

CAE 465/526 Building Energy Conservation Technologies

Fall 2023

November 16, 2023
Examples and utility programs

Built
Environment
Research

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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

PROJECT

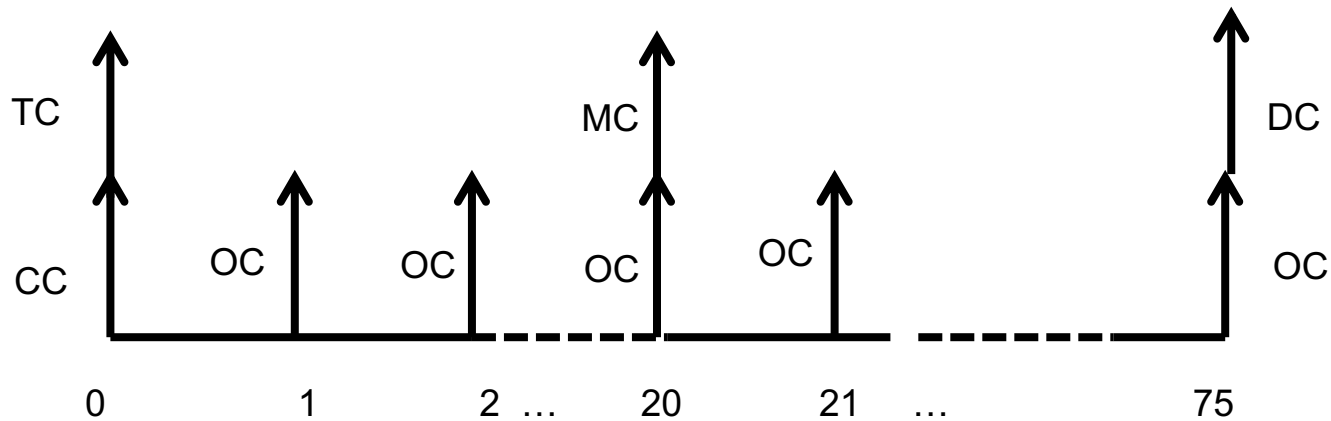
Project

- It is fine to submit Part 1 with Part 2 if you would like to spend more time
- November 28, 2023 is a hard deadline

NET PRESENT VALUE

Net Present Value

- Did you draw the cash flow to calculate the NPV?



- How does the equation look like?

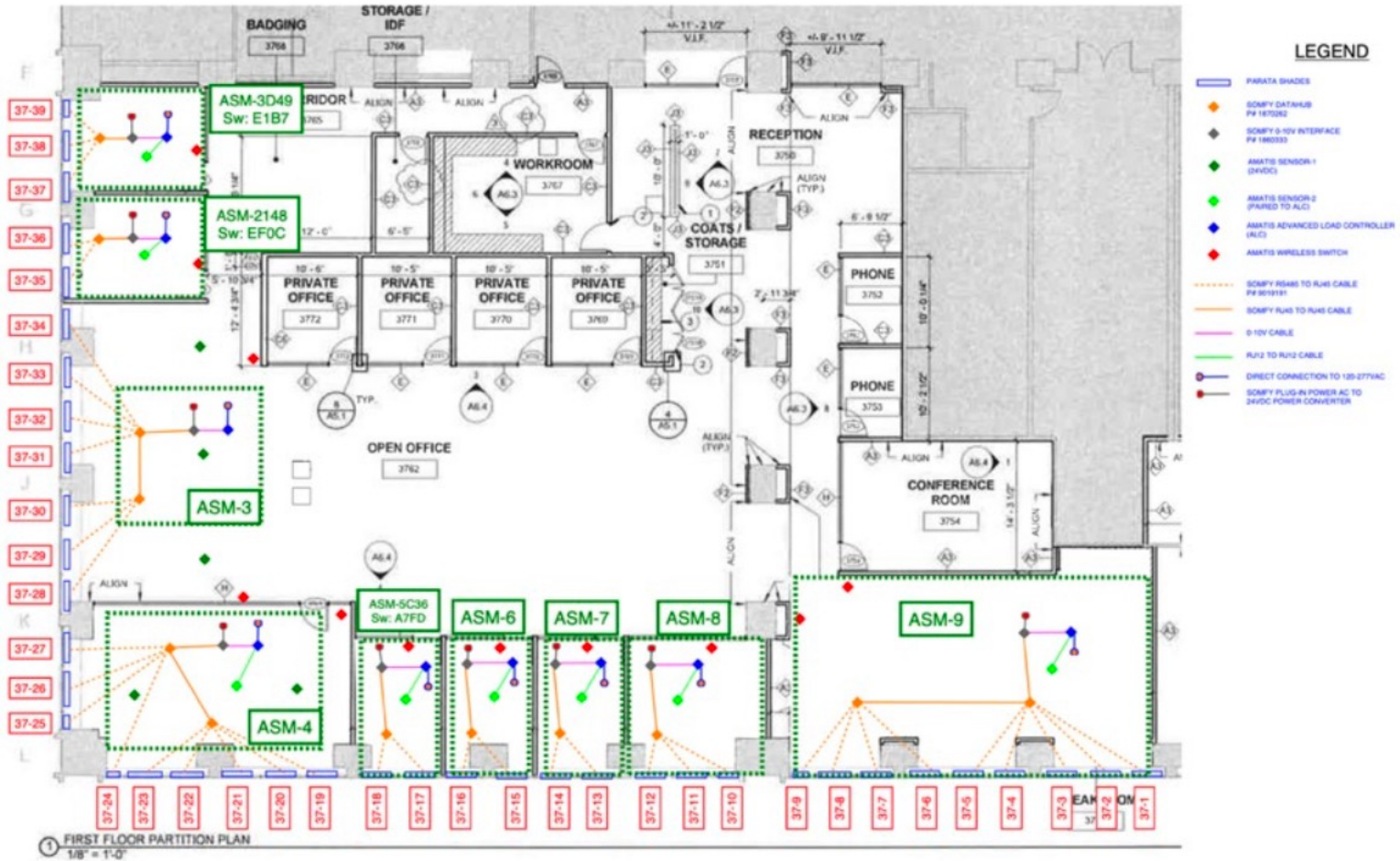
Net Present Value

$$NPV(i, N) = (CC + TC) + \frac{OC}{(1+i)^1} + \frac{OC}{(1+i)^2} + \dots + \frac{OC+MC}{(1+i)^{20}} + \dots$$
$$\dots + \frac{DC}{(1+i)^{75}}$$

PAYBACK PERIOD

Payback Period

- Let's look at an example:



Payback Period

- Let's look at an example:

Payback Period

- Let's look at an example:

Payback Period

- Let's look at an example:

DATA CLEANING

Data Cleaning

- Let's look at an example:
 - Meter
 - Consumption

Data Cleaning

- Let's look at an example:
 - Meter
 - Consumption

SETPOINT

Setpoint

- Energy data versus outdoor air temperature

Setpoint

- Energy data versus outdoor air temperature

Setpoint

- Energy data versus outdoor air temperature

SENSITIVITY ANALYSIS

Sensitivity Analysis

Sensitivity Analysis

UTILITY RATES

Utility Rates

- We are mostly aware of the flat rates, but there are time varying pricing utility rates. A few examples are:
 - Real-time pricing
 - Day-ahead pricing
 - Block and index pricing

Utility Rates

- Time varying utility programs are important. Why?

CAPITAL WEATHER GANG

Extreme heat pushes highs over 110 in Texas as power grid nears brink

The Electric Reliability Council of Texas projects record-high demand as temperatures skyrocket



By Matthew Cappucci

July 11, 2022 at 11:46 a.m. EDT

Texans urged to save energy as extreme heatwave strains power grid

Electricity demand expected to surpass supply as temperatures hit triple digits, shattering records



DEEP DIVE

The power grid faced heat waves, record demand and tight conditions in 2022. What happens next?

All over the country, a changing climate and extreme weather events – whether due to high temperatures, low temperatures or storms and hurricanes – are posing a threat to grid reliability in the U.S.

From Sichuan to California, Extreme Heat Is Pushing the Grid to Its Limit

A range of solutions, from market-based conservation measures to better grid infrastructure, could help prepare the electricity system for future extremes.

