



Industrial Decarbonization Peer Exchange

April 17th, 2024

Better Buildings, Better Plants Summit



[Congratulations 2023 goal achievers](#)

[Congratulations Better Project and Better Practice Award Winners](#)

Energy Bootcamp

Crash course in industrial energy system fundamentals, energy management, and industrial decarbonization

The next Energy Bootcamp is **May 13 - 17** at Oak Ridge National Laboratory

Last day to register is **April 29th**
[Register here!](#)



If you are interested in participating please contact the following individuals:

- Jennifer Travis (travisjm@ornl.gov)
- Wei Guo (guow@ornl.gov)
- Thomas Wenning (wenningtj@ornl.gov)

In-Plant Trainings (INPLTs)

Host Plant Name / City, State	Energy System Type	Date
PepsiCo / Charlotte, NC	Treasure Hunt Exchange	April 23-25, 2024
Leggett & Platt / High Point, NC	Treasure Hunt Exchange	April 28-30, 2024
Legrand North & Central America / Kenosha, WI	Process Heating	May 7-9, 2024
Owens Corning / Newark, OH	Water Efficiency	May 7-9, 2024
Leggett & Platt / Tupelo, MS	Treasure Hunt Exchange	May 19-21, 2024
Lockheed Martin / Owego, NY	Compressed Air	May 21-23, 2024
PepsiCo / Lynchburg, VA	Treasure Hunt Exchange	June 11-13, 2024
Lear Corporation / Southfield, MI	50001 Ready	May 7-9, 2024
Quanex Custom Components / St. Cloud, MN	Treasure Hunt	Aug 12-15, 2024
Saint-Gobain Corporation / Shreveport, LA	Process Heating	June 4-6, 2024
Stryker / Mahwah, NJ	Treasure Hunt	TBD



Next Round In-Plant
Training Application
Due May 6th

Better Plants and Better Climate Challenge Data



Submit energy data to TAMs
Reporting deadline **May 31st**



Submit your GHG emissions data
to TAMs by **May 1st** (if assistance needed)
Reporting deadline **May 31st**

Virtual In-Plant Training

Industrial Water Efficiency

May 21, 2024 to July 9, 2024

Participants will be trained on water system fundamentals and undertake a facility-level water assessment, including hands-on training on the Plant Water Profiler (PWP) tool



If you or your colleagues are interested in participating in the training, please [register here](#).

Questions? Contact Wei Guo (guow@ornl.gov)

