Cooling Tower Automation
Cooling Tower Automation

Automate Cooling Tower Project Savings (Amps)

Post Project Consumption
Pre Project Consumption
Cooling Tower Automation

Amps Vs Differential Temperature

- Blue line: Amps consumed
- Red line: Water Temperature
Cooling Tower Automation

- Automate Cooling Tower Fans at SPWTP, SMWTP and 5&6 WTP
  - Install VFD on fans (x12) and control the fan speed based on water temperature
    - 5 Fans – 75 HP, 4 Fans – 100 HP and 3 Fans – 150 HP
  - Currently, the fans are controlled by a high and low switch
  - All fans are running during winter which increases reliability risks
  - This would reduce maintenance and energy costs of running all fans throughout the year
  - Cost of Project: $330,000
  - Rebate Received: $165,000
  - Yearly MWh Savings: 3,422 MWh
  - Yearly Cost Savings: $171,116
  - DOE Better Project Award Winner
Thermal Flywheeling

Alex Woolf, PhD - Principal Data Scientist
Lineage Logistics
THE NEED FOR COLD
THE NEED FOR COLD
THE NEED FOR COLD
THE NEED FOR COLD
$T_{\text{Air}} < 0 \, ^{\circ}\text{P}$
LINEAGE INTRO
EBITDA = PRICE * QTY - POWER - LABOR

**Power Cost** = KWₜ

**Thermal Work**

**Efficiency**

Price / kW = $ / kWₑ
• Lineage - Macon, GA

• 129k sq ft
• Up to 1MW
• $450k Power Bill
• Real-time Pricing
  - No demand charge
$T_{\text{Air}} < 0 \, ^{\circ}\text{F}$
THERMAL MODEL

Heat Transfer ($\alpha$)

Warehouse

$C_{\text{air}} \frac{dT_{\text{air}}}{dt} = -\alpha(T_{\text{air}} - T(t))$

Heat Infiltration

$T(t) = A + mt + Be^{-t/\tau}$

$C_{\text{food}} \frac{dT_{\text{food}}}{dt} = \alpha(T_{\text{food}} - T(t)) + \Phi$

Heat Removal

Refrigeration System

$T_f(t) = A_f + mt + B_f e^{-t/\tau}$
THERMAL GRADIENTS
Macon Thermal Flywheeling

- Temperature Data (Cooling)
- Theoretical Fit (Cooling)
- Temperature Data (Warming)
- Theoretical Fit (Warming)

Fit Function: \( f(t) = A + mt + Be^{-t/\tau} \)

Cooling Period = 15.0 hrs
Heating Period = 8.0 hrs
• Lineage - Mira Loma, CA

• ~700k sq ft
• Up to 4MW
• $2.2M Power Bill
• TOU + Demand Rate
Example Demand Charges

<table>
<thead>
<tr>
<th>Type</th>
<th>Cost per MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>$18,550</td>
</tr>
<tr>
<td>On-Peak</td>
<td>$18,920</td>
</tr>
<tr>
<td>Mid-Peak</td>
<td>$3,630</td>
</tr>
</tbody>
</table>
• Karmarkar (1986): algorithm using interior point method faster than simplex for sets with many vertices

• Nesterov and Nemirovski (1994): class of linear barriers that guarantee convergence in $P$
# initial air temperature [F]
T0 = -2

# initial food temperature [F]
Tf0 = T0

# min/max temperature constraint [F]
Tmin = -20
Tmax = 0

# air and food temp versus time
T = cvx.Variable(hrs + 1)
Tf = cvx.Variable(hrs + 1)

# power consumption vs. time
x = cvx.Variable(hrs)

# define objective function
cost = cvx.sum_entries(cvx.mul_elemwise(p, x) + cvx.max(x) * D)
objective = cvx.Minimize(cost)

# prepare a list of all the constraints
constraints = [T <= Tmax, T >= Tmin, T[0] == T0, Tf[0] == Tf0, x <= 100, x >= 0]

# Temperature trace must obey thermal differential equation
for t in range(hrs):
    constraints.append(Cf * (Tf[t + 1] - Tf[t]) == -alpha * (Tf[t] - T[t]))
    constraints.append((T[t + 1] - T[t]) == (alpha * (Tf[t] - T[t]) - beta * x[t] + phi_h[t]))

prob = cvx.Problem(objective, constraints)
prob.solve()
FLYWHEELING SOLUTION

Energy Rate

Temperature Setpoints

Resulting Power Draw
FINANCIAL RESULTS

2016 2018 Pro Forma 2018 A

$1.94MM $3.18MM $2.10MM

$1.24MM $1.08MM
Thermal Control System

TECHNICAL FIELD

[0001] This document generally relates to systems and techniques for refrigeration management.

BACKGROUND

[0002] Cold storage facilities are used to cool and/or maintain stored content (e.g., inventory, food) at a reduced temperature. Cold storage facilities range across a wide array of sizes, from small (e.g., walk-in coolers) to large (e.g., freezer warehouses). The temperature within a cold storage facility is a result of a balance between heat removal from and heat intrusion into the facility.