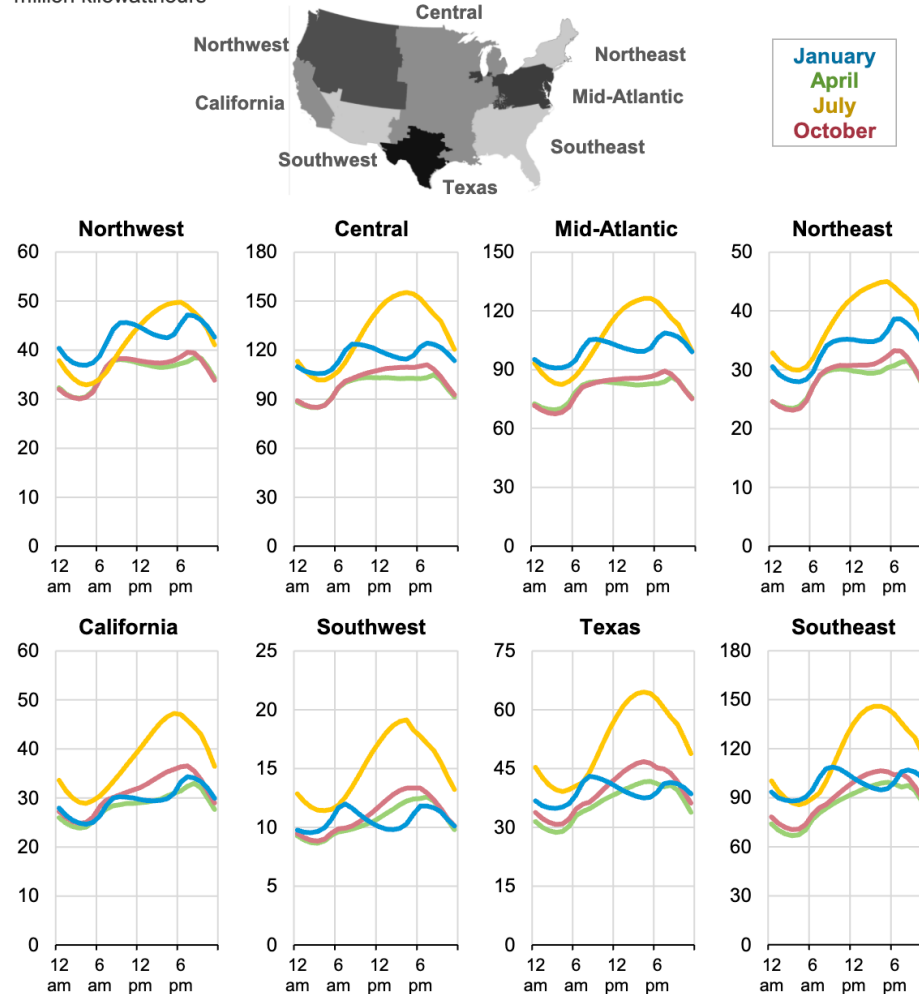
November 23, 2022

By Zihao Chen, Shuo GAO

Utility Rates

- Time varying utility programs are important. Why?

Average hourly electricity load during typical day by region, selected months
million kilowatthours



Source: U.S. Energy Information Administration, *U.S. Hourly Electric Grid Monitor*
Note: Hourly load shown is displayed for each region's local time zone.

Utility Rates

- **Demand response (DR)** is defined as “Changes in electric usage by end-use customers from their normal consumption patterns in response to:
 - Changes in the price of electricity over time
 - Incentive payments designed to induce lower electricity use at times of high wholesale market prices
 - When system reliability is jeopardized

Utility Rates

Demand Response and Time-Variable Pricing Programs

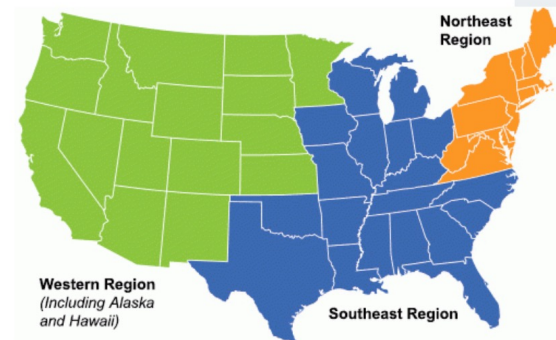
[Home](#) » Demand Response and Time-Variable Pricing Programs

The Federal Energy Management Program developed profiles of demand response and time-variable pricing programs throughout the United States. These profiles are grouped regionally by state.

- [Western States](#)
- [Northeastern States](#)
- [Southeastern and Midwestern States](#)

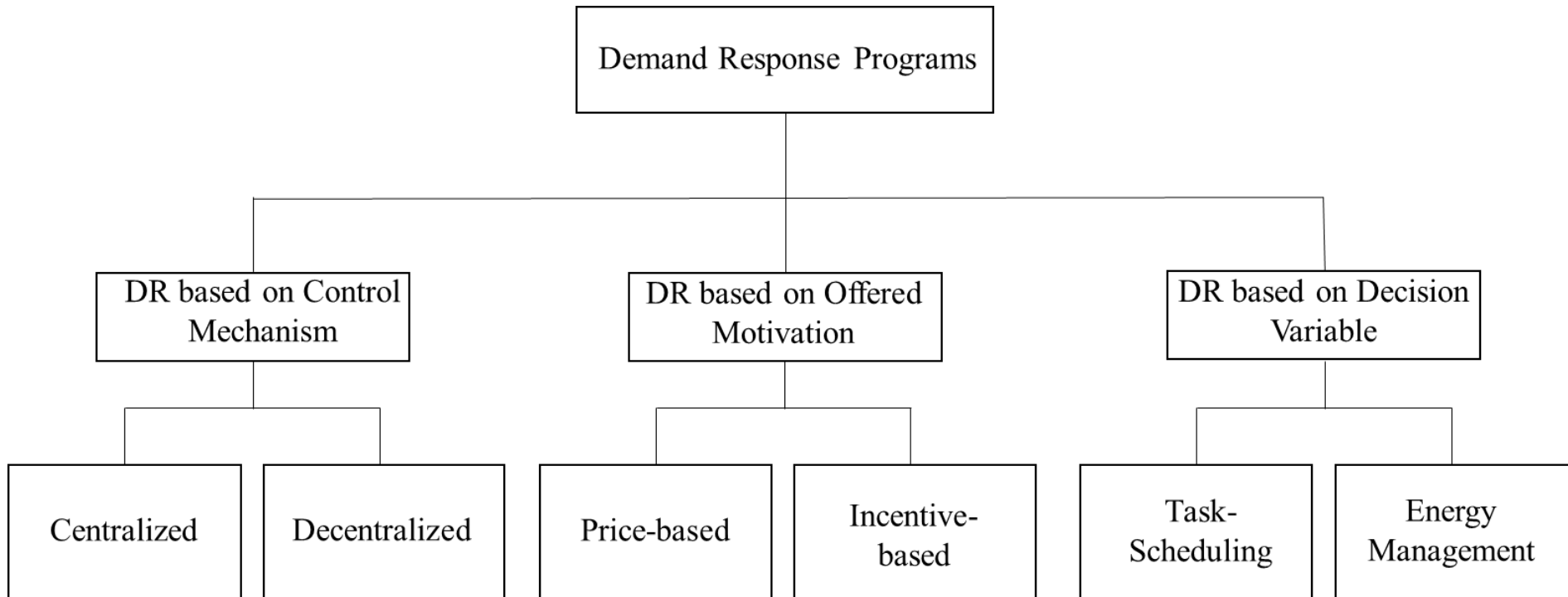
Demand response (DR) is a short-term, voluntary decrease in electrical consumption by end-use customers that is generally triggered by compromised grid reliability or high wholesale market prices. In exchange for conducting (and sometimes just committing) to curtail their load, customers are remunerated.

The majority of U.S. utilities offer their commercial and industrial customers at least some kind of DR option. In addition, the country's seven independent system operators/regional transmission organizations (ISO/RTOs) each sponsor DR programs.