Tools and Resources for Electrification ORNL and EPIXC

Speakers



Dr. Michael Baldea,

Professor at University of Texas Austin

EPIXC

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Poll Question #1

Poll Question 2

Poll Question 3



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R&D Assistant Staff

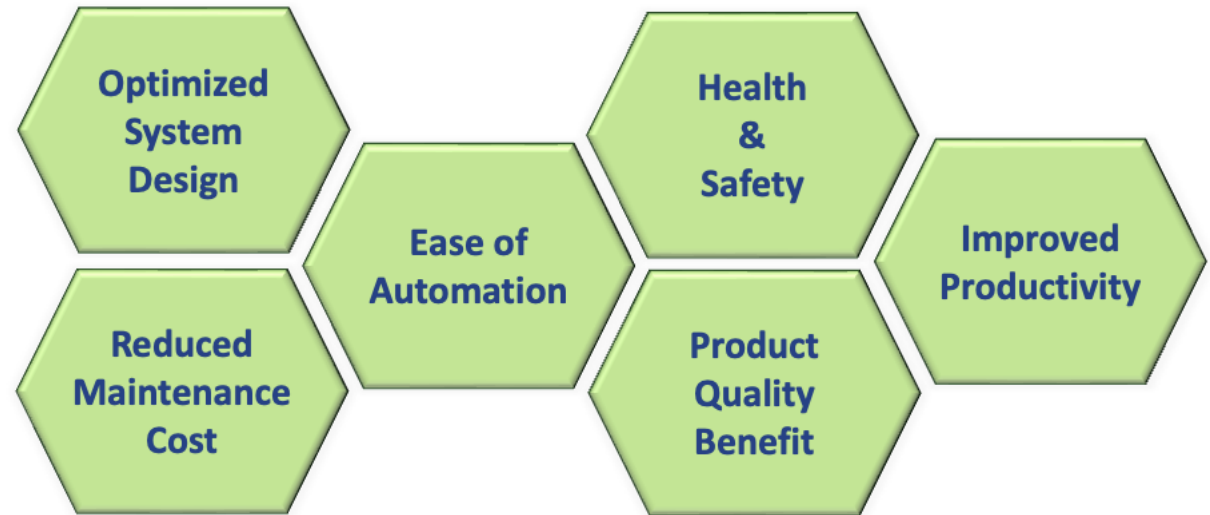
Oak Ridge National Lab

thirumarank@ornl.gov

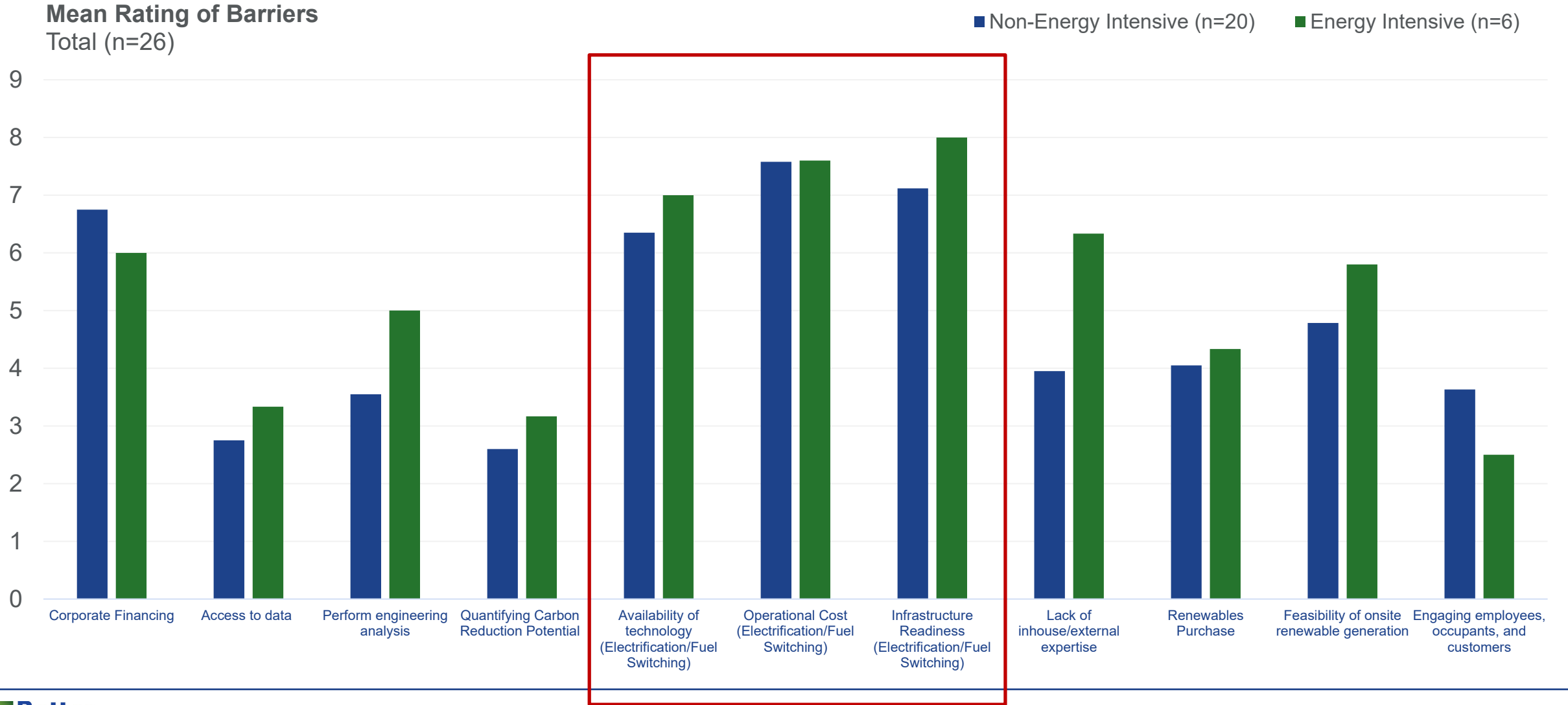
Why Electrification?

While decarbonization is a major driver for electrification, it is just one of the many benefits

- Productivity
- Product Quality (Scrap & Repair)
- Process Flexibility
- Up-time
- Labor Cost
- Capital (Equipment & Inventory)
- Product Features & New Products
- Health & Safety
- Environmental