[0003] Heat intrusion within a cold storage facility can come from many different sources, such as the environment (e.g., ambient air temperature, solar radiation), the stored content (e.g., warm product to be chilled), heat-producing equipment operating inside the facility (e.g., lights, forklifts), body heat from people working inside the facility, and facility operations (e.g., opening of doors as people and inventory pass into and out of the facility).

[0004] The rate of heat intrusion can vary over time. Heat intrusion generally increases during the day as outdoor summer temperatures rise and as the sun rises to its peak midday intensity, and generally decreases as outdoor summer temperatures and solar intensity fall. Heat intrusion can also increase during times of high activity, such as during the workday when doors are opened frequently, and decrease during times of low activity such as during after-hours when doors generally remain shut.
THANK YOU
WHY COMPRESSED AIR?

• Compressed air is the most costly source of energy usage at many of our plants.

• A ½” leak can cost a site up to $115,000 per year if left unchecked.

• Over 48% of our sites lack air leak tracking programs.

• 37% of sites want a compressed air audit
State of SGNA compressed air:

In a 2017 survey of 94 sites, **91%** have compressed air systems.

**Conditions of SGNA Compressed Air Systems**

- **40%** need to be replaced
- **48%** lack air leak tracking programs
- **37%** want a compressed air audit

The Sustainability Network recommends:

- Compressed air preferred vendor
- Leak detection and repair programs
- DOE INPLTs for compressed air
- Energy/compressed air audits
THE SUSTAINABILITY NETWORK FORMED COMPRESS IT

WHEN: October 29 – December 31

WHO: Open to all SGNA, with teams of up to 5

WHAT: A three-month, voluntary competition to see which site can identify and fix the most leaks, and make improvements to their compressed air system (both in operations and management)

Potential Annual Savings:
- 26 GWh of energy
- $2.5M of electricity costs

SGNA Compressed Air Challenge
### HOW DOES IT WORK?

**SITES SUBMIT TASKS IN AN ONLINE FORM FOR POINTS**

<table>
<thead>
<tr>
<th>Points</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Team name and photo</td>
</tr>
<tr>
<td>20</td>
<td>Compressed air audit completed in past 2 years</td>
</tr>
<tr>
<td>30</td>
<td>Form a compressed air team and/or leak detection and repair program</td>
</tr>
<tr>
<td>10</td>
<td>Monitor your compressed air system (i.e. sensors, meters)</td>
</tr>
<tr>
<td>20</td>
<td>Showcase use of at least (2) Sustainability Network compressed air resources</td>
</tr>
<tr>
<td>10 per leak</td>
<td>Find leaks (2 pts) and Fix leaks found (8 pts)</td>
</tr>
</tbody>
</table>

**BONUS**

1st place – 100
2nd place – 60
3rd place – 40

Innovative employee engagement (i.e. Smack talk video, video of team, team t-shirts, presentation, etc.)
HOW DO SITES REPORT LEAKS FOUND AND FIXED?
MULTIPLE LEAKS SUBMISSION FORM V2.0

SUBMISSION DATE: MM/DD/2018

If you are submitting multiple leaks at once and are utilizing one of Methods 1 through 3, you may upload this template to the submission form. Feel free to use this form to record information on each of your compressed air leaks and fixes throughout the challenge. There are up to 10 leaks represented in the form, but more may be added.

SUBMISSION FORM LINK

Method 1: 1) Orifice Method
Use if the air is leaking out of an orifice (i.e. nozzle, hole in pipe, tube, etc.)

<table>
<thead>
<tr>
<th>Leaks</th>
<th>Maintenance Tag #</th>
<th>Date Found</th>
<th>Date Fixed</th>
<th>Diameter of air leak (in)</th>
<th>Well-Rounded or Sharp Orifice?</th>
<th>Compressed air gauge pressure (psi)</th>
<th>Compressor flow (cfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SITE PARTICIPATION AS A RESULT OF THIS CHALLENGE...

**BUSINESS INVOLVEMENT**
19 SITES TOTAL

- **7** sites scheduled compressed air audits
- **4** sites formed a compressed air team and leak tracking system
- **6** sites utilized SGSN compressed air resources
- **24** sites attended the Compressed Air Challenge webinar
HOW WAS THIS COMMUNICATED?

CHALLENGE GUIDELINES DOCUMENT

COMpress IT.
COMPRESSED AIR CHALLENGE

OCTOBER 29 – DECEMBER 31

Join the Sustainability Network in Compress It, the Compressed Air Challenge launched for Saint-Gobain North America.

Compressed air is highly energy intensive and incredibly expensive, so this is a chance to make your systems more efficient and save money!

Find AND fix leaks at your site to win prizes!

ENTER TO WIN:

- Ultrasonic leak detector for the site to keep
- Solar backpacks for the whole team
- and BIWEEKLY mini-CONTESTS

Did you know?
A 1 ft3 leak can cost up to $115,000 per year!

