Energy Reduction and Sustainability Through Total Energy Management (TEM) Program

Plastic Shipping Container Institute

PSCI 2011
Monterey, CA

HUSKY
Keeping our customers in the lead

Husky Injection Molding Systems

- Founded in 1950, Husky is world's largest Injection Molding equipment supplier
- A technology and environmental leader with history of innovation
- 3300 employees worldwide
- Bought by Onex, a leading North American private equity firm, in 2006

Manufacturing Advisory Services

Provide operational consulting, design and project management services to support our existing and prospective customers

1. Consulting and Advisory Services
    - Comprehensive plant & operational assessment
    - Operational performance improvement & implementation
    - Facility planning and optimization
    - Total Energy Management Program
2. Building and Infrastructure Planning and Design
3. Project Management and Turnkey services

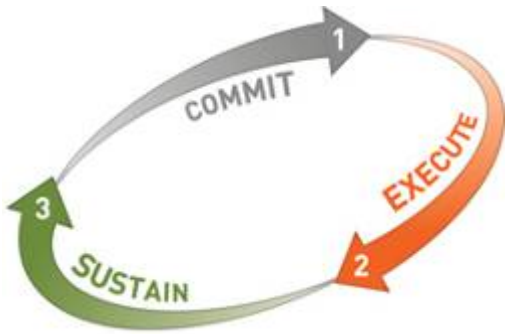
Two Approaches to Reduce Energy Cost

1. Reduce the cost per unit of energy ($/KWh) through negotiation and risk mitigation
    - Numerous consulting firms provide “Negotiation and risk mitigation” services
    - Alternative Energy generation
2. Reduce the amount of energy used (KW/lb):
    - Certain utility companies offer programs that provide molders rebates towards the purchase and installation of qualified equipment that improves their facility’s energy efficiency

These two approaches alone without an “Energy Management Program” can not be sustainable

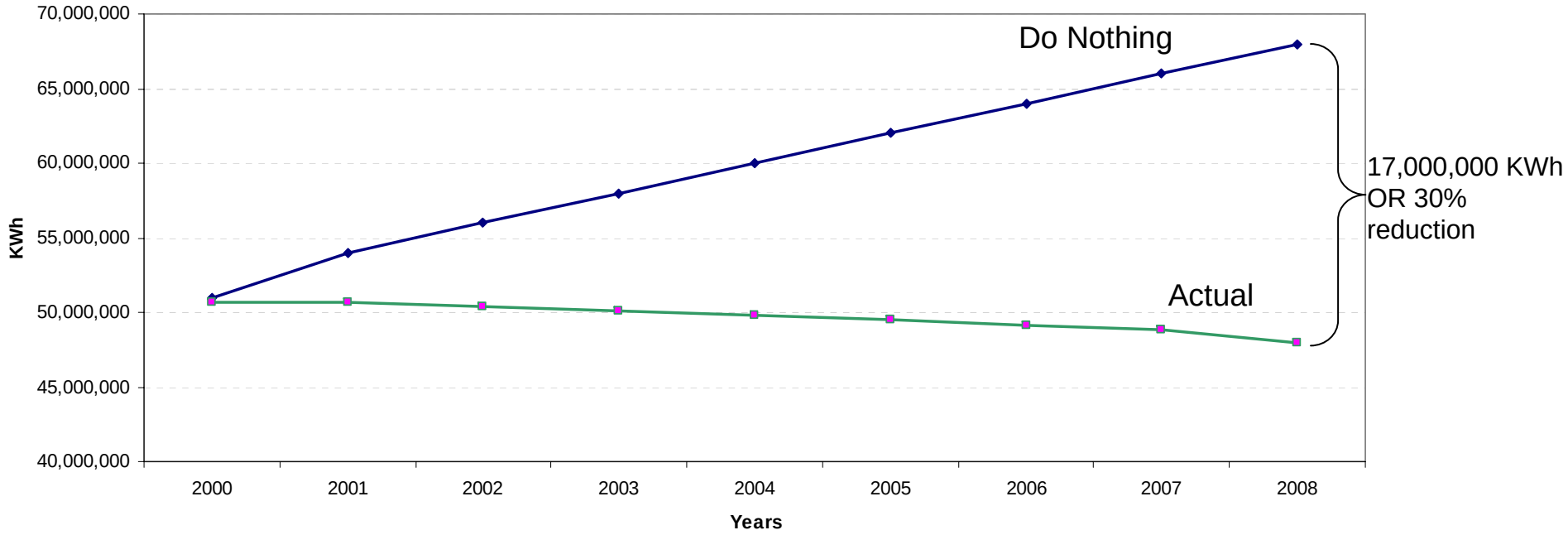
Total Energy Management

- Phase 1: Plant energy audits
- Phase 2: Implementation of policies and procedures to measure, set targets, and monitor energy related KPIs to continuously reduce and sustain energy consumption

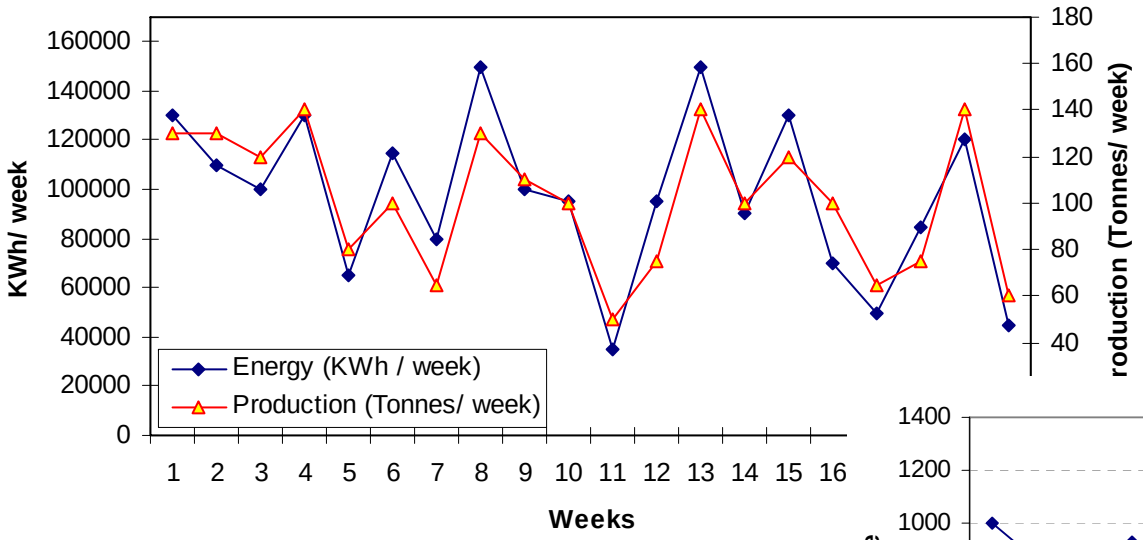


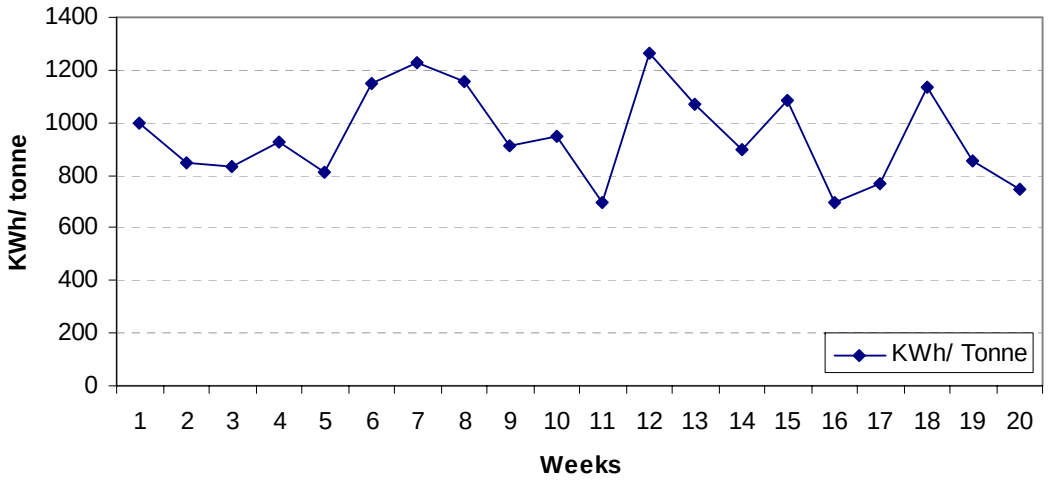
TEM Case Study - Husky

- A total of $2.7M saved since 2000
  - 30% reduction in KWh consumption (17,000,000 KWh or 1,800 metric tons of CO_2)



Common Energy KPIs





Although KWh/ Lb is a widely acceptable energy KPI, it fails to show if the energy consumption is optimized

