End-Use Savings Shapes

Public Dataset Release: Commercial 2023 Release 1

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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, webinar recording, and full dataset will be available next week. This will be announced by email.

Acknowledgment

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
- U.S. Department of Energy.

Agenda

1. Our Approach to Building Stock Energy Modeling
2. Changes Since End-Use Load Profiles Release
3. End-Use Savings Shapes: 2023 Release 1
4. Accessing the Dataset
5. Next Steps
6. Q&A

EULP and EUSS

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

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

Problem Statement

A lack of credible and relevant information results in 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?

Alignment and Impact

We are putting information in the hands of decision makers

In support of DOE goals to increase building energy efficiency, accelerate building electrification, and do so in ways that prioritize equity, affordability, and resilience

What the Datasets Provide

- Building stock characterization
- When and how 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
- Utility-integrated resource plans and load forecasts
- Policy and rate design

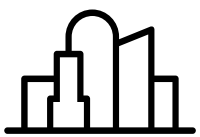
Our Approach to Stock Modeling

ComStock Workflow

The Making of the Datasets:

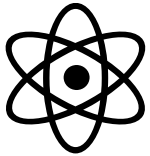
- Describe the U.S. building stock quantitatively using best-available public data
- Sample the description
- Model the samples
- Model changes to the samples – energy efficiency, electrification, etc. [EUSS only]
- Publish description, samples, models, results, aggregations, visualizations, and documentation

ComStock



Building stock characteristics database

- Variation in building type, size, location, vintage, HVAC system, etc.
- **Over 80** probability distributions of various attributes



Physics-based computer modeling

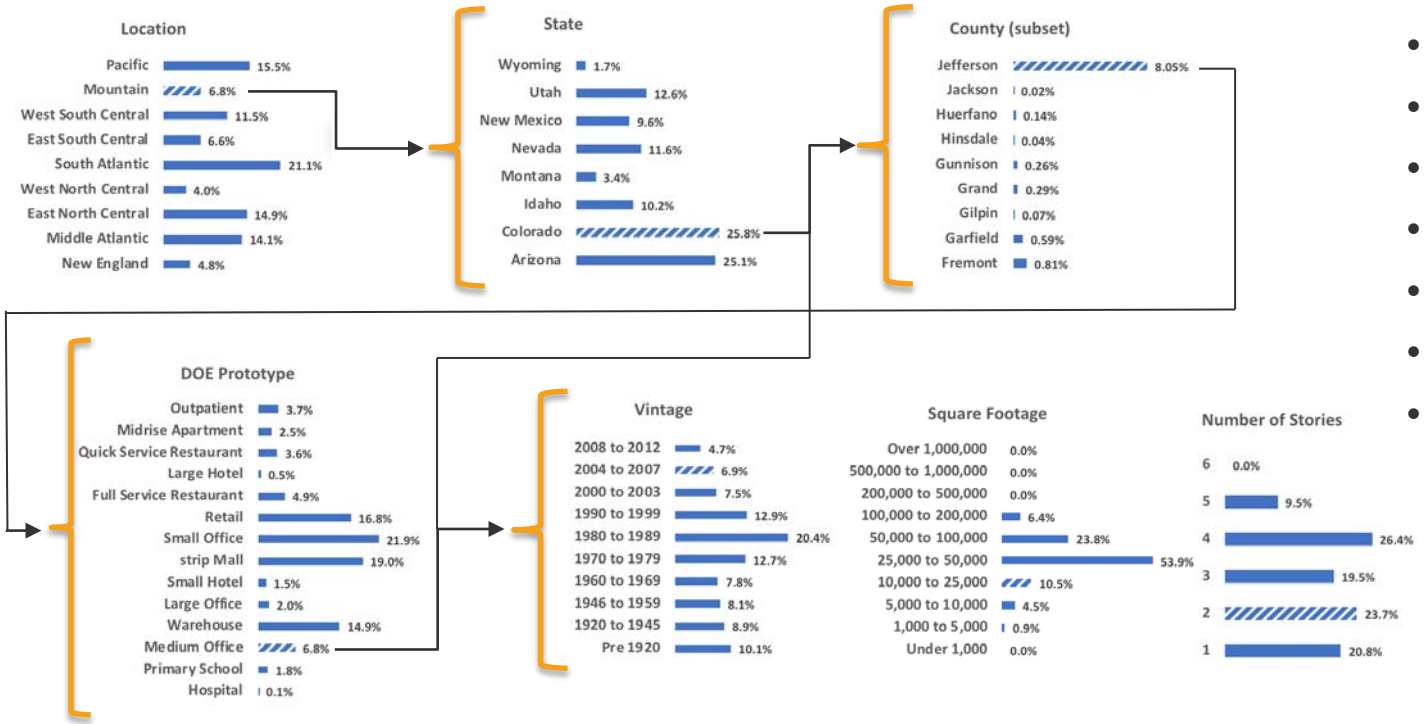
- Representative set of 350k OpenStudio energy models

High-performance computing

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

ComStock Workflow

Create distributions of building characteristics from available data sources →



- CoStar
- EIA CBECS
- ASHRAE
- HIFLD
- NFRC
- Analysis of AMI
- LightBox
- CPUC DEER
- Code Adoption

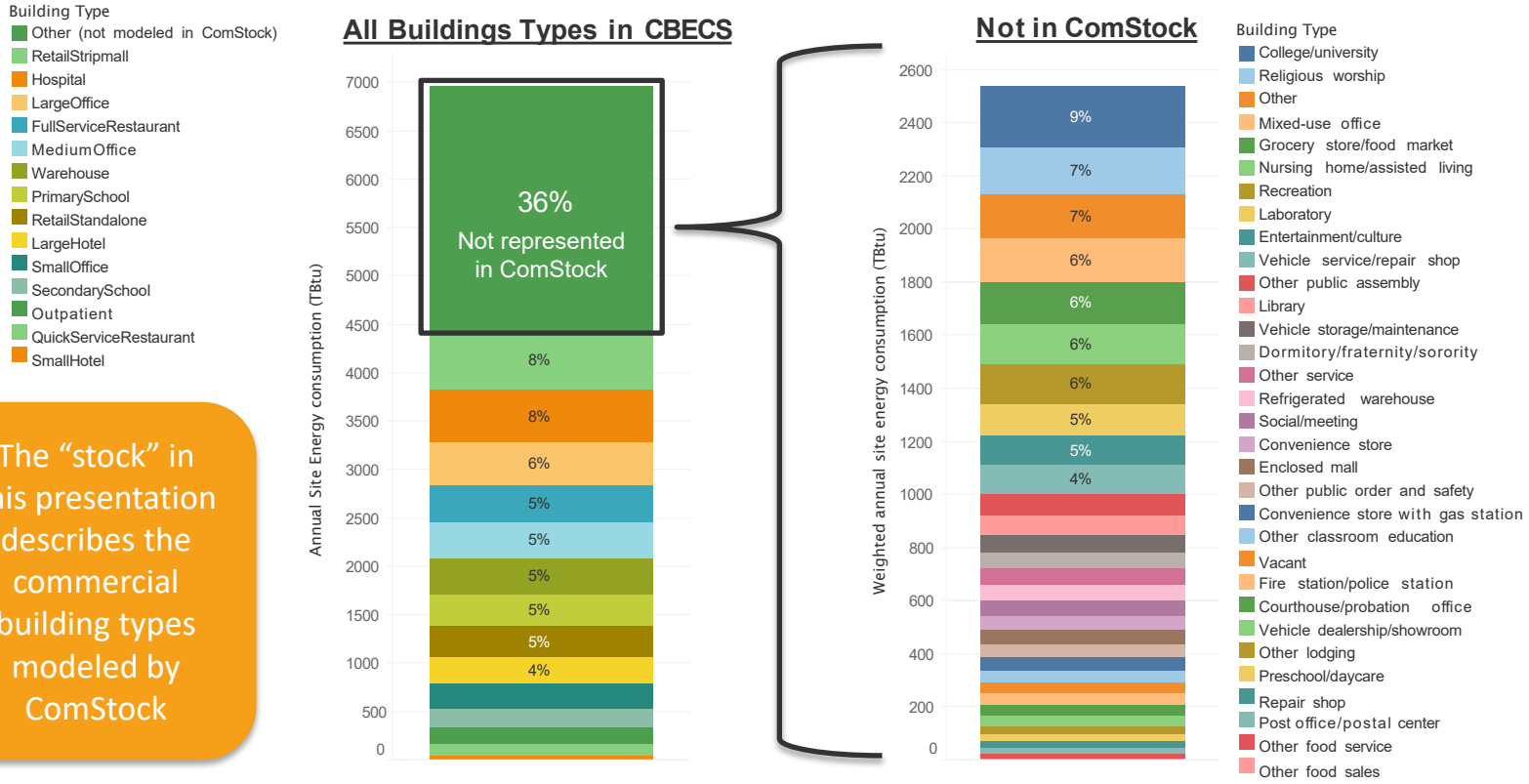
(see ComStock Reference Documentation for full list & acronyms)

Example of Select ComStock Building Characteristic Inputs

Location and Envelope Basics		Heating and Cooling		Energy Code Followed During Last Replacement	
Building ID	810	**Heating**	Central Single-zone RTU Furnace	**HVAC**	DOE Ref 1980-2004
City	St. Clair County Alabama	**Heating Fuel**	Natural Gas	**Service Water Heating**	DOE Ref 1980-2004
IECC Climate Zone	3A	**Cooling**	PSZ-AC with gas coil DX	**Interior Equipment**	DOE Ref 1980-2004
Building type	Stand Alone Retail	**Setpoints and offsets**	Heating: 67°F / 7°F	**Exterior Lighting**	90.1-2013
Year Built	1977		Cooling: 70°F / 8°F	**Roof**	DOE Ref Pre-1980
Floor area	3,000 sq ft	**Service Water Htg Fuel**	Electricity	**Walls**	DOE Ref Pre-1980
Stories	1	**Occupancy Schedule**		**During Original Building Construction**	DOE Ref Pre-1980
Windows	Double - No LowE - Clear – Aluminum	**Weekday Operating Hours**	9.25	**Interior Equipment**	
Average U Value	0.225 (Btu/ft2)	**Weekday Opening Time**	7.75	**Interior Lighting Generation**	Gen2 T8 Halogen
Window to Wall Ratio	0.18	**Weekend Operating Hours**	16.5	**Lighting base to peak ratio**	0.5
Wall type	Metal	**Weekend Opening Time**	6.25	**Equipment base to peak ratio**	0.1

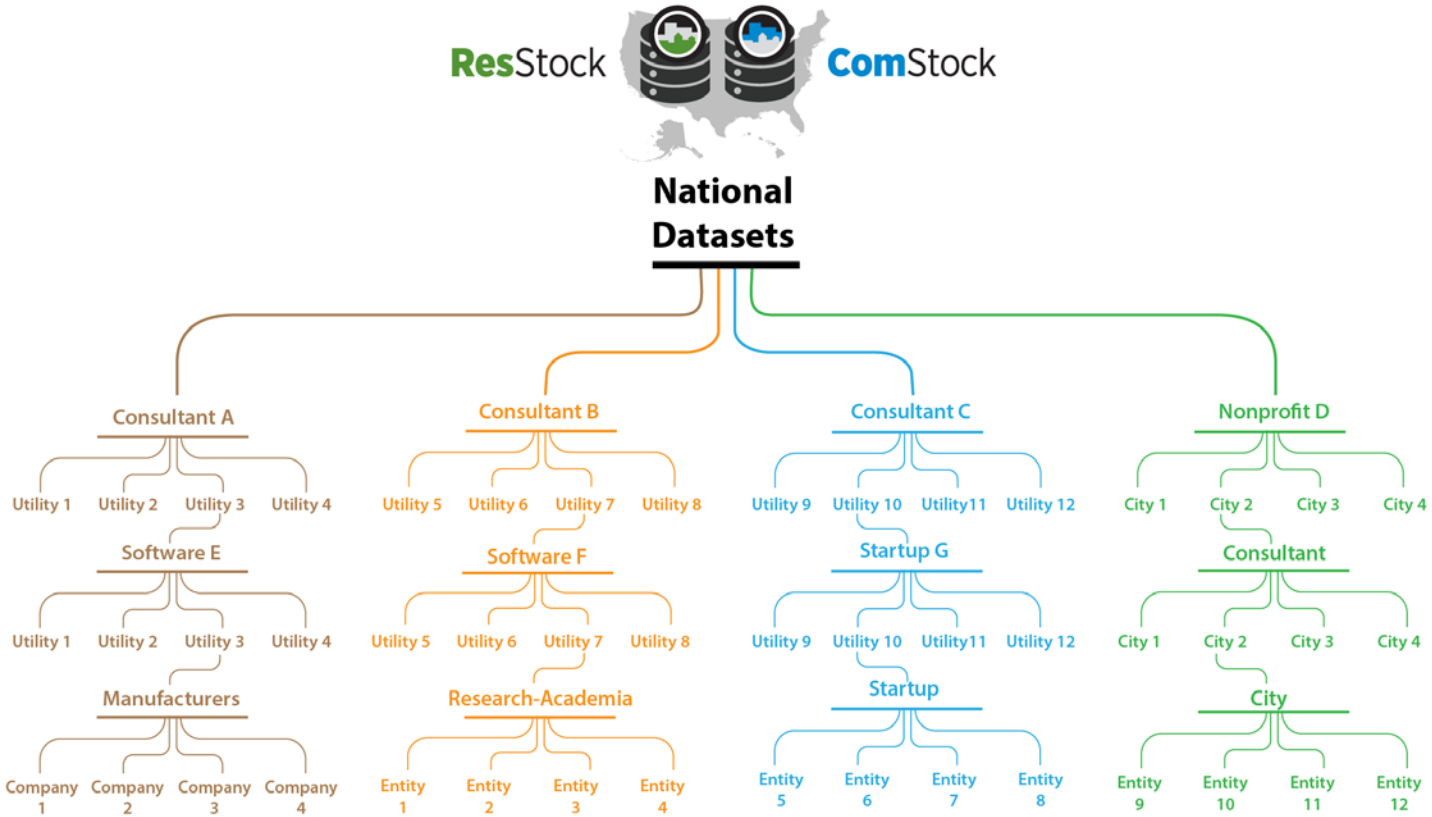
What Does ComStock Model?