The SGNNA Sustainability Network is launching our first Compressed Air Challenge, a voluntary competition to see who can identify and fix the most compressed air leaks at their site. Compressed air systems are significant energy users and they’re found in approximately 10% of SGNNA plants. Another 48% of steam is used for drying, so we created the challenge for sites to start identifying those leaks and provide quick wins for energy savings!

when?
The Challenge will be held from Monday, October 29 to Monday, December 31.

Who?
The Challenge is open to all Saint-Gobain employees in North America. Register in teams, with a minimum of 5 people per team. There can be multiple teams per site, but your site is responsible for managing this.

We’re list now what do we do?
Once you have formed your team, you must submit the team name and members, then begin completing the tasks in Table A and submit them by Friday of each week.

The Sustainability Network’s M3Cguide has a suite of resources to help you find, measure, and analyze leaks in the Compressed Air Challenge section. All updates will be posted on MySG, including the weekly leader scoreboard.

How do you determine who wins?
The ultimate Challenge winner will be the team with the highest energy savings from fixing the compressed air leaks. While there are a few methods to analyze compressed air leaks, we have limited the submission form to three methods:

1. Air leak diameter and compressed air pressure: Assuming the compressor runs to spec, the energy savings will be calculated using Table B.
2. Bag method: Cover a suspected leak with a Ziploc bag and calculate the number of seconds it takes to fill the bag (calculated in MS3A9).
3. Compressed Air Leakage Calculator: Use the Compressed Air Methodology pl. 21

If you want to use a different method, you may do so if you provide proof of calculations for how you reached the energy savings in kWh. The Compressed Air Challenge section of MySG has resources with methods to calculate those values.

If you have any questions about the Challenge, you may email us at SGNNA sustainable@saint-gobain.com.
### HOW WE ENCOURAGED SITES TO PARTICIPATE

**WEEKLY POSTING OF LEADER SCOREBOARD**

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Site Name</th>
<th>Business</th>
<th>Team Name</th>
<th>Points</th>
<th>Leaks Found</th>
<th>Percent Fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Oxford, NC</td>
<td>CT Roofing</td>
<td>Weeki Leaks</td>
<td>1,413</td>
<td>146</td>
<td>82%</td>
</tr>
<tr>
<td>2nd</td>
<td>Jackson, MI</td>
<td>CT Siding</td>
<td>Leak Stoppers</td>
<td>1,076</td>
<td>100</td>
<td>96%</td>
</tr>
<tr>
<td>3rd</td>
<td>Cody, WY</td>
<td>CT Gypsum</td>
<td>Cody</td>
<td>576</td>
<td>152</td>
<td>22%</td>
</tr>
<tr>
<td>4th</td>
<td>Ottawa, ON</td>
<td>CT Insulation</td>
<td>Whistle Breaker</td>
<td>368</td>
<td>67</td>
<td>25%</td>
</tr>
<tr>
<td>5th</td>
<td>Avery, OH</td>
<td>CT Roofing</td>
<td>The Avery Avengers</td>
<td>363</td>
<td>28.5</td>
<td>100%</td>
</tr>
<tr>
<td>6th</td>
<td>Ennis, TX</td>
<td>CT Roofing</td>
<td>Full of Hot Air</td>
<td>348</td>
<td>24</td>
<td>54%</td>
</tr>
<tr>
<td>7th</td>
<td>Moundsville, WV</td>
<td>CT Gypsum</td>
<td>VolunTold</td>
<td>304</td>
<td>32</td>
<td>63%</td>
</tr>
<tr>
<td>8th</td>
<td>Piedmont, MO</td>
<td>CT Roofing</td>
<td>Max-Air-Mizers</td>
<td>268</td>
<td>57</td>
<td>30%</td>
</tr>
<tr>
<td>9th</td>
<td>Wilmington, CA</td>
<td>CT Roofing</td>
<td>Wilmington Compressed Air faction (Wi-CAN)</td>
<td>194</td>
<td>83</td>
<td>0%</td>
</tr>
<tr>
<td>10th</td>
<td>Nashville, AR</td>
<td>CT Gypsum</td>
<td>Mystery Clan</td>
<td>189</td>
<td>48</td>
<td>21%</td>
</tr>
</tbody>
</table>
HOW WE ENCOURAGED SITES TO PARTICIPATE
BIWEEKLY CONTESTS AND PRIZES

2nd Week
Register Team Name and Photo

4th and 6th Week
Find and Fix 10 Leaks

8th Week
Innovative Employee Engagement

10th Week
Best Team Name

SMART PLUGS

SAINT-GOBAIN YETI TUMBLERS

ANKER POWER BANKS

SMART LIGHTS

SMART PLUGS
Join the Sustainability Network in Compress It, the SGNA Compressed Air Challenge, held from October 29 to December 31. All updates, scoreboards, and links will be posted here.

Submit your tasks here.

Note: You will need to create a Google account to submit files. You can create a temporary one with your Saint-Gobain email for the purposes of this challenge.

Access all of the resources here.

**MINI-CONTESTS AND SUPERLATIVES**

**BEST TEAM NAME** (due 12/31)

Vote for the best team name [HERE](#)!

Winners will get Wifi-enable smart plugs for the whole team!

