

CAE 465/526 Building Energy Conservation Technologies

Fall 2022

August 24, 2022

Introduction to CAE 465/526

Built
Environment
Research

@ IIT



*Advancing energy, environmental, and
sustainability research within the built environment*

www.built-envi.com

Dr. Mohammad Heidarinejad, Ph.D., P.E.
Civil, Architectural and Environmental Engineering
Illinois Institute of Technology

muh182@iit.edu

INTRODUCTION

About Me

- B.S.E., Mechanical Engineering
 - Sharif University of Technology Tehran, Iran, 2006
- M.S.E., Architectural Engineering
 - The Pennsylvania State University, 2011
- Ph.D., Mechanical Engineering
 - The Pennsylvania State University, 2014
- Experience relevant to this course
 - ASHRAE, DOE, EPA, HUD, NSF, and industry projects
 - University of Maryland College Park
 - Licensed Professional Engineer
 - ASHRAE New Investigator
 - Developed and taught several courses at Illinois Tech
 - Recipient of the Michael J. Graff Award for Innovation in Teaching



Introduce Yourself

- Please introduce yourself
- Why did you choose this course?
- What do you expect from the course?
- How do you think the course will have impact on your career?
- Do you have any relevant internship/work experience?
- Are you looking for summer internship or full-time job?
- Did you take your FE exam?
- Are you graduating this semester?

Course

Classroom and Meeting Time:

- CAE 465 Section 01: 15250 (undergraduate) – In class
- CAE 465 Section 02: 15239 (undergraduate) - Online
- CAE 526 Section 01: 15243 (graduate) – In class
- CAE 526 Section 02: 15244 (graduate) - Online

Classroom and Meeting Time:

- Location: HH 005
- Wednesdays, 1:50 PM – 4:30 PM

Course Website:

- All content will be provided on Blackboard

Course Catalog Description

- Identification of the optimal energy performance achievable with various types of buildings and service systems
- Reduction of infiltration
- Control systems and strategies to achieve optimal energy performance
- Effective utilization of daylight, heat pumps, passive and active solar heaters, heat storage and heat pipes in new and old buildings

Instructor's Course Objectives & Learning Outcomes

1. Analyze energy consumption patterns in the buildings
2. Understand impacts of the building rating systems and sustainability measures to design energy efficient buildings
3. Become an expert in preparing calibrated building energy models to predict energy consumption patterns of building energy end-uses
4. Perform different building energy retrofit scenarios to provide opportunities to reduce energy and greenhouse gas emissions of buildings
5. Understand the impacts of influential parameters on energy end-uses of buildings
6. Visualize and analyze building performance data and applying statistical methods to compare the metered with the simulated results

Office Hours

Instructor:

- Office hours are by appointment only. Please email me to schedule an appointment. Or stop by when you see my office door open to see if I'm free. I have an open door policy.

❑ Office: Alumni Memorial Hall Room 204

❑ Email: muh182@iit.edu

❑ Phone: (312) 567-3426

Office Hours

Teaching Assistant:

- TBD
 - Name: Mingyu Wang, Ph.D. Student, Architectural Engineering
 - Email: mwang88@hawk.iit.edu

Textbook

- Lecture notes are sufficient for this course. I will also rely on several other materials in this course. These materials are entirely optional for the student; handouts will be given when necessary, so that no one is required to purchase these items.
- You should have a copy of the 2017 or 2021 American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbook of Fundamentals (IP unit version) for use from your CAE 331/513: Building Science or CAE 464/517: HVAC Systems Design courses. I may refer to this for some of the topic in this class

Course Grading

Grading	Quantity	% of Total for Each	% of Total
Assignments	5	5	25
Exam	1	30	30
Project Reports (Interim)	2	11	22
Final Report	1	15	15
Final Presentation	1	8	8

Grading scale	A	B	C	D	F
UG and G	90% and up	80.0-89.9%	70.0-79.9%	60.0-69.9%	<60.0%

Homework Assignments

- Homework sets will be assigned based on lecture coverages. The homework will involve hand calculations, development of spreadsheets, and/or learning the fundamentals and data analysis. You must work on the homework assignments individually.
- Homework assignments and project reports are due at the midnight on the day that it is due. Homework assignments and project reports will receive an ***absolute 5-point deduction*** for every day that it is late.

Project and Presentation

- The course project focuses on retrofitting an existing building.
- The project has three deliverables described in the project assignment document.
- Each student is responsible for working on the first two deliverable course project individually. The third deliverable will be a group project submission.
- Students are required to present their report at the end of the semester during the assigned university exam week.

Exam

- There will be one take home class exam during the semester of the fundamental concepts and applications learned in the course. Each student is responsible for working on exam individually.

Course Topics

Week	Date	Topics	Assignment Due
1	08/24/22	Introduction to (i) course objectives, (ii) CAE 331/513 and CAE 464 review, and (iii) energy consumption in the building sector	
2	08/31/22	Building energy consumption patterns and building performance analysis	
3	09/07/22	Building energy balance, building energy simulations, brief overview of heating and cooling loads and intro to OpenStudio Project Assigned	Assignment #1
4	09/14/22	Building energy modeling training (OpenStudio training)	Assignment #2
5	09/21/22	Advanced building mechanical systems	Assignment #3
6	09/28/22	Building energy modeling training (OpenStudio training – advanced features)	
7	10/05/22	Model calibration and uncertainty analysis	Assignment #4
8	10/12/22	Building energy audits and commissioning	Project Deliverable #1

Course Topics

Week	Date	Topics	Assignment Due
9	10/19/22	Building retrofit and energy efficiency measures (EEMs) – Part 1	
10	10/26/22	Building performance metrics and life cycle analysis	Assignment #5
11	11/02/22	Exam (Take Home)	
12	11/09/22	Building retrofit and energy efficiency measures (EEMs) – Part 2	
13	11/16/22	Building retrofit and energy efficiency measures (EEMs) – Part 2 and class activity	Project Deliverable #2
14	11/23/22	Thanksgiving – No Class	
15	11/30/22	Building to grid integration and utility programs	
16	TBD	Student Project Presentations (During the Final Exam)	Final Presentation
17	TBD	Final Project Report	Final Report

Academic Honesty

- It is your responsibility to be familiar with IIT's Code of Academic Honesty. The Code of Academic Honesty can be found online: <https://www.iit.edu/student-affairs/student-handbook/fine-print/code-academic-honesty>
- You must submit your ***own work for homework***. You are encouraged to discuss and even work with other students on homework (unless explicitly told otherwise), but material that is submitted must be ***your own work***

Academic Honesty

- For a ***first violation*** of the IIT Code of Academic Honesty for a homework or project, the homework will receive a grade of ***zero for all involved students*** and the students will be reported to the Designated Dean for Academic Discipline (DDAD)
- For a first violation of the Code of Academic Honesty for a ***major project*** or an examination, the student will ***receive a failing grade*** for the course and the student will be reported to the DDAD. For a second violation, the student will receive also failing grade for the course and be reported to the DDAD

Personal Problems

- If you have illness or personal problems that will affect your performance during the course of the semester, please let me know *as soon as possible*
- **“After the fact”** provides little protection unless there are extreme circumstances. Contact the instructors by phone or e-mail at any time

Personal Problems

- Academic Regulations: <https://web.iit.edu/student-affairs/handbook/fine-print/academic-and-department-regulations>

*“All students are **expected to attend classes regularly**. Excessive absences may be grounds for a failing grade. Non-attendance does not constitute an official withdrawal. When illness or emergency requires a student to miss an exam and/or more than two days of class, the student must notify the course instructor. It is also recommended that the student **contact the office of the Dean of Students (dos@iit.edu) to request an excused absence**. It will be necessary to provide written documentation of the reason for the absence(s). The Office of Student Affairs manages the process for requesting and documenting excused absences but the decision to excuse an absence is generally made by the Professor. Faculty members determine their own policies for attendance and make-up work.”*

Students with Disabilities

- Reasonable accommodations will be made for students with documented disabilities. In order to receive accommodations, students must obtain a letter of accommodation from the Center for Disability Resources
- The Center for Disability Resources (CDR) is located in Life Sciences Room 218, telephone (312) 567-5744 or email: disabilities@iit.edu

Sexual Harassment and Discrimination Information

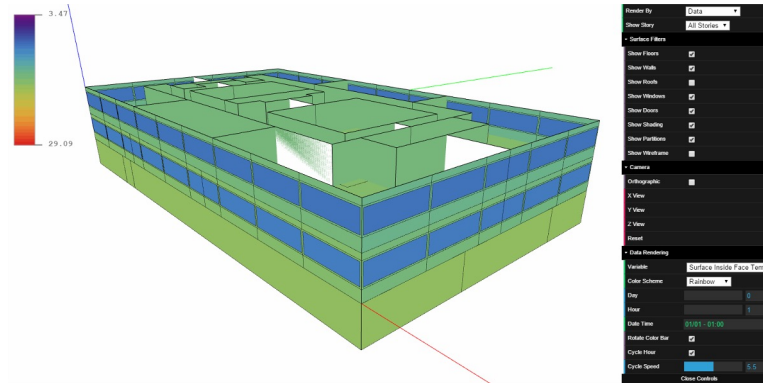
- Illinois Tech prohibits all sexual harassment, sexual misconduct, and gender discrimination by any member of our community. This includes harassment among students, staff, or faculty. Sexual harassment of a student by a faculty member or sexual harassment of an employee by a supervisor is particularly serious. Such conduct may easily create an intimidating, hostile, or offensive environment.
- Illinois Tech encourages anyone experiencing sexual harassment or sexual misconduct to speak with the Office of Title IX Compliance for information on support options and the resolution process.

Sexual Harassment and Discrimination Information

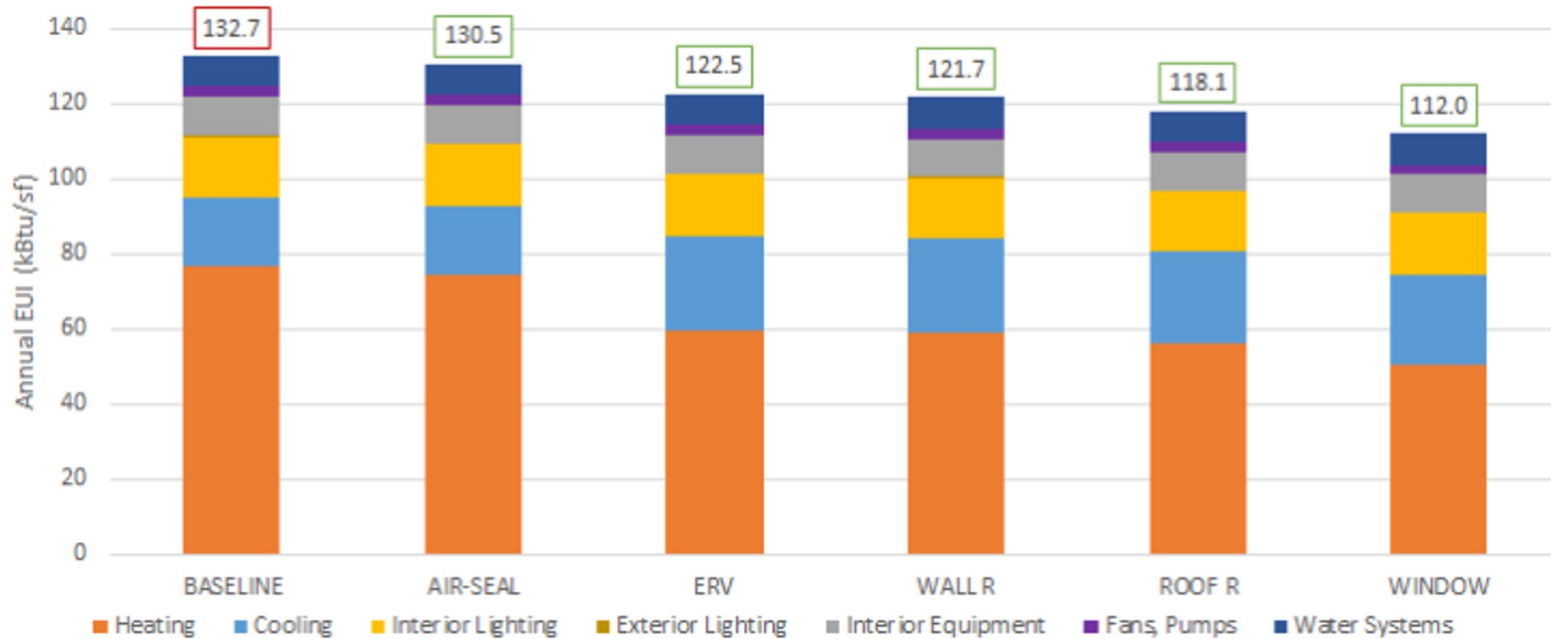
- You can report sexual harassment electronically at [iit.edu/incidentreport](https://www.iit.edu/incidentreport), which may be completed anonymously. You may additionally report by contacting the Title IX Coordinator, Virginia Foster at foster@iit.edu or the Deputy Title IX Coordinator at eespeland@iit.edu.
- For confidential support, you may reach Illinois Tech's Confidential Advisor at (773) 907-1062. You can also contact a licensed practitioner in Illinois Tech's Student Health and Wellness Center at student.health@iit.edu or (312)567-7550
- For a comprehensive list of resources regarding counseling services, medical assistance, legal assistance and visa and immigration services, you can visit the Office of Title IX Compliance website at <https://www.iit.edu/title-ix/resources>.

LAST YEARS PROJECTS

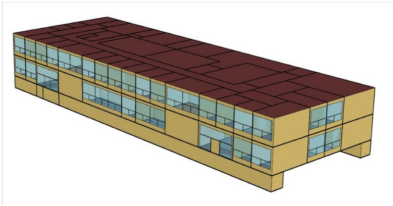
Final Project



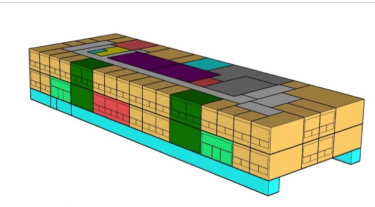
Annual EUI Reduction by Measure



Final Project



Building geometry render view by surface type



Building geometry render view by space type

GROSS FLOOR AREA: 39,636 ft²

CONSTRUCTION INPUT:

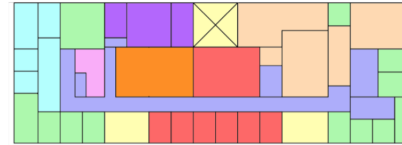
WALL	4" DOUBLE LAYERED BRICK
ROOF	R-9 INSULATED METAL ROOF
BASEMENT WALL	10" CONCRETE WALL
WINDOW TYP. 1	¼" SINGLE PANE
WINDOW TYP. 2	6.2 MM VACUUM GLASS
METAL DOOR	INSULATED METAL DOOR
GLASS DOOR	¼" SINGLE PANE

INTERNAL LOAD INPUT:

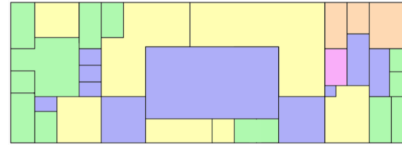
LIGHTING	ASSUMED LIGHTING RETROFIT IS ALREADY DONE (LED 18W)
PLUG	ADOPTED DOE PRE-1980 MID OFFICE DATASET

MAJOR SPACE TYPE

OFFICE	RESTROOM	CORRIDOR	MECH. ROOM
STAIR	LOBBY	LABORATORY	COMPUTER / BERG LABORATORY



2nd Floor Thermal Zone Map



1st Floor Thermal Zone Map



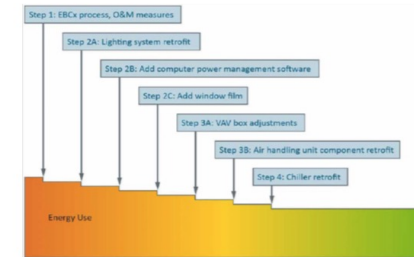
Basement Thermal Zone Map

HVAC EQUIPMENT INPUT

RTU	5
PTAC	24
Baseboard	39
EXHAUST FAN	2

RTU 1	PTAC W/ BASEBOARD
RTU 2	FAN ONLY BASEBOARD ONLY
RTU 3	UNCONDITIONED
RTU 4	
RTU 5	

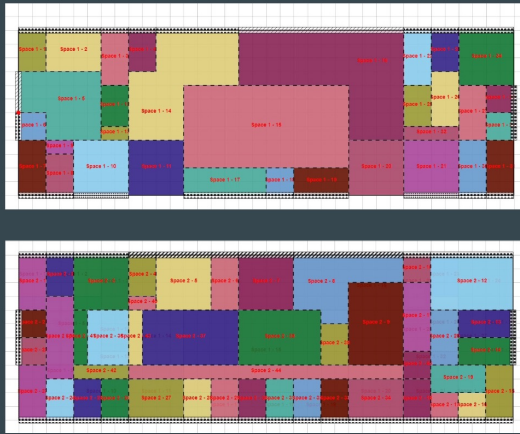
Scenario	Measure Combination
1 Control + Lighting + Equipment + PV	ECM1 + ECM2 + ECM3 + ECM4 + ECM9
2 Control + Lighting + Equipment + HVAC	ECM1 + ECM2 + ECM3 + ECM4 + ECM10
3 Control + Envelope	ECM1 + ECM2 + ECM5 + ECM6 + ECM7
4 Control + Envelope + PV	ECM1 + ECM2 + ECM5 + ECM7 + ECM9
5 Control + Envelope + HVAC	ECM1 + ECM2 + ECM5 + ECM7 + ECM10



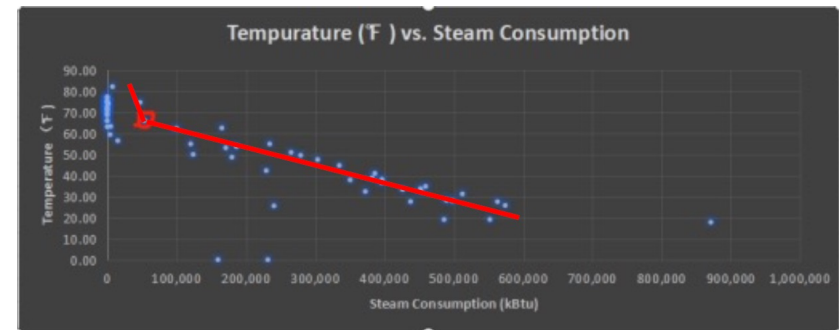
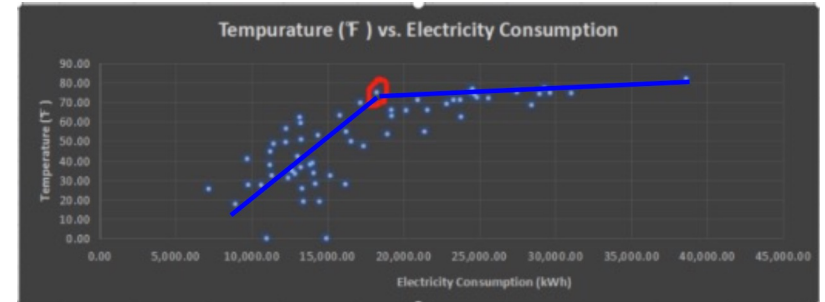
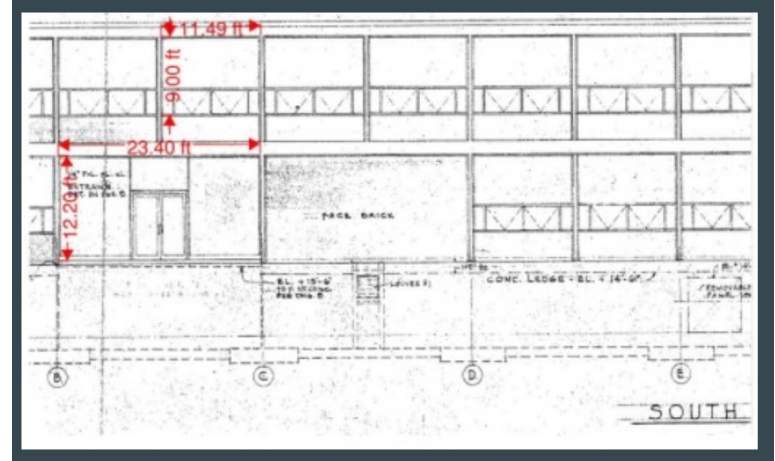
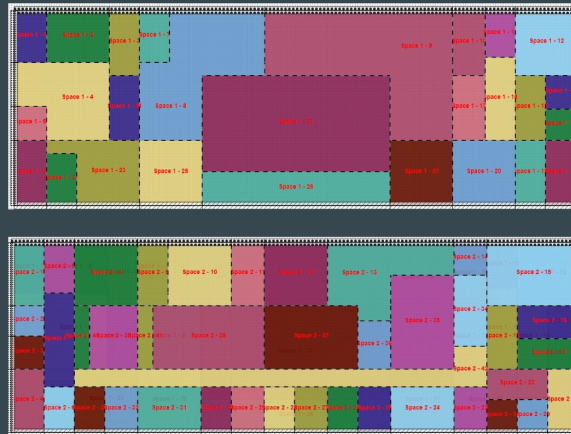
Scenario	Electricity		District Heating		Total Energy Saving Cost (\$/yr)	Implementation Cost (\$)	Rebate (\$)	PayBack Years
	Energy Consumption Difference (kWh/yr)	Energy Saving Cost (\$/yr)	Energy Consumption Difference (therm/yr)	Energy Saving Cost (\$/yr)				
1	-15,450.76	1,283.96	-134.90	118.71	9,560.93	316,212.77	2,825.90	32.78
2	211,286.34	-17,557.90	-23,765.84	20,913.94	3,356.04	302,588.72	165.73	90.11
3	-15,020.22	1,248.18	-10,059.02	8,851.94	10,100.12	977,691.08	47.73	96.80
4	-5,994.72	498.16	-5,460.35	4,805.10	13,461.53	1,022,172.41	2,707.90	75.73
5	114,507.62	-9,515.58	-23,765.84	20,913.94	11,398.36	1,008,548.36	47.73	88.48

Final Project

Model 1



Model 2



Final Project

Measure Name	EUI (kBtu/ft ²)	Total Electricity Use (kWh)	Total Steam Use (MBtu)	EUI Change (%)	Electricity Change (%)	Steam Change (%)
Baseline	67.9	274955.6	1352.9	-	-	-
Reduce Night Time Lighting Loads	67.2	267296.2	1356.6	-1.03%	-2.79%	0.27%
Reduce Night Time Electric Equipment Loads	66.6	253603.8	1382.8	-1.91%	-7.77%	2.21%
Increase R-value of Insulation for Exterior Walls to a Specific Value	65.2	271801.5	1272.8	-3.99%	-1.15%	-5.92%
Increase R-value of Insulation for Roofs to a Specific Value	49.8	248317.9	832	-26.72%	-9.69%	-38.50%
Set COP for Two Speed DX Cooling Units	66.3	259023.5	1352.9	-2.36%	-5.79%	0.00%
Reduce Electric Equipment Loads by Percentage	66.7	261599	1352.9	-1.77%	-4.86%	0.00%
Resize existing windows to match a given WWR	66.3	270208.7	1317.1	-2.30%	-1.73%	-2.65%
Add Exterior Lights	68.3	279319.6	1352.9	0.62%	1.59%	0.00%
Reduce Lighting Loads by Percentage	64.86	242101.8	1363.03	-4.48%	-11.95%	0.75%
Set Lighting Loads by LPD	65.3	249762.6	1351.8	-3.83%	-9.16%	-0.08%

RSMean data from **CORDIAN**

Search Data | Manage Estimates | **Square Foot Estimator** | Life Cycle Cost | Cost Alerts and Trends

Estimate Header Information

* Estimate Name: Increase R-Value of Exterior Wall

Estimate Address: 3201 S Dearborn Street

Zip/Postal Code: 60616

Notes:
 300 characters max

Cost Data Preferences

* Cost Data:Facilities Construction

* Type: Unit

* Format: MasterFormat 2018

* Measurement System: English

Line Item Details

* Line Number: 072216101932

Unit of Measure: S.F.

Description: Roof Deck Insulation, install polystyrene insulation, 4" thick, R20, 15 PSI compressive strength

	Bare Costs	Costs with Overhead & Profits
Material Cost	1.58	Material Cost O&P 1.74
Labor Cost	0.42	Labor Cost O&P 0.75
Equipment Cost	0	Equipment Cost O&P 0
Total Cost	2.00	Total Cost O&P 2.49

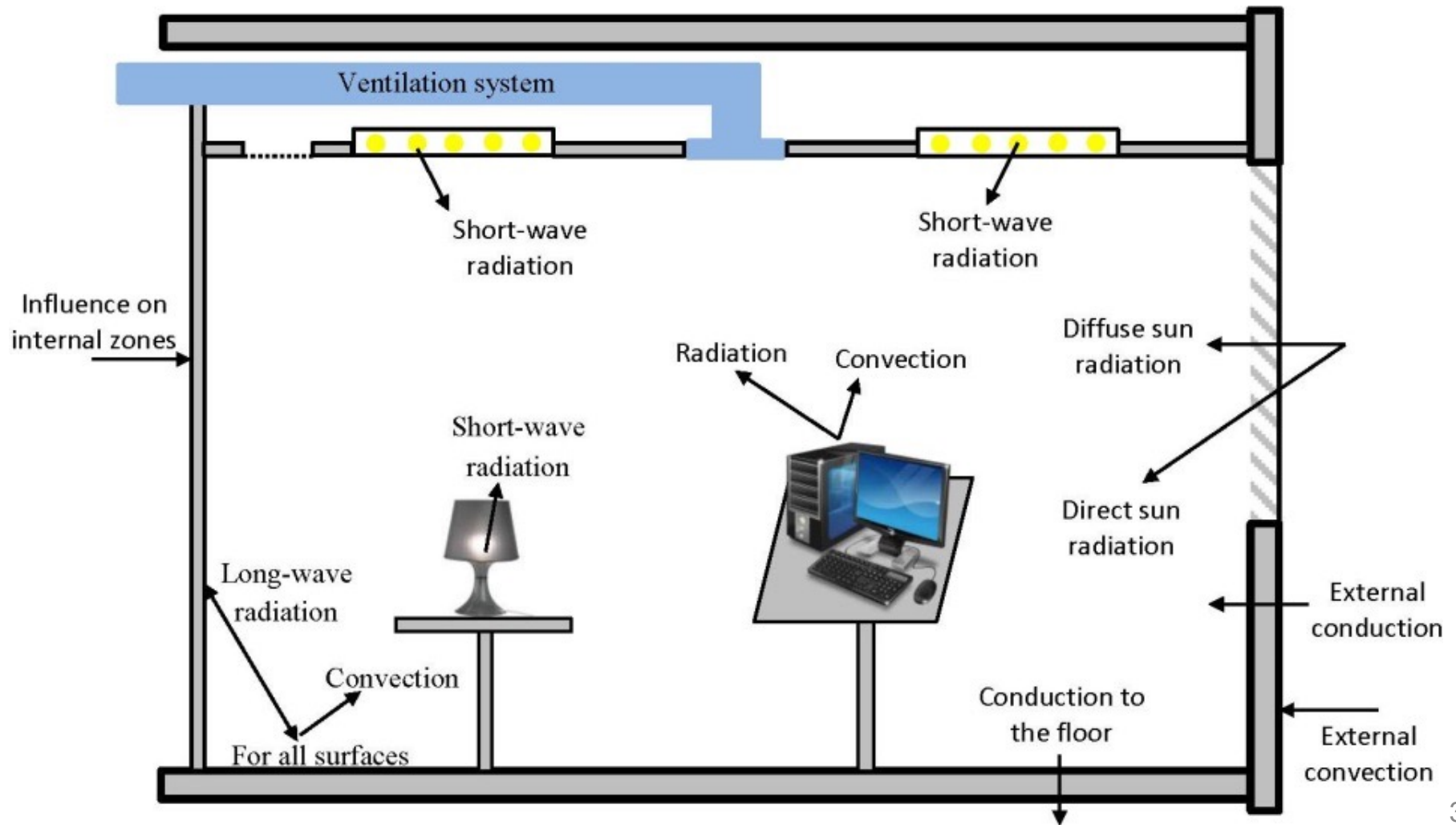
Line Item Notes:
 300 characters max

Cancel

REVIEW OF CAE 331/513 AND CAE 464

CAE 331, 464, 513

- How many of you have taken any of these courses?
 - Heat transfer processes



CAE 331, 464, 513

- How many of you have taken any of these courses?
 - Heat transfer processes
 - Thermal comfort
 - HVAC systems
 - Psychometrics
 - Ventilation and indoor air quality
 - Cooling and heating load calculations
 - Energy estimation
 - Building codes, standards, and guidelines

THE UTILITY OF BUILDING MEASUREMENTS

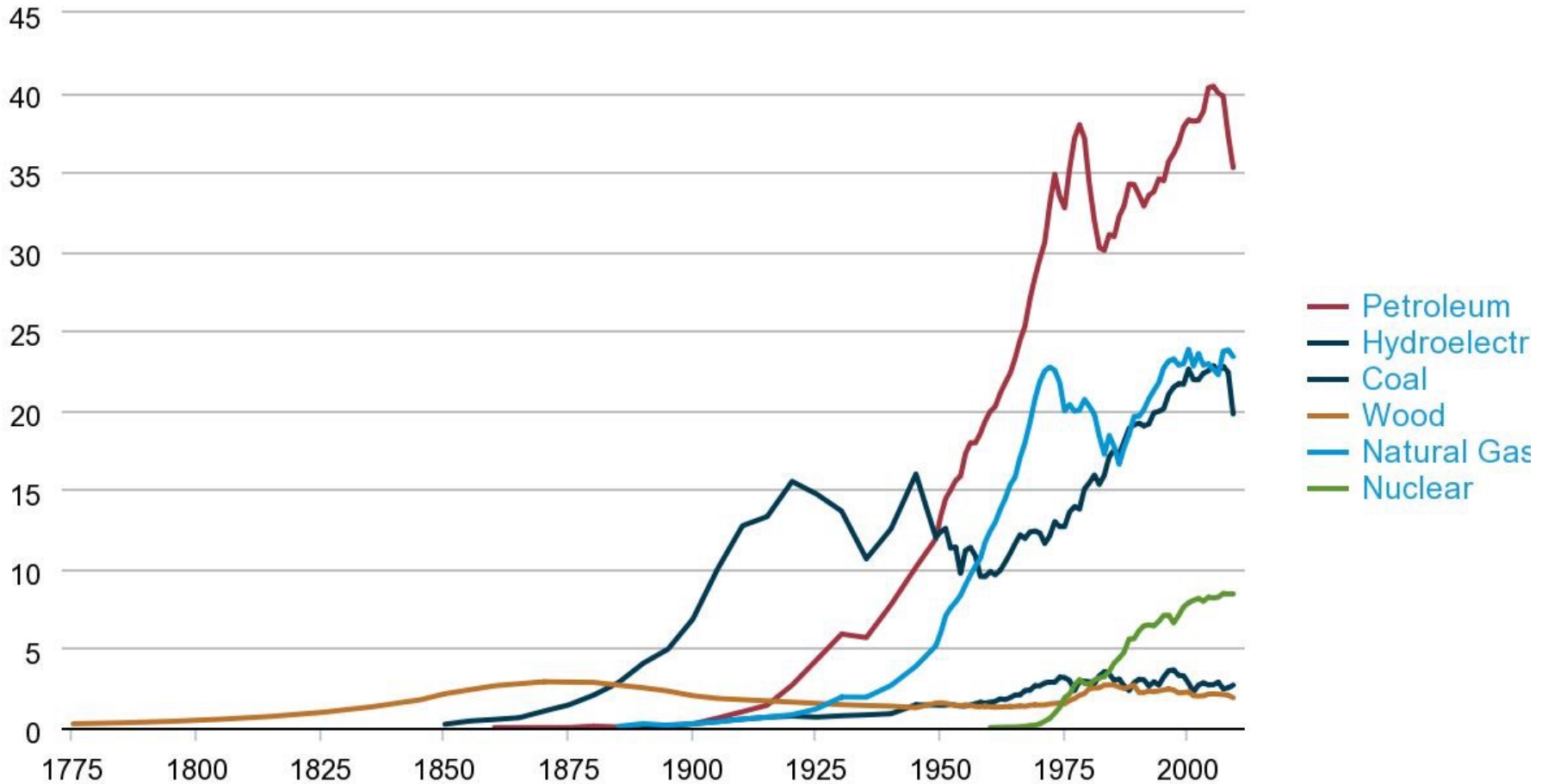
How do we consume energy in buildings?