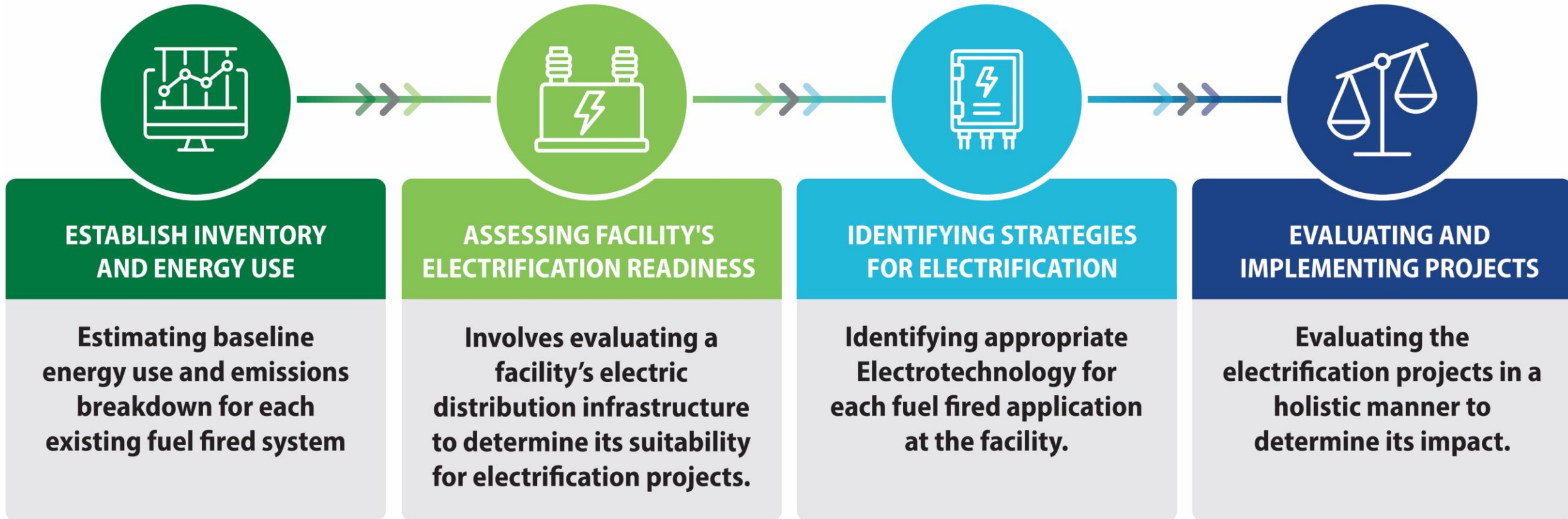


Barriers to Electrification



Electrification Assessment Framework

Developed through collaborative discussions within Better Climate Challenge partners as part of the Industrial Electrification working group held from August 18, 2022, to June 1, 2023.



1.) Establish Inventory and Energy Use

Understanding the existing fuel-fired systems can help better plan for electric transition

1. Inventorying

- Identifying existing system at the facility
- Determining key design and operational parameters

2. Establishing Energy Use (Baseline)

- Metering and Submetering
- Engineering estimates based on burner size and load fact
- Utility Bill Analysis
- Understanding the load profile
- Regression

3. Establishing Energy Use (Post Electrification)

- Determining additional Electric Load
- Determining impact on cost and emissions

Inventorying – Example

Equipment Name / ID	Install Date	Installed MMBTU/hr	Typical operating hours	Operating Temperature	Load Factor	Fuel Used	Estimated yearly MMBTU (gas)	Baseline Systems Efficiency	Expected Electric System Efficiency	System Size/Added kW Demand	Additional Amps Required (at 480V and 0.8 pf)
Furnace 1	2021	1.2	8,760	1700	42.00%	Natural Gas	4,415	0.5	0.75	185	279
Heat Treat Furnace 2	2010	3.5	1,664	1200	44.04%	Natural Gas/Propane	2,565	0.6	0.75	648	975
Gas Generator	2011	1.6	1,664	1900	44.10%	Propane	1,174	0.8	0.95	395	594
Drying Ovens	2010	1.5	3520	400	76.00%	Natural Gas	4,013	0.8	0.95	370	557
			Total				12,167			1,598	2,405

Note that this is first would be first order estimation and the actual increased demand with electrification will demand on multiple factors including the technology implemented, size and efficiency of the new system etc.



