APRIL
11-13
2023

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U.S. DEPARTMENT OF ENERGY

We Conduit: Lessons Learned from the Industrial Electrification Working Group

Thursday, April 13th, 2023
10:30 AM – 12:00 PM ET

Moderator Name: John O’Neill

Organization: Department of Energy (DOE)

U.S. DEPARTMENT OF ENERGY

Agenda

1. Welcome and Introductions
2. Electrification Working Group Overview
3. Industrial Electrification – Trane Technologies
4. Grow & Impact – Saint Gobain
5. Electrification Case Studies – Volvo Group
6. Closing and Q&A

Today's Presenters

- **Kiran Thirumaran, Research Associate**
  - Oak Ridge National Lab
- **Charles Jelen, Industrial Decarbonization Program Manager**
  - Trane Technologies
- **Bilal Mohammad, Sustainability Manager – CertainTeed Gypsum**
  - Saint-Gobain Corporation
- **Bert Hill, Manager of Health Safety & Environmental**
  - Volvo Group

Kiran Thirumaran

Oak Ridge National Laboratory (ORNL)

Agenda

- Electrification Overview
- Working Group - Summary
- Working Group - Deliverables
- Next Steps

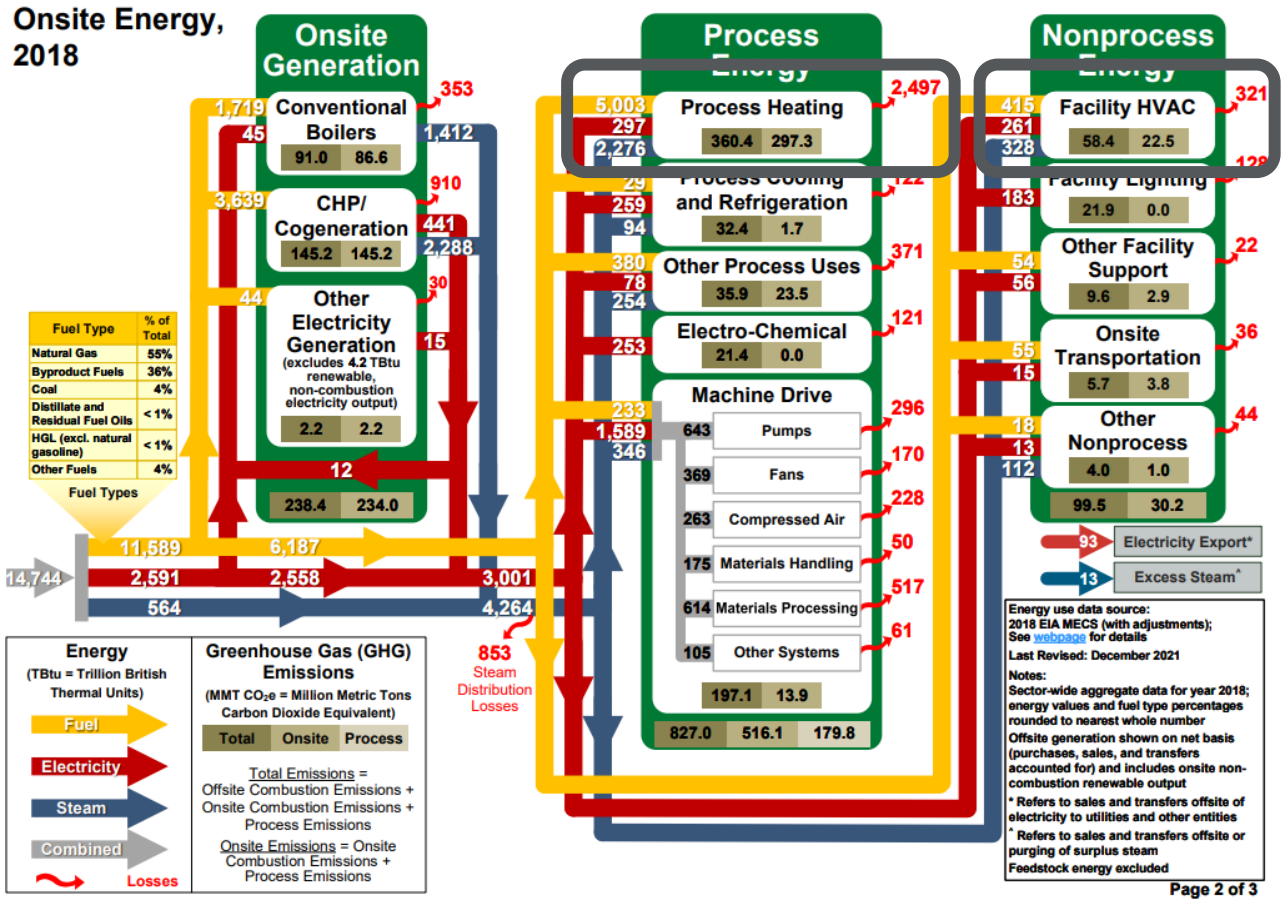
Electrification in Industries

Electrification: The shift from any non electric source of energy to electricity at the point of final consumption

Common Electrification Strategies in Industries

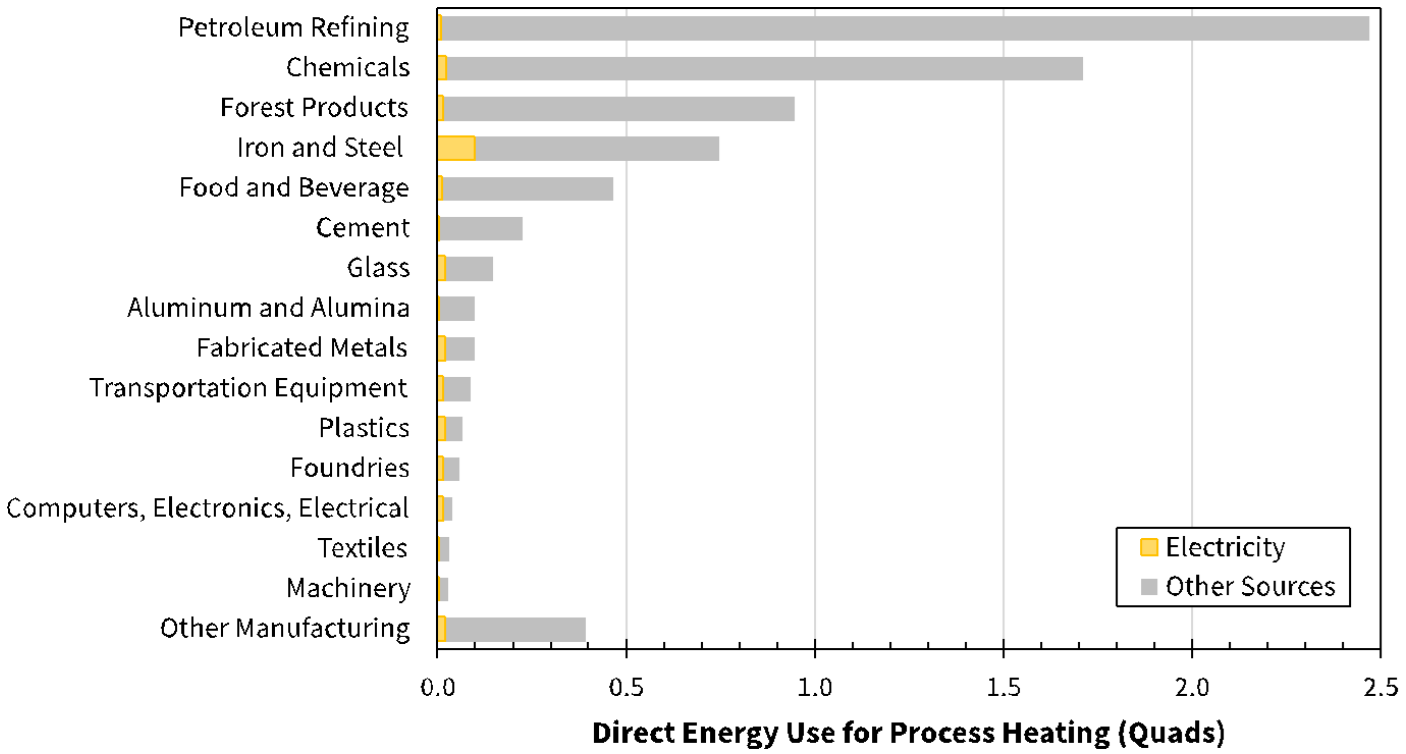
- Process Heating
  - Direct resistance melting
  - Electromagnetic heat treatment
  - IR curing
- Building HVAC
  - Electric Boilers
  - Heat pumps
  - Infrared and resistance heaters
- Electric steam generators
- Forklifts and fleet vehicles

US Manufacturing Energy Footprint

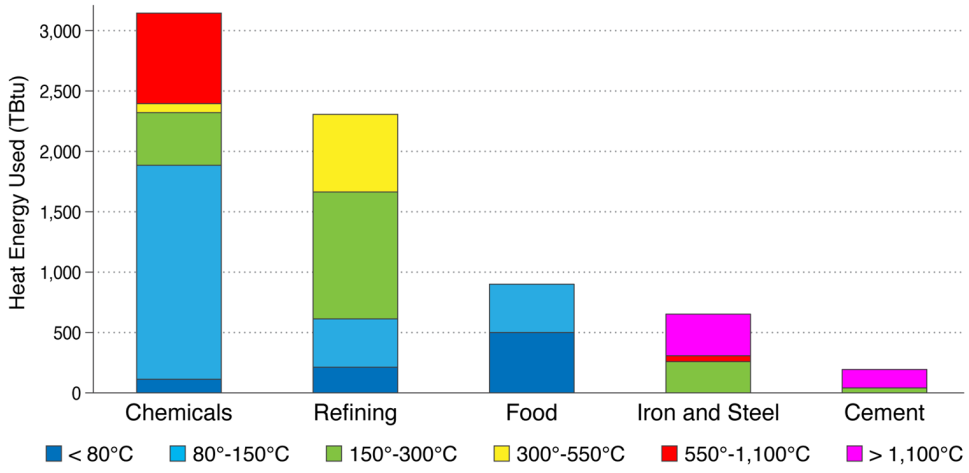


Less than 5% of Process Heating Energy and 26% of Facility HVAC Energy is from Electricity. Source: EIA Manufacturing Energy Consumption Survey 2018.

