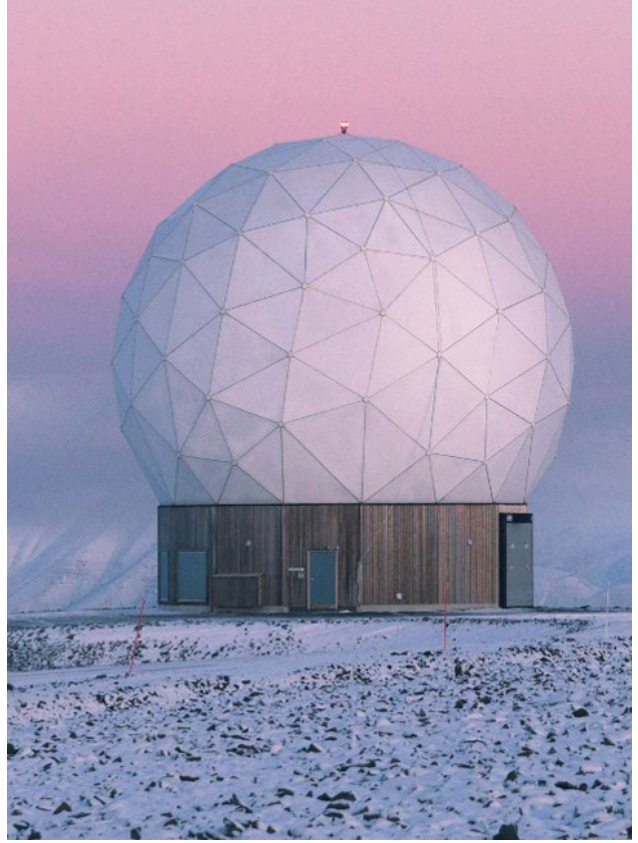





Raytheon Technologies

A Deep Dive into Treasure Hunts - And Other Ways to Find Energy Savings

Dave Chamberlain & Tracy Fialli
TURI Workshop, Session E

April 13, 2021

Presentation Overview

- Raytheon Technologies (RTX) overview
- Energy program overview, benchmarking & partnerships
- Analyzing your site load shapes & kWh data
- Treasure Hunt experience & lessons learned
- Project specific assessments
- Virtual assessments

Emphasize value of roadmaps and partnerships

Raytheon Technologies

OVERVIEW

The future of aerospace and defense

Raytheon Technologies (NYSE: RTX) is an aerospace and defense company that provides advanced systems and services for commercial, military and government customers worldwide. The company was formed in 2020 through the combination of Raytheon Company and the United Technologies Corporation aerospace businesses, and is headquartered in Waltham, Massachusetts.

195,000
Employees

60,000
Engineers

40,000
Patents

$74B
Pro forma combined annual revenue (2019)

190+
Years of combined innovation and industry leadership

~$8B
Annual company- and customer-funded research and development

KEY CAPABILITIES

- Actuation, Cargo, Landing and Propeller Systems
- Aerostructures
- Aircraft Engines and Auxiliary Power Systems
- Avionics
- Cybersecurity
- Data Analytics
- Interiors
- Missile Defense
- Mission Systems
- Power & Controls
- Precision Weapons
- Systems Integration and Sensors

Raytheon Technologies consists of four highly specialized businesses:

Collins Aerospace
Specializes in aerostructures, avionics, interiors, mechanical systems, mission systems, and power and control systems that serve customers across the commercial, regional, business aviation and military sectors.

Pratt & Whitney
Designs, manufactures and services the world's most advanced aircraft engines and auxiliary power systems for commercial, military and business aircraft.

Raytheon Intelligence & Space
Specializes in developing advanced sensors, training, and cyber and software solutions — delivering the disruptive technologies its customers need to succeed in any domain, against any challenge.

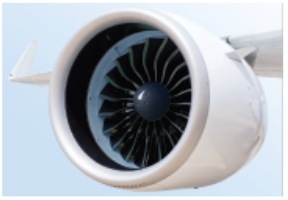
Raytheon Missiles & Defense
Provides the industry's most advanced end-to-end solutions to detect, track and engage threats.

Raytheon Technologies

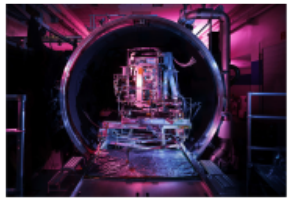
"Combining complementary portfolios with advanced technology and R&D platforms, we are delivering transformative solutions to usher in the future of aerospace and defense."
– Gregory J. Hayes, CEO, Raytheon Technologies

We are defining the future of aerospace and defense with ambitious technologies that push the limits of known science.

Collins Aerospace | The Grid
The Grid is a $50 million, 25,000-square-foot facility in Rockford, Illinois, where the company will design and test systems for the next generation of more electric aircraft. With initial operations expected to begin in 2020, it will be the industry's most advanced electric power systems lab.



Pratt & Whitney | GTF™ engine
The Pratt & Whitney GTF™ engine is the quietest, cleanest and most fuel-efficient engine in its class. With up to 20% better fuel efficiency, this geared turbofan engine has significantly lower nitrogen oxide emissions and a 75% smaller noise footprint.



Raytheon Intelligence & Space | Visible Infrared Imaging Radiometer Suite (VIIRS)
VIIRS is a key instrument in the Joint Polar Satellite System, the new-generation polar-orbiting operational environmental satellite system. VIIRS generates high-fidelity sea, land and atmospheric data for a variety of other applied products, including monitoring of wildfires, drought, flooding, vegetation health, algal blooms and nighttime phenomena.

Raytheon Missiles & Defense | Lower Tier Air and Missile Defense Sensor
The Lower Tier Air and Missile Defense Sensor (LTAMDS) is a next-generation radar that will defeat advanced threats like hypersonic weapons. It simultaneously detects and engages multiple threats coming from any direction, ensuring there are no blind spots on the battlefield.

Raytheon Technologies

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Our values span the enterprise and drive our actions, behaviors and performance.

TRUST
We act with integrity and do the right thing.

RESPECT
We embrace diverse perspectives and treat others the way they want to be treated.

ACCOUNTABILITY
We honor our commitments, expect excellence and take pride in our work.

COLLABORATION
We share insights, learn together and act as a team.

INNOVATION
We experiment, design, build and transform with speed and agility.

Social Impact

We believe we have a responsibility to change the world for the better. Raytheon Technologies supports leading nonprofit causes that are shaping the next generation of purpose-driven innovators and making a transformative impact on local communities around the world.