What are the fuel sources?

History of Energy Consumption in the U.S.

History of energy consumption in the United States, 1775-2009

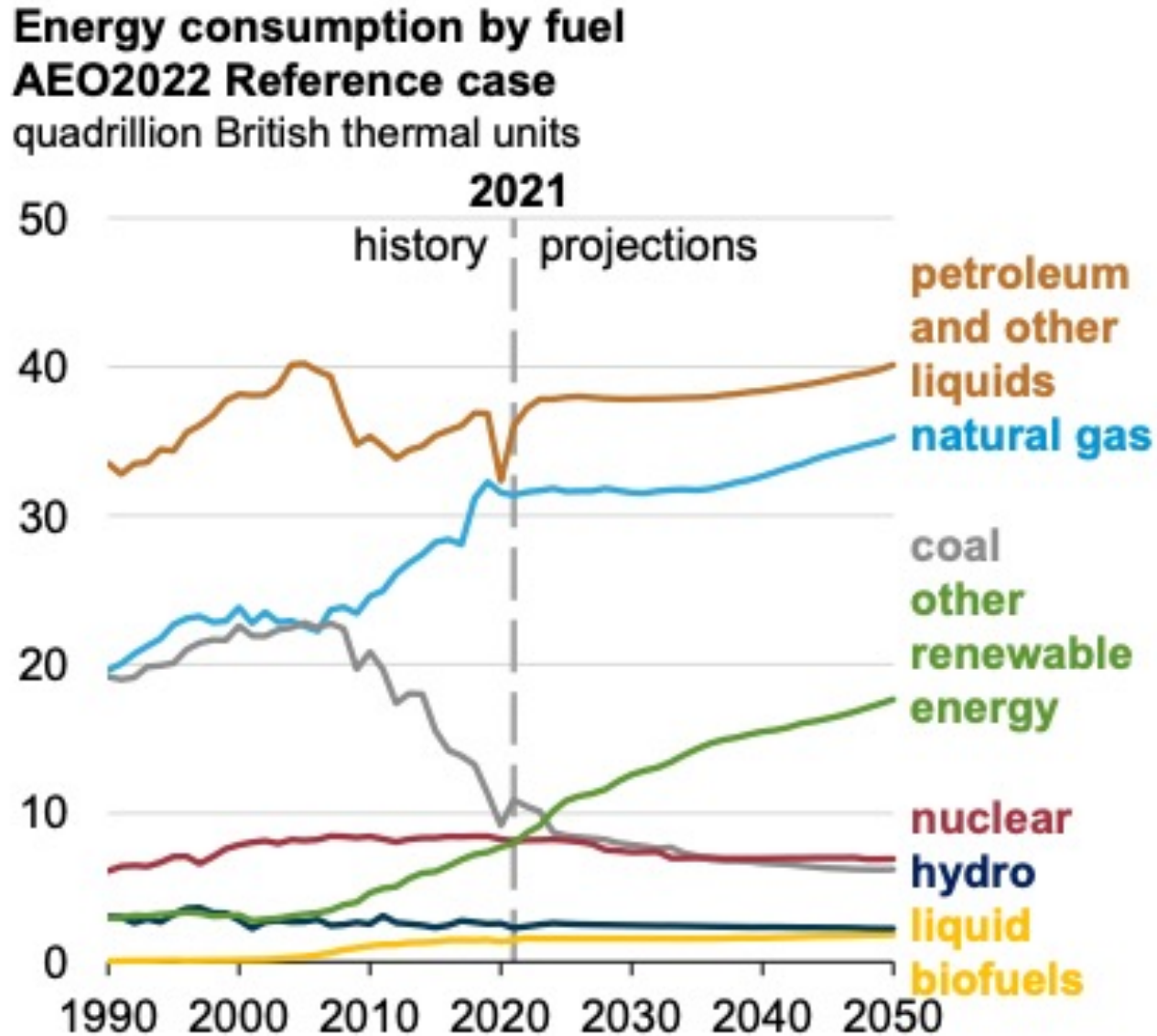
quadrillion Btu



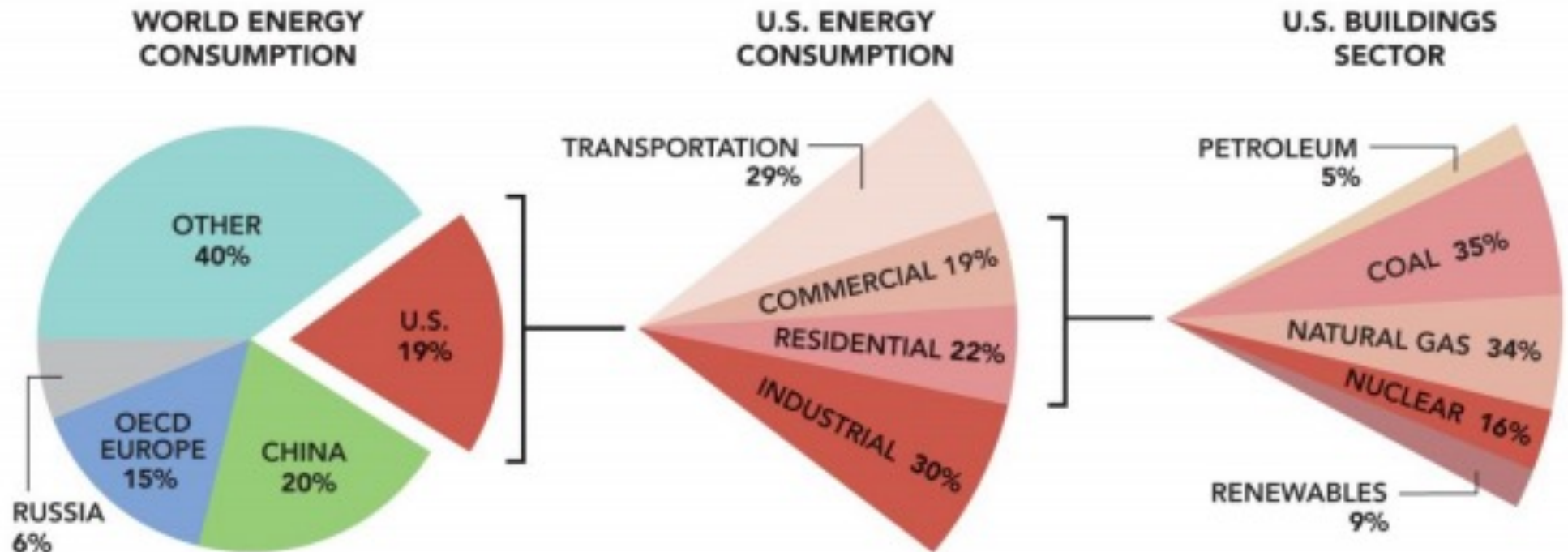
Source: U.S. Energy Information Administration - Annual Energy Review 2009

A quad (or quadrillion) = 10^{15} BTU or 1.055×10^{18} J

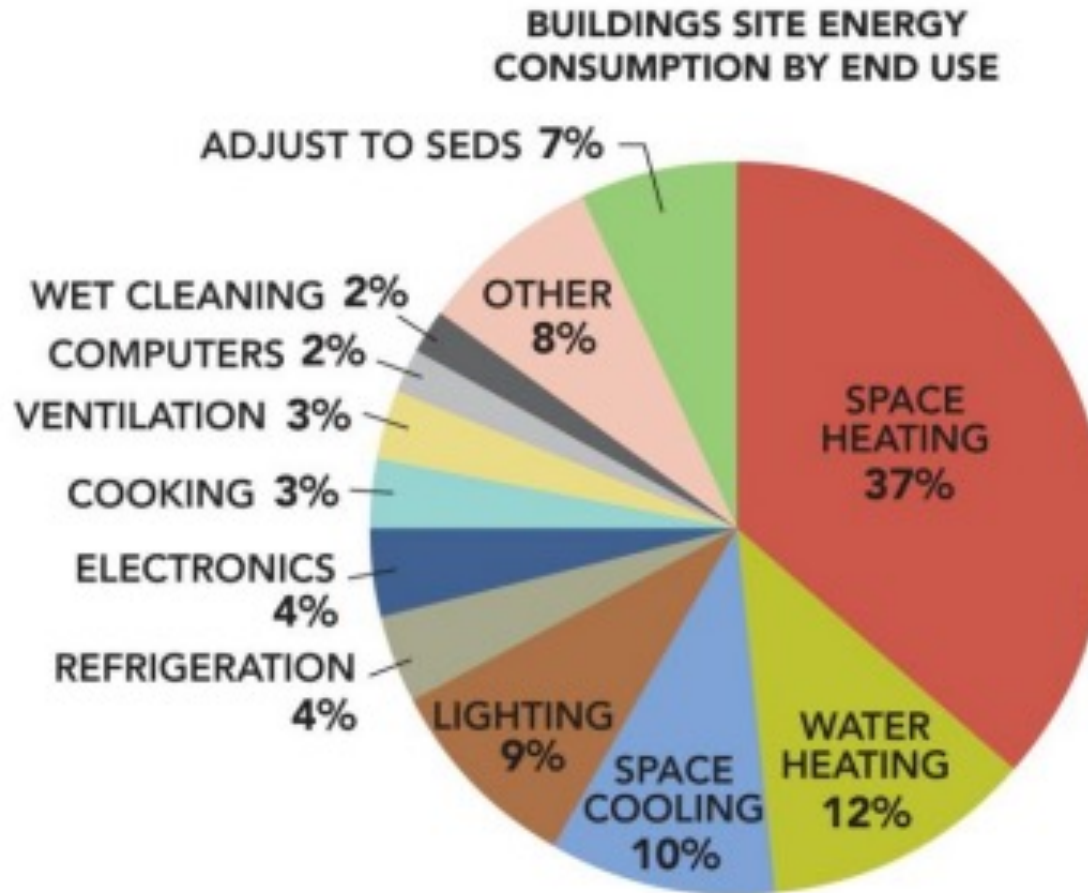
History of Energy Consumption in the U.S.



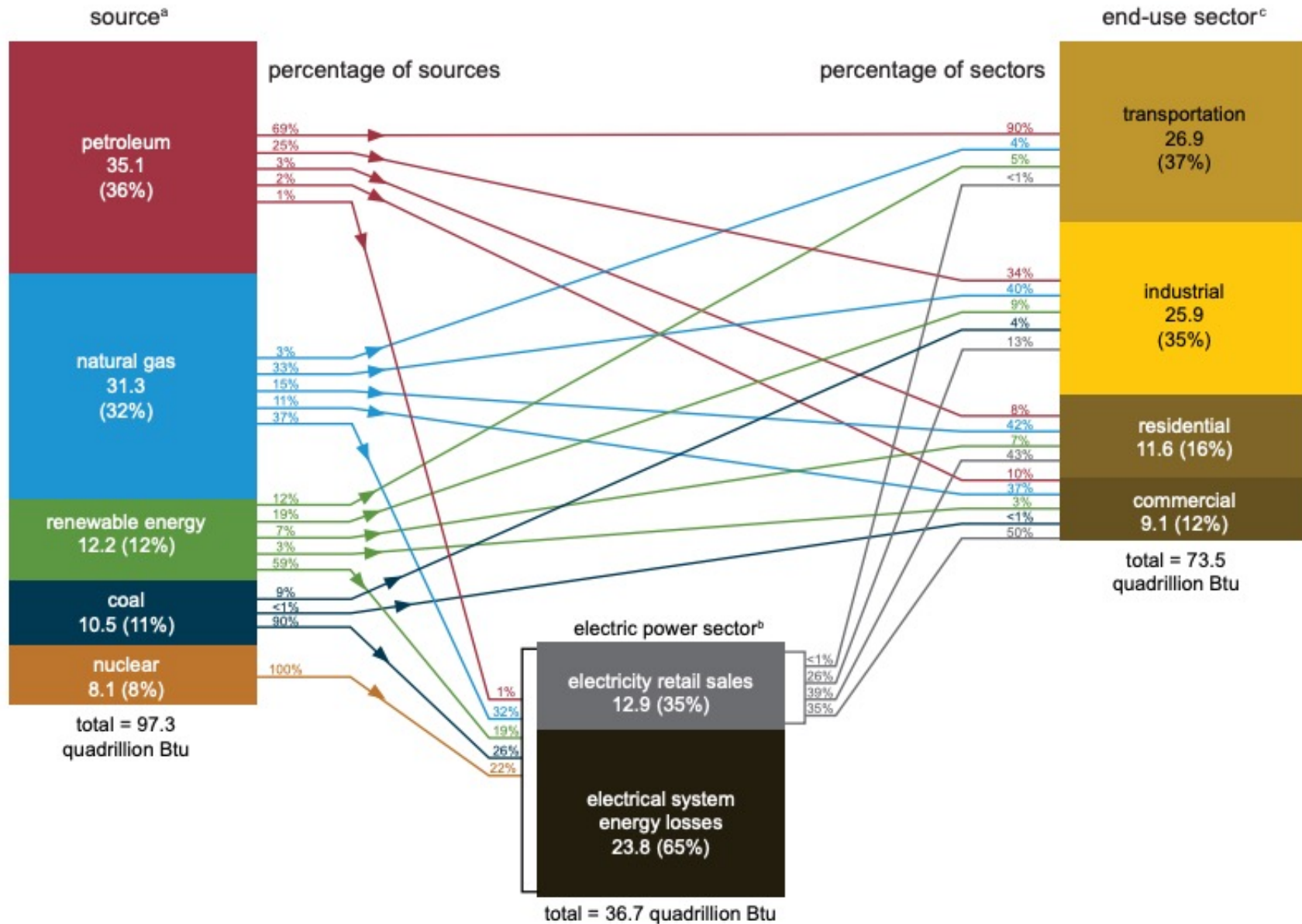
Energy Consumption Percentage



Energy Consumption Percentage



Energy Consumption Percentage



Energy Consumption Percentage

- Scout by the Department of Energy is a good resource to identify future energy projections:

The image shows a web-based energy calculator interface. On the left, there are four steps: 1. Projection Year, 2. Climate Zone, 3. Building Type, and 4. End Use/Technology. Step 4 is currently active. The main area is titled '4. Select end use(s) and technology type(s)'. It features a dropdown menu set to 'All'. Below this are two columns of options: 'Fuel Type' and 'Technology'. The 'Fuel Type' column has five options: All, Electricity, Natural Gas, Other Fuel, and Distillate. The 'Technology' column has four options: All, Air Source Heat Pump (Cooling), Air Source Heat Pump (Electric), and Air Source Heat Pump (Heating). At the bottom left, there is a 'Previous' button. On the right side, a green header reads 'Segment Size'. Below this, the results are displayed: 32.5 Quads (Primary Energy) and 1405 Mt (CO₂ Emissions). At the bottom right, there are 'Reset' and 'Calculate' buttons.

1. Projection Year

2. Climate Zone

3. Building Type

4. End Use/Technology

4. Select end use(s) and technology type(s)

All

Fuel Type

- All
- Electricity
- Natural Gas
- Other Fuel
- Distillate

Technology

- All
- Air Source Heat Pump (Cooling)
- Air Source Heat Pump (Electric)
- Air Source Heat Pump (Heating)

Segment Size

32.5
Quads
(Primary Energy)

1405
Mt
(CO₂ Emissions)

Reset Calculate

← Previous

ENERGY DEFINITIONS

Definition

- Steam typically measured based on volume or heat/energy content:
 - therm
 - British Thermal Unit (BTU)
 - CCF
 - 1 CCF = 100 cubic feet = about 1 therm = 100,000 BTU
 - Pound of steam (klb)
 - Example of conversion factors:
 - 1klb = 1194 kBtu
 - 3.412 kBtu = 1 kWh

Definition

- Chilled water is typically in heat/energy content:
 - Ton-Hr, BTU

$$\dot{Q} = \dot{m}C_p\Delta T = \rho\dot{V}C_p\Delta T$$

- $\rho = 999.78 \text{ kg/m}^3$
- $C_p = 4.19 \text{ kJ/kg-K}$

$$\dot{Q} = \dot{m}C_p\Delta T = \rho\dot{V}C_p\Delta T$$

- $\rho = 61.14 \text{ lb/ft}^3$
- $C_p = 1.00076 \text{ Btu/lb-F}$

$$\frac{(GPM)\Delta T}{24} = Ton$$

Natural Gas

www.peoplesgasdelivery.com

1

Customer Service 866-556-8001
 24-Hour Gas Emergencies 866-556-8002
 En Español 866-556-8003
 TDD Line 866-556-8007

2 Bill Date	06/04/2019	Unit Number	2000000-00001	Next Meter Read Date	06/29/2019	Amount Due	\$60.58	Payment Due Date	06/28/2019
--------------------	------------	-------------	---------------	----------------------	------------	------------	---------	------------------	------------

Customer Name: JOHN Q. CUSTOMER
Service Address: 123 MAIN ST, CHICAGO IL 60601-6207

4

Activity Since Last Bill:

04/29/2019 Previous Balance	\$92.79
05/20/2019 Payment	-\$92.79
Balance	\$0.00
Total Current Charges	\$60.58
Total Current Balance	\$60.58

5

Gas Service: Rate 1 - Small Residential Heating

Meter P9999999: Actual Reading 05/31/2019: 3654, Actual Reading 04/28/2019: -3625, Gas Use: 29 CCF

6

Delivery Charge:		
Customer Charge		\$32.36
Distribution Charge	30.0 Therms at \$0.19477	\$5.84
Storage Service Charge	30.0 Therms at \$0.03280	\$0.98
Gas Charge:	30.0 Therms at \$0.27387	\$8.22
Energy Efficiency Program	30.0 Therms at \$0.01490	\$0.45
Environmental Charge	30.0 Therms at \$0.01940	\$0.58
UEA - Gas Cost Adjustment	2.88% of \$8.22	\$0.24
Volume Balancing Adjustment	30.0 Therms at -\$0.04650	-\$1.40
Tax Cost Adjustment		-\$0.61
Qualified Infrastructure Plant Charge	23.44% of \$36.64	\$8.59
Taxes:		
Chicago Municipal Tax	8.24% of \$55.25	\$4.55
State Tax	0.1% of \$55.25	\$0.06
State Gas Revenue Tax	30.0 Therms at \$0.02400	\$0.72
Subtotal:		\$60.58
Gas Service Total:		\$60.58

Account Summary: Bill Period: 04/29/2019 to 05/27/2019

	May 2018	April 2018
Billing Days	33	30
Avg Daily Temp	44 F	34 F
Heating Deg Days	192	473
Cooling Deg Days	31	4
Therms Used	30.0	73.2
Therms / Day	0.9	2.4

3

Graphs:

Usage by Month:

Charges by Month:

The gas charge is the cost of the gas itself, which is passed directly on to you. The gas charge for May is 27.45 cents per therm and for April was 25.94 cents per therm.

Messages: You can view your bills online by enrolling in the My Account section of our website.

ACCOUNT NUMBER: 0602000000-0001

INVOICE: 1234567899

Page 1 of 1

WEG_PDF_Out 17 (0)

PEOPLES GAS NATURAL GAS DELIVERY

Please return this stub with your payment.

ACCOUNT NUMBER: 0602000000-0001

7

JOHN Q. CUSTOMER
 123 MAIN ST
 CHICAGO IL 60601-6207

8

Amount Due By	06/28/2019	\$60.58
A 1.5% late fee is charged on any unpaid balance.		
Please write your account number on your check.		
Amount Enclosed		
<input style="width: 100%; height: 20px;" type="text"/>		

I want to pledge \$1 per month to the Share the Warmth program, which helps pay energy expenses for those in need. I've added \$1 to my payment.

9

Peoples Gas
 PO Box 2968
 Milwaukee, WI 53201-2968

0150602912365000048 1000003610

https://accel.peoplesgasdelivery.com/home/reading_bill.aspx

43

Natural Gas



nicorgas.com/myaccount
1 888 Nicor4U 1 888 642-6748

Account Summary for John Doe **A**

Account Number: 08-88-88-8888 8	
Meter Number: 88888888	
Service Address: 123 Main Ave	
Bill Period: 10/26/15 - 11/23/15 (28 days)	
Bill Issue Date: 11/23/15	
Total Previous Balance (Credit)	-\$9.12
Payment Received 11/17/2015 - Thank you!	-\$37.00
Remaining Balance (Credit)	-\$46.12
New Charges - Utility	\$36.42
Total Amount Due	\$0.00
Your Account Balance is (Credit)	-\$9.70

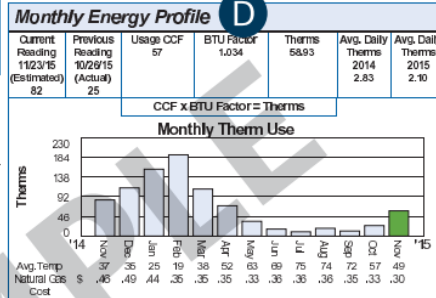
A Message for You **B**

Do you or anyone you know need assistance paying their utility bill? Funds are still available from the Low Income Energy Assistance Program (LI-EAP). Please visit liheapillinois.com or call 1-877-411-9276 for more information.

As you requested, your monthly Budget Plan payment and any applicable charges for additional services requested will be withdrawn automatically from your account on the due date of this bill.

New Charges - Residential - Heat **C**
Rate 1: Residential Service

Delivery Charges 10/26/2015 - 11/22/2015	\$16.92
Monthly Customer Charge	\$13.00
All Therms 58.93 @ \$0.0485	\$2.86
Environmental Cost Recovery 58.93 @ \$-0.0006 =	-\$0.04
Franchise Cost Adjustment	\$0.30
Efficiency Program 58.93 @ \$0.0043	\$0.25
Qualified Infrastructure Chrg \$ 3.28 @ 3.54%	\$0.12
Qualified Infrastructure Chrg \$ 12.04 @ 3.57%	\$0.43
Natural Gas Cost	\$18.06
October @ 12.63 Therms x \$0.33	\$4.17
November @ 46.30 Therms x \$0.30	\$13.89
Taxes	\$1.44
Utility Fund Tax \$34.98 @ 0.1%	\$0.03
State Revenue Tax 58.93 @ \$0.024 =	\$1.41
Total	\$36.42



FRF Please see the reverse side of this bill for additional billing explanations.



PO Box 2020
Aurora, IL 60507-2020

Receipt of Electronic Payment

----- manifest line -----

John Doe
123 Main Ave
Chicago IL 00000-0000

Account Number:
088888888 8

Due to your balance, \$0.00
will be withdrawn from your
account.

Thank you.

08 61 95 5690 8 0000000000 0000037002 922

Natural Gas

Budget Plan Update

Your budget plan balance is -\$53.55 (CR).

Your monthly budget plan amount is \$159.00.

Your re-calculation month is APR.

See reverse side of bill for more information.

Account: 11111111111

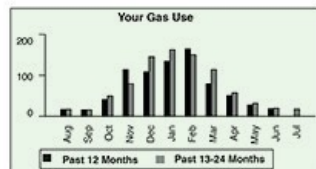
CUSTOMER NAME

Service Address: CUSTOMER ADDRESS



Billing date	Jul 7, 2015	
Previous balance		\$159.00
Payments received - Thank you		159.00 CR
Adjustments		159.00
Current charges		<u>159.00</u>
▶ Total due Jul 22, 2015		\$159.00

Your budget payment of \$159.00 will be paid by your financial institution Jul 22, 2015. Your budget plan balance will be \$0.00 after payment due is received.



	This Month	Last Year
Billing units:	0	18
Use per day:	0.0	0.6
Average cost per day:	\$0.00	\$0.85
Number of days in billing cycle:	0	31



	This Month	Last Year
Billing units:	0	10
Use per day:	0.0	0.3
Average cost per day:	\$0.00	\$0.76
Number of days in billing cycle:	0	31

DID YOU KNOW?

The District provides billing services for other municipalities (sewer, trash) as a cost-saving measure for all customers.

M.U.D. GAS RESIDENTIAL RATE A: Jun 4 to Jul 7

Meter Number 123456
 Current read (actual): 5820 - Previous read (actual): 5803 = 17 CCF
 Gas Use 17 CCF x 1.068 (heat value) = 18.156 therms
 13.884 therms at 0.4539 = \$6.30
 4.272 therms at 0.4474 = 1.91
 Service Charge 14.00
 Gas Cost \$22.21
 Gas Infrastructure Replacement 3.00



M.U.D. WATER RESIDENTIAL RATE: W-1 Jun 4 to Jul 7

Meter Number 12345678 Size 5/8 -inch
 Current read (actual): 2119 - Previous read (actual): 2108 = 11 CCF
 Water Use: 11,000 CCF or 8,228 gallons
 9,000 CCF at 1.1853 = \$10.67
 2,000 CCF at 1.6594 = 3.32
 Service Charge 12.52
 Water Cost \$26.51
 Water Infrastructure Replacement 4.00

CITY OF OMAHA SEWER 42.83

OTHER CHARGES

Sales Tax 6.90
 ▶ Current Charges \$105.45

Please return this portion of the bill with payment. Please do not staple payment to bill.

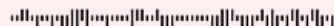
e-mail: customer_service@mudomaha.com
 website: www.mudomaha.com



METROPOLITAN UTILITIES DISTRICT

6850 0010 MR RP 13 01132015 YHANNY 01 999419 0002
 1723 Harney St • Omaha, NE 68102

JOE SMITH
 123 MAIN STREET
 ANYTOWN ST 12345-6789



- Apply \$ _____ to my budget plan balance.
- Check box and indicate change of mailing address or telephone numbers on the reverse side.

Please give to the Heat Aid Fund by checking a box below.

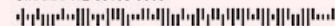
Monthly donation -- Add: \$2 \$3 \$5 Other \$ _____

Due on or before Jul 22: \$159.00

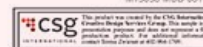
Your budget payment of \$159.00 is due Jul 22.

Amount Paid: _____

METROPOLITAN UTILITIES DISTRICT
 PO BOX 3600
 OMAHA NE 68103-0600



M15056 MUOD 081135



Natural Gas

- Where do we get the cost of natural gas?

North Shore Gas Historical Gas Charge Rates per therm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2022	\$0.5582	\$0.5931	\$0.6345	\$0.6554	\$1.0233	\$1.0998	\$1.0290	\$0.9531				
2021	\$0.3934	\$0.3833	\$0.4068	\$0.4161	\$0.4407	\$0.4725	\$0.5185	\$0.5184	\$0.5794	\$0.6719	\$0.6844	\$0.6093
2020	\$0.3158	\$0.3059	\$0.2731	\$0.2681	\$0.2679	\$0.2926	\$0.2873	\$0.2846	\$0.3125	\$0.3517	\$0.3874	\$0.3752
2019	\$0.4834	\$0.4470	\$0.3396	\$0.3322	\$0.3444	\$0.3349	\$0.3002	\$0.3040	\$0.3045	\$0.3245	\$0.3224	\$0.3333
2018	\$0.4152	\$0.4166	\$0.3676	\$0.3882	\$0.3747	\$0.3537	\$0.3502	\$0.3501	\$0.3478	\$0.3561	\$0.3815	\$0.4473
2017	\$0.4875	\$0.4878	\$0.4465	\$0.3959	\$0.3988	\$0.4057	\$0.4120	\$0.4130	\$0.4068	\$0.4012	\$0.3991	\$0.4447
2016	\$0.3462	\$0.3830	\$0.3377	\$0.3209	\$0.3175	\$0.3355	\$0.3246	\$0.3571	\$0.4086	\$0.4031	\$0.3115	\$0.4352
2015	\$0.4966	\$0.4431	\$0.4418	\$0.4064	\$0.3839	\$0.3909	\$0.4087	\$0.4224	\$0.4407	\$0.4048	\$0.3758	\$0.3585
2014	\$0.5200	\$0.5675	\$0.8816	\$1.2151	\$0.9199	\$0.8468	\$0.8307	\$0.7817	\$0.6889	\$0.5583	\$0.5193	\$0.5892
2013	\$0.4557	\$0.4536	\$0.4310	\$0.4717	\$0.5138	\$0.5387	\$0.5757	\$0.5882	\$0.4865	\$0.4890	\$0.4901	\$0.4790

Peoples Gas Historical Gas Charge Rates per therm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2022	\$0.5546	\$0.5958	\$0.6008	\$0.6125	\$0.9924	\$1.1773	\$1.2515	\$1.1236				
2021	\$0.2887	\$0.2940	\$0.3219	\$0.4633	\$0.5323	\$0.5770	\$0.6277	\$0.6524	\$0.6617	\$0.7256	\$0.7387	\$0.6814
2020	\$0.2901	\$0.2709	\$0.2178	\$0.1788	\$0.1789	\$0.1985	\$0.2057	\$0.2030	\$0.2289	\$0.2431	\$0.2795	\$0.2691
2019	\$0.4224	\$0.3460	\$0.2653	\$0.2594	\$0.2748	\$0.3200	\$0.2982	\$0.2933	\$0.2734	\$0.2826	\$0.2758	\$0.2922
2018	\$0.3296	\$0.3241	\$0.3228	\$0.3066	\$0.3065	\$0.3099	\$0.3169	\$0.3642	\$0.3577	\$0.3108	\$0.3471	\$0.4549
2017	\$0.3904	\$0.4182	\$0.3965	\$0.3628	\$0.3696	\$0.3846	\$0.4001	\$0.3758	\$0.3601	\$0.3421	\$0.3381	\$0.4032
2016	\$0.2695	\$0.2953	\$0.2808	\$0.2463	\$0.2393	\$0.2475	\$0.2702	\$0.2958	\$0.3492	\$0.3606	\$0.3238	\$0.3889
2015	\$0.3976	\$0.3141	\$0.3729	\$0.3534	\$0.3468	\$0.3418	\$0.3597	\$0.3904	\$0.3925	\$0.3641	\$0.3332	\$0.3000
2014	\$0.4773	\$0.5183	\$0.9336	\$1.1915	\$0.8458	\$0.8103	\$0.8627	\$0.7511	\$0.6913	\$0.4873	\$0.5160	\$0.5792
2013	\$0.4110	\$0.4097	\$0.3922	\$0.4286	\$0.4692	\$0.5130	\$0.5490	\$0.5552	\$0.5509	\$0.4735	\$0.4499	\$0.4437

Natural Gas

- Where do we get the cost of natural gas?