Utility Rates

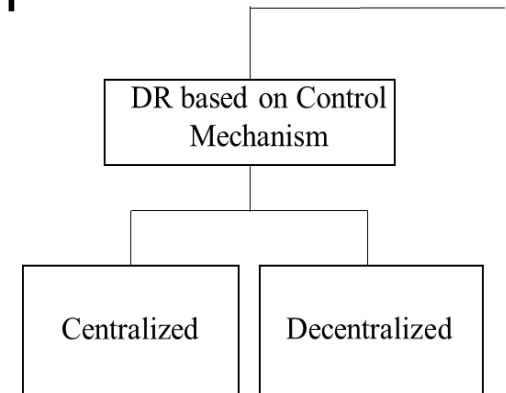
- We can look at the DR programs from this perspective:



Utility Rates

- The control mechanism is with interaction of power utility and its consumers:

- In Centralized section, the consumers directly communicate with power utility, without interacting with each



- In the distributed program the interaction between consumers gives information to the utility about total consumption. In this method, the consumers have information about grid state and are able to react, if the system's state is critical

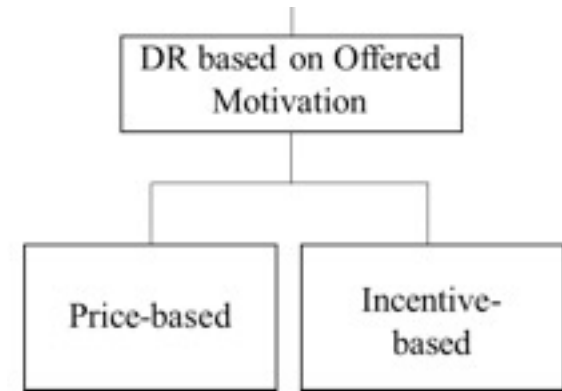
Utility Rates

- This DR is based on the motivation offered by provider to encourage the consumers to reduce the consumption which is based on:
 - The price-based (or time-based)
 - Incentive-based



Utility Rates

- In price-based, consumers are granted time-varying prices based on electricity costs in different time period:
 - Flat Pricing (FP)
 - Time of Use (TOU)
 - Critical Peak Pricing (CPP)
 - Peak Load Pricing (PLP)
 - Peak Day Rebate (PDR)
 - Real Time Pricing (RTP)



Utility Rates

- In *Flat Pricing*, customers know that the only way that they can reduce electricity bills is the reduction of electricity consumption

Utility Rates

- *Time of Use* is originally a flat pricing with its application in different time periods
- In this method the consumers are charged different rates for energy they consume in different period of Day.
 - Off-peak
 - Mid-peak
 - Peak

Utility Rates

Summer TOU utility costs and hours for commercial buildings in 7 major cities (cents/kWh)

City \ Rate	On-Peak	Mid-Peak	Off-Peak (Base)	Months
Austin	6.54 (2 PM – 8 PM)	3.91 (6 AM – 2 PM & 8 PM – 10 PM)	0.67 (10 PM – 6 AM)	Jun. to Sept.
Minnesota	15.13 (9 AM – 9 PM)	N/A	3.02 (9 PM – 9 AM)	Jun. to Sept.
Honolulu	16.9	16.9	16	All Year
New York City	18.99 (8 AM – 12 AM)	N/A	1.34 (12 AM – 8 AM)	Jun. to Sept.
Chicago	18.99 (8 AM – 12 AM)	N/A	1.34 (12 AM – 8 AM)	Jun. to Sept.
San Francisco	25.8 (12 PM – 6 PM)	23.4 (8:30 AM – 12 PM & 6 AM – 9:30 PM)	20.7 (12 AM – 8:30 AM & 9:30 PM – 12 AM)	May to Oct.
Phoenix (Summer)	15.41 (2 PM – 7 PM)	10.50 (11 AM – 2 PM & 7 PM – 11 PM)	5.48 (12 AM – 11 AM)	May to Oct.
Phoenix (Summer Peak)	16.48 (2 PM – 7 PM)	10.70 (11 AM – 2 PM & 7 PM – 11 PM)	5.15 (12 AM – 11 AM)	July to Aug.

Utility Rates

Summer TOU utility costs and hours for residential buildings in 7 major cities (cents/kWh)

City \ Rate	On-Peak	Mid-Peak	Off-Peak (Base)	Months
Austin	11.00 (2 PM – 8 PM)	6.22 (6 AM – 2 PM & 8 PM 10 PM)	1.19 (10 PM – 6 PM)	Jun. to Sept.
Minnesota	20.00 (9 AM – 9 PM)	N/A	3.02 (9 PM – 9 AM)	Jun. to Sept.
Honolulu	39.2 (5 AM – 10 PM)	25.6 (10 PM – 9 AM)	16.8 (9 AM – 5 PM)	All Year
New York City	20.53 (8 AM – 12 AM)	N/A	1.45 (12 AM – 8 AM)	Jun. to Sept.
Chicago	20.53 (8 AM – 12 AM)	N/A	1.45 (12 AM – 8 AM)	Jun. to Sept.
San Francisco	30.0 (3 PM – 8 PM)	N/A	22.0 (12 AM – 3 PM & 8 PM – 12 AM)	Jun. to Sept.
Phoenix	24.47 (12 PM – 7 PM)	N/A	6.11 (7 PM – 12 PM)	May to Oct.

Utility Rates

- TOU program for residential and small business (electricity demand is less than 50 kW) in Canada:

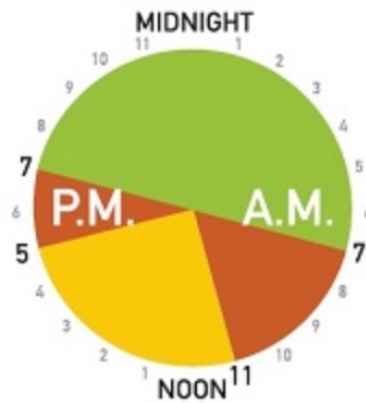
Ontario Electricity Time-of-Use Price Periods

Summer-Weekdays



May 1 - October 31

Winter-Weekdays



November 1 - April 30

Weekends & Holidays



Year Round



Utility Rates

TOU Prices - Winter - November 1, 2018 - April 30, 2019

DAY OF THE WEEK	TIME OF DAY	TOU PERIOD	TOU PRICE
Weekends & Holidays:	All day	Off-peak	\$0.065 per kWh
Weekdays:	7:00 a.m. to 11:00 a.m.	On-peak	\$0.132 per kWh
	11:00 a.m. to 5:00 p.m.	Mid-peak	\$0.094 per kWh
	5:00 p.m. to 7:00 p.m.	On-peak	\$0.132 per kWh
	7:00 p.m. to 7:00 a.m.	Off-peak	\$0.065 per kWh

TOU Prices - Summer - May 1, 2018 - October 31, 2018

DAY OF THE WEEK	TIME OF DAY	TOU PERIOD	TOU PRICE
Weekends & Holidays:	All day	Off-peak	\$0.065 per kWh
Weekdays:	7:00 a.m. to 11:00 a.m.	Mid-peak	\$0.094 per kWh
	11:00 a.m. to 5:00 p.m.	On-peak	\$0.132 per kWh
	5:00 p.m. to 7:00 p.m.	Mid-peak	\$0.094 per kWh
	7:00 p.m. to 7:00 a.m.	Off-peak	\$0.065 per kWh

Utility Rates

Current Time-of-Use Rates

effective May 1, 2019 to Oct. 31, 2019

6.5¢ per kWh off-peak

9.4¢ per kWh mid-peak

13.4¢ per kWh on-peak

Utility Rates

- Offer a plan to residential, low volume, designated and multi-unit residential:

Prices effective November 1, 2018 - April 30, 2019

SEASON	USAGE	PRICE	APPLIES TO
Winter (November 1 to April 30):	Up to 1,000 kWh/month	\$0.077 per kWh	Residential customers
	More than 1,000 kWh/month	\$0.089 per kWh	
All seasons:	Up to 750 kWh/month	\$0.077 per kWh	Non-residential customers
	More than 750 kWh/month	\$0.089 per kWh	

Utility Rates

- *Critical Peak Pricing (CPP)* is almost similar to TOU with price changes in at least one period due to the occasion of system stress
- The consumers usually receive notification of a new price in peak period a day ahead
- This method is not economically efficient for the consumers

Utility Rates

- In *Peak Load Pricing (PLP)* a day is separated to different period and different prices are assigned for each period
- The prices are announced a day ahead to the customers
- The price calculation is based on the average power consumption of the consumers in each period

Utility Rates

- In *Peak Day Rebates (PDR)* customers decide to whether reduce their consumption to critical events
- But they have also the opportunities to receive a rebate payment if they reduce their consumption below an estimated load threshold
- The results of a pilot study conducted in Connecticut, USA, showed that PDR is more advantageous compared to TOU, in terms of power reduction and consumer's satisfaction
- The same study showed that CPP is more beneficial than PDR

Utility Rates

- *Real Time Pricing (RTP)* is defined with significant participation between customers and provider:
 - The provider announces the price before the start of each period (e.g., 15 minutes beforehand)
 - The consumer decide to modify the energy usage which will decrease the electricity bill
 - Based on the feedback from the consumers, the provider makes decision to define the price for the upcoming period
- RTP is found to be beneficial in industrial and commercial building but not in residential ones.