- **STEM Education:** We support educational initiatives that inspire the next generation of scientists, engineers and business professionals.
- **Our Communities:** Through strategic investments in organizations serving veterans, military families and an array of social welfare needs, we're improving the communities where we live and work.
- **Sustainability:** In every respect — the environment, engineering, design or operations — sustainability is a business imperative.

Diversity & Inclusion

A diverse company is a strong company. The people of Raytheon Technologies come from different backgrounds. We value our different perspectives and styles of solving problems. We leverage those unique voices to generate solutions for a united and singular purpose: to define the future of aerospace and defense.

Join the conversation

www.rtx.com

Cross Company Cross Functional Team

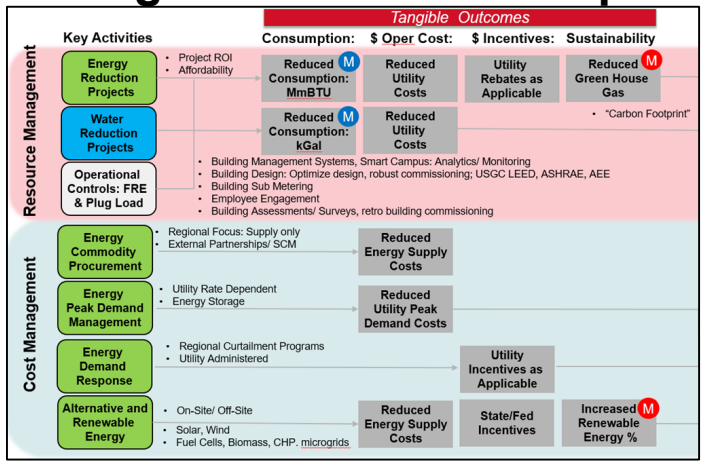
- Collaborative Teams at Raytheon since 1998
  - Enterprise Energy Team (EET)
  - Conserving Raytheon Energy and Water (CREW)
  - **April 2020**: RTX Team: Conserving RTX Energy and Water (CREW)
- Key aspects
  - Policies, best practices, project identification & execution
  - Standard metrics and reporting
  - Cost reduction strategies
  - Development of roadmap with key focus areas
- Awards and Recognition
  - Raytheon Company recognized by EPA ENERGY STAR 16 times
    - 13 consecutive Partner of the Year Sustained Excellence
  - Additional recognitions by multiple regional organizations
- Benchmarking & Partnerships
  - Strong history of partnerships across government and industry

ENERGY STAR AWARD 2020
PARTNER OF THE YEAR
Sustained Excellence

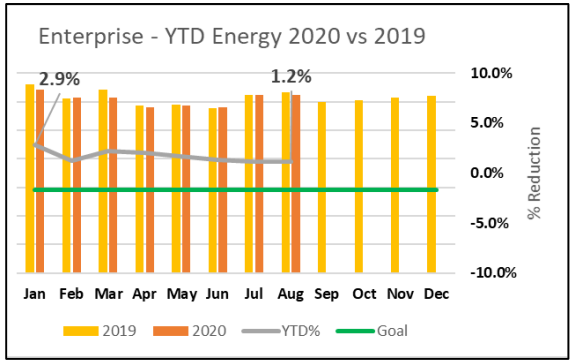
Raytheon Technologies

Energy and Water Program Overview

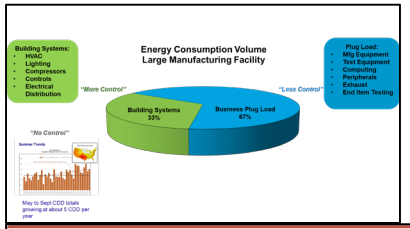
Manage cost and consumption

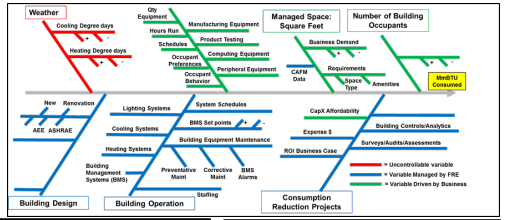


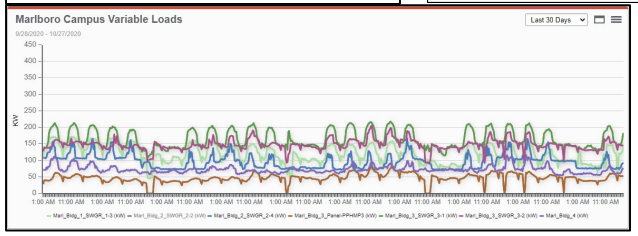
Goals and Reporting

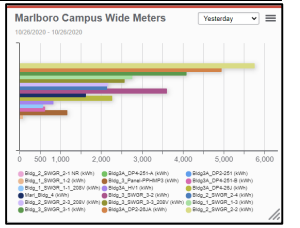


Understand consumption









Projects

Energy Project Summary		Corp	IDS	IIS	RMS	SAS
Identified Projects	142	6	41	17	47	31
Funding Status						
Funded	65	5	23	5	22	10
No Funding Required	5	0	0	0	5	0
Funding Pending (in plan)	11	0	0	0	2	9
Not Feasible	1	0	0	0	0	0
# Moved to next year	43	0	18	3	17	5
Completion						

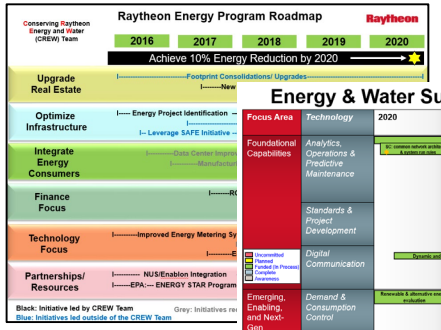
Energy Project	Site	State	Annual Electricity (-) reduction or mitigation (KWH)	Annual Gas (+) increase or (-) reduction (Therms)	Total Energy Annual (+) increase or (-) reduction (MMBtu)	Annual $ Savings	2019 $ Incentive or Payment
Huntsville JDD upgrade fixtures in MDF data room to LED with occ sensors	Huntsville JDD	AL	-1,000		-3.4	$90.0	
Hunstville JDD Metasys Integration (FAC19080)	Huntsville JDD	AL	-19,057		-65.0	$1,715.1	
Camden Bldg. 181 Lighting Improvements - DR (FAC18108)	Camden	AR	-145,136		-495.2	$13,062.2	
Complete Andover LED exterior lighting (A130)	Andover	MA	-138,846		-473.7	$19,438	$12,000
Andover Dock Door (A-17)	Andover	MA	-50,000	0	-170.6	$7,000	
Data Center HVAC System Upgrade PH 2 (A136)	Andover	MA	-350,000		-1,194.2	$49,000	$38,171