ComStock models ~64% of commercial building energy in the United States (CBECS 2012)



The "stock" in this presentation describes the commercial building types modeled by ComStock

Public datasets are intended to serve a broad set of use cases and audiences



Please Note

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

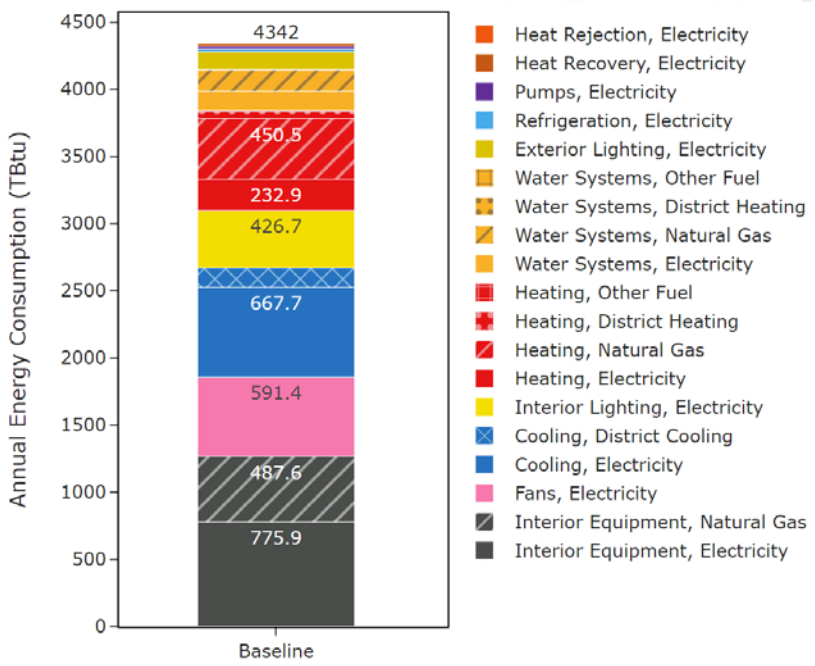
- Measures are **not intended to be comprehensive** of a given technology. As additional data becomes available, measure results can be updated.

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

Please Note Continued

- Compared to the disaggregated end-use energy data presented in CBECS 2012, in general ComStock is:
  - **Higher** on stock **electric heating** energy,
  - **lower** on stock **gas heating** energy, and
- Comparisons vary by building type.
- Measure results are relative to the ComStock baseline. Stock total savings and impact are sensitive to the baseline building assumptions.

ComStock Site Energy by Fuel and End Use

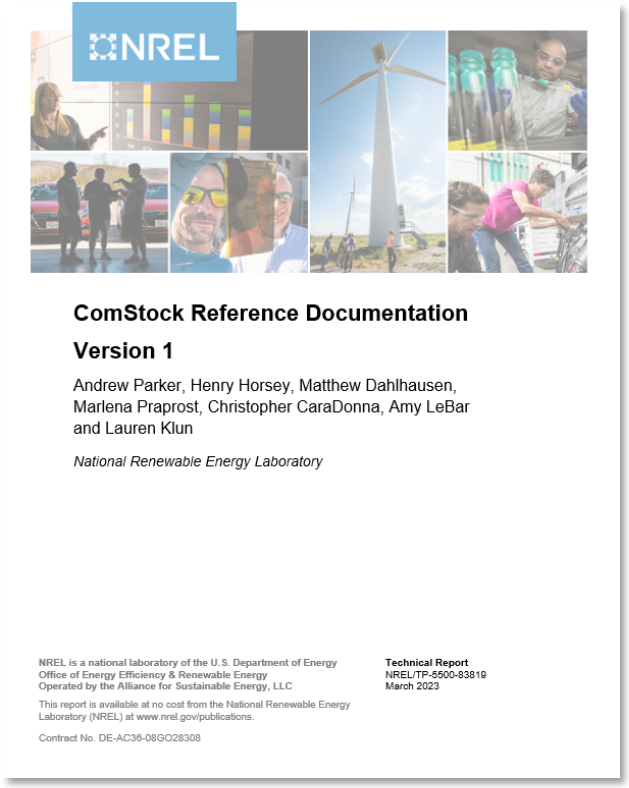


ComStock Documentation Released

ComStock Documentation is now public!

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

Link
https://www.nrel.gov/docs/fy23osti/83819.pdf

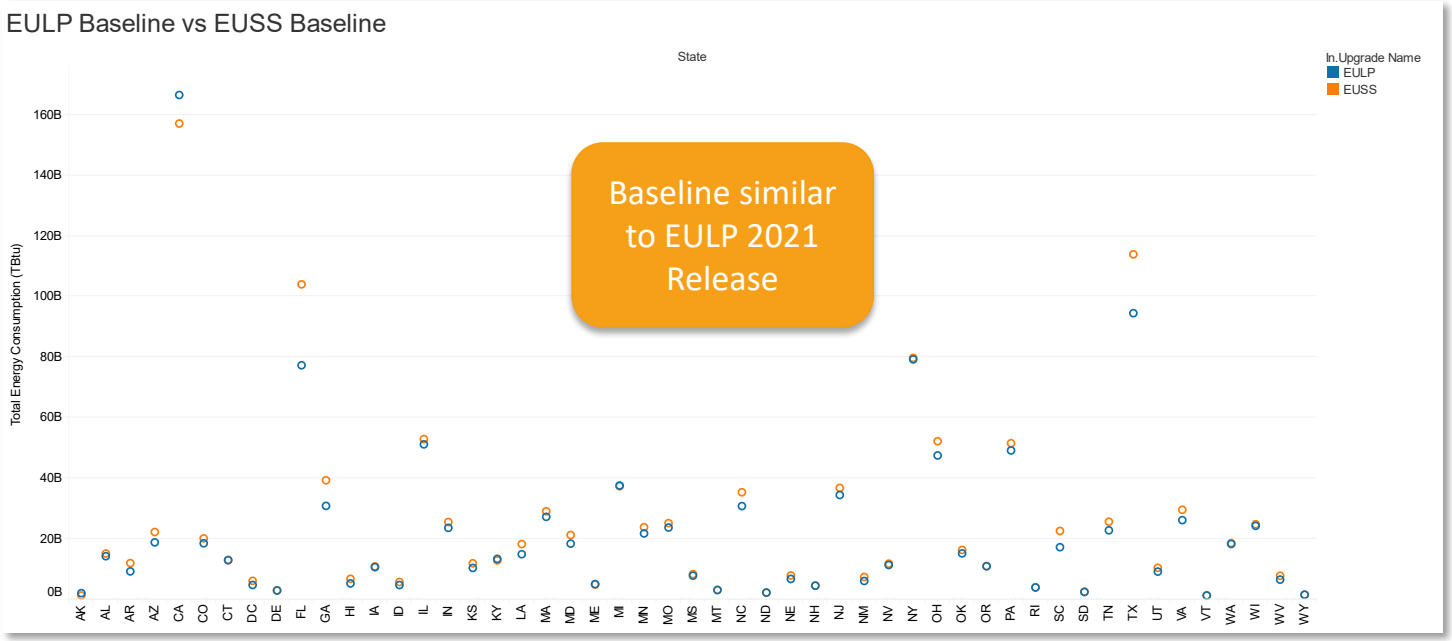


Changes Since EULP

Baseline Building Stock Representation

Major, 3-year calibration & validation process concluded fall 2021
- Technical report
- Published baseline dataset
- See project website for more information

Continuous improvements since then, including:
- Updated HVAC System and Fuel Type Distributions
- Ground Heat Transfer
- Wall Construction Type
- Technology Baselines for Lighting and Windows
- Update OpenStudio 2.9 to 3.4



End-Use Savings Shapes: Commercial 2023 Release 1

Measure methodology, results, and discussion

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 1 dataset represents the building stock circa 2018 using 2018 AMY weather

Measure Summary

Measure Name	Description	% of Stock Floor Area
Roof Top Unit (RTU) Heat Pump (HP)	Replace gas and electric RTUs with HP-RTU.	45%
Rooftop Ventilator + HP Split System	Replace gas and electric RTUs with Rooftop Ventilator + HP Split System in small commercial buildings (<20,000sf).	11%
Air to Water HP Boiler Retrofit	Replace gas boilers with heat pump boilers.	18%
LED Lighting	Upgrade all lighting to LED.	65%
Exterior Wall Insulation	Add exterior wall insulation panels.	98%
Secondary Windows	Add secondary windows.	>99%
Window Replacement	Replace windows.	>99%
Window Film	Add window film to windows.	>99%
Roof Insulation	Add roof insulation.	>99%

Greenhouse Gas Emissions

Electricity

- 3 grid electricity scenarios compared today; more included in published dataset
- 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 HighRECost	2022	15 years	NREL Cambium [1]
LRMER LowRECost	2022	15 years	NREL Cambium [1]
eGRID	2021	N/A	EPA eGRID [2]

Greenhouse gas emissions in dataset 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

Note on Heat Pump Modeling

- **Limited comprehensive heat pump performance maps exist** which are required for detailed energy modeling. This creates limitations of the 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.

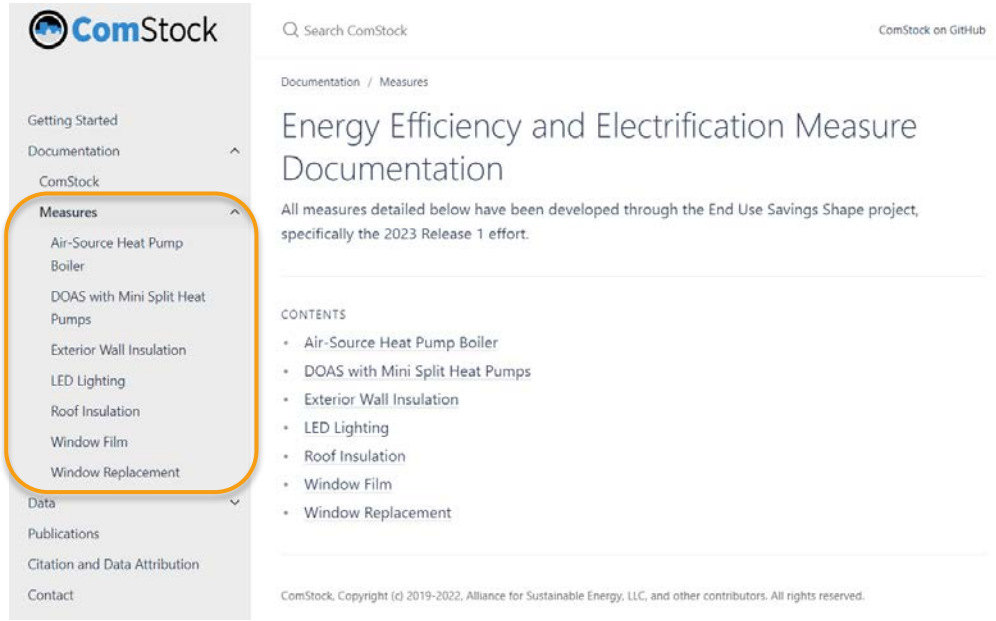
- This work attempts to use the most informative data available and makes documented assumptions about heat pump operation and performance. These will notably impact results. **Please consider these assumptions**.

- 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.

ComStock Measure Documentation Website

Comprehensive documentation available for each measure.

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



7 documents available now, remaining 2 available next week.

Access at: https://nrel.github.io/ComStock.github.io/docs/documentation/measures/measures.html

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 Units (HP-RTU)

Heat Pump Rooftop Units (HP-RTU)

Measure Concept

- Replace gas and electric RTUs with HP-RTU
- Variable speed, high efficiency (>17 IEER)

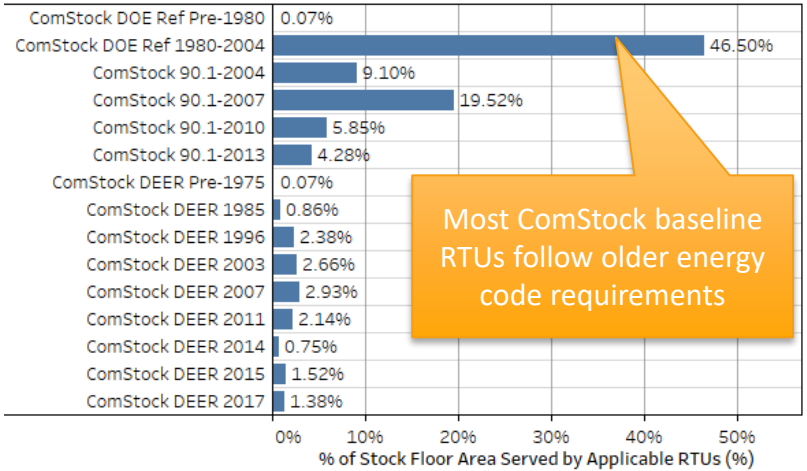
Applicability

- Buildings w/ gas or electric resistance RTUs
- **~45%** of stock floor area

HP-RTU Performance

- **Type:** Variable speed compressor and fan
- **Sizing:** Compressor sized to design cooling load; backup heat sized for remainder
- **Backup Heat:** Electric resistance
- **Compressor Lockout:** 0°F
- **Defrost:** Reverse cycle
- **Performance Data Source:** Mix of lab testing and manufacturer performance data

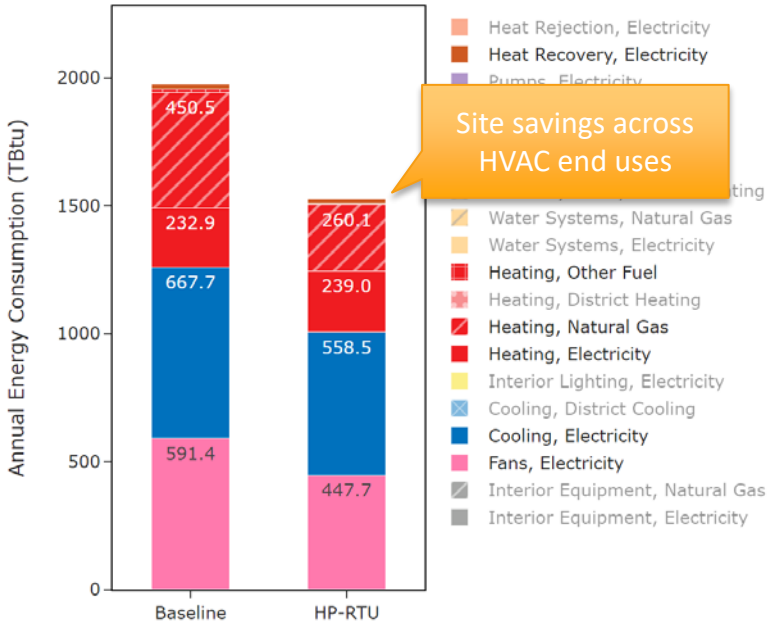
ComStock RTU Energy Code Followed



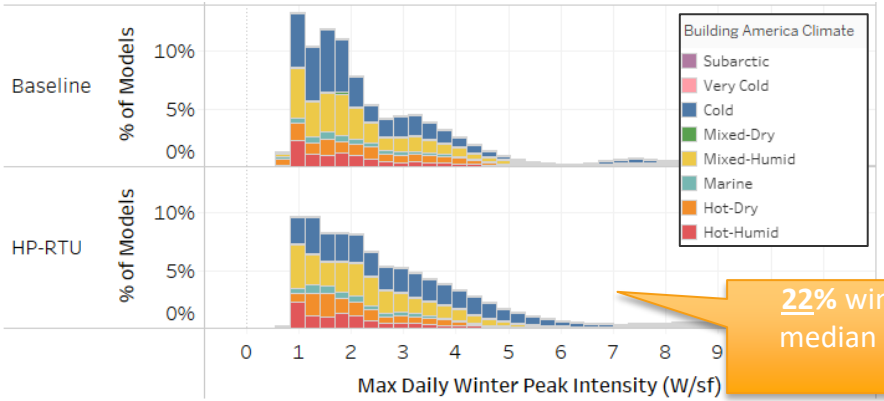
Heat Pump Rooftop Units (HP-RTU)