**FIX MORE LEAKS** (due 12/7)

Reach at least 10 leaks fixed to be entered into the drawing for portable power banks. For those teams who already have 10 fixed leaks, Fix 20. Remember for the contest I will accept a maintenance request!
INTERNAL WEBSITE FOR WEEKLY UPDATES AND RESOURCES
BEST PRACTICES AND RESOURCES
Weeki Leaks was a fierce contender, closely trailing behind Leak Stoppers for all but one week, with dramatic improvements in the last couple weeks bringing them to the top. Their site worked hard, took the Challenge seriously, and were rewarded.

Weeki Leaks
CT Roofing – Oxford, NC

146 leaks found
82% of leaks fixed

1st PLACE PRIZE

Solar-Charging Backpacks
Also a fierce contender, **Leak Stoppers** led the pack almost every week, finding and fixing many leaks both fast and early. How? Leak Stoppers held an internal competition for employees to find leaks with the Slogan "Help us find our leaks and we will help you fix yours." The winners were given a gift certificate to an auto repair shop.

**2nd PLACE PRIZE**

**Leak Stoppers**  
CT Siding – Jackson, MI

100 leaks found  
96% of leaks fixed

**Amazon Echo Dots**  
200 leaks found  
93% of leaks fixed
BONUS POINTS FOR INNOVATIVE EMPLOYEE ENGAGEMENT

1ST PLACE PRIZE

Full of Hot Air created a participant video of the site finding air leaks. Almost all departments got involved! Please enjoy this suspenseful, epic film depicting air leaks at the CertainTeed Ennis plant!

1ST PLACE PRIZE

Smart Lights

Full of Hot Air
CT Roofing – Ennis, TX

19 leaks found
5% of leaks fixed
The Team Name competition was administered on a Google Form, and the night of the deadline prompted a fierce competition between VolunTold and Weeki Leaks, with the winner changing every hour! The sites got all employees to participate.

1st PLACE PRIZE

Smart Plugs
POSITIVE IMPACTS

- Promotes the development of a continuous compressed air management and operations team
- Highlights best practices at different sites and provides the opportunity for sharing
- Sites found 824 leaks of varying sizes, and repaired 47% of them
- The collective fixed leaks resulted in potential energy savings of 26 GWh of electricity, or $2.5 million (assuming leaks found persisted for a year and are fixed). This is 5% of the 2018 energy spend for all 19 sites.

**ELECTRICITY CONSUMPTION**

- 26.1 GWh
- electricity use reduction from leaks fixed

**ELECTRICITY COSTS**

- $0.47
- $2.49 M electricity cost savings
CHALLENGE GOALS SUCCEEDED

- Provide a fun, low-cost way for sites to tackle the compressed air issue
- Empower sites to create their own solutions while still utilizing the resources provided by the Sustainability Network
- Help each site to develop or enhance a continuous and sustainable compressed air operations and management system in order to keep down compressed air costs
- Spur quick energy savings that could make an impact on the next year’s environmental reporting goals
Thank You
2019 BETTER PLANTS SUMMIT
AGROPUR – AMMONIA SYSTEM UPGRADES
Mark Minter CEM
INTRODUCTION


www.agropur.com
AGROPUR - AMMONIA SYSTEM UPGRADES

Background

- Historically ran at 20.4 PSI suction pressure in order to build ice in rooftop ice bank.
- Ice bank supplemented two undersized plate and frame heat exchangers that provided chilled water to the plant at 35F.
- To do this all three, 400 HP ammonia compressors ran year round.
- Using metered amp data it was shown that the ammonia compressors used 5,151,086 kWh a year or $396k.
AGROPUR - AMMONIA SYSTEM UPGRADES

The most dangerous phrase in the language is “we’ve always done it this way.”

Rear Admiral Grace Hopper
Project Details

- Contacted AC&R Specialists to conduct audit of system.
- Identified two ways to mitigate problem.
  1. Install new plate and frame heat exchanger similar in size to the existing two – 50% more capacity
  2. Remove existing plate and frame heat exchangers and install two new ones that combined would have 50% more capacity
- Both options allow the suction pressure to rise to 35.6 PSI.
AGROPUR - AMMONIA SYSTEM UPGRADES

Obstacles

- Limited space.
- Removal of ice bank from rooftop.
- Increased pipe size to heat exchangers.
- Cost, savings, and payback analysis.
  - Used Vilter ScrewPro Software to estimate roughly 1,000,000 kWh saved
  - Contacted local utility to have project pre-approved for rebate
AGROPUR - AMMONIA SYSTEM UPGRADES

Old Heat Exchangers

New Heat Exchangers
AGROPUR - AMMONIA SYSTEM UPGRADES

Data Gathering

Over 2,000,000 kWh Saved
Triggers Formal Measurement & Verification (M&V) From Utility

Approved by State of Minnesota for $64K Grant

Annual Savings of $157,000
AGROPUR - AMMONIA SYSTEM UPGRADES

Next Steps

- Gathering data at all other plants.
- Raised suction pressure by 10 psi at our Jerome, ID plant.
- Looking to lower discharge pressure at 2 other plants.
QUESTIONS?
MODULAR (PACKAGED) UTILITY SYSTEMS