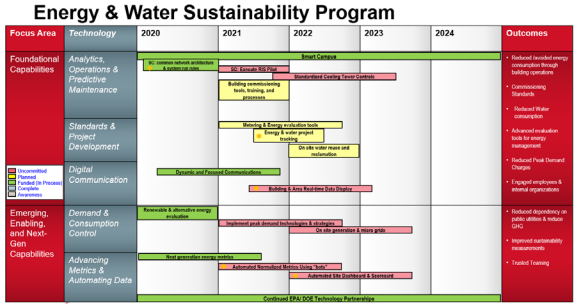
Best Management Practices

Energy/GHG

- Energy team
- Shut-it-off campaign
- Utility review
- Building automation
- HVAC
- Boilers /hot water /steam systems
- Lighting
- Building envelope
- Compressed air
- Process energy management /plug load
- GHGs Chemicals and Refrigerants

Strategy & Innovation





Manage Both Resources and Rates

Benchmarking & Partnerships

- EPA ENERGY STAR
  - Industrial Partners: Owens Corning, Corning, Nissan, ArcelorMittal & Celanese
  - Aerospace Focus Group: Boeing, Lockheed Martin, Gulfstream, Northrop Grumman, BAE & General Dynamics
  - ENERGY STAR Certified Buildings
- Department of Energy Better Buildings/Better Plants
  - Industrial Partners: 3M, GE & Bristol Myer Squib
  - Tools: In-Plant trainings, technical assistance & software tools
- United States Green Buildings Council
  - Follow LEED standards, pursue building Certifications and employee credentials
- Association of Energy Engineers
  - Education, training & regional networks
  - Employee certifications: Certified Energy Manager, Energy Procurement Professional, Building Commissioning Professional
- Other
  - International Facilities Management Association, Smart Energy Decisions, REBA

