End-Use Savings Shapes

Public Data Set Release: Commercial 2023 Release 2

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NREL Webinar

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Logistics

- We are recording the webinar.
- Because of the large number of participants, everyone is muted.
- Please use the Q&A box to send us questions at any time during the presentation.
- The webinar slides and webinar recording will be available in ~1 week. The data set is available now.

Acknowledgments

This work is the culmination of several years of research efforts.

We would like to thank the following for helping make this possible:

- ComStock™ and ResStock™ teams
- OpenStudio® and EnergyPlus® teams
- Lawrence Berkeley National Laboratory
- Argonne National Laboratory
- Pacific Northwest National Laboratory
- U.S. Department of Energy (DOE) Buildings Technologies Offices.

Agenda

1. End-Use Savings Shapes: Background
2. Our Approach to Stock Modeling with ComStock
3. End-Use Savings Shapes: 2023 Release 2
4. Accessing the Data Set
5. Next Steps
6. Q&A

Project Background

Problem Statement

A lack of credible and relevant information results in confusion and inaction by cities, states, utilities, and other major stakeholders.

Will electrification of buildings…

- Reduce carbon emissions in my city?
- Be feasible in my building stock?
- Overload the grid?

EULP and EUSS Road Map

- The **End-Use Load Profiles** (EULP) project:
  - Created a public data set for calibrated energy models of the U.S. commercial and residential building stock using ComStock and ResStock.

- The **End-Use Savings Shapes** (EUSS) follow-on project:
  - Adds the impact of several energy efficiency and electrification "what-if" scenarios ("measures") to the baseline stock models.
  - Residential EUSS Release 1 was presented September 2022.
  - Commercial EUSS 2023 Release 1 was presented March 2023.
  - This presentation is for **Commercial EUSS 2023 Release 2**.

Commercial EUSS Approach

End-Use Load Profiles (EULP)

Describe how and when energy is used in buildings **today.**

Public database of 350,000 individual building models and their energy end-use load profiles.

End-Use Savings Shapes (EUSS)

Describe how and when energy is used in **“what-if” scenarios.**

Adds measure impact profiles for energy efficiency and electrification packages versus the ComStock baseline.

EUSS 2023 Commercial Release 2 Data Set represents the building stock circa 2018 using 2018 actual meteorological year (AMY) weather.

Alignment and Impact

We are putting information in the hands of decision makers.

This effort supports DOE's goals to increase building energy efficiency, accelerate building electrification, and to do so in ways that prioritize equity, affordability, and resilience.

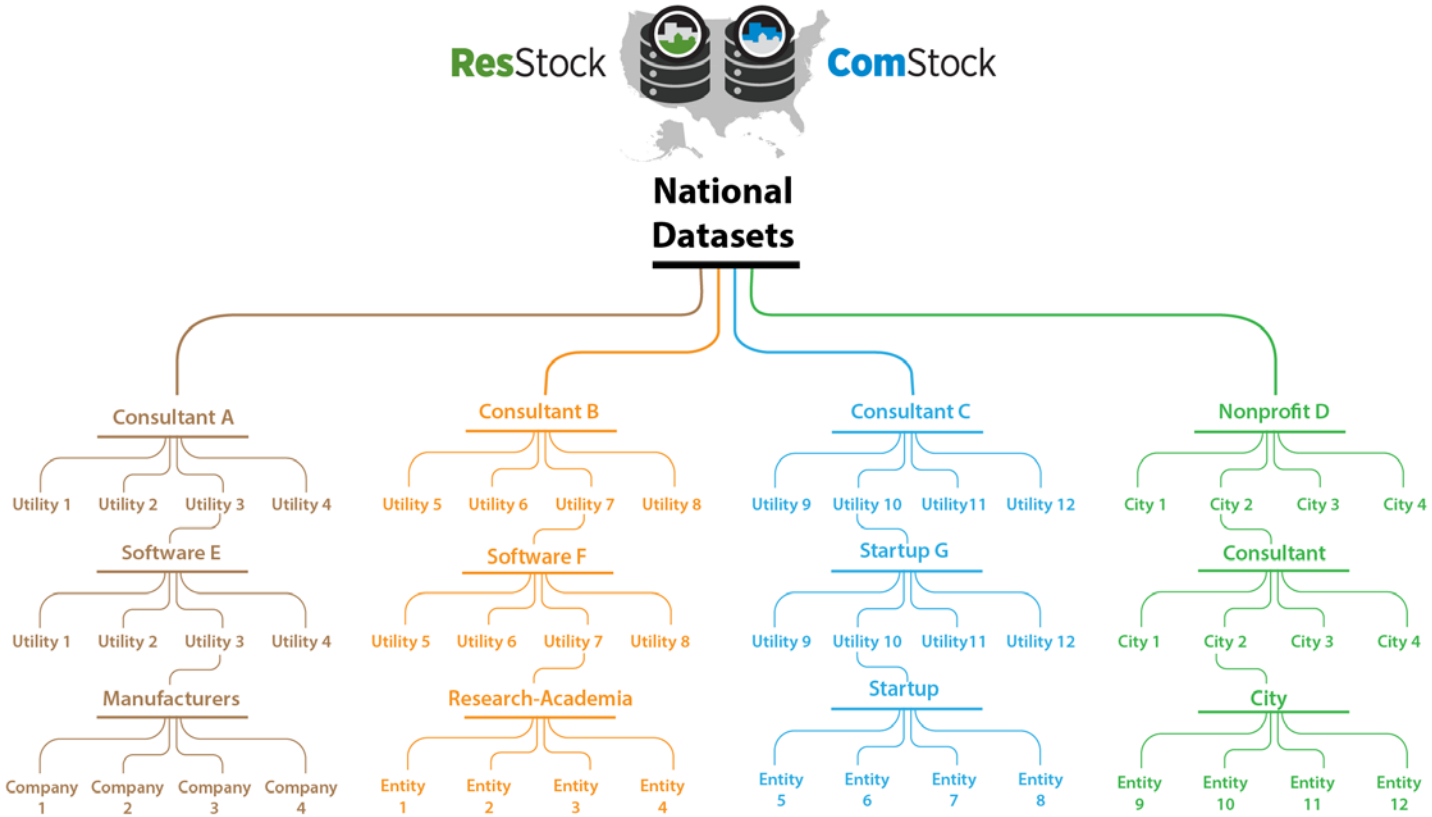
What the Data Sets Provide

- Building stock characterization
- How, where, and when buildings use energy
- Potential impacts of energy efficiency
- Information on time-sensitive value of energy resources
- Potential impacts of building electrification.

How the Information Is Used

- Electrification planning
- Emissions analysis
- Decarbonization decision-making
- Utility-integrated resource plans and load forecasts
- Policy and rate design.

Public Data Sets Are Intended To Serve a Broad Set of Use Cases and Audiences



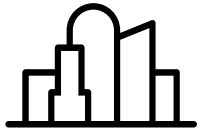
Our Approach to Stock Modeling

ComStock Workflow

The Making of the Data Sets:

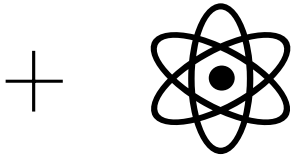
- Describe the U.S. building stock quantitatively using best-available public data
- Sample the description
- Model the samples
- Apply “what-if” scenarios to models—energy efficiency, electrification, etc. [EUSS only]
- Publish description, samples, models, results, aggregations, visualizations, and documentation.

ComStock



Building stock characteristics database

- Variation in building type; size; location; vintage; heating, ventilating, and air conditioning (HVAC) system; etc.
- **Over 80** probability distributions of various attributes.



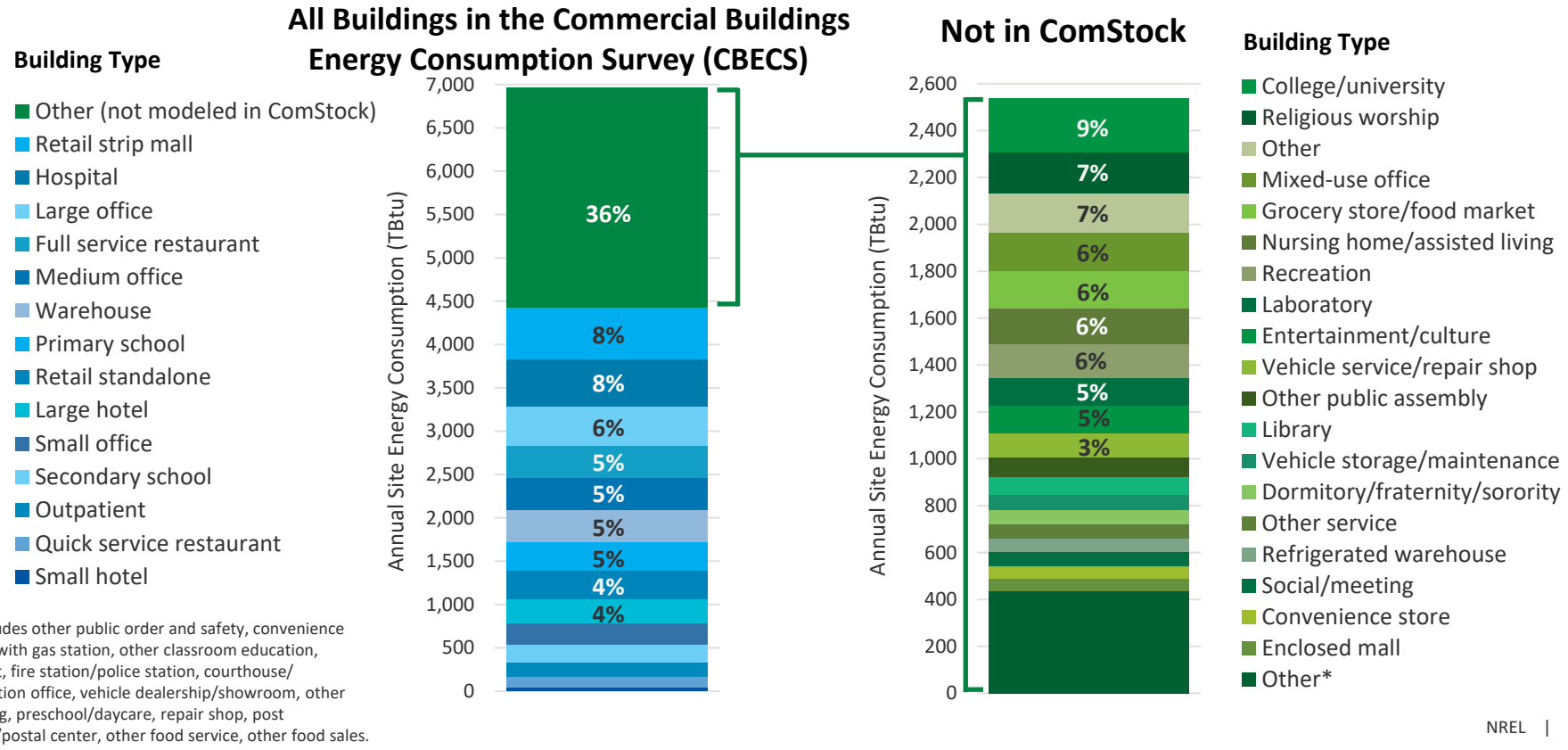
Physics-based computer modeling

- Representative set of 350K OpenStudio energy models.

High-performance computing

- Simulate models
- Process and publish data
- Apply scaling factors.

What Does ComStock Model?



* Includes other public order and safety, convenience store with gas station, other classroom education, vacant, fire station/police station, courthouse/ probation office, vehicle dealership/showroom, other lodging, preschool/daycare, repair shop, post office/postal center, other food service, other food sales.

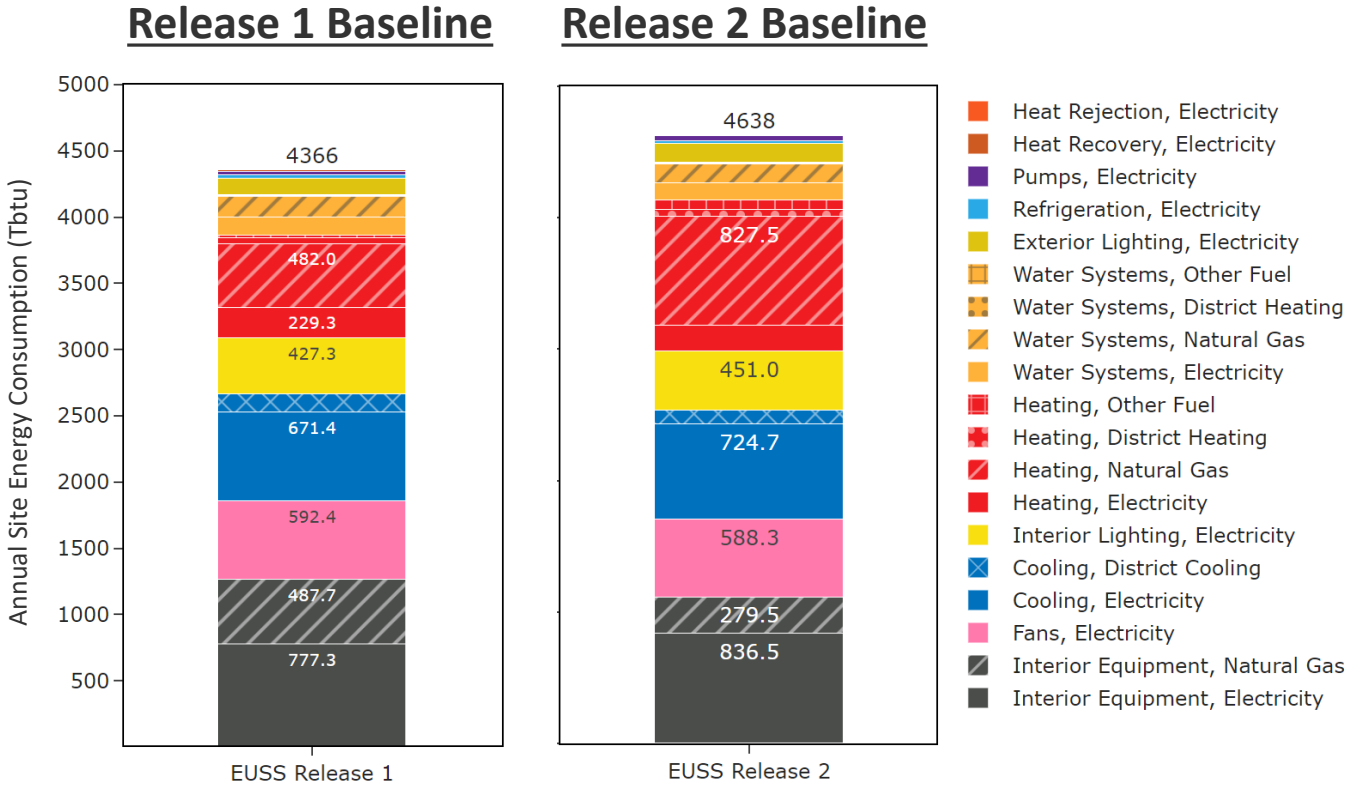
ComStock Baseline Updates Since Release 1

Continuous Improvements:

- Updated HVAC system and fuel type distributions
- Established technology baseline for commercial cooking equipment
- Implemented baseline economizer fault prevalence
- Enhanced infiltration methodology
- Updated to OpenStudio 3.4.0 to 3.6.1.

Future:

- Improve gas calibration (ComStock is low relative to other data sources)
- And more…



ComStock Documentation

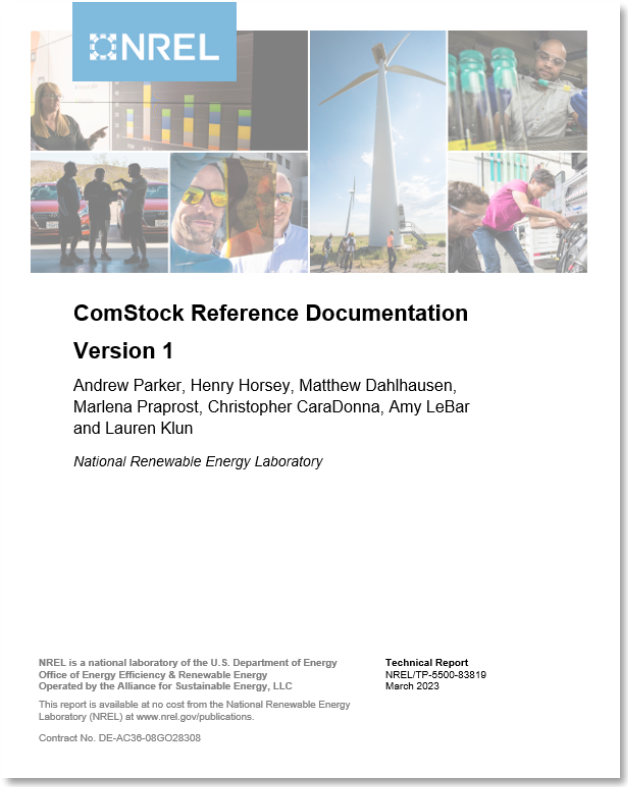
ComStock documentation is now public.