Energy Used for Thermal Processing



Process heating energy use by source for different industries (2018)



Distribution of process heat temperature ranges by industrial subsectors (2014)

Source: AMO Manufacturing Energy and Carbon Footprints

Source: MECS 2014

Working Group Vision

- Facilitate discussion among Better Climate Challenge partners and allies in a small group environment to discuss specific topics around GHG emissions reductions.
- The groups will share insights, strategies, and action plans, and DOE technical experts will support the working group participants
- Met every 6 weeks, for 8 meetings (Aug. 18th, 2022 to June 1st 2023)

- Develop DOE resources and BCC approaches incorporating feedback from all working group members
  - Facility-Level Electrification Assessment Framework
  - Facility Electrification Readiness Checklist
  - Technology-Specific Tools

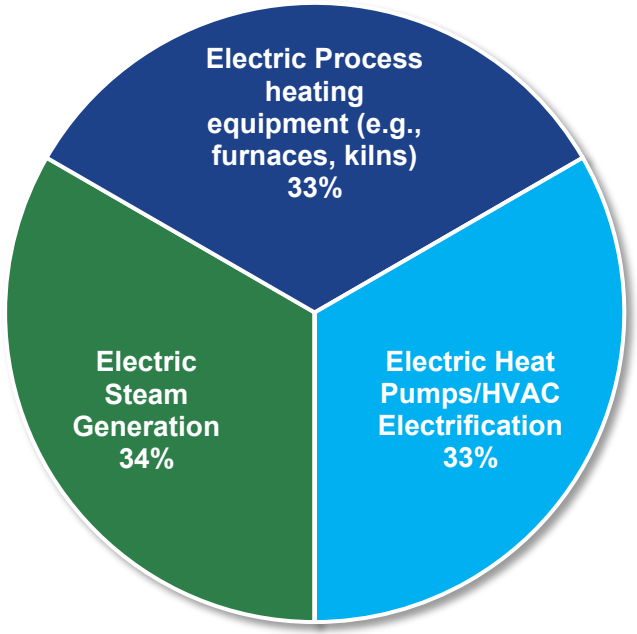
Thank you to the Participants

Organization	Participant
3M	Kalie Miera
Chemours	Catherine Collison
Colgate-Palmolive Company	Casey Mahalick
Deschutes Brewery	Mark Fischer
HNI	Lisa Brunie-McDermott
Honeywell	Kaylan Meinecke Manish Sharma Nikki Mehta
Ingersoll Rand Corporation	Gordon Smith
Johnson Controls Inc.	Heather DeLUcia
Lear Corporation - Planta NCG	Osiel Ramirez
Lundberg Family Farms	Lacey Moore

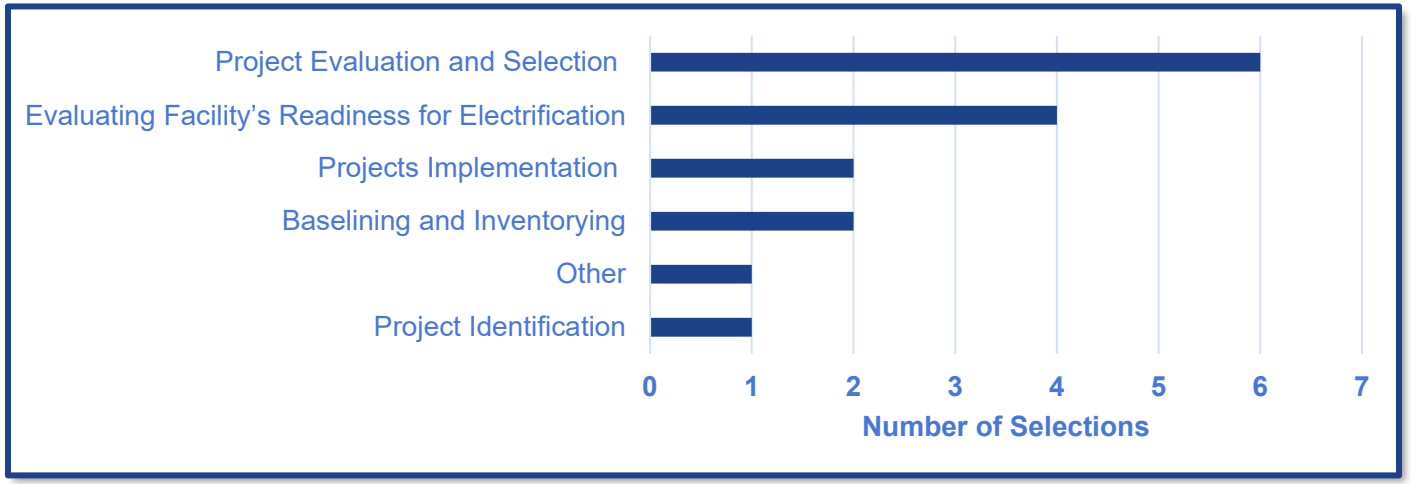
Organization	Participant
Saint-Gobain	Rochelle Samuel Blair Sturm
Schneider Electric	Anand Varahala
Siemens	Matt Helgeson Abigail Campbell Singer
Steelcase	Casey Dupuie
Stellantis	Kim Baslock Ernie Sommerville Fady Abuolba
Stryker	Eli Levine
Trane Technologies	David Ocamb
Volvo Group NA	Bert Hill
Whirlpool	Scot Blommel
Xerox Corporation	Marcus Lathrop

Early Discussions

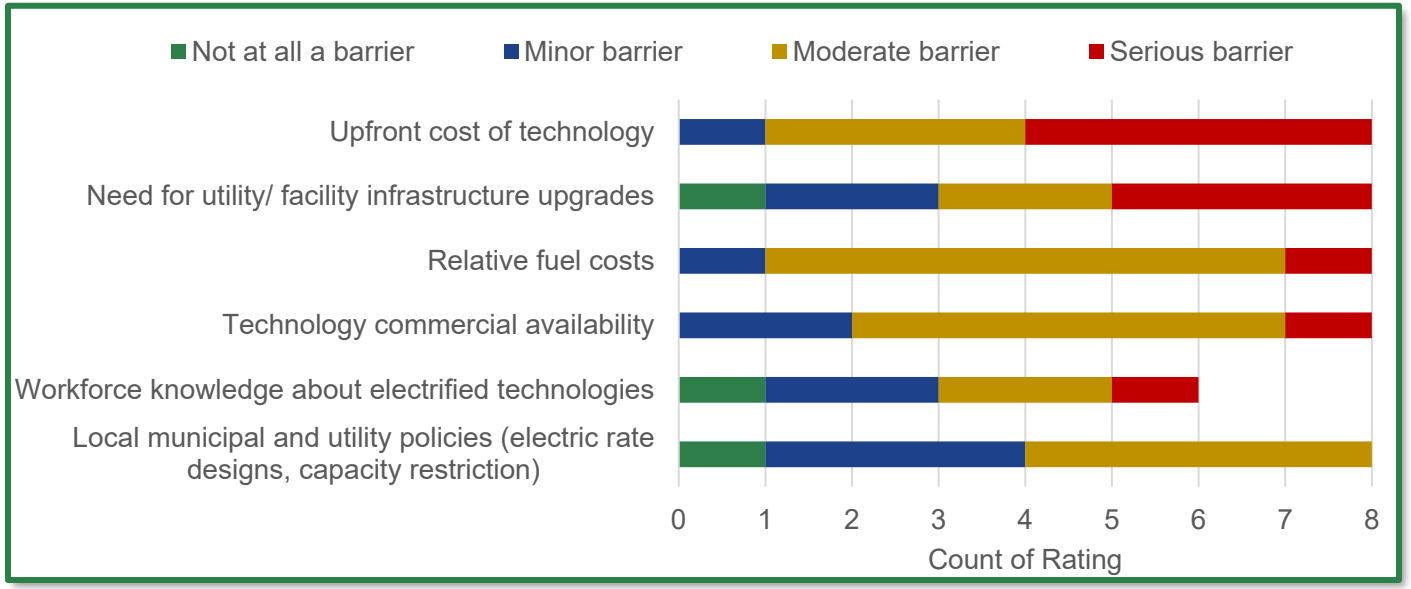
What are the Electrotechnologies of most interest to your organization?