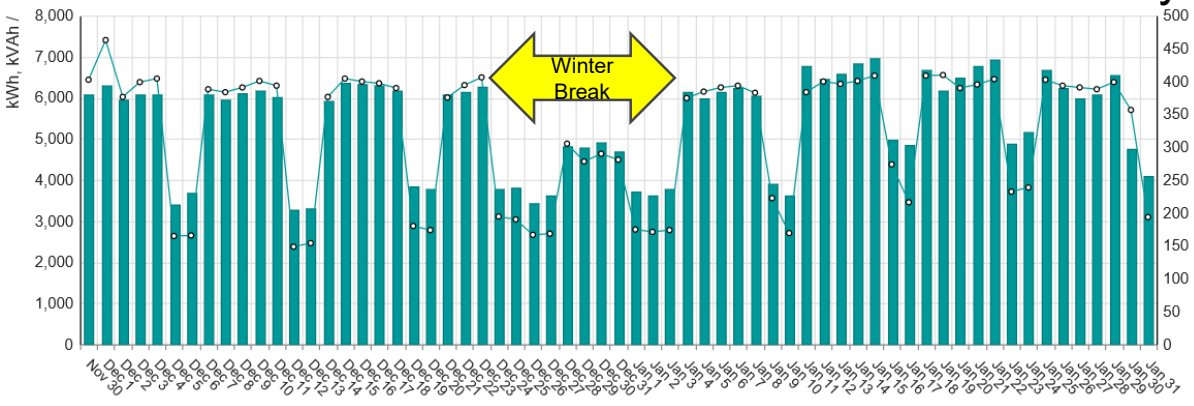
Industry Shares Openly

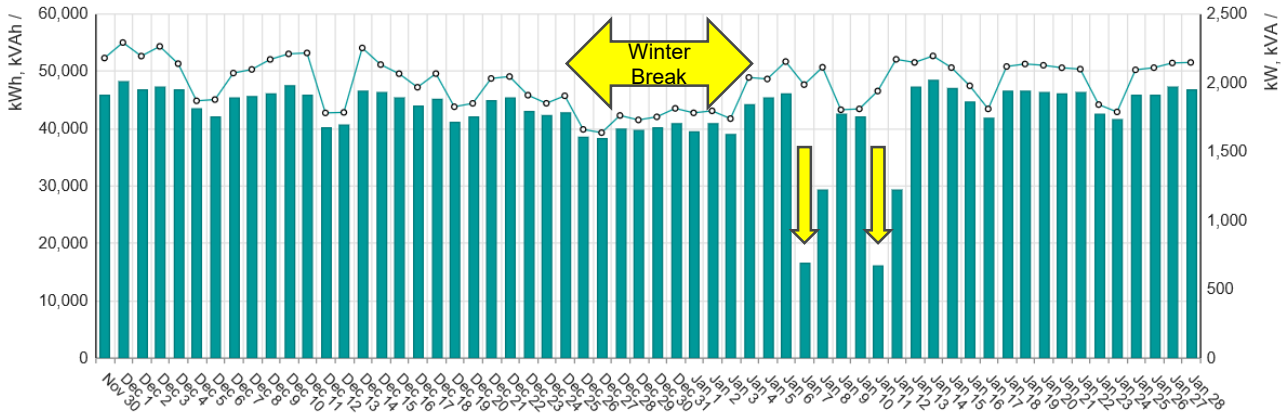
Daily and Hourly kWh Analysis

~150K SF Office Building

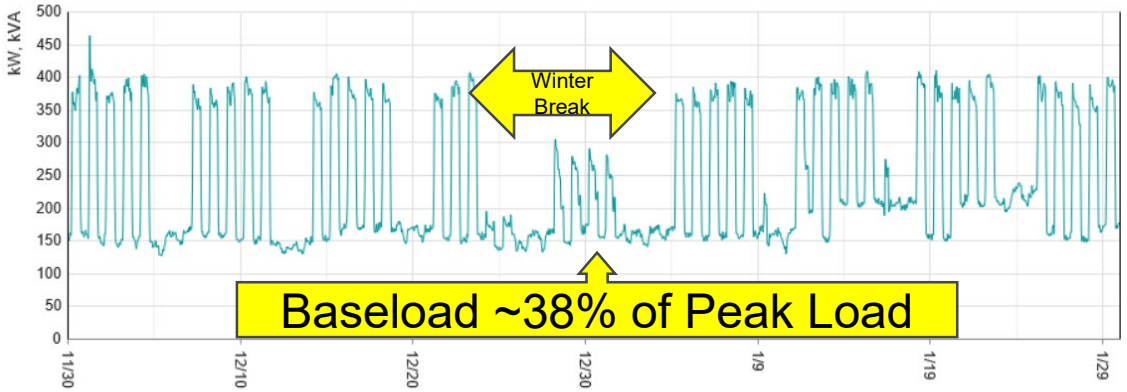
~700K SF Mixed Use

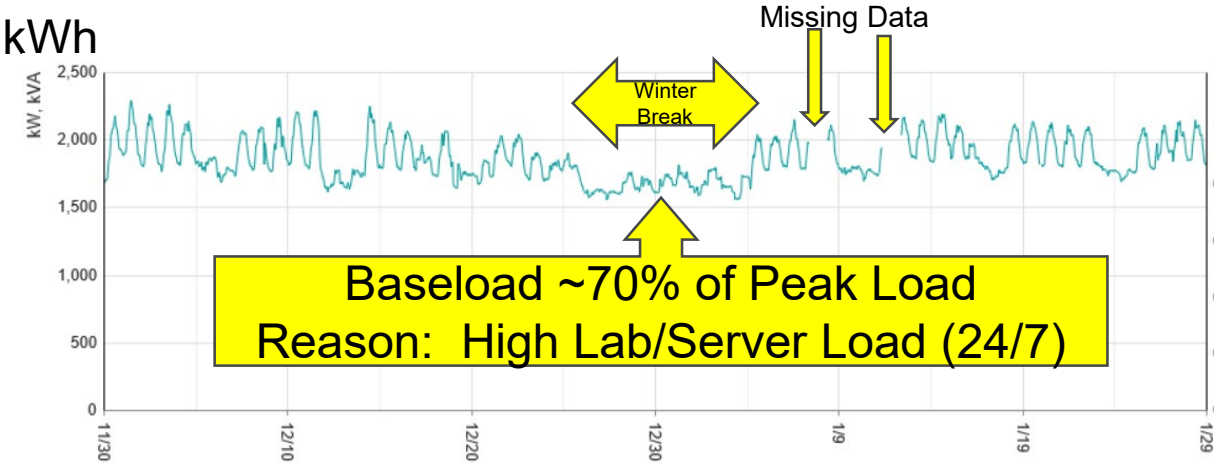
Daily kWh





Hourly kWh





Good pre-Treasure Hunt activity to understand where to focus

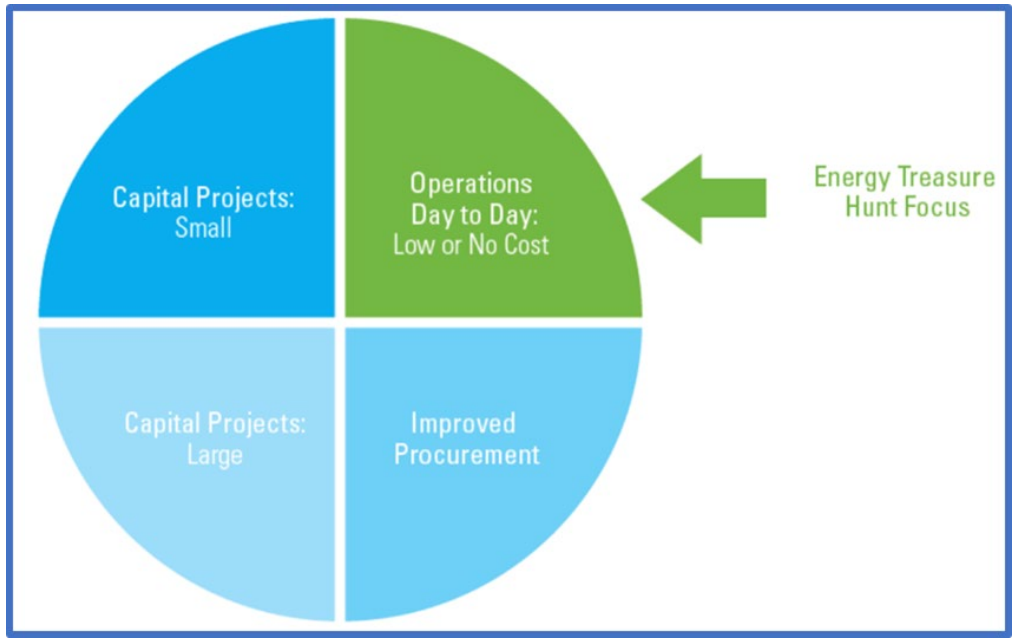
Treasure Hunt vs. Assessment vs. Energy Audit

- Energy Audits
  - In depth look at the entire facility
  - Focused on capital as well as low-cost expense opportunities
  - Usually costs money and requires extensive dedicated time of the site team
- Energy Assessment
  - Focused on specific system
  - External or internal expert or trusted supplier at no cost
- Treasure Hunt
  - Focused on improvements that can be made quickly and at little cost
  - Funding for implementation is generally expense related

	Energy Treasure Hunt	Energy Audit	Energy Assessment
Focus Area	Plant or building	Plant or building	Systems
Employee Engagement	Yes	Minimal	Yes
Resources External to Company or Facility	Yes	Yes	Yes
Operational Improvements	Yes	Minimal	Minimal
Capital Improvements	Minimal	Yes	Yes
Two-way Learning	Yes	Minimal	Yes
Summary Report	Yes	Yes	Yes
Cross-functional Focus	Yes	Minimal	Minimal

Apply the right process for the right need

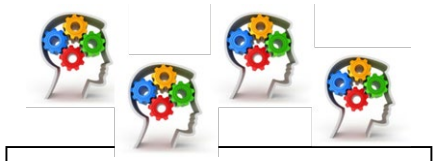
Energy Treasure Hunt Objective



- A two or three day employee engagement activity focused on:
  - Low cost and no cost actions to reduce energy consumption
  - Use of teams to identify, analyze, and evaluate energy savings opportunities by observing daily operations
  - Cross-functional brainstorming to reduce energy use throughout the plant
  - Ways to continuously improve and reduce energy consumption
  - Use of standard methodology and calculations to quantify opportunities for reduction

Employees implement the Treasure Hunt process

Treasure Hunt Background & Key Elements



Combine knowledge (Other plants, suppliers, consultants, etc)