Can be used to evaluate facilities infrastructure requirement

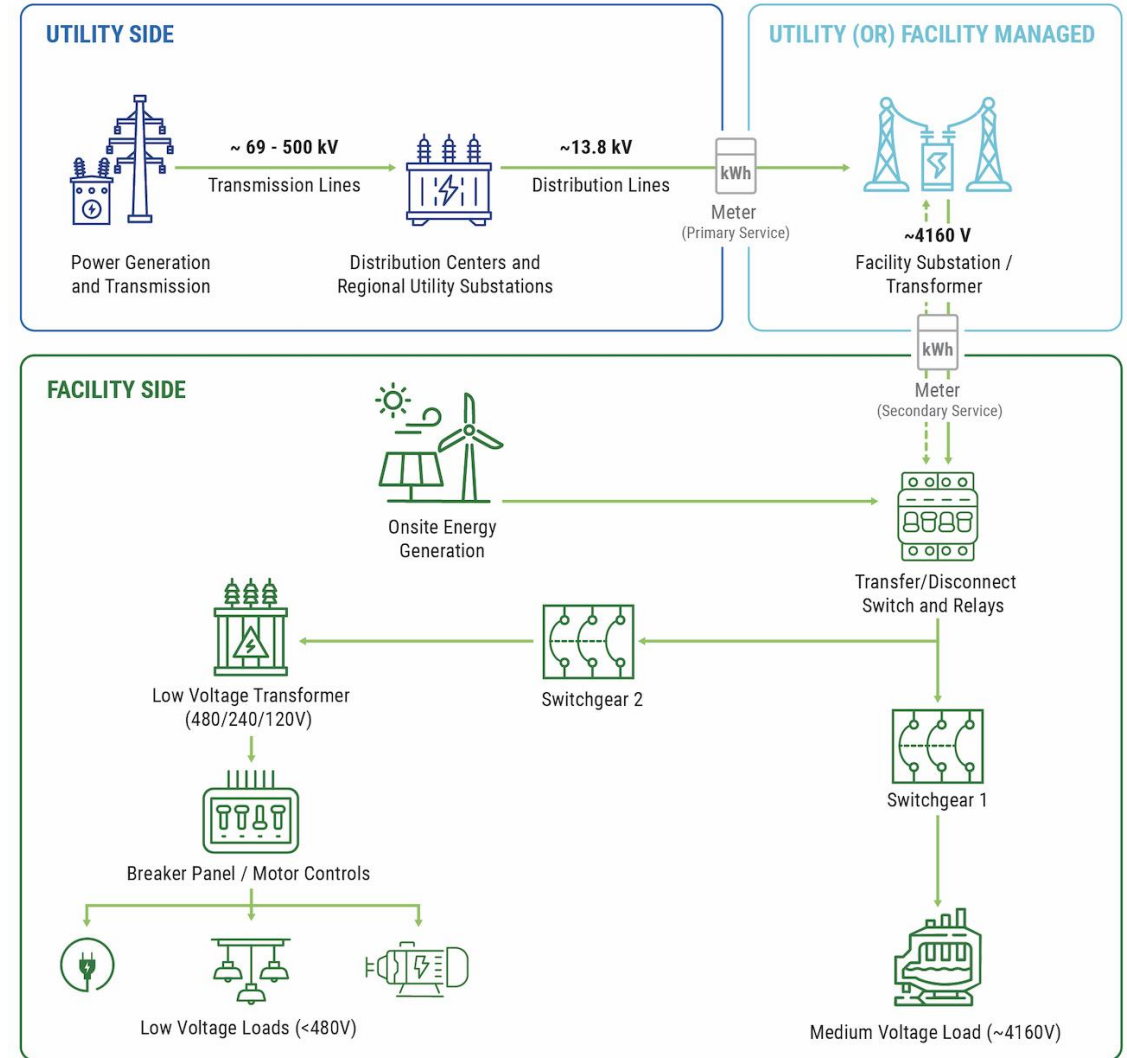
2.) Assessing Utility Side and Facility Side Infrastructure

Major Components

- Substations transformers used to step down transmission voltage and associated feeders
- Facility owned transformers to step down voltage at the plant
- Switchgear, motor control centers and control panel used to distribute power throughout the plant
- Electric load

Actionable Items

- Assessing distribution feed from one line diagram
- Discuss with the utility representative to understand the substation and feeder capacity to serve facility loads



3.) Identifying Strategies for Electrification

Studying existing process heating application and its operational demands can help identify the ideal technology pathways to investigation

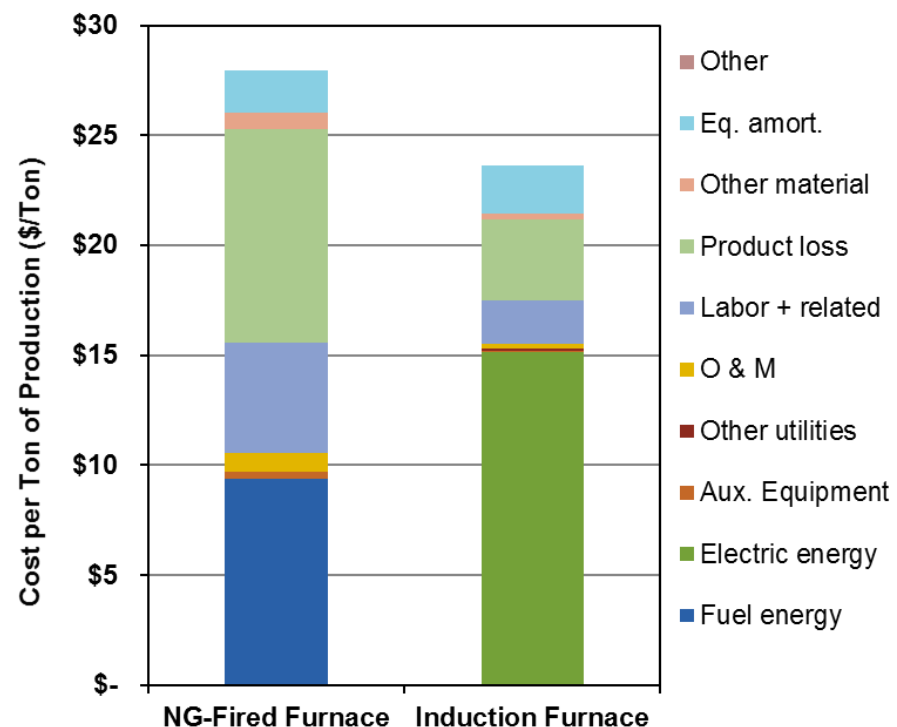
Thermal process	RH	IH	EAH	EIP	MWH	RFH
Fluid heating						
Steam generation						
Metal heating						
Metal melting						
Metal heat treating						
Smelting, agglomeration etc.						
Nonmetal heating, heat treating						
Nonmetal melting						
Calcining						
Drying						
Curing and thermal forming						
Thermal reactors						
Other heating						