Faster – Better - Cheaper

Paul Hartmeister
Energy Sustainment Manager

DoE Better Buildings Summit
July 10, 2019
New programs required major utility upgrades at 3 plants:
• Process design significantly trailing building engineering
• New chiller and process tower water systems
  > 18000 tons of chiller + tower cooling
• All systems the same … but all different, 4500 - 7500 t/site
• Varied capacities, heads, site interfaces, climates
• One GC, one A/E, but three PMs and site teams
  • Normal processes would drive 3 designs

Choices
• Do it the same way as always
• Do it a new way for a better outcome
• A few chose to pursue a new way … … (that takes a lot of push!)
• Packaged supplier approach chosen
WHAT IS A PACKAGED SYSTEM? JUST OFFSITE FAB?

Offsite Fabrication
• A/E designed - burden on A/E for shop details
• Fabricated to the A/E design - Owner still owns design issues
• Shop fabricated but …
  • Core stick built issues remain

Packaged Systems – More than offsite fabrication
• Owner-A/E specified for performance and content only
• Specialist system provider engineers to spec
  • Use packager’s experience base
  • Shortened schedule
  • Compacted layouts
• UL/ETL listed appliance
  • NOT real property
WHAT DOES THAT PROCESS LOOK LIKE?

Proposal Model
5 x 1500 T chillers
2 X 1500 T weld water systems
(3 future chillers also shown)

Build Model
5 x 1500 T chillers
2 X 1500 T weld systems
FT. WAYNE – 3000 T (PAINT) + 4500 T (BODY) & WELD WATER

Compact – Easy to maintain
Basis for other sites
Expands to 12000 T w/no down time
Drawings done for future maximum
BUILD SEQUENCE - SYSTEM 1 OF 3

14 x 42’ x 90k lbs. maximum module size
7500 tons +

GENERAL MOTORS
ELAPSED FIELD TIME – 2 ½ WEEKS

Ordered October 2015
On site July 18, 2016
Start up (potential) September 1, 2016, (actual) March 2017
ONE PLAN - THREE PLANTS

Fort Wayne Body/Paint (base build)

Arlington Body (w/future)

Flint Body (w/future)

Flint & Arlington are opposite 2/3s of FWA!
CHANGE IS HARD ... EXPECT PUSHBACK

Expect active and passive initial opposition from:
• Conventional A/E (reduced scope and control)
• General contractor (perceived risk from change)
• Teamed mechanical and electrical subcontractors (reduced scope)
• 3 out of 4 project managers (it’s different!)
• 4 out of 5 project engineers (hey, this is different)

Expect support from:
• 1 Construction group manager
• 1 Project manager

Why?
• Upsets traditional lines of supply
• Upsets traditional lines of control
• New (and frightening)

Beware of gravity
• Every traditionalist will pull back at every opening – never slip
• Prevent backsliding into detailed interference into the packager’s work
LESSONS LEARNED

Packaged utility supply can be faster IF you develop your supply base
• Shorten total project schedule by 6-10 months
• Reduce A/E time and hours dramatically
• Reduce typical field schedule from 18 months to 6-10 weeks

Packaged system supply can be cheaper
• Reduce A/E & owner staff time and hours by 80%
• Reduce field labor and duration by at least 80%
• Overall cost reduction of 20% readily achievable ($1200-1300/t installed)
• Future systems accumulate savings … keep the team together
BENTLEY MILLS: EAAS

David Turkes: Director of Sustainability
**Project Darkhorse**

**The Details**
8 Year Contract (2019 – 2026)

**Electricity**
- Replaced 3,455 Light Fixtures
- Air Compressor System (88 Leaks)
- Annual Electricity Savings – 1.4 Million kWh

**Water**
- All Restrooms – Low Flow Fixtures
- Water Softener Retrofits
- Annual Water Savings – 2.3 Million Gallons

**Contract Summary**
- Cumulative Electricity Savings - $450,088
- Cumulative Water Savings - $85,504
- Upfront Costs - $0
Online Dashboard
Project Progress

Before

After
Project Progress

Before

After
Questions?
Making Butanol “Greener”
Major Energy Reductions through Strategic Product Management

Sharon Nolen, P.E., CEM
Manager, Global Natural Resource Management
A global industry leader

• Fortune 500 specialty materials company with 2018 revenue of ~$10B
• Global manufacturer and marketer of advanced materials and specialty additives
• Operates four business segments
• Global team of ~14,500
• Serving customers in >100 countries
Sustainability matters.
The value we create as a company must vastly exceed the resources we use.

“Sustainability matters. The world faces enormous challenges, but I’m confident in Eastman’s ability to address them through strategic collaboration, responsible resource management and persistent innovation.”

– David A. Golden,
  Senior Vice President, Chief Legal & Sustainability Officer, and Corporate Secretary
Relentlessly Engaging the Market

Volume of n-Butanol

Further purification requires **211% more energy!!**

Only 11% of the customers required the higher purity product.
How we got there – Embracing Complexity

What can we do to get around it?

