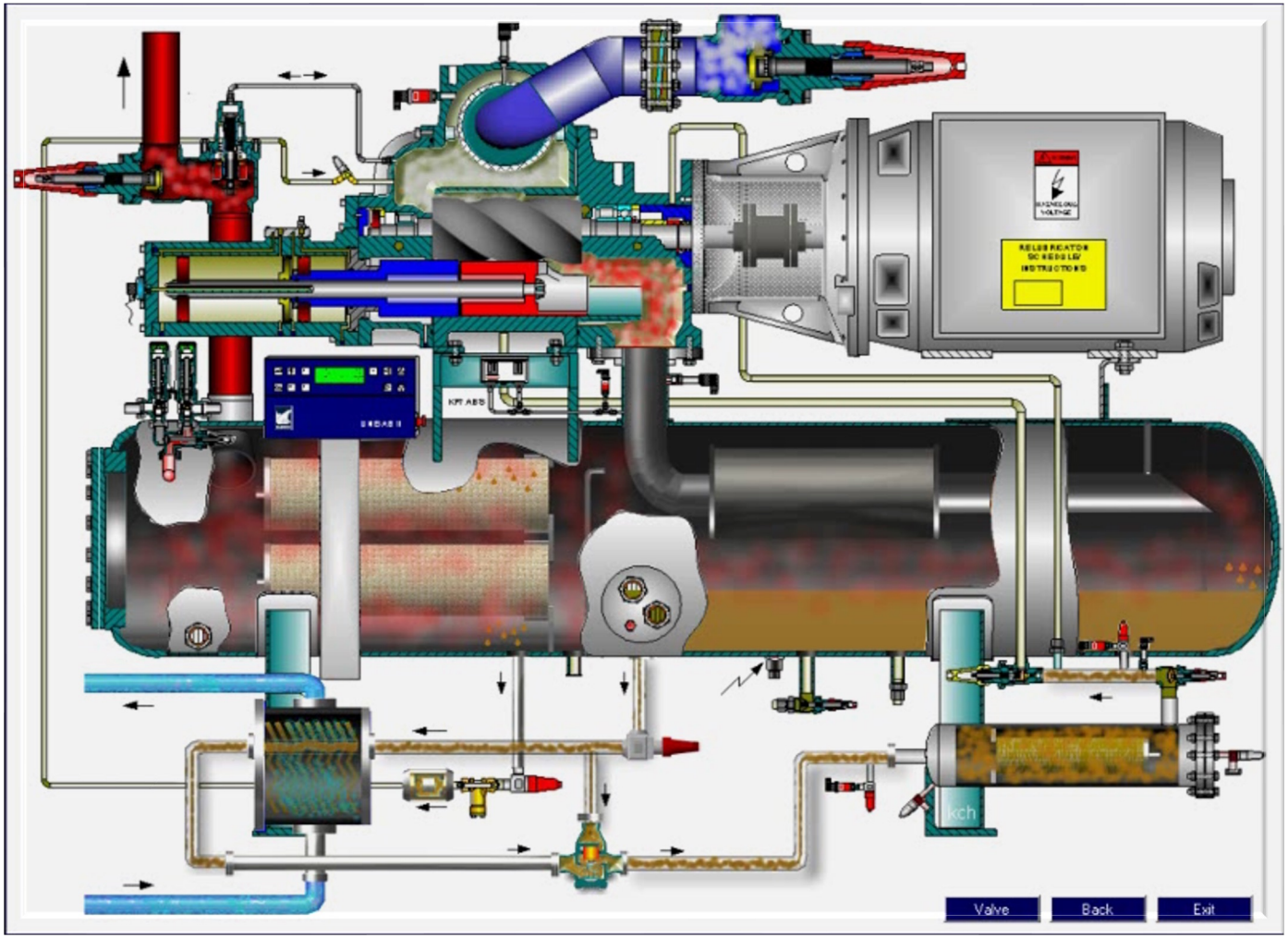
Compressor Basics

Type	Max HP	Pres. Ratio	Typical Type		
			Booster	High	Single
Reciprocating	300	8:1	X	X	
Rotary Screw	1,500	20:1	X	X	X
Rotary Vane	400	5:1	X		