- **42%** stock **heating gas** savings (190 TBtu)
- **-3%** stock **heating electricity** savings (-6 TBtu)
- **16%** stock **cooling electricity** savings (109 TBtu)
- **24%** stock **fan electricity** savings (144 TBtu)
- Cooling and fan savings could also be attributed to high-performance non-HP-RTUs
- Savings associated with premium units

Stock Site Energy by Fuel and End Use

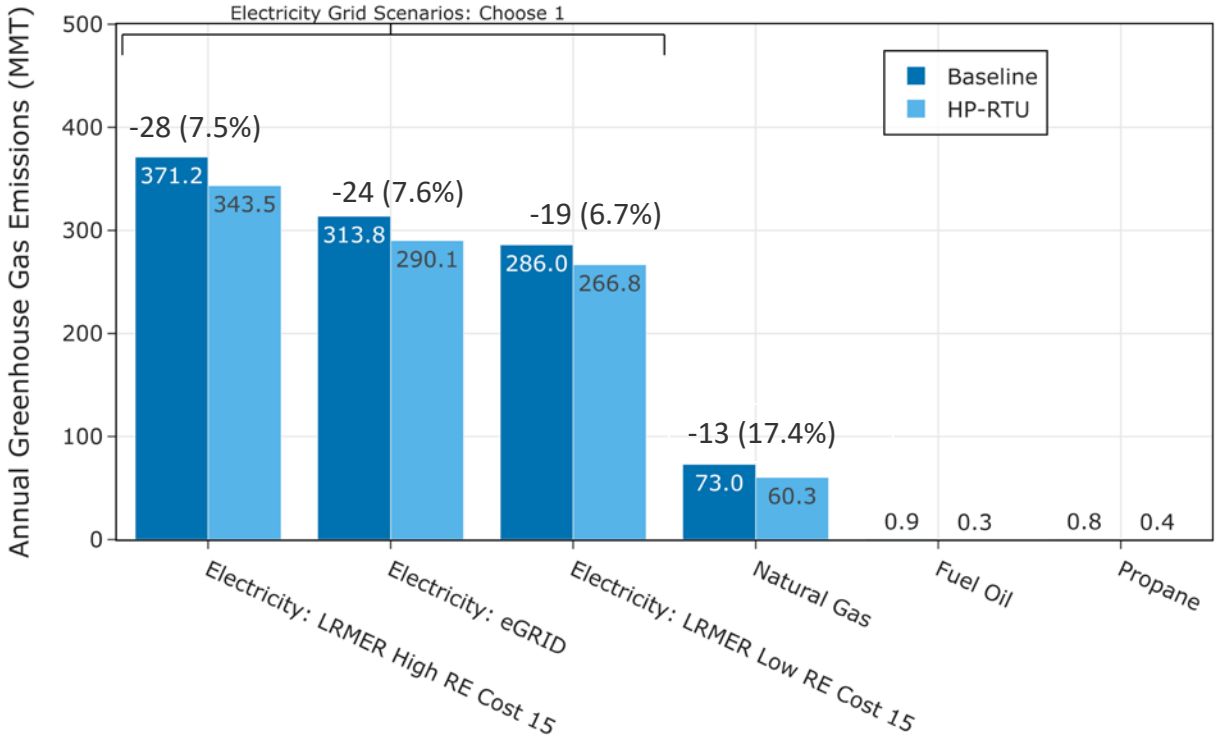


Non-Coincident Winter Peak for Buildings With Gas RTUs



22% winter electric peak intensity Increase for median HP-RTU model compared to ComStock baseline gas RTUs

Heat Pump Rooftop Units (HP-RTU)



- Emissions avoided across all grid scenarios
- Electricity emissions avoided are from cooling and fan end uses; also from replacing electric resistance RTUs with HP-RTUs

Dedicated Outdoor Air Units (DOAS) With Mini Split Heat Pumps

DOAS HP Mini Splits

Measure Concept

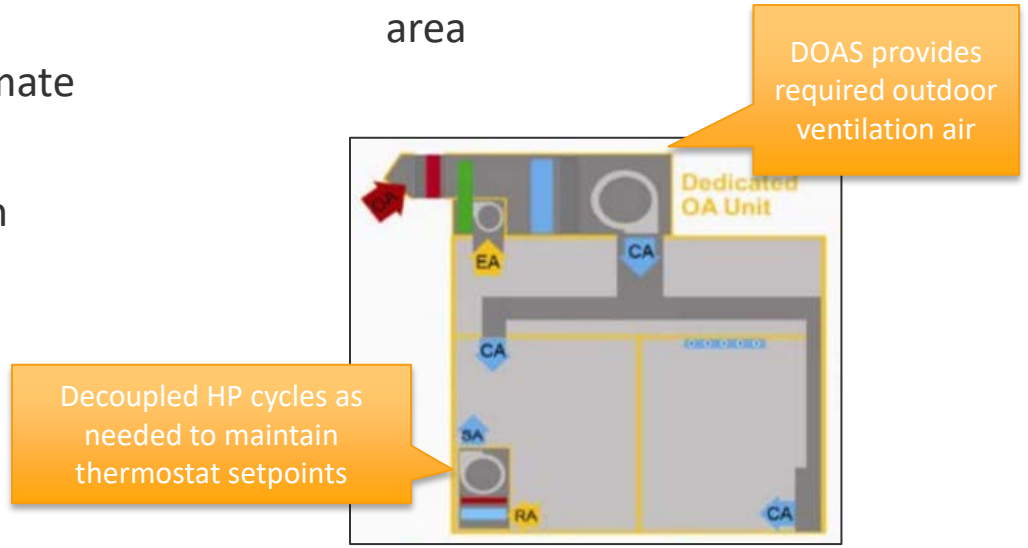
- Replace gas and electric RTUs with DOAS and HP mini splits (decoupled) in small commercial
- Premium efficiency (>25 SEER, >14 HSPF) & suitable for cold climates
- ERV or HRV added to DOAS based on climate

Mini Split HP Performance

- **Type:** Variable speed compressor and fan
- **Sizing:** Up to 135% design cooling load
- **Backup Heat:** Electric resistance
- **Compressor Lockout:** -15°F
- **Defrost:** Reverse cycle
- **Performance Data Source:** Previous lab testing

Applicability

- Buildings <20,000sf w/ applicable RTUs
- Applicable to **11%** of stock floor area

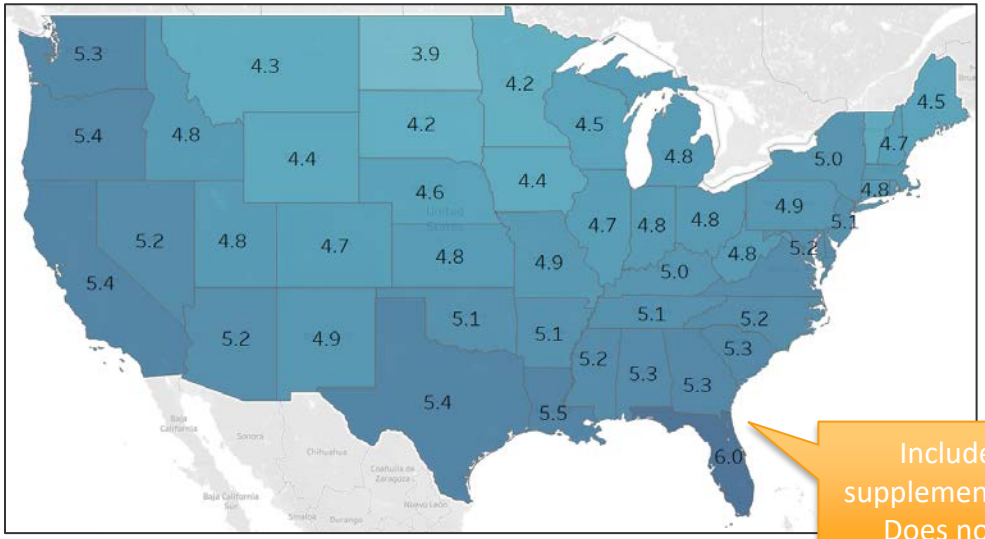


Source: R. C. Analytics 2021 [6]

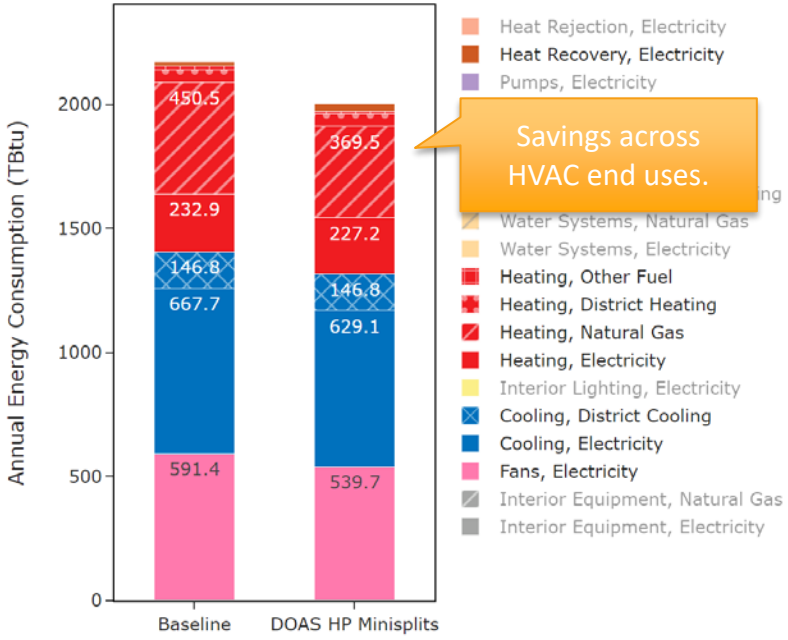
DOAS HP Mini Splits

- **2%** stock **heating electricity** savings (6 TBtu)
- **18%** stock **heating gas** savings (81 TBtu)
- **6%** stock **cooling electricity** savings (39 Tbtu)

Annual Average Model Effective Heating COP by State



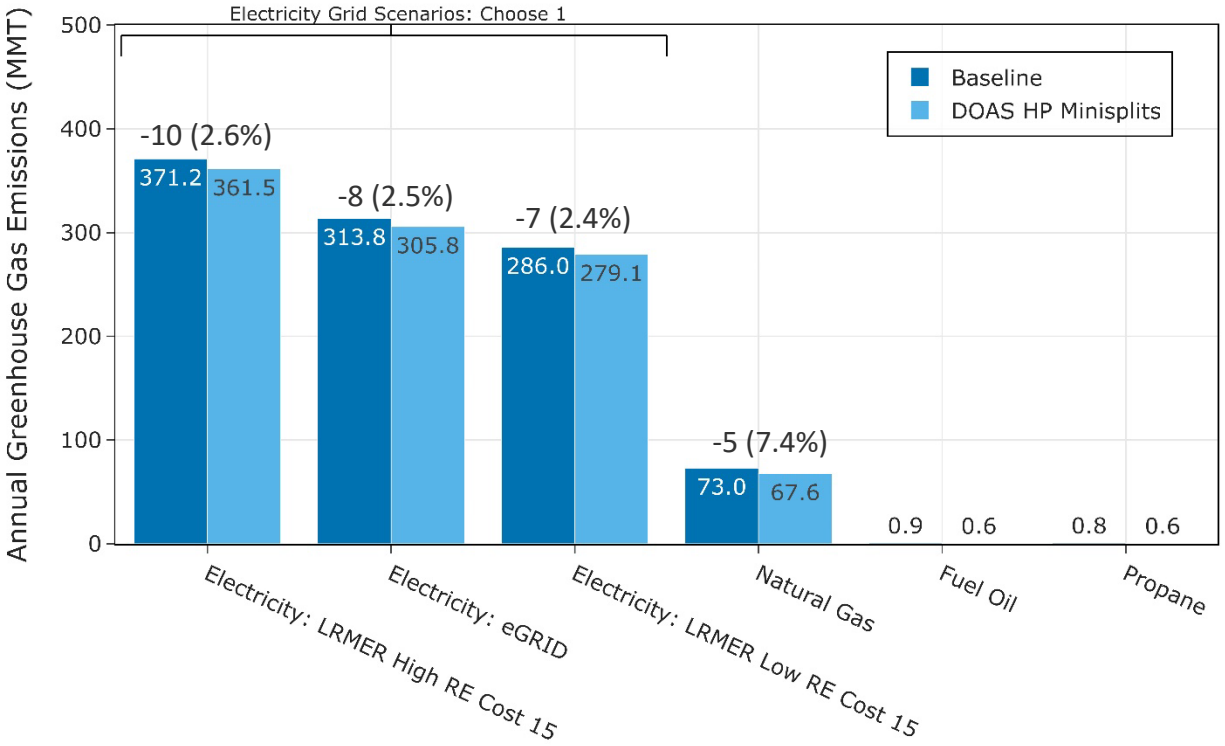
Stock Site Energy by Fuel and End Use



Savings across HVAC end uses.

Includes electricity due to supplemental heating and defrost. Does not include supply fan.