Go and see

Conceive new ideas and share existing ones

Increase energy awareness

Identify energy use in the workplace

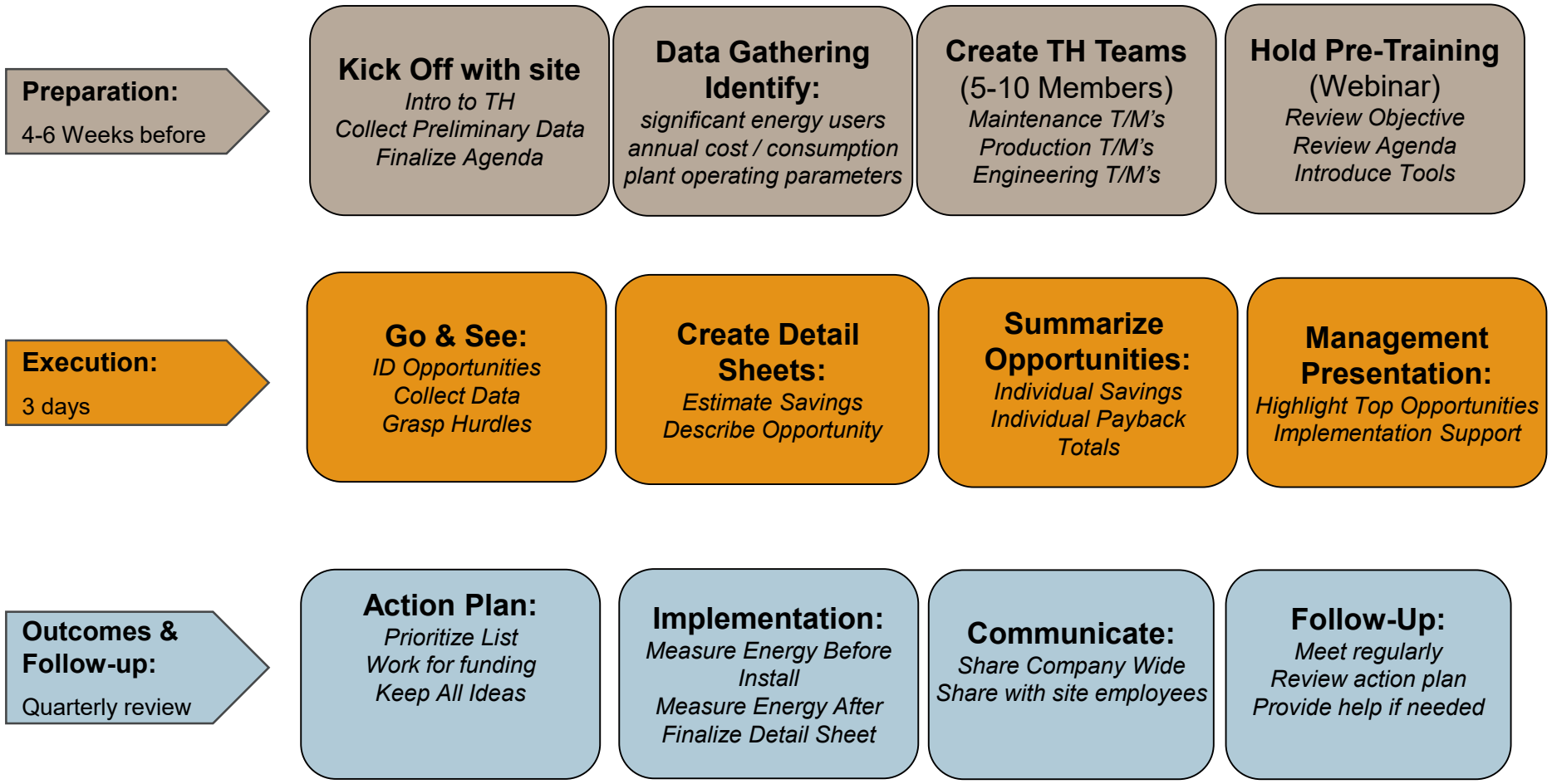
Find ways to save

- Toyota concept started in 1999
  - Shared best practice with numerous organizations
  - Provide culture change for employee engagement
- Focus on operational improvements and not capital intensive
- Observing the idle facility – usually start on Sunday or periods of reduced production
- Outside experts / participants facilitate the process, generate discussion, and help quantify opportunities
- Facility employees conduct Treasure Hunts and have ownership of the ideas / opportunities
- Local personnel will have the most expertise on optimizing facility production and operational changes
- Continuous activity, can be deployed company wide

Sample Agenda

Day	Activity	Function	Location
Thursday	Kick Off Meeting	Review Event Details & Team Assignments Treasure Hunt Introduction	Webex & Teleconference
Sunday	Observe Sleeping Facility Create Detail Sheets	Identify opportunities during weekend non production Enter plant and kaizen details into savings estimation tool (Kaizen Detail Sheet).	Host Facility
Monday AM	Observe Facility Startup Observe Production Create Detail Sheets Observe Lunch Break	Identify kaizen equipment starting too early Identify operational energy opportunities Enter plant and kaizen details into savings estimation tool (Kaizen Detail Sheet). Identify equipment to turn off during lunch (between shift if applicable)	Host Facility
Monday PM	Finish detail sheets Prepare Summary	Fill out opportunity sheets for remaining items, Refine sheets of Top opportunities Summarize total opportunity Highlight Top 3-5	Host Facility
Tuesday	Local Presentation	Senior management buy-in & support	Host Facility
Future	Follow up	Implementation update	Host discretion