CLASS ACTIVITY

Class Activity

- Spend up to 20 minutes to find the utility rates for
 - 2022, 2023, and/or the proposed 2024
 - Chicago and two other cities in the US (geographic location)
 - One flat rate and one time varying rate
 - Residential and commercial rates
 - Grid's emission rate (environmental disclosure)
- Complete this table:
 - <https://docs.google.com/spreadsheets/d/1eUYbP00uv7EYI3cB5poRmNHMOfJb292LX-gPelbX1Yo/edit#gid=2037454586>

REBATE PROGRAMS

Rebate Programs

- Utility providers usually offer a range of rebate programs

ComEd Energy Efficiency Program

Standard / Custom Incentives: January 1 - December 31, 2020

INDOOR AND OUTDOOR LIGHTING		
Fixtures / Retrofits	LED	\$0.50 per watt reduced
Sensors	Occupancy	\$0.10 per watt controlled
	Vacancy (indoor only)	\$0.10 per watt controlled
	Plug load occupancy	\$10 per sensor
LED Signs	"Open" sign	\$40 per sign
	Channel sign < 2 feet	\$12 per letter
	Channel sign > 2 feet	\$30 per letter
Daylighting controls (indoor only)		\$0.12 per watt controlled
Occupancy sensor plus daylighting controls (indoor only)		\$0.18 per watt controlled
Time clocks for lighting		\$0.03 per watt controlled
Photocells (outdoor only)		\$0.08 per watt controlled
Photocell plus time clock (outdoor only)		\$0.09 per watt controlled
NETWORKED INDOOR AND OUTDOOR LIGHTING		
OPTION ONE		
New LED fixture		\$0.60 per watt reduced
New lighting control system		\$0.25 per watt controlled
Measurement & verification		\$0.15 per kWh saved above target
OPTION TWO		
Keep existing fixtures or install new or retrofitted fixtures that don't meet option one fixture specs but may be eligible for standard lighting incentives		\$0.10 per kWh saved above baseline
New lighting control system		
Measurement & verification (optional)		
ENERGY MANAGEMENT SYSTEM (not eligible for online application)		
Installation of EMS on building with existing systems:	TIER 1 At least (3) control strategies implemented	TIER 2 At least (6) control strategies implemented
Non-programmable pneumatic thermostats	\$0.25 per sq. ft. of conditioned space	\$0.35 per sq. ft. of conditioned space
Non-programmable electronic thermostats	\$0.25 per sq. ft. of conditioned space	\$0.35 per sq. ft. of conditioned space
Programmable thermostats	\$0.15 per sq. ft. of conditioned space	\$0.25 per sq. ft. of conditioned space
Existing digital EMS older than 15 years	\$0.10 per sq. ft. of conditioned space	\$0.15 per sq. ft. of conditioned space
CUSTOM (not eligible for online application)		
Specialty/new construction lighting		\$0.07 per kWh saved
Closet-to-colocation		\$0.10 per kWh saved
Wastewater treatment - aeration improvements associated with blowers	without dissolved oxygen controls	\$0.12 per kWh saved
	with dissolved oxygen controls	\$0.21 per kWh saved
Data center new construction		\$0.07 per kWh saved
All other custom (includes combined heat & power)		\$0.12 per kWh saved

REFRIGERATION		
EC motor	for walk-in cooler or freezer	\$60 per motor
	for reach-in refrigerated case with evaporator fan controls	\$30 per motor
	for walk-in cooler or freezer controlled motor	\$90 per controlled motor
Q-Sync Motor	in place of EC Motor	\$10 per motor
	in place of Shaded Pole Motor	\$50 per motor
Anti-sweat heater controls for glass door cooler or freezer		\$25 per linear ft.
Display cases with doors	on coolers	\$180 per linear ft.
	on freezers	
Special door with low/no-anti sweat heaters	on cooler display cases	\$130 per door
	on freezer display cases	
Evaporator fan controls	on EC motor	\$50 per controlled motor
	on shaded-pole motor	\$25 per controlled motor
Demand defrost controls	on walk-in coolers	\$20 per evaporator fan motor
	on walk-in freezers	
Efficient refrigeration condenser		\$10 per ton
Floating head pressure controls	Single Compressor to Single Condenser System	\$60 per compressor HP
	Multiple Compressors to Single Condenser System	
LED refrigerated display case lighting	for closed case	\$40 per door
	for open case	\$15 per linear ft. of lamp
Display case lighting controls	for closed case	\$25 per door
	for open case	
ENERGY STAR®	Solid door freezer	\$100 per freezer
	Glass door freezer	\$200 per freezer
	Solid door refrigerator	\$45 per refrigerator
	Glass door refrigerator	\$45 per refrigerator
Refurbished vending machine		\$50 per machine
Night covers		\$10 per linear ft.
Strip curtains	Cooler / freezer door	\$4 per sq. ft.
	Freezer and cooler spaces	
Automatic high speed doors	Freezer and dock spaces	\$50 per sq. ft.
	Cooler and dock spaces	
Reach-in (novelty) cooler controls		\$40 per cooler
Beverage machine controls		\$100 per machine
Snack machine controls		\$40 per machine
Insulation of bare refrigeration suction lines		\$2 per linear ft.
LED STREET LIGHTING (not eligible for online application)		
Municipal owned streetlights		\$0.70 per watt reduced

Rebate Programs

- Focus on the indoor and outdoor lighting

INDOOR AND OUTDOOR LIGHTING		
Fixtures / Retrofits	LED	\$0.50 per watt reduced
Sensors	Occupancy	\$0.10 per watt controlled
	Vacancy (indoor only)	\$0.10 per watt controlled
	Plug load occupancy	\$10 per sensor
LED Signs	“Open” sign	\$40 per sign
	Channel sign < 2 feet	\$12 per letter
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New lighting control system		\$0.25 per watt controlled
Measurement & verification		\$0.15 per kWh saved above target
OPTION TWO		
Keep existing fixtures or install new or retrofitted fixtures that don't meet option one fixture specs but may be eligible for standard lighting incentives		\$0.10 per kWh saved above baseline
New lighting control system		
Measurement & verification (optional)		

Rebate Programs

- EMS rebate programs

ENERGY MANAGEMENT SYSTEM (not eligible for online application)		
Installation of EMS on building with existing systems:	TIER 1 At least (3) control strategies implemented	TIER 2 At least (6) control strategies implemented
Non-programmable pneumatic thermostats	\$0.25 per sq. ft. of conditioned space	\$0.35 per sq. ft. of conditioned space
Non-programmable electronic thermostats	\$0.25 per sq. ft. of conditioned space	\$0.35 per sq. ft. of conditioned space
Programmable thermostats	\$0.15 per sq. ft. of conditioned space	\$0.25 per sq. ft. of conditioned space
Existing digital EMS older than 15 years	\$0.10 per sq. ft. of conditioned space	\$0.15 per sq. ft. of conditioned space