The screenshot shows the EIA website header with the logo and navigation menu. Below the header, the title 'NATURAL GAS' is displayed. A navigation bar contains three tabs: 'OVERVIEW', 'DATA', and 'ANALYSIS & PROJECTIONS'. The 'DATA' tab is currently selected.

Natural Gas Prices

(Dollars per Thousand Cubic Feet, except where noted)

Area: Period:

Download Series History Definitions, Sources & Notes		Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	View History
Show Data By: <input checked="" type="radio"/> Data Series <input type="radio"/> Area	<input type="button" value="Graph"/> <input type="button" value="Clear"/>							
Citygate Price	<input type="checkbox"/>	5.47	4.89	5.35	6.22	NA	NA	1989-2022
Residential Price	<input type="checkbox"/>	12.09	10.21	10.05	11.79	12.57	19.15	1989-2022
Percentage of Total Residential Deliveries included in Prices	<input type="checkbox"/>	90.0	91.5	89.2	88.4	87.1	85.4	2002-2022
Commercial Price	<input type="checkbox"/>	10.93	9.27	9.10	10.36	11.76	16.83	1989-2022
Percentage of Total Commercial Deliveries included in Prices	<input type="checkbox"/>	36.6	43.4	39.3	37.3	32.3	25.7	1989-2022
Industrial Price	<input type="checkbox"/>	NA	NA	7.34	7.95	7.81	9.21	2001-2022
Percentage of Total Industrial Deliveries included in Prices	<input type="checkbox"/>	NA	NA	12.5	12.3	12.4	8.6	2001-2022
Electric Power Price	<input type="checkbox"/>	W	W	W	W	W	8.28	2002-2022

Click on the source key icon to learn how to download series into Excel, or to embed a chart or map on your website.

-- = No Data Reported; - = Not Applicable; NA = Not Available; W = Withheld to avoid disclosure of individual company data.

Notes: Prices are in nominal dollars. Gas volumes delivered for use as vehicle fuel are included in the State annual totals through 2009 but not in the State monthly components. Through 2001, electric power price data are for regulated electric utilities only; beginning in 2002, data also include nonregulated members of the electric power sector. Gas volumes delivered for use as vehicle fuel are included in the State annual totals through 2009 but not in the State monthly components. Estimates of gas volumes delivered for use as vehicle fuel are included in the State monthly totals for January 2010 forward. Preliminary electric power data for 2016 are shown as of the September 2017 Electric Power Monthly. They will not reflect revisions made in the 2016 Electric Power Annual, which was published after the 2016 Natural Gas Annual was released. Revised electric power data for 2016 will not be adjusted in the Natural Gas Monthly until the 2017 Natural Gas Annual is published. See Definitions, Sources, and Notes link above for more information on this table.

Release Date: 7/29/2022

Next Release Date: 8/31/2022

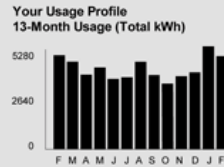
Definition

- Electricity
 - Power = kW
 - Energy consumed = kWh
 - Relationship = kW × Time = kWh

Electricity



comed.com
Customer Service / Power Outage
 English
 1-877-4COMED1 (1-877-426-6331)
 Español
 1-800-95-LUCES (1-800-955-8237)
 Hearing/Speech Impaired
 1-800-572-5789 (TTY)
 For Electric Supply Choices visit
 pluginillinois.org



Electric Usage

Month	kWh
Feb-15	4680
Mar-15	4440
Apr-15	3720
May-15	3960
Jun-15	3600
Jul-15	3840
Aug-15	4560
Sep-15	3960
Oct-15	3840
Nov-15	4080
Dec-15	4200
Jan-15	5280
Feb-15	4800

Average Daily

Month Billed	kWh	Temp
Last Year	156.0	27
Last Month	155.3	37
Current Month	160.0	27

Page 1 of 2

Account Number 000000000
 Name CUSTOMER NAME
 Service Location SERVICE ADDRESS CITY
 Phone Number 000-000-0000

Issue Date February 11, 2016

Bill Summary

Previous Balance	\$503.36
Total Payments - Thank You	\$503.36
Amount Due on February 26, 2016	\$485.86

Meter Information

Read Date	Meter Number	Load Type	Reading Type	Previous	Meter Reading Present	Difference	Multiplier X	Usage
1/12-2/11	000000000	General Service	Total kWh	513 Actual	553 Actual	40	120	4800
1/12-2/11	000000001	General Service	kW	1.11 Actual	1.19 Actual	0.08	120	9.60

Service from 1/12/2016 to 2/11/2016 - 30 Days **Commercial Demand - 0 to 100 kW**

Electricity Supply Services \$310.90

Electricity Supply Charge	4,800 kWh	X	0.05857	281.14
Transmission Services Charge	4,800 kWh	X	0.01095	52.56
Purchased Electricity Adjustment				-22.80

Delivery Services - ComEd \$94.54

Customer Charge				17.31
Standard Metering Charge				12.38
Distribution Facilities Charge	9.60 kW	X	6.18000	59.33
IL Electricity Distribution Charge	4,800 kWh	X	0.00115	5.52

Taxes and Other \$80.42

Environmental Cost Recovery Adj	4,800 kWh	X	0.00038	1.82
Renewable Portfolio Standard	4,800 kWh	X	0.00189	9.07
Zero Emission Standard	4,800 kWh	X	0.00195	9.36
Energy Efficiency Programs	4,800 kWh	X	0.00434	20.83
Franchise Cost	\$89.24	X	2.18900%	1.95
State Tax				15.53

(continued on next page)

Return only this portion with your check made payable to ComEd. Please write your account number on your check.



To pay by phone call 1-800-588-9477.
 A convenience fee will apply.



CUSTOMER NAME
 ADDRESS 1
 ADDRESS 2
 CITY, ST ZIP

Account Number
0000000000

Payment Amount



Please pay this amount by 2/26/2016

\$485.86

COMED
 PO BOX 6111
 CAROL STREAM, IL 60197-6111



Source vs. Site Energy

- Site energy or secondary energy is the energy consumed at the building site (e.g., electricity, steam, CHW)
- Source energy represents the raw amount of fuel, primary energy, that is required to operate the building (e.g., natural gas, fuel oil)
- Benefits of using of source energy:
 - Reduce likelihood of unintentionally penalized of one energy fuel type
 - Correlate more with the energy cost and impact on the climate
- Site energy also provides insights for the building energy use

Source vs. Site Energy

- There are conversion factors (source-to-site ratios) to convert the secondary energy to primary energy based on the location and fuel type
- The commonly accepted global conversion factors are presented by EPA:

Fuel Type	Source-to-Site Ratio	
	US	Canadian
Electricity (grid purchase)	2.8	1.96
Electricity (on-site solar or wind energy)	1.0	1.0
Natural Gas	1.05	1.01
Steam	1.20	1.33
Chilled Water	0.91	0.57

Energy Utilization Index

- Total energy use: HVAC and Non-HVAC
 - ❑ HVAC includes heating, cooling, fan, pump
 - ❑ Non-HVAC includes, Service Hot Water (SHW), lighting, receptacles, elevators, process
- EUI: Energy use intensity (kBtu/ft²):

$$EUI = \frac{\textit{Energy Use}}{\textit{Building Area}}$$

CLASS ACTIVITY

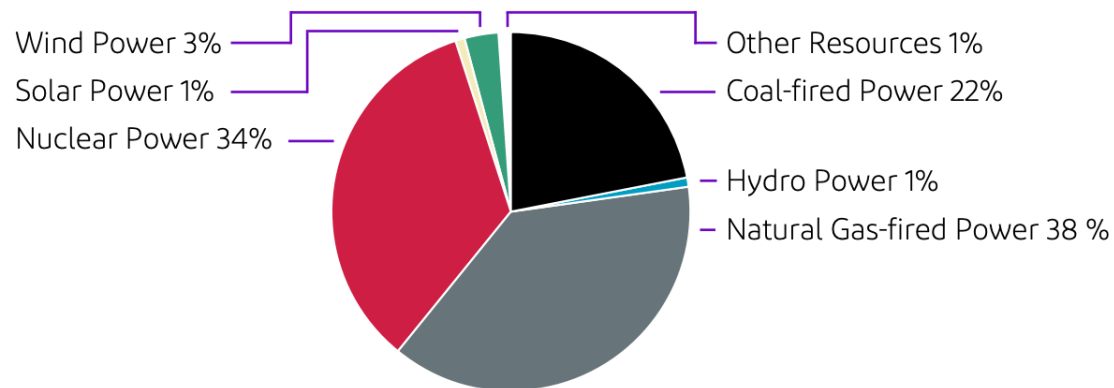
Class Activity

- What happens if we electrify all buildings right now in IL?

Class Activity

- Anything else?

Sources of Electricity for the 12 months ending December 31, 2021



Sources ¹ of Electricity Supplied for the 12 Months Ending December 31, 2021	% of Total
BIOMASS POWER	0%
COAL-FIRED POWER	22%
HYDRO POWER	1%
NATURAL GAS-FIRED POWER	38%
NUCLEAR POWER	34%
OIL-FIRED POWER	0%
SOLAR POWER	1%
WIND POWER	3%
OTHER RESOURCES	1%
UNKNOWN RESOURCES PURCHASED FROM OTHER COMPANIES	0%
TOTAL	100%

COMMERCIAL BUILDING ENERGY CONSUMPTION SURVEY (CBECS)

CBECS

- CBECS is a national sample survey:
 - ❑ Collect information on the stock of U.S. commercial buildings.
The scope is:
 - All buildings that at least half of the floorspace is used for a purpose that is not residential, industrial, or agricultural
 - Schools, hospitals, correctional institutions, and religious worship buildings
 - Traditional commercial buildings such as stores, restaurants, warehouses, and office buildings
 - ❑ Include information on:
 - Energy-related building characteristics
 - Energy usage data (consumption and expenditures)

CBECS

CONSUMPTION & EFFICIENCY

COMMERCIAL BUILDINGS ENERGY CONSUMPTION SURVEY (CBECS)

OVERVIEW

DATA ▾

ANALYSIS & PROJECTIONS

GLOSSARY ›

FAQS ›

2018 Commercial Buildings Energy Consumption Survey building characteristics results



Newly released data tables from the 2018 Commercial Buildings Energy Consumption Survey (CBECS) provide building characteristics information for the estimated 5.9 million U.S. commercial buildings in 2018. Building characteristics data tables include number of workers, ownership and occupancy, structural characteristics, energy sources and uses, energy related building features, and more.

[Data Tables](#)

Report  [PDF](#)  [PPT](#)

CBECS Status

[Background Information](#)

[About the CBECS](#)

[CBECS Survey Forms](#)

[CBECS Maps](#)

[CBECS Terminology](#)

[Survey Background & Technical Information](#)

[Building Type Definitions](#)

[Archived Reports](#)

CBECS

CONSUMPTION & EFFICIENCY

COMMERCIAL BUILDINGS ENERGY CONSUMPTION SURVEY (CBECS)

OVERVIEW DATA ANALYSIS & PROJECTIONS GLOSSARY FAQs

2018 Commercial Buildings Energy Consumption Survey Building Characteristics results

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[Data Tables](#)
[Report](#) [PDF](#) [PPT](#)

CBECS Status

Background Information

- [About the CBECS](#)
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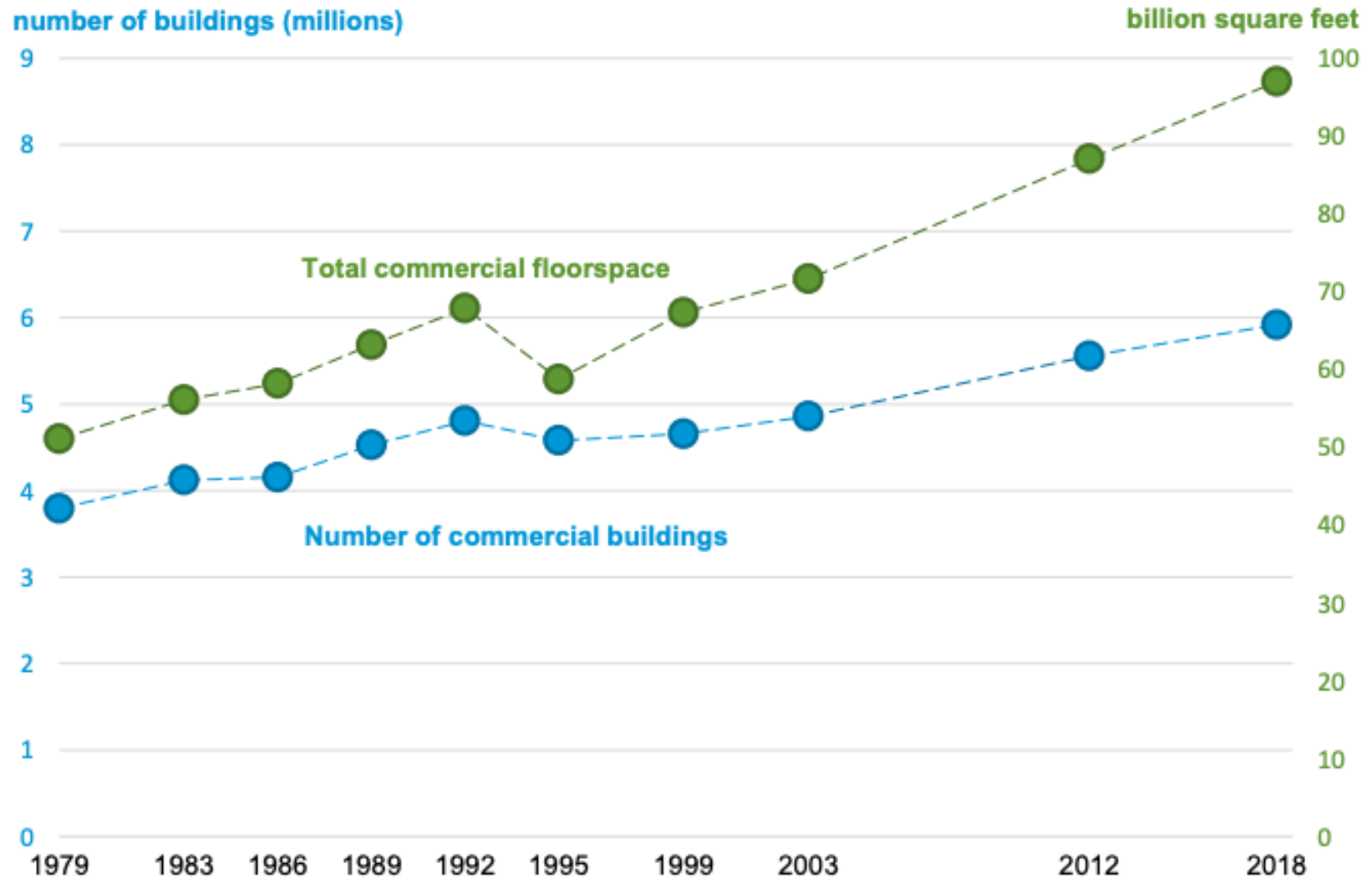
CBECS

Release date: September 2021

Table B11. Selected principal building activity: part 1, number of buildings, 2018

	Number of buildings (thousand)							
	Principal building activity							
	All buildings	Warehouse and storage	Office	Service	Mercantile	Public assembly	Religious worship	Education
All buildings	5,918	1,004	970	867	518	488	439	438
Building floorspace (square feet)								
1,001 to 5,000	2,837	444	518	515	181	215	169	148
5,001 to 10,000	1,358	249	198	218	107	115	100	98
10,001 to 25,000	966	194	135	96	142	95	118	62
25,001 to 50,000	397	60	54	28	47	43	42	40
50,001 to 100,000	218	33	35	9	23	14	8	57
100,001 to 200,000	93	15	17	Q	13	3	Q	25
200,001 to 500,000	40	8	9	Q	5	1	Q	7
Over 500,000	9	2	2	Q	1	1	N	0
Year constructed								
Before 1920	329	Q	85	Q	Q	64	57	Q
1920 to 1945	379	22	78	57	Q	40	Q	22
1946 to 1959	517	113	54	68	48	33	44	66
1960 to 1969	685	68	82	135	96	61	59	51
1970 to 1979	831	121	159	143	65	63	74	59
1980 to 1989	794	150	164	108	63	35	34	55
1990 to 1999	921	235	130	125	49	70	58	86
2000 to 2009	924	162	152	139	100	78	55	60
2010 to 2018	537	117	67	82	52	43	Q	26

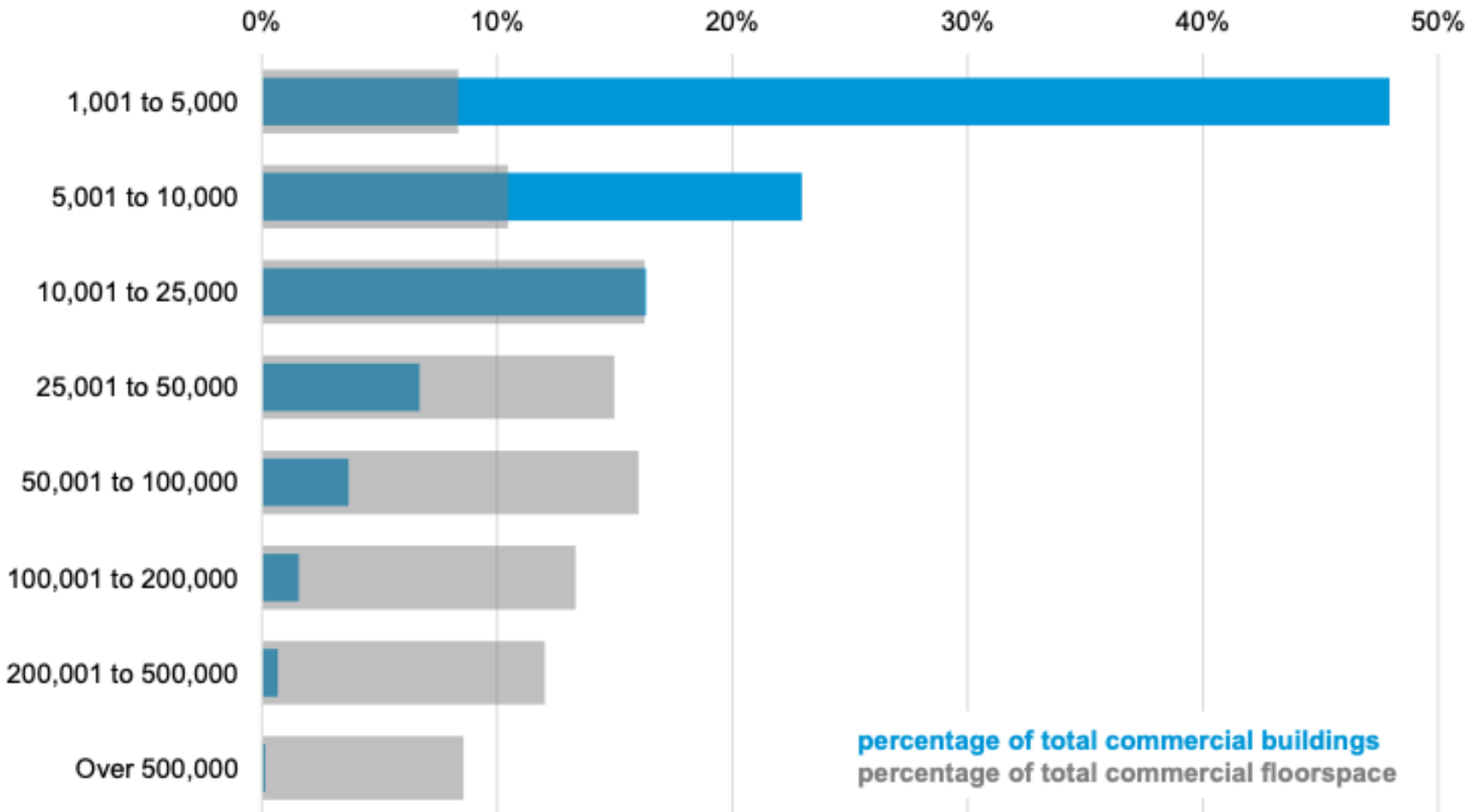
CBECS



What do you see here?

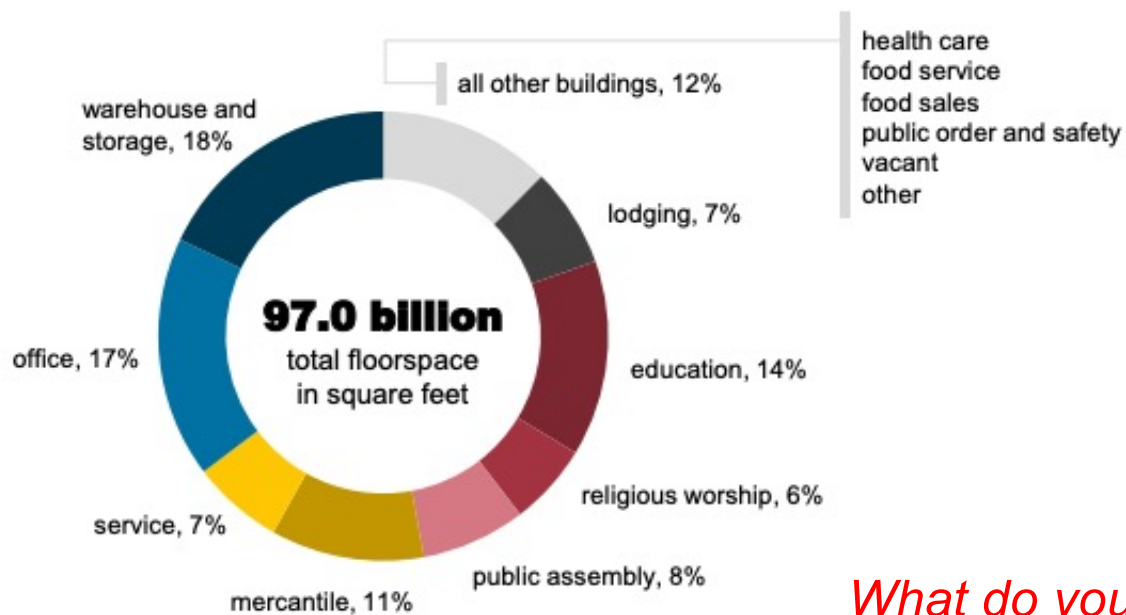
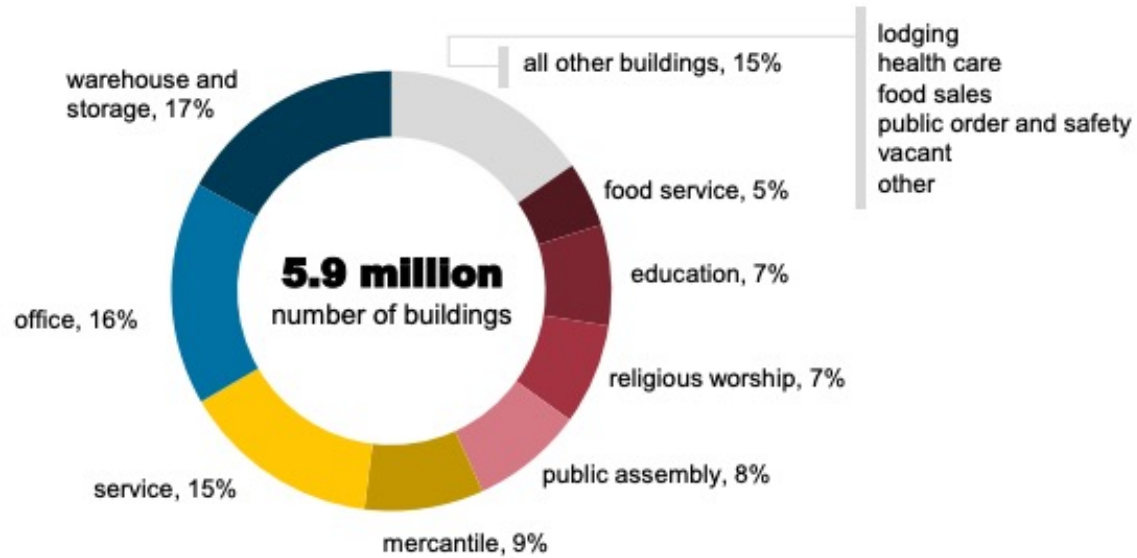
CBECS

Total commercial buildings and floorspace by square footage category percentage



What do you see here?

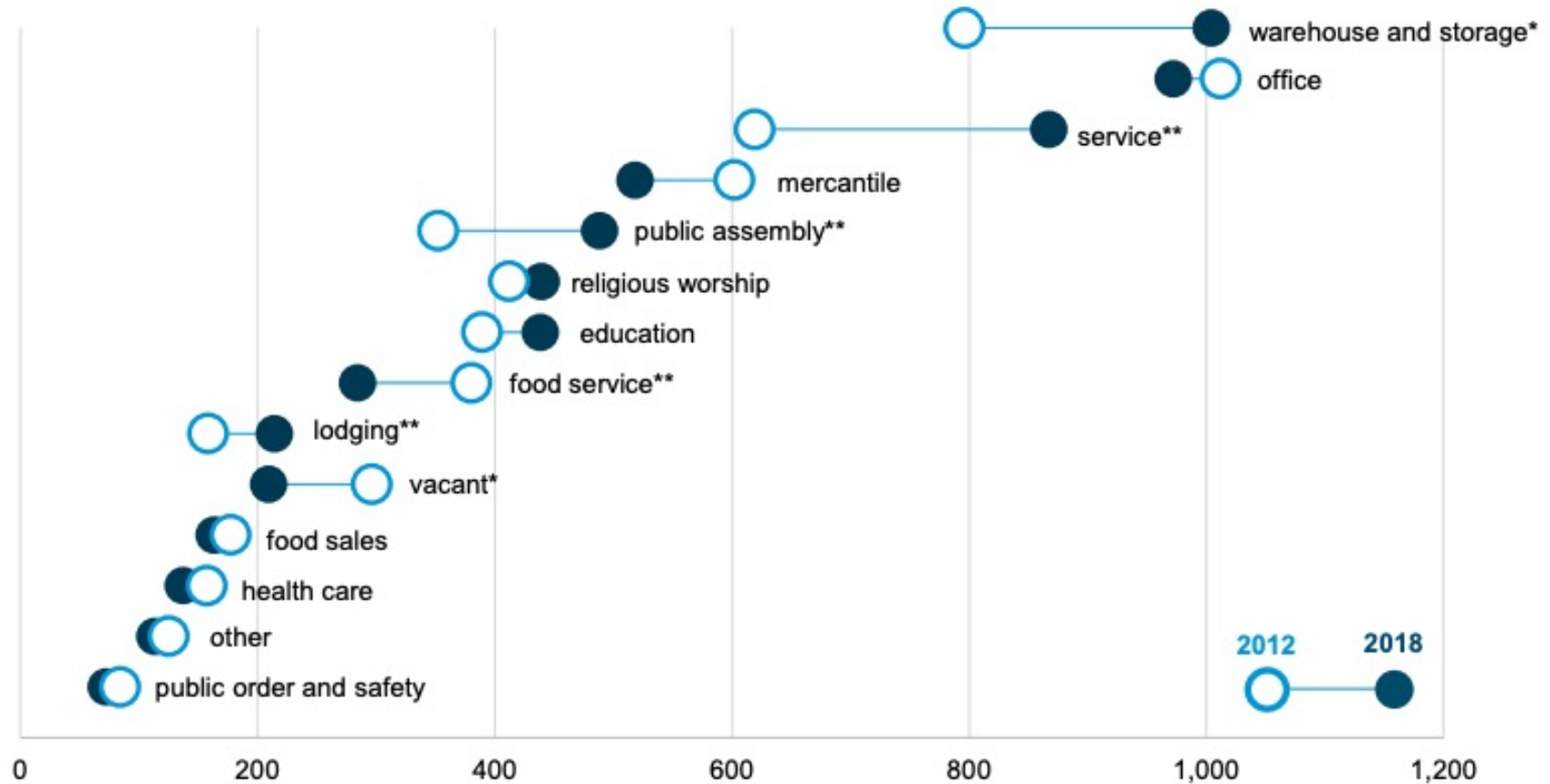
CBECS



What do you see here?