Treasure Hunt Process Flow

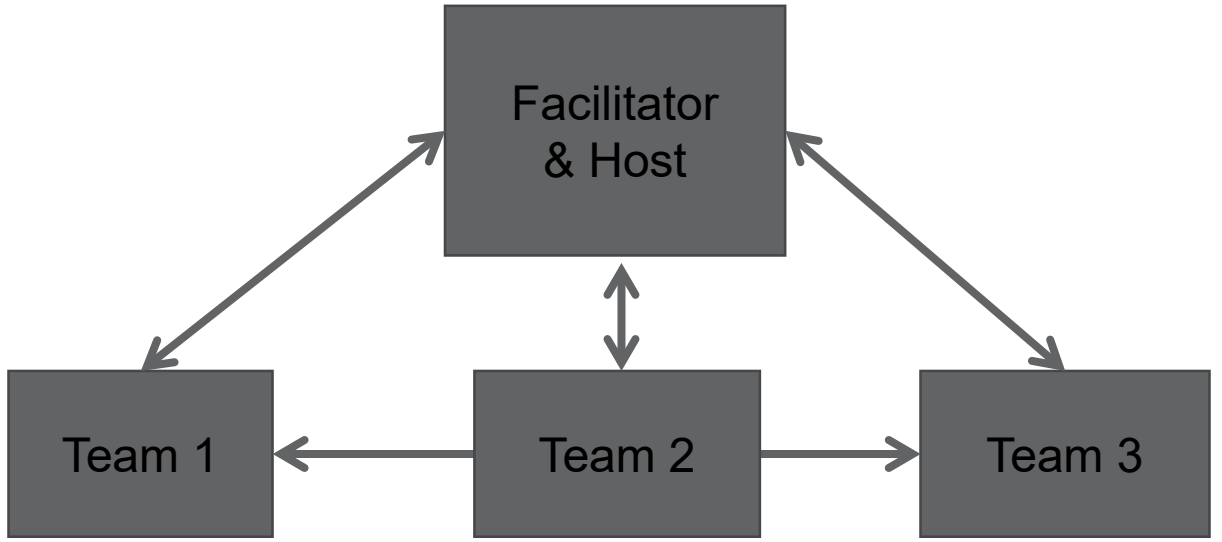


Data Gathering

- Done before the Treasure Hunt so teams can focus on “floor time” identifying opportunities during the event
- Identify significant energy users, annual cost / consumption, and plant operating parameters
- Additional information such as project lists and major upgrades that will affect the plant energy profile should be included
  - Plant energy profile – meter or utility data
  - Lighting count
  - Proposals for upgrades / projects
  - Existing projects / upgrades
  - Previous energy assessments
  - Utility rate structure / contracts

Assemble Teams

- Made up of
  - Host
  - Facilitator
  - Team Leaders
  - General participants
- Number of teams varies by site
- Focus of each team varies by site
- No more than 5 participants per team
- Assemble from different locations with different perspectives and skills



- Site Expert(s) - Knows where to get information and who makes decisions in their area of focus
- Maintenance – shift mechanic / electrician
- Production – operators, supervisors, leads
- Engineering – area engineer, process engineer
- Plant Subject Matter Expert / Owner – HVAC, Compressed Air, Electrical, etc.

Assemble Teams (continued)

- General Team Participants (continued)
  - Internal (fresh set of eyes)
    - Other organizations: Supply Chain, IT, EHS, Process Engineers, Communications, Planners, Project Management, Test engineers, continuous improvement
    - Trades: mechanics, electricians, hourly, salary
    - Anybody enthusiastic to participate
  - External
    - Consultants – compressed air, process heat, energy specialist, etc.
    - Nearby facilities, similar facilities, BU participants, internal experts, future Treasure Hunt hosts
    - Suppliers, vendors

Outside perspective for learning / sharing & items overlooked

Responsibilities

Host

- Provide data to facilitator
- Work to identify focus areas
- Identify any site people or local resources to participate
- Get buy-in from management
- Arrange event logistics
  - Team meeting space
  - One site person per team to coordinate access to plant resources
  - Close-out participants & logistics
- Assemble closeout presentation with facilitator

Facilitator

- Identify participants & team leaders
- Prepare detail sheets with host supplied data
- Conduct training with host / focus area leaders
- Present opening presentation, process, and agenda to participants during Energy Kaizen event
- Help teams use detail sheets to quantify opportunities
- Assist with closeout presentation with input from focus teams and site host

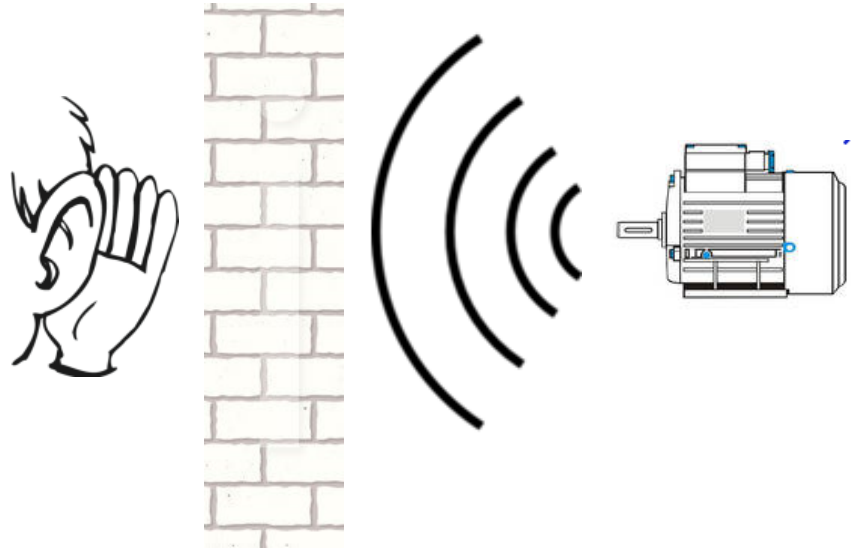
Team Leader

- Bring laptop
- Lead team to:
- Identify energy reduction opportunities
- Evaluate project viability and quantify with detail sheets
- Facilitate energy measurements
- Summarize focus area opportunities
- Oversee closing summary presentation content
- Present opportunities to management at closing summary

Identify the Right Person for Each Role

Observing The Idle (Sleeping) Facility

- Most important day for generating ideas
- Rarely is production activity 24 hrs / 7 days a week
- Take note of maintenance downtime / shift changes / off shifts
- **Use your eyes and ears to find wasted energy!**