This document serves as a guide and resource to the methodology and assumptions behind ComStock.

Links

[ComStock Documentation]

[Introduction to ComStock slides]



Greenhouse Gas Emissions

Electricity

- Three grid electricity scenarios compared today; more included in published data set.
- This work does not imply a preference for any grid emission scenario.

Electricity Grid Scenario	Start Year	Levelization Period (3% discount rate)	Data Source
LRMER High RE Cost*	2022	15 years	NREL Cambium [1]
LRMER Low RE Cost	2022	15 years	NREL Cambium [1]
eGRID*	2021	N/A	EPA eGRID [2]

Greenhouse gas emissions in data set represent equivalent CO_2 emissions.

On-Site Combustion Fuels

- Values from Table 7.1.2(1) of draft ANSI/RESNET/ICCC 301 [3]

Natural Gas	147.3 lb/mmbtu (228.0 kg/MWh)
Propane	177.8 lb/mmbtu (182.3 kg/MWh)
Fuel Oil	195.9 lb/mmbtu (303.2 kg/MWh)

* LRMER = Long Run Marginal Emissions Rate; RE = renewable energy; eGRID = Emissions & Generation Resource Integrated Database

Please Note

- The ComStock model is **continuously updated** with new information, methods, and improved quality assurance/quality control procedures. Data sets are released in 6-month increments.

- Measures are **not intended to be comprehensive** of a given technology. As additional data becomes available, measure results may be updated.

- The measure result summaries in this presentation are intended to be **high-level observations** to introduce the data set. For more detailed conclusions, please watch for updates on the publications section of our website or explore the data set.

End-Use Savings Shapes: Commercial 2023 Release 2

Technology modeling, results observations, and discussion

EUSS Release 2: What is the new data set?

Updated ComStock Baseline

- Improvements since Release 1

EUSS Release 1 Measures

- Nine existing measures, re-simulated with updated ComStock baseline

EUSS Release 2 Measures

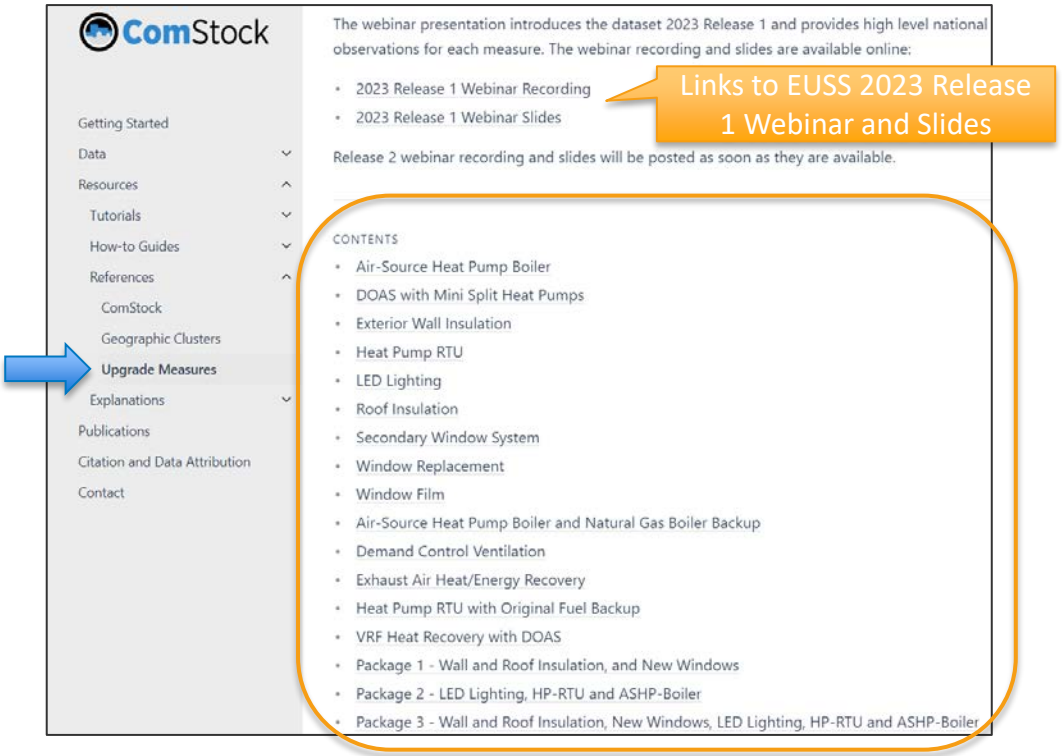
- Eight new measures/packages

Commercial EUSS Release 1 data set will remain available.

ComStock Measure Documentation Website

Comprehensive documentation is available for each measure.

Describes the modeling methodology, assumptions, limitations, relevant ComStock baseline features, and observations from results.



Access at: [ComStock Documentation Site]

Measure Summary: Existing From Release 1

Measure Name	Description
Heat Pump Rooftop Unit (HP-RTU) With Electric Resistance Backup	Replace gas and electric RTUs with HP-RTU.
Rooftop Ventilator + HP Split System	Replace gas and electric RTUs with rooftop ventilator + HP split system in small commercial buildings (<20,000 sq ft).
Air to Water HP Boiler Retrofit With Electric Backup	Replace gas boilers with heat pump boilers. Electric resistance boiler used for backup heat source.
LED Lighting	Upgrade all lighting to LED.
Exterior Wall Insulation	Add exterior wall insulation panels.
Secondary Windows	Add secondary windows.
Window Replacement	Replace windows.
Window Film	Add window film to windows.
Roof Insulation	Add roof insulation.

Included in Release 2 data set; not discussed in this presentation.

New EUSS 2023 Release 2 Measures

Measure Name	Description	% of Stock Floor Area
Heat Pump Rooftop Unit (HP-RTU) With Original Fuel Backup	Replace gas and electric RTUs with HP-RTU. Backup heat source matches fuel type of the original system.	36%
Air to Water HP Boiler Retrofit With Gas Backup	Replace gas boilers with heat pump boilers. Gas boiler used for backup heat source.	33%
Variable Refrigerant Flow (VRF) With Dedicated Outdoor Air System (DOAS)	Replaces air handling units (AHUs) with a VRF DOAS.	53%
Demand Control Ventilation (DCV)	Adds DCV to AHUs that do not have them.	73%
Energy Recovery	Adds heat or energy recovery to AHUs that do not have them.	70%
Package 1: Envelope	Combines wall insulation, roof insulation, and new windows measures.	100%
Package 2: Lighting + HVAC	Combines LED lighting and HP-RTU or HP-boiler measures.	89%
Package 3: Envelope + Lighting + HVAC	Combines packages 1 and 2.	100%

Note on Heat Pump Modeling

- **Limited comprehensive heat pump performance maps exist**, which are required for detailed energy modeling. This limits our understanding of heat pump performance and operation in this work.

- **Heat pump modeling is sensitive** to performance assumptions due to the strong relationship between efficiency and capacity with outdoor air temperature. This impacts both annual energy consumption and peak demand.

- This work attempts to use the most informative data available and makes documented assumptions about heat pump operation and performance. These will notably impact results. **Please consider these assumptions**.

- The assumptions used for the measures **represent one of multiple possible approaches**. They are intended to be reasonable but not necessarily optimal. Assumptions can be modified as our understanding of the technologies improves.

Note on Energy Savings

Stock Energy Savings

Represents energy-weighted savings across the stock, not just applicable buildings.

Does not represent the average savings that a building would experience for a measure.

For individual building savings, use the raw data to perform your analysis on specific building samples.

Site Energy Savings

Represents energy savings for resources used on site.

Does not necessarily translate proportionally to savings for source energy, operational cost, or avoided greenhouse gas emissions. These factors should also be considered where appropriate, especially for electrification measures that change the heating fuel type of buildings.

Heat Pump Rooftop Unit (HP-RTU) With Original Fuel Backup Heating

Heat Pump Rooftop Units (HP-RTUs) With Original Fuel Backup

Measure Concept

- Replace gas and electric RTUs with HP-RTUs
- Variable speed, high efficiency

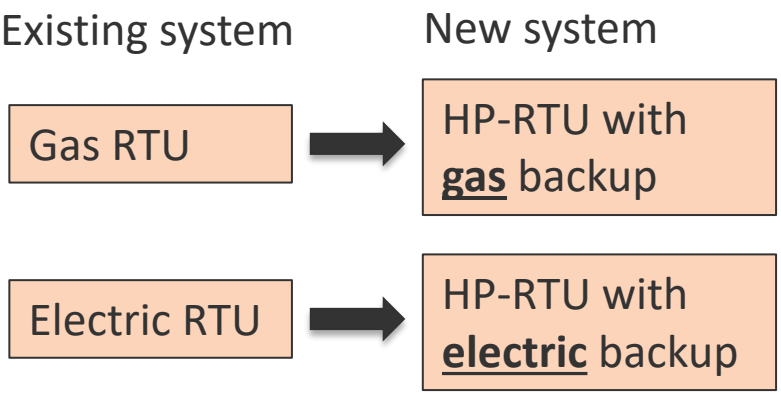
Applicability

- Buildings w/ gas or electric resistance RTUs
- **~36%** of stock floor area, varies regionally
  - **28%** gas RTU; **8%** electric RTU

HP-RTU Performance

- **Sizing:** Compressor sized to design cooling load; backup heat sized for remainder
- **Backup Heat:** Original heating fuel type
- **Compressor Lockout:** 0°F
- **Defrost:** Reverse cycle
- **Performance Data Source:** Mix of lab testing and manufacturer performance data

Backup Heat Scheme

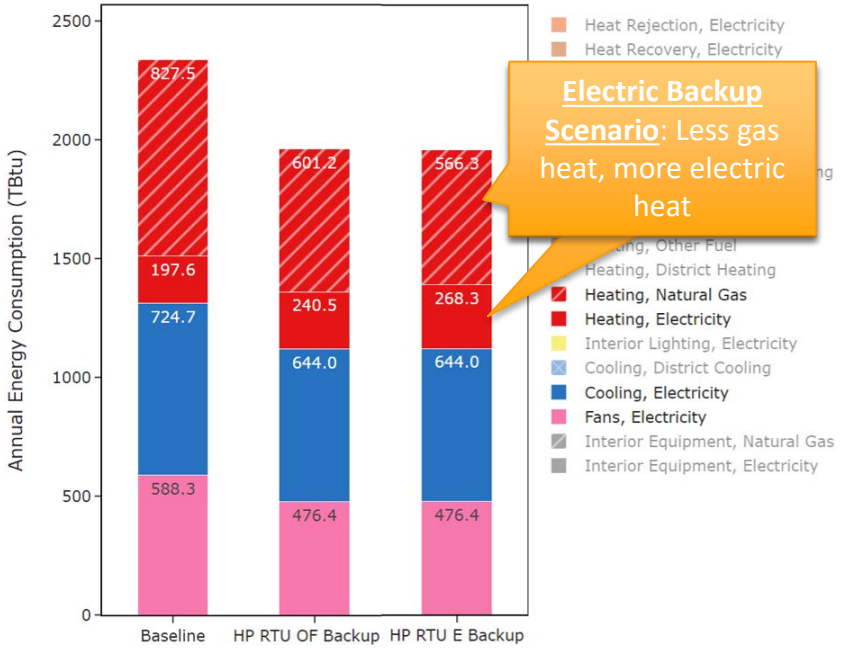


Heat Pump Rooftop Units (HP-RTUs) With Original Fuel Backup

For original fuel (OF) backup scenario:

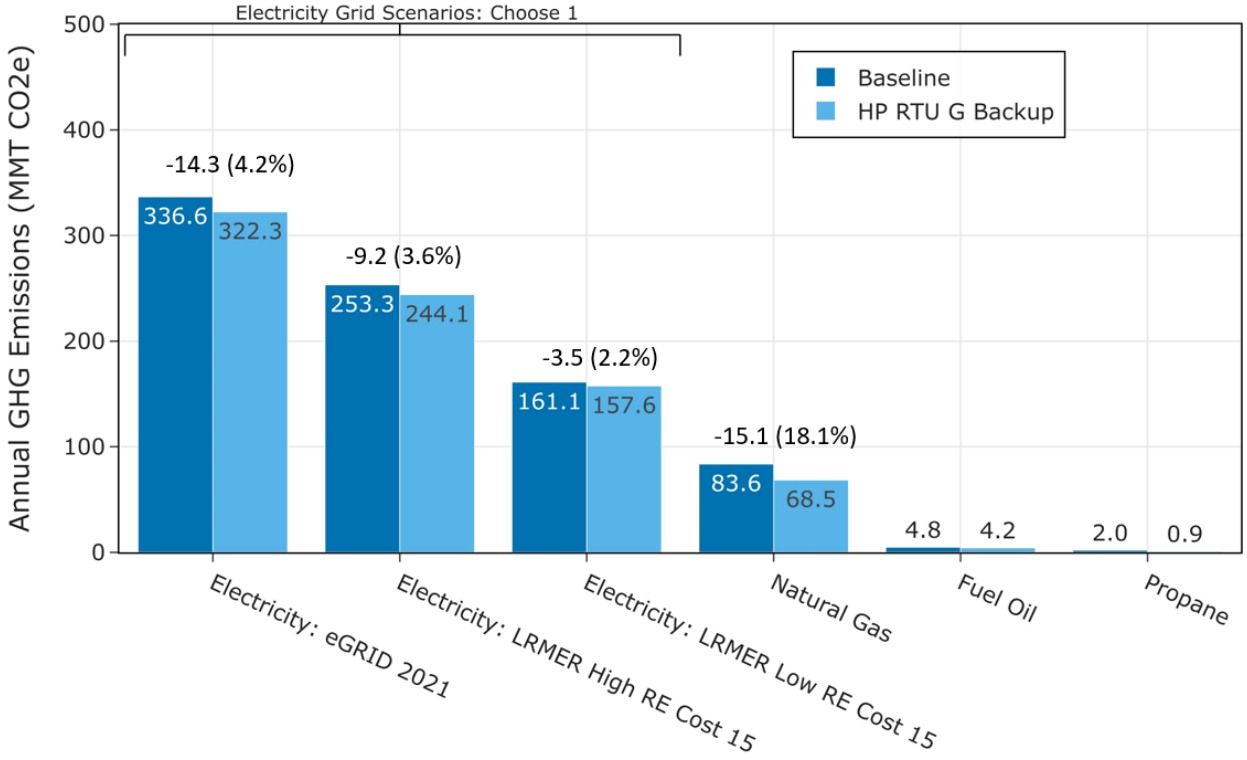
- **27%** stock **heating gas** savings (226 TBtu)
- **–22%** stock **heating electricity** savings (–43 TBtu)
- **11%** stock **cooling electricity** savings (81 TBtu)
- **19%** stock **fan electricity** savings (112 TBtu)
- Cooling and fan savings could also be attributed to high-performance non-HP-RTUs.
- Savings are associated with premium units.
- Electric backup scenario shows higher electricity and lower natural gas consumption compared to original fuel scenario.

Stock Site Energy by Fuel and End Use



OF = original fuel backup
E = electric backup

Heat Pump Rooftop Units (HP-RTUs) With Original Fuel Backup



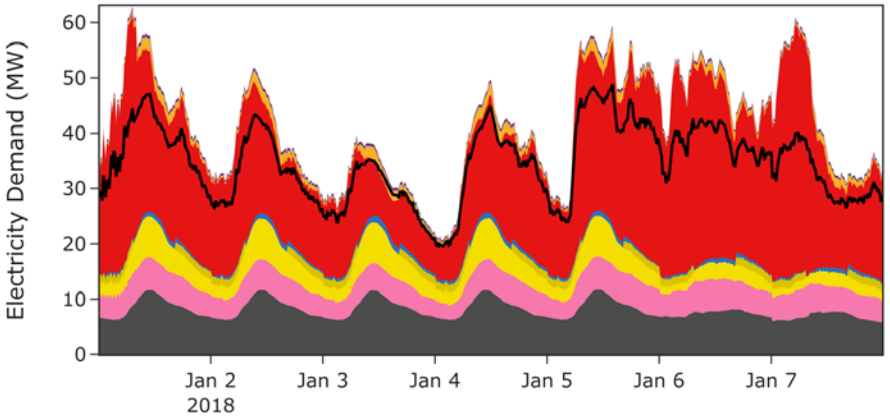
- Emissions avoided across all presented grid scenarios.
- Electricity emissions avoided despite electrifying furnaces from cooling and fan end uses; also from replacing electric resistance RTUs with HP-RTUs.