RH: Resistance Heating, IH: Induction Heating, EAH: Electric Arc Heating, EIP: Electric Infrared Processing, MWH: Microwave Heating, RFH: Radio Frequency Heating

Technology	Considerations
Resistance Heating	<ul style="list-style-type: none"> Requires a traditional mode of heat transfer (conductive or convective) Not very efficient (comparatively) for large applications
Electric Infrared Heating	<ul style="list-style-type: none"> Required “line of site” to operate – not suitable for complex shapes Cannot be used if the atmosphere contains gases, hazardous vapors
Induction Heating	<ul style="list-style-type: none"> Material must be conductive Production size - small production runs are not ideal Requires high voltage power
Microwave Heating	<ul style="list-style-type: none"> Suitable material coupling with microwave Material’s sensitivity to rapid heating

4.) Evaluating and Implementing Projects

While decarbonization is a major driver for electrification, it is just one of the many benefits - Evaluation of an electrification project should involve consideration of all relevant co-benefits



Some Unique Considerations when implementing electrification projects

1. System design and testing
2. Auxiliary Infrastructure Upgrades
3. Optimized Operations
4. Energy Reliability
5. Workforce Education

From case study on NG-Fired Furnace vs Induction Furnace in a Forging Plant

DOE Resources for Industrial Electrification

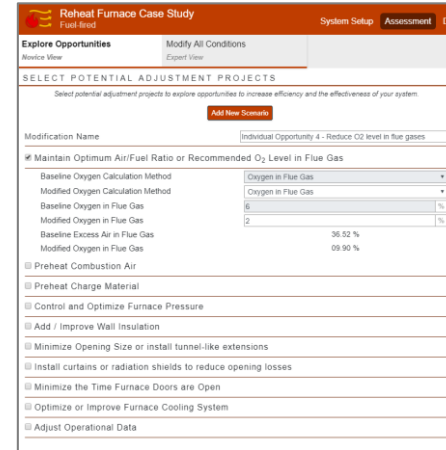
Available Tools: MEASUR

Model existing process heating systems

<https://measur.ornl.gov/landing-screen>

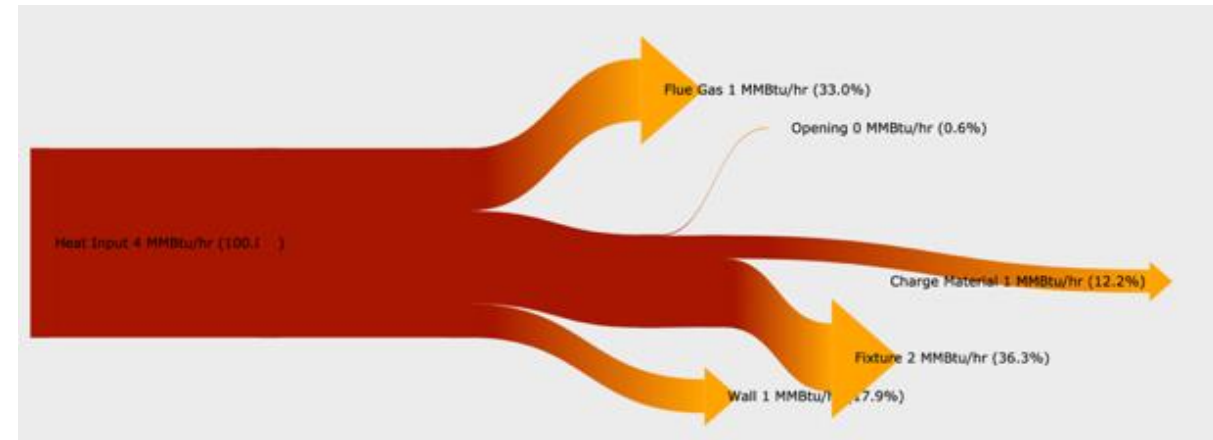
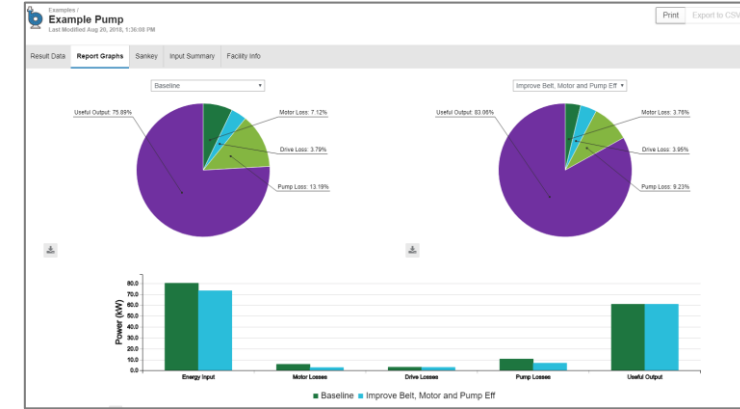