- Purer Feed?
- Higher Efficiency Refining?
- Increase Inventory Capacity?
- Embrace Logistical Complexity?

Butanol Process

Raw Materials

Energy Used to Produce

Eastman™ High Purity n-Butanol

Eastman™ n-Butanol

“Green” n-Butanol
Conclusion

- Relentlessly Engaging the Market led to an understanding of Butanol demand
- Embracing Complexity led to us being value oriented as opposed to veering from the difficult path

- Bypassing the final refining column to create a new product
- Cost Savings of $709k / year
- Total Energy Savings: -42%

Butanol Process

Raw Materials → Eastman™ High Purity n-Butanol

Energy Used to Produce

“Green” n-Butanol
Questions?
2019 Better Buildings Summit
Better Practice – Toyota ESCO Process
Toyota North America Operations

29 Million Sq.Ft.
http://www.toyota-global.com/sustainability/environment/challenge2050/

- Zero CO₂ emissions in all plants worldwide by 2050
- 2030 Milestone: Reduce CO₂ emissions from all plants worldwide by 35% from 2013 baseline

**How?** Innovative Technology, Renewable Energy and *Kaizen Activity

*ESCO supports the Kaizen Activity*
What is the Energy Savings Collaboration (ESCO)?

**Internal energy savings and minimization process**

- Identify/implement CO$_2$ reduction opportunities in manufacturing
- Support Toyota’s 2050 Challenge
- No impact to – Safety, Quality and Production
- Team Member Development (management, production, maintenance, engineers, group leaders, contractors and students)
- Promote reduction activities in daily work
What’s the difference?

ESCO

• Focus is on plant operations during “all times”
• One-to-two week, deep dive
• Walk throughs focus on:
  • High level and detailed inspection; processes, set points, startup/shutdown, human behaviors, ability to ask questions while plant is running, etc.

Treasure Hunt

• Focus is on plant operations when “sleeping”
• One-to-three day, quick fixes
• Walk throughs focus on:
  • High level inspection; equipment running, leaks, lights on, etc.
How does the ESCO Process work?

**Study where to look:**
- Data Analysis
- Evaluate KPIs
- Determine gaps
- Identify initial kaizens
- Create team

**Genchi Genbutsu (go & see):**
- Onsite 1-2 weeks
- Audit SEUs and processes
- Perform energy calculations
- Report findings to Plant Executives

**Kaizens discussed:**
- Low/no cost
- Confirm R&R
- Secure project funding
- Expect one year to implement
- Measure & verify
- Follow-up

**PREPARATION**

2 months (Pre-ESCO)

**SITE INVESTIGATION**

0 months

**IMPLEMENT**

+12 months (Post-ESCO)
Let’s Talk Numbers

ESCO Process Annual CO₂ Savings

<table>
<thead>
<tr>
<th></th>
<th>CO₂ (kMT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed</td>
<td>43</td>
</tr>
<tr>
<td>Ongoing</td>
<td>64</td>
</tr>
<tr>
<td>Planned</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>140</td>
</tr>
</tbody>
</table>

To date 8 ESCO activities (2016-2019) have been completed in which:

1. 155 low/no cost, low payback kaizens discovered & implemented by end of 2019
2. 186 kaizens w/ longer payback (> 2 yrs.) being reviewed to implement
What are some examples of kaizens discovered?

- **100 MT/washer CO₂ Savings**
  - Compressed air to electric blowers in washers
  - Nozzle: 18
  - Pressure at nozzle: 5kPa
  - Distance between parts and nozzle: 30mm

- **2,600 MT CO₂ Savings**
  - High Speed Valve
  - 90psi
  - High pressure tank to reduce compressor start ups

- **300 MT CO₂ Savings**
  - New oven burners allow set back during non-production times

- **360 MT CO₂ Savings**
  - Utilize waste heat from heat treatment
What are the challenges?

• Time
• Payback length
• Project Funding
• Manpower
Summary

• New opportunities added to master list
• Kaizens kept in database for sharing
• Educate Team Members
• ESCO ongoing process
• Toyota effectively growing energy team with every ESCO
Resource Conservation Team

Michael Apodaca
• Engineering Manager Gatorade
• 26 years with PepsiCo

Tremayne Harris
• Project Engineer Gatorade
• 11 years with PepsiCo

Robert Centner
• Engineering & Maintenance Sr. Resource Gatorade
• 13 years with PepsiCo
## AGENDA

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Company Overview</td>
</tr>
<tr>
<td>2</td>
<td>Project Background &amp; Objectives</td>
</tr>
<tr>
<td>3</td>
<td>Project Execution</td>
</tr>
<tr>
<td>4</td>
<td>Outcome &amp; Sustained Impact</td>
</tr>
</tbody>
</table>
AGENDA

1. Company overview

2. Project Background & Objectives

3. Project Execution

4. Outcome & Sustained Impact
Diversified Portfolio

Nutrition

Snacks

Beverages
Ambitious Sustainability Agenda

Internal to Operations

**GOAL NO. 1**
Cut water use by 25% by 2025

60% of NAB's beverage volume

**GOAL NO. 2**
Reduce absolute GHG emissions by 20% by 2030

330,000 metric tons

**GOAL NO. 3**
Eliminate waste to landfill by 2025

5,700 metric tons
AGENDA

1. Company Overview
2. Project Background & Objectives
3. Project Execution
4. Outcome & Sustained Impact
Typical Heat Recovery Systems