DOAS HP Mini Splits



- Emissions avoided across all grid scenarios
- Electricity emissions avoided are from cooling and fan end uses; also from replacing electric resistance RTUs with DOAS HP mini splits

Heat Pump Boiler

Heat Pump Boiler

Measure Concept

- Replace natural gas boilers for space heating with air source heat pump boiler
- 140°F supply temperature
- Electric resistance boiler added for backup

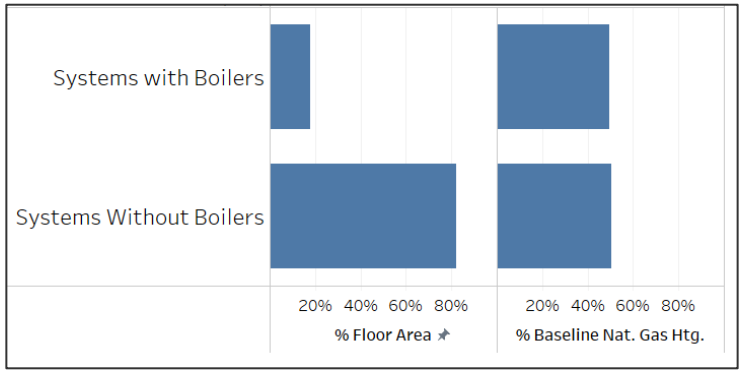
Applicability

- Buildings with natural gas boiler for space heating
- Applicable to **17.8%** of stock floor area

Heat Pump Boiler Performance

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

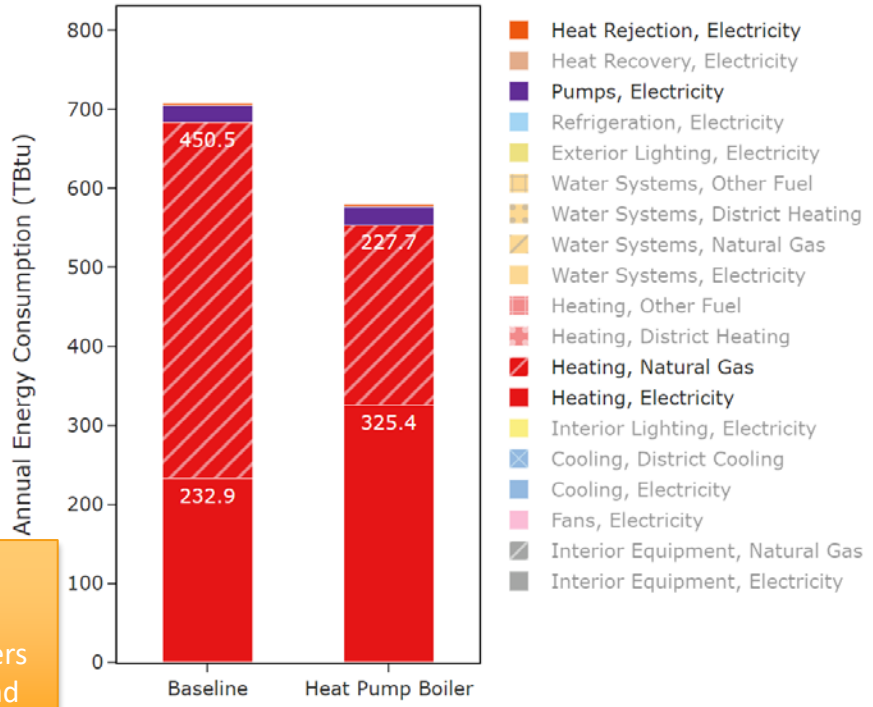
Gas Boiler Floor Area and Heating Energy (%)



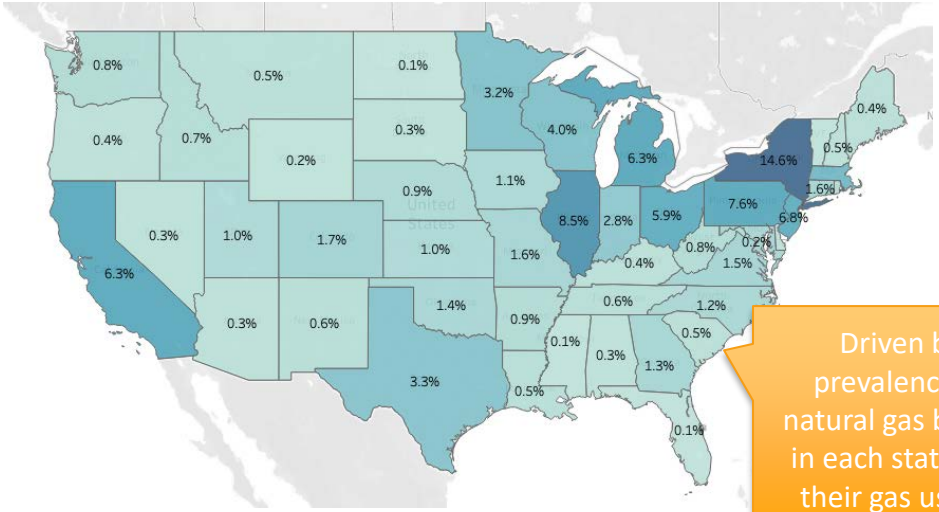
Heat Pump Boiler

- **49%** stock **heating natural gas** savings (223 TBtu)
- **-40%** stock **heating electricity** savings (-81 TBtu)

Stock Site Energy by Fuel and End Use

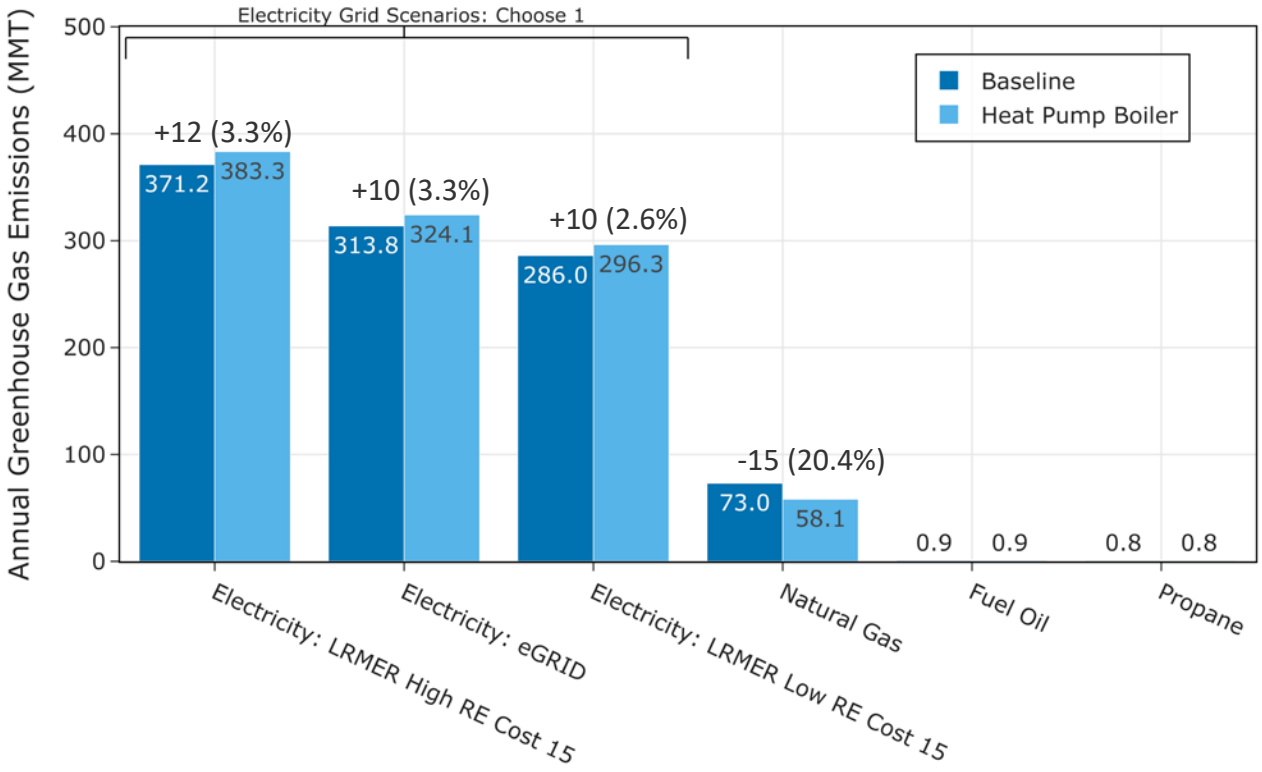


Where are the natural gas heating savings coming from?



Driven by prevalence of natural gas boilers in each state and their gas usage.

Heat Pump Boiler



- Net emissions avoided despite increased electricity emissions
- Increased electricity emissions from electrifying gas boilers

LED Lighting

LED Lighting

Measure Concept

- Replace all interior lighting in a building with LEDs

Applicability

- Buildings without LED interior lighting
- Applicable to **65%** of stock floor area

Baseline

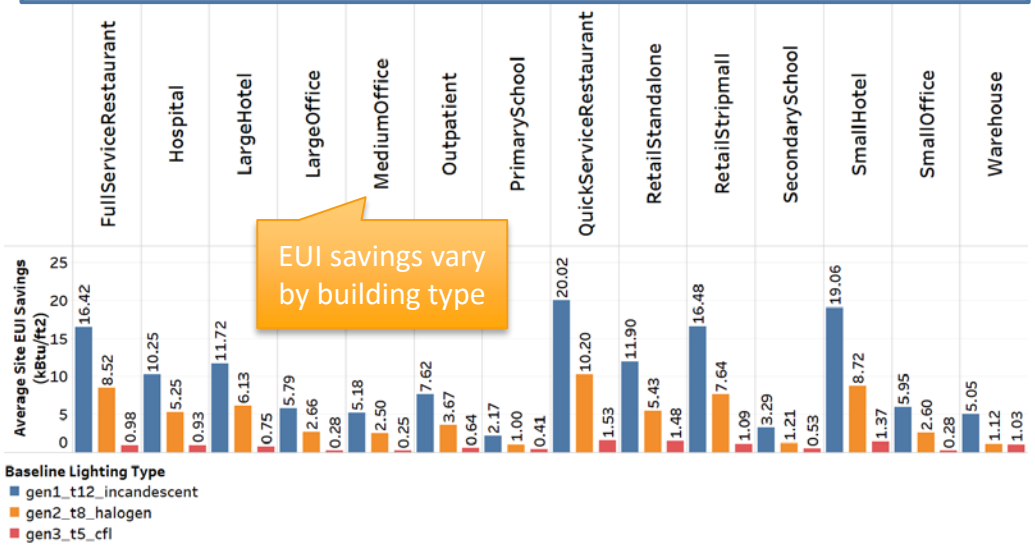
- Baseline lighting power density and technology distribution data from:
  - ASHRAE 90.1 Lighting Subcommittee space type lighting assumptions
  - *2015 U.S. Lighting Market Characterization* [4]
  - *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications* [5]

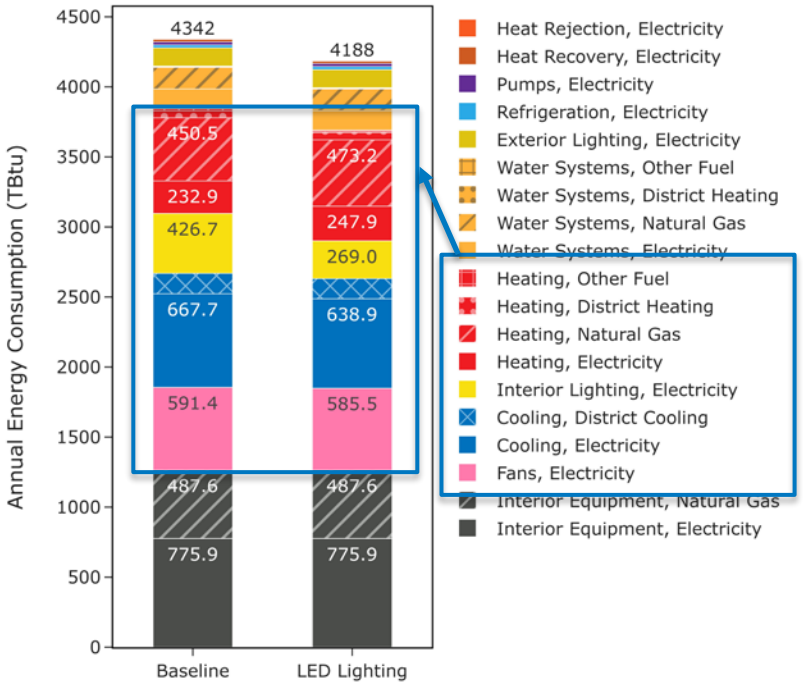
% Stock Floor Area per Lighting Type

ComStock Building Type	t12_incandescent	t8_halogen	t5_cfl	Gen 4 LED	Gen 5 LED
Full-Service Restaurant	0.5%	1.2%	0.1%	0.7%	0.2%
Hospital	0.7%	2.0%	0.3%	1.1%	0.4%
Large Hotel	0.7%	2.4%	0.2%	1.3%	0.3%
Large Office	1.3%	4.2%	0.4%	2.2%	0.7%
Medium Office	1.1%	3.7%	0.4%	2.2%	0.6%
Outpatient	0.6%	1.4%	0.2%	2.2%	0.2%
Primary School	1.8%	5.0%	0.6%	3.3%	0.7%
Quick-Service Restaurant	0.1%	0.2%	0.0%	0.2%	0.0%
Retail Stand Alone	1.4%	3.9%	0.4%	2.6%	0.6%
Retail Strip Mall	1.3%	4.4%	0.4%	2.8%	0.6%
Secondary School	1.0%	2.6%	0.3%	1.6%	0.3%
Small Hotel	0.2%	0.5%	0.1%	0.3%	0.1%
Small Office	1.2%	3.5%	0.4%	2.2%	0.5%
Warehouse	3.1%	11.1%	1.0%	6.6%	1.6%

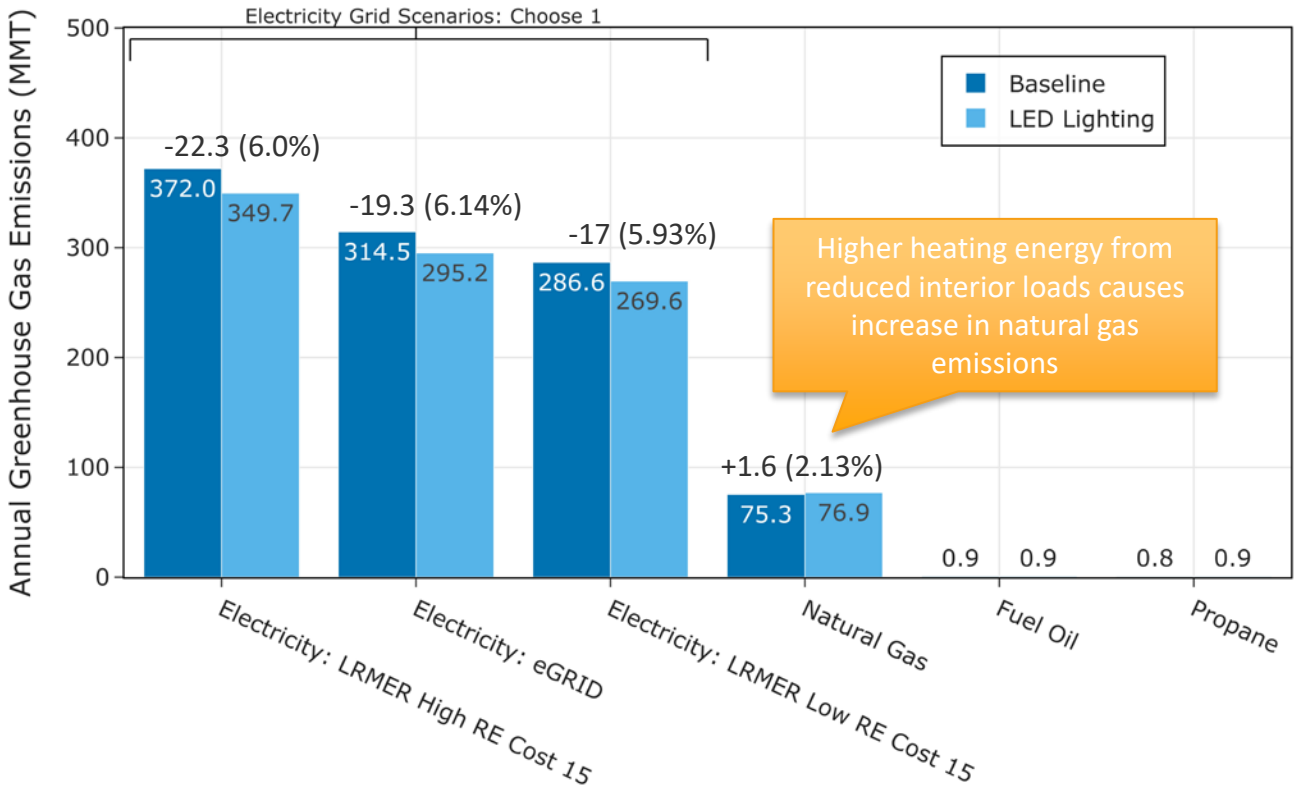
LED Lighting

- **48%** (157.7 TBtu) **electricity interior lighting** savings
- Small changes to cooling, heating, and fan energy from internal load reduction
- Higher site EUI savings for models with earlier generation interior lighting (T12/incandescent)