The MEASUR landing screen features the U.S. Department of Energy logo and the text "Welcome to the most efficient way to manage and optimize your facilities' systems and equipment." It includes a sidebar with navigation options like "All Assessments" and "Data Exploration". The main area contains buttons for "View Assessments" and "Equipment Calculators", and a row of icons for various assessment tools: Pump Assessment, Compressed Air Assessment, Process Heating Assessment, Fan Assessment, Steam Assessment, Treasure Hunt, Wastewater Assessment, and Motor Inventory. A "Data Exploration" icon is also present. The footer includes the U.S. Department of Energy logo and the text "Energy Efficiency & Renewable Energy".




The "Reheat Furnace Case Study" interface shows a "System Setup" tab with "Assessment" and "Data" sub-tabs. It includes a "SELECT POTENTIAL ADJUSTMENT PROJECTS" section with a list of optimization options such as "Maintain Optimum Air/Fuel Ratio or Recommended O₂ Level in Flue Gas", "Preheat Combustion Air", and "Preheat Charge Material". A table displays "Oxygen in Flue Gas" data for baseline and modified conditions.

Modification Name	Individual Opportunity 4 - Reduce O ₂ level in flue gases
Baseline Oxygen Calculation Method	Oxygen in Flue Gas
Modified Oxygen Calculation Method	Oxygen in Flue Gas
Baseline Oxygen in Flue Gas	6 %
Modified Oxygen in Flue Gas	2 %
Baseline Excess Air in Flue Gas	36.52 %
Modified Excess Air in Flue Gas	09.90 %



Available Tools: Electrification for Decarbonization Tool

Determine location-based emissions reduction. Available at <https://electrification.ornl.gov/>

 Electrification for Decarbonization

Annual Operating Hours hrs/yr

Current Fuel Based Equipment

Energy Source

Fuel Cost \$/MMBtu

Fuel-Fire Equipment Efficiency %

Heat Input for Fuel-Fire Equipment MMBtu/hr

Carbon Emissions 53.06 kg CO₂/MMBtu

Methane Emissions 1 g CH₄/MMBtu

Nitrous Oxide Emissions 0.1 g NO₂/MMBtu

Current CO₂ Emissions 4,648.06 tonne CO₂/yr

Current Fuel Costs \$700,800 /yr

Potential Electrical Equipment

Electricity Cost \$/kWh

Electrically Heated Equipment Efficiency %

Estimated Electric Peak Demand 1,953.32 kW

eGrid Region

eGrid Subregion

Carbon Emissions 225.2 kg CO₂/MWh

Methane Emissions 15.42 g CH₄/MWh

Nitrous Emissions 1.81 g N₂O/MWh

Potential CO₂ Emissions 3,853.41 tonne CO₂/yr

Potential Electricity Costs \$1,129,329 /yr

Results Help

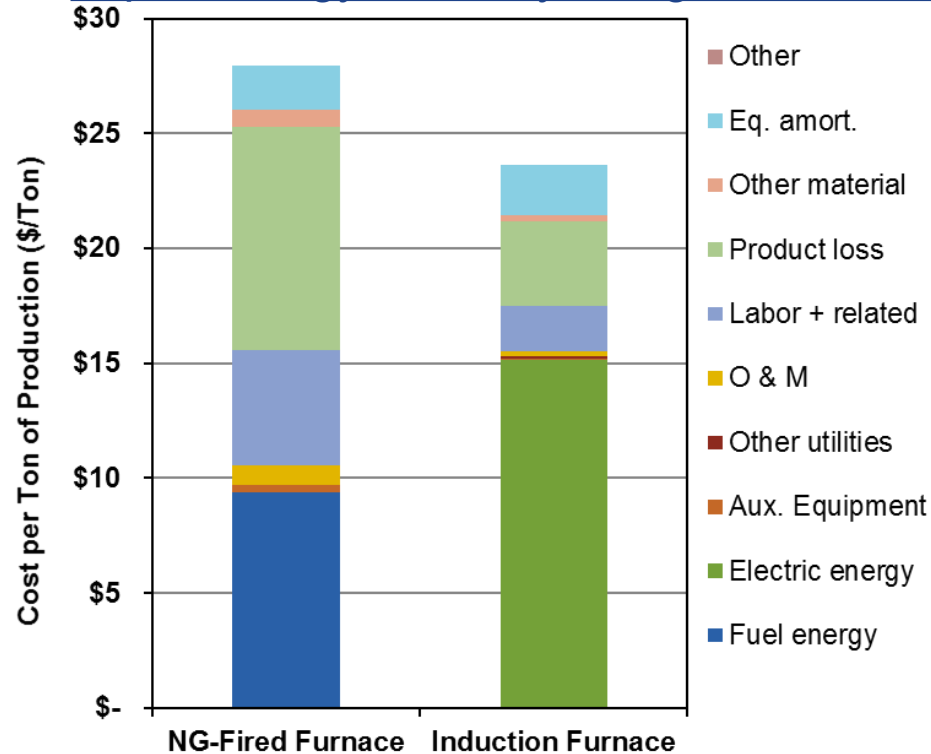
Current Fuel Usage	
Fuel Use	87,600 MMBtu/yr
Fuel Use (MWh)	25,673 MWh/yr
Energy Cost	\$700,800 /yr
CO ₂ Emissions	4,648 MT CO ₂ /yr
CO ₂ e Emissions	4,653 MT CO ₂ e/yr