City Water

Storage Tank

Steam Water Heater

~70°F

Water Purification

Purified Water Storage Tank

Existing Heat Recovery

~90°F

Remaining Process

>180°F

Steam Pasteurization

~110°F

Existing Heat Recovery

During Day

~70°F
AGENDA

1. Company Overview
2. Project Background & Objectives
3. Project Execution
4. Outcome & Sustained Impact
Innovative Heat Recovery Systems

1. City Water
2. Storage Tank
3. Steam Water Heater
4. ~70°F
5. Water Purification
6. Purified Water Storage Tank
7. Existing Heat Recovery
8. During Day ~90°F
9. Remaining Process ~180°F
10. Steam Pasteurization ~140°F
11. Existing Heat Recovery ~130°F
12. New Heat Recovery
13. Boiler
14. Economizer
Product Heat Recovery System P&ID

- Tie into 4 boiler stacks
- Flu Ace Condensing Economizer
- Condensate Generation to Cooling Towers
- Boiler Make Up Water Heat Exchanger
- Add Solar Thermal to Heat Recovery System
- Tie into Atm Condensate Receiver
- Potential for New Line
- Product Heat Exchangers
Add Solar to Heat Recovery System

• Existing
  – Solar was not always absorbed
    • Production lines go down throughout the day because of flavor or product changes, cleaning/sanitation, or maintenance
    • In the event of power outages all production lines could go down
    • Solar temperature could exceed temperature limits
  – Benefits
    – Additional heat sink to increase annual energy savings
    – Protect the solar system from overheating
    • In event of no production the condensing economizer is converted to an evaporative cooler
Product Economics

- Installation Costs
  - $1.4MM

- Annual Savings
  - $250M – Fuel
  - $15M – Water
  - $200M Utility incentive
  - 10% reduction in sites fuel usage
AGENDA

1. Company Overview
2. Project Background & Objectives
3. Project Execution
4. Outcome & Sustained Impact
Reapplication

Additional Installation Details / Modification's

- Second Site Completed in Florida
  - Trap resizing and push condensate to boiler room condensate receiver
    - All flash at condensate receiver in boiler room
  - Tied boiler exhaust, DA vent, and atmospheric condensate receiver to the condensing economizer
  - Plant has a shrink label system which uses direct steam at thermal source.
    - This venting steam was added to condensing economizer loop and doubled thermal recovery

- Third site under construction in Texas
Condensate Generation

- Condensing economizer generates a significant amount of condensate
- Simplest home is down the drain
- Second simplest is cooling tower and where previously used (120F-140F)
- When in combustion recovery alone pH is low, when steam tunnel recovery is added pH in close to neutral
- Second installation worked with boiler chemistry provider
  - Studied opportunity and potential challenges
  - Added ability to send water to boiler and cooling tower
  - Working well in boiler
  - Condensate is higher quality than city water so helped reduce water chemistry and boiler blow down losses
QUESTIONS?
Executive Summary

- **Background**
  - 3 manufacturing sites with more than 14 million square feet of conditioned space
  - Learned about chilled water optimization through Better Plants and ENERGY STAR partners
  - Realized energy savings from the chilled water optimization system in the Canton Vehicle Assembly Plant

- **Implementation and Execution**
  - Installed new controllers
  - Replaced valves and actuators
  - Developed new user interface

- **Outcomes**
  - Energy Savings
    - 2,966 MWh of electric energy savings in 2018
  - Sustained Impact
    - Evaluating chilled water optimization throughout facilities
    - Evaluating optimization options of other facility systems (e.g. hot water systems, air handlers, etc.)
Background

- **3 Manufacturing Sites**
  - Located in southeastern United States
    - Hot and humid during cooling season
  - > 14 million square feet of conditioned space
  - Electric load increases immensely for cooling and dehumidification

- **Benchmarking and Canton Optimization Pilot Program**
  - First learned of chilled water optimization during benchmarking with Better Plants and ENERGY STAR partners
  - Studied and implemented a pilot program at the Canton Vehicle Assembly Plant
  - Realized success of the Canton chilled water optimization and began studying feasibility of chilled water systems in Decherd and Smyrna

- **Results of Initial Studies**
  - Found the need to automate the chilled water systems
    - Actuating valves, variable speed drives, electric controls
  - Determined that a new user interface (UI) needed to be developed to monitor the system
  - Began implementation process in 2016
**Smyrna Fascia and Decherd Chilled Water Optimization**

- **Smyrna Fascia**
  - 2,400 tons of refrigeration
  - Previously operated manually through remote HMI
  - Converted to a variable flow system from a primary-secondary pumping system
    - Determined that the secondary pumps could handle the required flow through the chillers and the chilled water loop

- **Decherd**
  - 3,800 tons of refrigeration
  - Previously operated manually through remote HMI