LED Lighting



- Emissions avoided for all grid scenarios from reduced lighting energy and cooling loads
- Additional heating load from reduced internal loads causes slight increase in combustion fuel emissions

Exterior Wall Insulation

Exterior Wall Insulation

Measure Concept

Add rigid insulation under exterior cladding outside structural elements

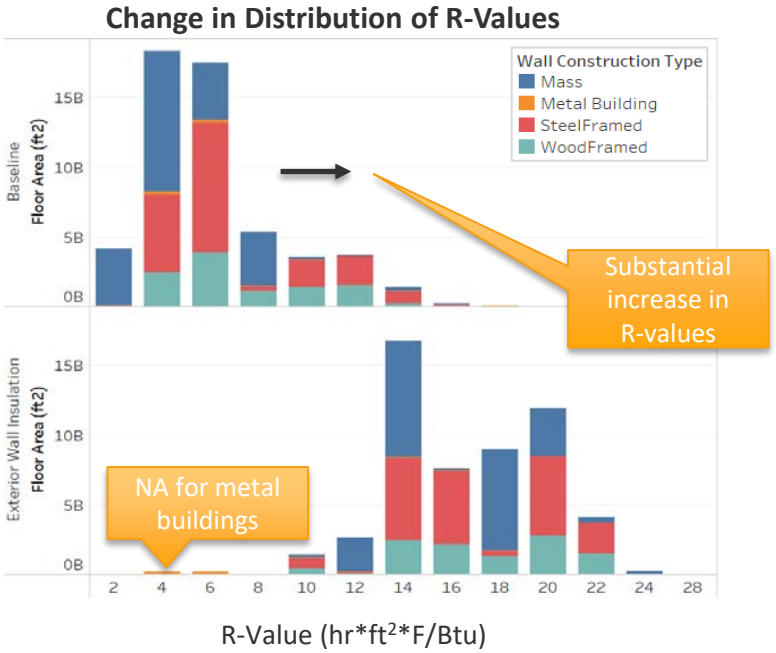
- Not applicable to metal building walls
- Round to nearest 1” of insulation
- If < 0.5” required, NA
- Target total performance ~R-13 to 29

Wall Insulation Performance

AEDG Target Values	Climate Zone	R-Value (hr*ft^{2*}F/Btu)
Opaque Wall Assembly Thermal Performance	1	13
	2	13
	3	16
	4	16
	5	19
	6	21
	7	21
	8	29

Applicability

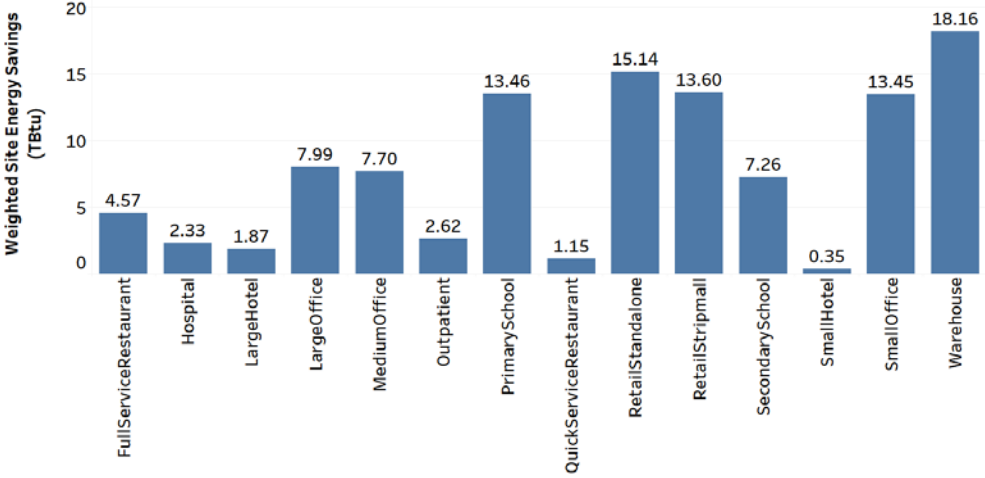
- Buildings with mass, steel-framed, or wood-framed walls
- Applicable to **98%** of stock floor area



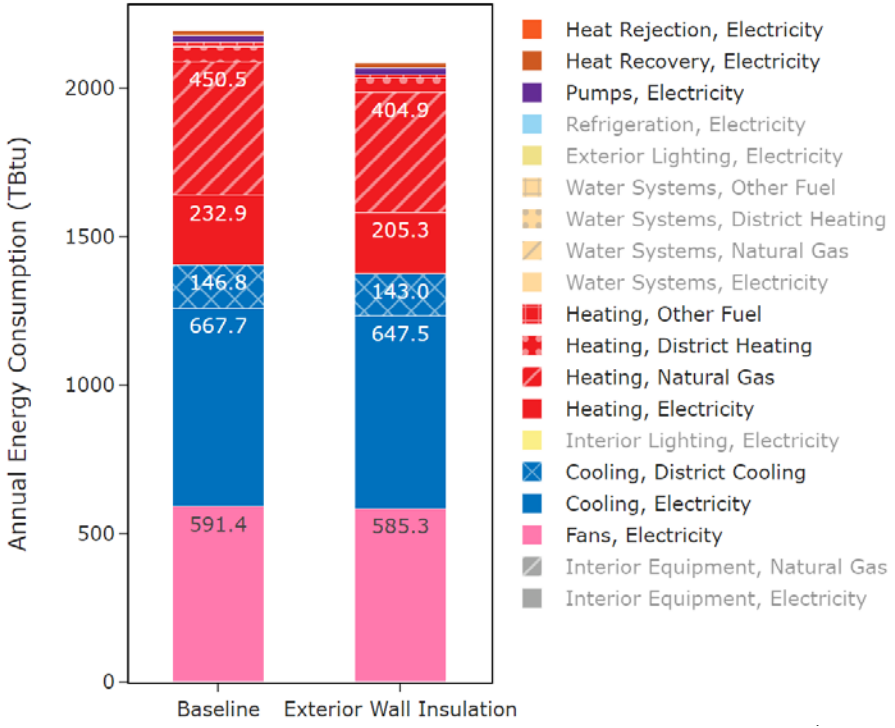
Exterior Wall Insulation

- **12%** stock **heating electricity** savings (79 TBtu)
- **10%** stock **heating gas** savings (46 TBtu)
- **3%** stock **cooling electricity** savings (20 TBtu)
- **1%** stock **fan electricity savings** (6 Tbtu)
- Generally decreases heating and cooling loads
- Sometime causes increased cooling loads

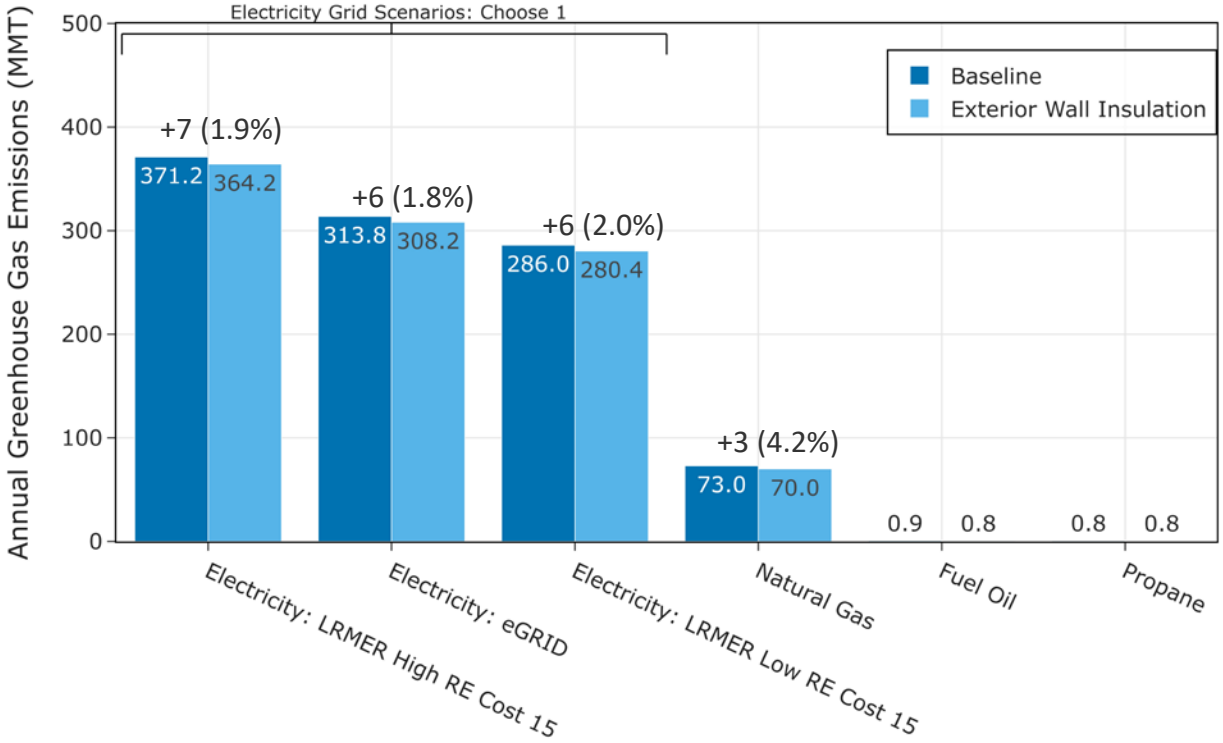
Stock Site Energy Savings by Building Type



Stock Site Energy by Fuel and End Use



Exterior Wall Insulation



Emissions avoided across all grid scenarios and combustion fuels from HVAC load reductions

Window Films

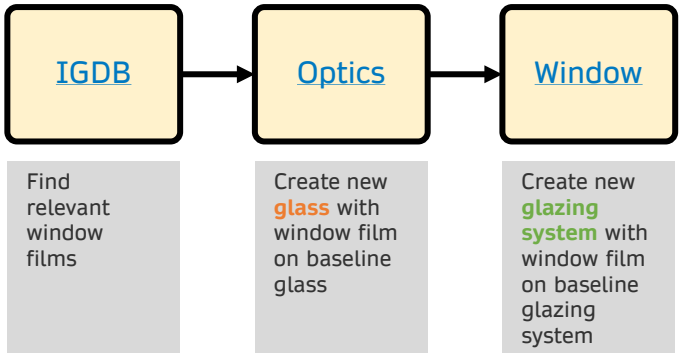
Window Films

Measure Concept

- Add window film to existing windows
- Film properties vary by climate and existing window
- Adds low-e coatings and/or reduced solar heat gain coefficient (SHGC) to existing window

Applicability

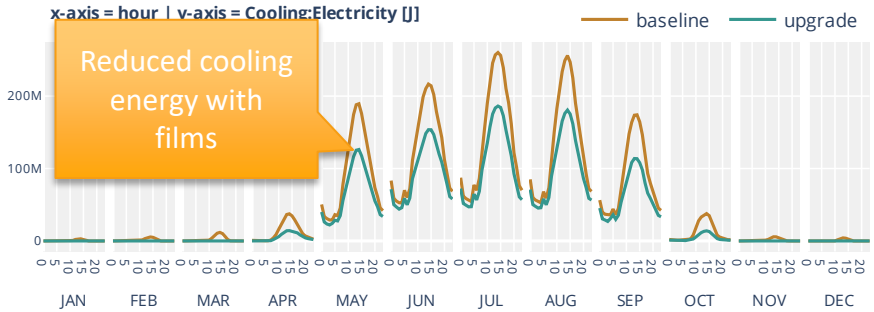
- Added to all non-triple pane windows in ComStock baseline
- Applicable to over **99%** of ComStock floor area