Potential Electricity Results	
Electricity Use	17,111 MWh/yr
Electricity Use (MMBtu)	58,385 MMBtu/yr
Energy Cost	\$1,129,329 /yr
CO ₂ Emissions	3,853 MT CO ₂ /yr
CO ₂ e Emissions	3,869 MT CO ₂ e/yr

Available Tools: Cost Comparison Calculator

Calculate holistic cost of switching to electrotechnology

<https://energyefficiency.ornl.gov/tools-training/>



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

Forging Plant

Electrotechnology vs Fuel Fired Thermal Processing Cost Comparison Model

Developed by E3M Inc. under contract with Oak Ridge National Laboratory

Overview of Process Heating Systems

Control Page

Items	Instruction
Guide - Instructions	Guidance on using the tool
Cost Comparison Calculator	Main input page for the tool
Other Impacts	Qualitative Analysis of impacts to the facility and product

Supporting Calculators

Energy Use	The "Supporting Calculators" are provided to help estimate the various components of the inputs, used in the analysis The user may choose to use these calculator as required The "Supporting Calculators" can also be accessed directly from the "Comparison Calculator" page
Maintenance Cost	
Auxiliary Equipment	
Other Utilities	
Other Materials Cost	
Labor Cost	
Water Use Module	

Cost Report

Resources being built

The Electrification Assessment Framework

A comprehensive guide to identifying, evaluating and implementing electrification opportunities in a manufacturing facility

System Specific Scoping tools

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

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



Facility Level Electrification Assessment Framework

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Guidance and templates to support a facility level electrification planning

Electrification Readiness Worksheet

Assessing Facility's Transformer Capacity		
Transformer ID		<p>Facility Transformers: Industrial facilities typically have one or more dedicated transformers that step down the voltages from 12.47 kV to 4,160 V (medium) or 480 V (low). The number of feeder circuits available, its maximum capacity, and present load will determine the hosting constraints at these facility transformers.</p> <p>[1] Primary and Secondary Service: Depending on the contractual agreement with the utility, these transformers can be owned and maintained either by the utility or the facility. The type of service is also typically dictated based on this ownership of these assets. Depending on the size of the electrification opportunity at the site, understanding existing utility agreements and potentially re-negotiating them becomes critical.</p> <p>[2] Transformer Lifespan: The age of the transformer can help determine if it is close to its end of life and if a replacement/upgrade is warranted. The typical lifespan of a transformer can vary depending on factors such as its type, usage conditions, and maintenance. General-purpose dry-type transformers typically last more than 25 years, Oil-filled transformers have a typical lifespan of around 20-30 years.</p> <p>How to collect data? The transformers and other electrical components on the facility's electric distribution side can be evaluated by reviewing the facility's one-line electrical diagram and as part of a scheduled arc flash study.</p> <p>It is to be noted that in the rated capacity can be represented in kVa (apparent power) in cases as opposed to kW (real power). kW can be calculated from kVa using the formula: $kVa = kW \times \text{power factor}$. Power factor can be assumed to be 0.7-0.8 if not known.</p>
What is the type of service from the utility ¹	Primary/Secondary	
Is the transformer nearing the end of its lifespan? ²	Yes/No	
What is the primary and secondary voltage at the transformer?	V	
What is the total capacity of the facility transformer?	(a) kW	
What is the present peak load on the transformer?	(b) kW	
B1. Total Additional Capacity Available at the Facility Substation: [(a) - (b)]		<input type="text"/> kW
Transformer ID		
What is the type of service from the utility ¹	Primary/Secondary	
Is the transformer nearing the end of its lifespan? ²	Yes/No	
What is the primary and secondary voltage at the transformer?	V	
What is the total capacity of the facility transformer?	(a) kW	
What is the present peak load on the transformer?	(c) kW	
B2. Total Additional Capacity Available at the Facility Substation: [(a) - (b)]		<input type="text"/> kW