What are the topical areas this working group should focus on?



Rate the barriers to implementing Electrotechnologies



Electrification Framework Document

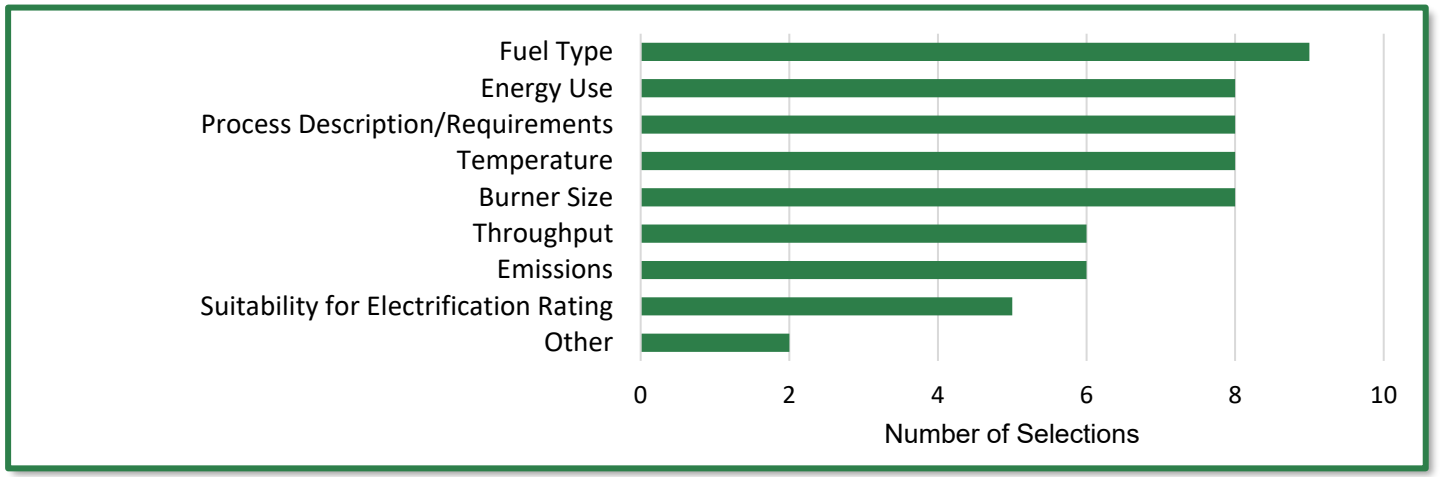
1.) Inventory and Portfolio Management	2.) Assessing Facility's Electrification Readiness	3.) Identifying Strategies for Electrification	4.) Evaluating and Implementing Projects
• Identify Significant Energy Users (SEU) and KPI • Estimating baseline energy use and emissions breakdown by system	• Estimating increase in electric power demand • Assessing facility and utility side infrastructure • Assessing utility rates • Local grid emissions • Workforce Development	• Technologies for Process heating, HVAC and Forklifts • Guidance on project Identification	• Guidance on technology selection • Building holistic cost comparison models • Quantifying non-energy benefits • Project Prioritization

Inventorying and Electrification Readiness

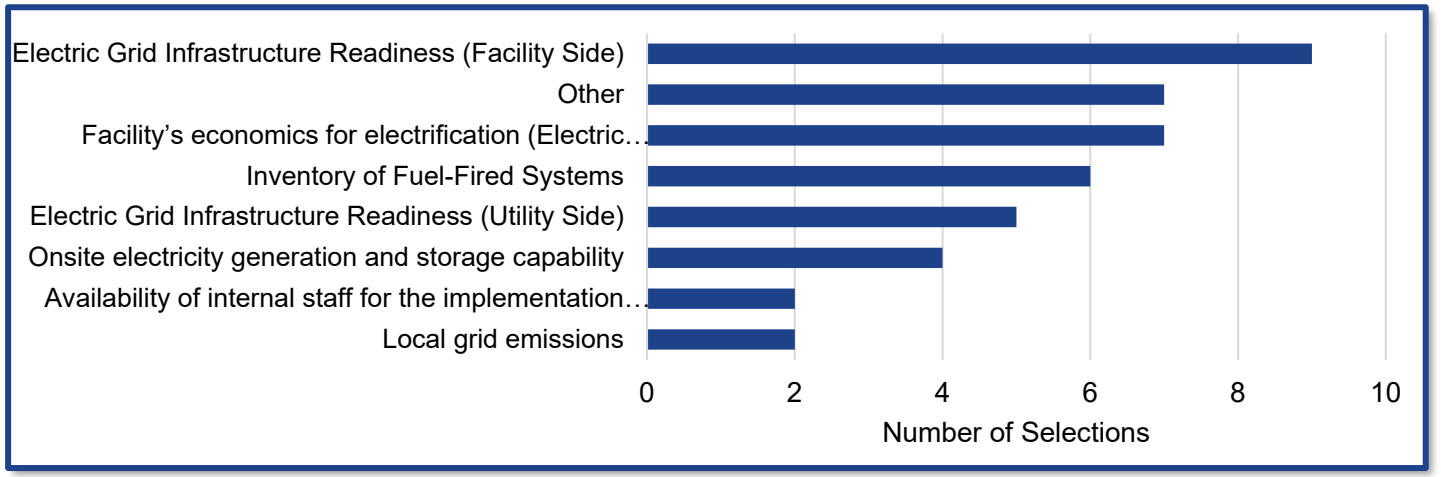
- Inventorying helps understand a facility's baseline systems and is the first step on the electrification journey
- Electrification impacts multiple auxiliary systems and operations at a facility hence knowledge of a facilities and its infrastructure readiness for electrification is key.
- Assessing a facility's electric infrastructure involves
  - Estimating Electric Capacity Requirement
  - Assessing Utility Side and Facility Side Infrastructure
  - Understanding Utility Rate Structure Option
  - Determining Local Grid Emissions

The "Electrification Framework Document" will provide guidance and tools to help with inventorying and assessing a facility's electrification readiness

Select the key parameters that need to be tracked as part of an inventory for fuel-fired systems.



What components are most important in understanding a facility's electrification readiness?



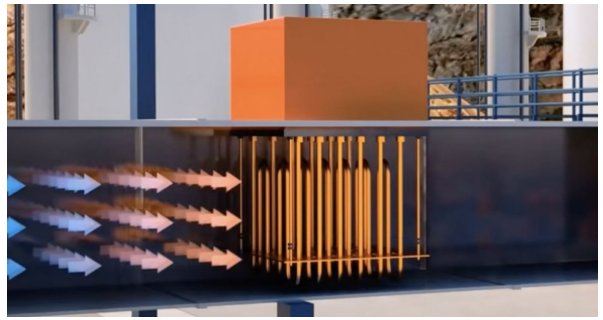
Electric Systems for HVAC Applications - Summary from Discussions

Implementation of electrification is presently predominately in HVAC and low temperature process application (drying, water heating etc.)

HVAC Applications – Highlights

- Resistance coils and IR systems are very common in comfort heating
- Heat pumps are being implemented for HVAC application where temperature is appropriate. (E.g. Stellantis)
- Heat pumps still needs to be proven in in colder climates. Need for resistance backup is a limitation for using HP
- For several partners, their European offices leverage heat pumps more than their U.S. buildings because of higher natural gas prices in the European Union.
- Electric hot water heaters are being implemented by a couple of partners and steam boilers are being considered by a few partners - the additional electric demand poses a big barrier.

Heat Pumps



Resistance Based Duct (air) Heaters

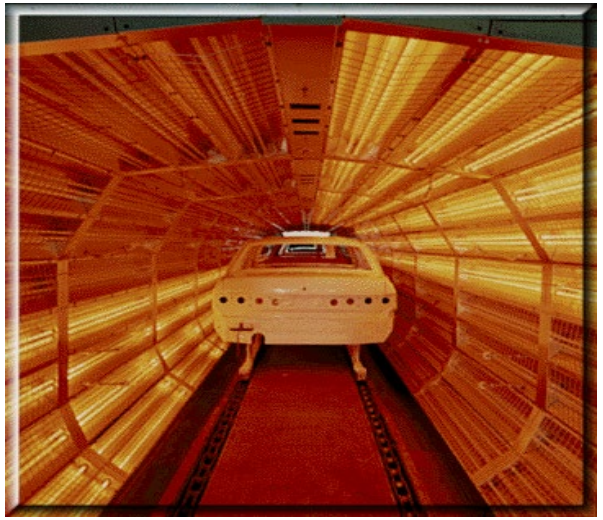
Infrared Heaters

Sources: Johnson Controls, Clevebrooks, Spaceray

Electric Systems for Process Applications - Summary from Discussions

Process Applications – Highlights

- Electric IR for paint drying process is already being implemented by partners
- Infrared is suitable for metal part drying and paint/coating curing as it has a lower maintenance cost and produces faster curing times than using natural gas but require line-of-sight so it is not well-suited for complex geometries.
- Heat pumps for process applications are not widely adopted in the US yet but has high potential
- In tank fluid heating is of interest for many partners
- Electric coils to replace steam jackets can reduce thermal load
- High Voltage Electric Resistive Boilers are being considered by a few partners, but the high electric demand is a limitation.