Total Energy Management Program

1 - Understand your “Base” and “Process” loads

2 - Create site energy profile

3 - Understand when and how much energy is used

4 - Identify, Quantify, and Prioritize opportunities

5 - Eliminate waste and reduce consumption through

- Implementation of selected energy reduction projects

Phase 1: Energy audit & reduction strategy

6 - Monitoring and Targeting

- Understand Where energy is used

7 - Data analysis and reporting energy KPIs

- (Energy dashboard) by department

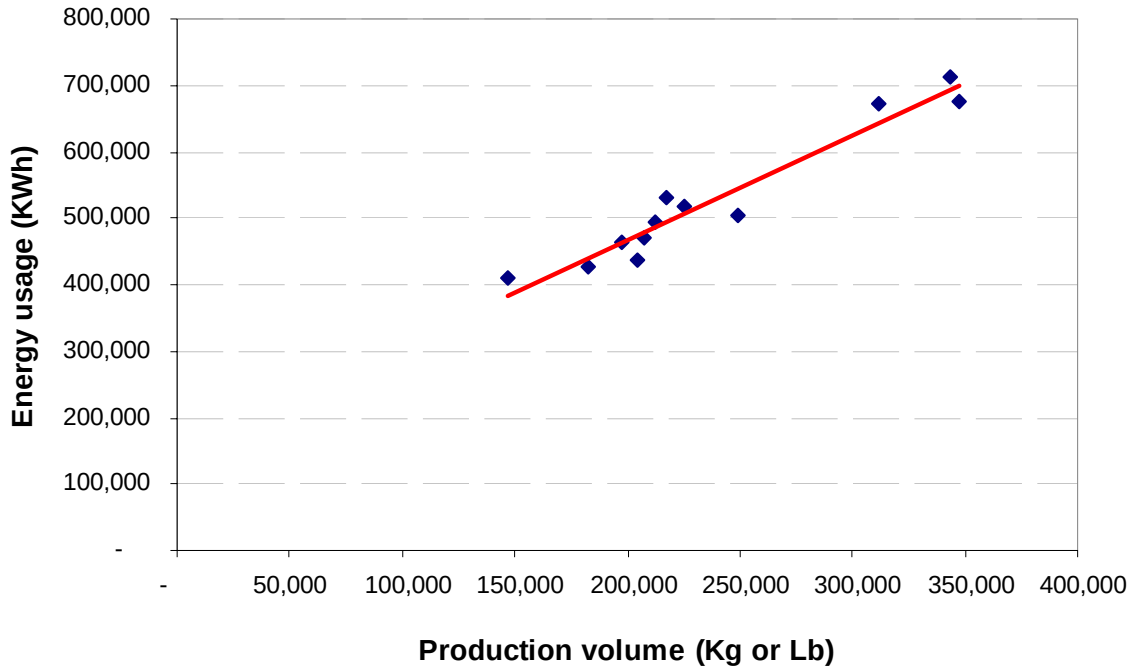
8 - Conduct internal and external benchmarking

9 - Repeat the steps – Continuous improvement

Phase 2: Sustainability Through M&T

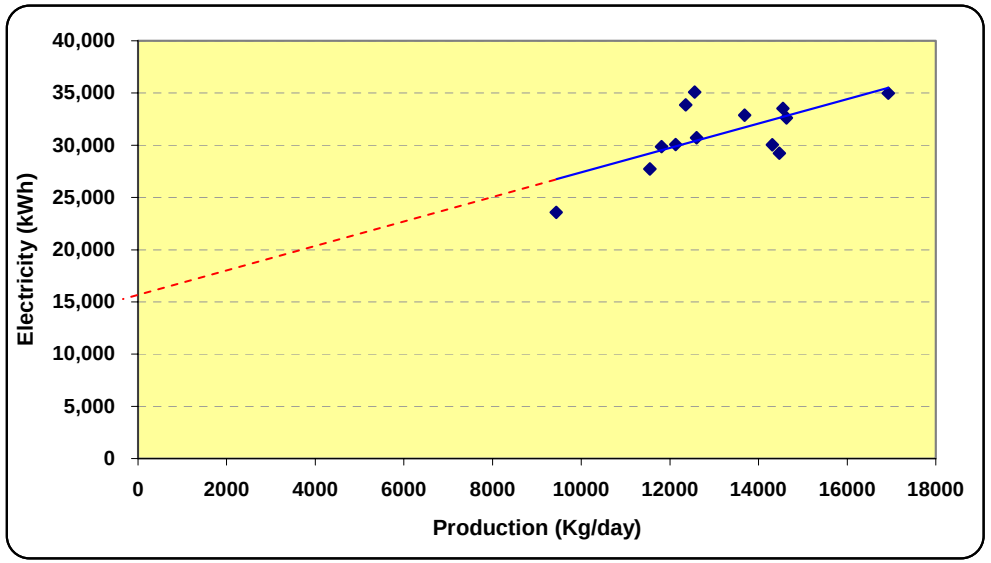
1 - Identify Base & Process Loads

- Energy has variable and fixed costs and both can be affected
- Performance Characteristic Line (PCL) provides an operational signature of the plant that is closely related to the way the plant management runs the plant



Linear Regression Analysis Tool

Month	Date	Electricity kWh	Production Kg/day	Include
1	1-Jan-09	29,230	14,473	Yes
2	1-Feb-09	23,585	9,434	Yes
3	1-Mar-09	34,991	16,931	Yes
4	1-Apr-09	32,629	14,632	Yes
5	1-May-09	33,531	14,552	Yes
6	1-Jun-09	30,726	12,602	Yes
7	1-Jul-09	35,097	12,557	Yes
8	1-Aug-09	33,864	12,355	Yes
9	1-Sep-09	29,852	11,810	Yes
10	1-Oct-09	32,869	13,684	Yes
11	1-Nov-09	30,070	12,130	Yes
12	1-Dec-09	27,722	11,551	Yes
13	1-Jan-10	30,052	14,310	Yes



Edit Historical Data | Ex/Include Point

Degree Day Parameters
Cooling Balance Point Temp 18
Heating Balance Point Temp 18

Duration
Months 13

Starting
Date 1-Jan-09
or
Sequence # 1

X-Y Graph | Line Graph

Independent Variable is: Production

Regression Model

Dependent Variable . . . Electricity
Independent Variable . Production

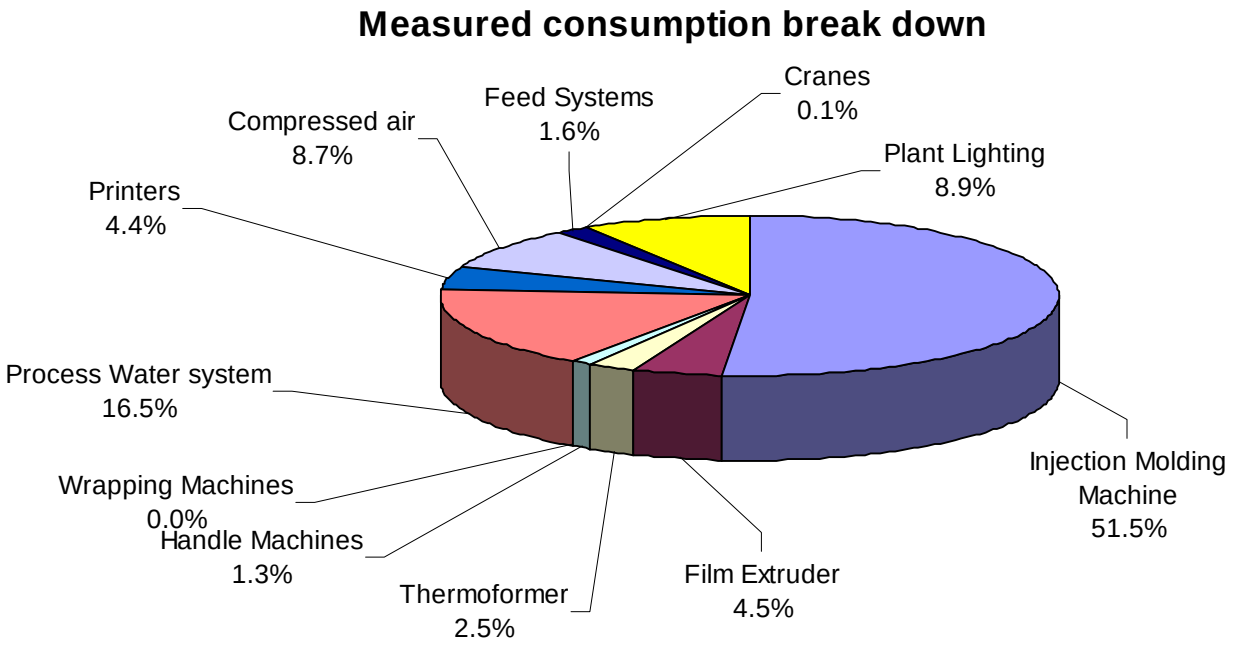
Slope.	1.169	kWh/Kg
Intercept.	15,706	kWh/day
R^2	0.454	

- Overall plant process load (1.16 KWh/Kg) is within ballpark.
- Overall plant base load (15,706 Kwh/ day) is approx. 51% of the total average load. This seems to be very high and typically an indication of electrical usage in the plant which may not be related to production. (low hanging fruit)
- Correlation coefficient (R^2) which indicates linearity between energy usage and production volume is very low (0.454). This typically indicates poor control of electrical usage.