Rebate Programs

- Custom rebate programs

CUSTOM (not eligible for online application)		
Specialty/new construction lighting		\$0.07 per kWh saved
Closet-to-colocation		\$0.10 per kWh saved
Wastewater treatment - aeration improvements associated with blowers	without dissolved oxygen controls	\$0.12 per kWh saved
	with dissolved oxygen controls	\$0.21 per kWh saved
Data center new construction		\$0.07 per kWh saved
All other custom (includes combined heat & power)		\$0.12 per kWh saved

Rebate Programs

- HVAC rebate programs

HVAC		
Water cooled chiller	Centrifugal	\$4 per IPLV improvement per ton
	Scroll or helical-rotary (screw)	
	Reciprocating	
Air cooled chiller	\$5 per IPLV improvement per ton	
Chilled water reset controls		\$5 per ton
SEHA tier 1 room air		\$30 per ton
Package terminal AC/ package terminal heat pump		\$30 per ton
Guest room energy management system	Electric heat/AC	\$65 per guest room
	Non-electric heat/AC	\$25 per guest room
Demand controlled ventilation	Conditioned space (interior)	\$40 per 1,000 sq. ft.
	Parking garage (enclosed)	\$300 per exhaust fan HP
	Commercial kitchen exhaust hoods	\$400 per exhaust fan HP
Restroom exhaust fan occupancy sensor		\$10 per fan
Wireless pneumatic thermostat		\$100 per thermostat
Air-side economizer		\$50 per ton
Electronically commutated motor on fan-powered box		\$50 per motor
High efficiency pumps and pumping efficiency improvements (retrofits)		\$15 per HP
Cogged V-belts for HVAC fans		\$5 per nominal motor HP
Rooftop unit		\$10 per ton per EER above efficiency requirement
Ground Source Heat Pump		\$30 per ton per EER above minimum efficiency
Adsorbent Air Cleaning		\$0.10 per SCFM
Energy Recovery Ventilator	Installation of enthalpy wheel	\$0.20 per SCFM
	Installation of enthalpy plate	\$0.10 per SCFM
VSD	on HVAC chiller	\$40 per HP
	on HVAC fan or pump \leq 200 HP*	\$80 per HP

Rebate Programs

- Laboratory rebate programs

LABORATORY	
High performance low flow fume hood	\$400 per linear ft.
Variable air volume fume hood	\$250 per linear ft.
Fume hood occupancy control	\$100 per linear ft.
Automatic fume hood sash closer	\$150 per linear ft.
Sash stops	\$5 per linear ft.
Low pressure drop HEPA filters	\$50 per 1,000 CFM
Low pressure drop high efficiency (non-HEPA) air filters	\$15 per 1,000 CFM
Reduce/optimize air changes per hour (ACH) in laboratory space	\$0.75 per CFM

Rebate Programs

- Motor and pump rebate programs

INCENTIVES AVAILABLE ON ONLINE APPLICATION ONLY	
Escalator motor efficiency controller	\$20 per HP
Network desktop power management software	\$15 per desktop computer
VSD on pool pump	\$100 per HP

Rebate Programs

- Make sure to follow the worksheets for each of these rebate programs

The screenshot shows the ComEd website interface. The header includes the ComEd logo (An Exelon Company), the tagline 'powering lives', and navigation links for Outage, Pay Bill, Moving, Español, and Contact Us. A search bar and a Sign In button are also present. The main navigation bar highlights 'Ways to Save'. The left sidebar lists various services, with 'Applications & Worksheets' selected. The main content area is titled 'Applications & Worksheets' and provides information about the ComEd Energy Efficiency Program Applications and Incentives Worksheets, available in Adobe PDF format. It includes a link to download the most recent version. Below this, a list of categories is shown, each with a plus sign to expand: Agriculture, Commercial Kitchen Equipment, Custom, Energy Efficiency Service Provider, Grocery, HVAC, Industrial Systems, Instant Discounts, Lab Equipment, and Lighting. A 'Standard App' sidebar on the right offers a 'Get Started' button and a note that the program is funded in compliance with state law and offers are subject to change.

Category	Expandable
Agriculture	+
Commercial Kitchen Equipment	+
Custom	+
Energy Efficiency Service Provider	+
Grocery	+
HVAC	+
Industrial Systems	+
Instant Discounts	+
Lab Equipment	+
Lighting	+

Rebate Programs

- Make sure to follow the worksheets for each of these rebate programs

The screenshot shows the Peoples Gas website's "Home Energy Rebate Program" page. The header includes the Peoples Gas logo with the tagline "We Keep Life Moving®", navigation links for "Payment & Billing", "Services & Programs", "Ways to Save", and "Safety", and utility links for "My Account Sign In", "Emergencies", and "Contact Us". The breadcrumb trail is "Home / Ways to Save / Home Savings". The main heading is "Home Energy Rebate Program". The text explains that residential customers can maximize energy savings by getting rebates on qualifying projects. It lists eligible equipment: furnaces, boilers, water heaters, smart thermostats, and insulation/air sealing. Eligibility criteria include new, fully installed equipment meeting energy-efficiency specifications, with old equipment removed. Rebates cannot exceed project costs. A link to "Complete terms and conditions" is provided. The section "HVAC, Water Heating and Smart Thermostat Rebates" lists applications: Online, English (PDF), and Spanish (PDF). A table titled "Rebates" lists the following:

Natural gas boiler	Rebate
Boiler + integrated domestic hot water two-in-one unit	\$500
Hot water boiler 88% AFUE or greater	\$350
Steam boiler 82.5% AFUE or greater	\$150
Natural gas furnace	Rebate
95% AFUE or greater	\$200

GAS RATES

Gas Rates

- Two options are:
 - Index-Based Pricing
 - Fixed Rates



[Home](#) [About](#) [Service Areas](#) [Service Type](#) [Plans](#) [Resources](#) [Contact Us](#)






AVAILABLE PLANS

OFFERS FOR ZIP CODE: 60402

Enrolling is fast and easy. Get started by choosing a plan below. Remember to have your utility account number available.

Change ZIP



FEATURED PRODUCT	TERM	FEATURES	RATE	SIGN UP
 Managed Rate 12	12 MONTHS	MANAGED See Details	\$0.345 per Therm	Enroll Now
 Fixed Rate 24	24 MONTHS	FIXED See Details	\$0.349 per Therm	Enroll Now
 Fixed Rate 12	12 MONTHS	FIXED See Details	\$0.349 per Therm	Enroll Now

Gas Rates

- Two options are

Price (Rate):	<p>The current Managed Price rate is \$0.3450 per Therm for August 2019. The rate may or may not be the monthly rate you pay based on your service start dates on this plan. The rate may remain the same or may change based on CenterPoint's assessment of gas supply costs including, but not limited to, applicable market conditions, historical costs, and future cost projections. Specific costs that may be considered include, but are not limited to, transportation, fuel, storage, pooling fees, balancing, and basis. For example: If CenterPoint purchases gas at \$3.50 per Mcf and creates an adder of \$0.70 per Mcf (based on factors similar to the factors identified above), then the cost to you would be \$4.20 per Mcf. If the adder is \$1.00 per Mcf, then the cost to you would be \$4.50 per Mcf.</p>
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Gas Rates