CBECS

Number of commercial buildings by principal building activity
thousands



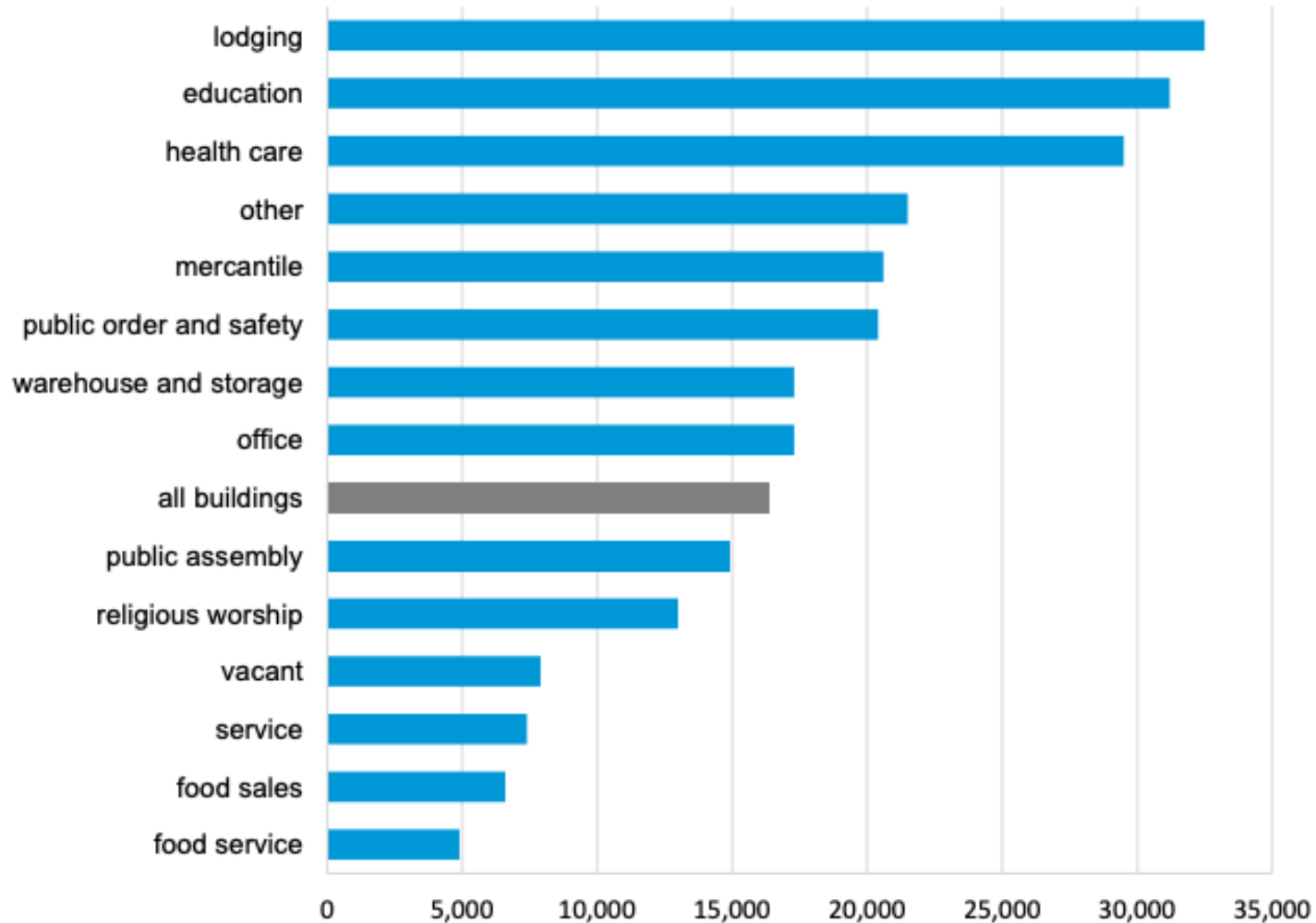
* Change is statistically significant at the 90% confidence level.

** Change is statistically significant at the 90% and 95% confidence levels.

What do you see here?

CBECS

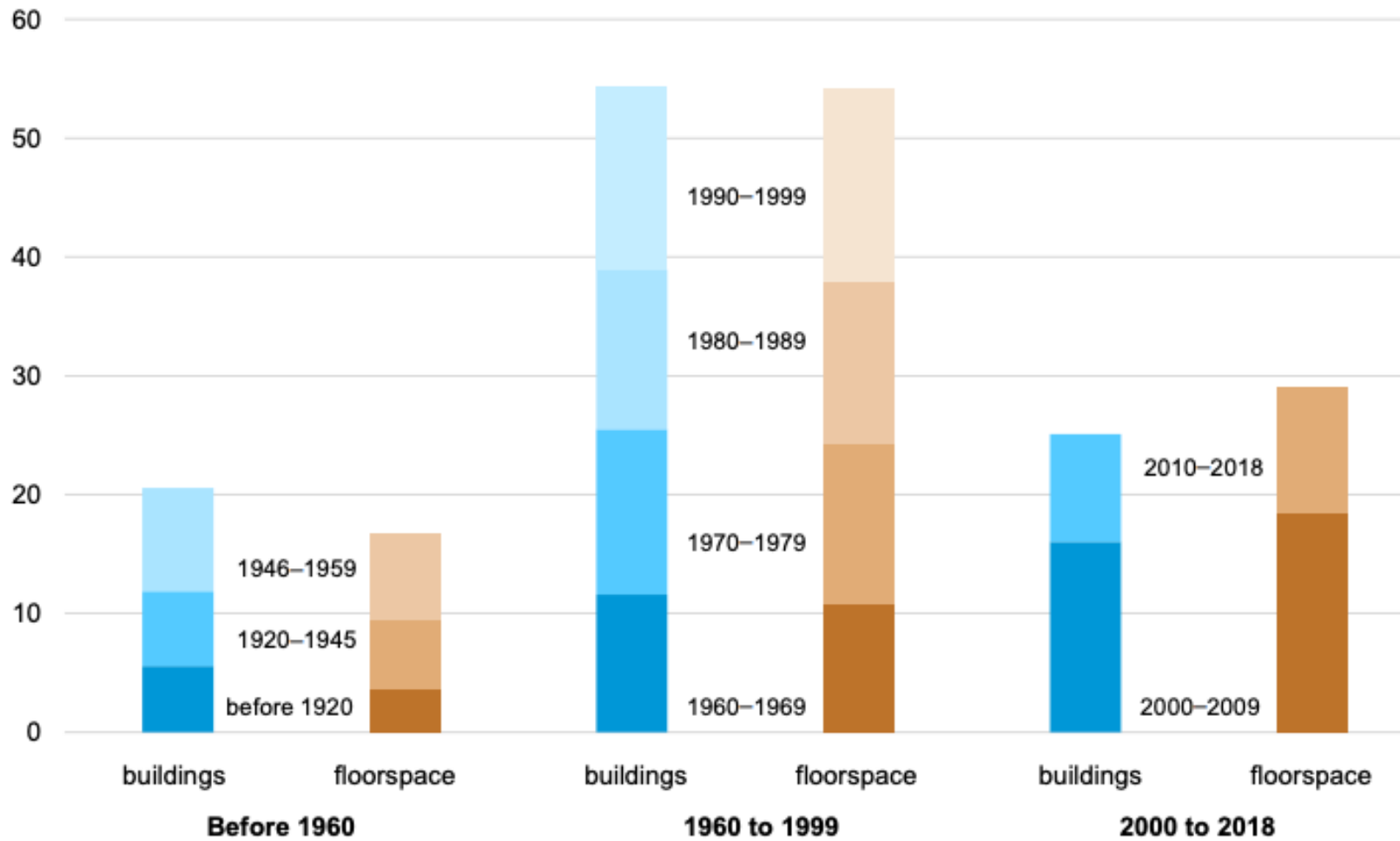
Average floorspace by principal building activity
square feet per building



What do you see here?

CBECS

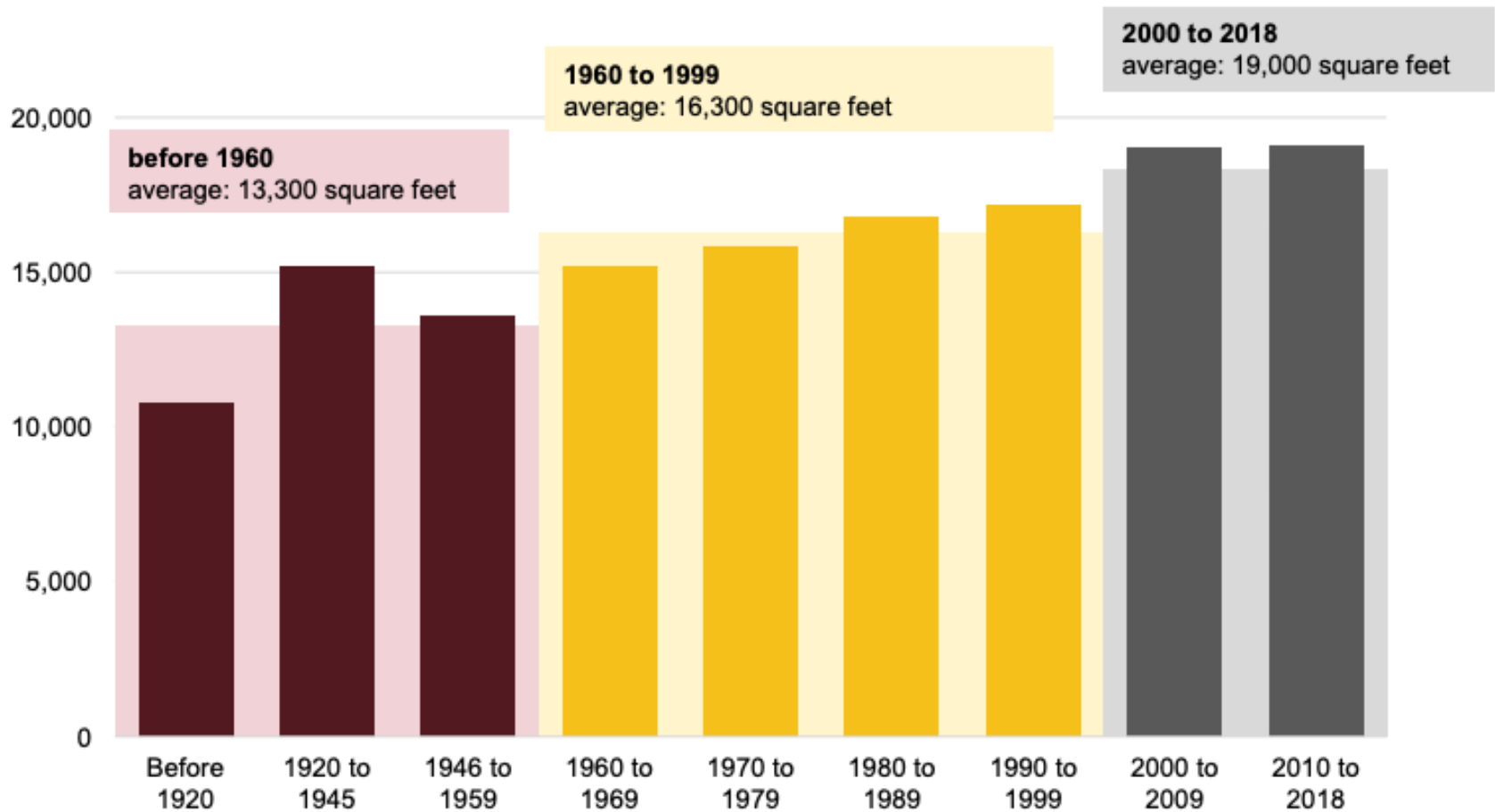
Share of number of buildings and floorspace by year constructed
percentage of total for all buildings



What do you see here?

CBECS

Average building size by year of construction
square feet



What do you see here?

CBECS

Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft ²)	Site EUI (kBtu/ft ²)	Reference Data Source - Peer Group Comparison
Entertainment/Public Assembly	Stadium	Indoor Arena	112.0	56.2	CBECS - Public Assembly
		Race Track			
		Stadium (Closed)			
		Stadium (Open)			
		Other - Stadium			
	Other	Aquarium			
		Casino			
		Zoo			
		Other - Entertainment/Public Assembly			
		Bar/Nightclub			
Food Sales & Service	Convenience Store	Convenience Store with Gas Station	592.6	231.4	CBECS - Food Sales
		Convenience Store without Gas Station			
	Restaurant/Bar	Bar/Nightclub	297.0	130.7	CBECS - Bar/Pub/Lounge
		Fast Food Restaurant	886.4	402.7	CBECS - Fast Food
		Restaurant	573.7	325.6	CBECS - Restaurant/Cafeteria
		Other - Restaurant/Bar			
	Supermarket/Grocery Store*		444.0	196.0	CBECS - Grocery Store/Food Market
	Wholesale Club/Supercenter*		120.0	51.4	CBECS - Retail Store
	Other	Food Sales	592.6	231.4	CBECS - Food Sales
		Food Service	527.7	270.3	CBECS - Food Service

CBECS

U.S. National Median Reference Values for All Portfolio Manager Property Types

Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft ²)	Site EUI (kBtu/ft ²)	Reference Data Source - Peer Group Comparison	
Banking/Financial Services	Bank Branch *		209.9	88.3	CBECS - Bank/Financial	
	Financial Office*		116.4	52.9	CBECS - Office & Bank/Financial	
Education	Adult Education		110.4	52.4	CBECS - Education	
	College/University		180.6	84.3	CBECS - College/University	
	K-12 School*		104.4	48.5	CBECS - Elementary/Middle & High School	
	Pre-school/Daycare		131.5	64.8	CBECS - Preschool	
	Vocational School		110.4	52.4	CBECS - Education	
	Other - Education					
Entertainment/Public Assembly	Convention Center		109.6	56.1	CBECS - Social/Meeting	
	Movie Theater		112.0	56.2	CBECS - Public Assembly	
	Museum					
	Performing Arts					
	Recreation	Bowling Alley		112.0	50.8	CBECS - Recreation
		Fitness Center/Health Club/Gym				
		Ice/Curling Rink				
		Roller Rink				
Swimming Pool						
Other - Recreation						
Social/Meeting Hall		109.6	56.1	CBECS - Social/Meeting		

CBECS

Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft ²)	Site EUI (kBtu/ft ²)	Reference Data Source - Peer Group Comparison
Healthcare	Ambulatory Surgical Center		138.3	62.0	CBECS - Outpatient Healthcare
	Hospital	Hospital (General Medical & Surgical)*	426.9	234.3	Industry Survey
		Other/Specialty Hospital	433.9	206.7	CBECS - Inpatient Healthcare
	Medical Office*		121.7	51.2	CBECS - Medical Office
	Outpatient Rehabilitation/Physical Therapy		138.3	62.0	CBECS - Outpatient Healthcare
	Residential Care Facility		213.2	99.0	Industry Survey
	Senior Living Community*		213.2	99.0	Industry Survey
Urgent Care/Clinic/Other Outpatient		145.8	64.5	CBECS - Clinic/Outpatient	
Lodging/Residential	Barracks*		107.5	57.9	CBECS - Dormitory
	Hotel*		146.7	63.0	CBECS - Hotel & Motel/Inn
	Multifamily Housing*		118.1	59.6	Fannie Mae Industry Survey
	Prison/Incarceration		156.4	69.9	CBECS - Public Order and Safety
	Residence Hall/Dormitory*		107.5	57.9	CBECS - Dormitory
	Residential Care Facility		213.2	99.0	Industry Survey
	Senior Living Community*		213.2	99.0	Industry Survey
	Single Family Home		N/A	N/A	None Available
Other - Lodging/Residential		143.6	63.6	CBECS - Lodging	
Manufacturing/Industrial	Manufacturing/Industrial Plant		N/A	N/A	None Available
Mixed Use	Mixed Use Property		89.3	40.1	CBECS - Other
Office	Medical Office*		121.7	51.2	CBECS - Medical Office
	Office*		116.4	52.9	CBECS - Office & Bank/Financial
	Veterinary Office		145.8	64.5	CBECS - Clinic/Outpatient
Parking	Parking		N/A	N/A	None Available

CBECS

Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft ²)	Site EUI (kBtu/ft ²)	Reference Data Source - Peer Group Comparison
Public Services	Courthouse*		211.4	101.2	CBECS - Courthouse
	Drinking Water Treatment & Distribution <i>(Average EUI presented in Energy per Flow in gallons per day)</i>		5.90	2.27	AWWA - Water Treatment Plant
	Fire Station		124.9	63.5	CBECS - Fire Station/Police Station
	Library		143.6	71.6	CBECS - Library
	Mailing Center/Post Office		96.9	47.9	CBECS - Service
	Police Station		124.9	63.5	CBECS - Fire Station/Police Station
	Prison/Incarceration		156.4	69.9	CBECS - Public Order and Safety
	Social/Meeting Hall		109.6	56.1	CBECS - Social/Meeting
	Transportation Terminal/Station		112.0	56.2	CBECS - Public Assembly
	Wastewater Treatment Plant* <i>(Average EUI presented in Energy per Flow in gallons per day)</i>		7.51	2.89	AWWA - Wastewater Plant
	Other - Public Services		89.3	40.1	CBECS - Other
Religious Worship	Worship Facility*		58.4	30.5	CBECS - Religious Worship
Retail	Automobile Dealership		124.1	55.0	CBECS - Retail other than Mall
	Convenience Store	Convenience Store with Gas Station	592.6	231.4	CBECS - Food Sales
		Convenience Store without Gas Station			
	Mall	Enclosed Mall	170.7	65.7	CBECS - Enclosed Mall
		Lifestyle Center	228.8	103.5	CBECS - Strip Shopping Mall
		Strip Mall			
		Other - Mall	225.3	101.6	CBECS - Enclosed Mall and Strip Shopping Mall
	Retail Store*		120.0	51.4	CBECS - Retail Store
	Supermarket/Grocery Store*		444.0	196.0	CBECS - Grocery Store/Food Market
Wholesale Club/Supercenter*		120.0	51.4	CBECS - Retail Store	

CBECS

Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft ²)	Site EUI (kBtu/ft ²)	Reference Data Source - Peer Group Comparison
Technology/Science	Data Center* <i>(Average PUE presented in place of EUI: PUE = Total Energy / IT Energy)</i>		1.82	1.82	EPA - Data Center
	Laboratory		318.2	115.3	CBECS - Laboratory
	Other – Technology/Science		89.3	40.1	CBECS - Other
Services	Data Center* <i>(Average PUE presented in place of EUI: PUE = Total Energy / IT Energy)</i>		1.82	1.82	EPA - Data Center
	Personal Services (Health/Beauty, Dry Cleaning, etc.)		96.9	47.9	CBECS - Service
	Repair Services (Vehicle, Shoe, Locksmith, etc.)				
	Other - Services				
Utility	Drinking Water Treatment & Distribution <i>(Average EUI presented in Energy per Flow in gallons per day)</i>		5.90	2.27	AWWA - Water Treatment Plant
	Energy/Power Station		89.3	40.1	CBECS - Other
	Wastewater Treatment Plant* <i>(Average EUI presented in Energy per Flow in gallons per day)</i>		7.51	2.89	AWWA - Wastewater Plant
	Other - Utility		89.3	40.1	CBECS - Other
Warehouse/Storage	Self-Storage Facility		47.8	20.2	CBECS – Non-refrigerated Warehouse
	Warehouse/Distribution Center	Distribution Center*	52.9	22.7	CBECS – Non-refrigerated Warehouse & Distribution Center
		Non-Refrigerated Warehouse*			
		Refrigerated Warehouse*	235.6	84.1	CBECS – Refrigerated Warehouses
Other	Other		89.3	40.1	CBECS - Other

CLASS ACTIVITY

Class Activity

- From a group of two:
 - ❑ Look at three different year consumption
 - ❑ Pick a category (e.g., electricity, major fuels, ...)
 - ❑ Pick a category (e.g., Table C13, C14, ...)
 - ❑ Compare the values for these three data collection years

The screenshot shows the 'COMMERCIAL BUILDINGS ENERGY CONSUMPTION' website. The main navigation bar includes 'OVERVIEW', 'DATA', and 'ANALYSIS & PROJECTIONS'. A dropdown menu under 'DATA' is open, showing years: 2018, 2012, 2003, 1999, 1995, 1992, and 'Previous'. The page title is '2012 Commercial Buildings Energy Consumption Survey Data'. Below the title, there are tabs for 'Building', 'Consumption & Expenditures', 'Microdata', and 'Methodology'. The 'Consumption & Expenditures' tab is active. The content area shows a description of the data and a list of categories: Major fuels, Electricity, Natural gas, Fuel oil, District heat, and End-use consumption. A '+ EXPAND ALL' link is visible at the bottom right of the category list.

RESIDENTIAL BUILDING ENERGY CONSUMPTION SURVEY (RECS)

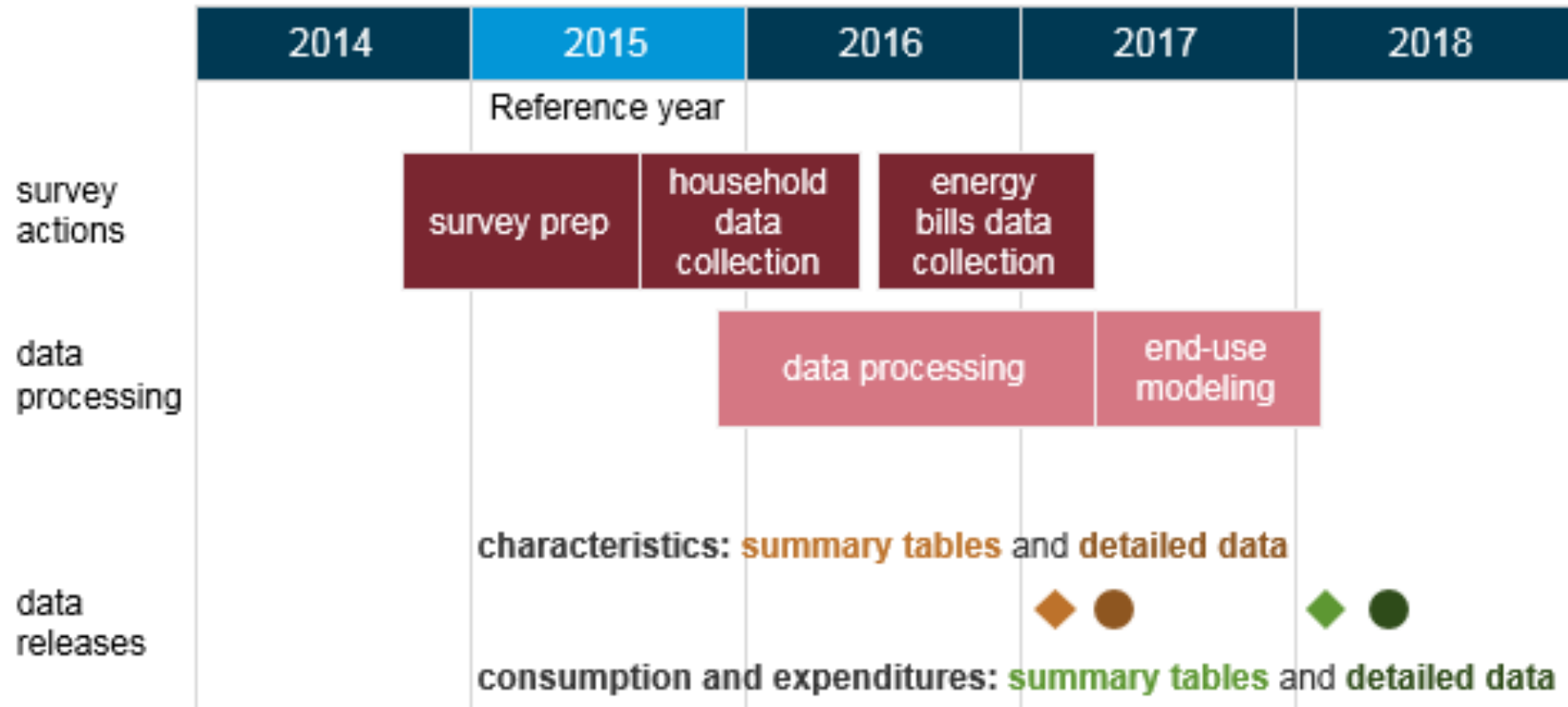
RECS

- RECS is a national sample survey of housing units:
 - ❑ Collect information on:
 - Energy characteristics on the housing unit
 - Usage patterns
 - Household demographics
 - ❑ 2015 survey cycle conducted via Web and mail forms, in addition to in-person interviews
 - The fourteenth RECS collected data
 - More than 5,600 households in housing units
 - Represent the 118.2 million housing units that are occupied as a primary residence
 - ❑ 1978, the first survey was conducted
 - ❑ 2020 is the most recent survey

RECS

Timeline of EIA's 2015 Residential Energy Consumption Survey (RECS)

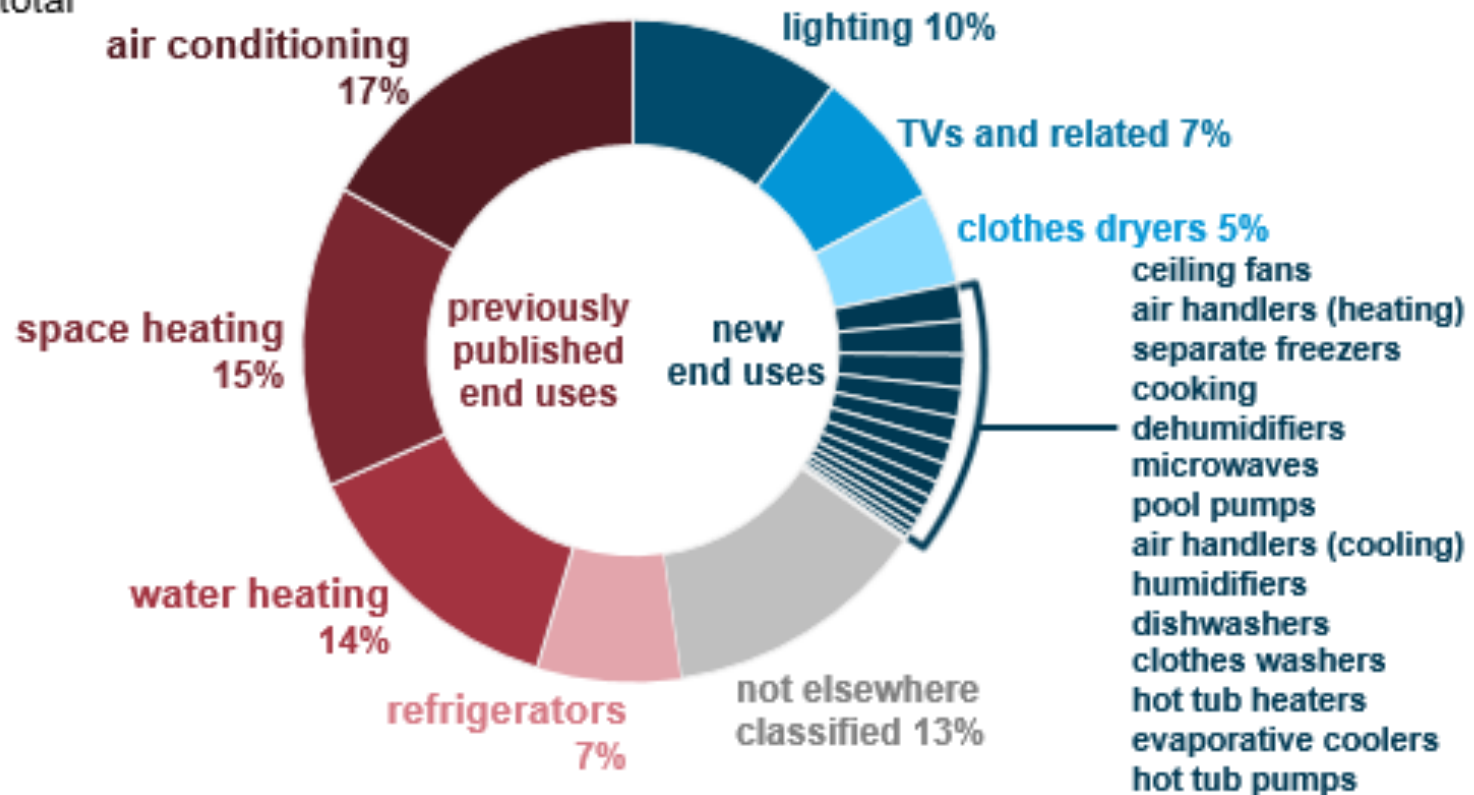
Timeline of EIA's 2015 Residential Energy Consumption Survey



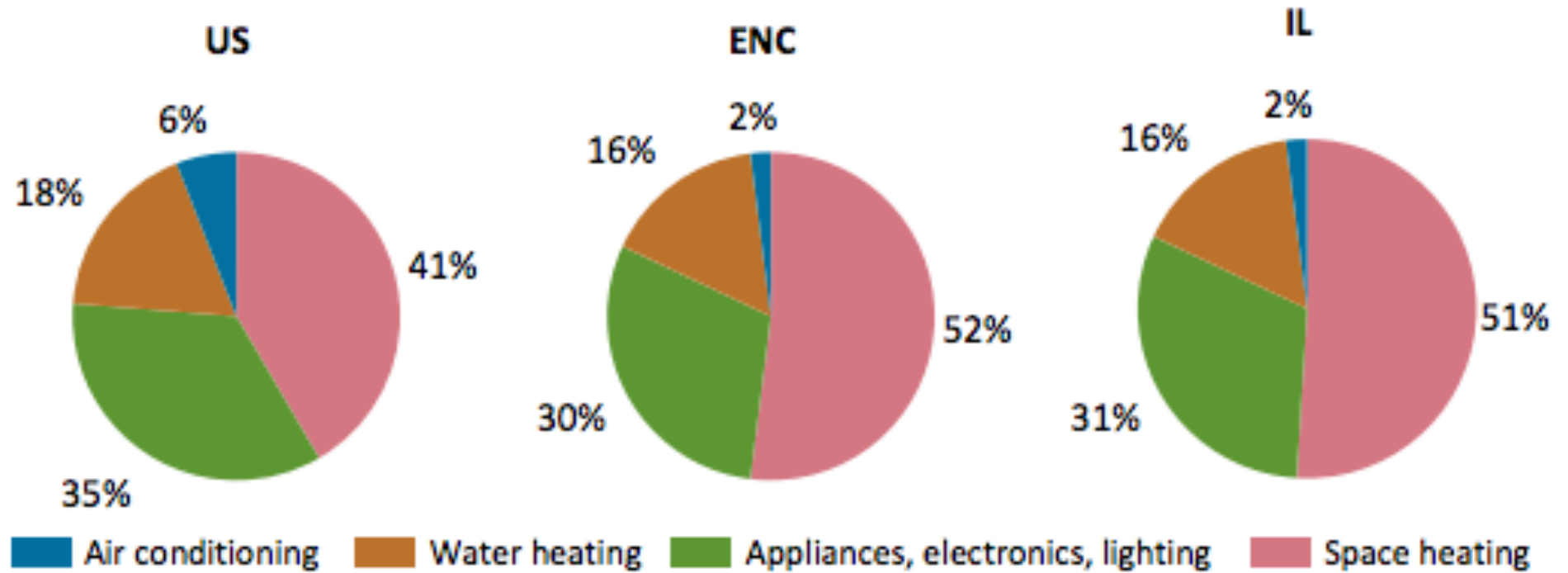
RECS

EIA's residential energy survey now includes estimates for more than 20 new end uses