HP-RTU: Electric vs. Original Fuel Backup Load Profile for Winter Peak

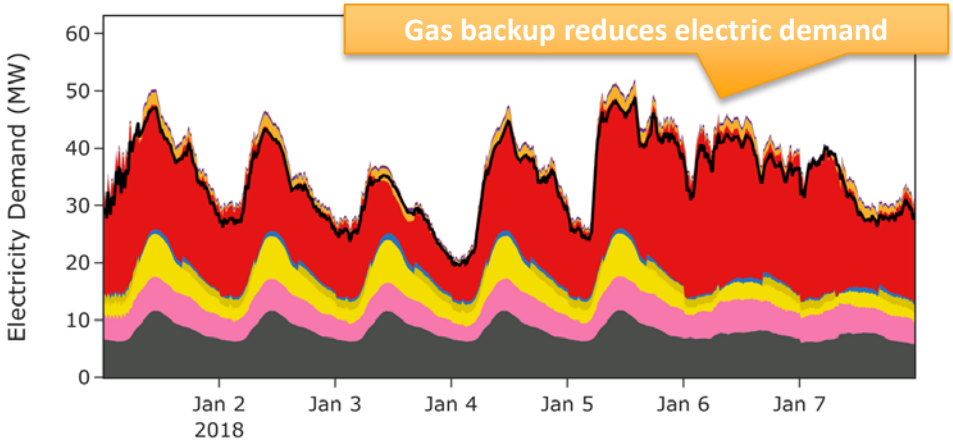
Sample Location: Boston, MA (Suffolk County)
Time step: 15 minutes

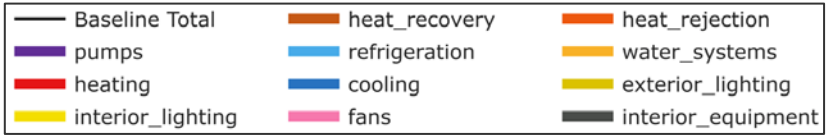
Scope: Total commercial stock
Fuel: Electricity

HP-RTU, Electric Backup



HP-RTU, Original Fuel Backup





Note that load profiles are **heavily influenced** by assumptions for heat pump sizing routine, lockout temperature, and performance curves.

Air to Water Heat Pump Boiler With Gas Backup Heating

Heat Pump Boiler With Gas Backup

Measure Concept

- Replace natural gas boilers for HVAC application with air source heat pump boilers
- Natural gas boiler backup
- 140°F supply temperature

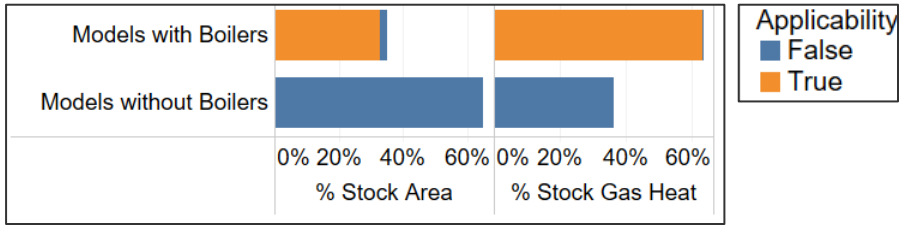
Heat Pump Boiler Performance

- **Sizing:** Meet loads down to 17°F
- **Compressor Lockout:** −5°F
- **Defrost:** Integrated into performance curves
- **Performance Data Source:** Manufacturer data

Applicability

- Applicable to **33%** of stock floor area
- Doesn't apply to natural gas boilers serving condenser water loops

Stock Boiler Prevalence

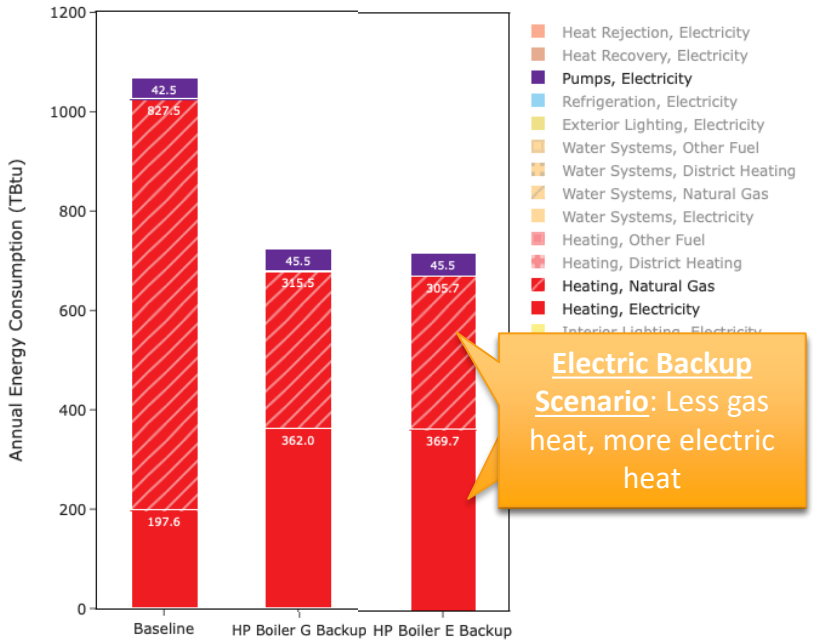


Heat Pump Boiler With Gas Backup

For Gas Backup Scenario:

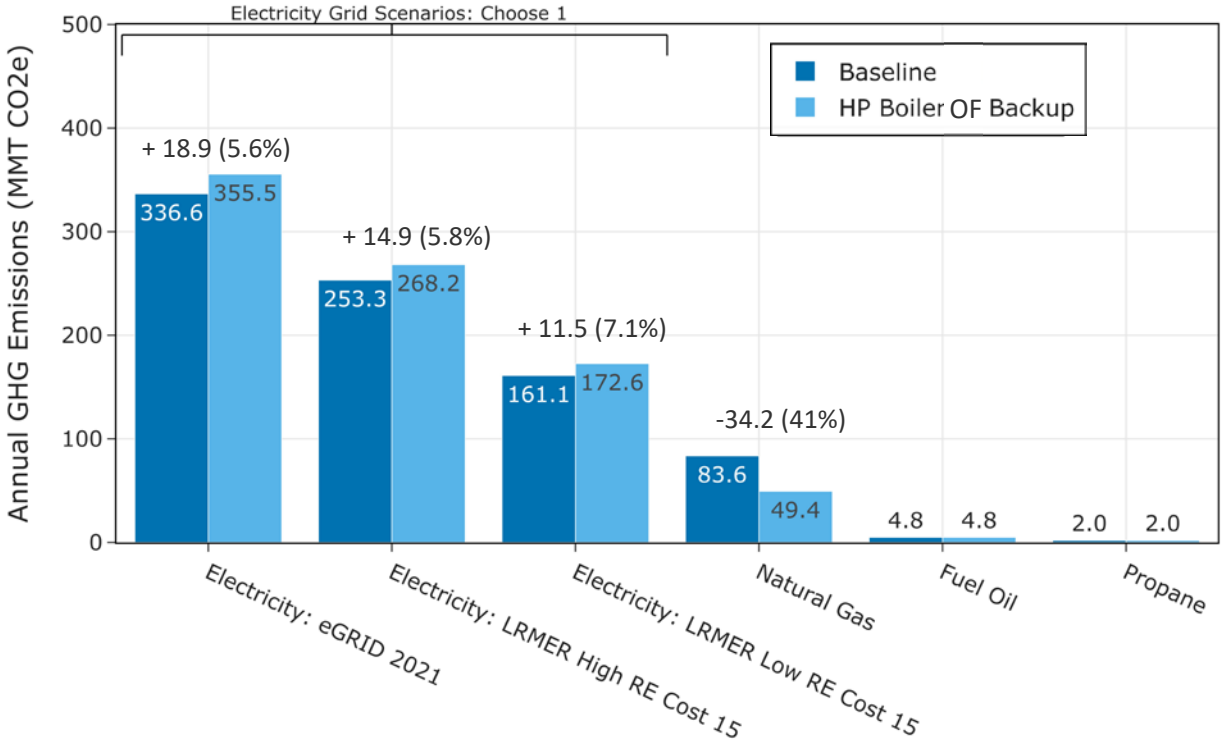
- **61.9%** stock **heating gas** savings (512 TBtu)
- **83.2%** stock **heating electricity** increase (164 TBtu)
- Large reduction in stock natural gas heating and increase in electric heating from electrifying boilers
- Gas backup shows slightly higher gas consumption and lower electricity consumption.

Stock Site Energy by Fuel and End Use



G = gas backup
E = electric backup

Heat Pump Boiler With Gas Backup



- Increased electricity emissions from electrifying gas boilers
- Decreased natural gas emissions from electrifying natural gas boilers
- Net emissions avoided for all comprehensive scenarios shown despite increased electricity emissions.

Variable Refrigerant Flow (VRF) With Dedicated Outdoor Air System (DOAS)

VRF With DOAS

Measure Concept

- Replace RTUs/variable air volumes (VAVs) with VRF with DOAS
- Cold climate VRF technology (rated to −22°F)
- Outdoor ventilation air provided by heat/energy recovery DOAS with electric heat and DX cooling
- Decoupled ventilation

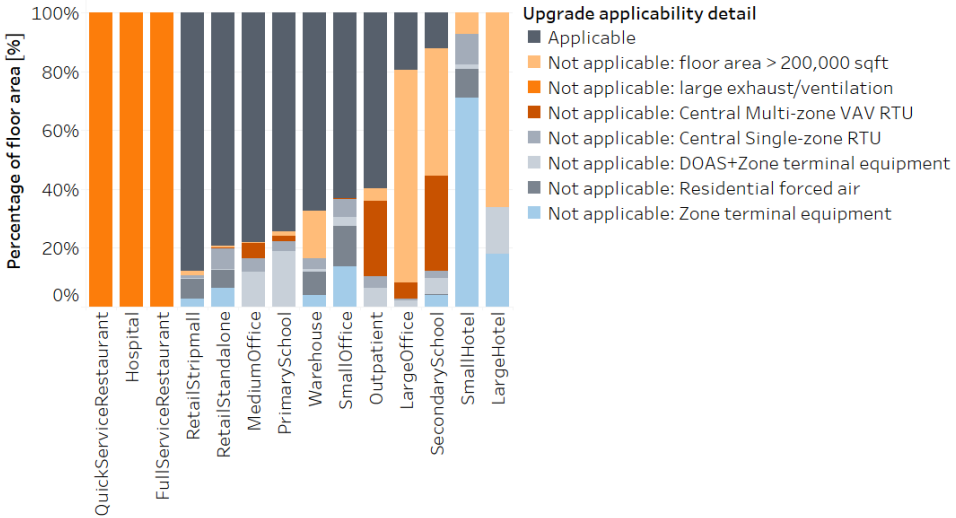
VRF Performance

- **Sizing:** Based on design cooling load
- **Supplemental heat:** Electric resistance
- **Compressor lockout:** −22°F
- **Performance Data Source:** Manufacturer data

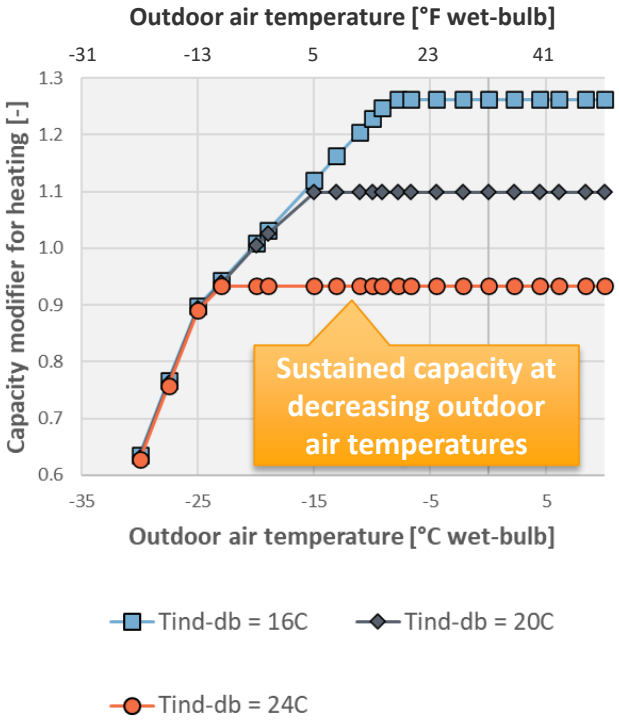
Applicability

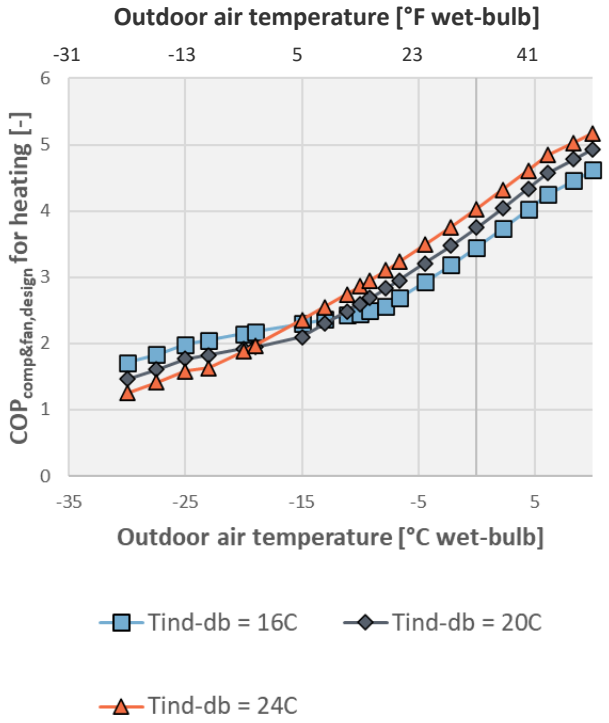
- Buildings with RTUs/VAVs (with limitations)
  - Limitations = building/space type, size, indoor unit count, or original fuel type (i.e., district).
- Applicable to **53%** of stock floor area

VRF DOAS Applicability (%)



VRF With DOAS





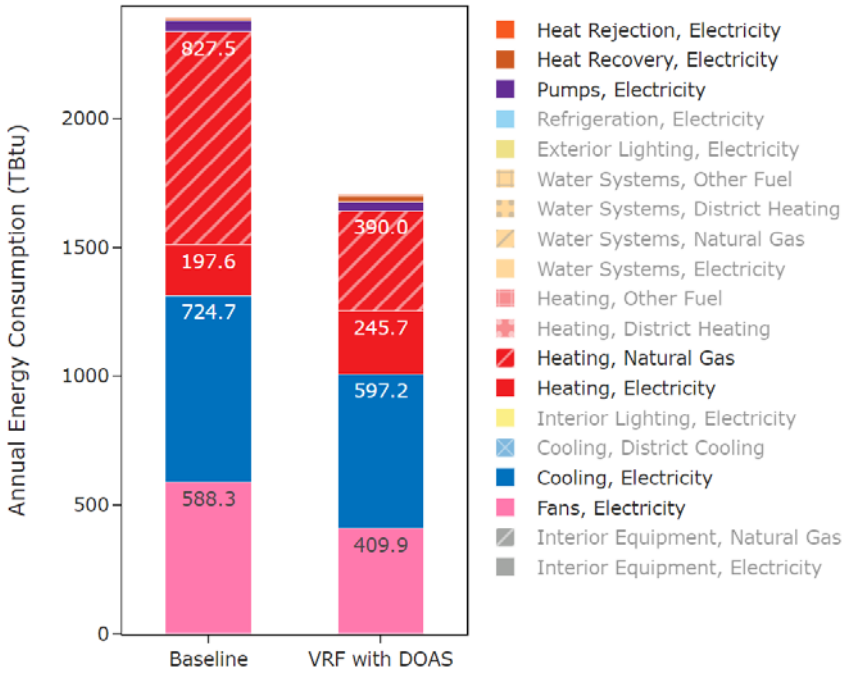
- VRF design heating performance
- $COP_{comp\&fan,design}$
  - Only accounts for compressor and outdoor unit fan power
  - Reflects design conditions (and not operating conditions)

Performance maps from manufacturer data tables.