Screw Compressor Components



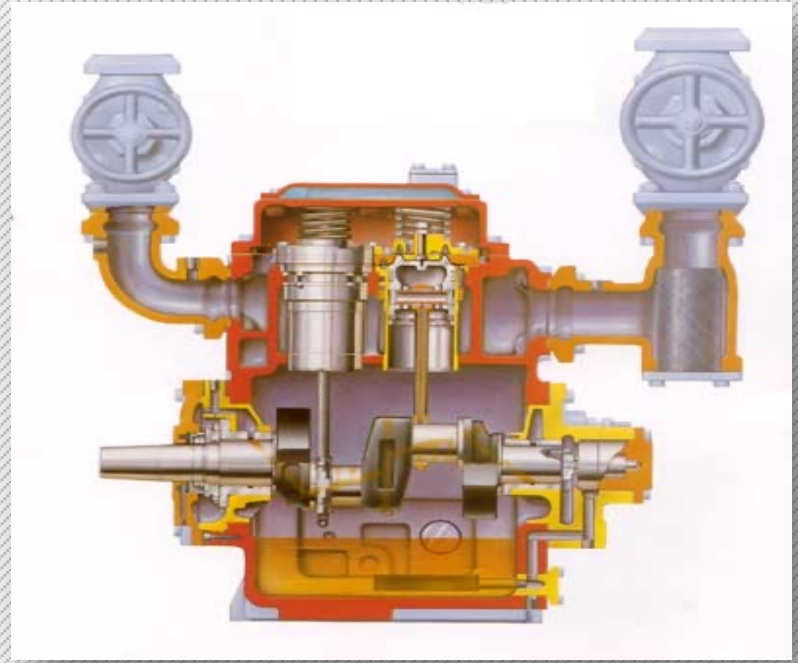
Twin Screw Compressor



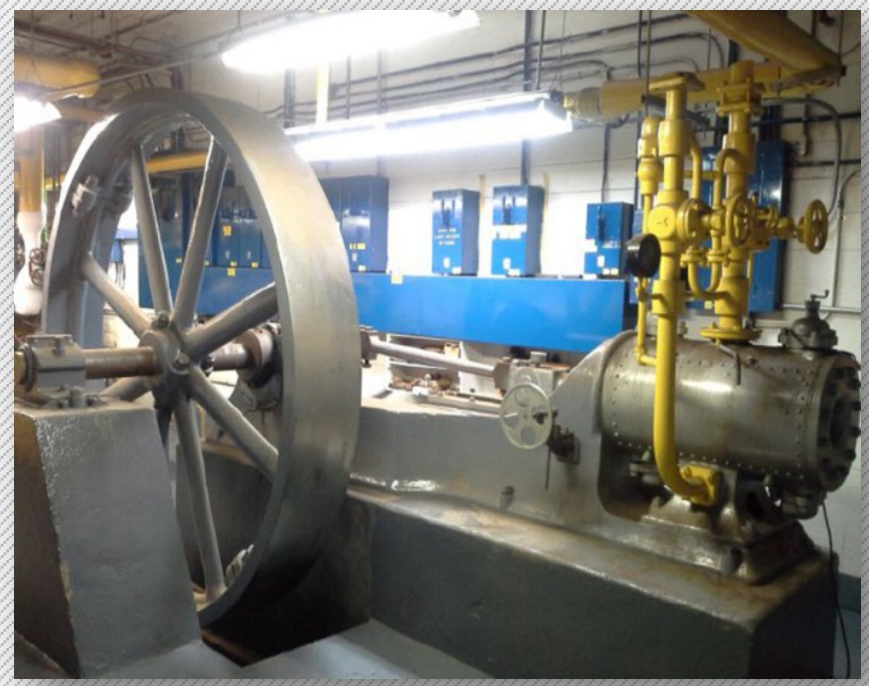
Screw Compressors: Key Energy Issues

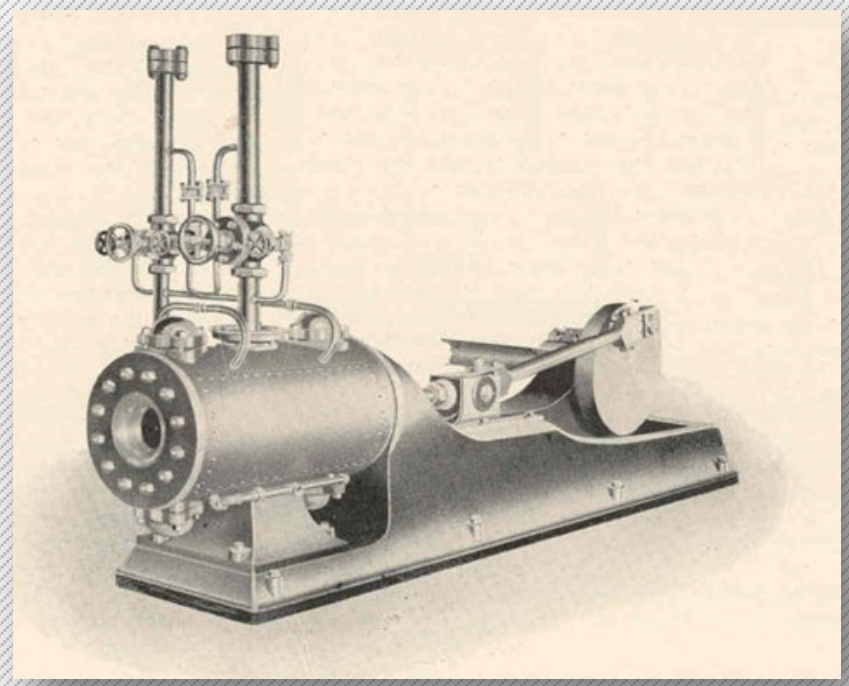
1. Lift (suction and discharge)
2. Capacity control
3. Volume ratio
4. Cooling
5. Economizing

Reciprocating Compressors



25-Ton "Recip" from the Early 1900's





What's the Ideal?

- Minimal Lift (max suction, min discharge)
- Slide Valve Properly Functioning
- Minimal Inefficient Unloading
- Correct Volume Ratio
- Controls Telling the Truth

What's the Largest Factor Driving Compressor Energy Use?

Reduce Lift = Reduce Compressor Work

- **Raise Suction:** More Capacity (TR)
- **Lower Discharge:** Less Power (BHP)

Compressor Work = BHP/TR

Rules of Thumb

2% compressor savings per °F of increase in **suction** temperature

1.5% compressor savings per °F of decrease in **condensing** temperature

(Must work in saturated temperature, not pressure.)

Homework

1. Utility bill questions
2. Refrigeration system questions
3. Sketch your refrigeration system

Email to: steve.koski@cascadeenergy.com

Go to kahoot.it

Kahoot!

Join from your phone