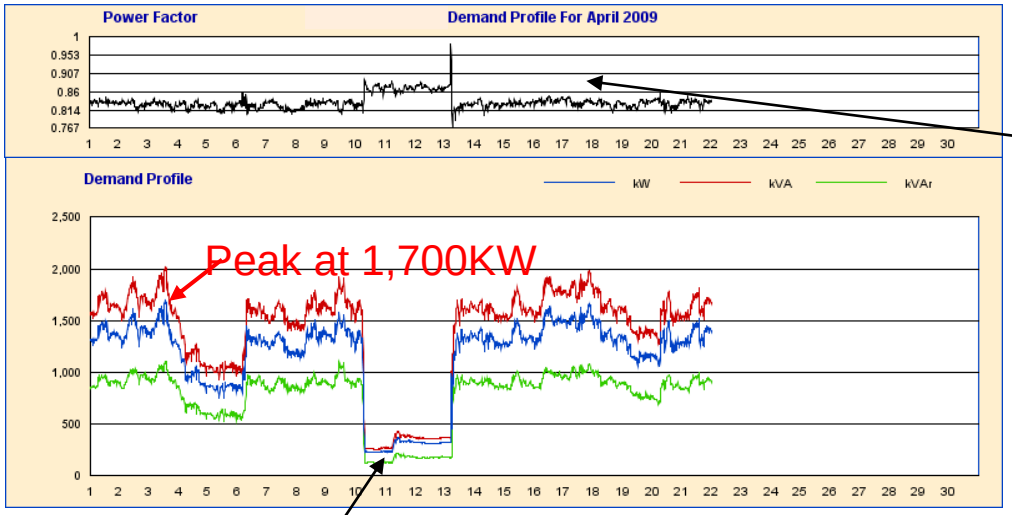
Preliminary Analysis – Case Study

2- Site Energy Profile

- Create Site energy profile through actual on-site measurements

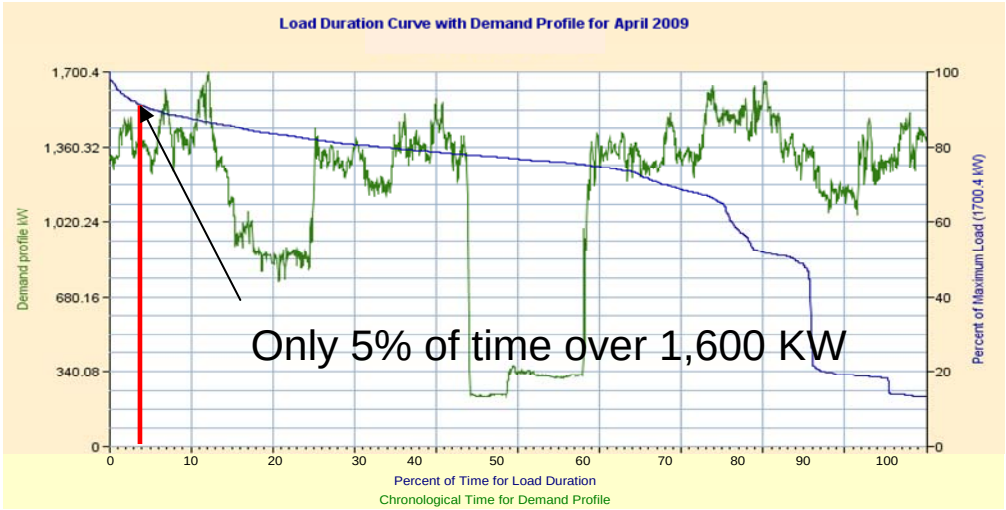


3 – Understand “When” and “How much”



Average PF of 0.84
Goal is to be above 0.9

Base load at 300KW
(25% of average load)
Goal is to be @ 10% of average load



Total Energy Management Program

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2 - Create site energy profile

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Phase 1: Energy audit & reduction strategy

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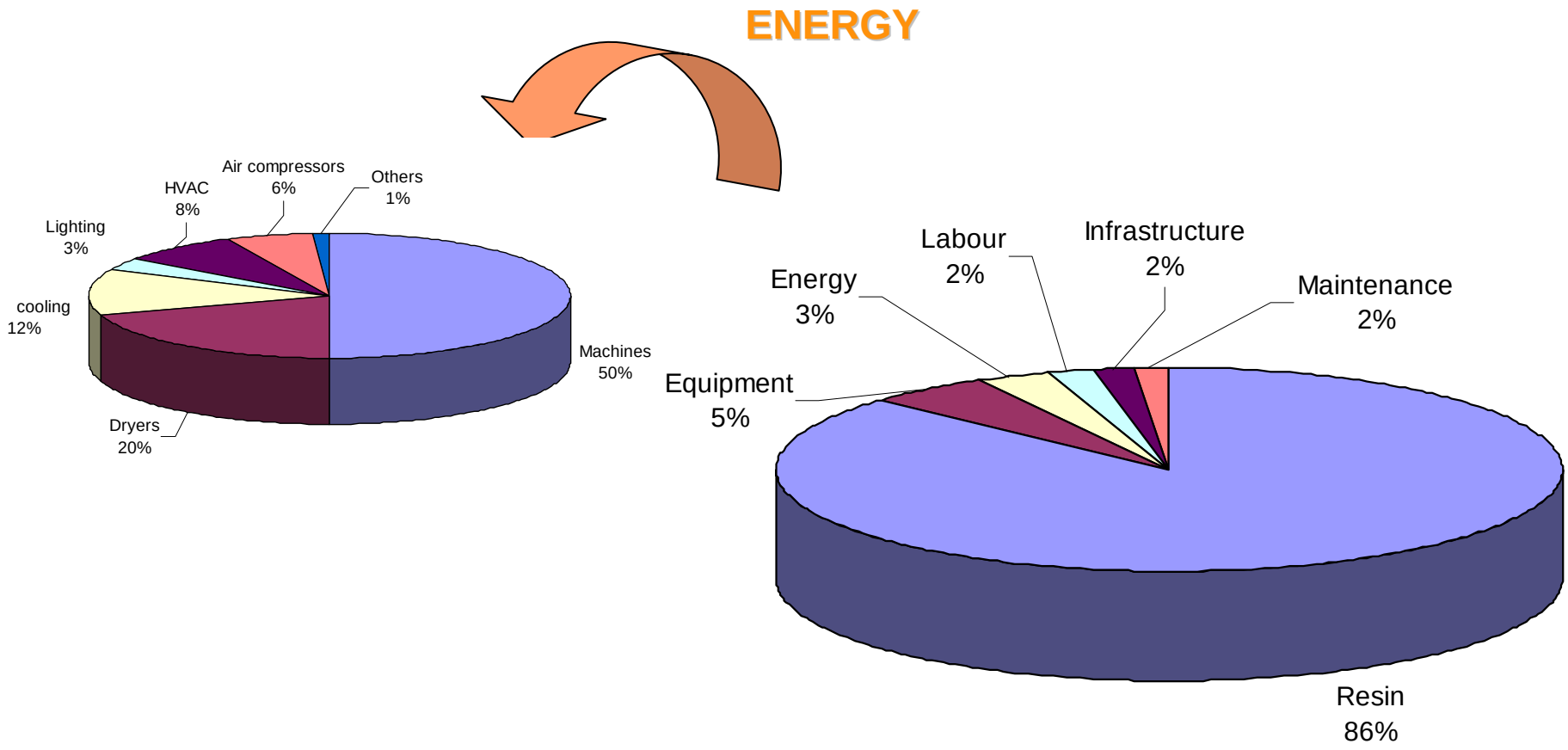
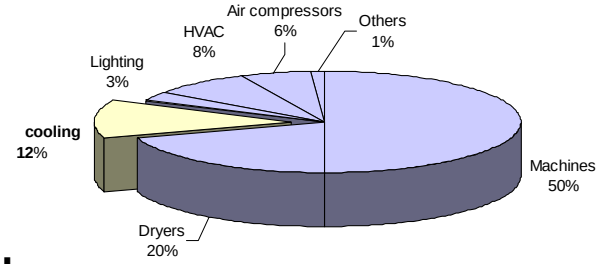
Phase 2: Sustainability Through M&T

Typical Part Cost and Energy Break Down



Machine Cooling



Cooling Towers

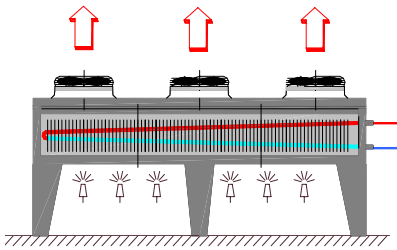
- Contamination in water
- Scale and oxidation in pipes
- High water and chemical consumption
- Cost of water disposal

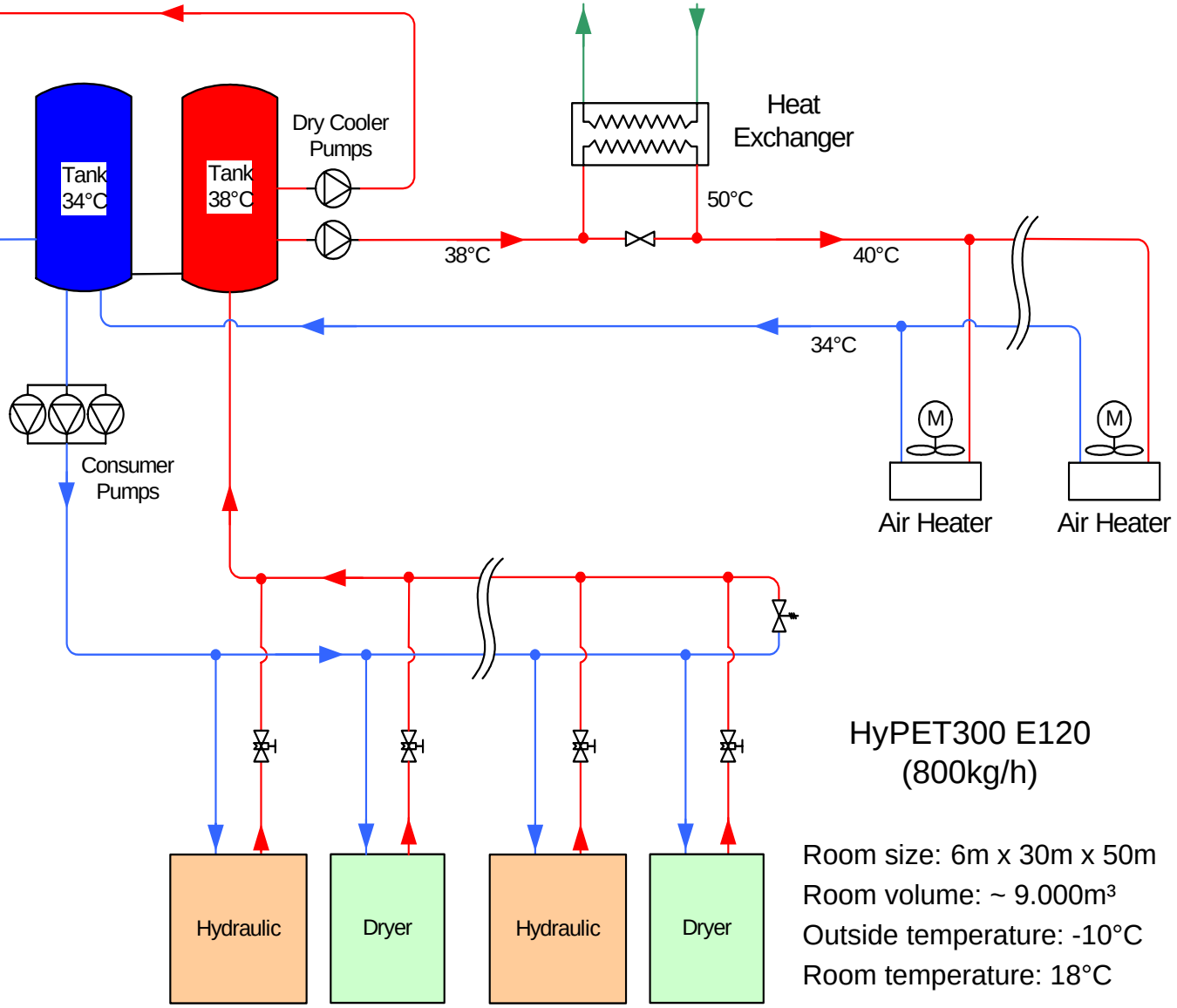
Dry Coolers

- Clean water to process
- No scale or corrosion
- Minimal maintenance
- Reduced energy consumption
- No water disposal
- No water treatment chemical consumption