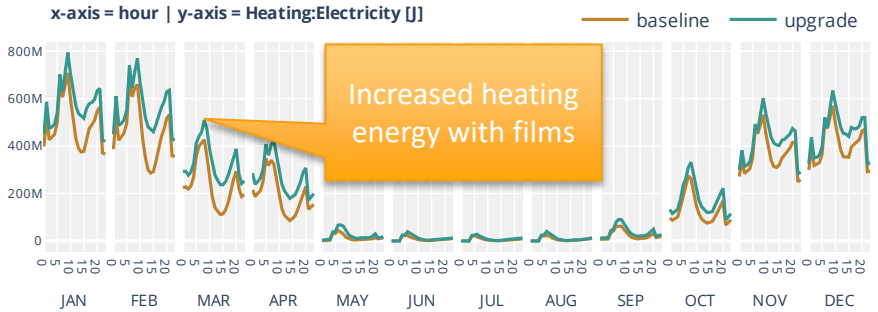
Window Films

There can be a seasonal trade-off

Electricity used for space cooling

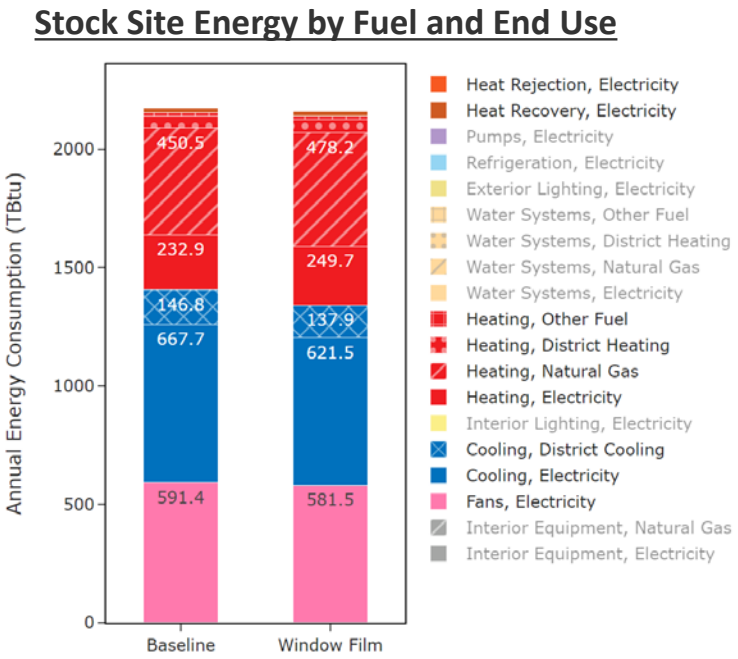


Electricity used for space heating

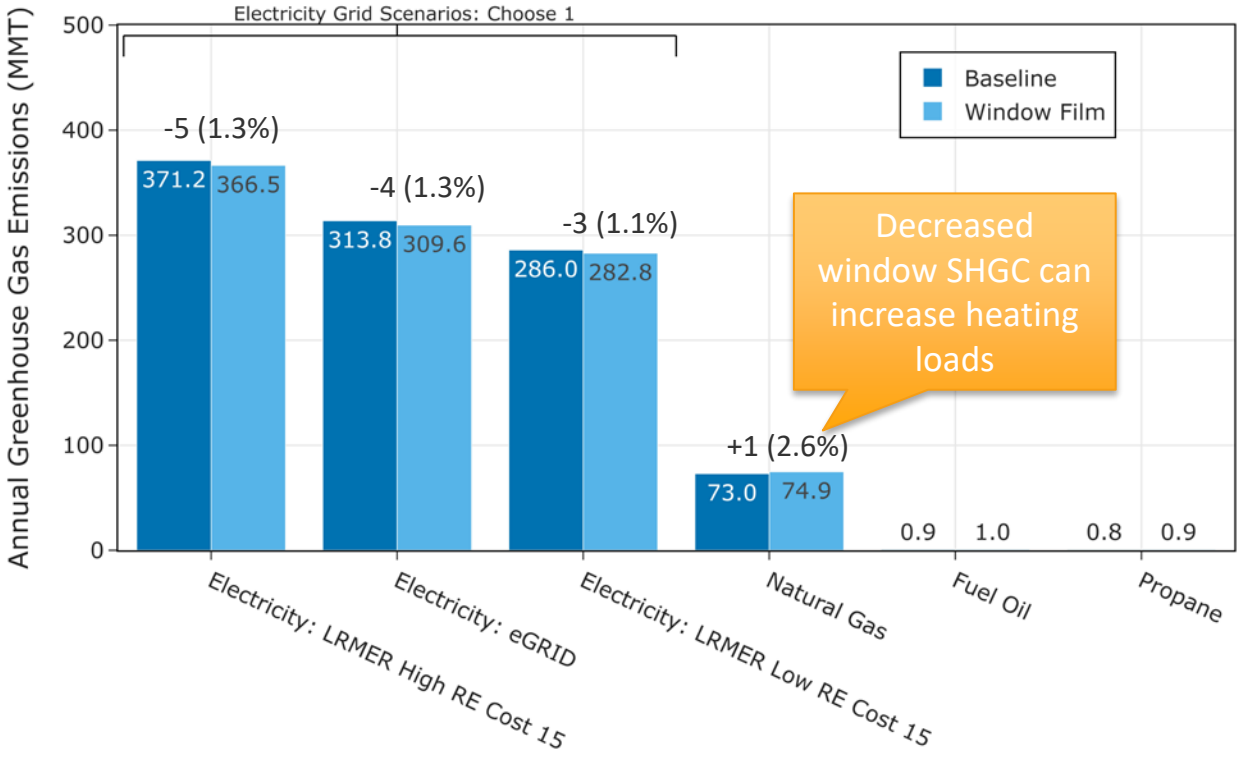


Window Films

- **7%** stock **cooling electricity** savings (46 Tbtu)
- **5%** stock site **district cooling** savings (8 Tbtu)
- **2%** stock **fan electricity** savings (10 Tbtu)
- **-7%** stock **heating (gas and electric)** savings (-45 TBtu)
- Variation in savings by building type, baseline window type, and climate zone



Window Films

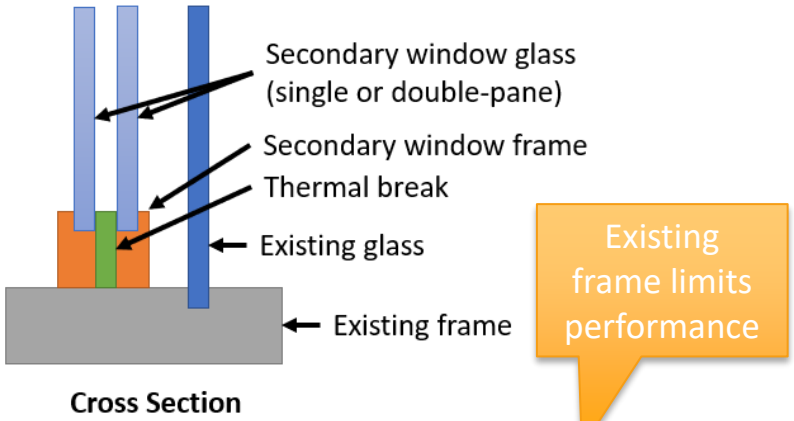


- Emissions avoided across all grid scenarios
- Heating increase from reduced SHGC causes slight increase in combustion fuel emissions

Secondary Windows

Secondary Windows

Measure Concept: Install a second window within the frame or reveal an existing window



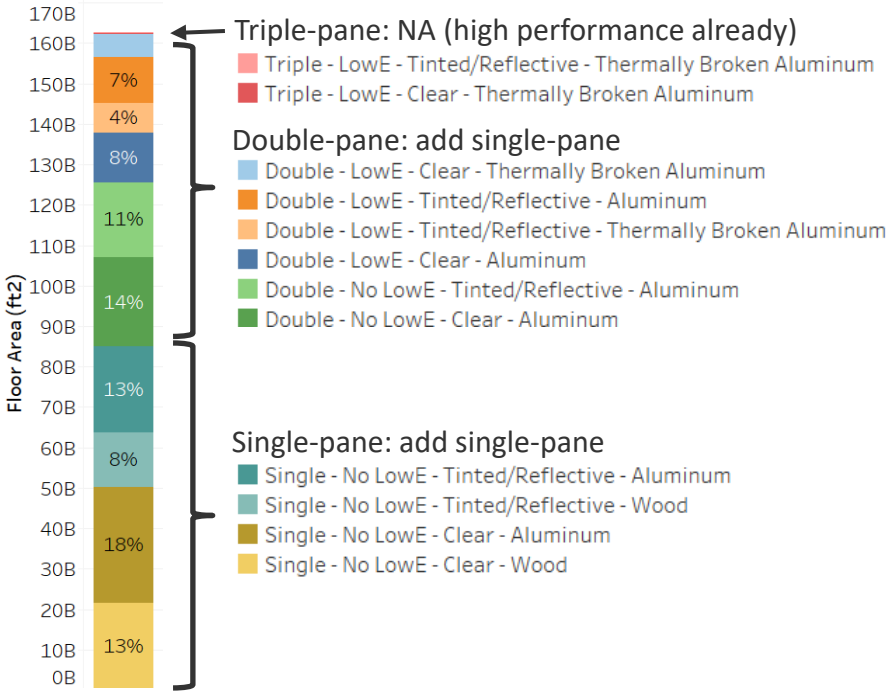
Existing frame limits performance

- Total performance ~R-1.6 to R-2.7
- Assumed frame-within-frame install
- Assumed no impact on infiltration

Some qualitative evidence against this assumption

Baseline Windows

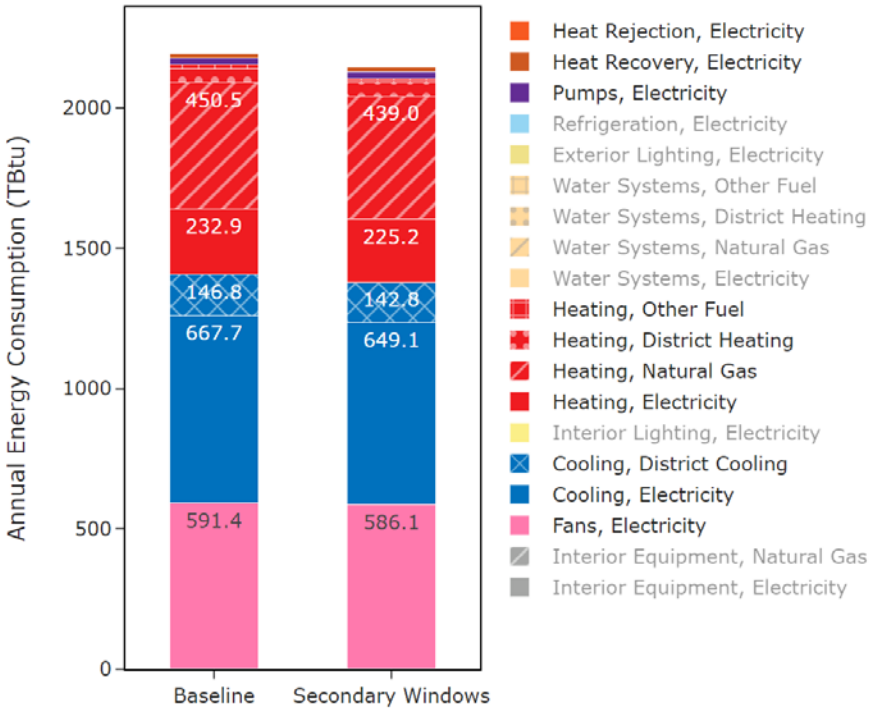
Applicability: Applies to most of existing stock



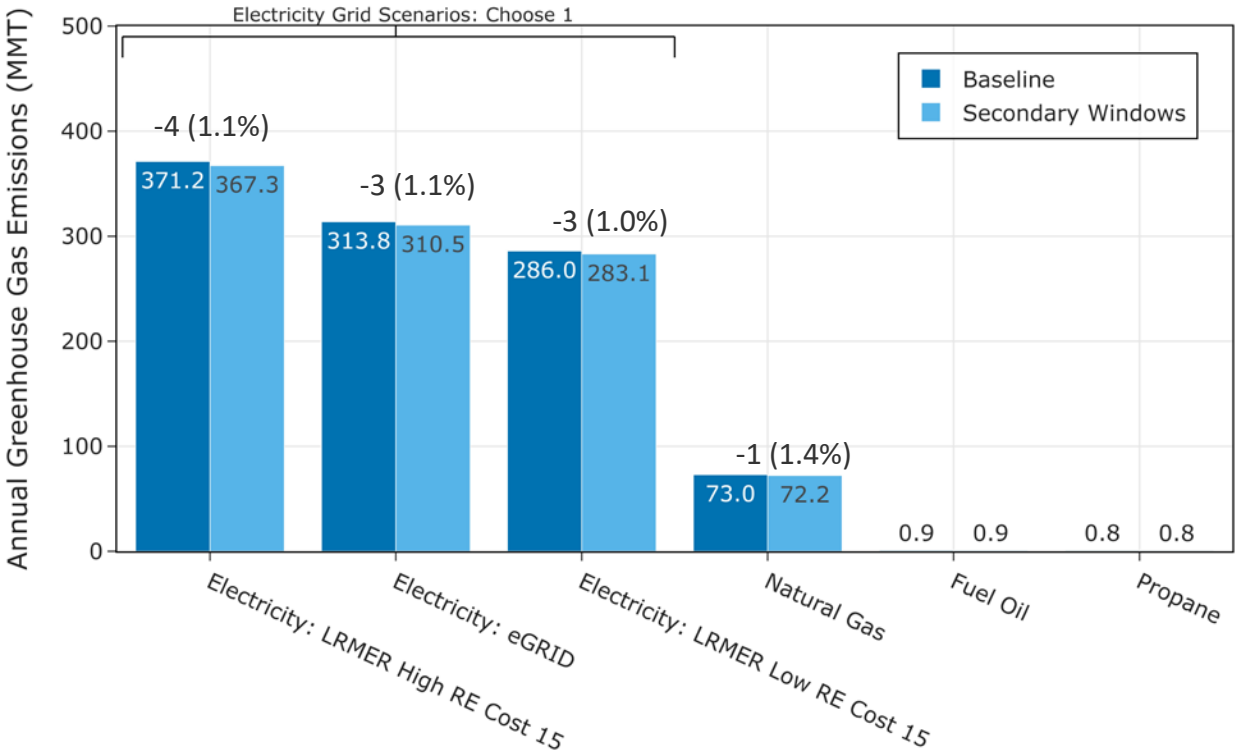
Secondary Windows

- **3%** stock site **heating electricity** savings (8 TBtu)
- **3%** stock site **heating gas** savings (12 TBtu)
- **3%** stock site **electricity cooling** energy savings (19 TBtu)
- **1%** stock site **electricity fan** energy (5 TBtu)
- Reduced loads from increased window insulation and decreased SHGC
- Complex relationship, savings per building vary by climate, building type, baseline window type, and other design factors

Stock Site Energy by Fuel and End Use



Secondary Windows



Emissions avoided across all grid scenarios and combustion fuels due to HVAC load reductions

Window Replacement

Window Replacement

Measure Concept

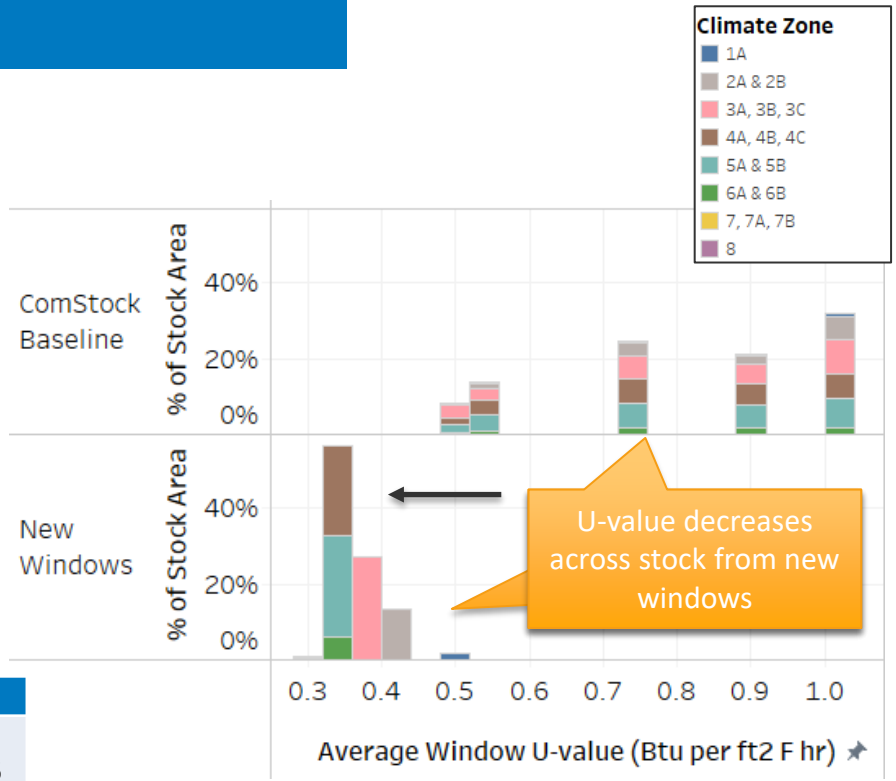
- Replace existing windows with those that align with *Advanced Energy Design Guide* (AEDG) properties