Tools

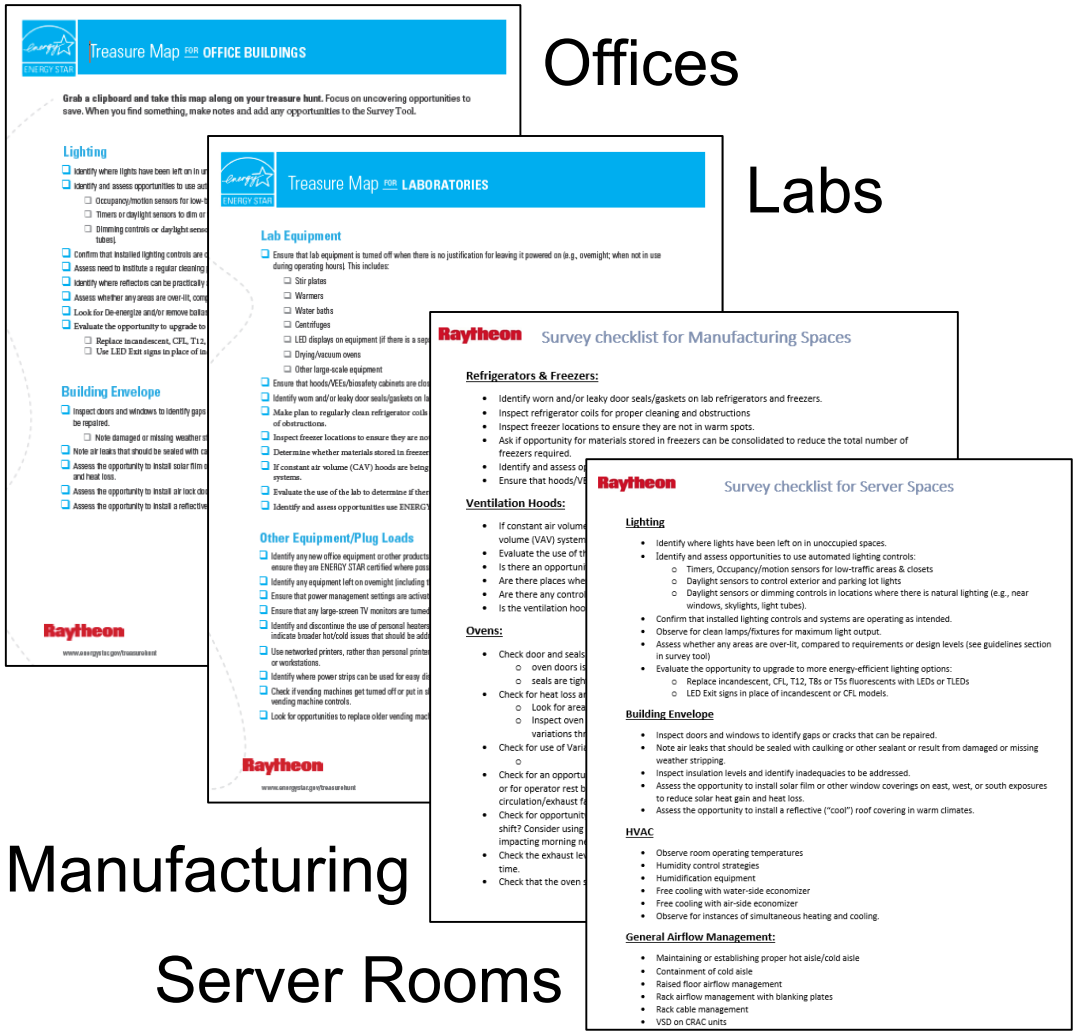
Data Gathering

Raytheon

Toolbox Inventory- list of items in the toolbox along with the Qty, what it is used for and link to manuals

Tool	Manufactuerer	Grainger #	Qty	Online Manual	Use/Specs
Data Logger,Room Occ to 12m/Light,128 KB	HOBO	35YW61	1		The HOBO Occupancy and Light data logger monitors room occupancy and indoor light changes to identify occupancy patterns, and determine energy usage and potential savings. The HOBO UX90-006 Room Occupancy/Light Data Logger is capable of 84,650 measurements. The logger is for use in indoor environments.
Laser Distance Meter 164 ft. Max. Distance, ±1/16" Accuracy	BOSCH	450W76	1		Real Time Distance, Area, Volume, Indirect, Add/Substract, Memory, Long Range Measuring, Compact Size, Jobsite Tough to Withstand Rain or Dusty Conditions, Calculates: Distance, Square Footage, Volume and Indirect Measurements
Backlit LCD Infrared Thermometer, Laser Sighting: Single Dot, -40° to 1076° Temp. Range (F)	GENERAL	53CJ25	2		Provides Surface Temperature Readings In Hard to Reach Places, Safely Determine Temperature Readings From A Distance, Can Be Use with A Phone As A Second Screen for Easier Visibility, Connects Wirelessly to iPhone and Android Phones with Application
Infrared Camera, 14° to 302°, 0.15m to Infinity	FLIR	32MX57	1	Link	Useful for evaluating structures, door seals, insulation, oven hot spots, etc.
Light Meter,0 To 40K Fc,0 To 400K Lux	EXTECH	1AEV6	1		Compact meter features a backlight for viewing readings in low light, LCD with analog bar graph, Min./max. function that stores highest and lowest readings; data hold freezes reading in display. 12" coiled cable is expandable to 24".
Data Logger,USB Interface,Temp and RH	EXTECH	1TZP9	2	Link	
Anemometer with Humidity,99 to 3937 fpm	UEI TEST INSTRUMENTS	35WC98	1	Link	Measure airflow and help quantify leakage around seals (process heat, building envelope)
Temp/Humdty Mtr,5 to 95 per Rel Hum Rnge	FLUKE	5YE63	2		
Digital Tally Counter, Black, Number of Digits: 5, Hand Held Mounting	CONTROL COMPANY	9GGF0	2		Used to count items during a survey; fixtures, windows…
Data Logger,Motor On/Off,128 KB	HOBO	35YW57	1		The HOBO Motor On/Off data logger recordsmotor on and off conditions within an AC magnetic field with its internal sensor, or mechanical contact closures from external sensing devices. This data logger is ideal for tracking the usage and runtimes of motors, pumps, compressors, and other equipment. The HOBO UX90-004 Motor On/Off Data Logger is capable of 84,650 measurements. This logger is for use in indoor environments
Ultrasonic Diagnostic Tool	SPECTRONICS	21D133	1	Link	Detects Leaks in Refrigerant, Compressed Air,Natural Gas,Propane, Gear and Bearing Wear, Electrical Discharge, Seal and Gasketintegrity, et

Checklists



Offices

Labs

Manufacturing

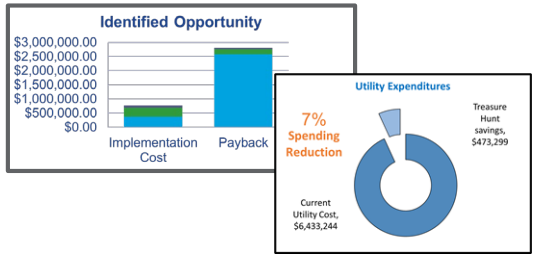
Server Rooms

Documentation and Calculation

- An “Opportunity sheet” is the excel calculator used to document and quantify an opportunity during an Energy Treasure Hunt
- Create an “Opportunity sheet” for each opportunity
- Each opportunity sheets quantifies a “before” and “after” state for the equipment
  - Consider equipment operating profiles
  - Note nameplate energy consumption or take a measurement