Electric IR for Paint Lines

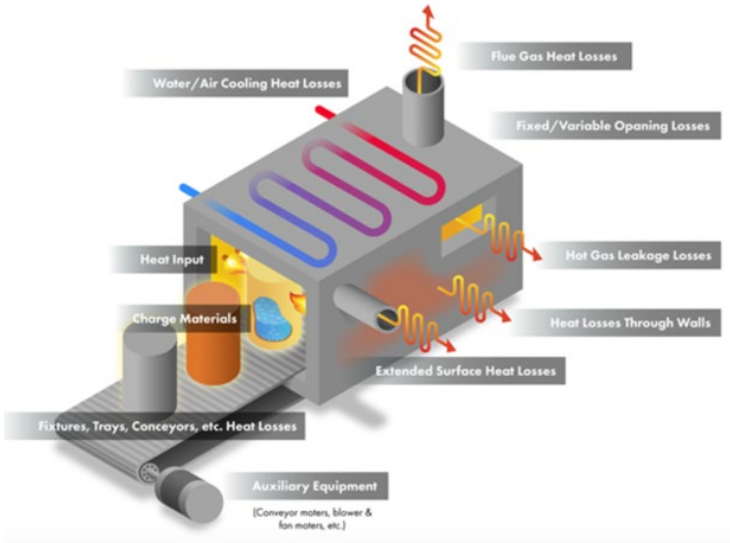
MW used in Drying

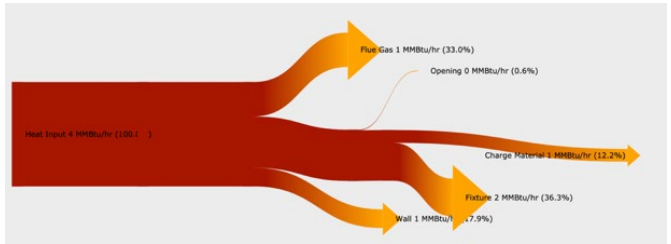
Induction furnaces for melting metals

Sources: Johnson Controls, Clevebrooks, Spaceray

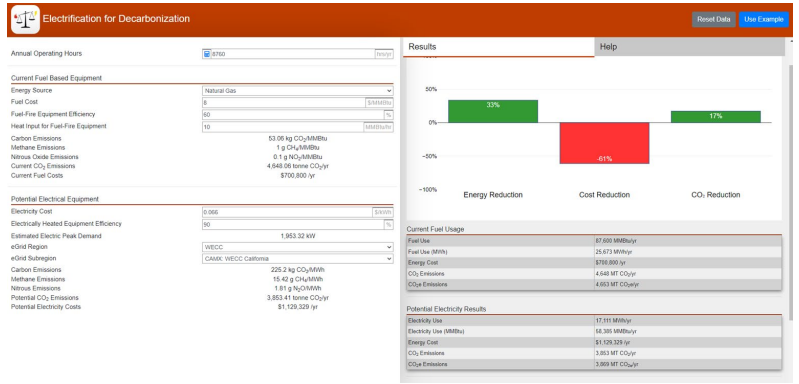
Available Tools

- MEASUR – Energy Modelling Tool
  - Model existing process heating systems
  - https://measur.ornl.gov/landing-screen
- Thermal Processing Cost Comparison Model
  - Calculate holistic cost of switching
  - https://energyefficiency.ornl.gov/tools-training/
- Electrification for Decarbonization Tool
  - Location based emissions reduction
  - https://electrification.ornl.gov/

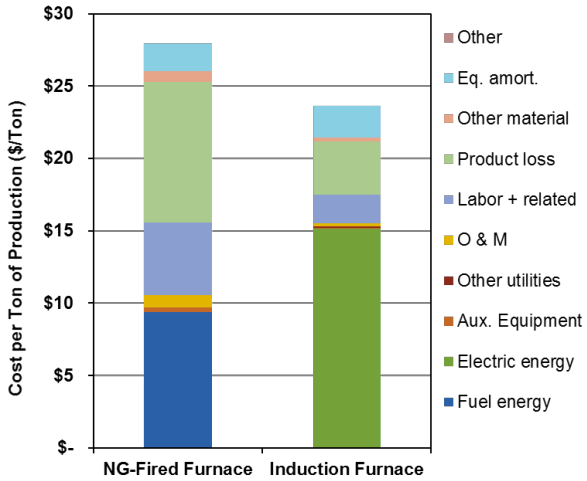




Results from Energy Modelling using MEASUR platform's process heating module



Electrification Impact Calculator



Cost Modelling comparing NG-Fired Furnace vs Induction Furnace in a Forging Plant

Tools being built by working group team

Checklist for Facility Readiness

Helps users assess a facility's preparedness to integrating electric technologies.

Checklist format with questions related to power threshold, electric infrastructure, utility rates, workforce availability

System Specific Scoping tools

Helps users take the "first step" to understand the scope/opportunity for specific electric technologies (Heat Pumps) at your facility

Simple questionnaire format for inputs with a score card result without need for much data

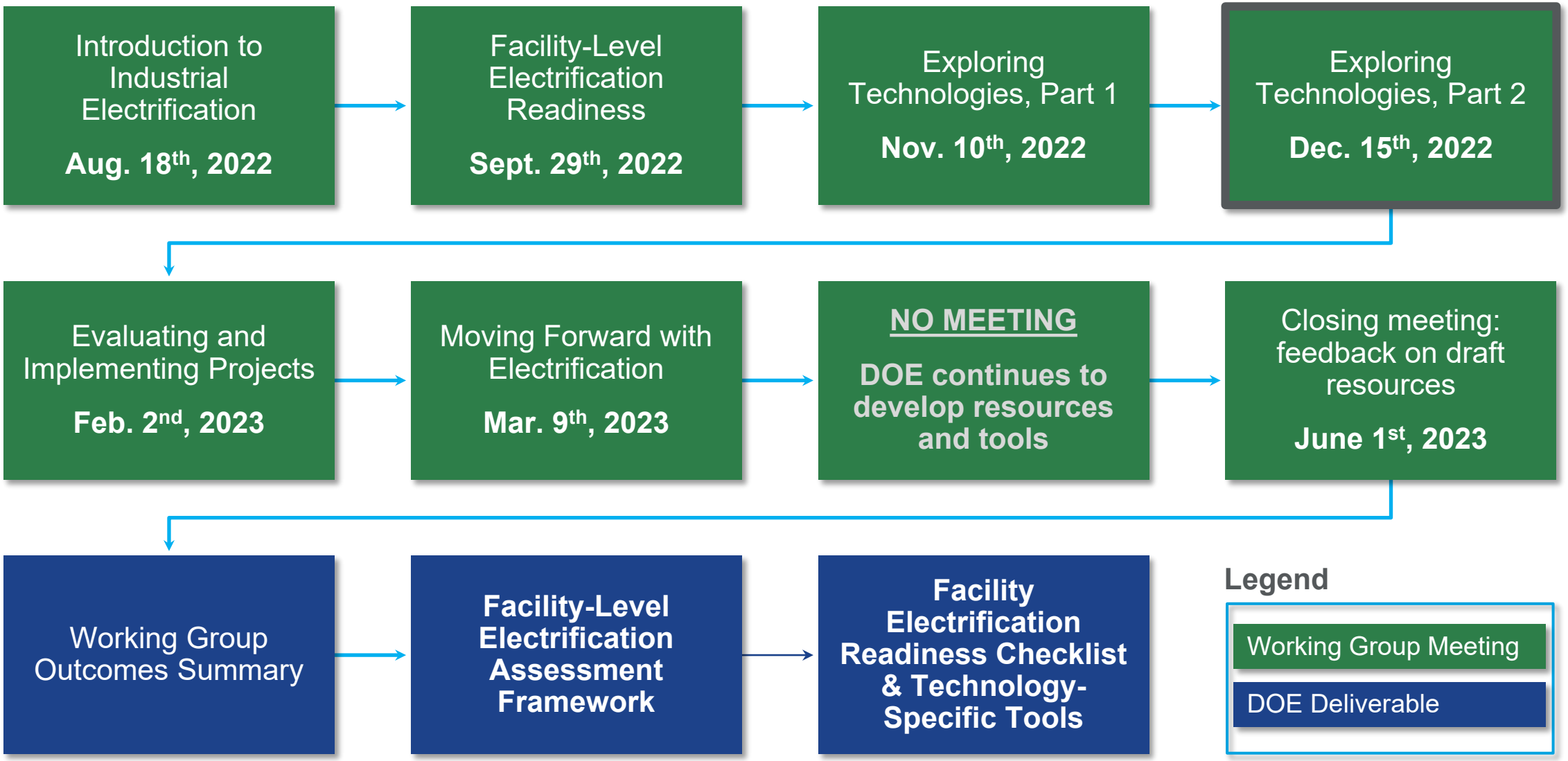
Inventorying Template

Identify and track the SEU at the facility your electrification projects and its emission reduction in a single tool

Billing Analysis

Spreadsheet tools to help analyze current utility rate structure and its impact with electrification

Electrification Working Group – Next Steps



Thank you!