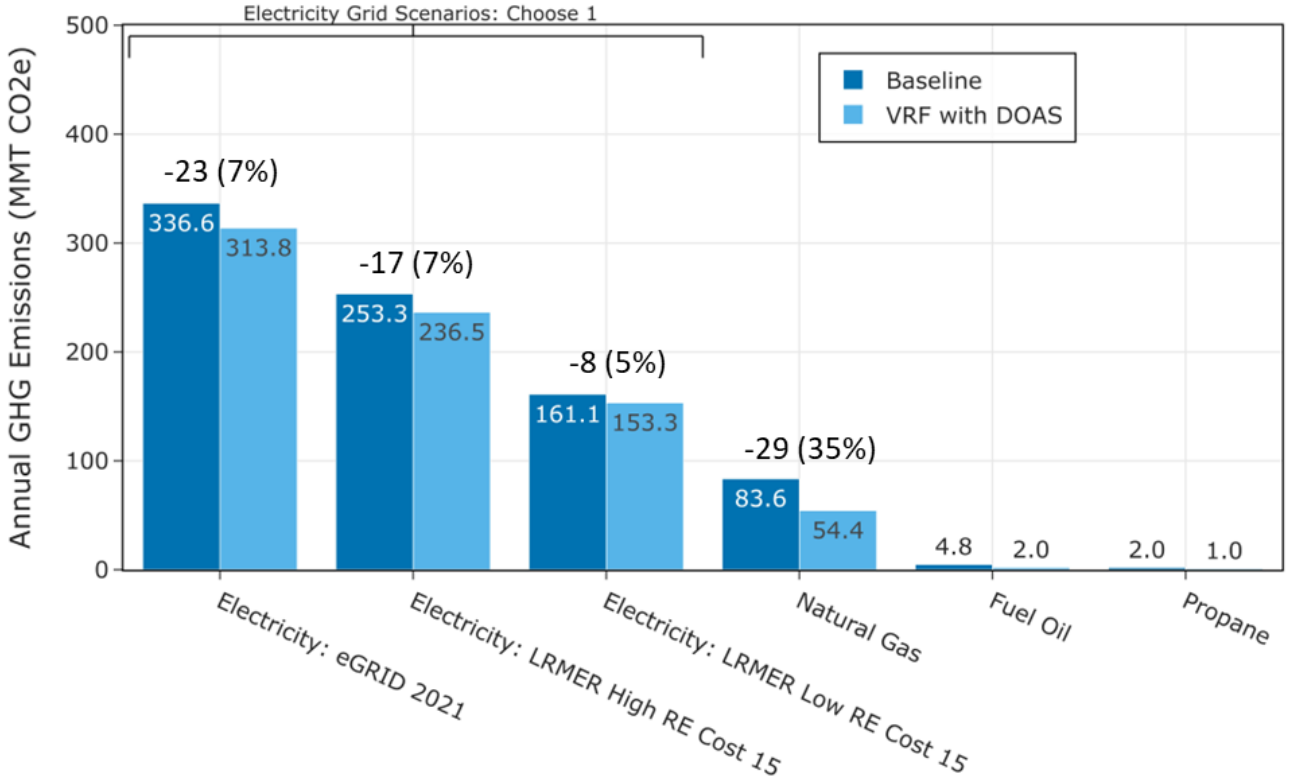
VRF With DOAS

- **53%** stock **heating natural gas** savings (438 TBtu)
- **–24%** stock **heating electricity** savings (–48 TBtu)
- **18%** stock **cooling electricity** savings (128 TBtu)
- **30%** stock **fan electricity** savings (178 TBtu).
- Heat/energy recovery reduces heating and cooling loads
- High-performance VRF system saves cooling energy
- Decoupled ventilation and high-efficiency motors saves fan energy.

Stock Site Energy by Fuel and End Use



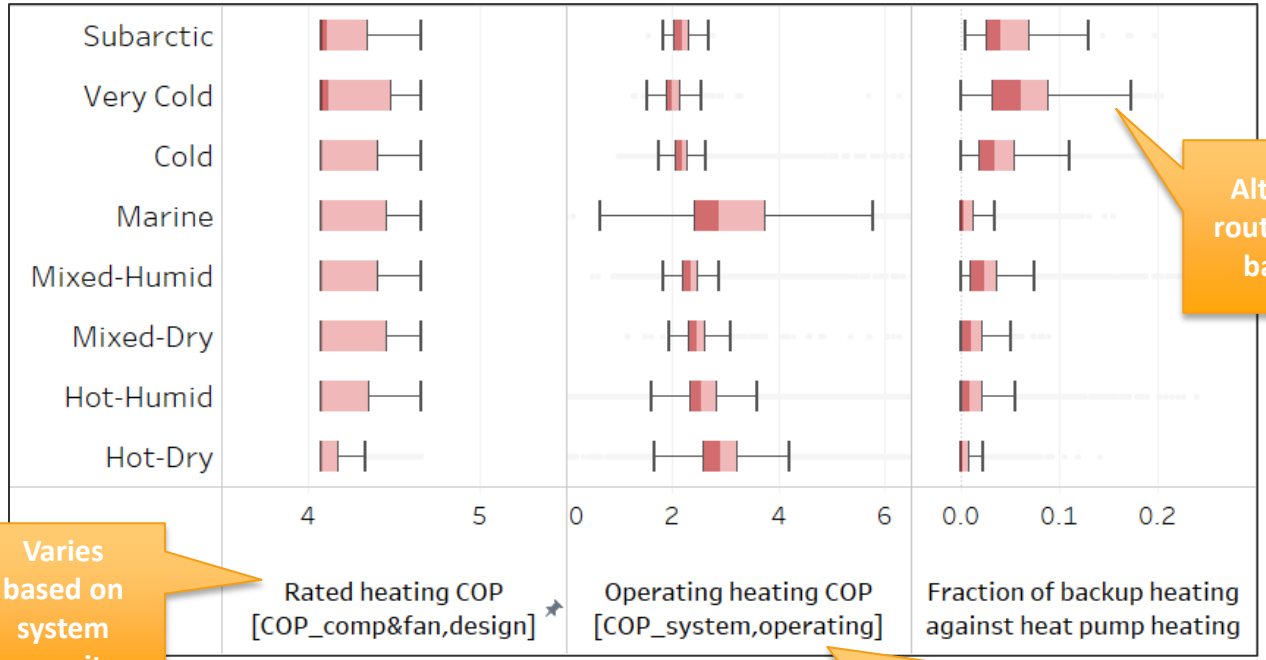
VRF With DOAS



- Net emissions avoided across all comprehensive grid scenarios and fuel types presented
- Electricity savings from fans, cooling, and heat/energy recovery savings outweigh heating electricity increase, resulting in net electricity emissions avoided

VRF With DOAS

Building Annual Average Heating COPs



Alternative sizing routines can reduce backup heating

Varies based on system capacity

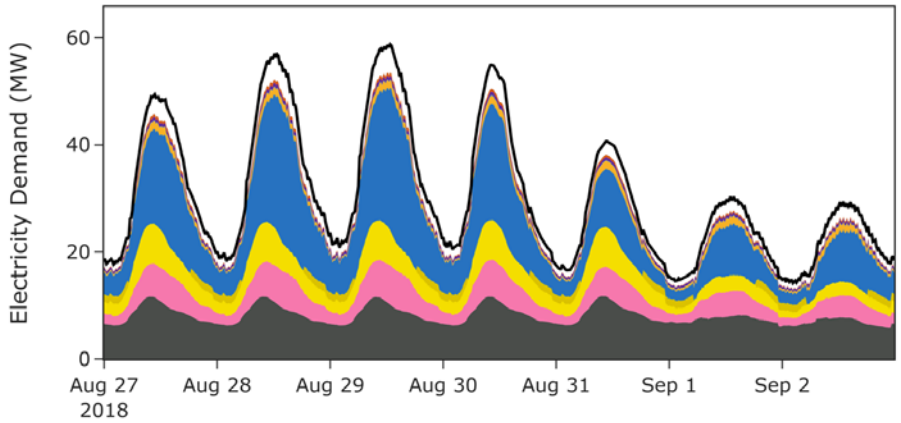
Includes backup heating electricity and other operational factors

VRF With DOAS: Summer vs. Winter Peak

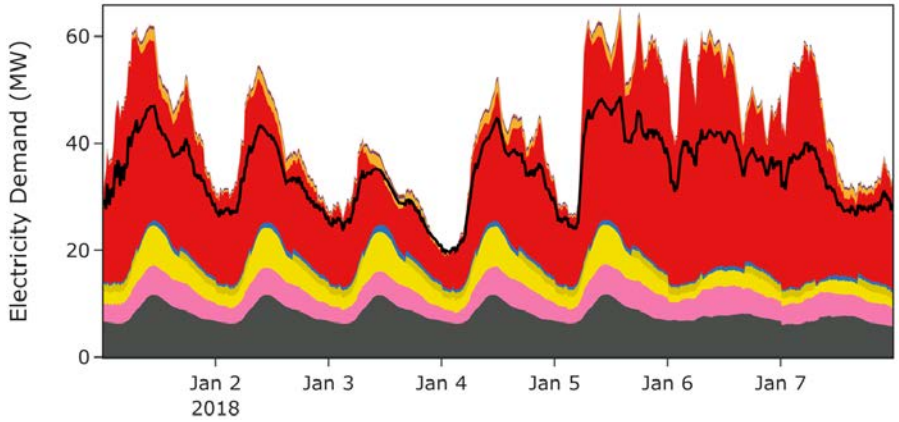
Location: Boston, MA (Suffolk County)
Time step: 15 minutes

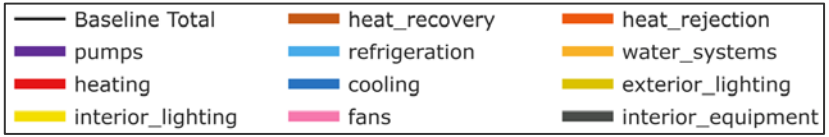
Scope: Total commercial stock
Fuel: Electricity

Summer Peak



Winter Peak





Note that load profiles are **heavily influenced** by assumptions for heat pump sizing routine, lockout temperature, and performance curves.

Demand Control Ventilation (DCV)

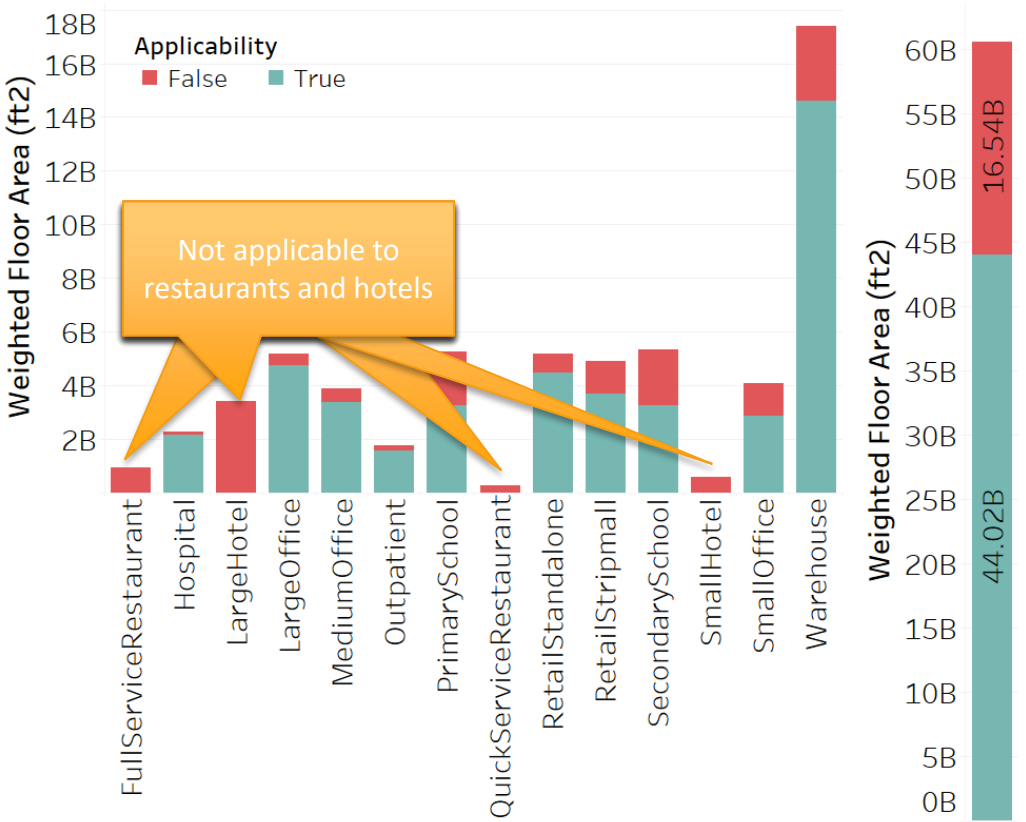
Demand Control Ventilation

Measure Concept

- DCV reduces outdoor ventilation air during periods of detected low occupancy.
- Measure adds DCV to air handling units (AHUs) that do not already contain it.

Applicability

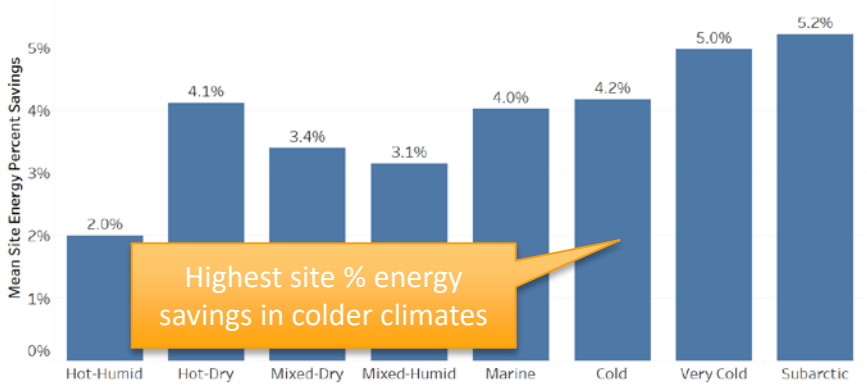
- Applicable to **73%** of stock floor area.
- Applies to air handling units.
- Not applicable to:
  - Hotels and restaurants
  - Space types where ventilation is not occupancy-driven (e.g., operating rooms)
  - Models with DOAS, or non-AHU system types.



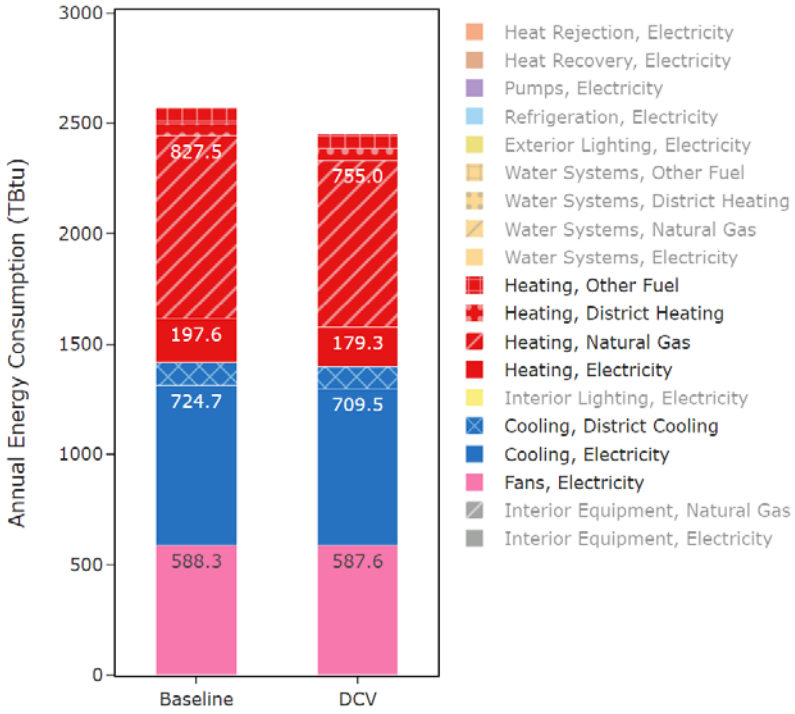
Demand Control Ventilation

- **8.8%** stock **heating gas** savings (73 TBtu)
- **9.3%** stock **heating electricity** savings (18 TBtu)
- **2.1%** stock **cooling electricity** savings (15 TBtu)
- Generally decreases heating and cooling loads
- Some increased cooling loads in models without economizers

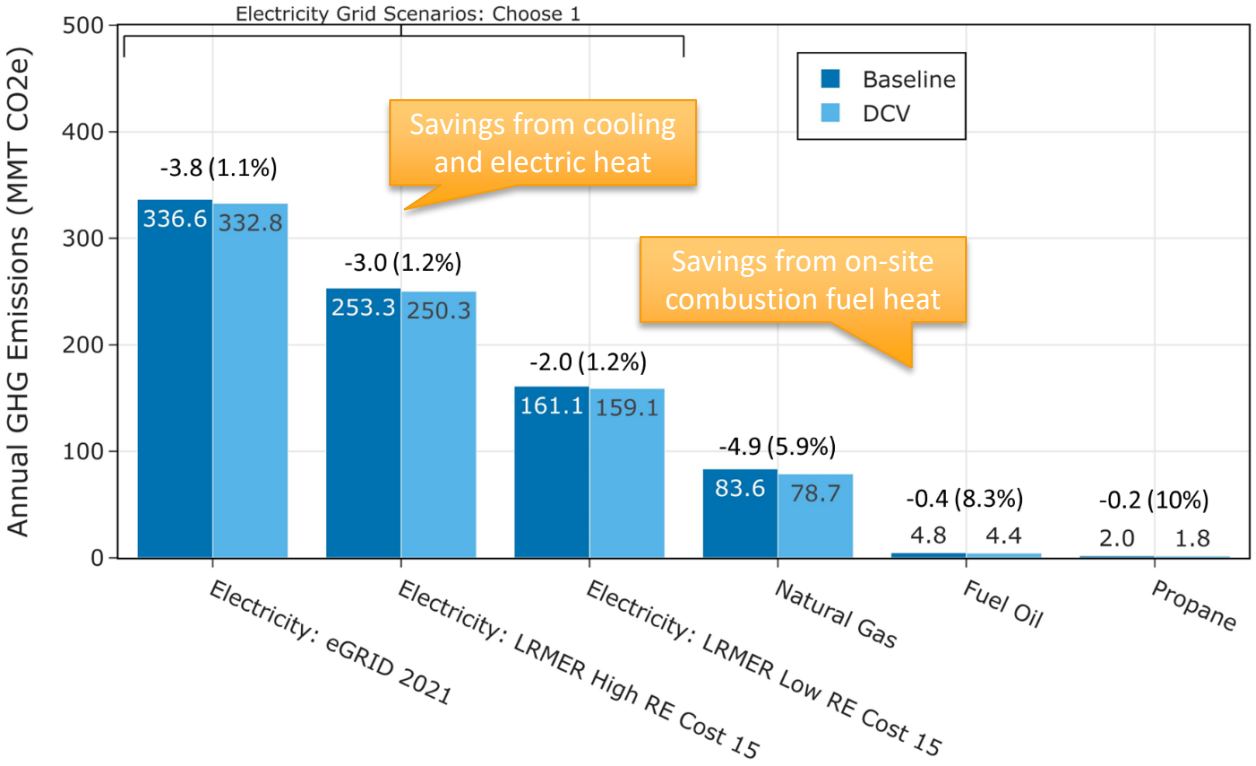
Mean Site Energy Percent Savings by Climate Zone



Stock Site Energy by Fuel and End Use



Demand Control Ventilation



Emissions avoided across presented grid scenarios and on-site combustion fuels.