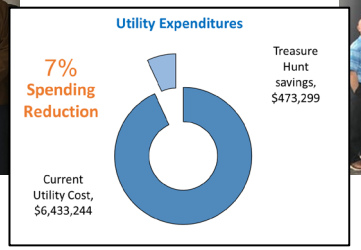
Generate: walk through facility

Assess: feasibility, gather data, quantify



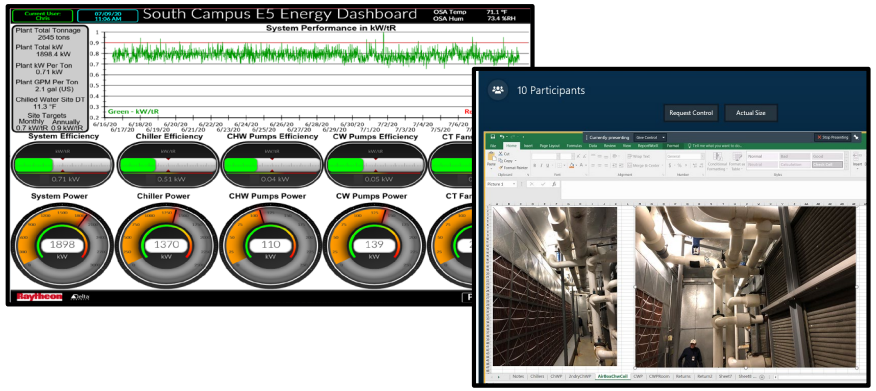
Consolidate: top opportunities

Site Treasure Hunts – 2019 & 2020



Onsite

- 2019 Performed at 4 sites
- 17 employees from 10 different locations
- Train the trainer to created larger pool for future Treasure Hunts.
- ~$470K savings identified
  - Compressed air leaks & pressure reduction
  - Lighting upgrades
  - Central chiller plant controls upgrade
  - Exhaust system upgrades



Virtual

- 2020 converted using technology
- Focus on Chiller Plants
  - Assess plant's performance against KPI of 0.65kW/tR – 0.85kW/tR
  - Provide recommendations to improve performance
- Optimize utilization of SMEs & exchange of knowledge
- Performed at 3 sites and 2 more planned
- Includes members from all 4 Businesses

Modified the Process for Current State

Treasure Hunt Suggestions & Links

- ENERGY STAR Treasure Hunts web page
- Treasure Hunt process established by Toyota (Bruce Bremer, 2005)
- Seeing is believing: Watch videos to learn from others
  - "Four steps to hosting a successful energy treasure hunt"
  - "Uncover hidden energy savings with an ENERGY STAR Treasure Hunt"
- Get familiar with detail sheets (i.e. data collection)
  - Instruction tab explains how to use
  - Tabs for plant information, opportunity summary & project details
  - Project details feed automatically to opportunity summary & analysis tabs
- US DOE Better Building program has additional tools & resources

Project specific assessments (Hint: utilities can help)

- You and your colleagues may already know some opportunities
  - Add details to TH project tabs
  - Keep calculations simple if possible
  - Submit multiple project savings to Find The Treasure campaign
  - Use this data for MassSave incentive applications
  - Utility reps can help guide you or call 1-866-527-SAVE (7283)
    - Technical assistance may be available for some projects

Title:	Opportunity Short Title					
Area:	Insert text describing the project area within the plant.				Date	Enter Date
Opportunity Type:	○ Operational	○ Equipment Modification	○ Equipment Upgrade	◉ Other	Originator(s):	

Opportunity Description

Background	Insert text describing the background.
Opportunity	Insert text description of opportunity.

Current Situation (before Opportunity)			Projected Situation (after Opportunity)		
Equipment Name:			Equipment Name		
Running:	Production Hours	Non-Production Hours	Running:	Production Hours	Non-Production Hours
Hours/Day			Hours/Day		
Days/Month			Days/Month		
Months			Months		
Set point			Set point		
Other			Other		

Energy/Utility Use

Utility Use (Annual)				Utility Use (Annual)			
Electricity			KWh	Electricity			KWh
Natural Gas			MMBtu	Natural Gas			MMBtu
Propane			MMBtu	Propane			MMBtu
Heating Oil			MMBtu	Heating Oil			MMBtu
Coal (bituminous)			MMBtu	Coal (bituminous)			MMBtu
Water			Kgal	Water			Kgal
Sewer			Kgal	Sewer			Kgal
Other 1			User defined	Other 1			User defined
Other 2			User defined	Other 2			User defined
Other 3			User defined	Other 3			User defined

Project Cost & Savings Estimates

Implementation Costs			Projected Annual Savings			
Cost Type	Hours	$	Utility	$	Units	
Engineering Svcs		0.00	Electricity	0.00	0.0	KWh
In-House Labor		0.00	Natural Gas	0.00	0.0	MMBtu
Contract Labor		0.00	Propane	0.00	0.0	MMBtu
Other 1		0.00	Heating Oil	0.00	0.0	MMBtu
Other 2		0.00	Coal (bituminous)	0.00	0.0	MMBtu
Other 3		0.00	Water	0.00	0.0	Kgal
			Sewer	0.00	0.0	Kgal
Material Costs			Other 1	0.00	0.0	User defined
Other Costs			Other 2	0.00	0.0	User defined
			Other 3	0.00	0.0	User defined
Total Implementation Costs		0.00	Total Cost Savings	0.00	$	
			Simple Payback	0.00	Years	
			Source Energy Savings	0.00	MMBtu (Source)	
			Source Energy Savings	0.00	%	
			Site Energy Savings	0.00	MMBtu (Site)	
			Site Energy Savings	0.00	%	
			CO_2e Savings	0.00	Metric Tons CO_2e	
			CO_2e Savings	0.00	%	

Virtual Assessments

- Develop a virtualized energy efficiency offering for large commercial & industrial customers;
- First step on continuum of options;
- Use available utility data to review customer operations; look for patterns and anomalies, such as equipment running during unoccupied hours;
- Identify a pipeline of opportunities, which can be further assessed and verified with future studies and site visits;
- Enhanced data analysis offers customers a low-touch option.

Goal: Engage Customers & Identify Opportunities

Finding Efficiency Opportunities

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EVERSOURCE

(hyper link to Energy Profiler Online & other resources)

Thank you.