Adiabatic Dry Coolers

- Ambient air (dry bulb) is used to cool the water
- Clean water to process
- No scale or corrosion, minimal maintenance
- Reduced energy consumption
- No water disposal
- No water treatment chemical consumption
- Adiabatic cooling – maintains ability to deliver cool water even in HOT ambient conditions with minimal water consumption
- DC Variable Speed fans – extremely low energy consumption
- Less than 20 times less water than tower





HyPET300 E120
(800kg/h)

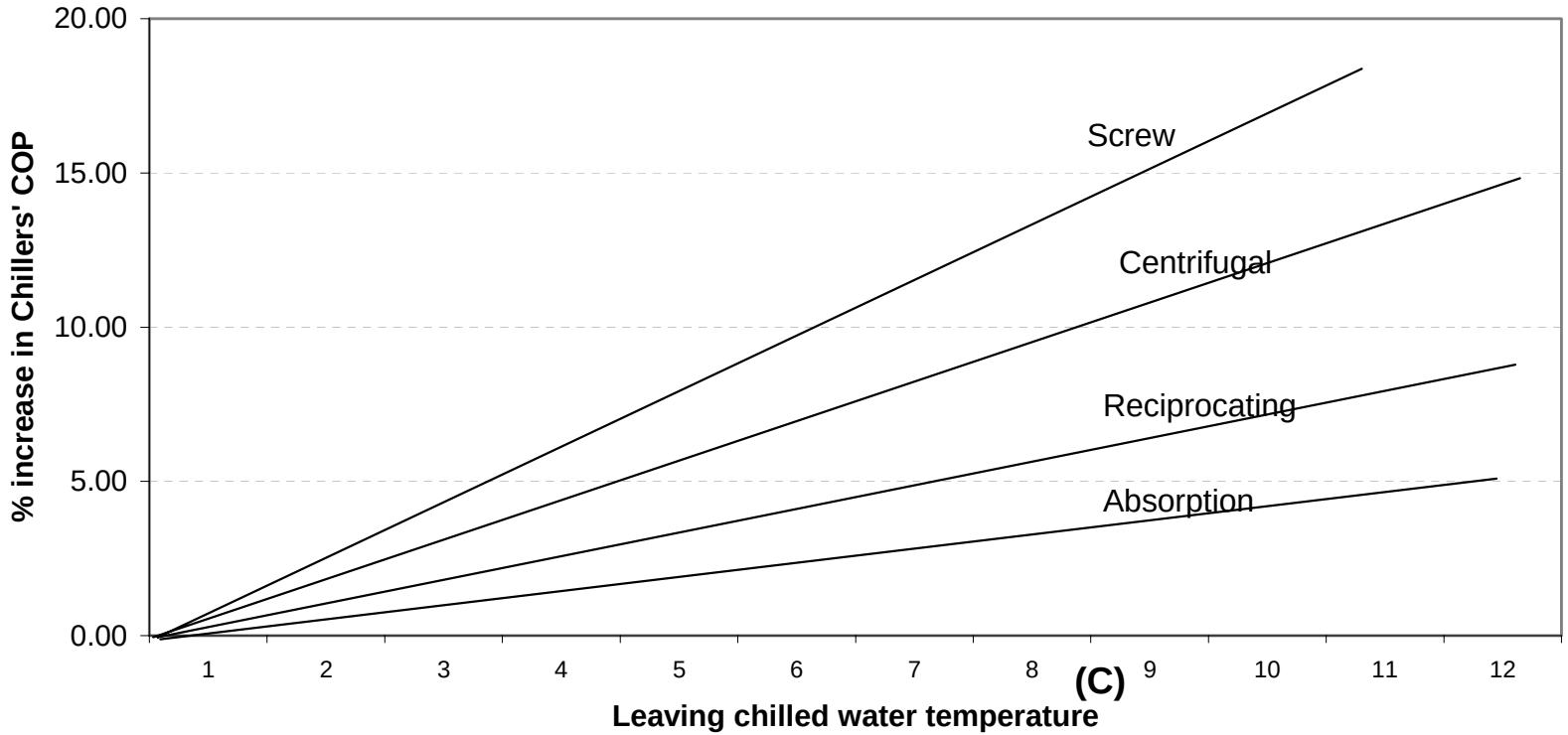
Room size: 6m x 30m x 50m
Room volume: ~ 9.000m³
Outside temperature: -10°C
Room temperature: 18°C

Energy Saving by Heat Recovery

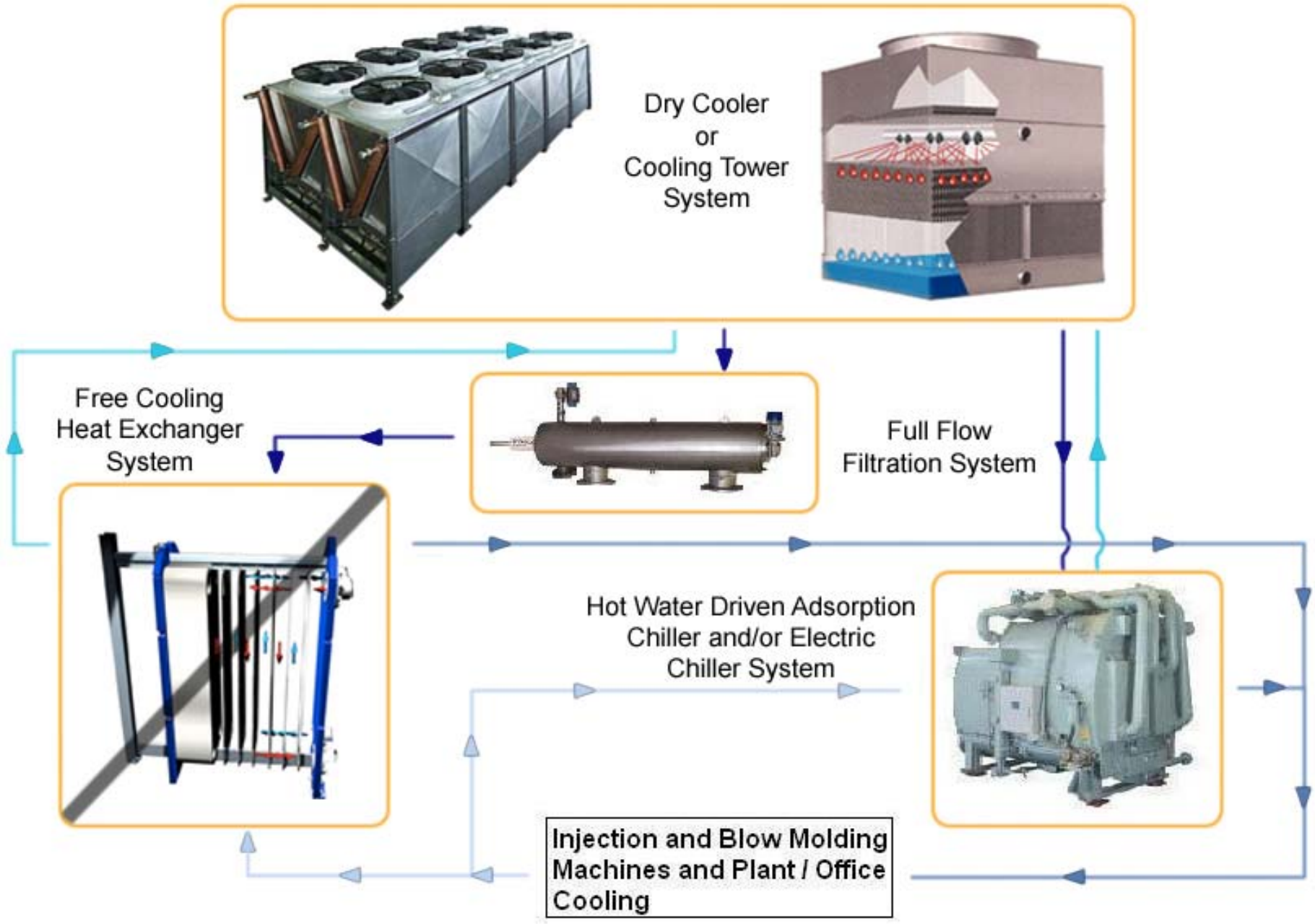
1- Water Temperature:

- Typically every 1^{oF} increase in leaving water temperature results to 2% to 3% reduction in energy consumption