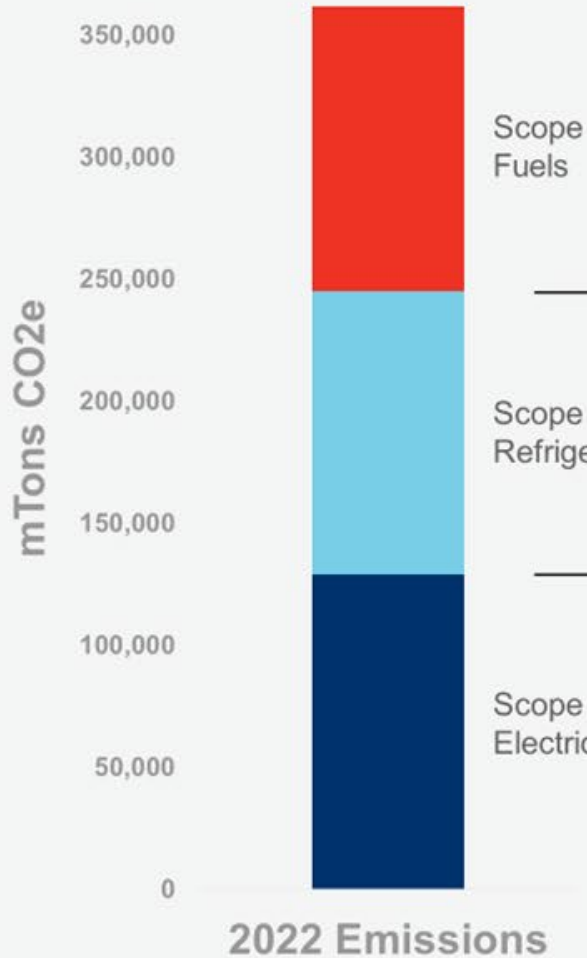
Charles Jelen
Trane Technologies

Industrial Electrification

Charles Jelen – Industrial Decarbonization Program Manager

Trane Technologies

Emissions Profile



Scope 1 - Fuels

Scope 1 - Refrigerants

Scope 2 - Electricity

Path to Carbon Neutrality

Efficiency

Electrification

Lower GWP

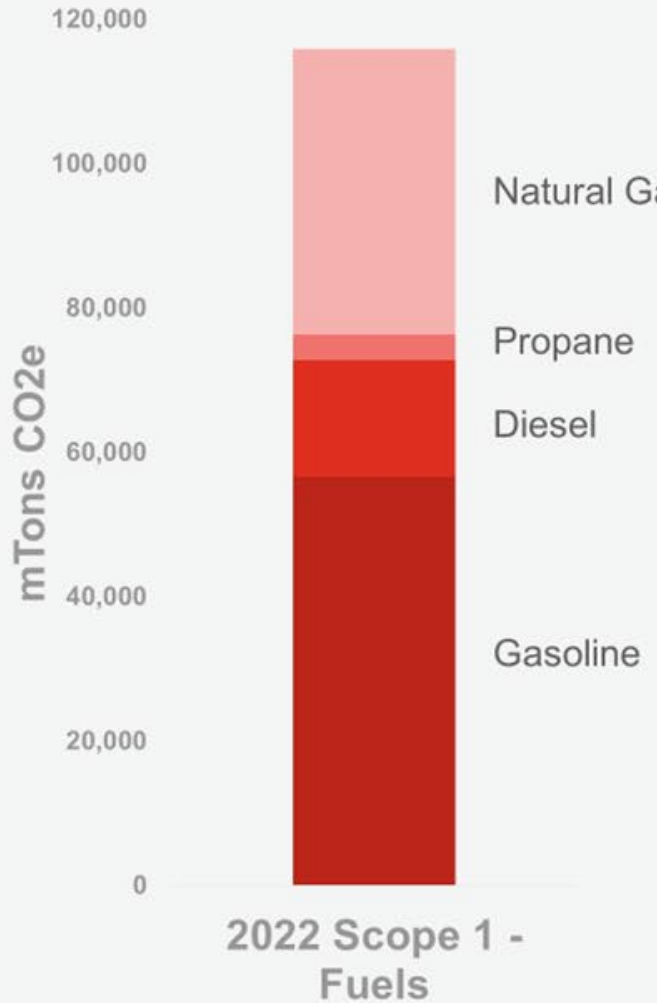
Refrigerant Destruction

Efficiency

Renewables

Trane Technologies

Emissions Profile - Fuels



Natural Gas

Propane

Diesel

Gasoline

33% of Fuel Emissions

10% of Total Emissions

Natural Gas End Uses

Process Heating

Space Heating

Water Heating

Electrification

Charmes, France

Facility Data

Built: 1974

Manufacturing SqFt: 170,000

Office Space: 24,000

Project Goals

Replace End of Life Boilers

Reduce Emissions

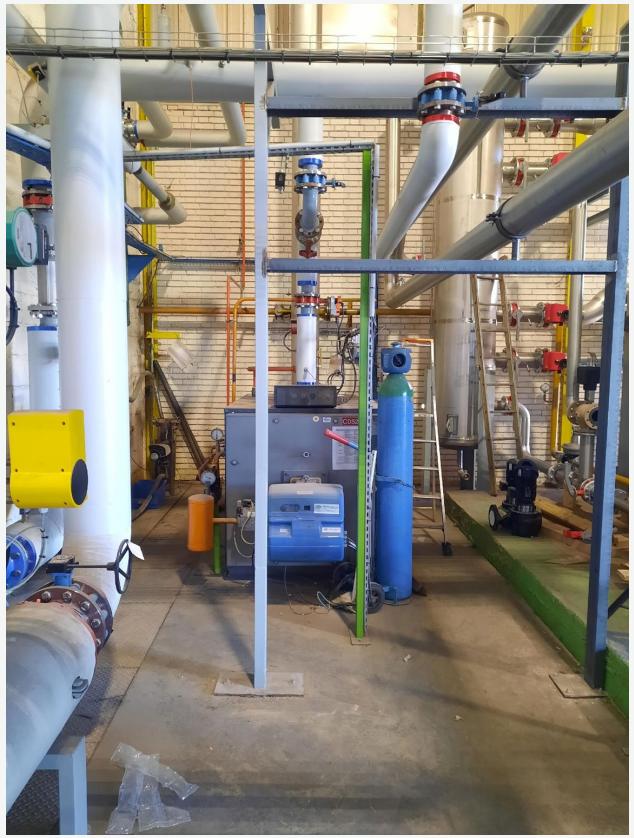
Reduce Natural Gas Consumption

Demonstrate Feasibility

Natural Gas System

Charmes, France

2 Natural Gas Boilers
185F Design Point



Air Handlers
Single Row Heating Coils

Challenge:
-Space for New Equipment
-Electrical Infrastructure
-Hot Water Temperature