Residential electricity consumption by end use, 2015
percent of total

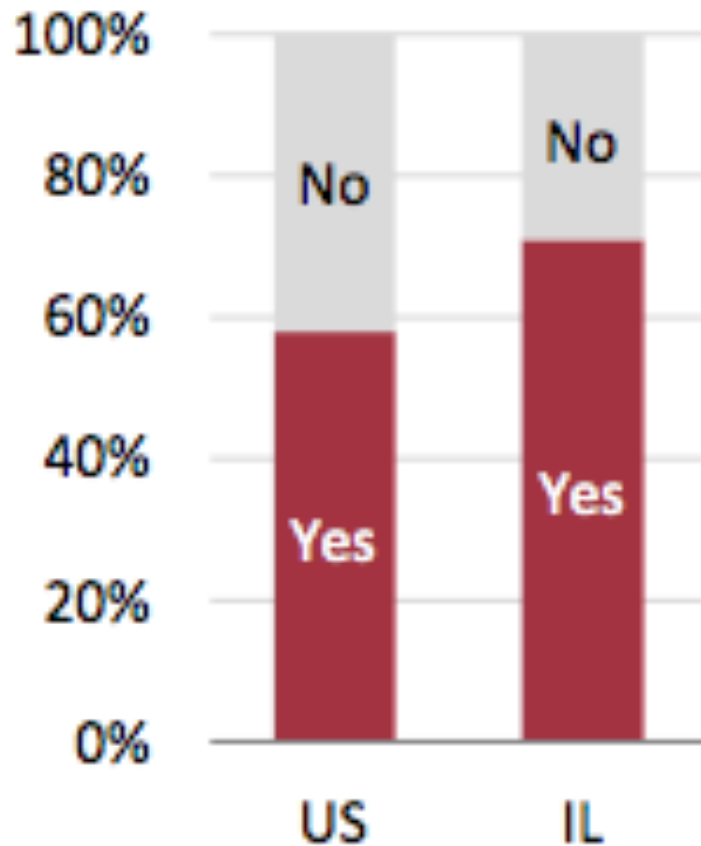


RECS

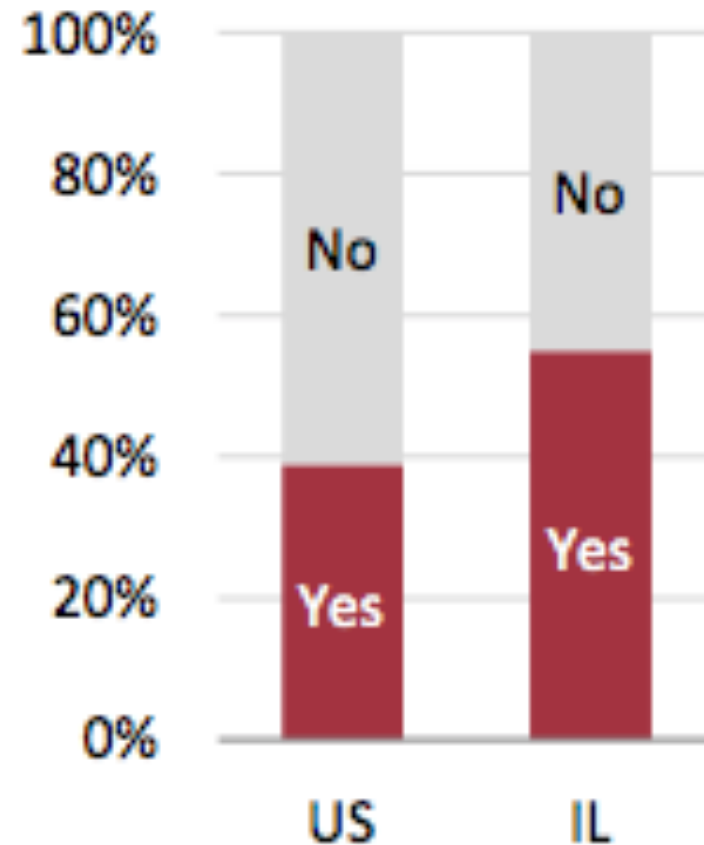


RECS

HAVE DOUBLE/TRIPLE PANE WINDOWS



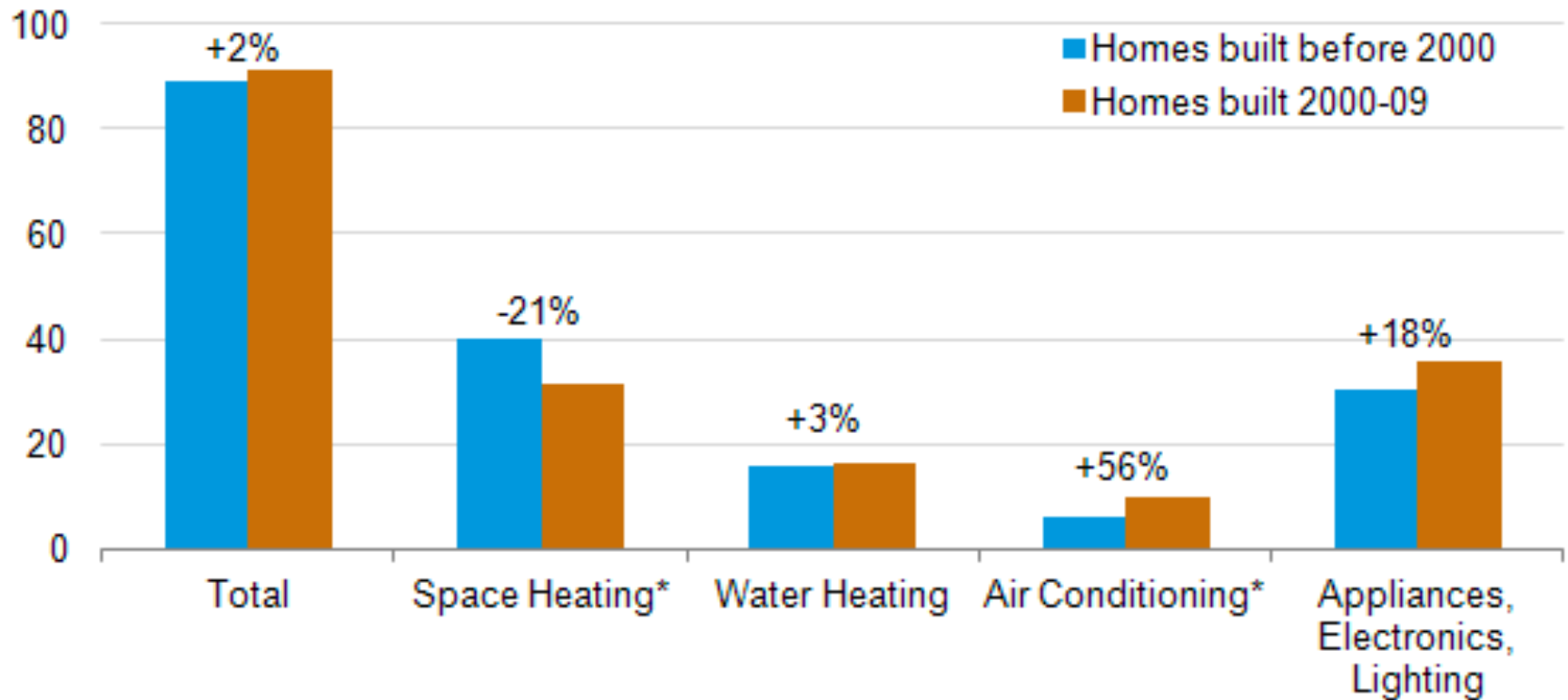
HAVE A PROGRAMMABLE THERMOSTAT



New vs. Old Buildings

- Newer U.S. homes are 30% larger but consume about as much energy as older homes

Average household site energy consumption by end use, 2009
million Btu per household



CLASS ACTIVITY

Class Activity

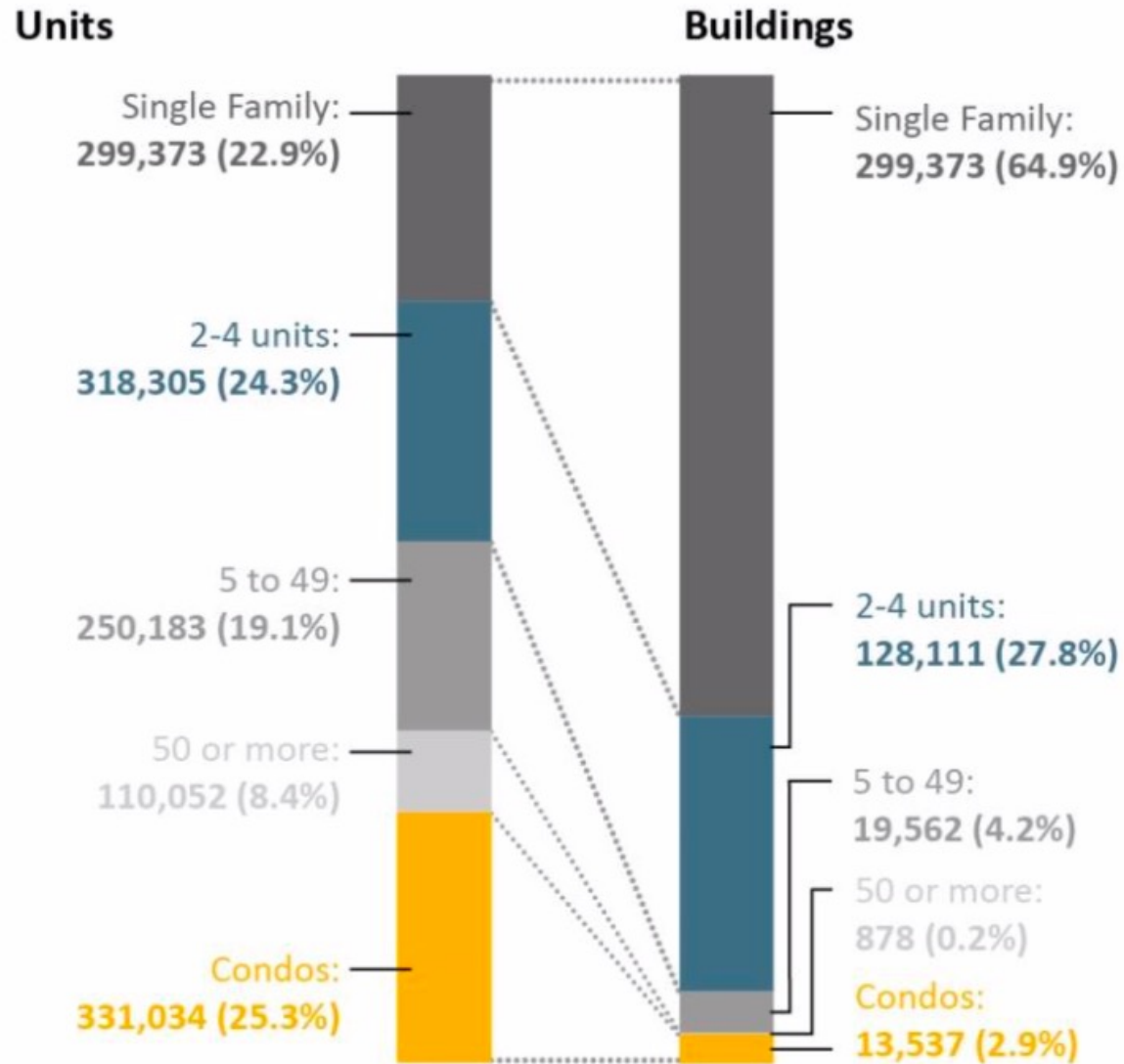
- From a group of two:
 - Calculate the percentage of heat pump installed in the past three years of data collection

BUILDINGS IN CHICAGO

Buildings in Chicago

- Buildings in Chicago:
 - ❑ 75% of Chicagoans live in a multifamily building
 - ❑ 1.3 million housing units exist (Estimate)
 - 77% (or around 1 million units) are in multifamily buildings
 - 33% (300,000 units) of these multifamily units are condominiums (likely to be owner-occupied)
 - 67% (700,000 units) are likely to be rental units
 - ❑ Chicago's multifamily building stock is old
 - Energy intensive
 - 75% of Chicago's multifamily housing was built before 1942

Buildings in Chicago



Buildings in Chicago

	N	EUI	Energy Star Score	Notes
Building Performance Database^{vi}	689	55 (median, site, national)	n/a	5+ units
Chicago Energy Benchmarking (2016)^{vii}	952	N/A	55	≥50,000 square feet
Elevate Energy Chicago Data (2007-2015)	459	111 (gas only, median, site, pre-retrofit) 94 (gas only, median, site, post-retrofit)	n/a	5+ units; Master-metered gas heated buildings
Fannie Mae National Survey (2011)^{viii}	536	127.9 (median, source) 78.8 (median, site)	n/a	
Los Angeles (2010)^x	104400	46.5 (median, site)		N is parcels, not buildings
Minnesota^{xi}	322	58 (owner-paid heat and hot water)	n/a	
New York City (2012)^{xii}	8687	121 (median, source)	n/a	≥50,000 square feet
RECS (2009)	1924	54.5 (mean, site, national) 66 (mean, site, Midwest)	n/a	5+ units
Seattle (2013)^{xiii}	1565	30.3 (low-rise, median, site) 34.3 (mid-rise, median, site) 49.0 (high-rise, median, site)	77 (low-rise, median) 85 (mid-rise, median) 47 (high-rise, median)	≥20,000 square feet Energy Star Scores are preliminary

CITY BENCHMARKING

Energy Benchmarking

Table 1
Table of benchmarking and audit legislation.

City	Legislation/ordinance	Benchmarking requirement, frequency	Benchmarking disclosure	Auditing requirement, frequency	Auditing disclosure
New York	Local laws 84, 87	Annual disclosure of total energy use and building characteristics	Public	ASHRAE Level 2 for all buildings every ten years	To City only
San Francisco	Energy Performance Ordinance	Annual disclosure of total energy use and building characteristics	Public	ASHRAE Level 1 or 2 for each building every five years	Public
Seattle	CB 116731	Annual disclosure of total energy use and building characteristics	Only to potential buyers and tenants	None	None

Table 3
Descriptive statistics for building typology. Zeroes added to ambiguous fields, in order to omit these values from the regression models.

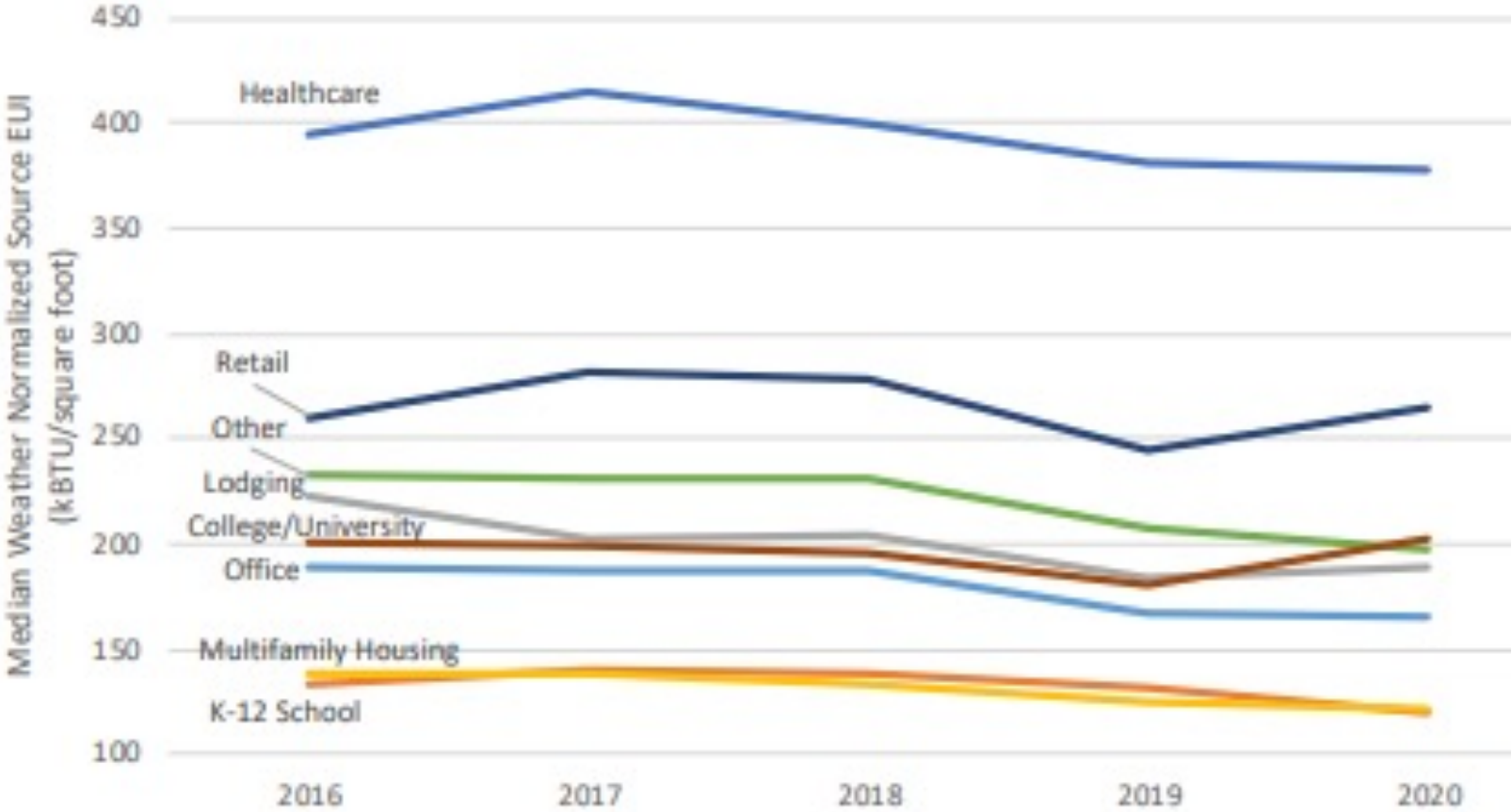
	Variable	Mean	Std dev	Min	q25%	Median	q75%	Max
1	Area (m ²)	14,591.0	9563.8	92.9	6271.0	14,492.9	22,900.6	31,122.5
2	Floors	34.4	19.8	1.0	16.0	35.0	53.0	62.0
3	Volume (000 m ³)	2155.2	2070.4	0.4	428.2	1491.8	3291.8	7370.5
4	Buildings on lot	3.8	3.6	1.0	2.0	2.0	2.0	16.0
5	Apartment units	165.4	201.6	0.0	52.0	102.0	203.0	1744.0
6	Commercial spaces	2.6	9.1	0.0	0.0	1.0	3.0	155.0
7	Building age	1189.8	956.1	0.0	0.0	1926.0	1961.0	2009.0
8	Boiler age	15.1	15.6	0.0	0.0	11.0	26.0	64.0
9	Burner age	10.8	13.4	0.0	0.0	5.0	19.0	68.0

Chicago Energy Benchmarking

- Chicago energy benchmarking:
 - ❑ Cover all commercial, institutional, and residential buildings larger than 50,000 square feet
 - ❑ Requires existing municipal, commercial, and residential buildings larger than 50,000 square feet to:
 - Track whole-building energy use
 - Report to the City annually
 - Verify data accuracy every three years
 - ❑ Cover less than 1% of Chicago's buildings
 - ❑ Account for approximately 20% of total energy used by all buildings

Chicago Energy Benchmarking

- Chicago energy benchmarking:

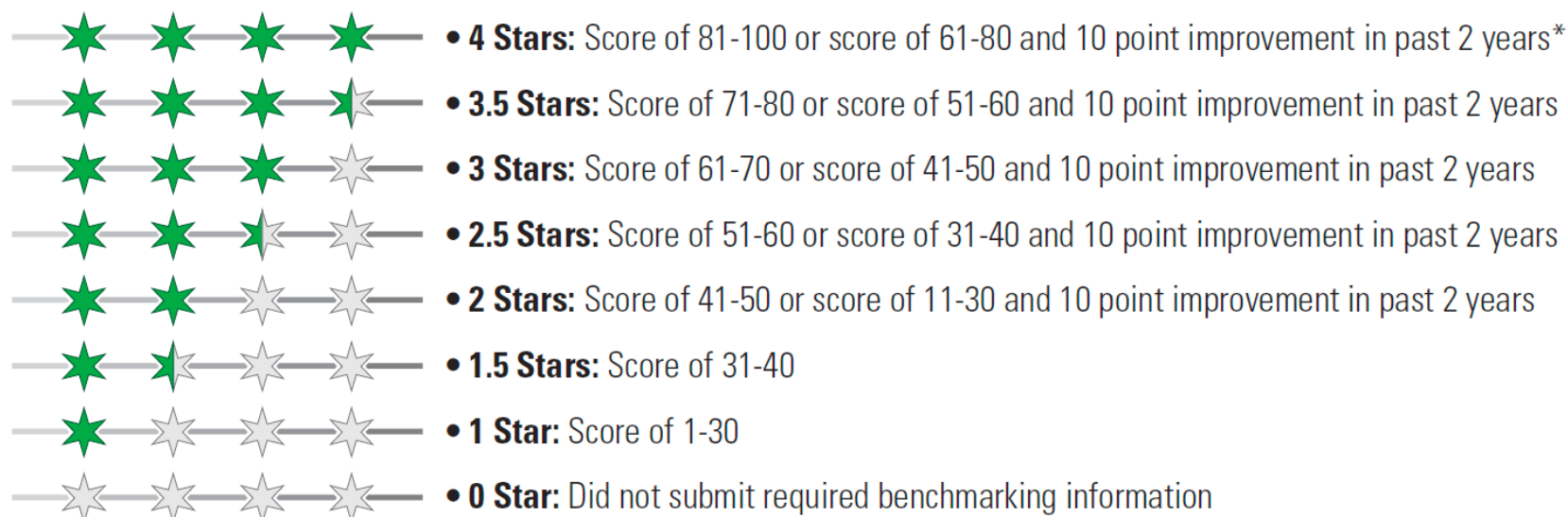


Chicago Energy Benchmarking

- Chicago City Council approved updates to the Chicago Energy Benchmarking Ordinance in 2017:
- Chicago Energy Rating System is implemented in 2019 to:
 - Improve visibility and transparency of the information reported
 - Keep existing requirements
 - Require to place a placard in the building
 - Range from zero to four based on Energy Star score
 - Make Chicago the first city to assign an energy performance rating

Chicago Energy Benchmarking

CHICAGO ENERGY RATING SYSTEM (WITH HALF-STARS)



*Note: Any building with ENERGY STAR certification also receives four stars.

- Building can earn an extra star by improving its score by 10 points within the past two years

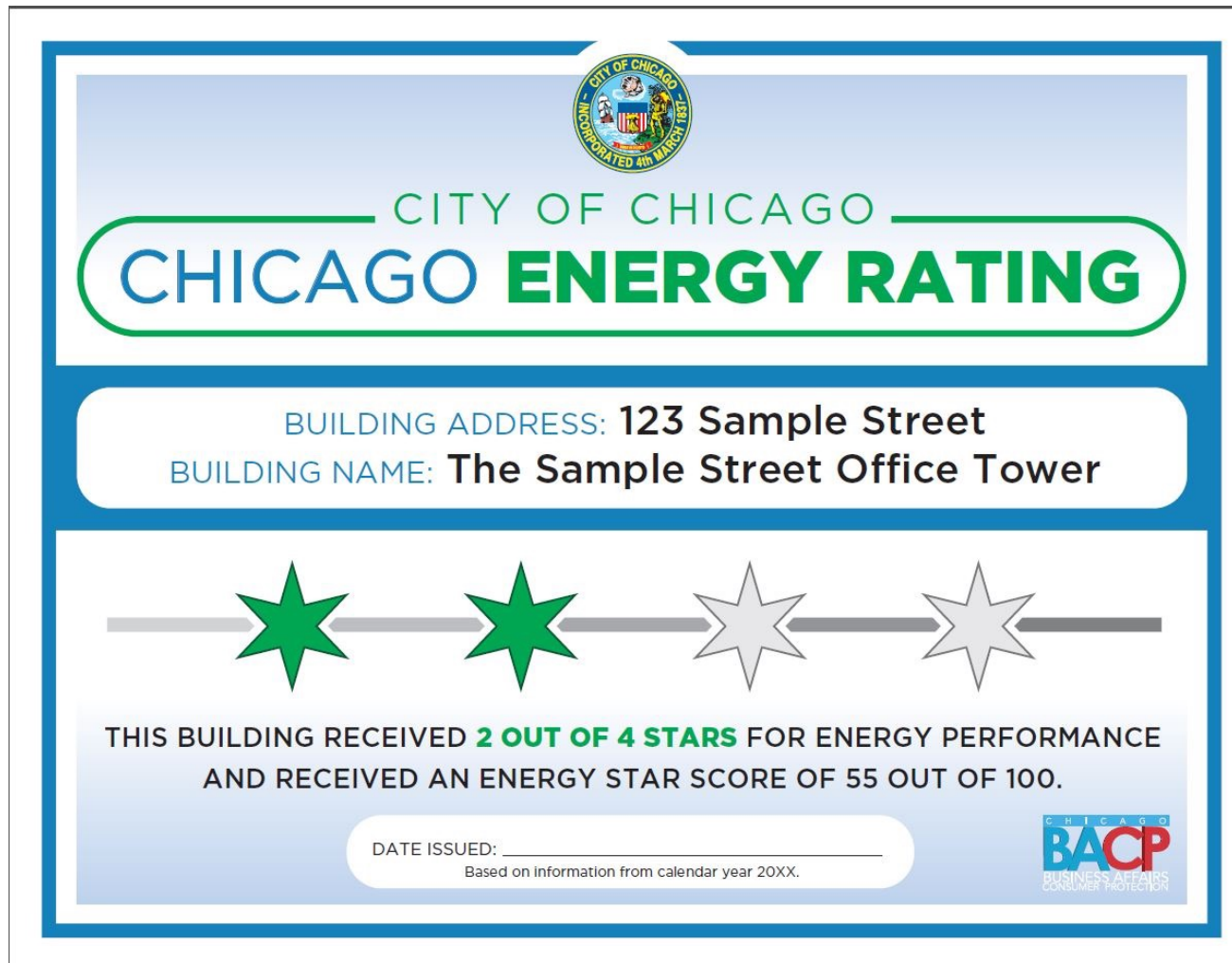
Chicago Energy Benchmarking

- The scale is based on:
 - 4 stars -> 1st to 25th percentile for Source EUI
 - 3 stars -> 25th to 50th percentile for Source EUI
 - 2 stars -> 50th to 75th percentile for Source EUI
 - 1 star -> Above the 75th percentile for Source EUI

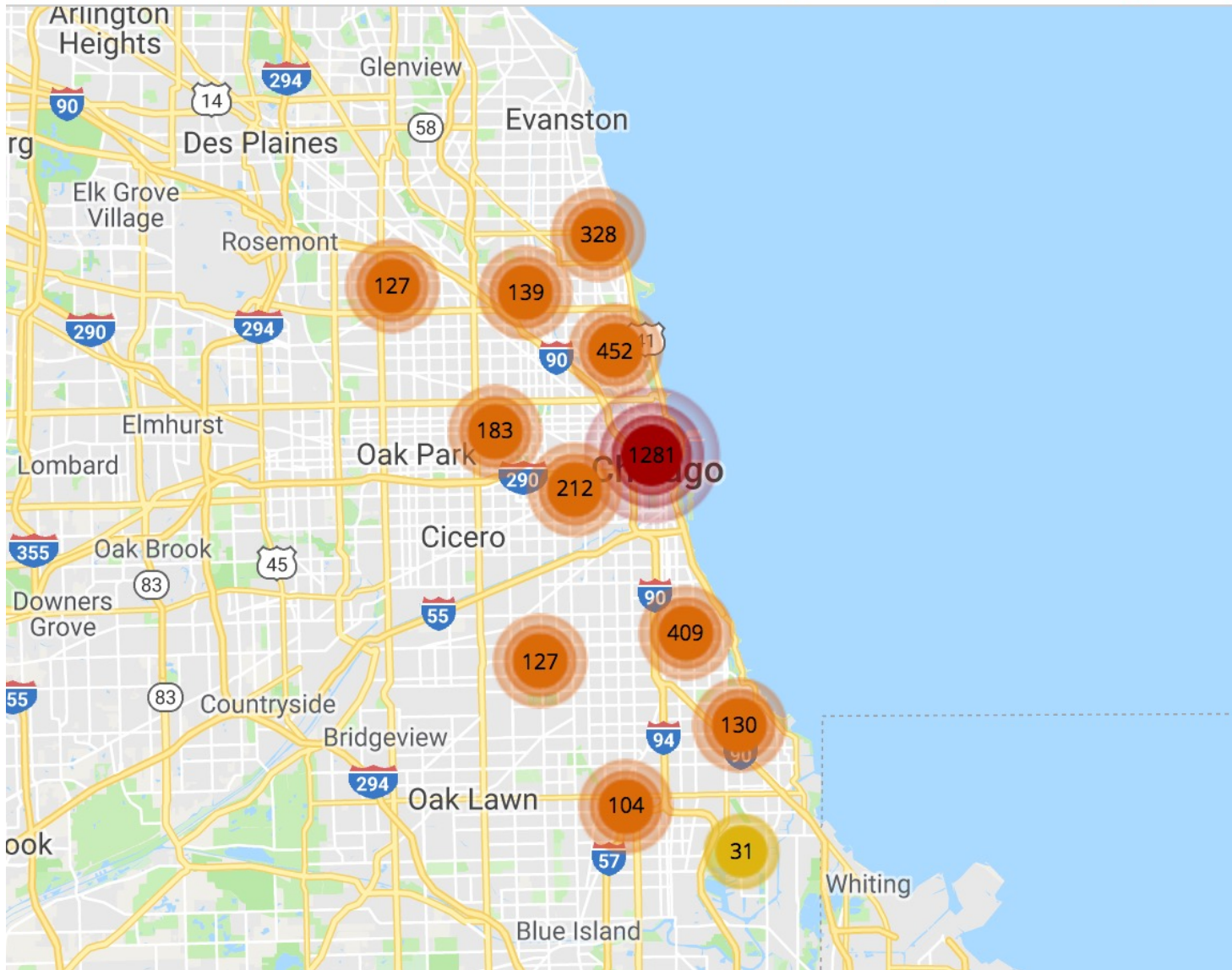
- About 15% of buildings are unable to receive 1-100 Energy Star Score (EUI comparison is used)

Chicago Energy Benchmarking

- A placard of 11” by 17” needs to be installed on a prominent location at the building



Chicago Benchmarking Data



Chicago Benchmarking Data



CHICAGO
DATA PORTAL

Chicago Data Portal

Browse

Chicago Energy Benchmarking - 2019 Data Reported in 2020

View Data

Visualize ▾

Export

API

...