Measure Applicability

- Applies to all non-triple pane windows
- **>99%** of stock floor area

AEDG Target Values:

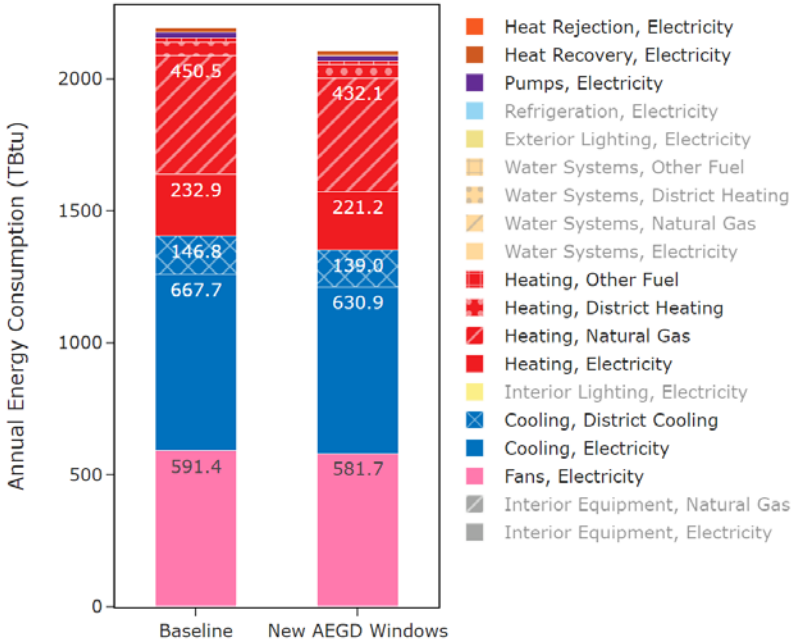
Climate Zone	1	2	3	4	5	6	7	8
Maximum Assembly U-Factor	0.48	0.43	0.40	0.34	0.34	0.32	0.28	0.25
Maximum SHGC	0.22	0.22	0.24	0.34	0.36	0.36	0.38	0.38



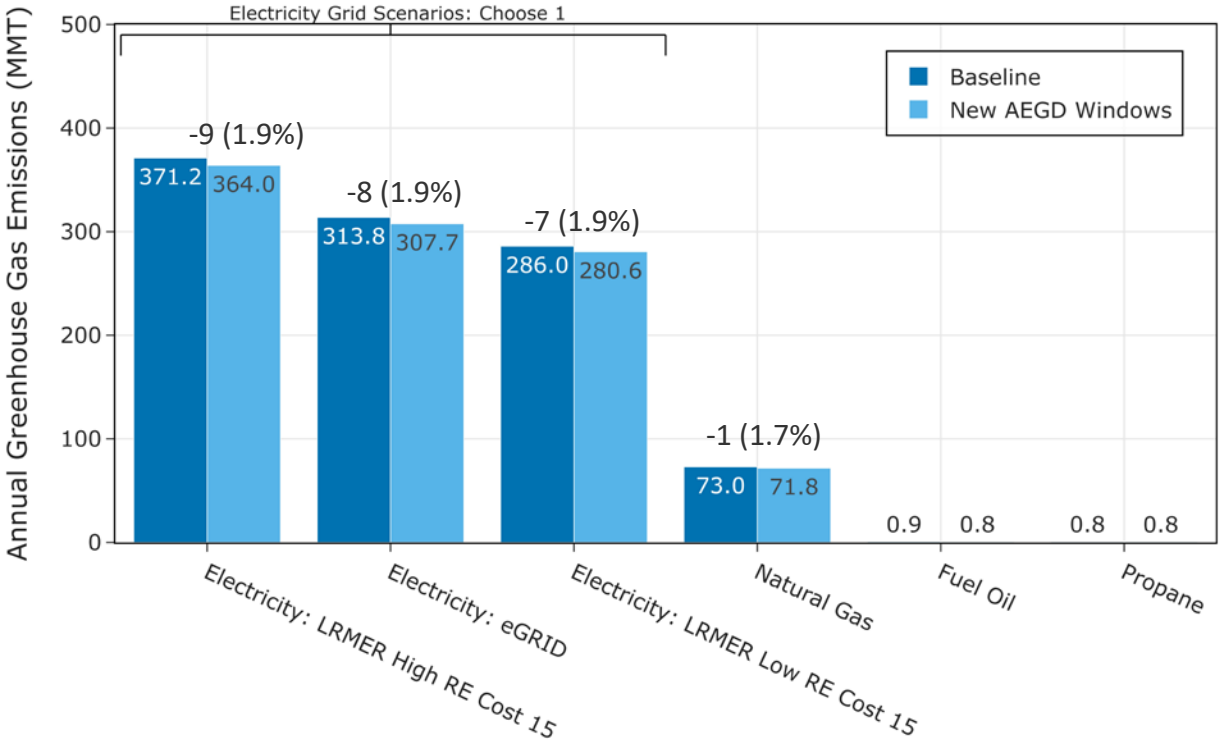
Window Replacement

- **5%** stock **heating electricity** energy savings (12 TBtu)
- **4%** stock **heating gas** energy savings (18 TBtu)
- **4%** stock **cooling electricity** savings (37 TBtu)
- Reduced loads from increased window insulation and reduced SHGC
- Increased cooling energy in some buildings

Stock Site Energy by Fuel and End Use



Window Replacement



Emissions avoided across all grid scenarios and combustion fuel sources due to HVAC load reductions

Roof Insulation

Roof Insulation

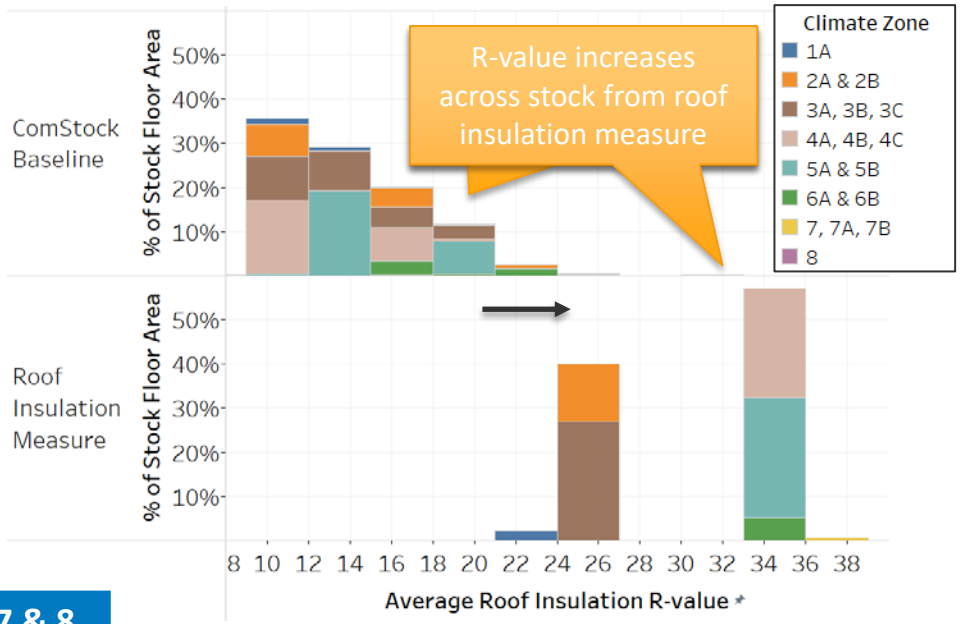
Measure Concept

- Increase roof insulation to align with AEDG R-values
- Rounded to nearest 1” of XPS (R-5/in.) insulation

Applicability

- All buildings not already meeting R-value targets
- **>99%** of stock floor area

Stock Roof R-Value Distribution Change

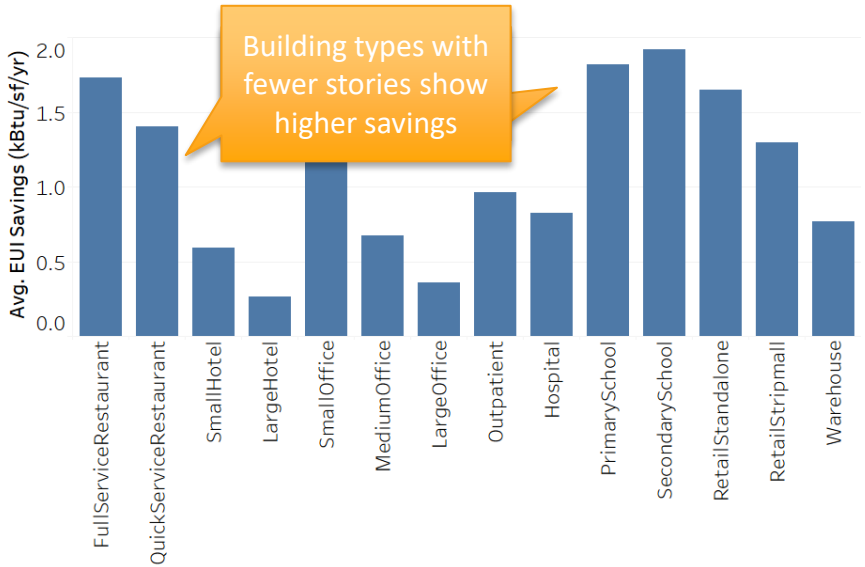


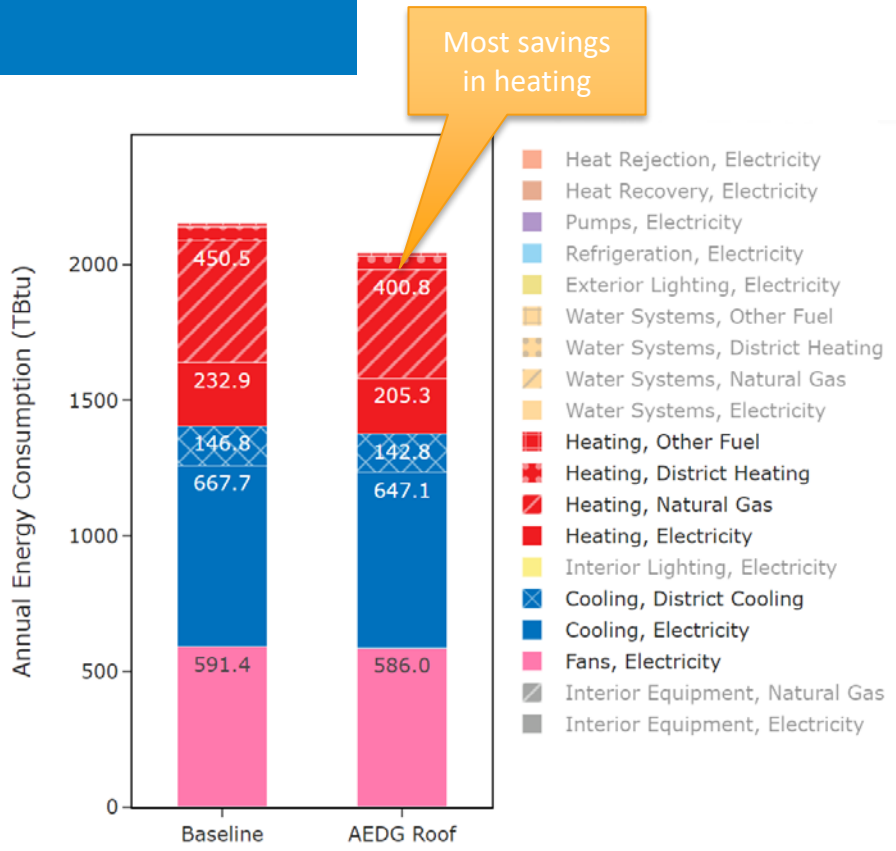
AEDG Target R-Values:

Climate Zone	1	2 & 3	4, 5, & 6	7 & 8
R-Value	21	26	33	37

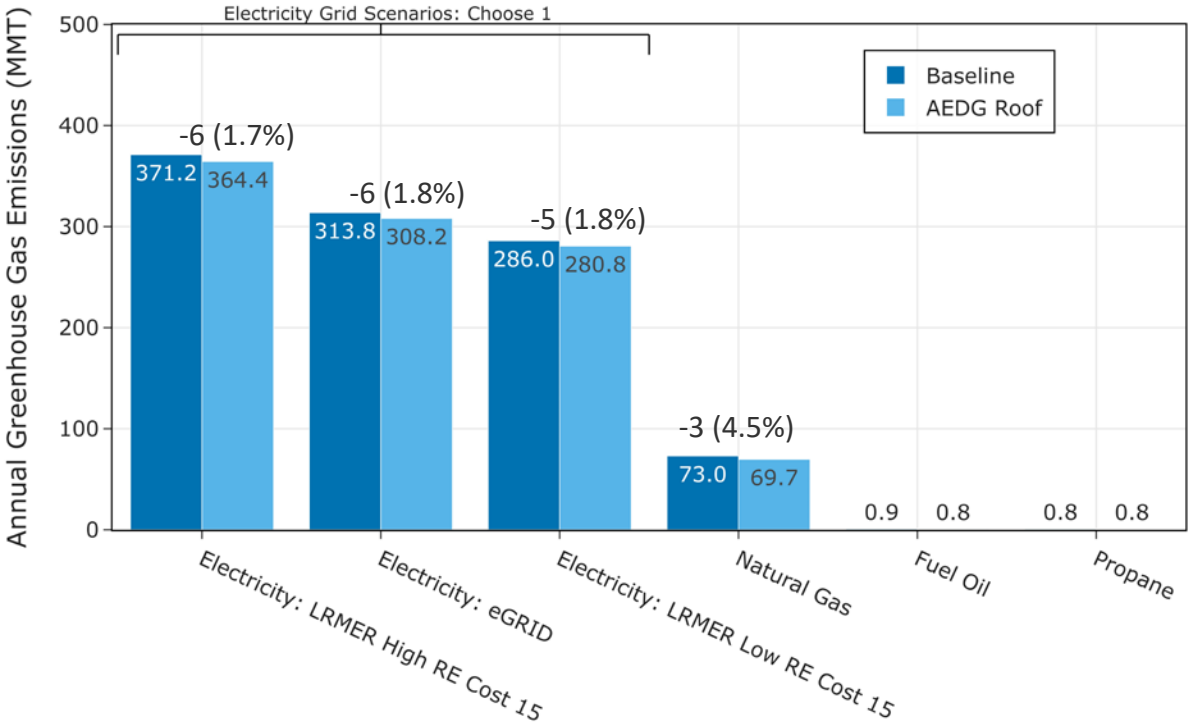
Roof Insulation

- **11%** stock site **heating** energy savings (82 TBtu)
- **3%** stock site **cooling** energy savings (25 TBtu)
- Reduced heating and cooling loads from increased roof insulation
- Variation in savings by building type, baseline R-value, and climate zone