Electrified System

Charmes, France

Heat Recovery
Air-Source Heat Pumps
120F Hot Water Temp

Air Handlers
Multi Row Heating Coils

Project Outcomes

Charmes, France

Natural Gas Consumption

5,069,000 kWh

Emissions

895 mTons CO2e

Electrified System

1,986,000 kWh

Emissions

138 mTons CO2e

System Benefit

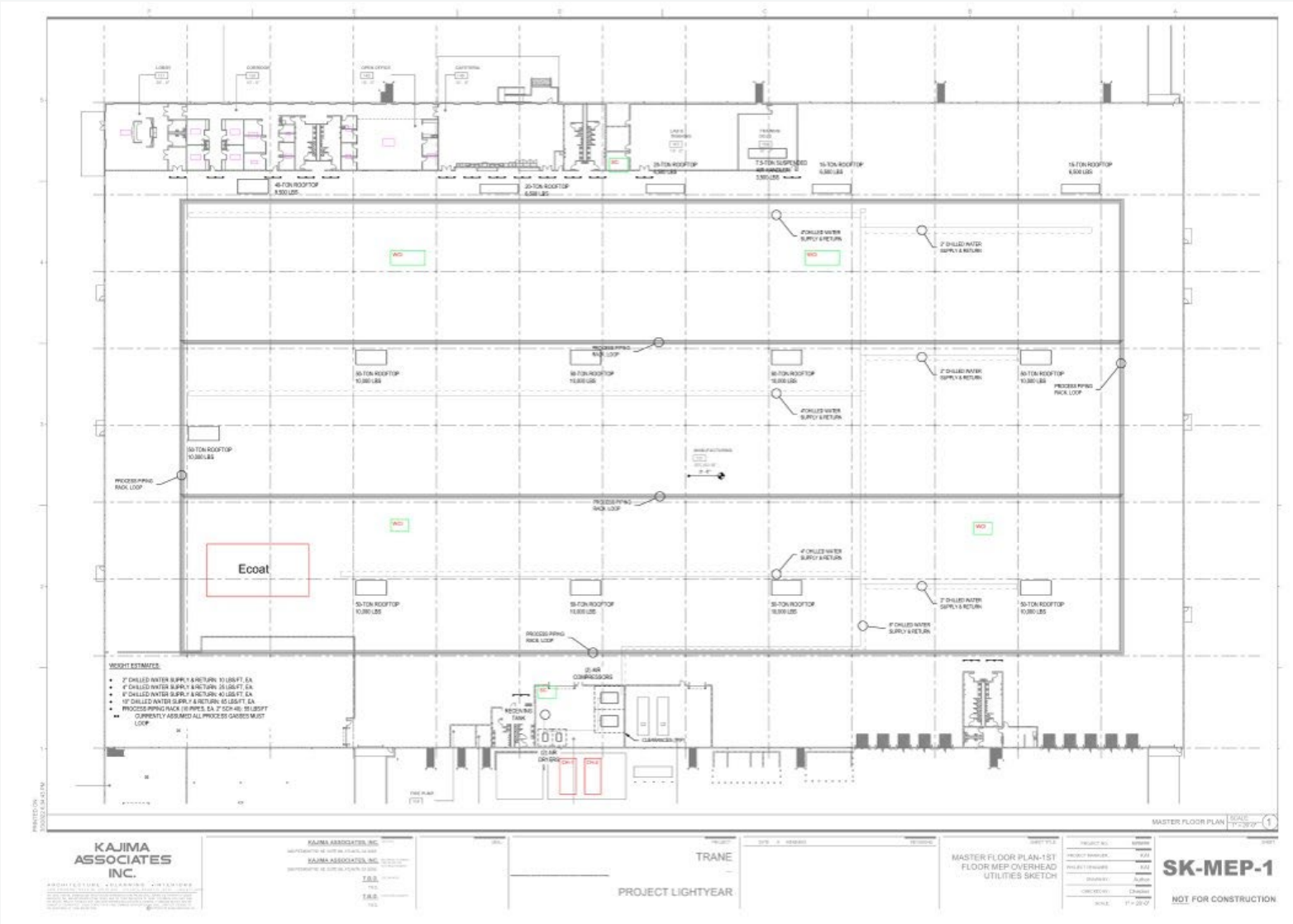
61% Reduction

Emissions

85% Reduction

Electrification

Greenville, SC



Facility Data

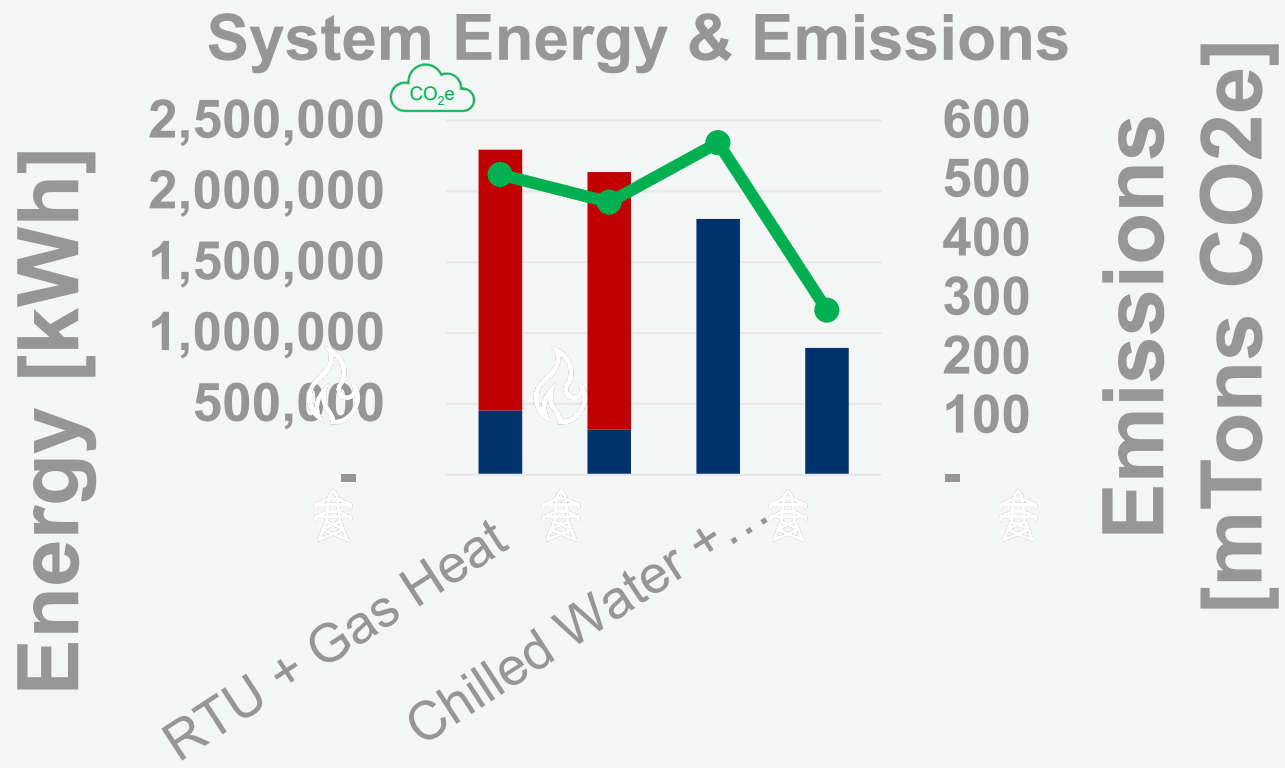
Built: New Construction
Manufacturing SqFt: 270,000
Office Space: 30,000

Project Goals

Electrified Design
Showcase Capabilities

Electrification

Greenville, SC



Other Projects

Electrification

Office Space

VRF Systems

RTU Heat Pump Systems

Split System Heat Pumps

Dual Fuel Heat Pumps – Cold Climate

Warehouse

RTU Heat Pump Systems

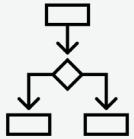
Dual Fuel Heat Pumps – Cold Climate

Manufacturing

RTU Heat Pump Systems

Dual Fuel Heat Pumps – Cold Climate

Air Turn Over Units



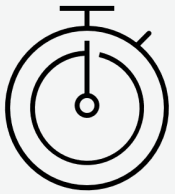
Process Heating

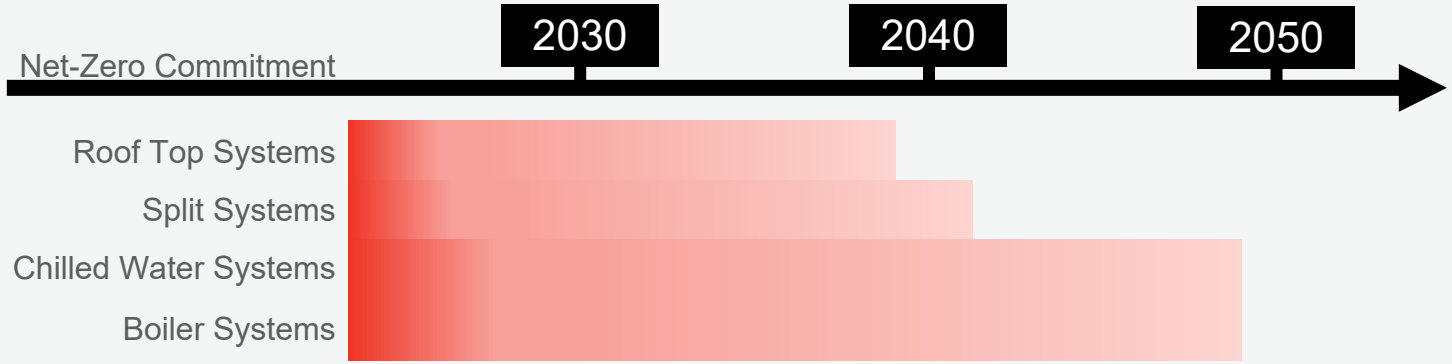
Low Temp Boiler Replacements

Suggestions

Electrification

Reason for Action





Staging Projects

Ideal External Conditions:

- ☑ Low Emission-Factor Utility Grid
- ☑ Low Spark Spread
- ☑ Utility Incentives

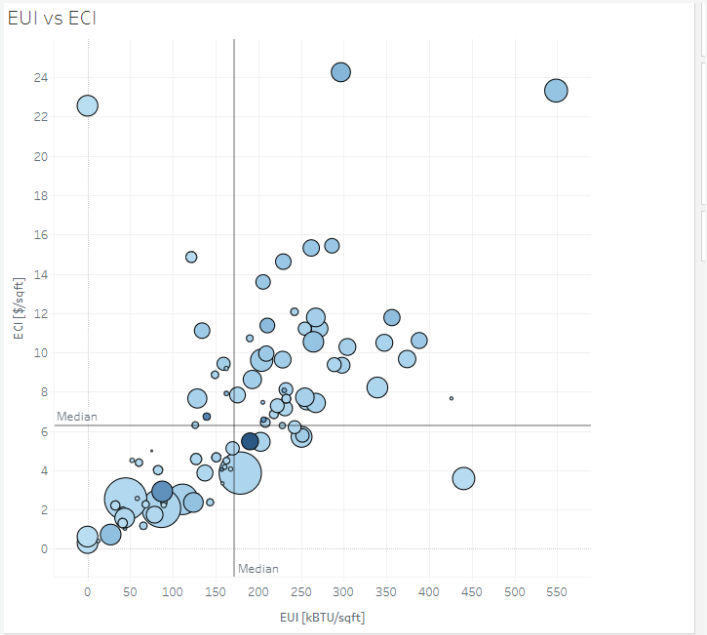
☑ Other Considerations:
Mild Ambient

System Selection

Space Heating
Domestic Water Heating
Process Heating <180F

Process Heating 180F+

+Visualizations
+ IRA Technologies



Bilal Mohammad

Saint-Gobain Corporation

BETTER BUILDINGS BETTER PLANTS SUMMIT

BILAL MOHAMMAD

SAINT-GOBAIN

SAINT-GOBAIN NORTH AMERICA AT-A-GLANCE

GROW & IMPACT

More than
18,000
employees

With Businesses
in Operation for over
115 years

Over 145
manufacturing facilities in
the U.S. and Canada

2022 Sales *
~$10.5bn

#1 building materials manufacturer in the United States and Canada

SAINT-GOBAIN

CARBON REDUCTION GROUP OBJECTIVES

GROW & IMPACT

2030

+ Scope 1 + 2 **-33%**

+ Scope 3 **-16%**

Reduction in absolute emissions vs 2017

2050 NET ZERO CARBON

Definitions

Scope 1 ► *emissions are direct emissions from company-owned and controlled resources. In other words, emissions released to the atmosphere as a direct result of a set of activities, at a firm level*