Electrification Readiness Report								
Expected Power Demand Increase from Electrification - Identified from Inventorying								
Process Heating Equipment			HVAC Equipment			Warehouse Utility Vehicles (UTV)		
	Expected Demand Increase	Priority Rating		Expected Demand Increase	Priority Rating		Expected Demand Increase	Priority Rating
Equipment 1			Equipment 1			Equipment 1		
Equipment 2			Equipment 2			Equipment 2		
Equipment 3			Equipment 3			Equipment 3		
Equipment 4			Equipment 4			Equipment 4		
Capacity Availability - Identified from Electrification Readiness Evaluation								
Capacity Available at the Site This is based on the capacity available at the Switchgears						<input type="text"/>	From result C1 in the Electrification Readiness Worksheet	
Potential Capacity with Facility Level Upgrades This is based on the capacity limitation at the facility transformers						<input type="text"/>	From result B1 and B2 in the Electrification Readiness Worksheet	
Potential Capacity with Utility Upgrades This is based on the capacity limitation at the utility						<input type="text"/>	From result A1 in the Electrification Readiness Worksheet	
Electrification Plan								
Projects/Activities (near term)			Projects/Activities (midterm)			Projects/Activities (long term)		
•			•			•		
Following consideration can help build an effective electrification plan. <ul style="list-style-type: none"> Projects are categorized into the appropriate timeframe by comparing the increase in electric demand with electrifying individual electric equipment with the capacity available. For competing projects, the system's priority rating can be considered. Near term projects can be implemented with the additional capacity available at the site while midterm and long-term projects have capacity demand higher than what is available at the facility transformers and/or utility substation. Re-evaluate the plan when significant changes occur within the facility, such as expansion, upgrades, or shifts in operational priorities. 								

Heat Pump for HVAC

General Characteristics

Location: Washington, DC

Building Type: Warehouse

Building Size: 50,000 sqft

Equipment Life: 15 yr

Cooling Design Temp: 94 °F

Heating Design Temp: 14 °F

Cooling Requirement: 35.0 tons

Heating Requirement: 40.0 tons

Meteorological Data

Performance Characteristics

	Cooling	Heating
Air-Source Heat Pump	3.5 COP	3.3 COP
Water-Source Heat Pump	4.7 COP	3.5 COP
Ground-Source Heat Pump	4.7 COP	3.5 COP
AC & Natural Gas	3.4 COP	85%
AC & Propane	3.4 COP	85%
AC & Fuel Oil	3.4 COP	85%

	Air-Source HP	Water-Source HP	Ground-Source HP	AC & Natural Gas	AC & Propane	AC & Fuel Oil
Cooling Energy	174.12 MMBtu/yr	170.53 MMBtu/yr	170.53 MMBtu/yr	178.02 MMBtu/yr	178.02 MMBtu/yr	178.02 MMBtu/yr
Heating Energy (Primary)	200.26 MMBtu/yr	177.58 MMBtu/yr	177.58 MMBtu/yr	672.58 MMBtu/yr	672.58 MMBtu/yr	672.58 MMBtu/yr
Heating Energy (Auxiliary)	28.09 MMBtu/yr	0.00 MMBtu/yr	0.00 MMBtu/yr	0.00 MMBtu/yr	0.00 MMBtu/yr	0.00 MMBtu/yr
Hours Requiring Auxiliary	330.9 hr	0.0 hr	0.0 hr	0.0 hr	0.0 hr	0.0 hr

Energy Prices¹

Electric: \$38.09/MMBtu

Natural Gas: \$12.49/MMBtu

Propane: \$20.87/MMBtu

Fuel Oil: \$16.81/MMBtu

CO2 Emissions Factors²

Electric: 342.89 lb/MMBtu

Natural Gas: 116.65 lb/MMBtu

Propane: 138.63 lb/MMBtu

Fuel Oil: 163.45 lb/MMBtu

Annual Energy Comparison

	Air-Source HP	Water-Source HP	Ground-Source HP	AC & Natural Gas	AC & Propane	AC & Fuel Oil
Total Energy Costs	\$229,950	\$198,891	\$198,891	\$227,719	\$312,262	\$271,302
Total CO2 Emissions	2,070,036 lb	1,790,439 lb	1,790,439 lb	2,092,458 lb	2,314,208 lb	2,564,610 lb

Tool Inputs

- Location (decimal degrees)
- Building Type
- Building Area (sqft)
- Baseline Equipment and Fuel
- Efficiencies

Notes

1. Energy Prices represent state-level averages for 2021 (<https://www.eia.gov/state/seds/>)
2. Electric Emissions Factors represent state-level averages for 2021 (<https://www.eia.gov/electricity/state/unitedstates/>)

This tool estimates energy and CO2 emission savings for various electric, natural gas, and propane HVAC equipment. Can ideally be used as a high-level screening tool to understand HP application for a region or a facility

Thank you!