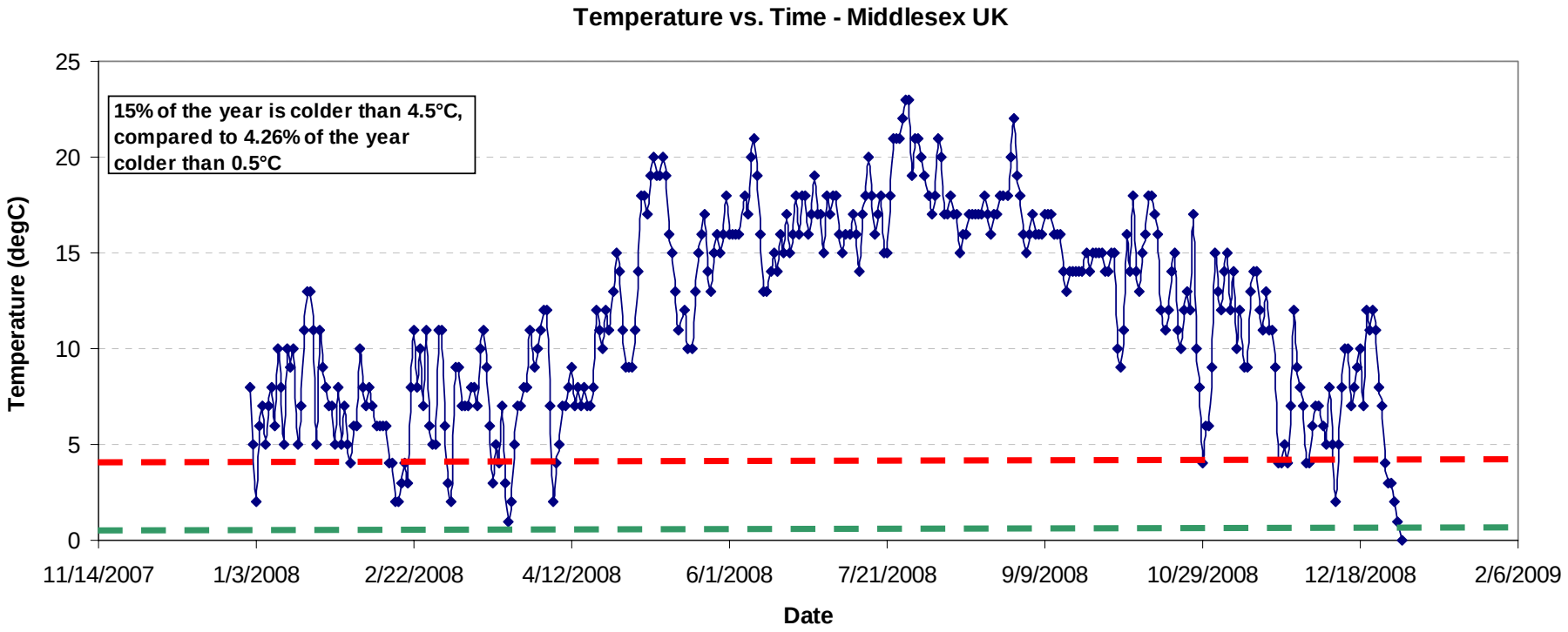
2- Technology



Mold Cooling



Free Cooling



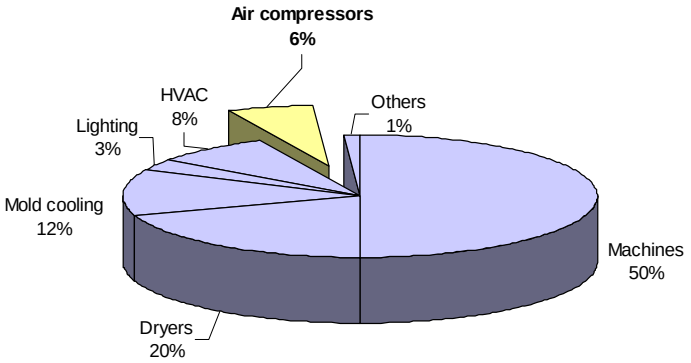
Effect of 43F vs. 50F chilled water temp. on free cooling:

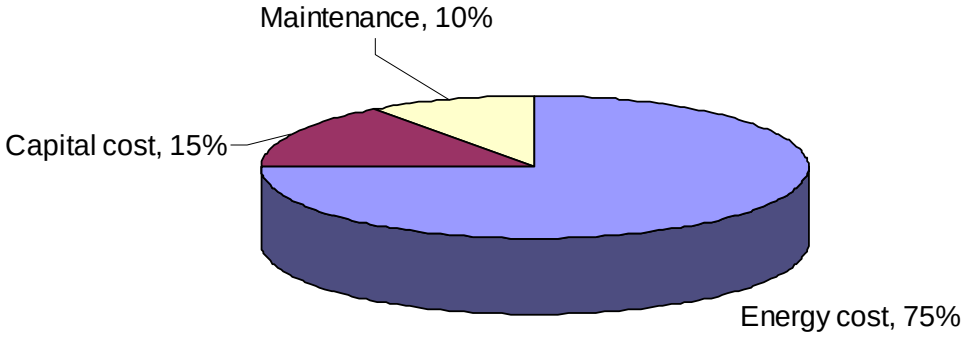
- 15% of the year with 50ºF (including dry cooler and heat exchanger approach)
- 4% of the year with 43ºF (including dry cooler and heat exchanger approach)

- Estimated savings around € 40,000/ year Vs. € 11,000/ year

Free Cooling

- Compressors are only 5-15% efficient
- Compressed air is expensive energy
  - At point of use compressed air costs 10 times more than equivalent quantity of electrical power
- Most of the life cycle cost of a compressor is in the energy it uses





Compressed Air

Operating Conditions Influence Energy Costs

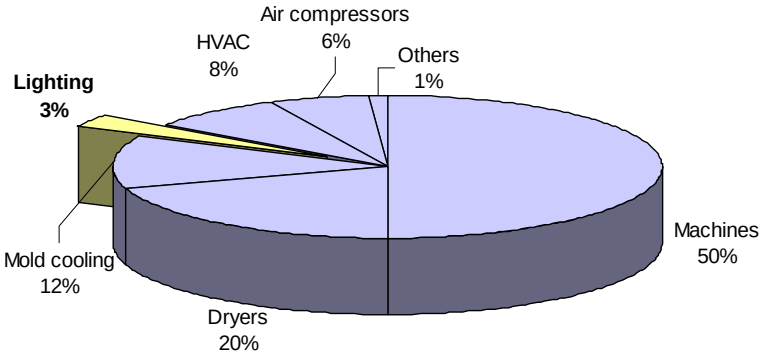
- Part load operation
  - 40–80% of full kW at part load
- System pressure
  - each 5psi = up to 5% more power
- Air inlet temperature
  - each 7°F lower = 1% more air
- Pipe sizing
  - Each 5psi drop = 2% more energy
- Leaks commonly constitute 25% of total compressed air use

Size	CFM	HP	$/Yr
1/4”	104	26	$15,300

One 1/4" leak is equal to 300 60-watt lamps!

Fluorescent T5 (0.2 KW)

Metal Halide (0.4 KW)



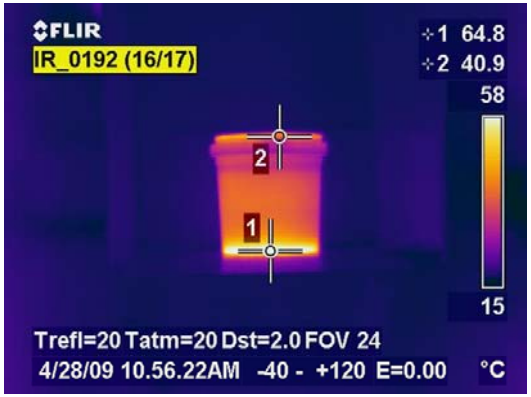
Functioning MH
Consumes 400W
Light level: 400 LUX

Dirty MH
Consumes 400W
Light level: 150 LUX

80% burnt MH
Consumes 400W
Light level: 100 LUX

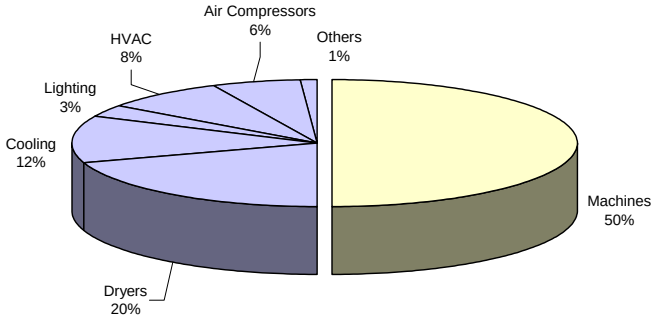
Burnt MH
Consumes 60W
Light level: 0 LUX