Scope 2 ► *emissions are indirect emissions from the generation of purchased energy, from a utility provider. In other words, all GHG emissions released in the atmosphere, from the consumption of purchased electricity, steam, heat and cooling*

Scope 3 ► *emissions are the result of activities from assets not owned or controlled by the reporting organization, but that the organization indirectly impacts and may be able to influence via its value chain. Scope 3 emissions include all sources not within an organization's scope 1 and 2 boundary*

SAINT-GOBAIN

WE ARE ACCELERATING OUR ENERGY TRANSITION

GROW & IMPACT

World-first zero carbon production of glass with

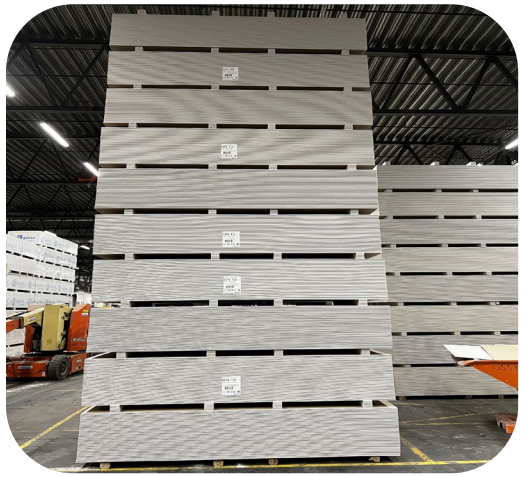
100% recycled glass

World-first zero carbon plants for plasterboard production in 2023 and 2024

ON TRACK TO MEET OUR 2050 NET ZERO CARBON AMBITION

SAINT-GOBAIN

WE ARE DELIVERING



Fredrikstad, Norway

WORLD FIRST

Zero manufacturing carbon plasterboard produced in March 2023

Full scale electrification

40% Increase in Production

Utilizing Green Hydro Power

Montréal, Canada

NORTH AMERICAN FIRST

1st Zero manufacturing carbon in NA upcoming Dec 2024

Full scale electrification

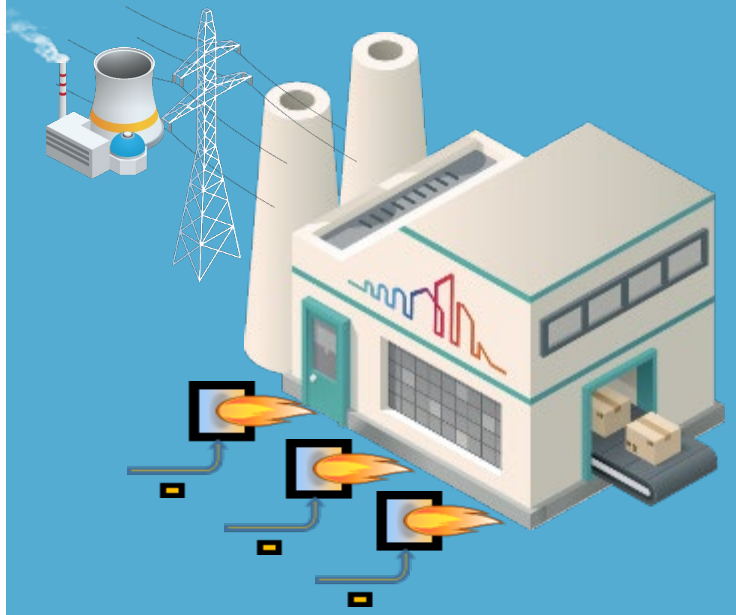
40% Increase in Production

Utilizing Green Hydro Power

OPTIONS TO REDUCE EMISSIONS

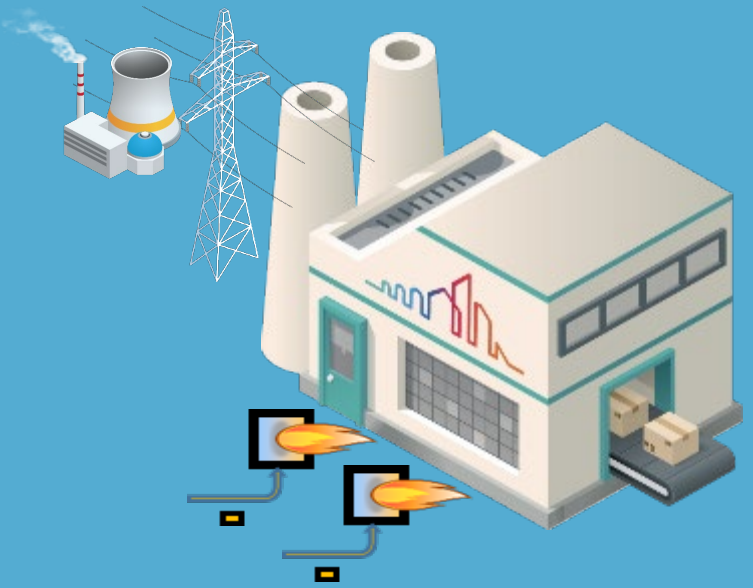
GROW & IMPACT

Current



Electrification

Reduce Gas Consumption



FOCUSED ANALYSIS – ELECTRIFY OR OPTIMIZE

- *Old damaged burner with inconsistent flame*
- *Consistent damage to refectory increasing maintenance cost*
- *High % excess air*
- *$3,000,000 per year of natural gas*
- *Scope 1: 20,000 tonnes CO2*
- *Scope 2: 4,000 tonnes CO2*

FOCUSED ANALYSIS – ELECTRIFY OR OPTIMIZE

Reduce Gas Consumption		Electrification
8%	EFFICIENCY	20%
10% Increase	PRODUCTION	10% Increase
$500,000	CAPEX	$10,000,000 ($5,000,000)
$2,750,000	OPEX ($3,000,000)	$10,150,000
18,400 TONNES	Scope 1 (20,000 tonnes)	0 TONNES
4,000 TONNES	Scope 2 (4,000 tonnes)	36,000 TONNES

FOCUSED ANALYSIS – ELECTRIFY OR OPTIMIZE

ROADBLOCKS

Road blocks Removed

- Commitment
- Know how
- CAPEX

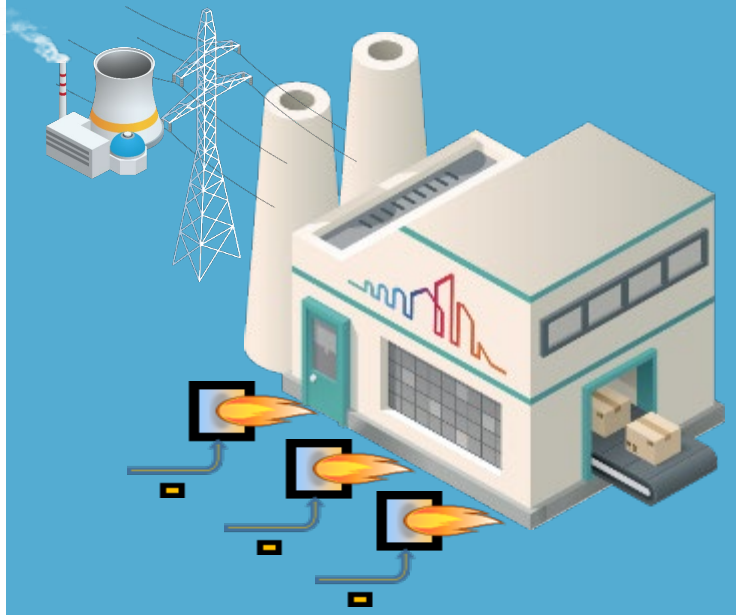
Remaining Road blocks

- OPEX
- GRID Emission Factor
- Customer Demand

Options to reduce emissions

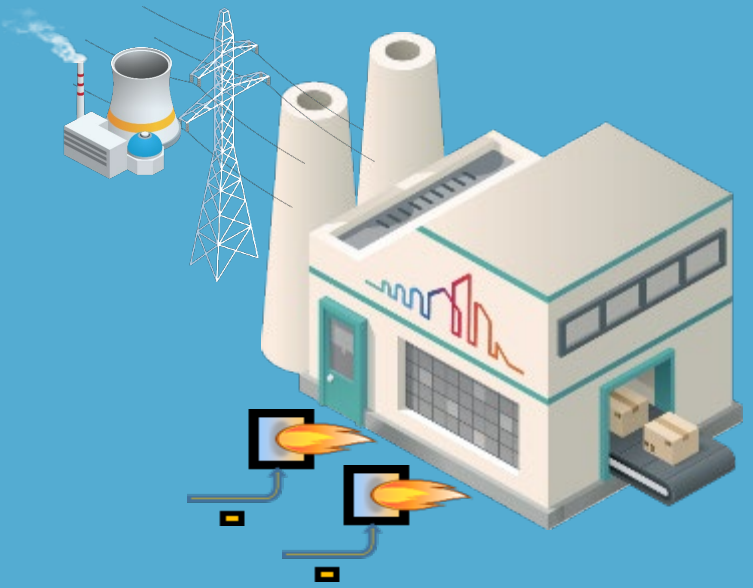
GROW& IMPACT

Current



Electrification

Reduce Gas Consumption



Bert Hill
Volvo Group

VOLVO

Electrification case studies

2023 Better Buildings, Better Plants Summit

Volvo Group

Bert Hill

Boiler Replacement

- **Current Boiler Supports**
  - Building heat
  - Process equipment

- **Recommendation for replacement**
  - Increasing maintenance cost
  - Exceeded the useful life
  - Needed repairs due to compliance related issues