- Providers in Chicago
 - Nicor
 - People's gas

Gas Rates

- Daily Henry Hub Gas Price

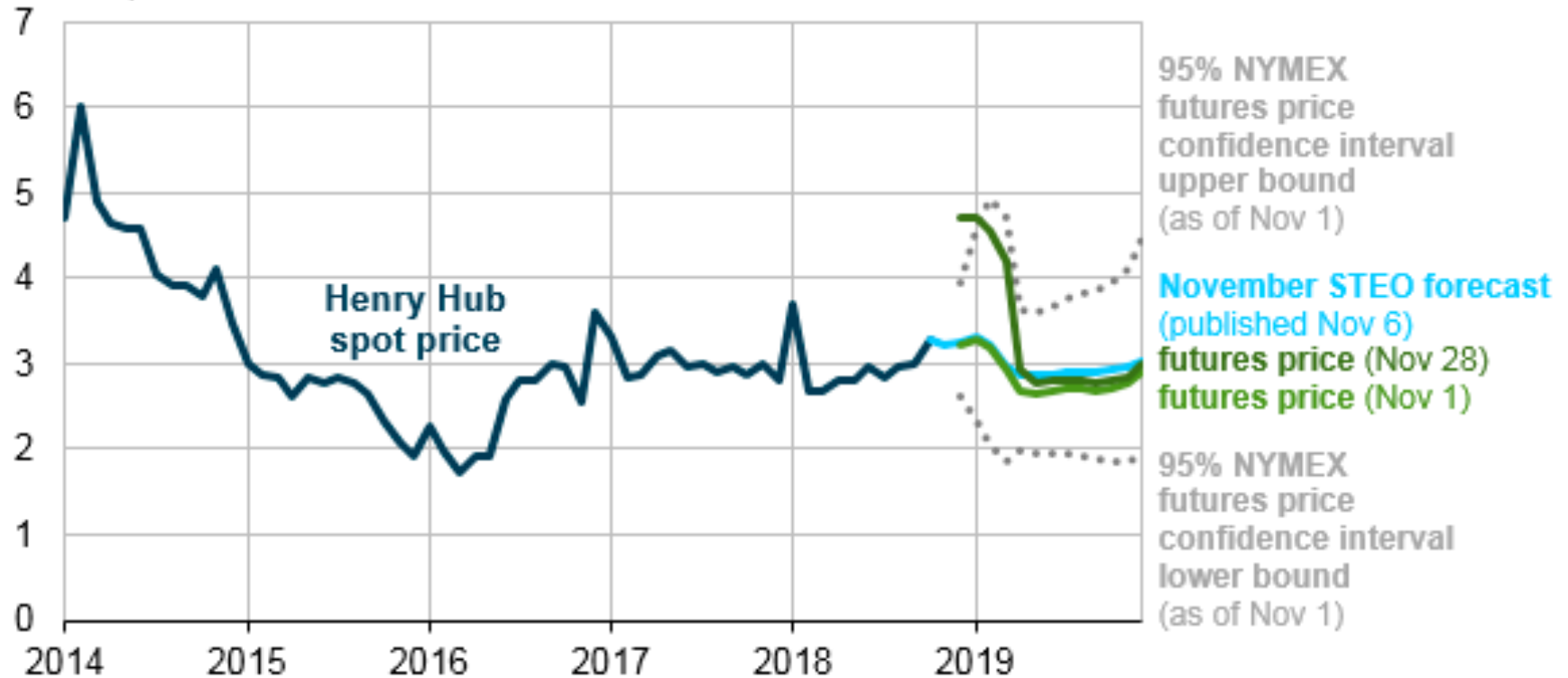
Daily Henry Hub natural gas spot price (Jan 2, 2014-Dec 3, 2018)
dollars per million British thermal units



Gas Rates

- Future prediction

Monthly Henry Hub natural gas price and NYMEX confidence intervals (2014-2019)
dollars per million British thermal units



CLASS ACTIVITY

Class Activity

- Spend up to 15 minutes to find the utility rates for
 - ❑ 2022, 2023 and/or the proposed 2024
 - ❑ Chicago and two other cities in the US (geographic location)
 - ❑ Residential and commercial rates
- Complete this table:
 - ❑ <https://docs.google.com/spreadsheets/d/1eUYbP00uv7EYI3cB5poRmNHMOfJb292LX-gPeIbX1Yo/edit#gid=792149192>

OTHER GASES RATES

Other Gases Rates

- Consider other gases, e.g. propane, in different states:

Weekly Heating Oil and Propane Prices (October - March)

(Dollars per Gallon Excluding Taxes)

Area: Period:

Download Series History Definitions, Sources & Notes									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"/>	02/18/19	02/25/19	03/04/19	03/11/19	03/18/19	03/25/19	
Wholesale Heating Oil	<input type="checkbox"/>		2.098	2.116	2.106	2.107	2.081	2.089	2013-2019
Residential Propane	<input type="checkbox"/>		1.772	1.771	1.751	1.748	1.744	1.734	1990-2019
Wholesale Propane	<input type="checkbox"/>		0.742	0.794	0.764	0.786	0.779	0.702	2013-2019

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.

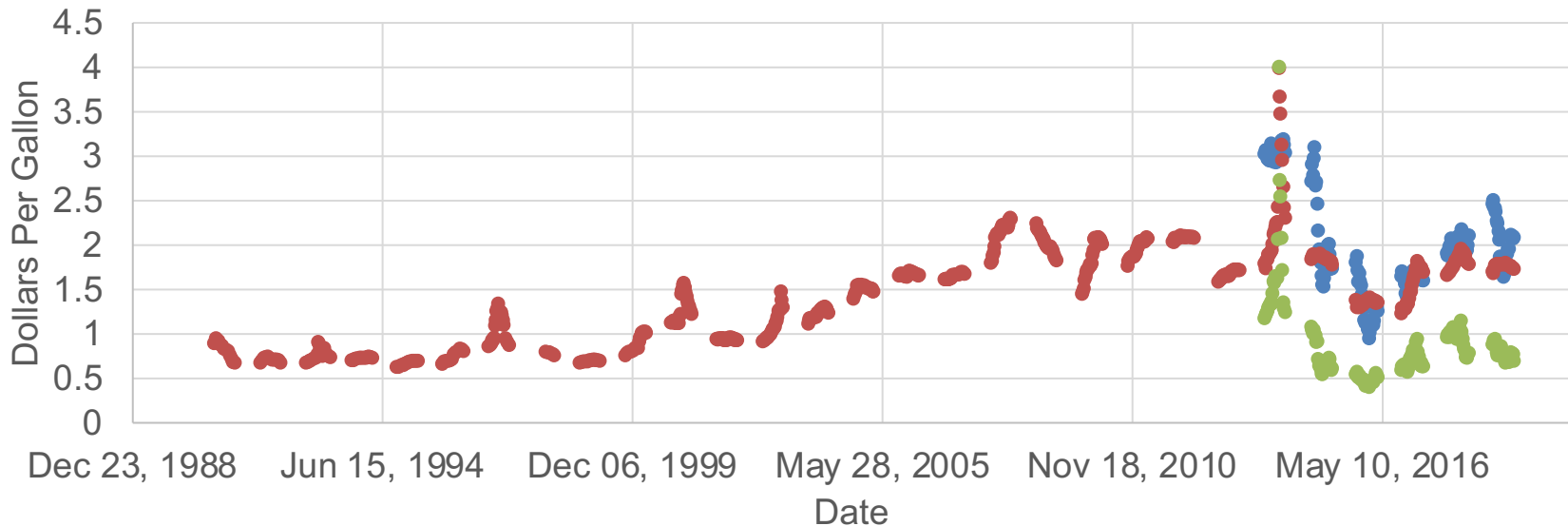
Notes: Weekly heating oil and propane prices are only collected during the heating season which extends from October through March. Due to updated weighting methodology, national and regional residential heating oil and propane prices from October 2009 to March 2013 have been revised since they were first published. See [Excel spreadsheet](#) for changes to published data. Values shown for the previous week may be revised to account for late submissions and corrections. See Definitions, Sources, and Notes link above for more information on this table.

Release Date: 07/24/2019

Next Release Date: 07/31/2019

Other Gases Rates

- Consider other gases, e.g. propane, in different states:



- Weekly Missouri No. 2 Heating Oil Wholesale/Resale Price (Dollars per Gallon)
- Weekly Missouri Propane Residential Price (Dollars per Gallon)
- Weekly Missouri Propane Wholesale/Resale Price (Dollars per Gallon)