Lighting



Base Line Exit Temperature

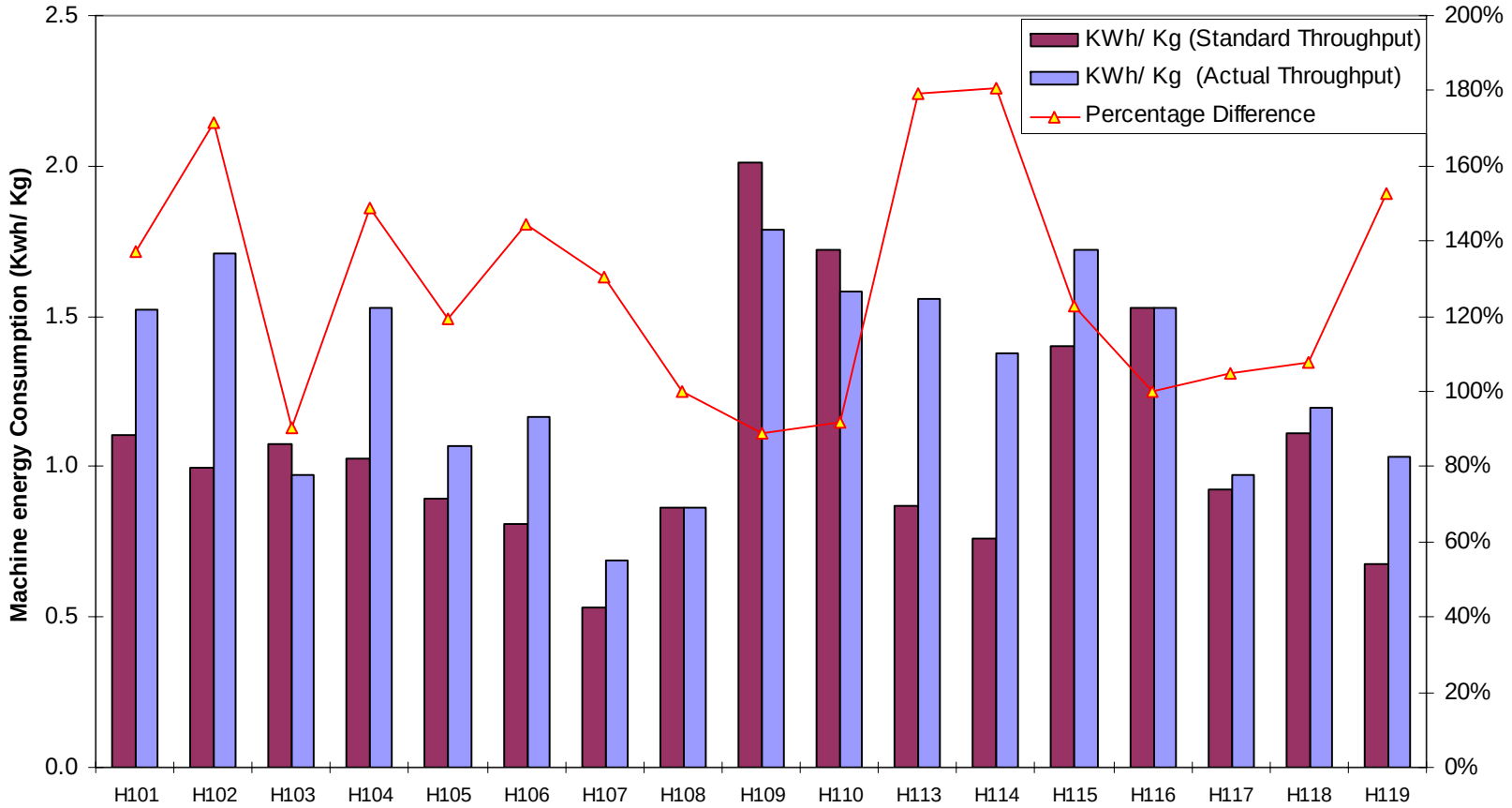
Faster Cycle Exit Temperature



	Equipment Description	Measured Power (kW)	Power Factor 480V	Cycle Time (sec)	Part Weight (g)	Number of Parts per Cycle	Machine Process Load (kW/kgHr)
Before	**Husky-HL160RS55/50**	**30.440**	**0.76**	**13.4**	**174**	**1**	**0.651**
After	**Husky-HL160RS55/50**	**30.811**	**0.76**	**12.6**	**174**	**1**	**0.613**
	Percent improvement			**6%**			**6%**

Effect of Cycle Time on Energy

- Reduction in throughput due to cavity/ cycle deviation increases the KWh/ Lb of processed resin

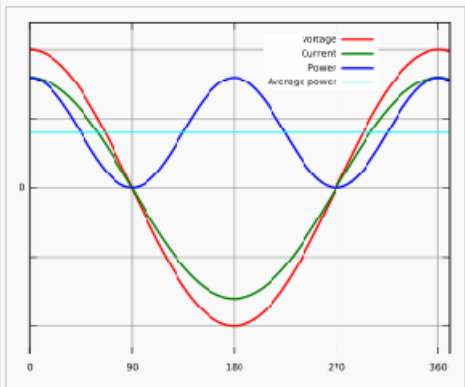


Effect of Throughput on Energy

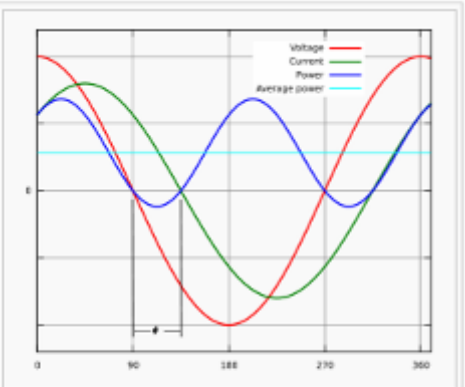
Other Energy Reduction Opportunities

Power Factor:

> “Over $16 billion dollars of Electricity is unusable energy, but billable in the U.S."
>
> U.S. Dept. Of Energy



Instantaneous and average power calculated from AC voltage and current with a unity power factor (ϕ=0, cosϕ=1)



Instantaneous and average power calculated from AC voltage and current with a lagging power factor (ϕ=45, cosϕ=0.71)

Operations

- Operational efficiencies have major impact on energy consumption (OEE)
  - Unscheduled down time, Scrap, Cycle and Cavitations efficiency
  - Excessive mold change time will waste energy if the machine is idling. QMC saves energy and increases OFE
- Staggering start-ups preferably at off peak rates (reduces demand charges)
- Turn the machine's motor on after the machine heat is closed to the set temperature (Improves PF)
- Size equipment right
  - Lightly loaded machines tend to have low Power Factor
  - Motors are more efficient near design loads
- Switch machines and/or dryers off for idle periods longer than 20 min
- Stop circulating water through mold when idle
- Use barrel insulation if possible (Generally under one year payback)
- Chilled water at the highest temperature without affecting cycle time

Electric Motors

- Electrical motors account for 40% to 60% of the electricity used in a typical molding plant
- Considering the “Life Cycle Costing”, the cost of energy to run a motor is generally 150 times the cost of purchasing that motor
- Match the motor to the load. Motors are more efficient near the design load
  - Motors are most efficient running at 80% to 90% of their rated loads
  - Large motors at part load are less efficient than small motors at full load
  - A lightly loaded motor could reduce PF
- Rewinding motors builds in 1% permanent inefficiency in the motor

Total Energy Management Program

1 - Estimate and verify site energy profile
2 - Understand your “Base” and “Process” loads
3 - Understand when and how much energy is used
4 - Identify, Quantify, and Prioritize opportunities
5 - Eliminate waste and reduce consumption through
    - Implementation of selected energy reduction projects

Phase 1:
Energy audit & reduction strategy

6 - Monitoring and Targeting
    - Understand Where energy is used
7 - Data analysis and reporting energy KPIs
    - (Energy dashboard) by department
8 - Conduct internal and external benchmarking

Phase 2:
Sustainability Through M&T

6- Monitoring & Targeting

- Energy is a controllable cost that should be monitored and controlled in the same way as other direct, production-related costs such as labor, raw materials, parts, and supplies.
- Divide the plant into energy-accountable centers (EAC).
  - Molding workcell (includes machines and automation)
  - Auxiliaries (includes chillers, compressors)
- Supervisors and managers of each area are responsible and accountable for energy use
  - Implement KPI
  - Set targets
  - Evaluate

- Departments to be accountable for their energy usage by assigning existing meters to each department (to be investigated)

Current

Meter 506 (2000 Amp)	Meter 503 (1000 Amp)	Meter 502 (1500 Amp) ?
H101	H115	Two Chillers
H102	H116	Pumps
H103	ECKEL 1	
H104	ECKEL 2	
H 105	ECKEL 5	
H106	One Chiller	
H 107		
H 108		
H 109		
H 110		
H 113		
H114		
H117		
H118		
H119		
CST1		
CST2		
ECKEL 3		
ECKEL 6		
Lighting		
Sorting machine		
Conveyors		
Bag sealer		
Dehumidifiers		
Cranes		
Offices/ Maint.		
Air Handlers		

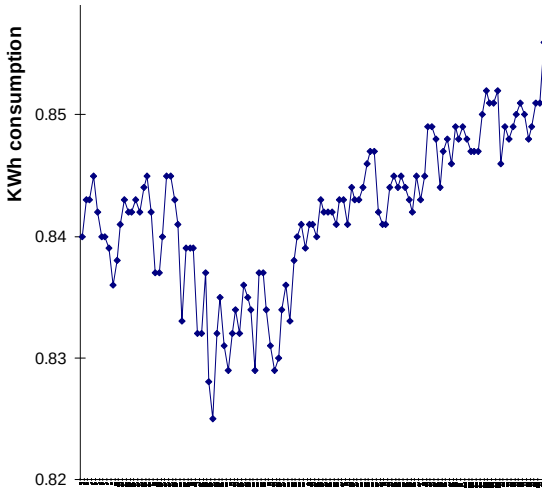
Proposed

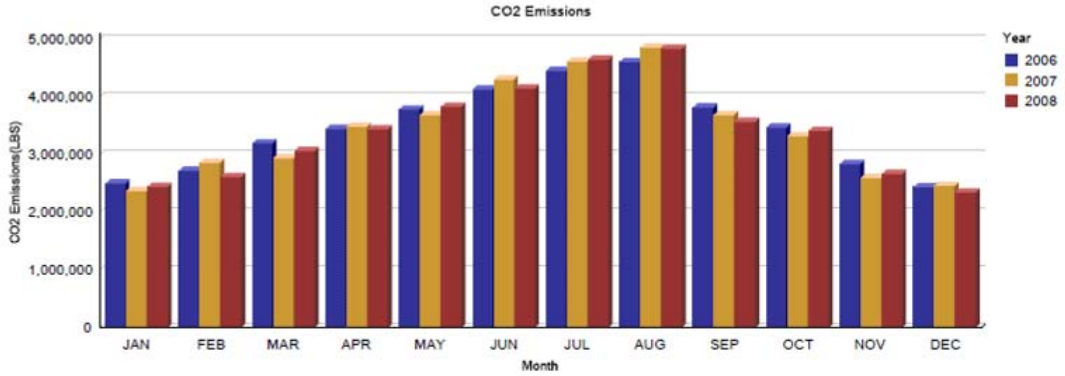
Meter 506 (2000 Amp)	Meter 503 (1000 Amp)	Meter 502 (1500 Amp) ?
H101	ECKEL 1	Two Chillers
H102	ECKEL 2	One Chiller
H103	ECKEL 3	Pumps
H104	ECKEL 5	
H 105	ECKEL 6	
H106	CST1	
H 107	CST2	
H 108		
H 109		
H 110		
H 113		
H114		
H117		
H118		
H119		
H115		
H116		
Lighting		
Sorting machine		
Conveyors		
Bag sealer		
Dehumidifiers		
Cranes		
Offices/ Maint.		
Air Handlers		

Live Monitoring – Case Study

Live Monitoring and Predictive Maintenance

Increase in electrical consumption could be used as a predictive tool to prevent failure