- **Control System**
  - Uses manufacturer data to determine chiller load sharing based on condenser water temperature and chilled water load
  - Coordinates cooling towers and pumps to drive condenser water temperature to allow the most efficient operation at the given chilled water load
  - Controls chilled water pumps to maintain a set differential pressure between the supply and return
Smyrna Central Utilities Plant Condenser Water Optimization

- 17,000 tons of cooling capacity
- Manually controlled through a remote HMI
- Tied to both the compressed air system and the chilled water system
  - Needed to ensure that condenser water temperature was not driven too low in order to maintain compressor oil temperature

Controls
- Coordinates cooling towers and condenser water pumps to drive the condenser water sump temperature to allow for the most efficient operation of the chillers at the given chilled water load
- Added a schedule to the existing remote HMI that allowed for automatic staging of chillers instead of manually staging
- Included a minimum condenser water sump temperature to avoid adversely impact the air compressors
User Interface

- Focused on UI after completing controls design
- Graphics includes pumps, valve, chillers, cooling towers, and expansion tanks (where applicable)
- Primary KPI is kW/Ton
Trending Data

- Multiple equipment and system trend points including motor speeds, percentage of full-load amps, efficiencies, power, loads, and energy consumption
- Calculates an “Old kW” based on the Operator’s sequence of operations and equipment specifications
Challenges Faced

- Old Equipment
  - Valves with deteriorated seats
    - Replaced as they were found
  - Pneumatic actuators
    - Replaced with electric actuators
  - Outdated controls

- “Old Habits”
  - Manually operating an automated system
    - Taking the system out of automatic control and controlling using the remote HMI
  - Setting VFDs in hand and increasing pump speeds
    - Increasing pump speeds when supply pressure is too low
  - Turning on chillers locally
Outcomes and Sustained Impact

Outcomes

- Energy Savings
  - 2,966 MWh in 2018
  - 3,661 MWh since start of operation at Smyrna Fascia
- Large step toward carbon footprint reduction efforts
  - Nissan Green Program 2022
- Increased direct and indirect efficiencies
  - Frees operators from constantly monitoring systems

Sustained Impact

- Studying possible applications for other chilled water systems
- Studying and implementing projects to automate and optimize other systems such as air handlers, hot water systems, etc.
- Using the extensive data collected to justify the replacement of aged equipment
2019 Better Practice
Real-time Energy Monitors
Background
Background
Objectives

1. Reduce our overall energy intensity by 20% over 10 years.
2. Provide real-time energy data and pump efficiency information to maintenance, repair and operations (MRO) personnel to help them make informed operational and maintenance decisions.
Barrier #1

Wire-to-water efficiency
Solution #1
Barrier #2

**Operator knowledge & data presentation**

- Dedicated energy monitors for each plant
- Licensed, highly skilled operators are experts at water treatment and pumping but knew little about energy use and consumption.
Solution #2
Approach

1. Obtain top management support.
   – CEO fully supported.

2. Develop implementation plan.
   – Select hardware, quotes, acquisition, contractor, coordination with IT, etc.

3. Obtain funding.
   – CEO directed CFO to create a capital account and transfer funds.

4. Execute the plan.
Execution

- Hardware was purchased and a contractor installed the meters.
Execution

- Hardware was purchased and contractor installed.
- Internal control systems specialists
  - Added submeters to SCADA and trending
Execution

• Hardware was purchased and contractor installed.
• Internal control systems specialists
  – Added submeters to SCADA and trending
  – Programmed server to display
    • Wire-to-water efficiency of pumps (SEUs)
    • Month-to-date electric consumption with real-time cost
    • Real-time demand
    • Peak demand and current monthly demand cost
    • EnPI
Execution

• Operations personnel were provided training on
  – Electric terminology
  – Electric demand/consumption
  – Pump efficiency
  – Distribution system dynamics
## Summary of costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Sixty PowerLogic ethernet electric meters</td>
<td>$60,900</td>
</tr>
<tr>
<td>Contractor labor and materials</td>
<td>$79,600</td>
</tr>
<tr>
<td>Network switches, communication converters, thin-client, monitors</td>
<td>$37,200</td>
</tr>
<tr>
<td>Internal labor</td>
<td>$27,000</td>
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<tr>
<td><strong>TOTAL INVESTMENT</strong></td>
<td><strong>$204,700</strong></td>
</tr>
</tbody>
</table>
Outcomes – Energy Performance Indicator

EnPI improved 9.2%
2016-2018
Outcomes – Electric consumption reduced

Primary source electric consumption was reduced 10,600,000 kWh in 2018.
Outcomes – Electric consumption reduced

Primary source electric consumption was reduced 10,600,000 kWh in 2018.

Saving $184,370/yr
Outcomes – Electric consumption reduced

Primary source electric consumption was reduced 10,600,000 kWh in 2018.

Saving $184,370/yr

Payback = 1.1 years
Outcomes – 5-year annualized ROI

$717,150

$204,700

35.1%
Outcomes – CO$_2$ emissions

CO$_2$ emission were reduced by 5,650 metric tons/yr