Exhaust Air Heat/Energy Recovery

Exhaust Air Heat/Energy Recovery (H/ER)

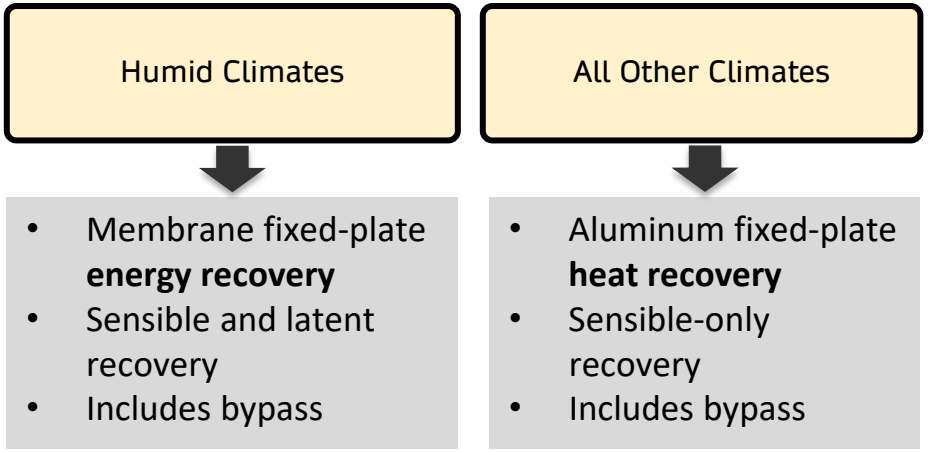
Measure Concept

- Adds E/HR to existing air handlers
- Recovers energy from exhaust air stream to pretreat ventilation air
- 90% return air assumed
- Fan static pressure increased

Applicability

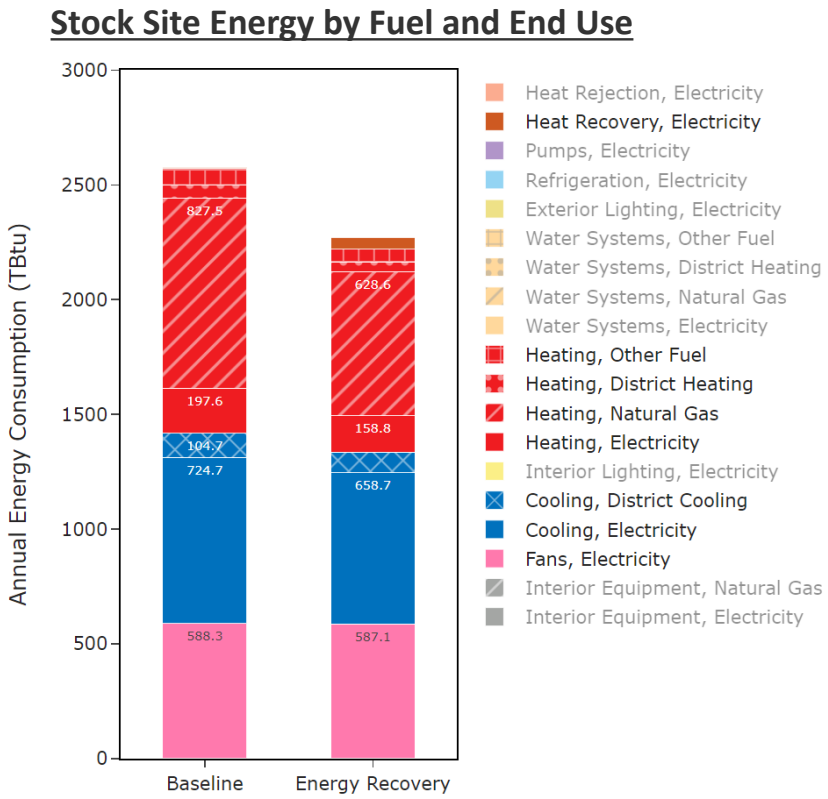
- Added to air handlers without existing H/ER
- Not added to food service space types
- Applicable to **~70%** of stock floor area

Technology Specifications

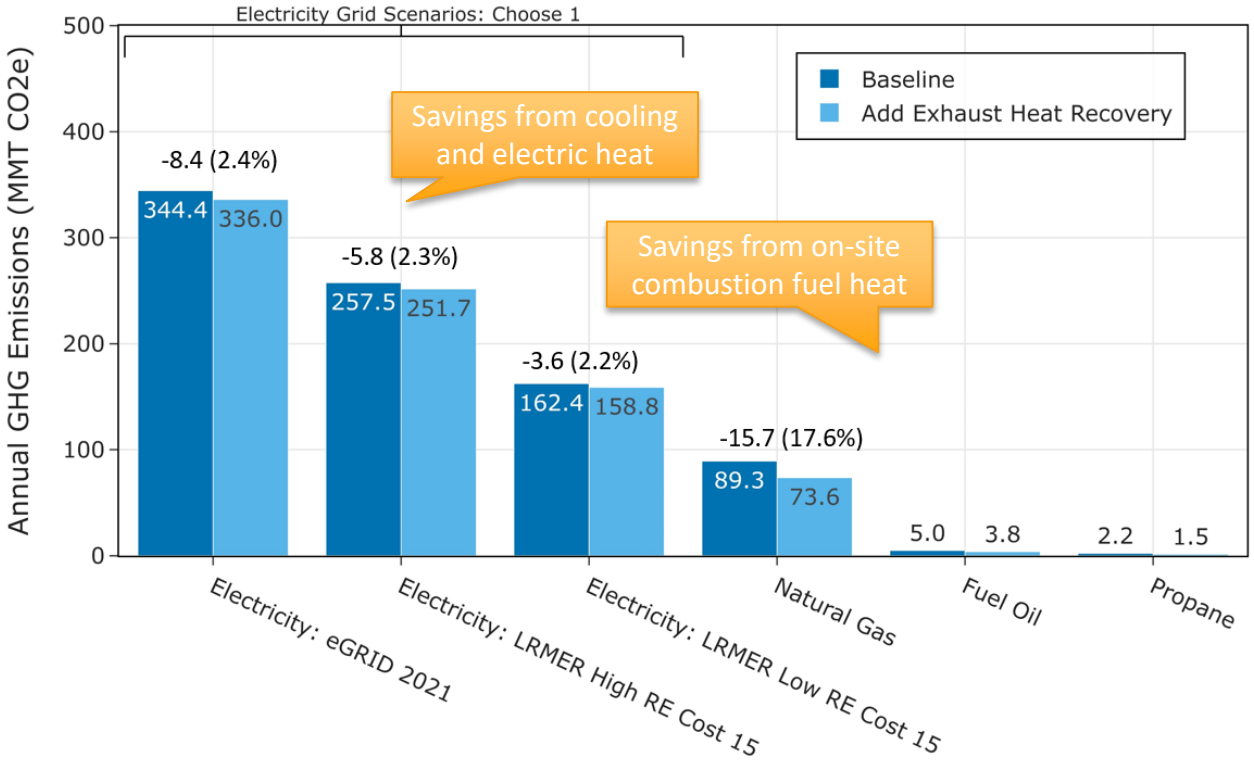


Exhaust Air Heat/Energy Recovery

- **23%** stock **heating** savings (268 TBtu)
- **10%** stock **cooling** savings (82 TBtu)
- **–8%** stock combined **fan** and **heat recovery** penalty (–46 TBtu)
- Heating and cooling savings are from reduced ventilation loads.
- Heat recovery end use represents added fan energy for E/HR system.



Exhaust Air Heat/Energy Recovery



- Emissions avoided across presented grid scenarios.
- Reduced ventilation loads yield avoided emissions.

Package 1: Envelope Upgrades

Package 1: Envelope Upgrades

Package Concept:

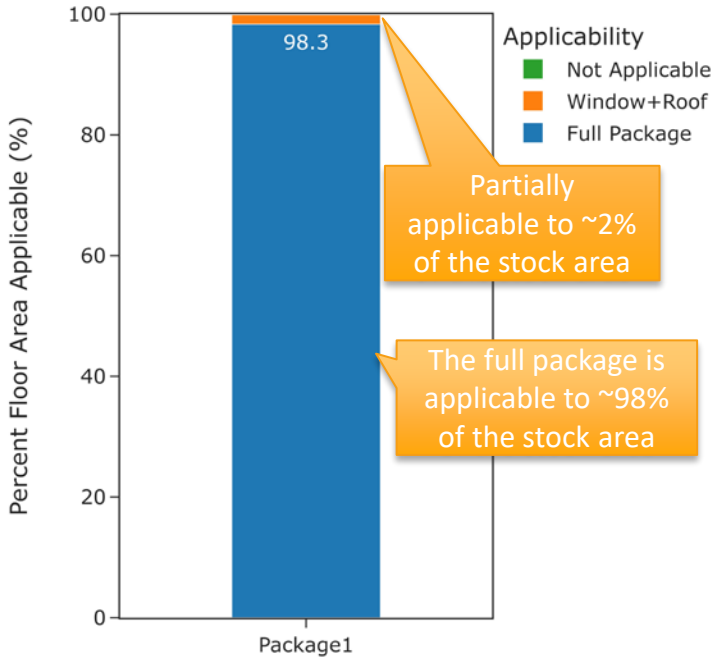
Combination of three measures from 2023 Release 1:

- Window Replacement
- Exterior Wall Insulation
- Roof Insulation

Applicability

- Package 1 is applicable to **100%** of stock for at least one measure.
- Window Replacement: All non-triple-pane windows (>99%)
- Exterior Wall Insulation: All buildings not already meeting R-value targets (98%)
- Roof Insulation: All buildings not already meeting R-value targets (>99%)

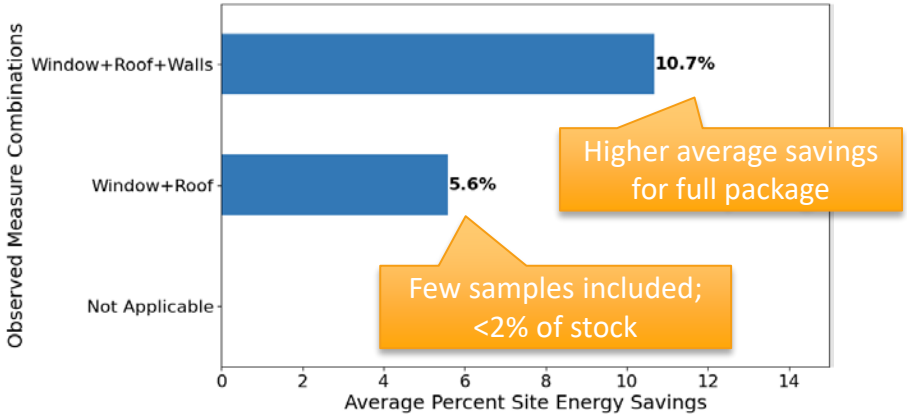
Applicability: % Floor Area per Measure Combination



Package 1: Envelope Upgrades

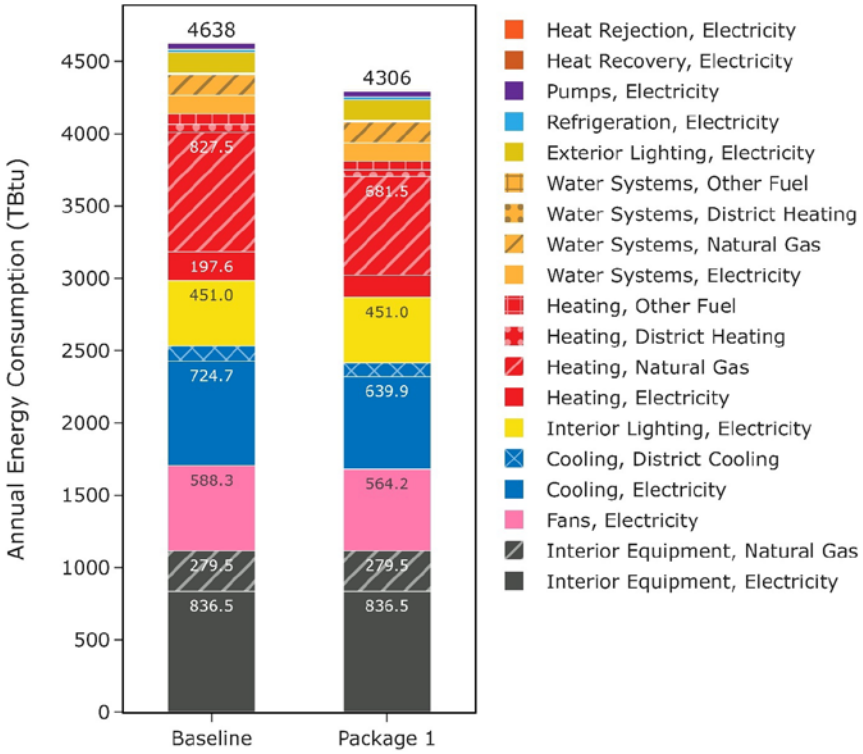
- **23%** stock site **heating electricity** savings (146 TBtu)
- **18%** stock site **heating gas** savings (44 TBtu)
- **12%** stock site **electricity cooling** energy savings (85 TBtu)
- **4%** stock site **electricity fan** energy (21 TBtu)
- Reduced heating and cooling load from envelope measures.

Average Site % Savings* by Measure Applicability

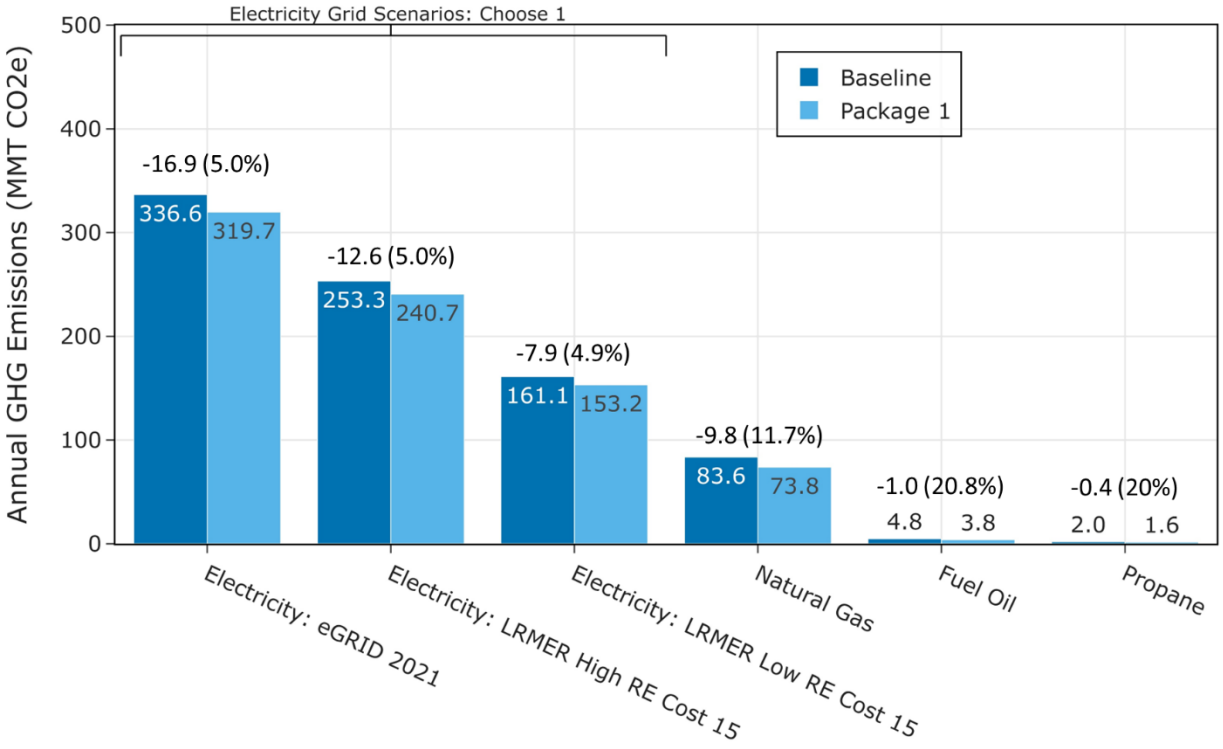


**Note that site energy savings do not necessarily translate proportionally to savings for source energy, operational cost, or avoided greenhouse gas emissions.*

Stock Site Energy by Fuel and End Use



Package 1: Envelope Upgrades



Emissions avoided across all presented grid scenarios and on-site combustion fuels due to HVAC load reductions from improved thermal properties of windows, walls, and roofs.