View based on [Chicago Energy Benchmarking](#)

Environment & Sustainable Development

The Chicago Building Energy Use Benchmarking Ordinance calls on existing municipal, commercial, and residential buildings larger than 50,000 square feet to track whole-building energy use, report to the City annually, and verify data accuracy every three years. The law, which phases in from 2014-2017, covers less than 1% of Chicago's buildings, which account for

[More](#)

Updated
February 24, 2022
Data Provided by
City of Chicago

About this Dataset

Updated
February 24, 2022

Data Last Updated
February 24, 2022

Metadata Last Updated
May 26, 2021

Date Created
March 9, 2021

Views
3,496

Downloads
323

Data Provided by
City of Chicago

Dataset Owner
Jonathan Levy

Contact Dataset Owner

Metadata

Changes and Other Historical Information Useful to Understanding This Dataset
<http://dev.cityofchicago.org/open%20data/data%20portal/2021/05/26/energy-benchmarking-correction.html>

Data Owner
City of Chicago Sustainability Program

Time Period
2019

Frequency
Annual

Topics

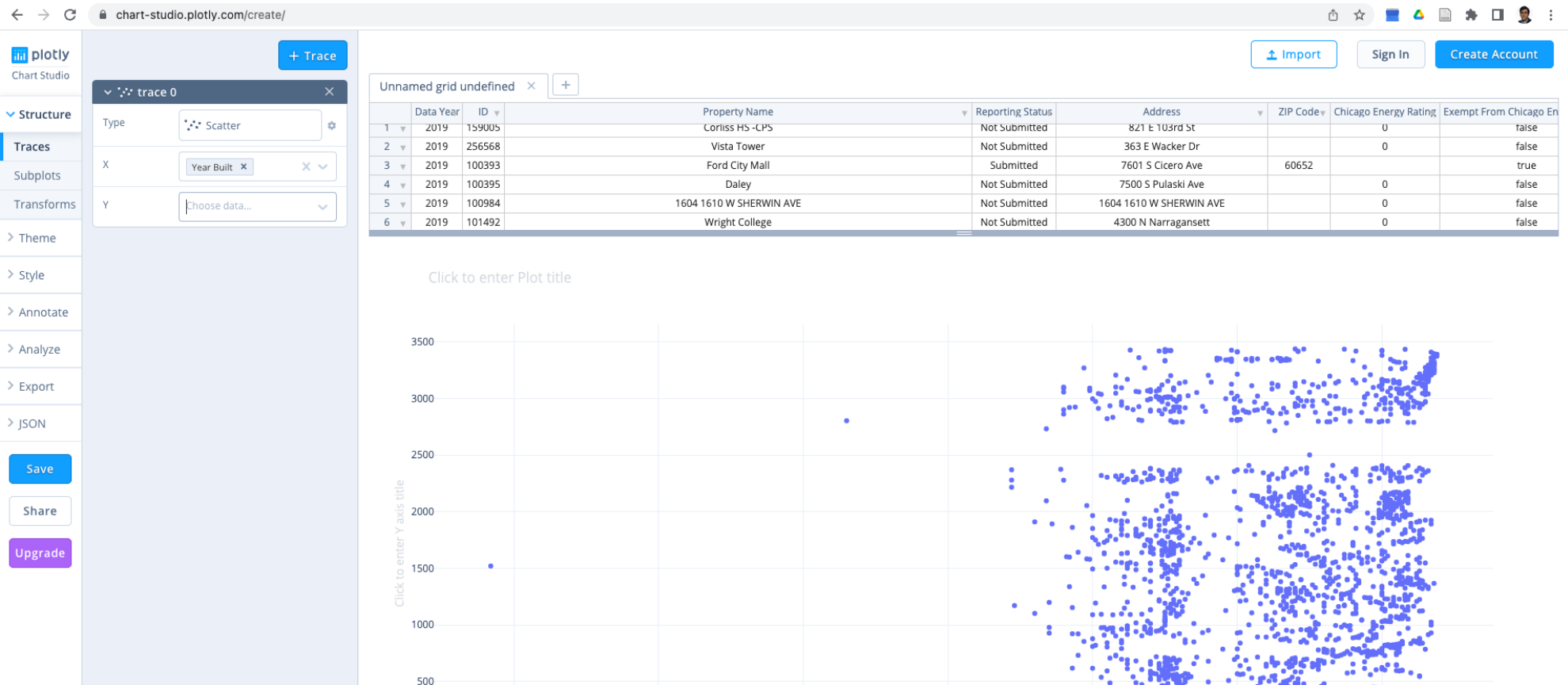
Category
Environment & Sustainable Development

Tags
[2019](#), [buildings](#), [energy](#), [sustainability](#), [link to article present](#)

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Chicago Benchmarking Data



LEADERSHIP IN ENERGY AND ENVIRONMENT DESIGN (LEED)

LEED Buildings

Do LEED buildings save energy?

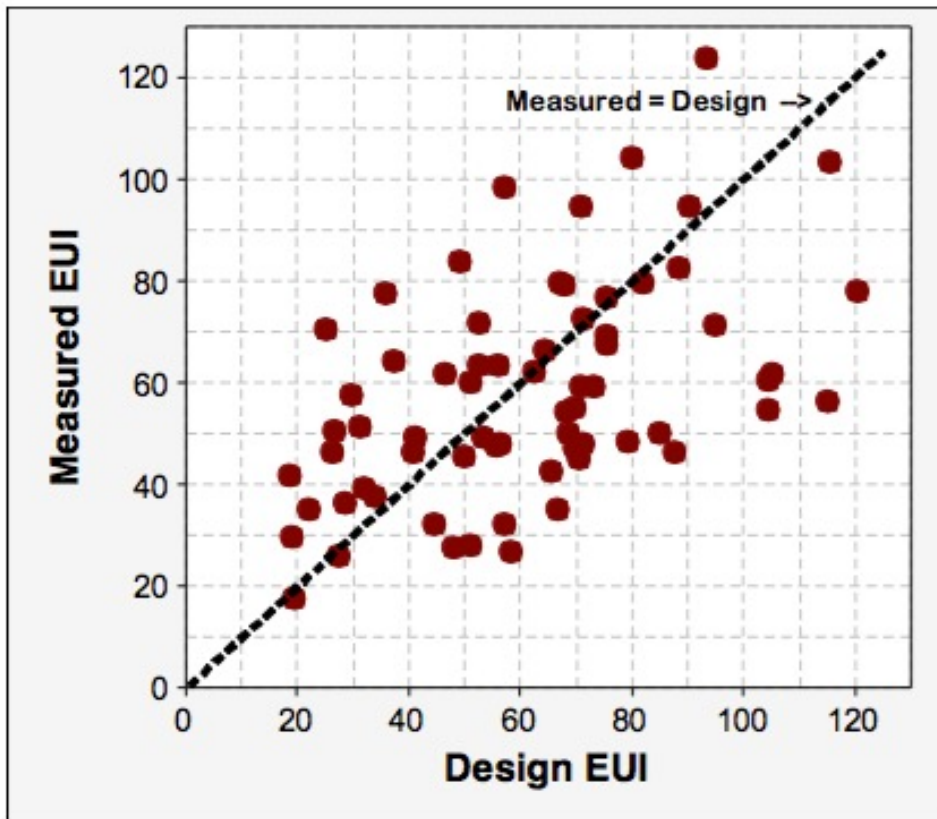


Figure ES- 4: Measured versus Design EUIs
All EUIs in kBTu/sf

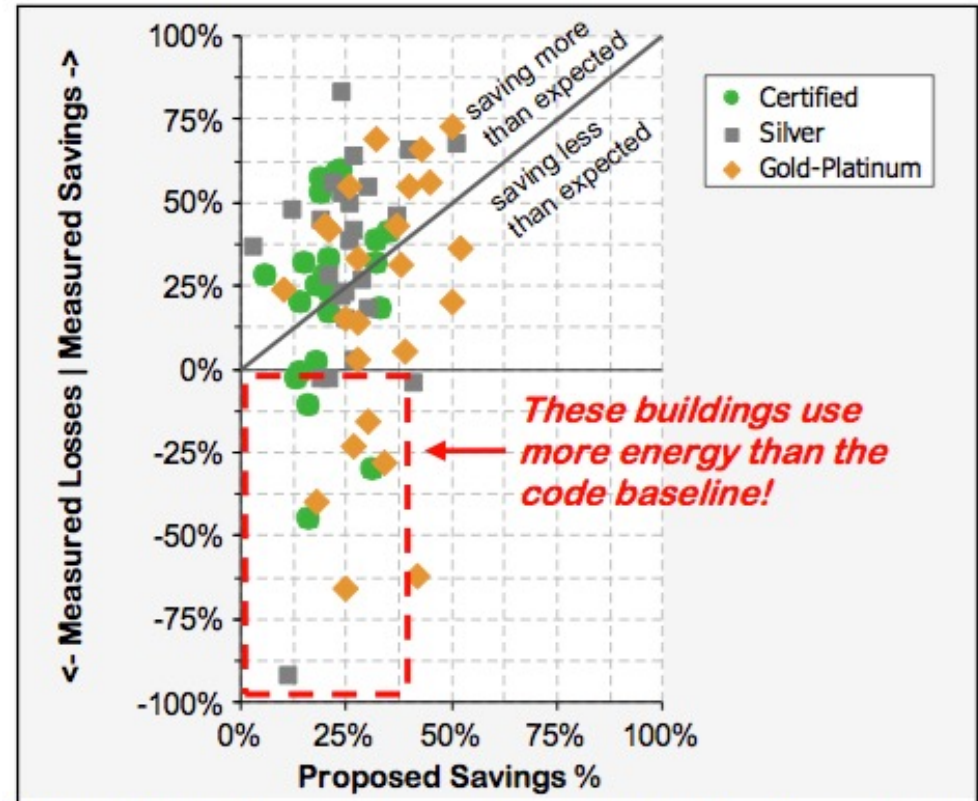
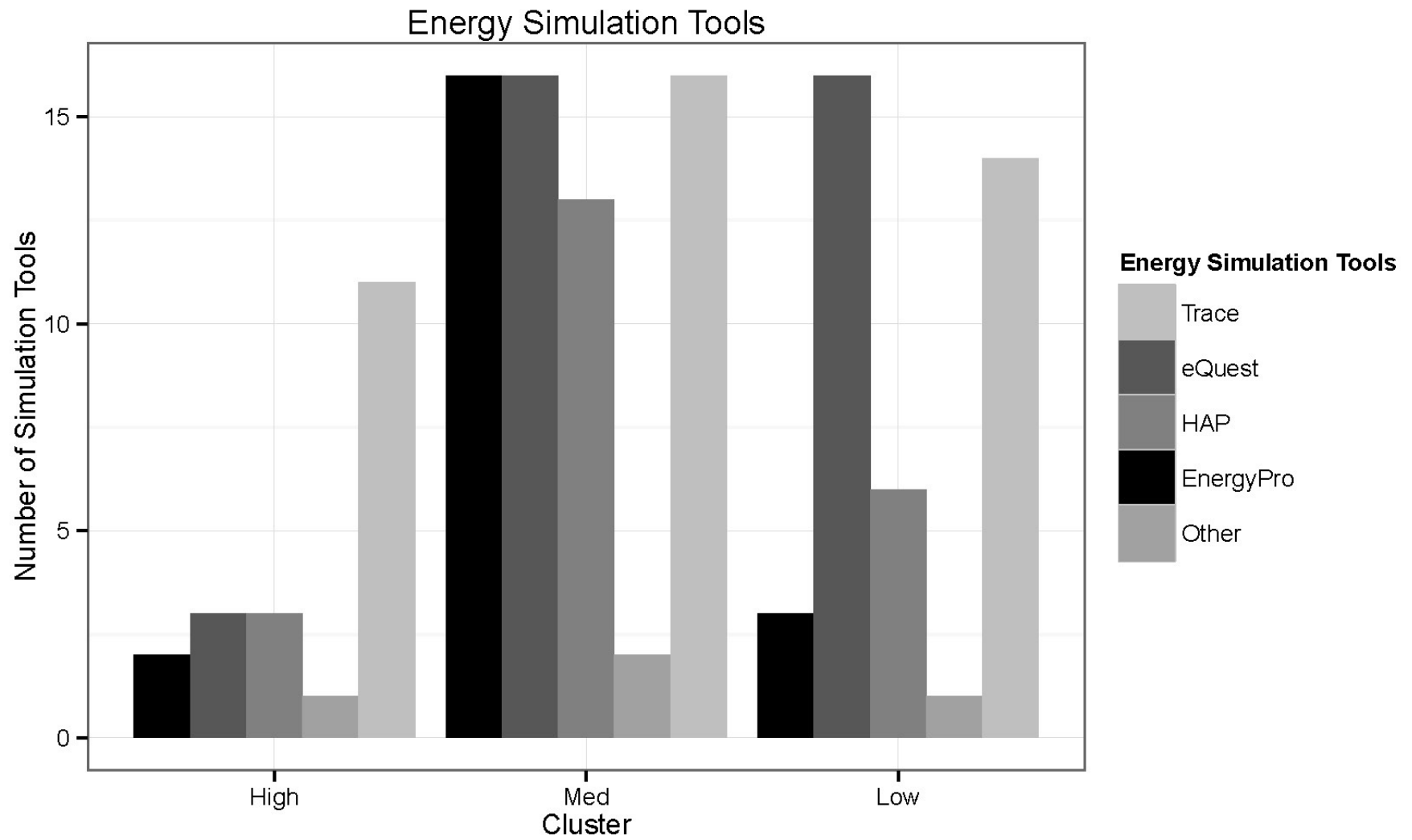
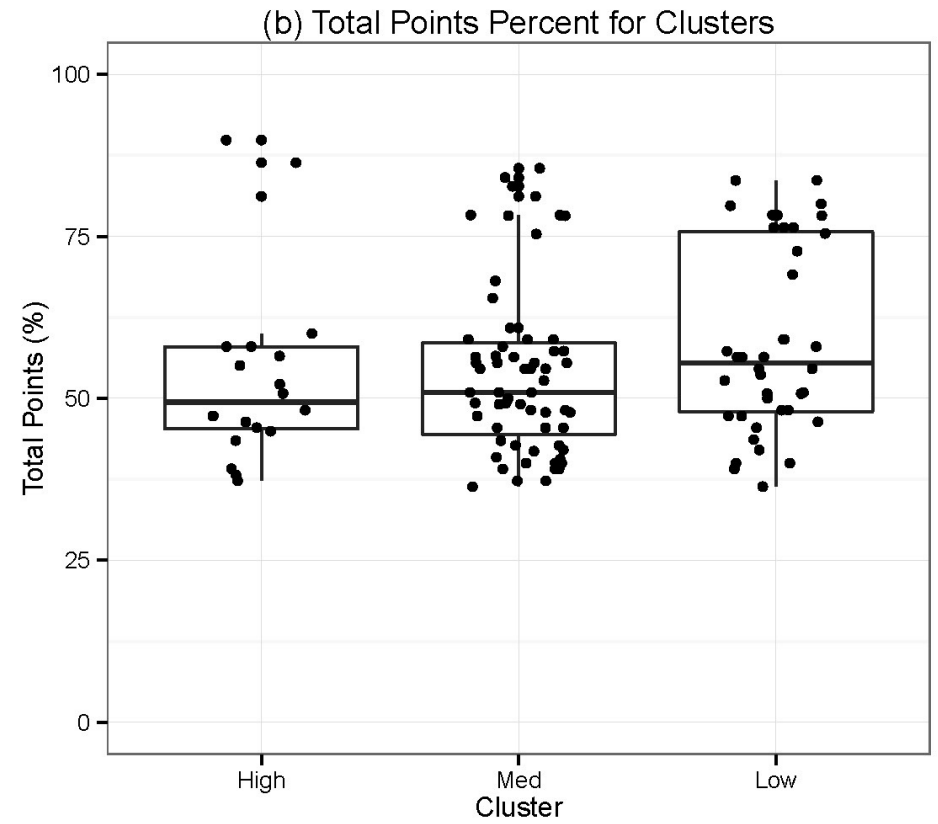
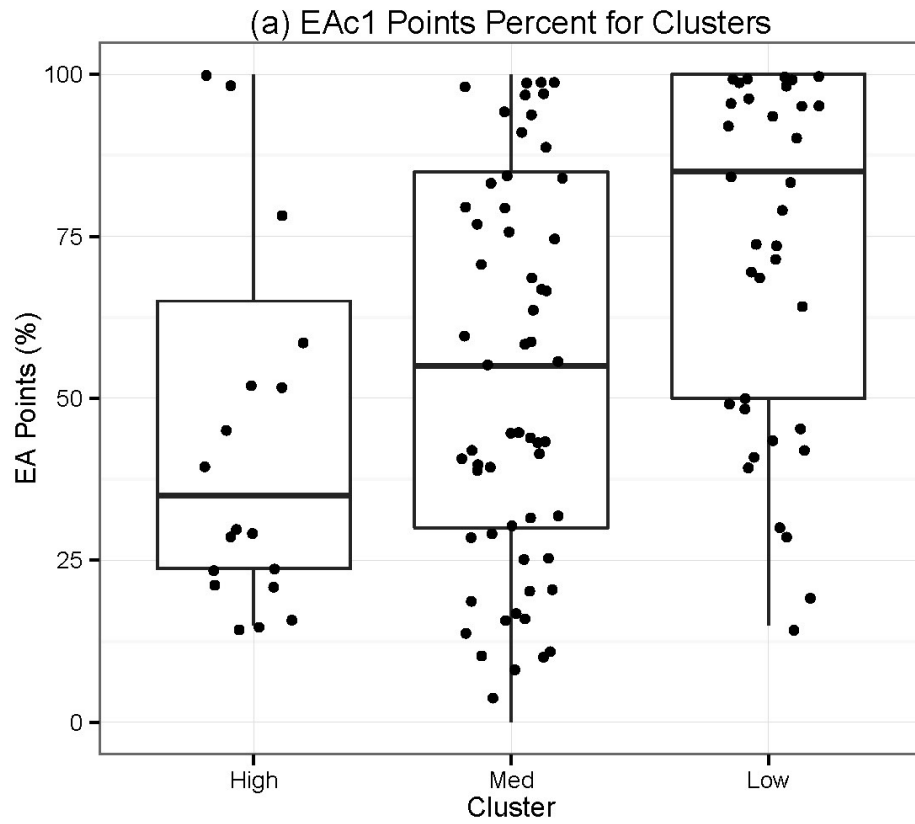


Figure ES- 5: Measured versus Proposed Savings Percentages

LEED Buildings

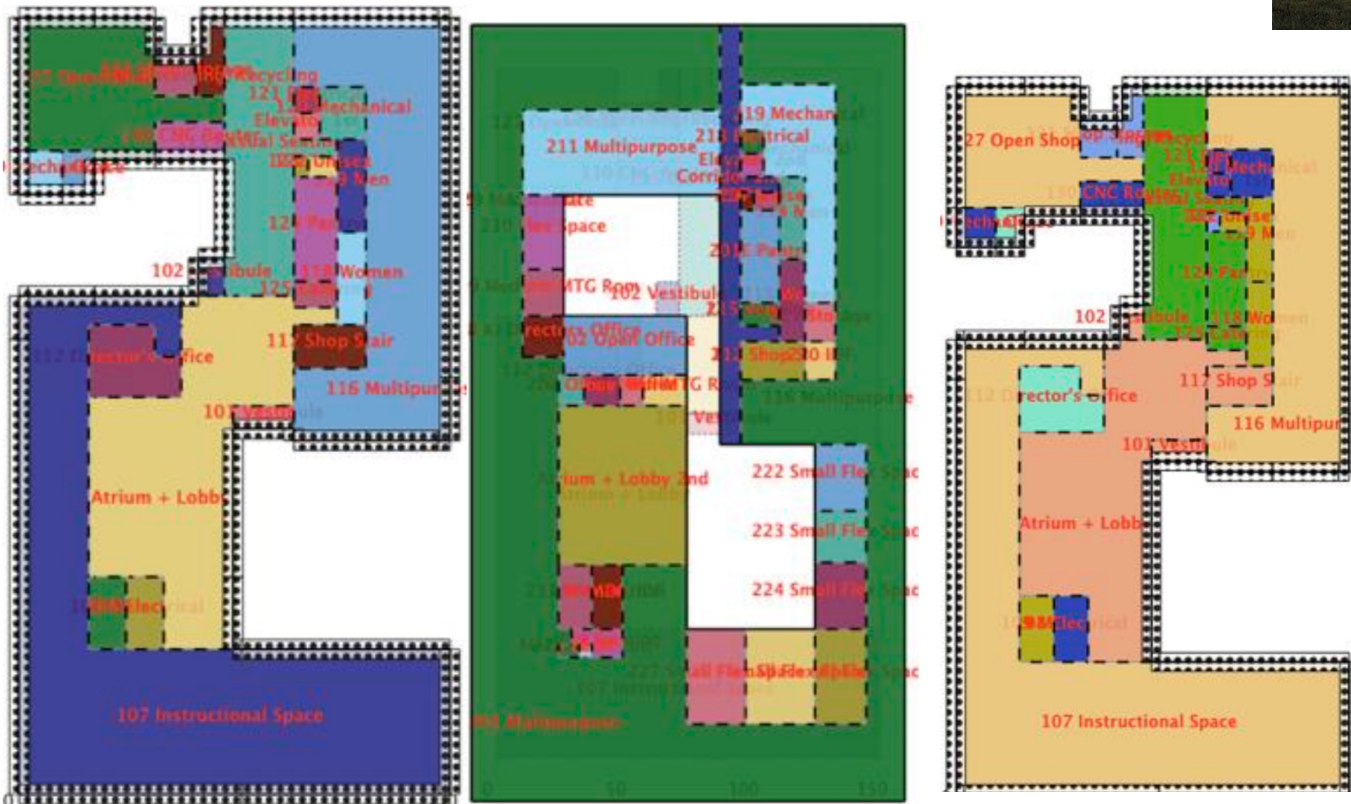


LEED Buildings



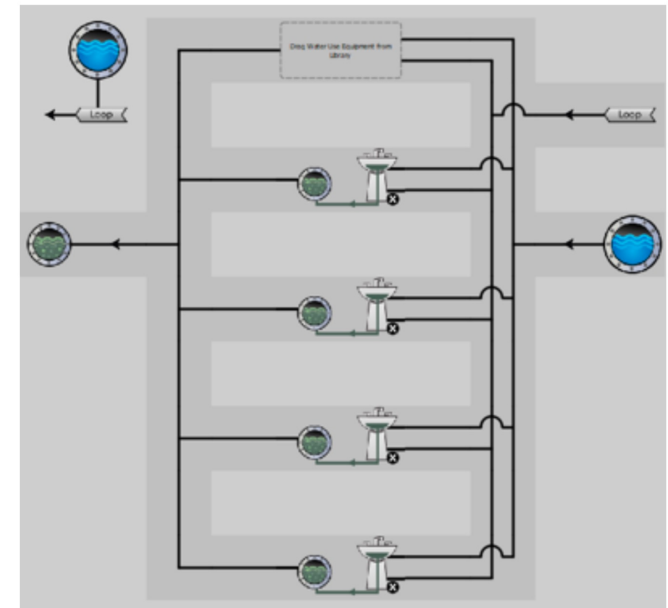
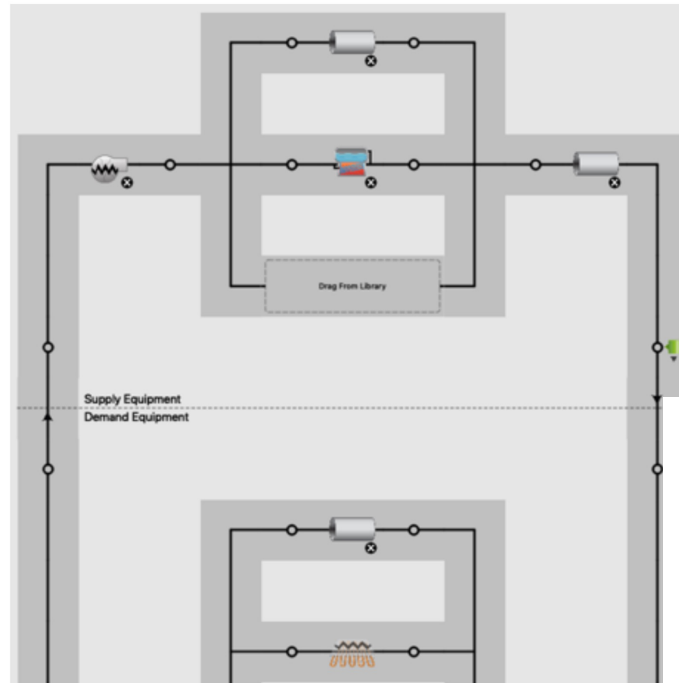
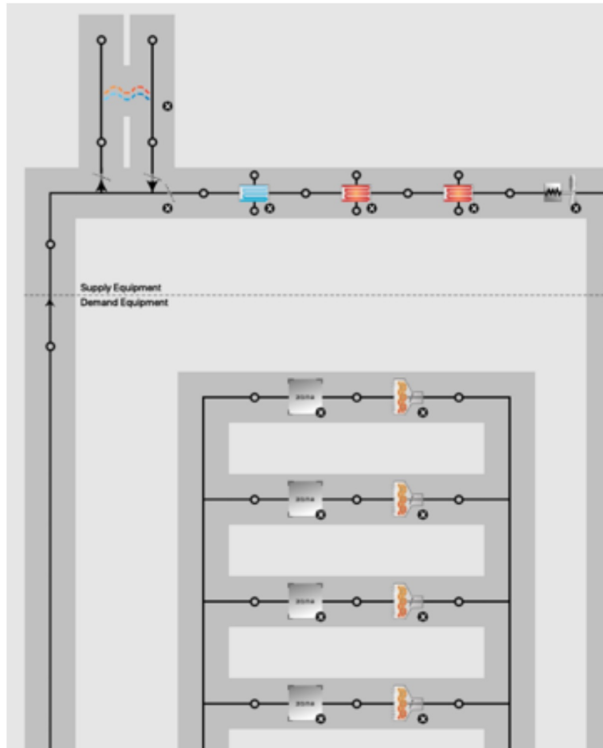
BUILDING ENERGY MODELING

Building Energy Modeling



- Classroom
- Restroom
- Print/Mech-Elec/Print/IT rooms
- Cafeteria
- Closed office
- Lobby
- Storage
- Stairs

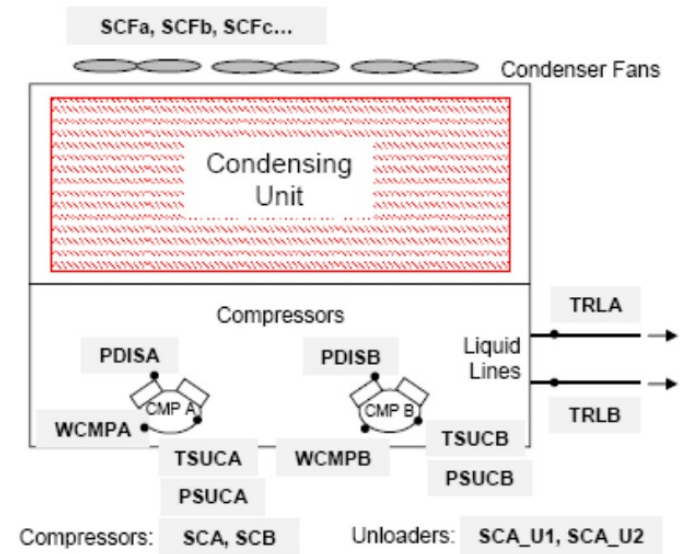
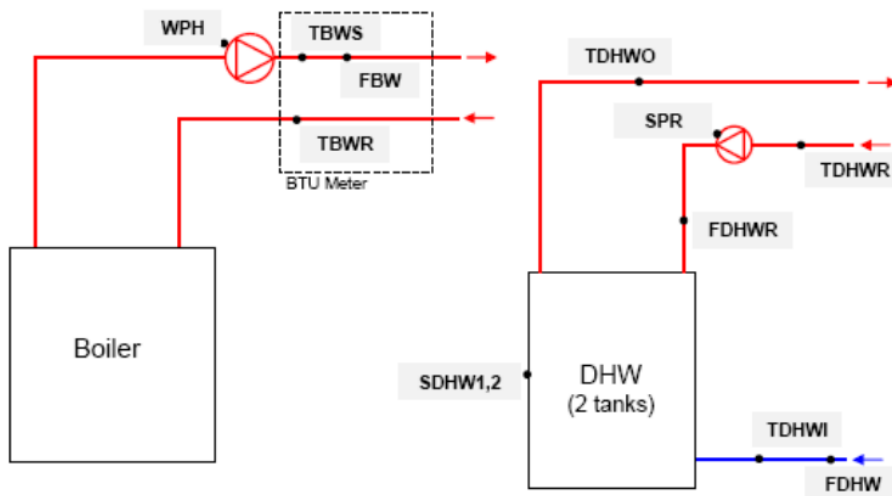
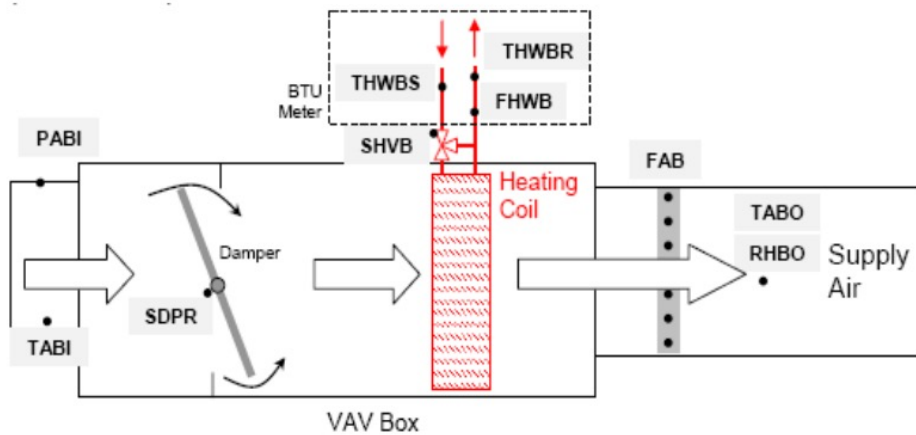
Building Energy Modeling



130 CNC Router	<input type="checkbox"/>	Face 286	Wall	Typical Insulated Exteri	Outdoors
	<input type="checkbox"/>	Face 282	RoofCeiling	Construction Internal S	Surface
	<input type="checkbox"/>	Face 283	Wall	Typical Interior Wall	Surface
	<input type="checkbox"/>	Face 284	Wall	Typical Interior Wall	Surface
	<input type="checkbox"/>	Face 285	Wall	Typical Interior Wall	Surface
	<input type="checkbox"/>	Face 281	Floor	Construction Internal S	Ground

Sub-metering

- Sub-metering a commercial building is very expensive
 - Sub-metering all components



Building Energy Modeling

EEM	Cost / Unit	Cost	Source
Occupancy Sensors	\$1.06/ft ²	\$ 44,991	RSMeans, "5 fixtures per 1000 S.F., including occupancy and time switching"
Condensing Boiler	\$20,706 + \$13.82/MBH	\$ 31,401	RSMeans, commercial gas boilers
Light Power Density Reduction	\$4.78/ft ²	\$ 202,886	RSMeans, "Fluorescent high-bay 4 lamp fixture, 1W/sf,59FC, 4 fixtures per 1000 S.F."
Condensing Unit Replacement	\$7,909 + \$766/ton	\$ 132,687	RSMeans, packaged air-cooled refrigerant compressor and condensor
Window Film	\$18.93/ft ² glazing	\$ 182,311	RSMeans, "Solar Films on Glass" average of min/max value
Wall Insulation	\$4.78/ft ² wall area	\$ 927,930	RSMeans, "4 in. EPS insulation, Commercial renovation Exterior Insulation and Finish System",

Building Energy Modeling

Energy Efficiency Measures	Simple Payback
Condensing Boiler	9.4
Occupancy Sensors	10.4
Light Power Density Reduction	32.4
Condensing Unit Replacement	41.2
Window Film	70.7
Wall Insulation	247.0

BUILDING ENERGY MODELING INPUTS

Complexity of Data Collection

Ease of Collection	Variability	Impact on Energy Use	Variable Type	Examples	Inferable for Simple	Inferable for Advanced	Inferable for Beyond Advanced	
Easy	Low	Low	A1	Floor plate type		X	X	
Easy	Low	Medium	A1			X	X	
Easy	Low	High	A1			X	X	
Easy	Medium	Low	A1			X	X	
Easy	Medium	Medium	S1	Floor area	X			
Easy	Medium	High	S1	Building vintage	X	X	X	
Easy	High	Low	S1	Wall type	X	X	X	
Easy	High	Medium	S1	Lighting type	X	X	X	
Easy	High	High	S1		X	X	X	
Moderate	Low	Medium	A2	Insulation thickness				
Moderate	Low	High	A2	Window solar heat		X	X	
Moderate	Medium	Medium	A2	gain coefficient		X	X	
Moderate	Medium	High	S2	Shading dimension	X			
Moderate	High	Medium	S2	HVAC efficiency	X	X	X	
Moderate	High	High	S2		X	X	X	
Moderate	Low	Low	A3	Wall insulation				
Moderate	Medium	Low	A3	thickness		X	X	
Moderate	High	Low	A3	Service hot water efficiency		X	X	
Difficult	Low	Low	BA1	Fan blade efficiencies				
Difficult	Low	Medium	BA1					X
Difficult	Low	High	BA1					X
Difficult	Medium	Low	BA1					X
Difficult	High	Low	BA1					X
Difficult	Medium	Medium	BA2	Air infiltration rates				
Difficult	Medium	High	BA2	Wall insulation R-value			X	
Difficult	High	Medium	BA2				X	
Difficult	High	High	BA2				X	

(a) S = simple level (minimum required set of user inputs).