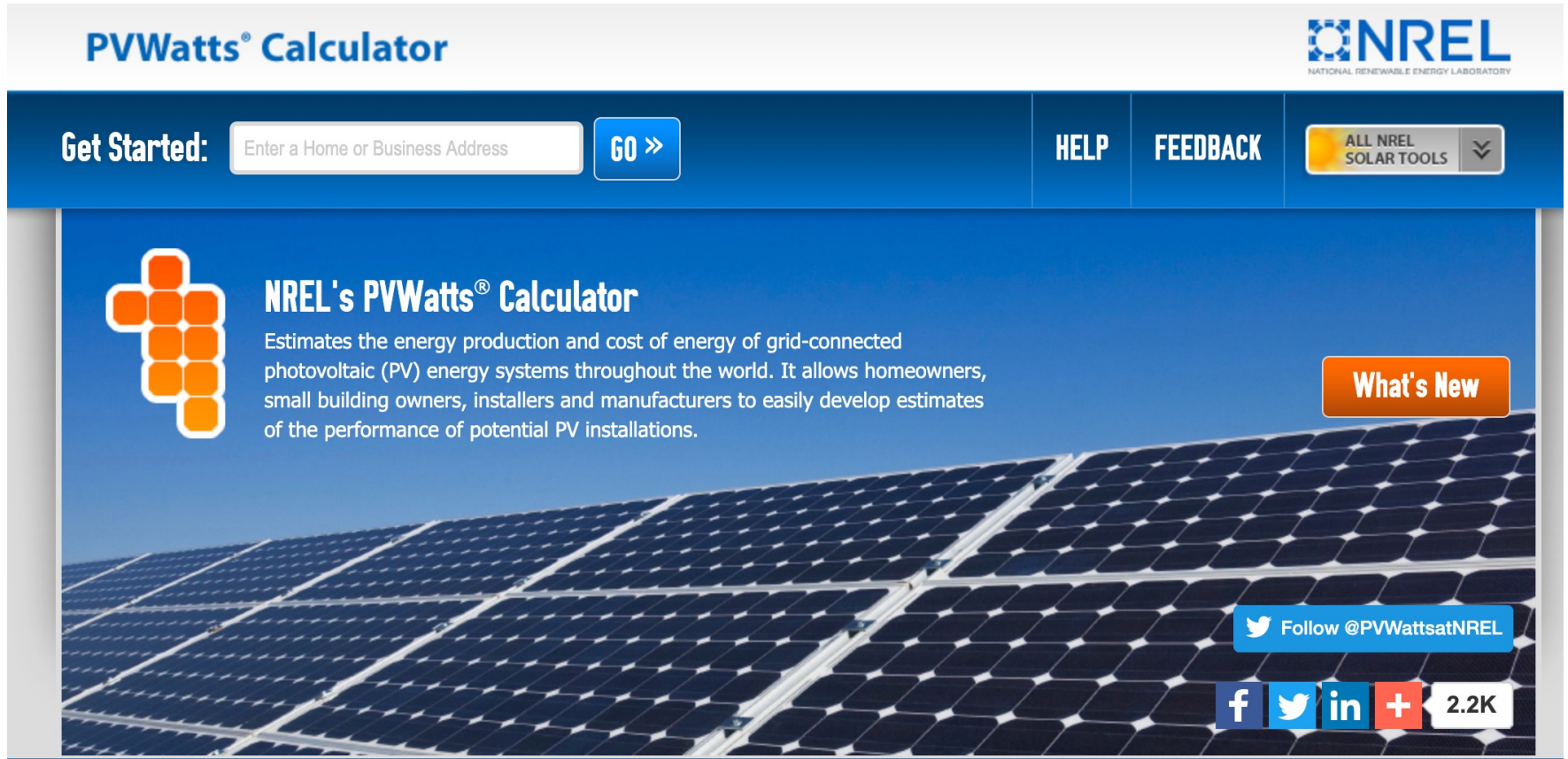
RENEWABLE ENERGY (SOLAR)

Renewable Energy (Solar)

- There are a lot software tools available:
 - PVWatts
 - ComEd's Solar Calculator
 - Helioscope

Renewable Energy (Solar)

- PVWatts:
 - Navigate to the page:



The screenshot shows the PVWatts Calculator website. At the top left, it says "PVWatts® Calculator". On the right is the NREL logo (National Renewable Energy Laboratory). Below the header is a navigation bar with "Get Started:" followed by a text input field "Enter a Home or Business Address" and a "GO >>" button. To the right are "HELP" and "FEEDBACK" links, and a dropdown menu for "ALL NREL SOLAR TOOLS". The main content area features a large image of solar panels. On the left is the PVWatts logo (a grid of orange squares) and the text "NREL's PVWatts® Calculator". To the right of the logo is a description: "Estimates the energy production and cost of energy of grid-connected photovoltaic (PV) energy systems throughout the world. It allows homeowners, small building owners, installers and manufacturers to easily develop estimates of the performance of potential PV installations." In the bottom right corner of the main area, there is a "What's New" button, a "Follow @PVWattsatNREL" button, and social media icons for Facebook, Twitter, LinkedIn, and a plus sign, with a "2.2K" follower count.

<https://pvwatts.nrel.gov/>

Renewable Energy (Solar)

- PVWatts:
 - Select the site

SOLAR RESOURCE DATA

The latitude and longitude of the solar resource data site is shown below, along with the distance between your location and the center of the site grid cell. Use this data unless you have a reason to change it.

Solar resource data site: Lat, Lon: 41.85, -87.62 0.6 mi

Resource Data Map

The blue rectangle on the map indicates the NREL NSRDB grid cell for your location. If your location is outside the NSRDB area, the map shows a pin for the nearest available NREL international data site instead of a rectangle. If you want to use data for a different NSRDB grid cell, double-click the map to move the rectangle. *Dragging the rectangle will not move it.* Use the Legacy Data Options check boxes to show pins for legacy data sites. Click a legacy data pin to use legacy data instead of the recommended NSRDB data. See [Help](#) for details.

Map Satellite

Legacy Data Options:

- NSRDB MTS1 (TMY2)
- NSRDB MTS2 (TMY3)
- NREL International

Map data ©2020 Google 20 m Terms of Use Report a map error

Renewable Energy (Solar)

- PVWatts:
 - Add your inputs for the solar panels:

The screenshot displays the PVWatts Calculator interface. At the top, the title "PVWatts Calculator" is on the left, and the NREL logo is on the right. Below the title bar, there are navigation tabs: "My Location" (with "60616, USA" and a "Change Location" link), "HELP", "FEEDBACK", and "ALL NREL SOLAR TOOLS". The main content area is divided into three tabs: "RESOURCE DATA", "SYSTEM INFO" (which is active), and "RESULTS".

The "SYSTEM INFO" section is titled "SYSTEM INFO" and includes a "RESTORE DEFAULTS" button. Below the title, it says "Modify the inputs below to run the simulation." The input fields are:

- DC System Size (kW): 4
- Module Type: Standard
- Array Type: Fixed (open rack)
- System Losses (%): 14.08
- Tilt (deg): 20
- Azimuth (deg): 180

There is a "Loss Calculator" icon next to the System Losses field. Below these fields is a "+ Advanced Parameters" button. To the right of the input fields is a "Draw Your System" section with the text "Click below to customize your system on a map. (optional)" and a small map interface showing a solar panel layout on a map.

At the bottom of the "SYSTEM INFO" section is the "RETAIL ELECTRICITY RATE" section, which includes the text: "To automatically download an average annual retail electricity rate for your location, choose a rate type (residential or commercial). You can change the rate to use a different value by typing a different number." The input fields are:

- Rate Type: Residential
- Rate (\$/kWh): 0.104

On the left and right sides of the main content area, there are orange arrow icons pointing left and right, with the text "Go to resource data" and "Go to PVWatts results" respectively.

Renewable Energy (Solar)

- PVWatts:
 - ❑ Revise the default values based on the recommendation (when click on “I”)

PVWatts Documentation

Tilt (deg)

The tilt angle is the angle from horizontal of the photovoltaic modules in the array. For a fixed array, the tilt angle is the angle from horizontal of the array where 0° = horizontal, and 90° = vertical. For arrays with one-axis tracking, the tilt angle is the angle from horizontal of the tracking axis. The tilt angle does not apply to arrays with two-axis tracking.

The PVWatts[®] default value for the tilt angle depends on the array type: For a fixed array, the default value is 20 degrees, and for one-axis tracking the default value is zero. A common rule of thumb for fixed arrays is to set the tilt angle to the latitude of the system's location to maximize the system's total electrical output over the year. Use a lower tilt angle favor peak production in the summer months when the sun is high in the sky, or a higher tilt angle to increase output during winter months. Higher tilt angles tend to cost more for racking and mounting hardware, and may increase the risk of wind damage to the array.

For an array installed on a building's roof, you may want to choose a tilt angle equal to the roof pitch. Use the table below to convert roof pitch in ratio of rise (vertical) over run (horizontal) to tilt angle.