Package 2: Lighting Upgrades and HP-Boiler or HP-RTU

Package 2: Lighting Upgrades and HP-Boiler or HP-RTU

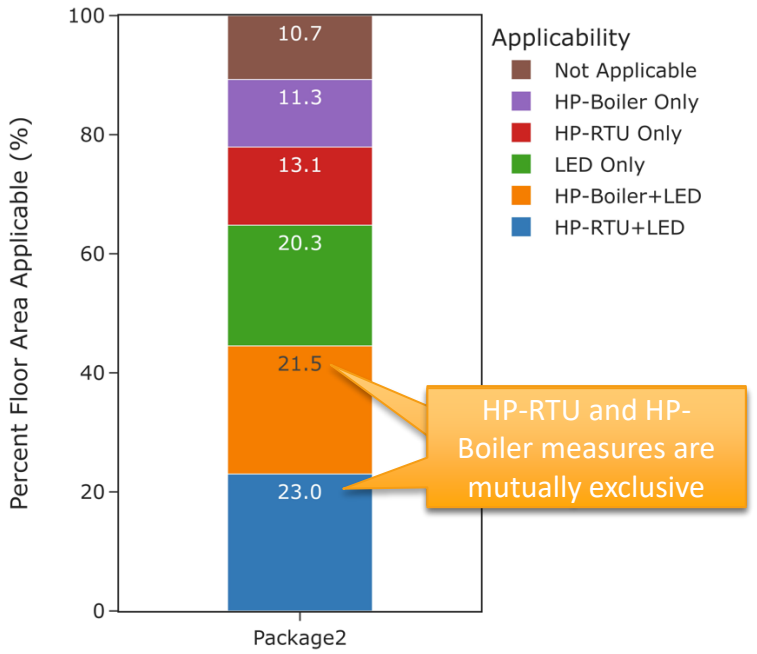
Package Concept:

Combination of three measures from 2023 Release 1: LED Lighting, HP-RTU, and HP-Boiler

Applicability

- Package 2 is applicable to **89%** of stock for at least one measure.
- LED Lighting: Buildings without LED interior lighting (65% stock applicability)
- HP-RTU, Electric Backup: Buildings with gas or electric resistance RTUs (36% stock applicability)
- HP-Boiler, Electric Backup: Buildings with natural gas boiler for space heating (33% stock applicability)

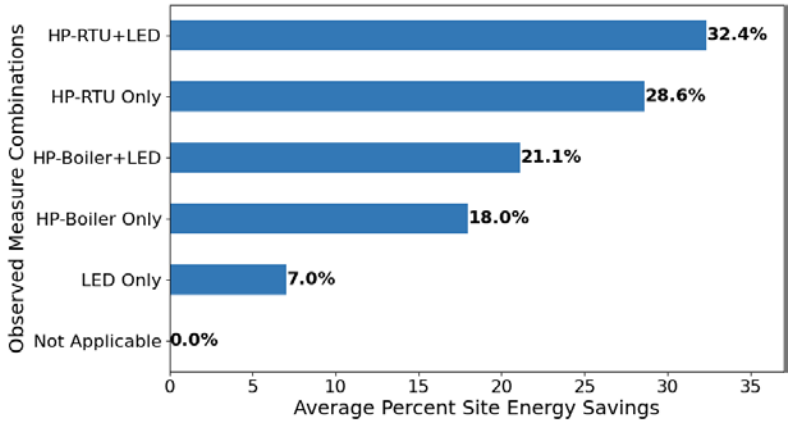
Applicability: % Floor Area per Measure Combination



Package 2: Lighting Upgrades and HP-Boiler or HP-RTU

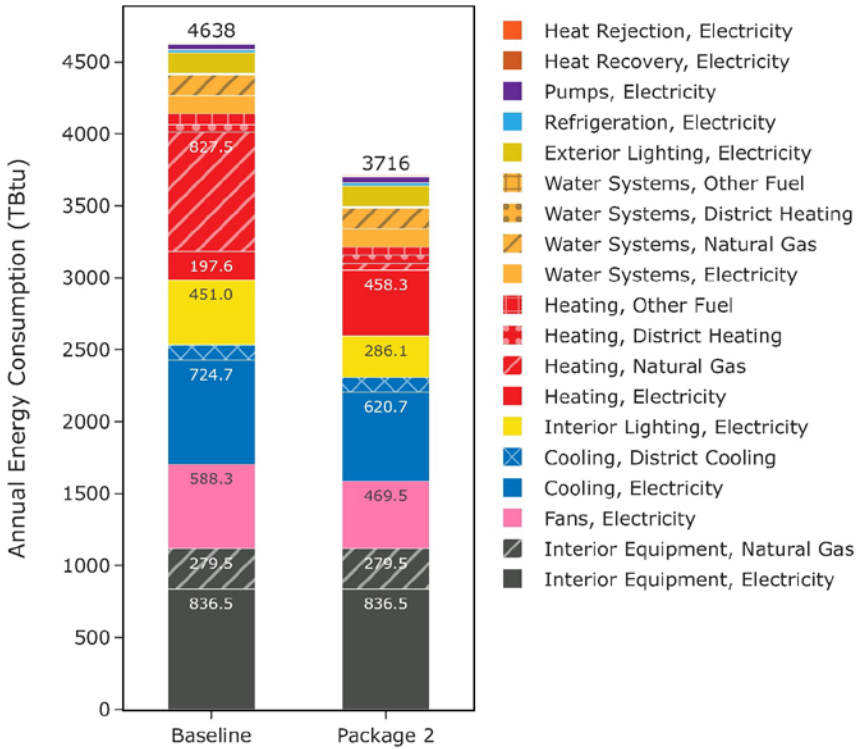
- **94%** stock **heating gas** savings (779 TBtu)
- **–132%** stock **heating electricity** savings (–261 TBtu)
- **37%** stock **interior lighting electricity** savings (164.9 TBtu)
- **20%** stock **fan electricity** savings (119 TBtu)
- **14%** stock **cooling electricity** savings (104 TBtu)

Average Site % Savings* by Measure Applicability

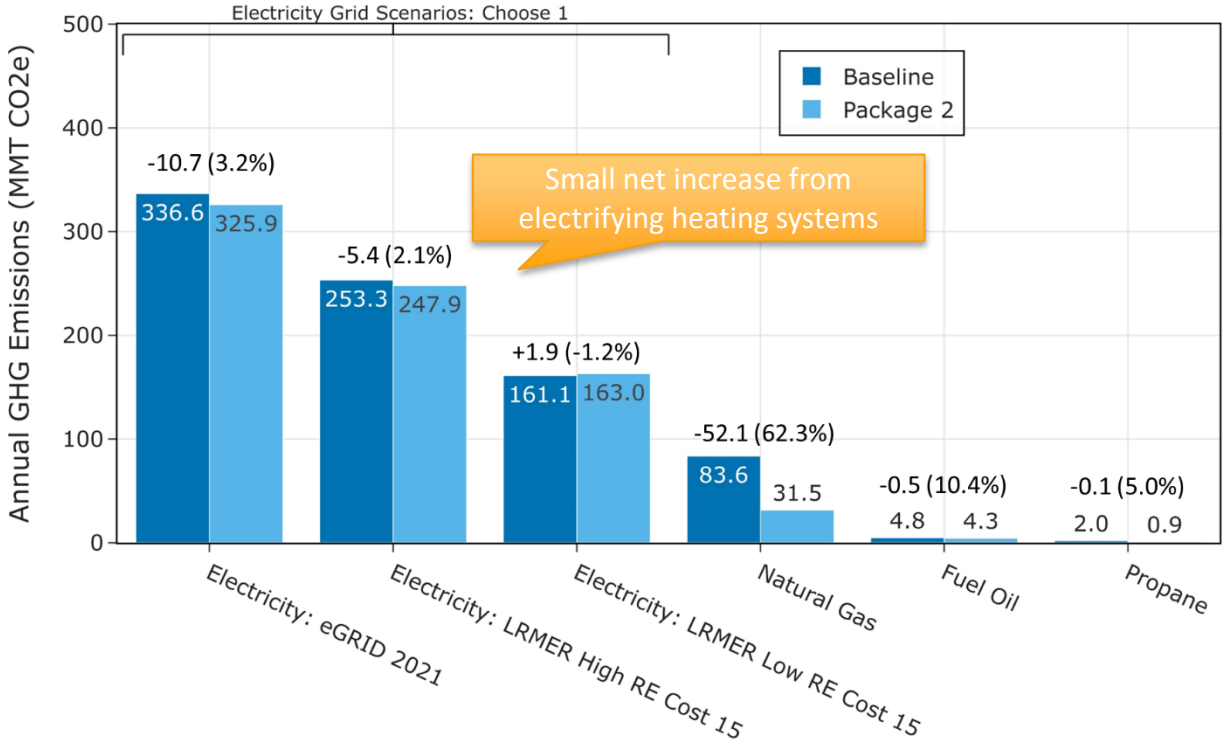


**Note that site energy savings do not necessarily translate proportionally to savings for source energy, operational cost, or avoided greenhouse gas emissions.*

Stock Site Energy by Fuel and End Use



Package 2: Lighting Upgrades and HP-Boiler or HP-RTU



- Net emissions avoided despite increased electricity emissions.
- Increased electricity emissions from electrifying gas boilers.
- Electricity emissions avoided are from cooling and fan end uses; also from replacing electric resistance RTUs with HP-RTUs and LED lighting installation.

Package 3: Combine Package 1 and 2

Package 3: Combine Package 1 and 2

Package Concept:

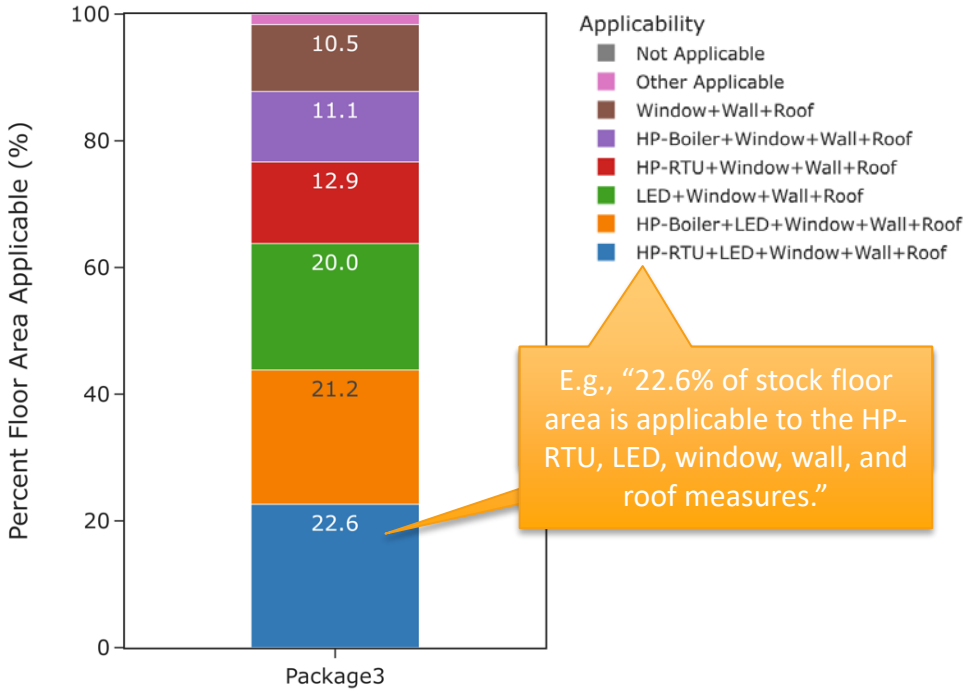
Combination of six measures from 2023 Release 1:

- Window Replacement
- Exterior Wall Insulation
- Roof Insulation
- LED Lighting
- HP-RTU
- HP-Boiler

Applicability

- Package 3 is applicable to **100%** of stock for at least one measure.

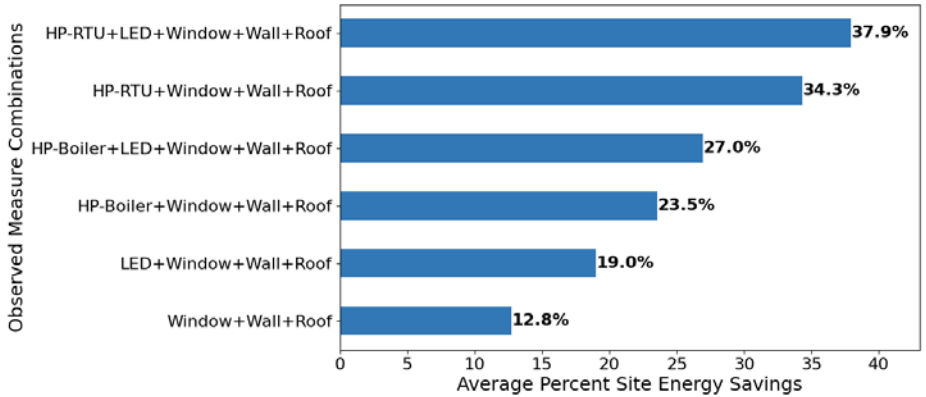
Applicability: % Floor Area per Measure Combination



Package 3: Combine Package 1 and 2

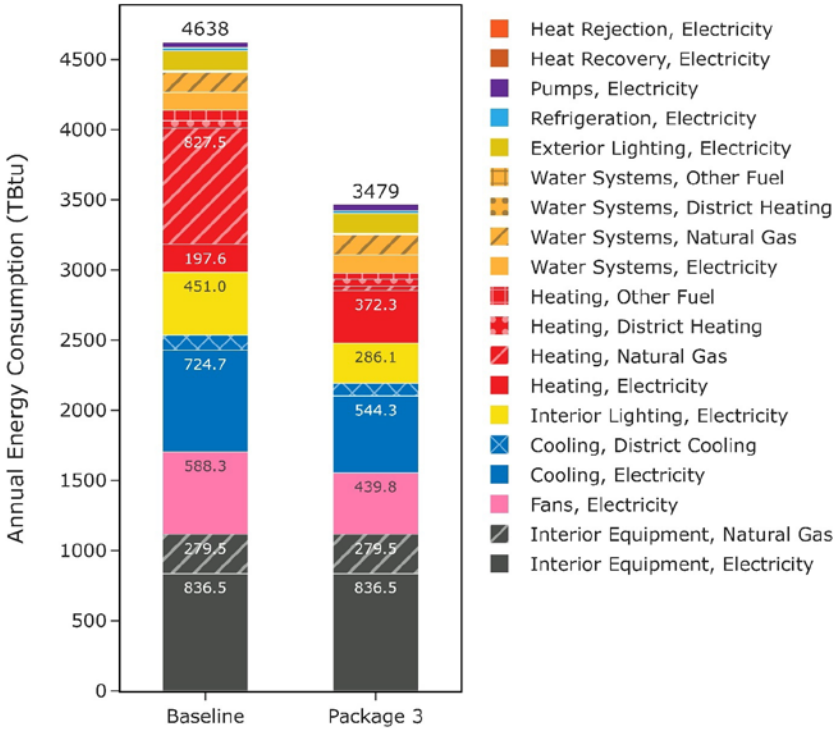
- **96.3%** stock **heating gas** savings (795.6 TBtu)
- **–88.4%** stock **heating electricity** savings (–174.7 TBtu)
- **36.5%** stock **interior lighting electricity** savings (164.9 TBtu)
- **25.2%** stock **fan electricity** savings (148.5 TBtu)
- **24.9%** stock **cooling electricity** savings (180.4 TBtu)

Average Site % Savings* by Measure Applicability

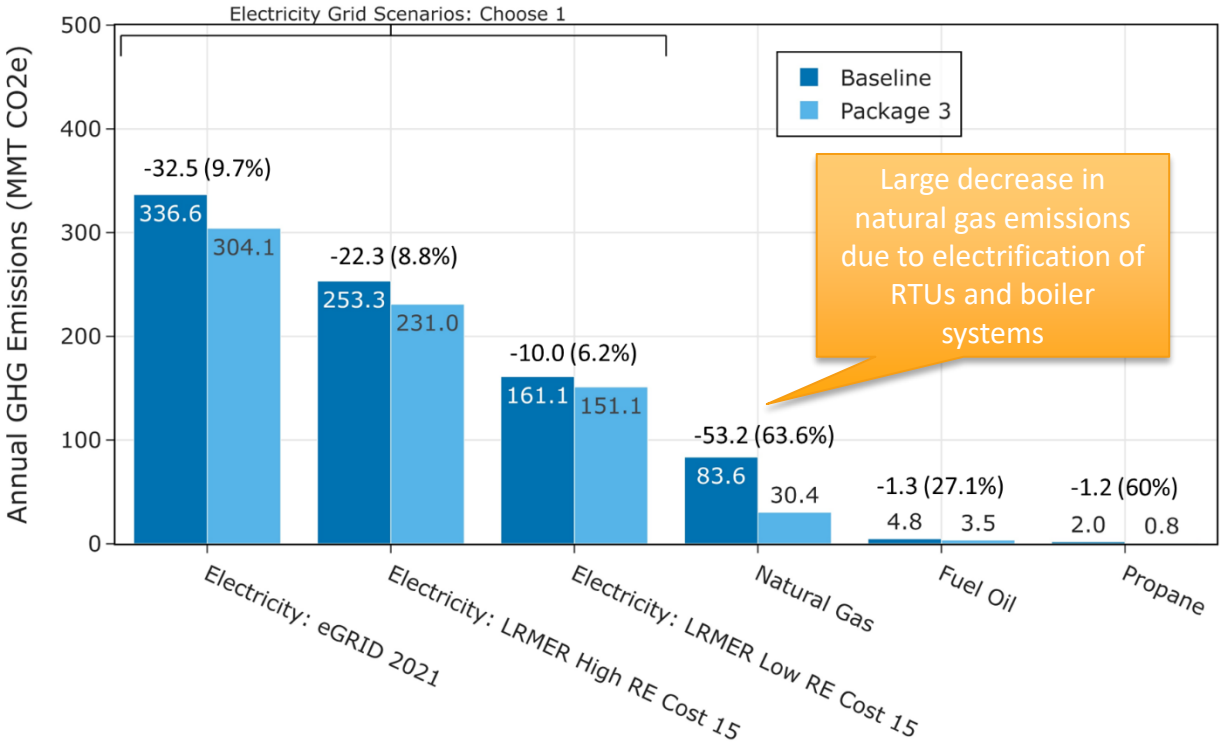


*Note that site energy savings do not necessarily translate proportionally to savings for source energy, operational cost, or avoided greenhouse gas emissions.