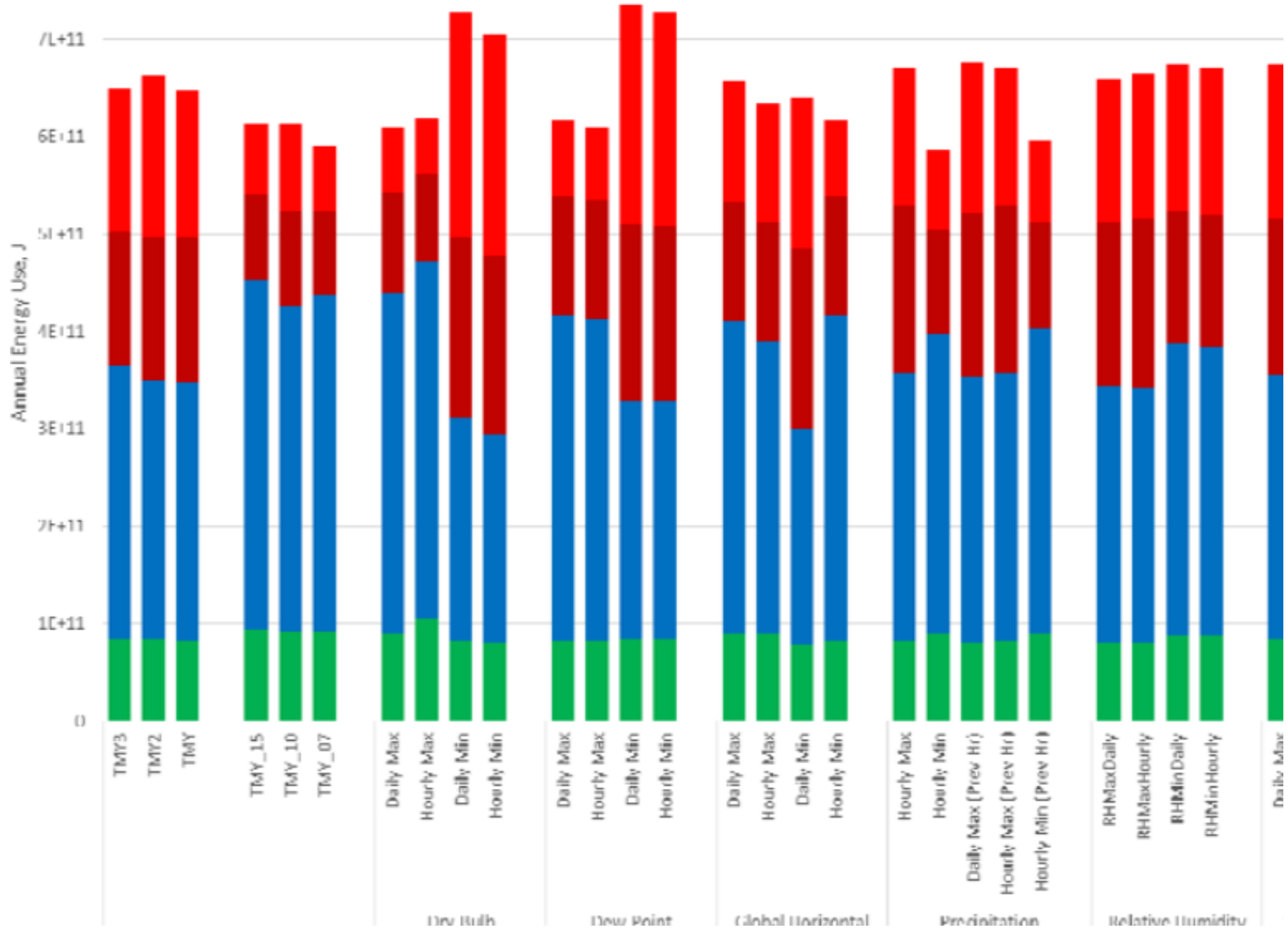
(b) A = advanced level (minimum required set of user inputs for an advanced score).

(c) BA = beyond advanced level (additional user inputs for more accurate results).

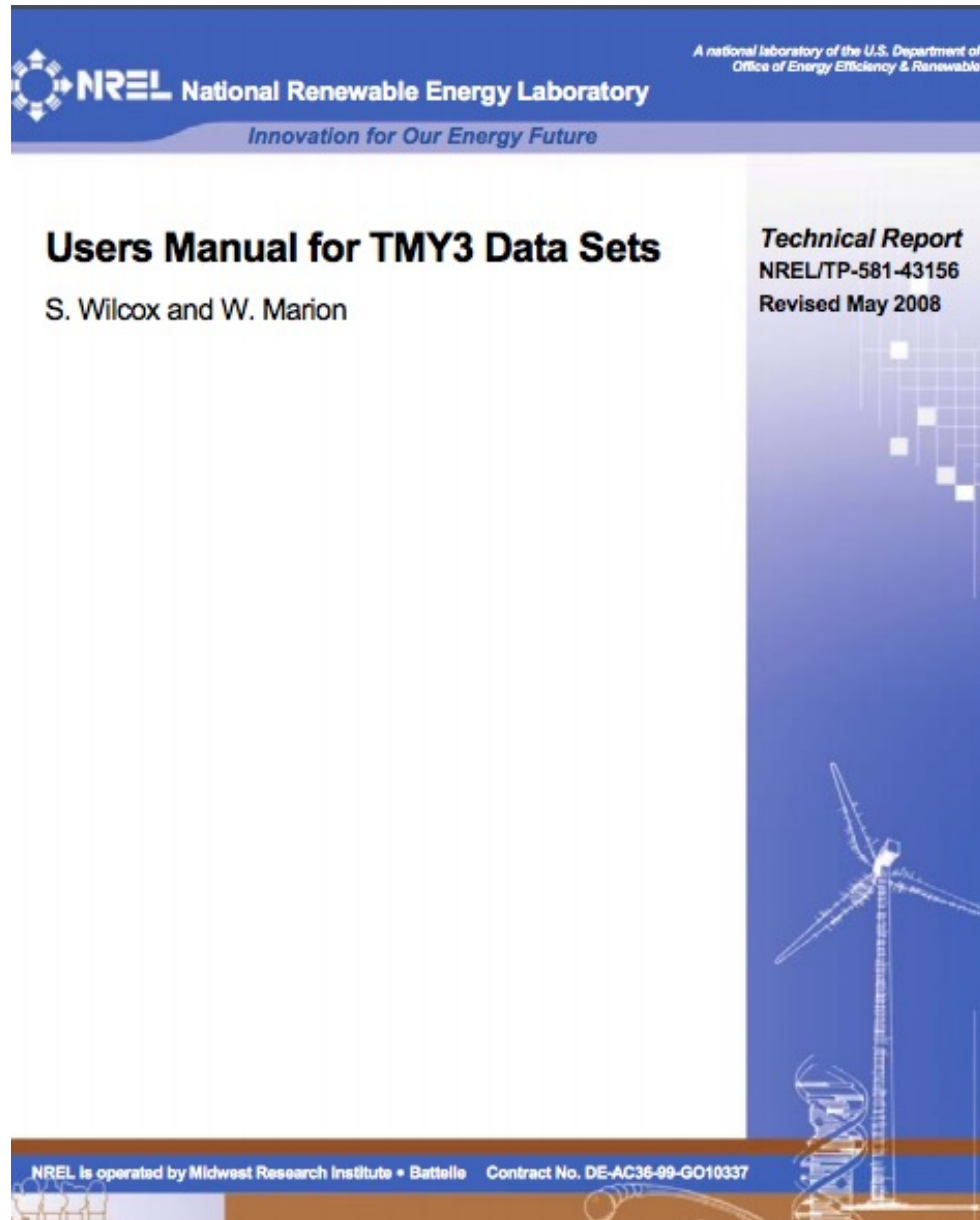
Weather Data

- What is the best option for the selection of a weather data type?
 - Actual Meteorological Year (AMY)
 - Typical Meteorological Year (TMY)
 - eXtreme Meteorological Year (XMY)

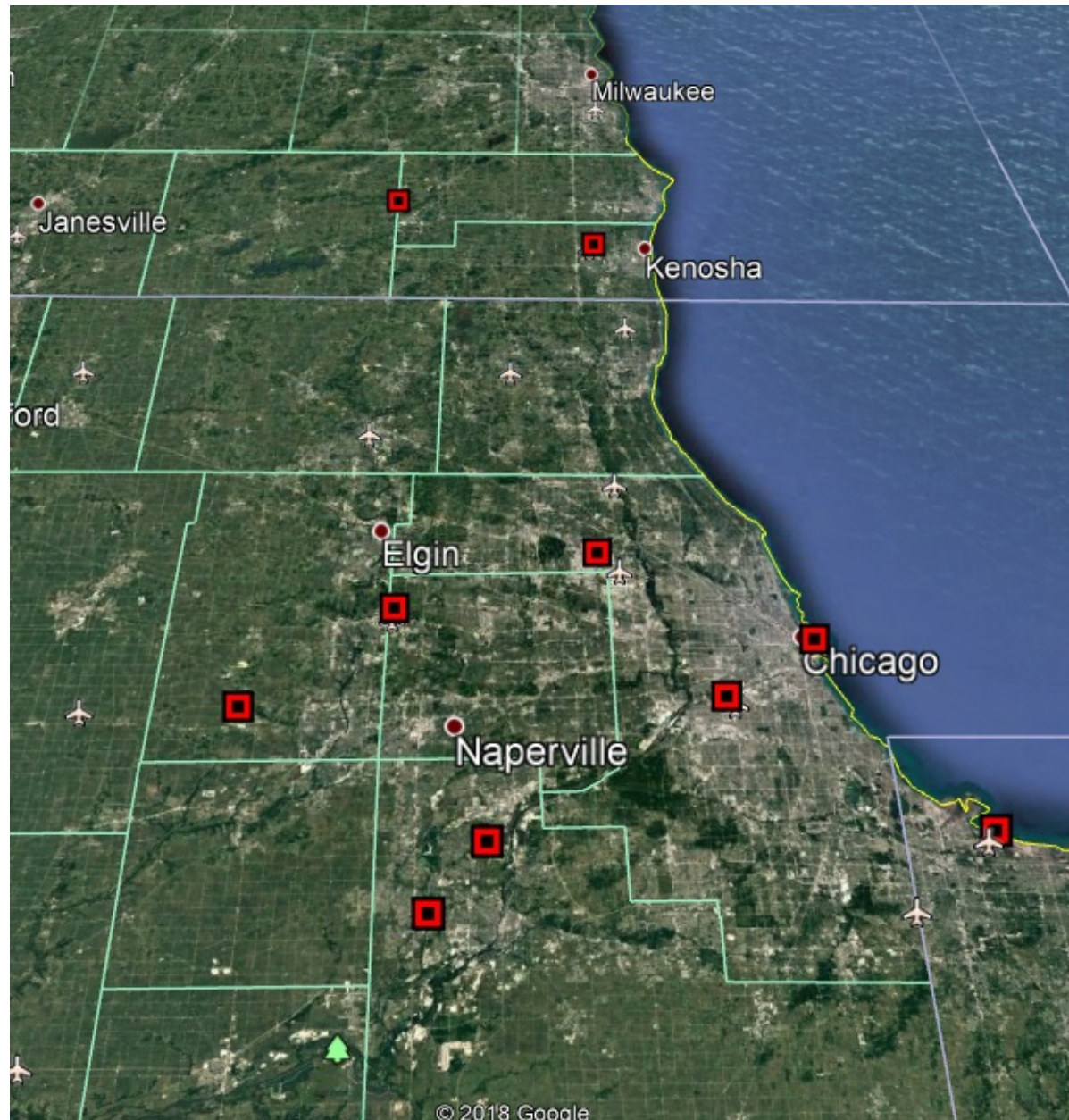
Impacts of Weather Data on Energy Use



Weather Data



Weather Stations in Chicago



IIT Weather Station

Elev 597ft 41.83 °N, 87.63 °W

Chicago, IL

71° ILLINOIS TECH STATION | REPORT | CHANGE

TODAY

HOURLY

10-DAY

CALENDAR

HISTORY

WUNDERMAP

Daily

Weekly

Monthly

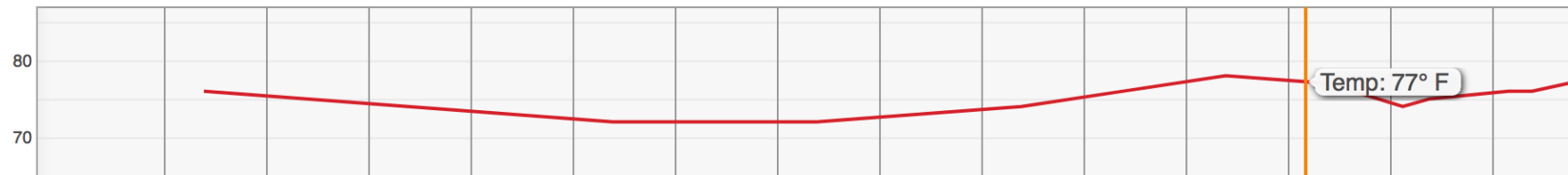
August

20

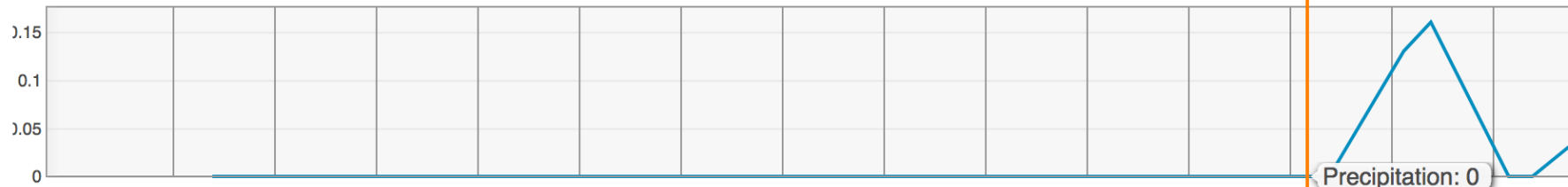
2018

View

12 AM 1 AM 2 AM 3 AM 4 AM 5 AM 6 AM 7 AM 8 AM 9 AM 10 AM 11 AM 12 PM 1 PM 2 F



Temperature



Precipitation

Weather Station Calibration

Daily Observations

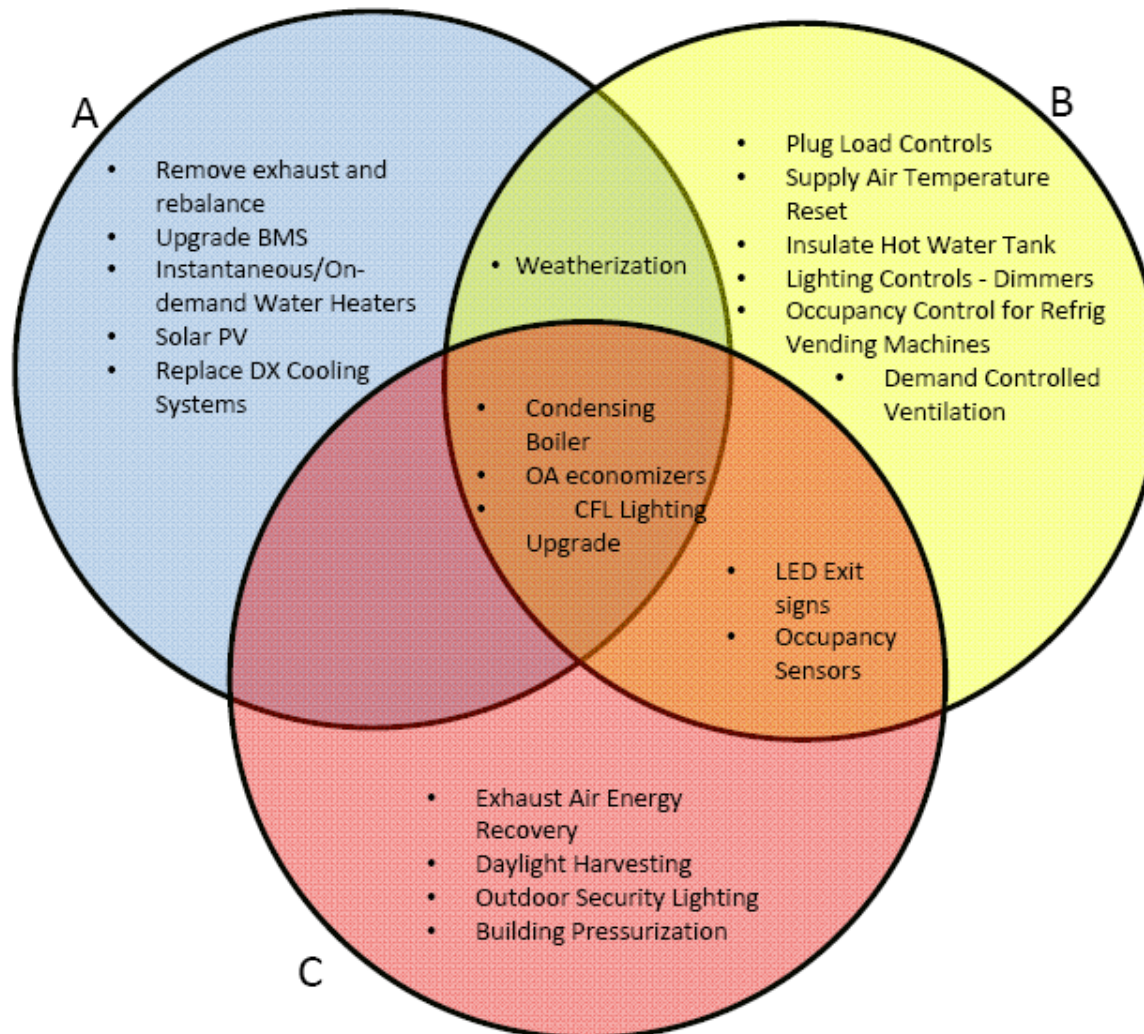


Time	Temperature	Dew Point	Humidity	Wind	Wind Speed	Wind Gust	Pressure	Precip.	Precip Accum	Condition
1:39 PM	76 ° F	72 ° F	87 %	ESE	10 mph	0 mph	29.2 in	0.0 in	0.0 in	Cloudy
12:53 AM	76 ° F	66 ° F	71 %	ESE	8 mph	0 mph	29.3 in	0.0 in	0.0 in	Cloudy
2:53 AM	74 ° F	65 ° F	73 %	SE	8 mph	0 mph	29.3 in	0.0 in	0.0 in	Cloudy
3:53 AM	73 ° F	64 ° F	73 %	ESE	9 mph	0 mph	29.3 in	0.0 in	0.0 in	Mostly Cloudy
4:53 AM	72 ° F	64 ° F	76 %	ESE	10 mph	0 mph	29.3 in	0.0 in	0.0 in	Mostly Cloudy
5:53 AM	72 ° F	64 ° F	76 %	ESE	9 mph	0 mph	29.3 in	0.0 in	0.0 in	Mostly Cloudy
6:53 AM	72 ° F	64 ° F	76 %	ESE	9 mph	0 mph	29.3 in	0.0 in	0.0 in	Mostly Cloudy
7:53 AM	73 ° F	64 ° F	73 %	SE	10 mph	0 mph	29.3 in	0.0 in	0.0 in	Cloudy
8:53 AM	74 ° F	64 ° F	71 %	ESE	13 mph	0 mph	29.3 in	0.0 in	0.0 in	Cloudy
9:53 AM	76 ° F	65 ° F	69 %	E	12 mph	0 mph	29.2 in	0.0 in	0.0 in	Cloudy
10:53 AM	78 ° F	67 ° F	68 %	ESE	15 mph	0 mph	29.2 in	0.0 in	0.0 in	Cloudy
11:53 AM	77 ° F	69 ° F	76 %	E	10 mph	0 mph	29.2 in	0.0 in	0.0 in	Light Rain
12:37 PM	74 ° F	71 ° F	91 %	ESE	8 mph	0 mph	29.2 in	0.1 in	0.0 in	Light Rain
12:53 PM	75 ° F	72 ° F	90 %	E	8 mph	0 mph	29.2 in	0.2 in	0.0 in	Rain
1:53 AM	75 ° F	65 ° F	71 %	SE	10 mph	0 mph	29.3 in	0.0 in	0.0 in	Cloudy
1:53 PM	76 ° F	72 ° F	87 %	ESE	17 mph	23 mph	29.2 in	0.0 in	0.0 in	Cloudy
2:14 PM	77 ° F	73 ° F	88 %	E	20 mph	0 mph	29.2 in	0.0 in	0.0 in	Mostly Cloudy
2:53 PM	77 ° F	73 ° F	88 %	E	14 mph	23 mph	29.2 in	0.0 in	0.0 in	Cloudy
3:00 PM	76 ° F	72 ° F	87 %	E	14 mph	0 mph	29.1 in	0.0 in	0.0 in	Cloudy
3:53 PM	77 ° F	72 ° F	84 %	ESE	14 mph	0 mph	29.1 in	0.0 in	0.0 in	Cloudy
4:53 PM	78 ° F	73 ° F	84 %	ESE	13 mph	0 mph	29.1 in	0.0 in	0.0 in	Cloudy
5:53 PM	79 ° F	71 ° F	77 %	ESE	17 mph	22 mph	29.1 in	0.0 in	0.0 in	Mostly Cloudy

BUILDING ENERGY RETROFIT

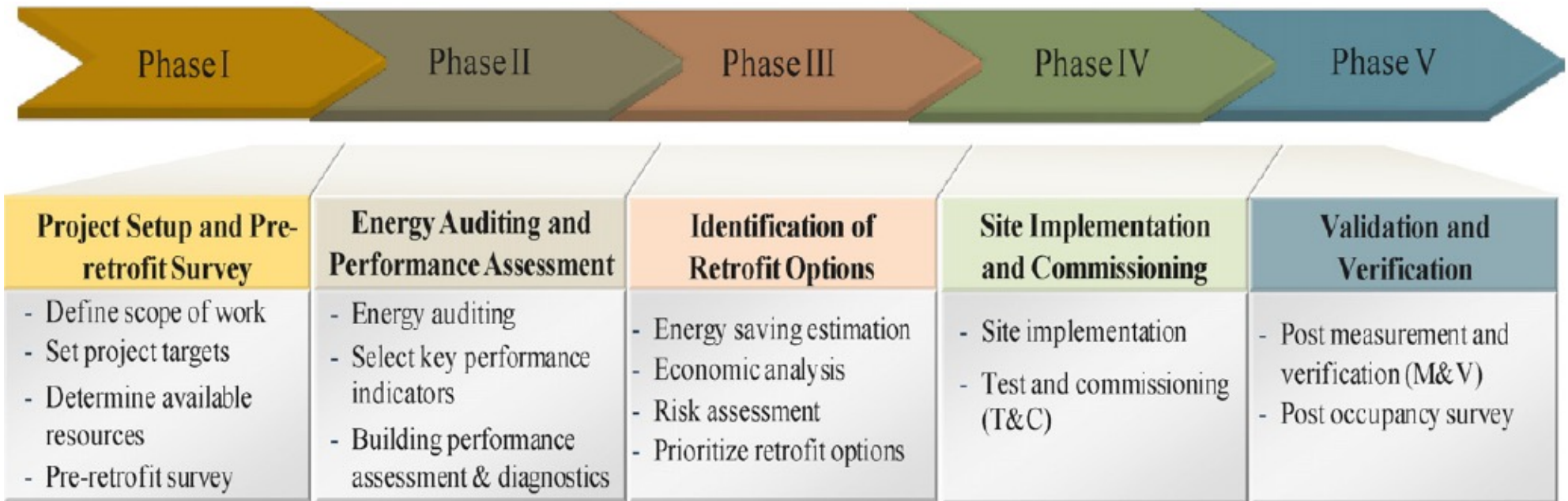
Retrofit Suggestions

- Can we assume all auditors suggest the same retrofit packages?



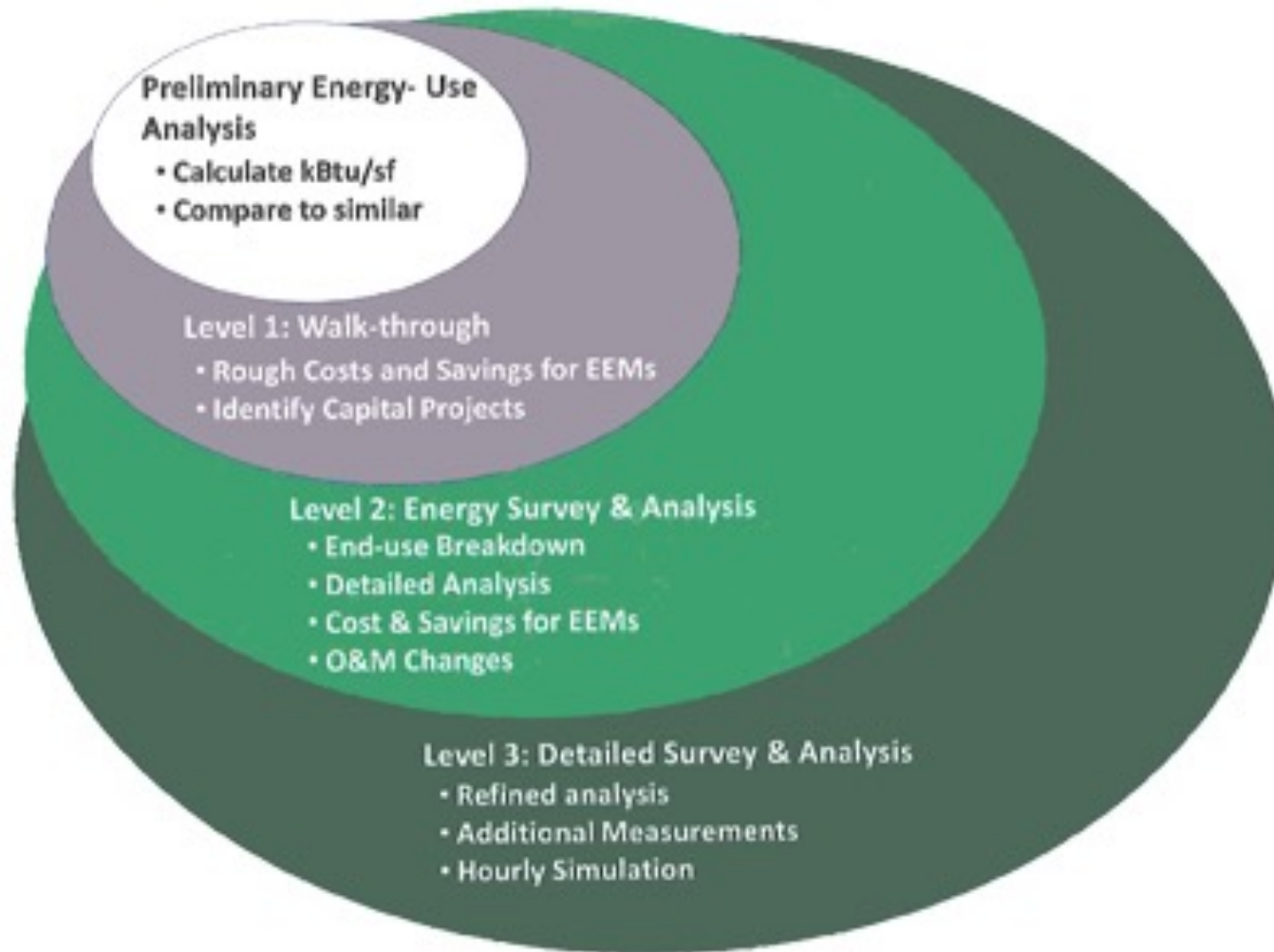
Retrofit Phases

- Suggested retrofit phases



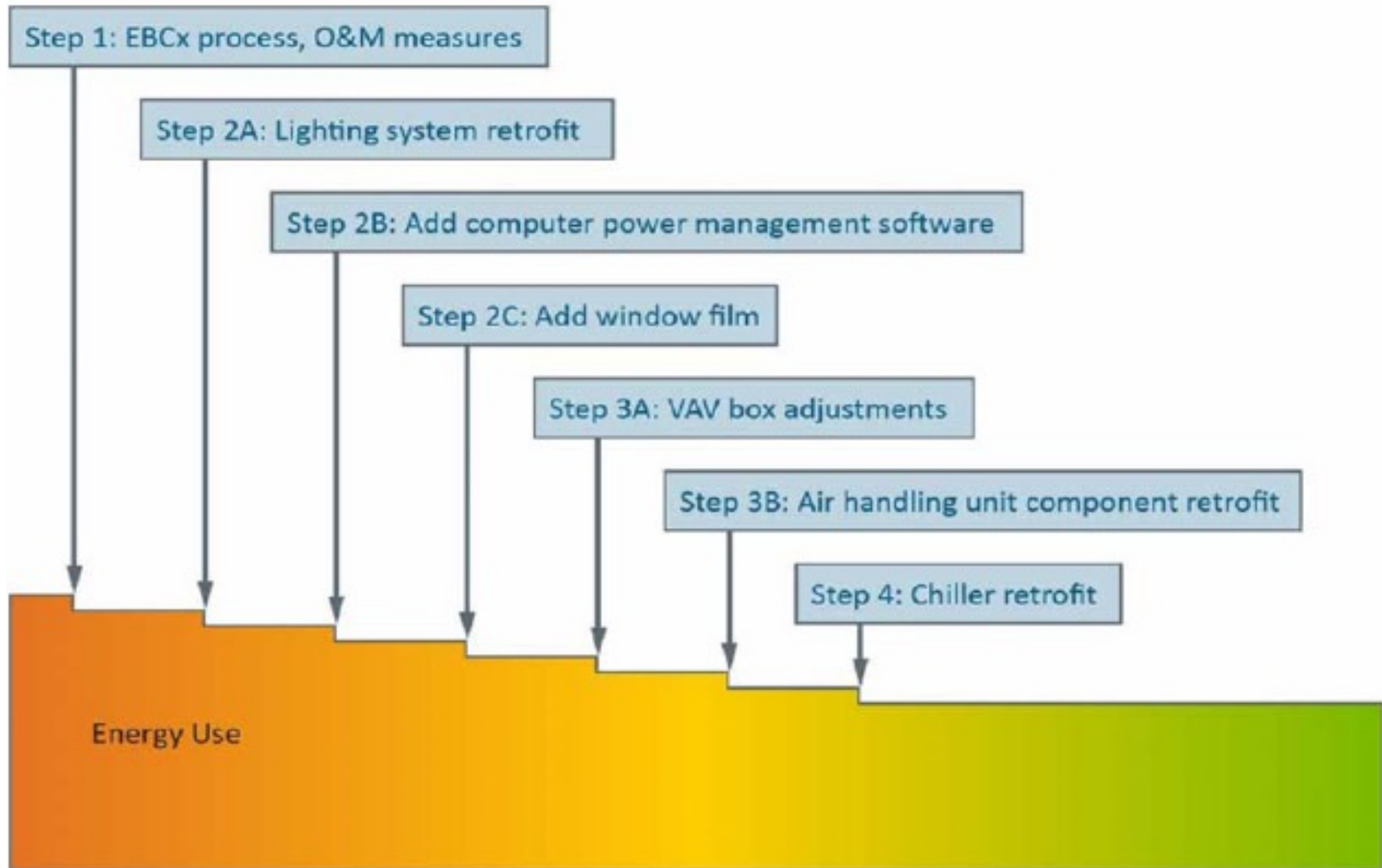
ASHRAE Audit Levels

- Suggested retrofit phases



Retrofit Path

- Why do we consider this path?