Roof Insulation



Emissions avoided across all grid scenarios and combustion fuel sources due to HVAC load reductions

Accessing the Dataset

Accessing the Data

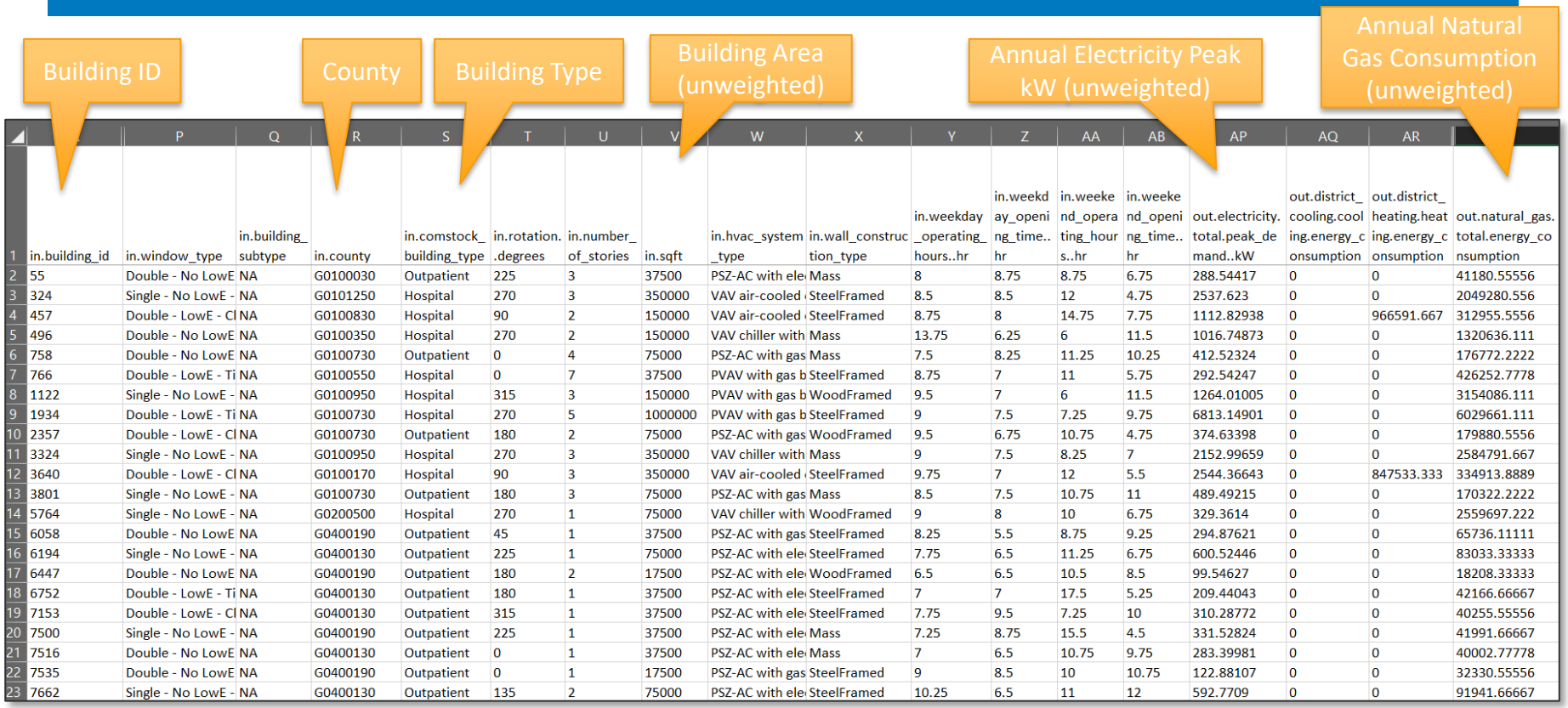
	Metadata	Individual Load Profiles	Aggregate Load Profiles	Data Viewer	Full Database
Data Format	.csv and .parquet files	.csv and .parquet files	.csv and .parquet files	Dashboard with .csv exports	Amazon S3 bucket
Time scale	Annual	15-min intervals	15-min intervals	Customizable	Annual or 15-min intervals
Grouped by	Individual Building ID	Individual Building ID	Geograhies: climate zone, ISO/RTO region, state	Customizable	Customizable
Fields by	Building Input Charateristics	-	-	-	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	OpenEI Data Lake	OpenEI Data Lake	Open EI Data Lake	ComStock.nrel.gov	Scripting Languages

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 (timeseries 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 [OpenEI Data Lake]

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

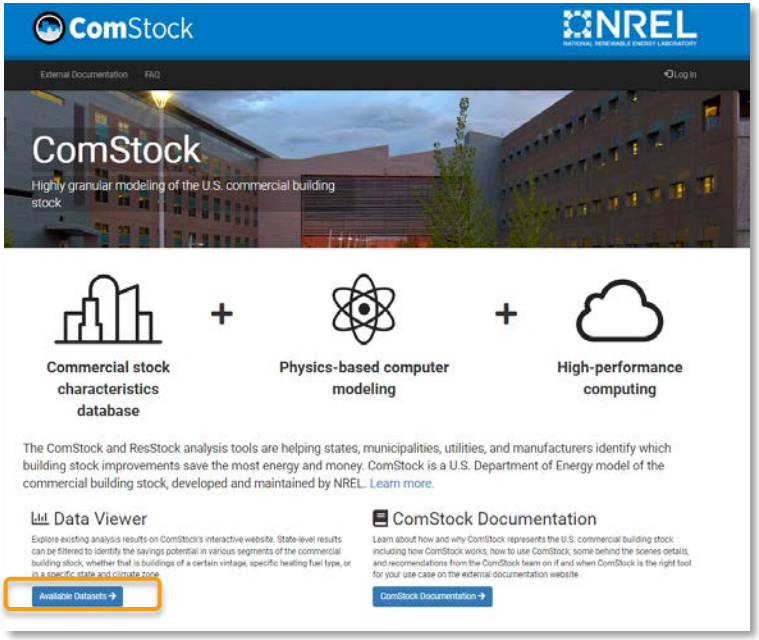
Exterior Lighting Consumption (kWh)

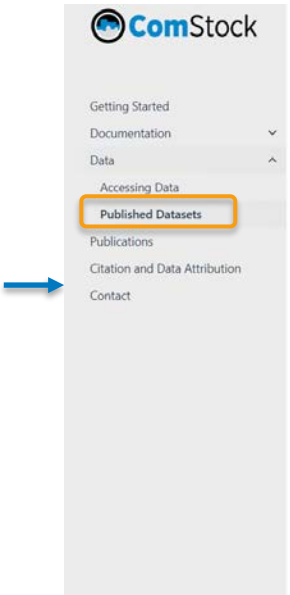
Interior Lighting Consumption (kWh)

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

Summary of Dataset Links





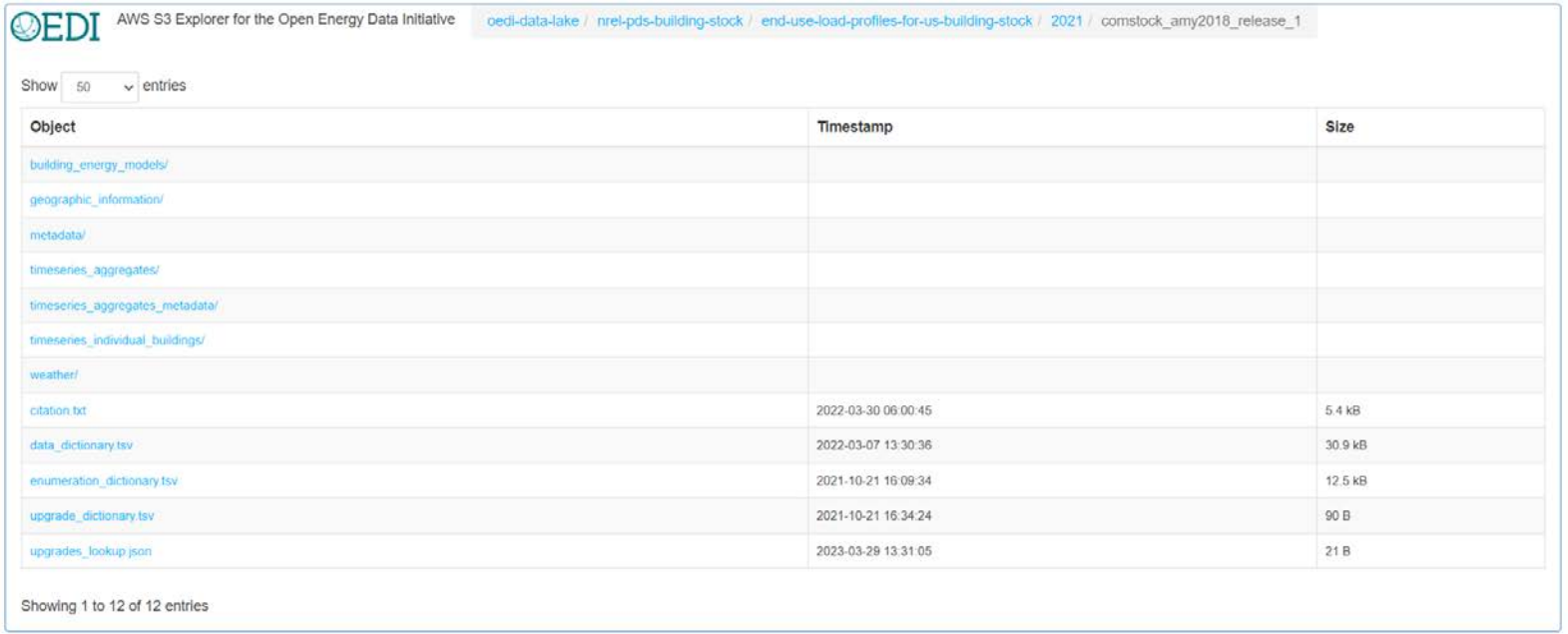
Published Datasets

ComStock dataset releases are summarized in the following table with links for accessing the aggregate results.

Publication Date	Oct-21	Oct-21
Release #	1	1
Building Stock Represented	U.S. commercial sector circa 2018	U.S. commercial sector circa 2018
Upgrades Applied	None	None
Weather Year	amy2018	tmy3
Data Viewer Links Annual and Timeseries Energy	by_state, by_puma_northeast, by_puma_midwest, by_puma_south, by_puma_west	by_state, by_puma_northeast, by_puma_midwest, by_puma_south, by_puma_west
Data Table with Characteristics and Annual Energy Use	metadata	metadata
OEDI Data and Dictionaries	suppl_data_dict	suppl_data_dict

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

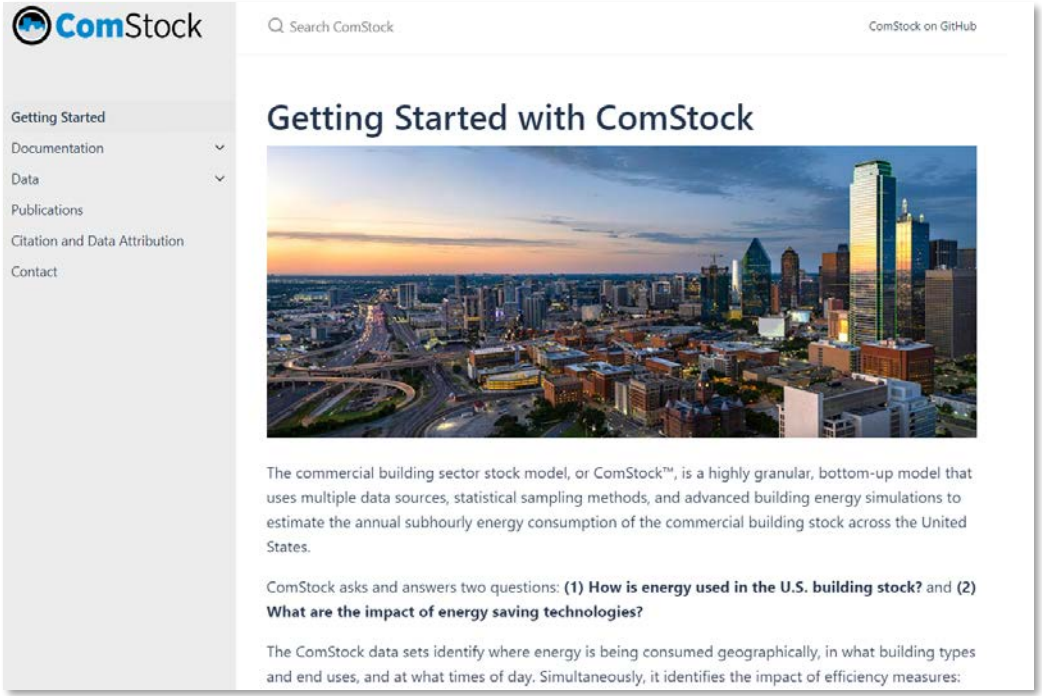
OEDI Folder Structure



Folder structure: year/comstock_weather file_release_#/[metadata, timeseries - aggregate, indv, etc]

Access at: [Open EI Data Lake]

ComStock Documentation Website



Access at: https://nrel.github.io/ComStock.github.io/

Where to find it…

ComStock Documentation Website

https://nrel.github.io/ComStock.github.io/

Getting Started • Publications • Technical Documentation

AWS OEDI Repository

https://data.openei.org/submissions/4520

Metadata & annual results • Aggregate load profile results • Individual model results & input files including weather

Data dictionary and enumeration dictionary • Geospatial information

Web Data Viewer

https://comstock.nrel.gov

Graphical in-browser data visualizations • Custom aggregation tool

Requires free account

A Few Reminders

- All time stamps 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 driven by current limitations with the data viewer.)

Next Steps

Commercial EUSS Round 2

Proposed List For Commercial EUSS 2023 Release 2; Expected September 2023

Measure Name	Description
Demand Control Ventilation (DCV)	Add demand control ventilation to air handling units.
DOAS with VRF retrofit	Replaces VAV systems with DOAS/VRF system.
Airside Economizers	Add economizers controls to air handling units (non-DOAS) that do not already have them.
Heat/Energy Recovery	Add heat or energy recovery to air handling units where not already included.
HP-RTU with Gas Backup	Apply gas backup to HP-RTUs to understand carbon, energy, and peak demand trade-offs of the backup heating fuel source.
HP Boiler with Gas Backup	Apply gas backup to HP-boilers to understand carbon, energy, and peak demand tradeoffs of the backup heating fuel source.
Package 1: High Efficiency Envelope	Apply package with upgraded wall insulation, roof insulation, and windows to align with target values per climate zone.
Package 2: Lighting + HP-RTU + HP-Boiler	Apply package with LED lighting, HP-RTU, and HP-boiler.
Package 3: High Efficiency Case (7+8)	Combine packages 1 and 2

Q&A
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Citation and Attribution Guidance

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