Stock Site Energy by Fuel and End Use



Package 3: Combine Package 1 and 2



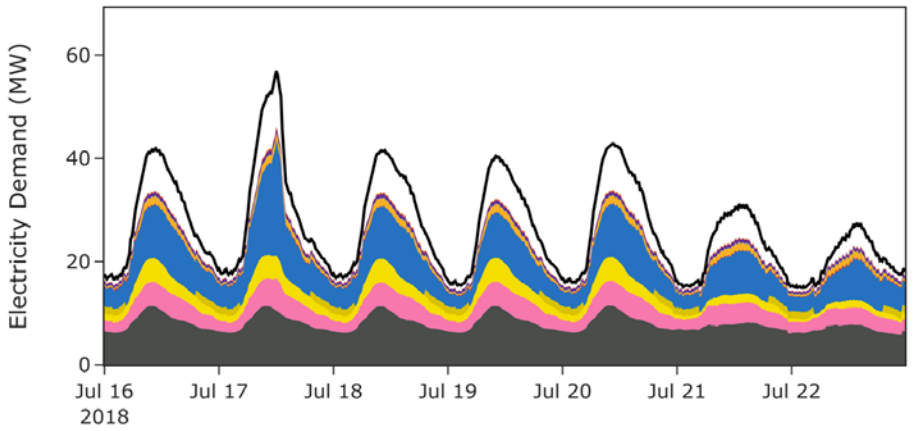
- Emissions avoided across all grid scenarios and combustion fuels presented.
- Electricity emission reductions include interior lighting and fan and cooling end uses, as well as the increase in electricity from electrifying gas furnace and boiler systems.

Package 3: Summer vs. Winter Peak

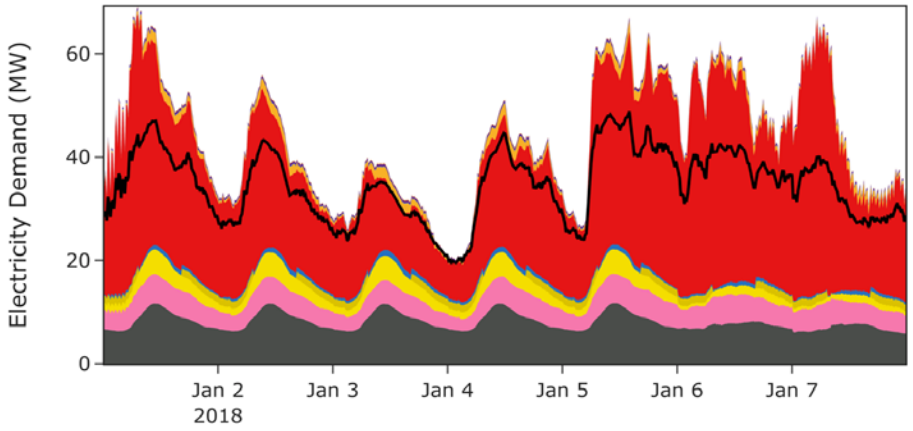
Location: Boston, MA (Suffolk County)
Time step: 15 minutes

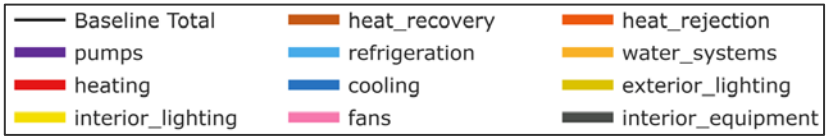
Scope: Total commercial stock
Fuel: Electricity

Summer Peak



Winter Peak





Note that load profiles are **heavily influenced** by assumptions for heat pump sizing routine, lockout temperature, and performance curves.

Accessing the Data Set

Accessing the Data

	Metadata	Individual Load Profiles	Aggregate Load Profiles	Data Viewer	Full Database
Data Format	.csv and .parquet files	.csv and .parquet files	.csv and .parquet files	Dashboard with .csv exports	Amazon S3 bucket
Time Scale	Annual	15-minute intervals	15-minute intervals	Customizable	Annual or 15-minute intervals
Grouped by	Individual building ID	Individual building ID	Geograhies: climate zone, ISO/RTO region, state	Customizable	Customizable
Fields by	Building input characteristics	-	-	-	Building input characteristics
	Energy consumption	Energy consumption	Energy consumption	Energy consumption	Energy consumption
	Energy savings	Energy savings	Energy savings	Energy savings	Energy savings
	Emissions	-	-	-	Emissions
	Calculated fields	-	-	-	Calculated fields
Accessed via	OEDI	OEDI	OEDI	ComStock.nrel.gov	Scripting languages

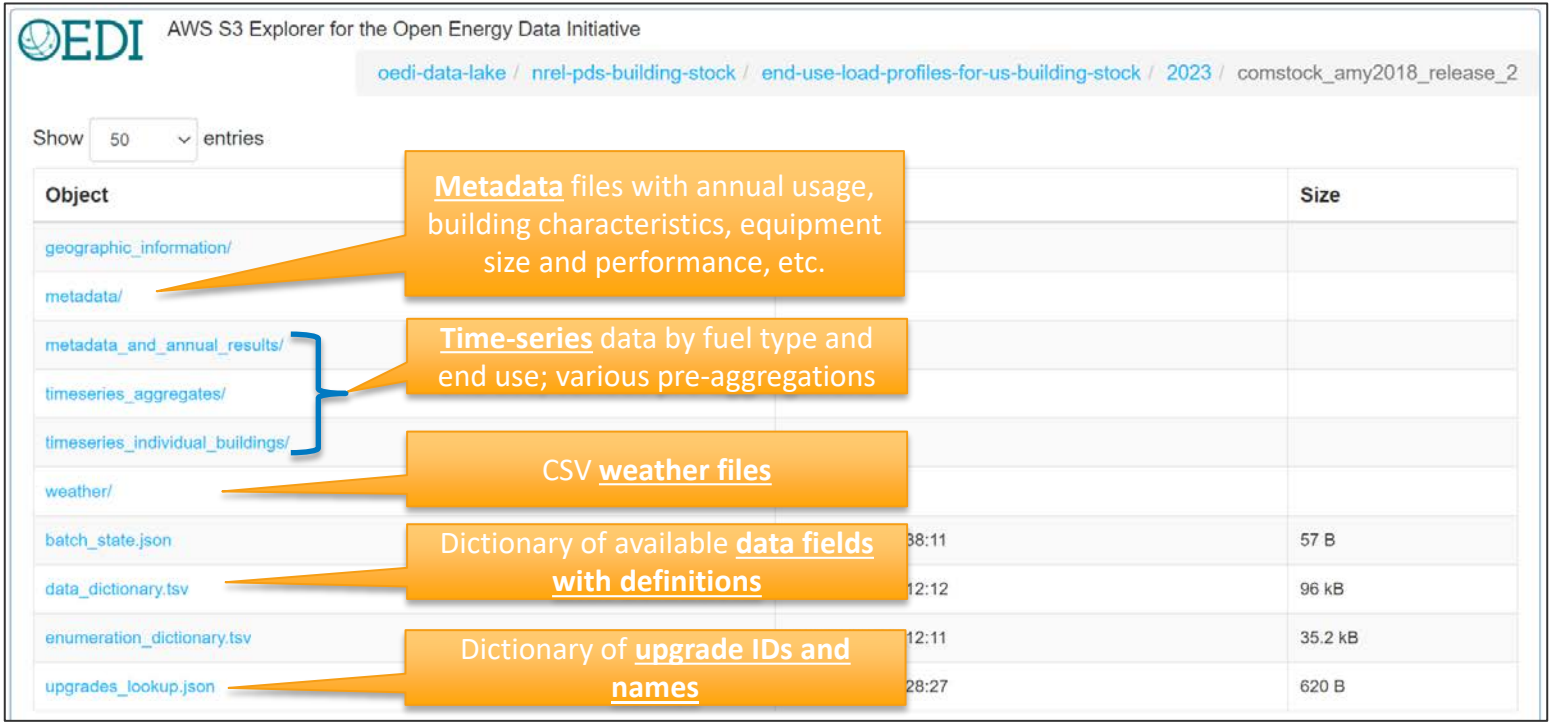
OEDI = Open Energy Data Initiative

Field Naming Convention

Prefix or Name	Count	Description	Example
in.	64	Inputs of building characteristics and geospatial codes	in.window_type
out.	352	Simulation outputs	out.electricity.refrigeration.energy_consumption
calc.	159	Calculated values such as totals and % savings	calc.weighted.electricity.cooling.energy_consumption..tbtu
weight	1	Value for scaling single model results to national scale	4.8960474
bldg_id	1	Unique ID of the building model	3324
upgrade	1	Unique ID number for upgrade	5
model_count	1	Number of models aggregated (time-series files)	5334
applicability	12	Upgrade names	FALSE
Second Level			
out.[fuel type]	6	Fuel type: electricity, natural gas, etc.	out.natural_gas.water_systems.energy_consumption
out.emissions	20	Emission values	out.emissions.electricity.egrid..co2e_kg
out.params	197	Model parameters and summary statistics	out.params.dx_cooling_average_cop..cop
out.qoi	15	Quantities of interest such as peak demand	out.qoi.maximum_daily_use_summer_kw..kw
out.site_energy	4	Total of all end uses, site energy	out.site_energy.total.energy_consumption
Third Level			
out.[fuel type].[end use]	136	End uses: heating, cooling, lighting, water systems, etc.	out.electricity.heating.energy_consumption
Units			
..foo	-	".." denotes the start of the unit name	..kWh_per_ft2