Type of Energy	Actual Consumption	Design Consumption	Actual Value ($)	Design Value ($)	Profit/ Loss ($)
Electricity	195,345	156,745	11,720	9,407	-2,313

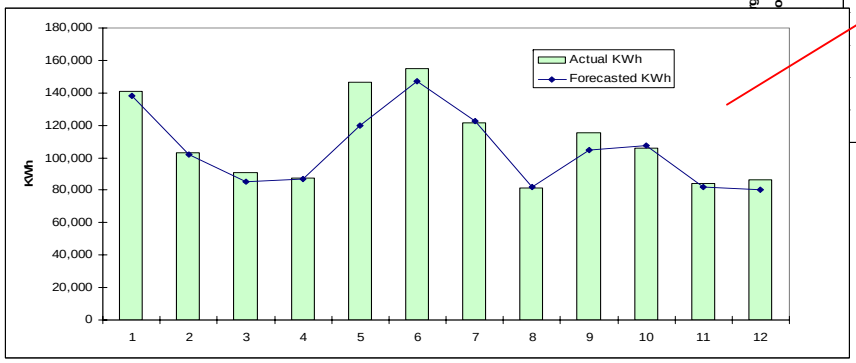
Shotscope NX by HUSKY

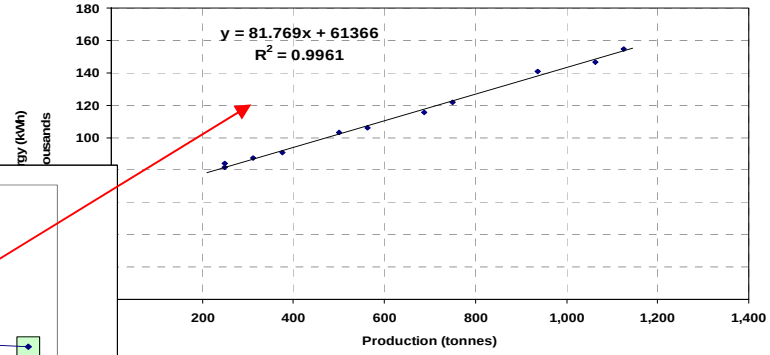
Live Monitoring and Six Sigma

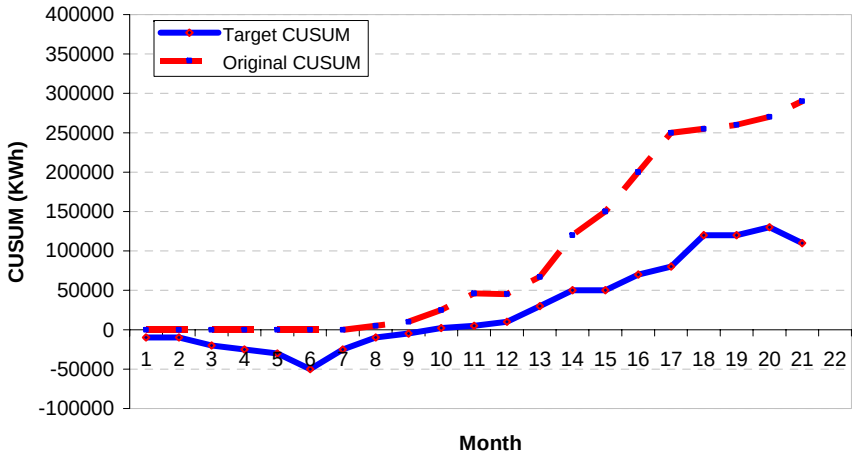
Correlation of live process water monitoring and machine parameters reduces reject rates and eliminates process variations

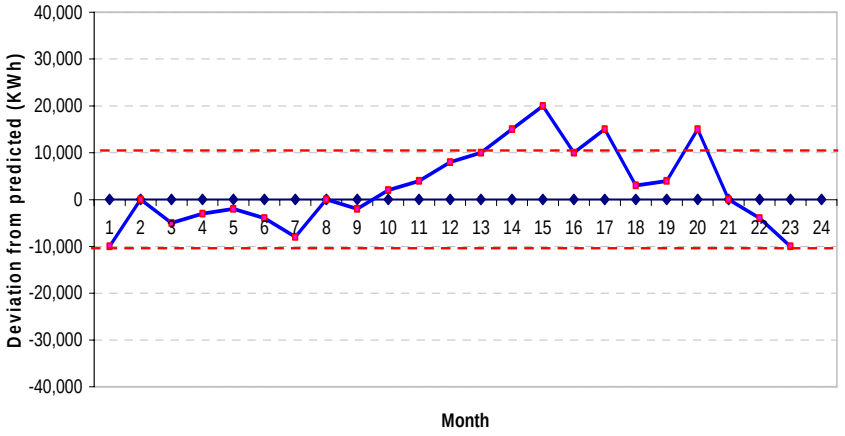
Shotscope NX by HUSKY

7 – Data Analysis and Energy KPIs

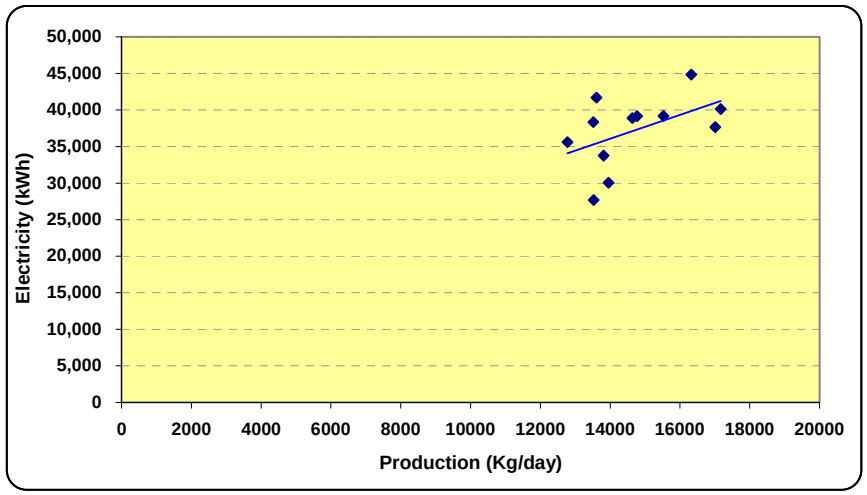








Energy on Management Agenda



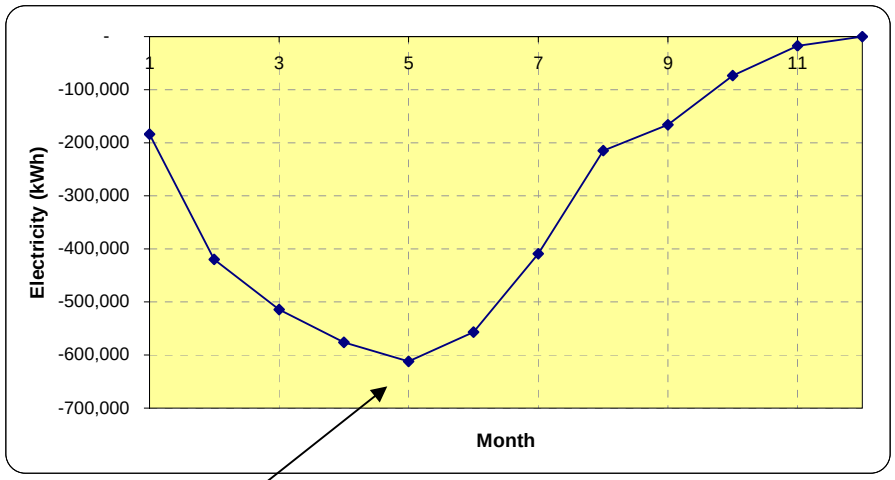
Regression Model

Dependent Variable . . . Electricity
Independent Variable . Production
Slope. . . . . 1.654 kWh/Kg
Intercept. . . . . 12,906 kWh/day
R^2 . . . . . 0.248

Y = (Slope x Production) + Base load

Predicted KWh/ month =
(1.654 x 432,644) + (12,906 x 31)

Predicted KWh/ month = 1,115,527 KWh



Month	Date dd-mmm-yy	Actual Electricity kWh	Production Kg	Baseline Predicted kWh	Difference (Act - Base) kWh	CUSUM kWh
1	1-Jan-10	931,597	432,644	1,115,527	- 183,930	- 183,930
2	1-Feb-10	857,833	419,353	1,093,548	- 235,715	- 419,645
3	1-Mar-10	1,054,170	476,310	1,149,020	- 94,850	- 514,495
4	1-Apr-10	1,046,133	428,159	1,108,110	- 61,977	- 576,472
5	1-May-10	1,203,271	514,999	1,238,810	- 35,539	- 612,011
6	1-Jun-10	1,205,198	453,620	1,150,215	54,983	- 557,028
7	1-Jul-10	1,344,641	489,703	1,196,979	147,662	- 409,365
8	1-Aug-10	1,291,993	421,762	1,097,532	194,461	- 214,904
9	1-Sep-10	1,103,742	396,005	1,054,938	48,804	- 166,100
10	1-Oct-10	1,150,565	405,666	1,058,009	92,556	- 73,543
11	1-Nov-10	1,213,465	457,939	1,157,357	56,108	- 17,435
12	1-Dec-10	1,174,952	465,840	1,157,517	17,435	-

A change in the slope suggests a change in the process or management of the plant that affected the operating characteristics of the plant