BUILDING ENERGY MODELING WITH OPENSTUDIO

OpenStudio

baseline_sys07.osm

File Preferences Components & Measures Help

Site: Weather File & Design Days Life Cycle Costs Utility Bills

Weather File

Name: 2207942878
 Latitude: 39.096
 Longitude: -76.82
 Elevation: 52
 Time Zone: -5
 Download weather files at www.energyplus.net/weather

Measure Tags (Optional):

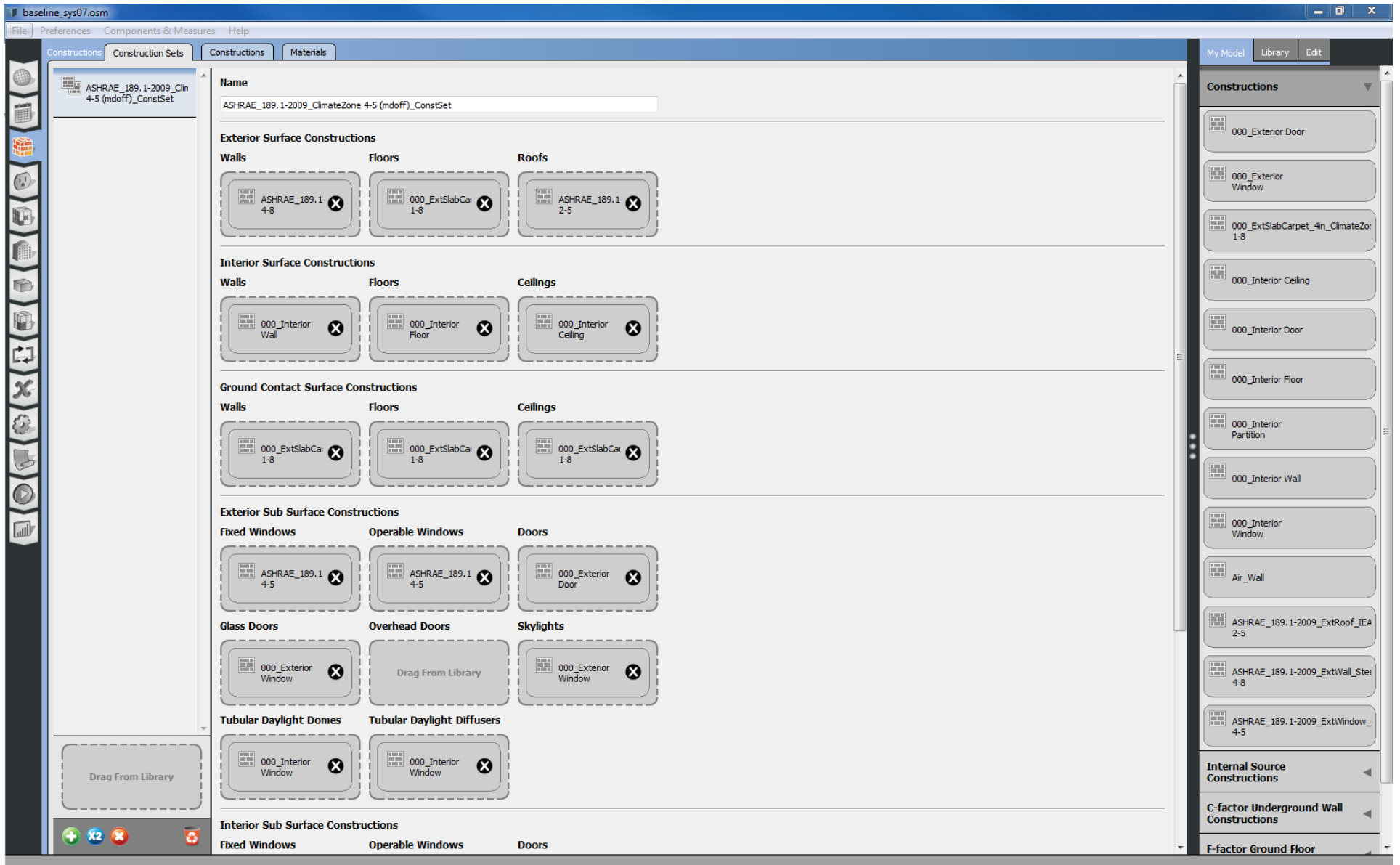
ASHRAE Climate Zone
 CEC Climate Zone

Design Days

Design Days

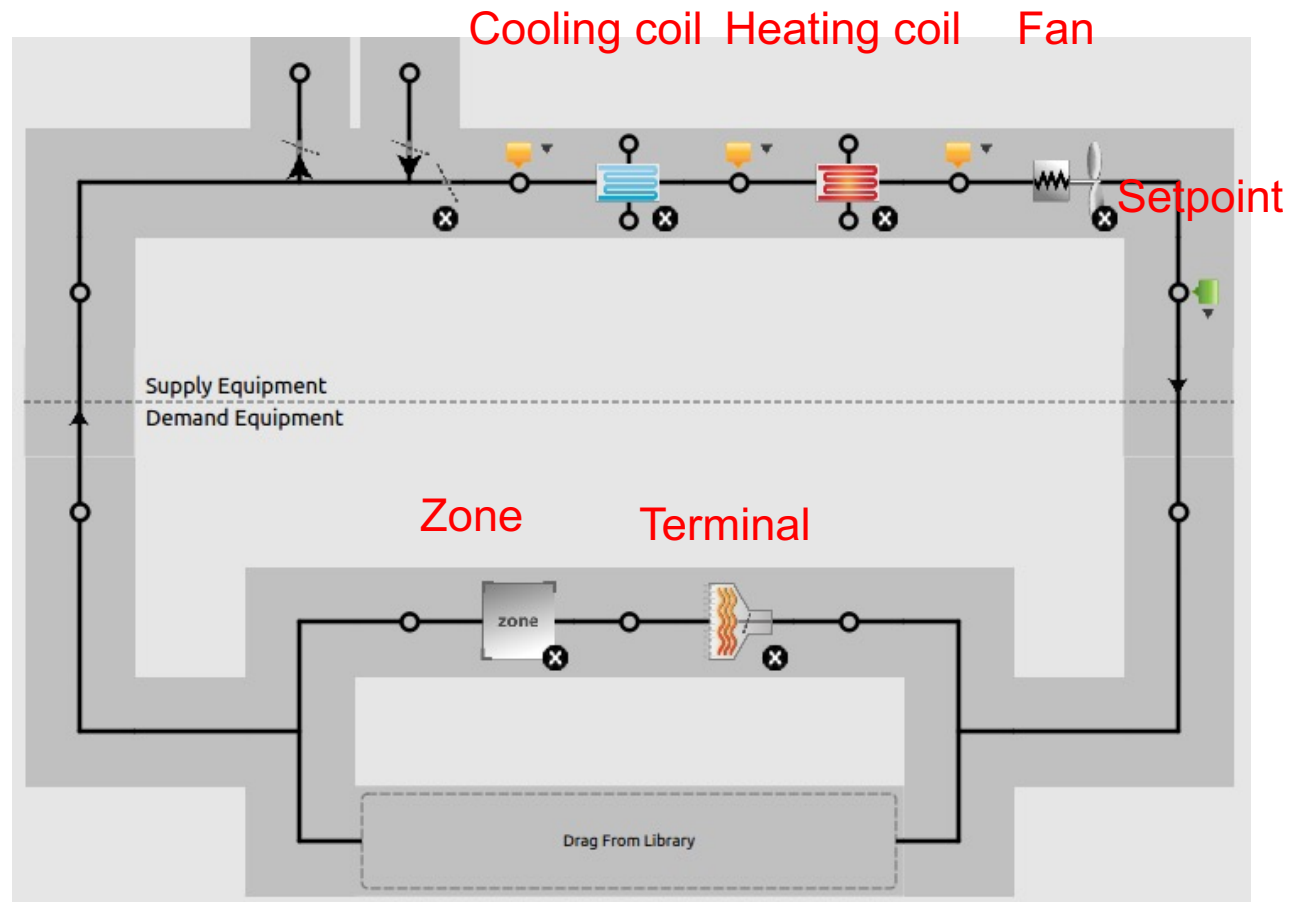
Design Day Name	All	Day Of Month	Month	Day Type	Daylight Saving Time Indicator
	<input type="checkbox"/>	<input type="text" value="Apply to Selected"/>	<input type="text" value="Apply to Selected"/>	<input type="text" value="Apply to Selected"/>	
cago Ohare Intl Ap Ann Clg .4% Conds DB=>MWB	<input type="checkbox"/>	<input type="text" value="21"/>	<input type="text" value="7"/>	<input type="text" value="SummerDesignDay"/>	<input type="checkbox"/>
icago Ohare Intl Ap Ann Clg .4% Conds DP=>MDB	<input type="checkbox"/>	<input type="text" value="21"/>	<input type="text" value="7"/>	<input type="text" value="SummerDesignDay"/>	<input type="checkbox"/>
ago Ohare Intl Ap Ann Clg .4% Conds Enth=>MDB	<input type="checkbox"/>	<input type="text" value="21"/>	<input type="text" value="7"/>	<input type="text" value="SummerDesignDay"/>	<input type="checkbox"/>
cago Ohare Intl Ap Ann Clg .4% Conds WB=>MDB	<input type="checkbox"/>	<input type="text" value="21"/>	<input type="text" value="7"/>	<input type="text" value="SummerDesignDay"/>	<input type="checkbox"/>
Chicago Ohare Intl Ap Ann Htg 99.6% Conds DB	<input type="checkbox"/>	<input type="text" value="21"/>	<input type="text" value="1"/>	<input type="text" value="WinterDesignDay"/>	<input type="checkbox"/>
e Intl Ap Ann Htg Wind 99.6% Conds WS=>MCDB	<input type="checkbox"/>	<input type="text" value="21"/>	<input type="text" value="1"/>	<input type="text" value="WinterDesignDay"/>	<input type="checkbox"/>
hare Intl Ap Ann Hum_n 99.6% Conds DP=>MCDB	<input type="checkbox"/>	<input type="text" value="21"/>	<input type="text" value="1"/>	<input type="text" value="WinterDesignDay"/>	<input type="checkbox"/>

OpenStudio



OpenStudio

- Air loop
 - Cooling coil
 - Heating coil
 - Fan
 - Setpoint manager
 - Zone
 - Terminal



Heating and Cooling Systems



Heating and Cooling Systems



RETROFIT INCENTIVES

Cooking Appliances

Energy Efficient Cooking Appliances Comparison

Appliance	Temperature	Time	Energy	Cost
Electric Oven	350	1 hour	2.0 kWh	\$.16
Electric Convection Oven	325	45 min.	1.39 kWh	\$.11
Gas Oven	350	1 hour	.112 therm	\$.07
Electric Frying Pan	420	1 hour	.9 kWh	\$.07
Toaster Oven	425	50 min.	.95 kWh	\$.08
Electric Crockpot	200	7 hours	.7 kWh	\$.06
Microwave Oven	"High"	15 min.	.36 kWh	\$.03

Source: consumerenergycenter.org

Rebate Programs

Apply Online or Check Rebate Status [Get Started](#)



Upgrade your heating and cooling systems to boost your energy efficiency and save with ComEd Rebates when a ComEd Energy Efficiency Service Provider installs these home improvements.

For a closer look at qualifying rebates, see more [program details](#).

Equipment	Type	Maximum Rebate Amount*
Central Air Conditioner	≥ 18 SEER	\$600
Central Air Conditioner	≥ 16 SEER	\$400
Central Air Conditioner	≥ 15 SEER	\$300
Furnace Blower Motor (ECM)	Upgraded fan in an existing furnace or air handler	\$100
Furnace Blower Motor (ECM)	Factory-installed	\$50
Air Source Heat Pump	≥ 18 SEER	\$600
Air Source Heat Pump	≥ 16 SEER	\$500
Air Source Heat Pump	≥ 14.5 SEER	\$400
Ductless Mini-Split Heat Pump	≥ 17 SEER and ≥ 9.5 HSPF	\$400
Geothermal (ground source) Heat Pump System (including loop)	Installation must be pre-approved and completed by a GAOI-certified ComEd Energy Efficiency Service Provider	\$1,000 per ton, up to \$6,000 per home max
Geothermal (ground source) Heat Pump Indoor Unit Replacement	≥ 20 EER Installation must be completed by a GAOI-certified ComEd Energy Efficiency Service Provider	\$1,200

Rebate Programs

Appliance Rebates

Apply Online or Check Rebate Status [Get Started](#)



Every appliance comes with two price tags: the purchase price and the cost of operating the product. ENERGY STAR® certified appliances help consumers save money on operating costs by reducing energy use without sacrificing performance. ComEd appliance rebates put the power to save directly into your hands. Rebates are available on these ENERGY STAR certified appliances when purchased in store or online.

ENERGY STAR® Appliance	Requirement	Rebate
Air Purifier	---	\$50
Clothes Washer	---	\$50
Dehumidifier (stand alone unit only)	---	\$50
Electric Clothes Dryer	≥ 4.4 Cubic Feet	\$50
Freezer	≥ 7.75 Cubic Feet	\$50
Refrigerator	≥ 7.75 Cubic Feet	\$50
Room Air Conditioner	---	\$25

Look for EnergyStar Labels

The image shows a yellow EnergyGuide label for a refrigerator-freezer. At the top, it says 'U.S. Government' and 'Federal law prohibits removal of this label before consumer purchase.' The title 'ENERGYGUIDE' is in large black letters with a downward arrow. Below the title, it lists 'Refrigerator-Freezer' with features: 'Automatic Defrost', 'Side-Mounted Freezer', and 'Through-the-Door Ice'. To the right, it says 'XYZ Corporation', 'Model ABC-L', and 'Capacity: 23 Cubic Feet'. The central section is titled 'Estimated Yearly Operating Cost' and shows '\$67' in a large font, with a horizontal line below it representing a 'Cost Range of Similar Models' from '\$57' to '\$74'. Below this, it shows '630 kWh' in a large font, labeled 'Estimated Yearly Electricity Use'. At the bottom, it says 'Your cost will depend on your utility rates and use.' and includes a list of three footnotes. The Energy Star logo is in the bottom right corner.

U.S. Government Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Refrigerator-Freezer

- Automatic Defrost
- Side-Mounted Freezer
- Through-the-Door Ice

XYZ Corporation
Model ABC-L
Capacity: 23 Cubic Feet

Estimated Yearly Operating Cost

\$67

\$57 \$74

Cost Range of Similar Models

630 kWh

Estimated Yearly Electricity Use

Your cost will depend on your utility rates and use.

- Cost range based only on models of similar capacity with automatic defrost, side-mounted freezer, and through-the-door ice.
- Estimated operating cost based on a 2007 national average electricity cost of 10.65 cents per kWh.
- For more information, visit www.ftc.gov/appliances.

ENERGY STAR

Callout 1 (top left): Lists key features of the appliance you're looking at and the similar models that make up the cost range below.

Callout 2 (top right): The maker, model, and size tell you exactly what product this label describes.

Callout 3 (middle left): What you might pay to run the appliance for a year, based on its electricity use and the national average cost of energy. The cost appears on labels for all models and brands, so you can compare energy use just like you would price or other features.

Callout 4 (middle right): The cost range helps you compare the energy use of different models by showing you the range of operating costs for models with similar features.

Callout 5 (bottom left): An estimate of how much electricity the appliance uses in a year based on typical use. Multiply this by your local electricity rate on your utility bill to better judge what your actual operating cost might be.

Callout 6 (bottom right): If you see the ENERGY STAR logo, it means the product is better for the environment because it uses less energy than standard models.

Smart Thermostats

- Examples of smart thermostats and associate savings

- Targeting buildings with standalone rooftop units

Building	Qty of Rooftop Units
Perlstein	19
Siegel	7
Alumni	3
Machinery	1



- Smart thermostats provide many improvements:

- Programmable schedules
- Setback temperatures at night / weekends
- Remote access for maintenance staff
- Smart recovery

- Annual energy savings of:

- 500,000 KBTU



Home Electric Measurements & Utilities

- Advanced Power Strips



TRICKLESTAR 7-OUTLET APS

\$12

 After a \$10 Instant Rebate

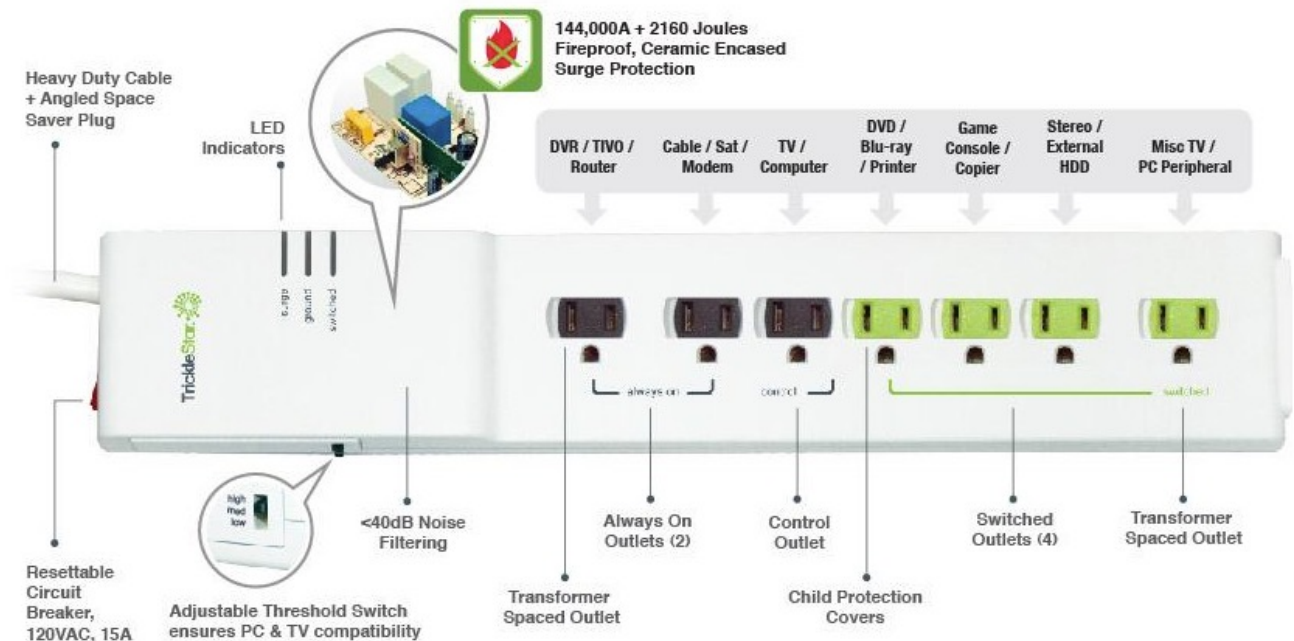


TRICKLESTAR 7-OUTLET MULTI SENSING
APS

\$48

Home Electric Measurements & Utilities

- Advanced Power Strips works based on the idea of plug load managements. They include:
 - Couple of controlled outlets:
 - Different thresholds (e.g. 10 W, 22 W, and 42 W)
 - 1-2 always on outlet(s)
 - 1 master outlet



Weatherization

Weatherization Rebates

Stay comfortable all year round and save money now with instant discounts for weatherization upgrades. You can receive up to \$1,600 in instant discounts from ComEd and your natural gas company for qualifying projects when you use a ComEd Energy Efficiency Service Provider.



Customers that use electricity delivered by ComEd for the majority of their home's heating, or natural gas provided by Nicor Gas, Peoples Gas or North Shore Gas for the majority of their home's heating, may be eligible for the following rebates.

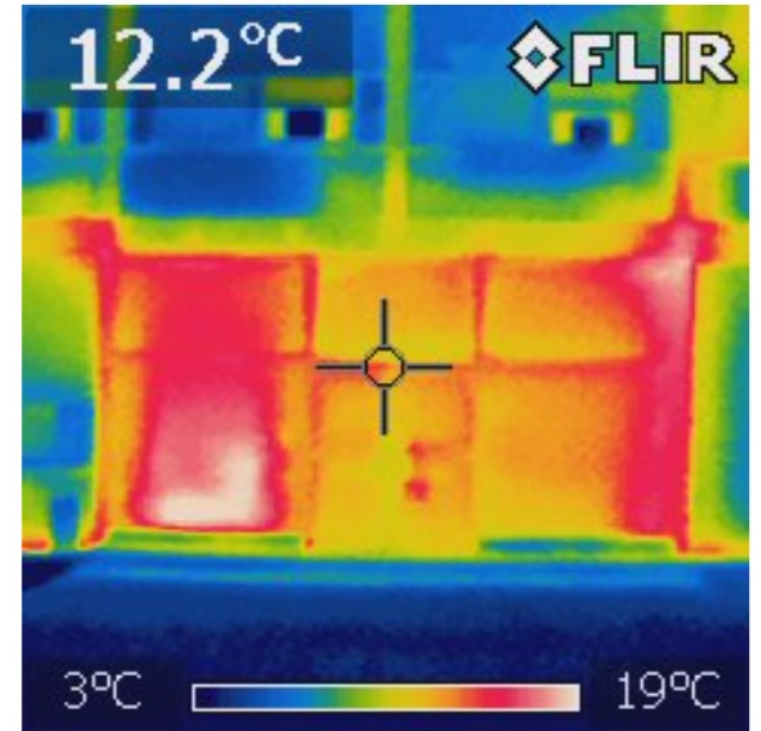
Improvement	Maximum Rebate per Home
Attic Insulation	\$300
Air Sealing	\$400
Wall Insulation	\$400
Duct Sealing	\$500

Weatherization

Infrared image of a home



Weatherization



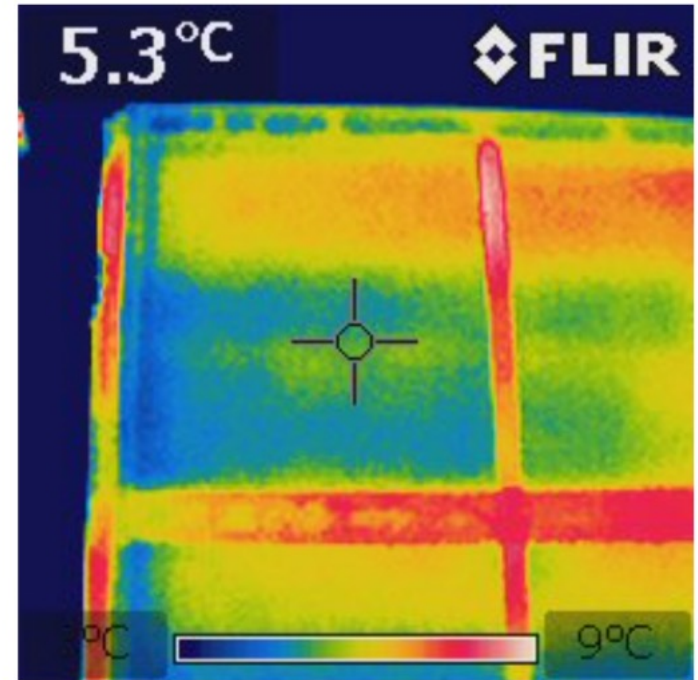
37.4 F

66.2 F

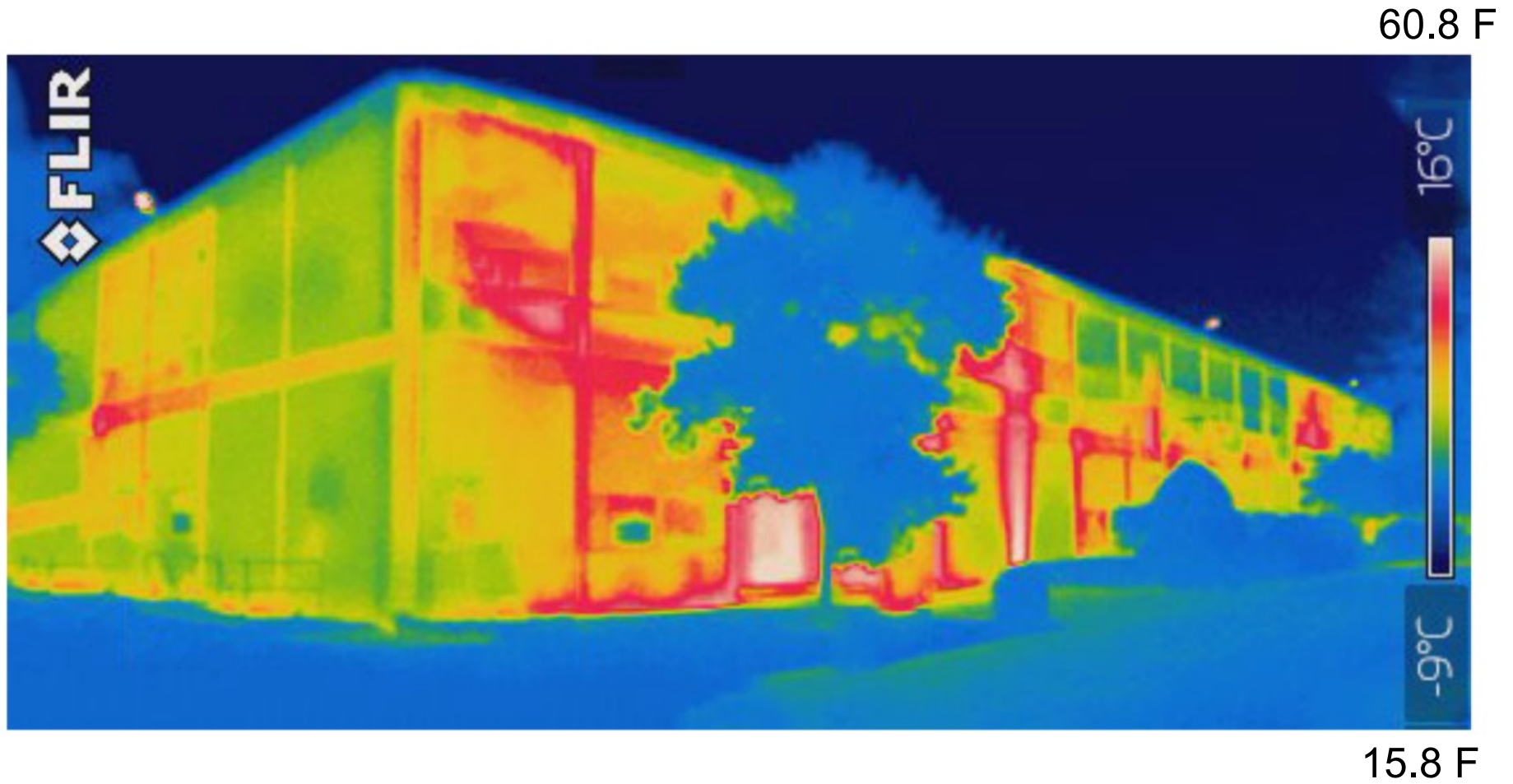
Weatherization



41.5 F



Weatherization



Weatherization

- Examples of insulating the system

Brick layer: 4" thick, R-0.6 (IP)

Fiberglass insulation and studs: 6" thick, R-21.3 (IP)

Wood studs: 6" thick, R-6.5 (IP)

Gypsum board: 0.5" thick, R-0.4 (IP)



Weatherization