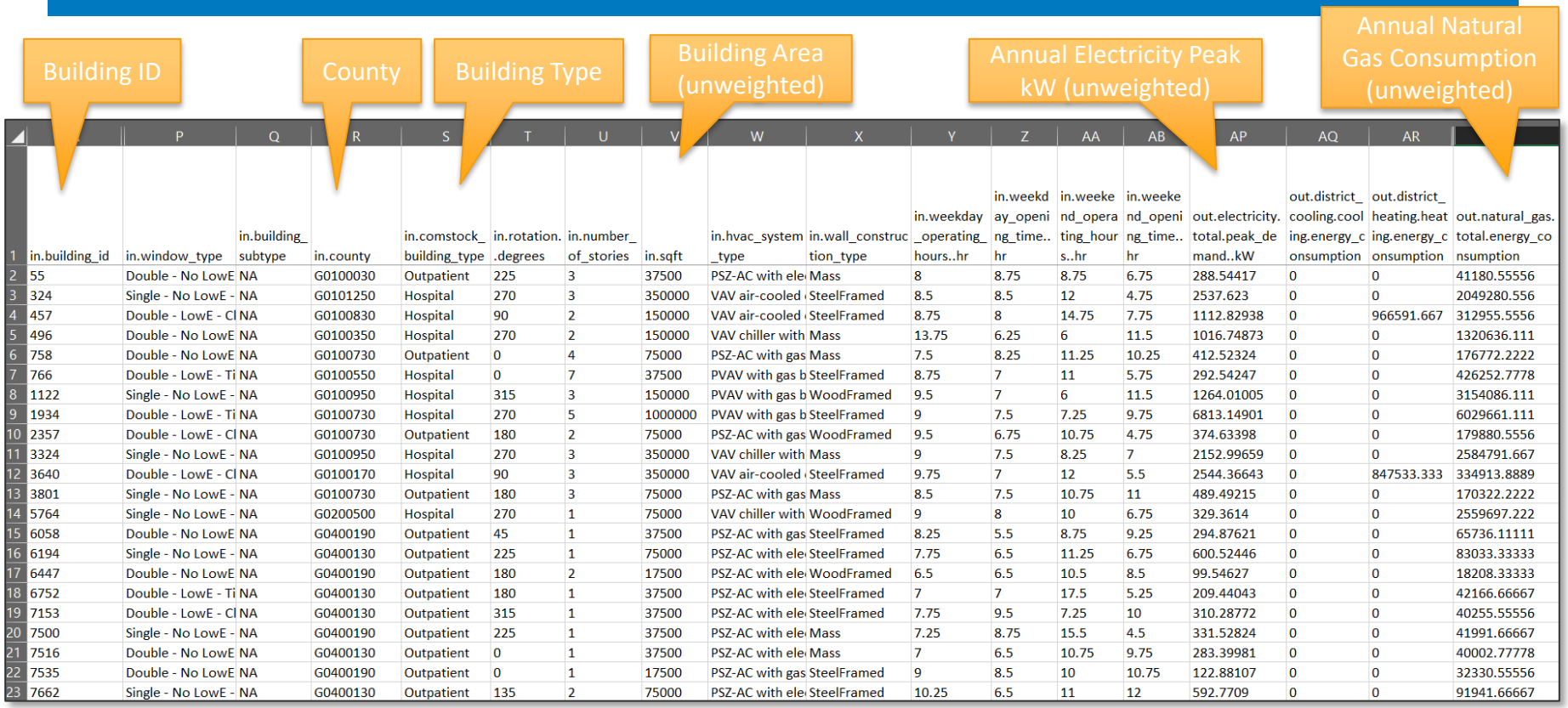
Data dictionary available at OEDI

Open Energy Data Initiative (OEDI) Folder Structure



Access at: OEDI

Example Metadata File



	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AP	AQ	AR	
1	in.window_type	in.building_subtype	in.county	in.comstock_building_type	in.rotation..degrees	in.number_of_stories	in.sqft	in.hvac_system_type	in.wall_construction_type	in.weekday_operating_hours..hr	in.weekday_opening_time..hr	in.weekend_operating_hours..hr	in.weekend_opening_time..hr	out.electricity.total.peak_demand..kW	out.district_cooling.cooling.energy_consumption	out.district_heating.heating.energy_consumption	out.natural_gas.total.energy_consumption
2	Double - No LowE	NA	G0100030	Outpatient	225	3	37500	PSZ-AC with ele	Mass	8	8.75	8.75	6.75	288.54417	0	0	41180.55556
3	Single - No LowE -	NA	G0101250	Hospital	270	3	350000	VAV air-cooled	SteelFramed	8.5	8.5	12	4.75	2537.623	0	0	2049280.556
4	Double - LowE - Cl	NA	G0100830	Hospital	90	2	150000	VAV air-cooled	SteelFramed	8.75	8	14.75	7.75	1112.82938	0	966591.667	312955.5556
5	Double - No LowE	NA	G0100350	Hospital	270	2	150000	VAV chiller with	Mass	13.75	6.25	6	11.5	1016.74873	0	0	1320636.111
6	Double - No LowE	NA	G0100730	Outpatient	0	4	75000	PSZ-AC with gas	Mass	7.5	8.25	11.25	10.25	412.52324	0	0	176772.2222
7	Double - LowE - Ti	NA	G0100550	Hospital	0	7	37500	PVAV with gas b	SteelFramed	8.75	7	11	5.75	292.54247	0	0	426252.7778
8	Single - No LowE -	NA	G0100950	Hospital	315	3	150000	PVAV with gas b	WoodFramed	9.5	7	6	11.5	1264.01005	0	0	3154086.111
9	Double - LowE - Ti	NA	G0100730	Hospital	270	5	1000000	PVAV with gas b	SteelFramed	9	7.5	7.25	9.75	6813.14901	0	0	6029661.111
10	Double - LowE - Cl	NA	G0100730	Outpatient	180	2	75000	PSZ-AC with gas	WoodFramed	9.5	6.75	10.75	4.75	374.63398	0	0	179880.5556
11	Single - No LowE -	NA	G0100950	Hospital	270	3	350000	VAV chiller with	Mass	9	7.5	8.25	7	2152.99659	0	0	2584791.667
12	Double - LowE - Cl	NA	G0100170	Hospital	90	3	350000	VAV air-cooled	SteelFramed	9.75	7	12	5.5	2544.36643	0	847533.333	334913.8889
13	Single - No LowE -	NA	G0100730	Outpatient	180	3	75000	PSZ-AC with gas	Mass	8.5	7.5	10.75	11	489.49215	0	0	170322.2222
14	Single - No LowE -	NA	G0200500	Hospital	270	1	75000	VAV chiller with	WoodFramed	9	8	10	6.75	329.3614	0	0	2559697.222
15	Double - No LowE	NA	G0400190	Outpatient	45	1	37500	PSZ-AC with gas	SteelFramed	8.25	5.5	8.75	9.25	294.87621	0	0	65736.11111
16	Single - No LowE -	NA	G0400130	Outpatient	225	1	75000	PSZ-AC with ele	SteelFramed	7.75	6.5	11.25	6.75	600.52446	0	0	83033.33333
17	Double - No LowE	NA	G0400190	Outpatient	180	2	17500	PSZ-AC with ele	WoodFramed	6.5	6.5	10.5	8.5	99.54627	0	0	18208.33333
18	Double - LowE - Ti	NA	G0400130	Outpatient	180	1	37500	PSZ-AC with ele	SteelFramed	7	7	17.5	5.25	209.44043	0	0	42166.66667
19	Double - LowE - Cl	NA	G0400130	Outpatient	315	1	37500	PSZ-AC with ele	SteelFramed	7.75	9.5	7.25	10	310.28772	0	0	40255.55556
20	Single - No LowE -	NA	G0400190	Outpatient	225	1	37500	PSZ-AC with ele	Mass	7.25	8.75	15.5	4.5	331.52824	0	0	41991.66667
21	Double - No LowE	NA	G0400130	Outpatient	0	1	37500	PSZ-AC with ele	Mass	7	6.5	10.75	9.75	283.39981	0	0	40002.77778
22	Double - No LowE	NA	G0400190	Outpatient	0	1	17500	PSZ-AC with gas	SteelFramed	9	8.5	10	10.75	122.88107	0	0	32330.55556
23	Single - No LowE -	NA	G0400130	Outpatient	135	2	75000	PSZ-AC with ele	SteelFramed	10.25	6.5	11	12	592.7709	0	0	91941.66667

Example Time-Series File

Building ID

Timestamp

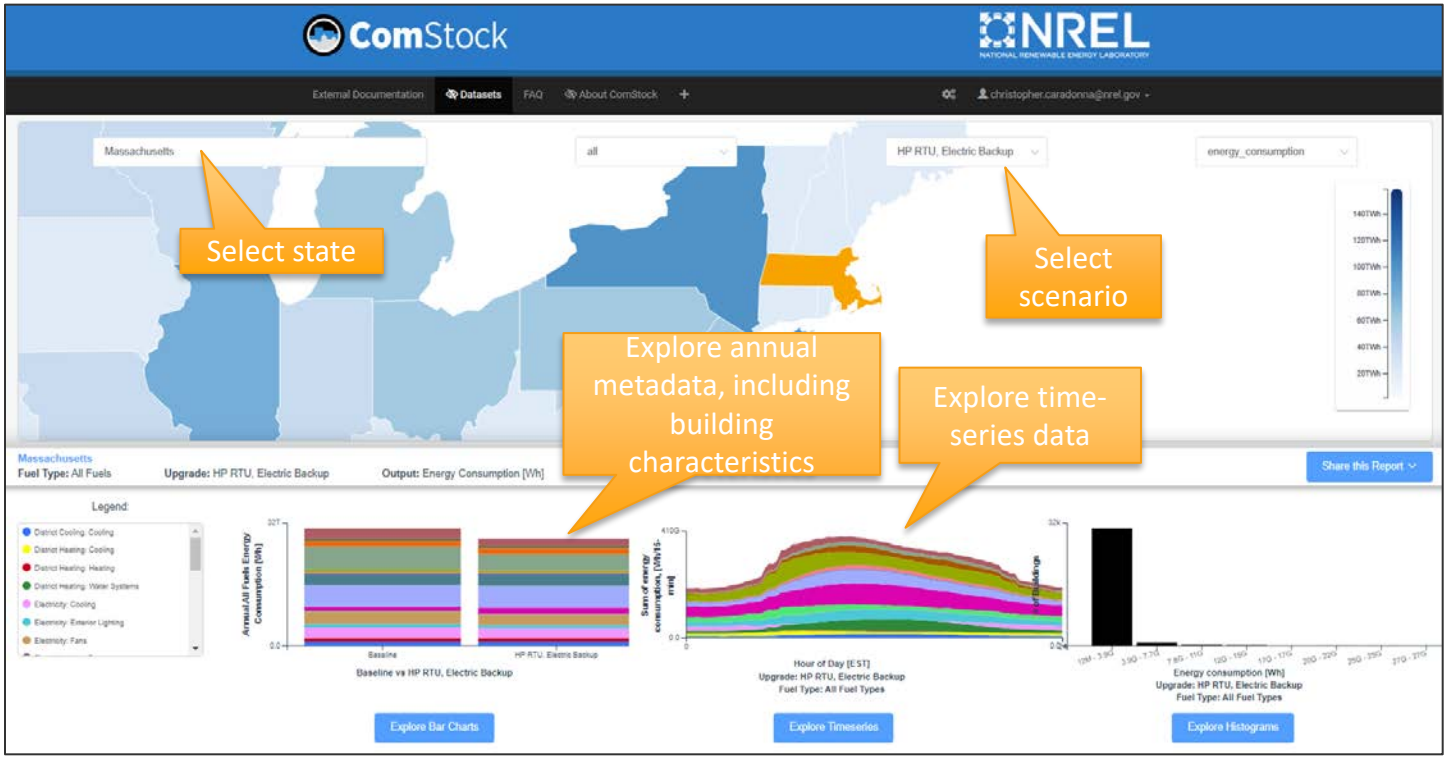
Exterior Lighting Consumption (kWh)

Interior Lighting Consumption (kWh)

Gas Heating Consumption (kWh)

	B	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	bldg_id	timestamp	out.electricity.cooling.energy_consumption	out.electricity.exterior_lighting.energy_consumption	out.electricity.fans.energy_consumption	out.electricity.heat_recovery.energy_consumption	out.electricity.heat_rejection.energy_consumption	out.electricity.heating.energy_consumption	out.electricity.interior_equipment.energy_consumption	out.electricity.interior_lighting.energy_consumption	out.electricity.pumps.energy_consumption	out.electricity.refrigeration.energy_consumption	out.electricity.water_systems.energy_consumption	out.natural_gas.heating.energy_consumption	out.natural_gas.interior_equipment.energy_consumption	out.natural_gas.water_systems.energy_consumption
2	5324	1/1/2018 0:15	0	1.2107	3.4499	0	0	0	2.3114	0.3319	0.0003	0	0	0	0	0.278477731
3	5324	1/1/2018 0:30	0	1.2107	3.4499	0	0	0	2.1577	0.2885	0.0003	0	0	0	0	0.763094899
4	5324	1/1/2018 0:45	0	1.2107	3.4499	0	0	0	1.8502	0.2017	0.0003	0	0	0	0	0.678523028
5	5324	1/1/2018 1:00	0	1.2107	3.4499	0	0	0	1.6965	0.1583	0.0003	0	0	0	0	0.262133379
6	5324	1/1/2018 1:15	0	1.2107	3.4499	0	0	0	1.2485	0.1461	0.0003	0	0	0	0	0.801860046
7	5324	1/1/2018 1:30	0	1.2107	3.4499	0	0	0	1.0245	0.1399	0.0003	0	0	0	0	0.608005027
8	5324	1/1/2018 1:45	0	1.2107	3.4499	0	0	0	0.5764	0.1277	0.0003	0	0	0	0	0.242852543
9	5324	1/1/2018 2:00	0	1.2107	3.4499	0	0	0	0.3524	0.1216	0.0003	0	0	0	0	0.834873996
10	5324	1/1/2018 2:15	0	1.2107	3.4499	0	0	0	0.5835	0.0811	0.0003	0	0	0	0	0.524560196
11	5324	1/1/2018 2:30	0	1.2107	3.4499	0	0	0	0.6991	0.0608	0.0003	0	0	0	0	0.298359756
12	5324	1/1/2018 2:45	0	1.2107	3.4499	0	0	0	0.9302	0.0203	0	0	0	0	0	0.420222982
13	5324	1/1/2018 3:00	0	1.2107	3.4499	0	0	0	1.0457	0	0	0	0	0	0	0.053723496
14	5324	1/1/2018 3:15	0	1.2107	3.4499	0	0	0	1.0449	0.0026	0	0	0	0	0	0
15	5324	1/1/2018 3:30	0	1.2107	3.4499	0	0	0	1.0445	0.0039	0	0	0	0	0	0
16	5324	1/1/2018 3:45	0	1.2107	3.4499	0	0	0	1.0437	0.0065	0	0	0	0	0	0
17	5324	1/1/2018 4:00	0	1.2107	3.4499	0	0	0	1.0433	0.0078	0	0	0	0	0	0
18	5324	1/1/2018 4:15	0	1.2107	3.4499	0	0	0	1.0424	0.0104	0	0	0	0.438	0	0
19	5324	1/1/2018 4:30	0	1.2107	3.4499	0	0	0	1.042	0.0117	0	0	0	0.3853	0	0
20	5324	1/1/2018 4:45	0	1.2107	3.4499	0	0	0	1.0412	0.0143	0	0	0	0.2948	0	0
21	5324	1/1/2018 5:00	0	1.2107	3.4499	0	0	0	1.0408	0.0156	0	0	0	0.16	0	0
22	5324	1/1/2018 5:15	0	1.2107	3.4499	0	0	0	1.04	0.0183	0	0	0	0.1943	0	0
23	5324	1/1/2018 5:30	0	1.2107	3.4499	0	0	0	1.0396	0.0196	0	0	0	0.2245	0	0
24	5324	1/1/2018 5:45	0	1.2107	3.4499	0	0	0	1.039	0.0215	0	0	0	0.2503	0	0.474015352
25	5324	1/1/2018 6:00	0	1.2107	3.4499	0	0	0	0.9423	0.0579	0	0	0	0.278	0	0

ComStock Data Viewer

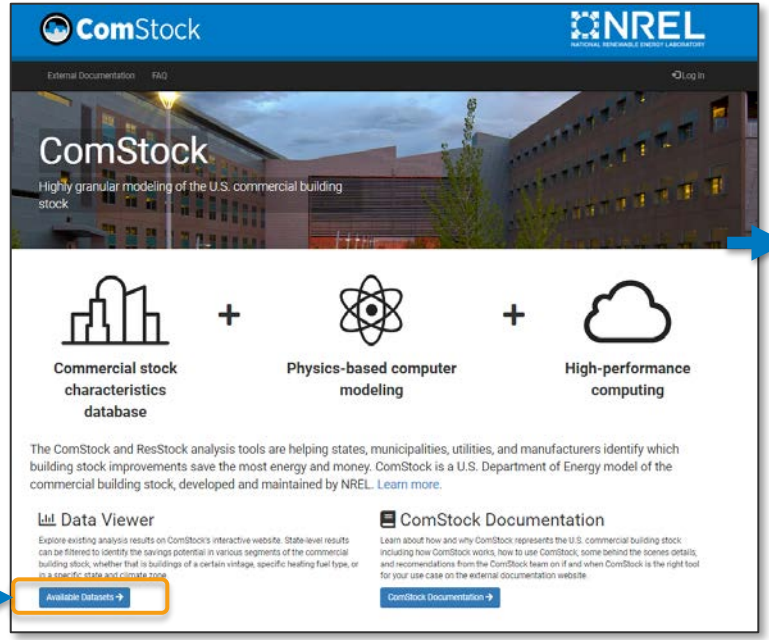


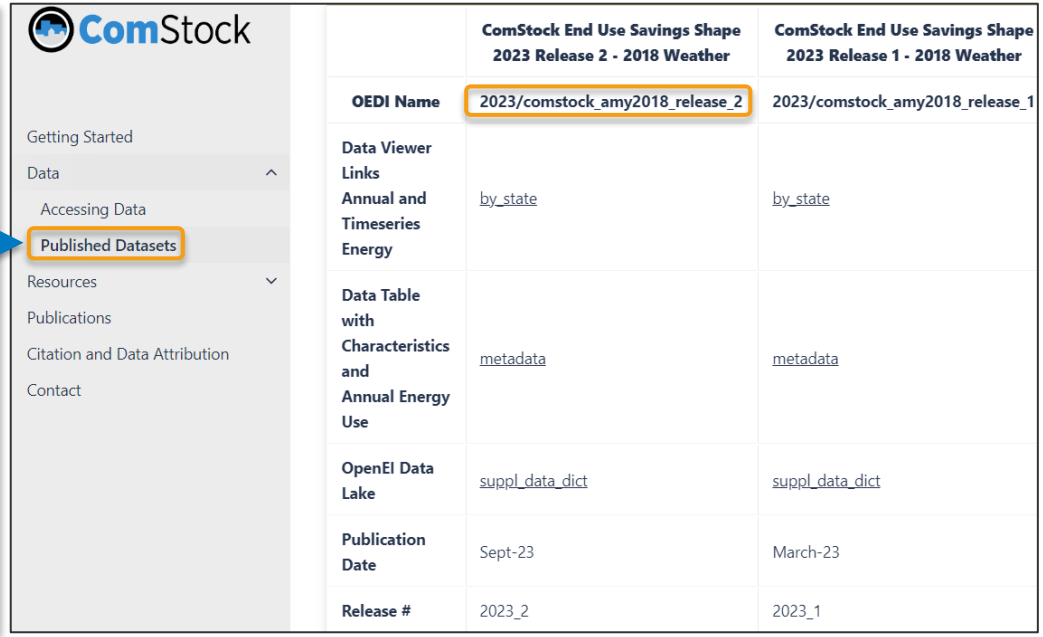
- Visualize data
- Export to csv

Requires free account

Access at: ComStock.nrel.gov

Summary of Data Set Links





	ComStock End Use Savings Shape 2023 Release 2 - 2018 Weather	ComStock End Use Savings Shape 2023 Release 1 - 2018 Weather
OEDI Name	2023/comstock_amy2018_release_2	2023/comstock_amy2018_release_1
Data Viewer Links Annual and Timeseries Energy	by_state	by_state
Data Table with Characteristics and Annual Energy Use	metadata	metadata
OpenEI Data Lake	suppl_data_dict	suppl_data_dict
Publication Date	Sept-23	March-23
Release #	2023_2	2023_1

Access at: ComStock.nrel.gov and ComStock Documentation Site

A Few Reminders

- All time stamps are time-period-ending and are in EST.
- Annual metadata files provide weighting factors for national scaling. Columns with “weighted” in the title already have this factor applied.
- Check your sample sizes on custom aggregations—too few samples can increase uncertainty.
- All “out.” columns without units denoted are in kWh.
  (This is driven by current limitations with the data viewer.)

Next Steps

Commercial EUSS FY24

Email us with measure/package requests for future releases!

Proposed List for Commercial EUSS 2024 Release 1; Expected March 2024

Measure Name	Description
HP-RTU, Standard Performance	Replaces gas and electric resistance RTUs with standard efficiency HP-RTUs.
HP-RTU With Heat/Energy Recovery	Adds heat/energy recovery to HP-RTUs.
Single-Zone VAV RTUs	Retrofits existing constant air volume RTUs to single-zone variable air volume RTUs.
Economizers	Adds economizers to air handling units (non-DOAS) that do not already have them.
Electric Cooking Equipment	Replaces major gas cooking equipment (ranges, ovens, etc.) with electric equipment.
VRF With 25% Upsizing Allowance	Allows VRF to size up to 25% beyond cooling design for heating as needed.
No Outdoor Air During Unoccupied Times	Closes outdoor air dampers during unoccupied periods for buildings not already doing so.
Package 1: HP-RTU Standard Performance + Lighting	Package combines standard performance HP-RTU and LED lighting.
Package 2: Max Tech HVAC	Applies HP-RTU or HP-Boiler along with economizers, heat/energy recovery, and demand control ventilation.
Others	Geothermal heat pumps; demand flexibility.

Q&A

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[1] Gagnon, Pieter. n.d. "Cambium | Energy Analysis | NREL." National Renewable Energy Laboratory. https://www.nrel.gov/analysis/cambium.html.

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[3] Vijayakumar, G. et al. 2022. "ANSI/RESNET/ICC 301-2022 - Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index." Oceanside, CA, 2022.