Data Analysis - CUSUM Analysis

Control Chart Tool

Duration

Months 12

Starting Date

Date 1-Jan-10

or

Sequence # 1

Model for Current Pattern

Variables

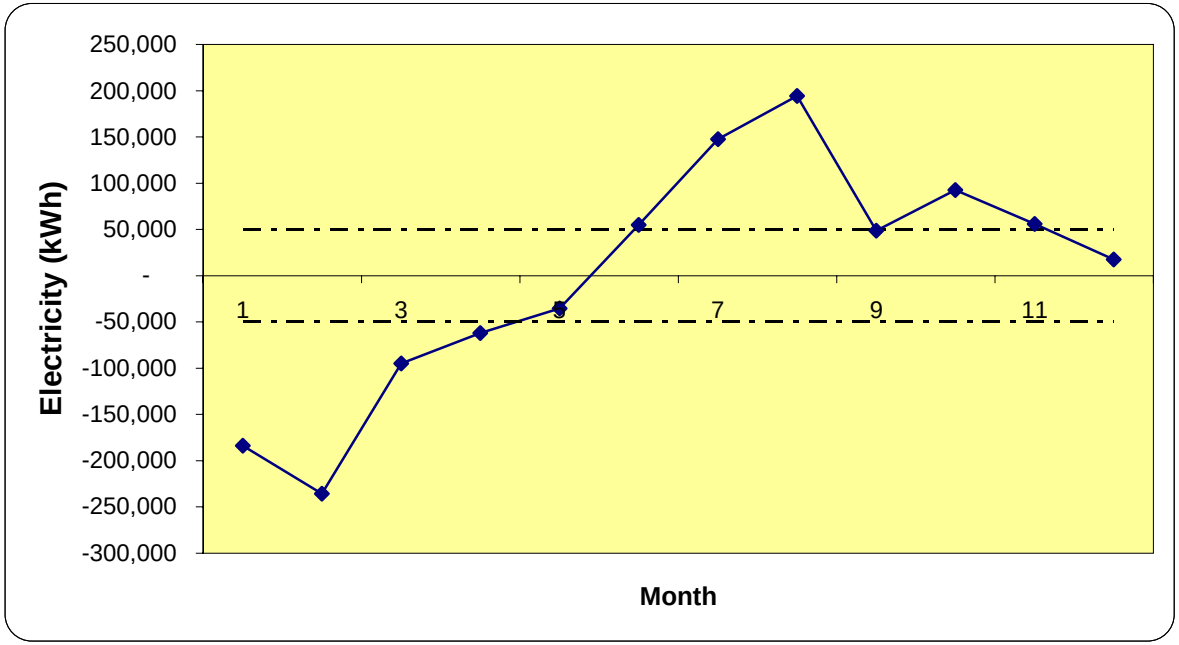
Dependent	Electricity
Independent	Production

Parameters

Slope	1.654	kWh/Kg
Intercept	12,906	kWh/day

Control Limits

Upper	50,000
Lower	- 50,000



- Adopt SPC type analysis for monitoring your consumption

Month	Date dd-mmm-yy	Actual Electricity kWh	Production Kg	Control Chart Predicted kWh	Difference (Act - Pred) kWh
1	1-Jan-10	931,597	432,644	1,115,527	183,930
2	1-Feb-10	857,833	419,353	1,093,548	235,715
3	1-Mar-10	1,054,170	476,310	1,149,020	94,850
4	1-Apr-10	1,046,133	428,159	1,108,110	61,977
5	1-May-10	1,203,271	514,999	1,238,810	35,539
6	1-Jun-10	1,205,198	453,620	1,150,215	54,983
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11	1-Nov-10	1,213,465	457,939	1,157,357	56,108
12	1-Dec-10	1,174,952	465,840	1,157,517	17,435
-		-	-	-	-

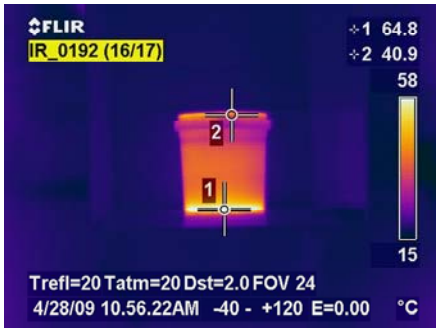
Data Analysis - Control Charts

8- Internal and External Benchmarking

- Site Specific Energy Consumption (KWh/Kg)
- Plant Energy Use (MMBTU/yr)
- Plant Energy Intensity (KBTU/ ft^2/ yr)
- Load Factor (%)
  - LF provides direction on what to focus on
  - High LF (above 0.7), focus on reducing energy not demand

Manufacturing Advisory Services
Total Energy Management

Market:	Pail
Date:	2009
Geography:	North America
Customer Size:	26 Injection Molding machines
Financial Impact:	$178,000 / 1.4 year payback



Background

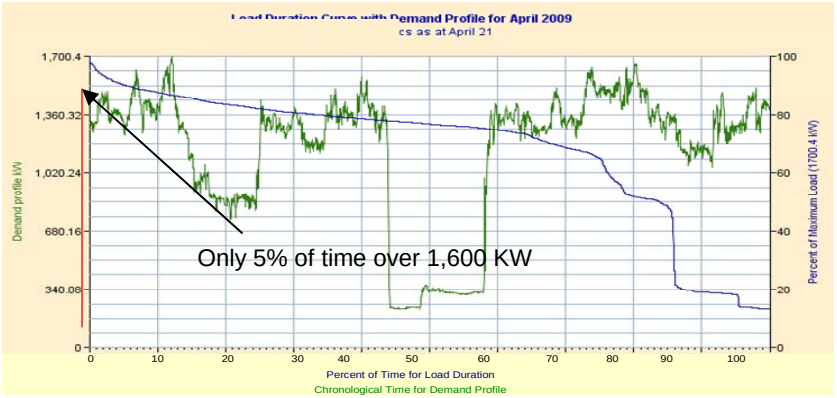
- Pail manufacturer with 26 machines ranging from 150 to 500 ton
- Six Husky H500. The rest are Engel, Nissei, Mitsubishi, and SuperMaster. Six printers, two Thermoformers, and one film extruder as secondary operations

Challenge

- Identify, quantify, and prioritize the energy savings opportunities within the entire plant

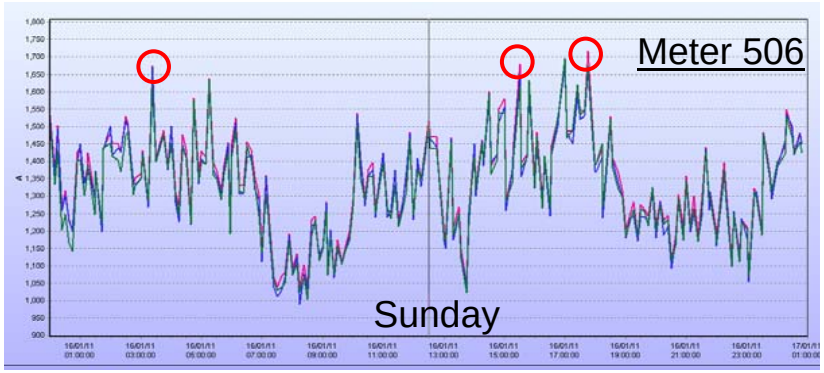
Customer Benefit

- 18% reduction in energy has been identified with $248K in capital investment and 1.4 years payback.
- Identified energy reduction opportunities resulted to 407 ton of carbon foot print reduction
- Process water system: Free cooling with 2.1 years payback
- Compressed air: Air leaks/ controls with 0.7 year payback
- Lighting: Retrofit to T5 with 2.1 years payback
- Power factor: Power factor correction with 2.4 years payback
- Cycle times: Cycle improvement with 1 year payback



Case Study – Energy Audit

Manufacturing Advisory Services Energy Assessment



Market:	Packaging
Date:	2011
Geography:	Middle East
Customer Size:	17 Injection Molding machines
Financial Impact:	1,172,000 / Immediate to 4.3 years payback (Currency signs omitted to maintain confidentiality)

Background

- A state of the art closure manufacturer with 17 machines and secondary operations

Challenge

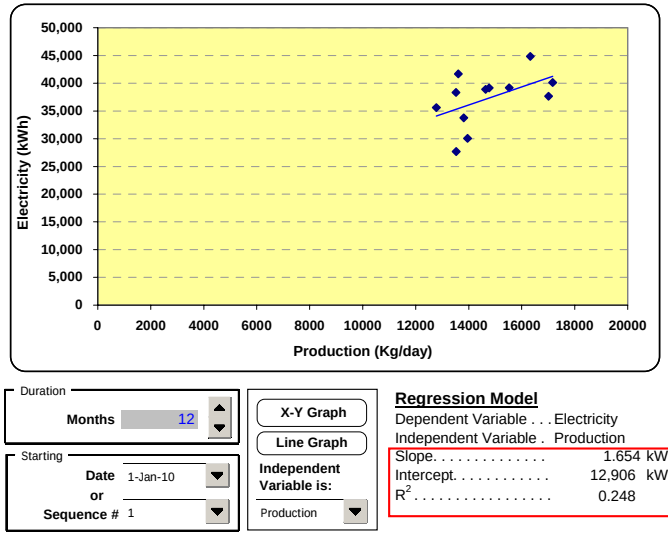
- Identify, quantify, and prioritize the energy savings opportunities within the entire plant

Customer Benefit

- A total of 2,157,119 KWh potential energy reduction has been identified that corresponds to 18.9% overall reduction compared to 2010 consumption
- Total savings estimated at 1,171,000 with capital costs estimated at 3,820,000
- The energy reduction opportunities come from the following areas:

Process cooling	31.4% reduction in energy, 1.5 years payback
Barrel heaters:	5% reduction in energy, 1.8 years payback
Operational practices:	56% reduction in energy, immediate payback
Light fixtures:	80% reduction in energy, 2.1 years payback
Cavity efficiency:	18% reduction in energy, 4.3 years payback
Air conditioning:	19,000 savings, immediate payback
Air leaks:	24,000 savings

- In addition to the above, the possibility of using solar energy (photovoltaic cells) has been investigated with revenue generating potentials of 370,000 /year and 6.2 years payback.



Case Study – Energy Audit

Audit Your Facility

- Start with auditing your plant
  - Most utility providers offer financial incentives to cover portions or all of the audit cost
  - Some utility providers offer programs that provide rebates towards the purchase and installation of qualified equipment that improves their facility's energy efficiency
- Implement an "Energy Management Program" in parallel with "Rate negotiation/ Risk mitigation" and "Installation of energy efficient equipment"

Energy Reduction and Sustainability Through Total Energy Management (TEM) Program

Plastic Shipping Container Institute

PSCI 2011
Monterey, CA

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