Proposed Alternative

Electric Boiler –Upgraded primary service

- PPL provides new outside transformer and new lines into the main gear inside the building – no cost
- New indoor 4000 amp switchboard and 3200 amp main circuit breaker
- New 1200 amp circuit breaker for new boiler
- Lead time for materials 10-12 months
- Time for install – 1 week (100% plant closure) – power outage required
- Downtime for office heating and production related process equipment – Wash Bay
- Boiler - $153,940
- Upgraded Electrical Service – $482,712

Environment

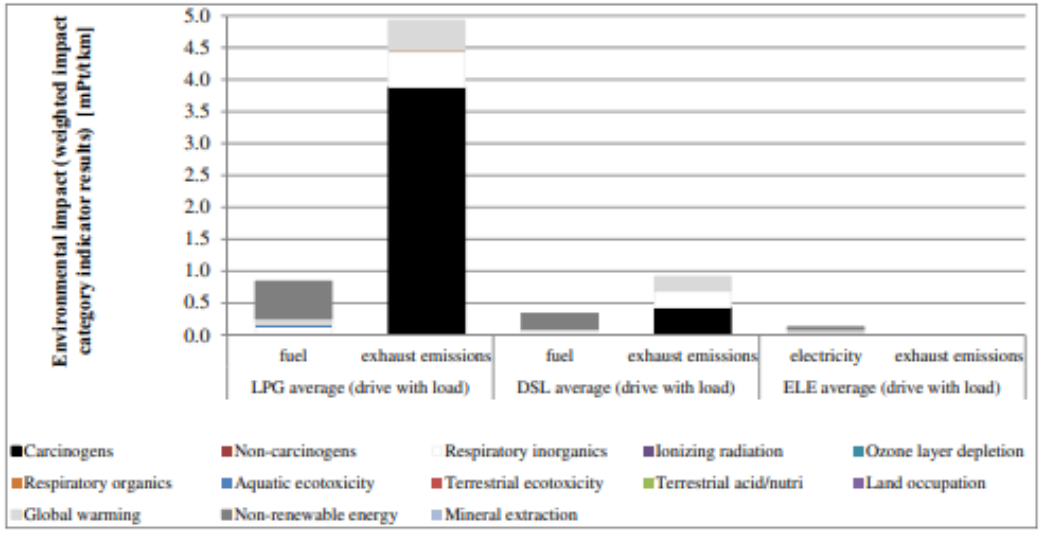
Boiler Replacement

CLIMATE AND RESOURCES			
CO2 Emissions	Increase or Decrease	What is the % impact compare with current set-up	
	Decrease	Reduction of 387 metric tons per year	
Energy Consumption	Increase or Decrease	What is the impact on renewable energy?	
	Increase	Favorable impact on renewable energy	
Chemical	Increase/Decrease	Any chemicals from Black or Grey-list to be used	
	None	NA	
Waste	Increase/Decrease	New type or waste?	Waste to landfill?
	None	NA	NA
Water	Increase or Decrease		
	None	NA	
Other Environmental Impacts	Is this best available technic?	Do we increase circularity?	
	Yes	Reduce fossil fuel consumption, reduce CO2 emissions and increase renewable energy consumption	

Forklift replacement

	Fuel cell	Lithium	Lead acid	LPG
Pro's	• Emission-free • Fast refuel • More energy-efficient than LPG	• Emission-free • Higher capacity than lead acid • Shorter charging time • Longer life than lead acid	• Emission-free • Well established	• Established technology • Fast refuel
Con's	• Lower overall efficiency than batteries • More infrastructure needed • New technology • Not available for all models on all markets	• New technology • Not available for all models on all markets	• Long charging time • Space needed for charging and battery change • Shorter expected life than than Lithium	• Some emission • Fossil fuel • Noise from combustion

Forklift replacement



An environmental life cycle assessment of forklift operation: a well-to-wheel analysis. International Journal of Lifecycle Analysis. (2016) 21:1438–1451

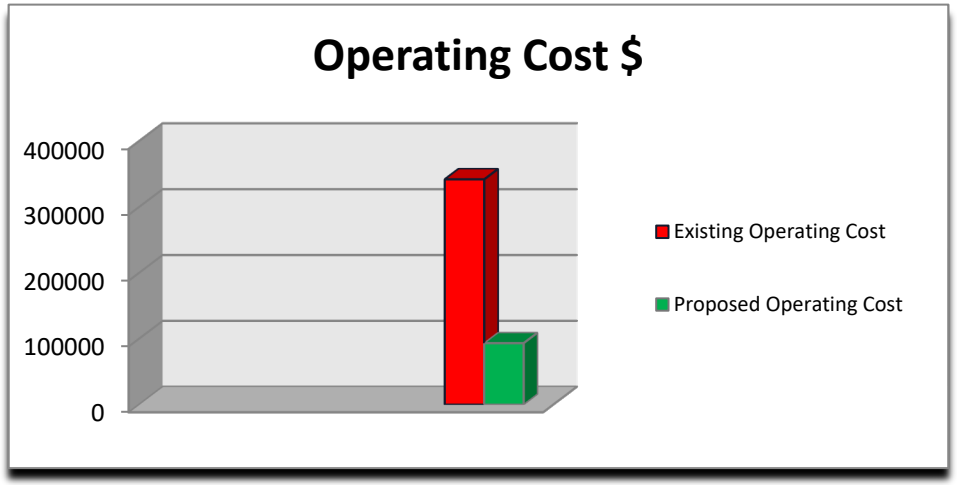
Truck Type	kg CO2
Electric (lead acid)	4,600
Diesel	13,980
LPG	17,640

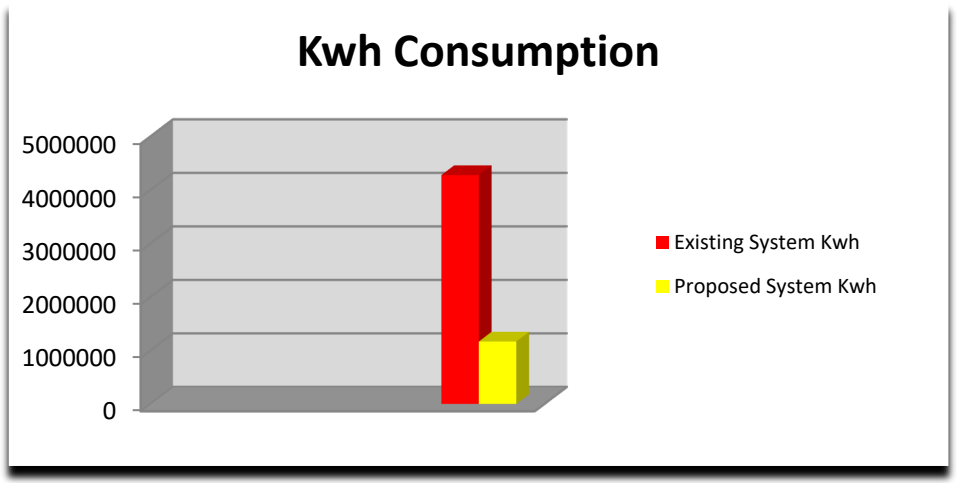
Standard 2000 kg counterbalanced truck working 2000 hrs per year. UK electricity grid.

Benefits of a Lithium-Battery Fleet

- **Higher efficiency** – lithium battery forklifts are more efficient than lead-acid, they can provide power for lifting heavy loads while requiring less electricity to do so
  - Need less rentals
  - Less electricity usage saves roughly $60K per year
- **Lasts Longer = Less Downtime** – lithium batteries have a lifespan of 5-7 years, which is double that of lead-acid ones
  - Less equipment needed due to longer runtimes and quicker charging (8 units)
- **Environmental Impact** – lithium batteries are significantly more environmentally friendly
  - No hazardous material
- **Lower Maintenance Costs** – lithium batteries require less maintenance

Forklift replacement





Thank you!

Q & A

Thank You!

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