Photovoltaic array tilt angle for different roof pitches

Roof Pitch (rise/run)	Tilt Angle (deg)
4/12	18.4
5/12	22.6
6/12	26.6
7/12	30.3
8/12	33.7
9/12	36.9
10/12	39.8

Advanced Parameters

DC to AC Size Ratio: 1.2

Inverter Efficiency (%): 96

Ground Coverage Ratio: 0.4

RETAIL ELECTRICITY RATE

To automatically download an average annual retail electricity rate for your location, choose a rate type (residential or commercial). You can change the rate to use a different value by typing a different number.

Rate Type: Residential

Renewable Energy (Solar)

- PVWatts:
 - Make sure to visit the advanced parameters

The screenshot displays the PVWatts Calculator interface. At the top, the title is "PVWatts® Calculator" and the NREL logo is visible. The location is set to "60616, USA". The interface is divided into three main sections: RESOURCE DATA, SYSTEM INFO (currently active), and RESULTS. The SYSTEM INFO section contains several input fields for system parameters, each with an information icon (i):

- DC System Size (kW): 4
- Module Type: Standard
- Array Type: Fixed (open rack)
- System Losses (%): 14.08
- Tilt (deg): 20
- Azimuth (deg): 180

Below these are the "Advanced Parameters" section, also with information icons:

- DC to AC Size Ratio: 1.2
- Inverter Efficiency (%): 96
- Ground Coverage Ratio: 0.4

On the right side of the SYSTEM INFO section, there is a "RESTORE DEFAULTS" button and a "Draw Your System" section with a map interface. Navigation arrows on the left and right sides point to "Go to resource data" and "Go to PVWatts® results" respectively.

RETAIL ELECTRICITY RATE

To automatically download an average annual retail electricity rate for your location, choose a rate type (residential or commercial). You can change the rate to use a different value by typing a different number.

Renewable Energy (Solar)

- PVWatts:
 - Review the monthly and hourly production

My Location 3201 s dearborn chicago
» Change Location

HELP FEEDBACK ALL NREL SOLAR TOOLS

RESOURCE DATA SYSTEM INFO RESULTS

RESULTS

Print Results

5,275 kWh/Year*

System output may range from 5,050 to 5,496 kWh per year near this location.
Click [HERE](#) for more information.

Month	Solar Radiation (kWh / m ² / day)	AC Energy (kWh)	Value (\$)
January	2.41	270	28
February	3.34	325	34
March	4.35	451	47
April	5.44	530	55
May	5.82	566	59
June	6.57	598	62
July	6.64	622	65
August	6.09	557	58
September	5.27	476	50
October	3.82	374	39
November	2.75	275	29
December	2.13	232	24
Annual	4.55	5,276	\$ 550

User Comments

Type here to add optional comments to printout.

Download Results: [Monthly](#) | [Hourly](#)

Find A Local Installer

* The PVWatts energy estimate is based on an hourly performance simulation using a typical-year weather file that represents a multi-year historical period for Chicago, IL for a Fixed (open rack) photovoltaic

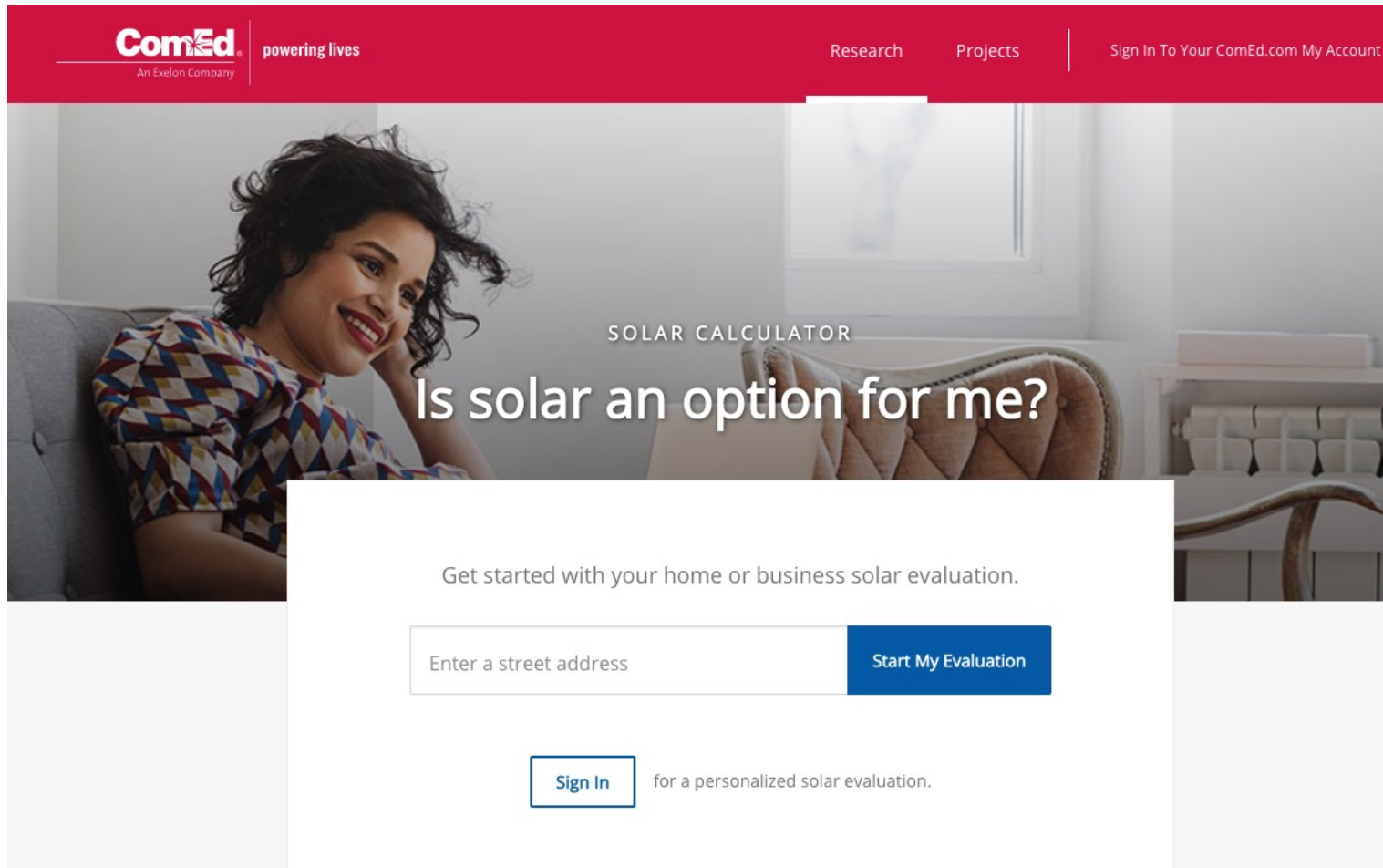
Renewable Energy (Solar)

- ComEd's Solar Calculator
 - Navigate to the page:

The screenshot shows the ComEd website's 'Solar 101' page. The header includes the ComEd logo (An Exelon Company) and the tagline 'powering lives'. Navigation links include 'Outage', 'Pay Bill', 'Moving', 'Español', and 'Contact Us'. A search bar and 'Sign In' button are also present. The main navigation menu includes 'My Account', 'Outages', 'Ways to Save', 'Smart Energy', 'Safety & Community', and 'Marketplace'. The left sidebar lists various services, with 'Solar 101' highlighted in red. The main content area features a breadcrumb trail: 'Home > Smart Energy: My Green Power Connection > Solar for Home & Business > Private Solar > Solar 101'. The 'Solar 101' section includes a heading, a paragraph about solar energy, and a photo of a person with arms raised in a field. Below this is a section titled 'The Power of the Sun' with a paragraph about solar energy. The right sidebar contains a 'LAUNCH OUR Solar Calculator' button and a 'Solar Brochure' section with links for 'Residential (pdf)', 'Spanish (pdf)', and 'Business (pdf)'.

Renewable Energy (Solar)

- ComEd's Solar Calculator
 - ❑ Put your building address:



ComEd[®] powering lives
An Exelon Company

Research Projects | Sign In To Your ComEd.com My Account

SOLAR CALCULATOR

Is solar an option for me?

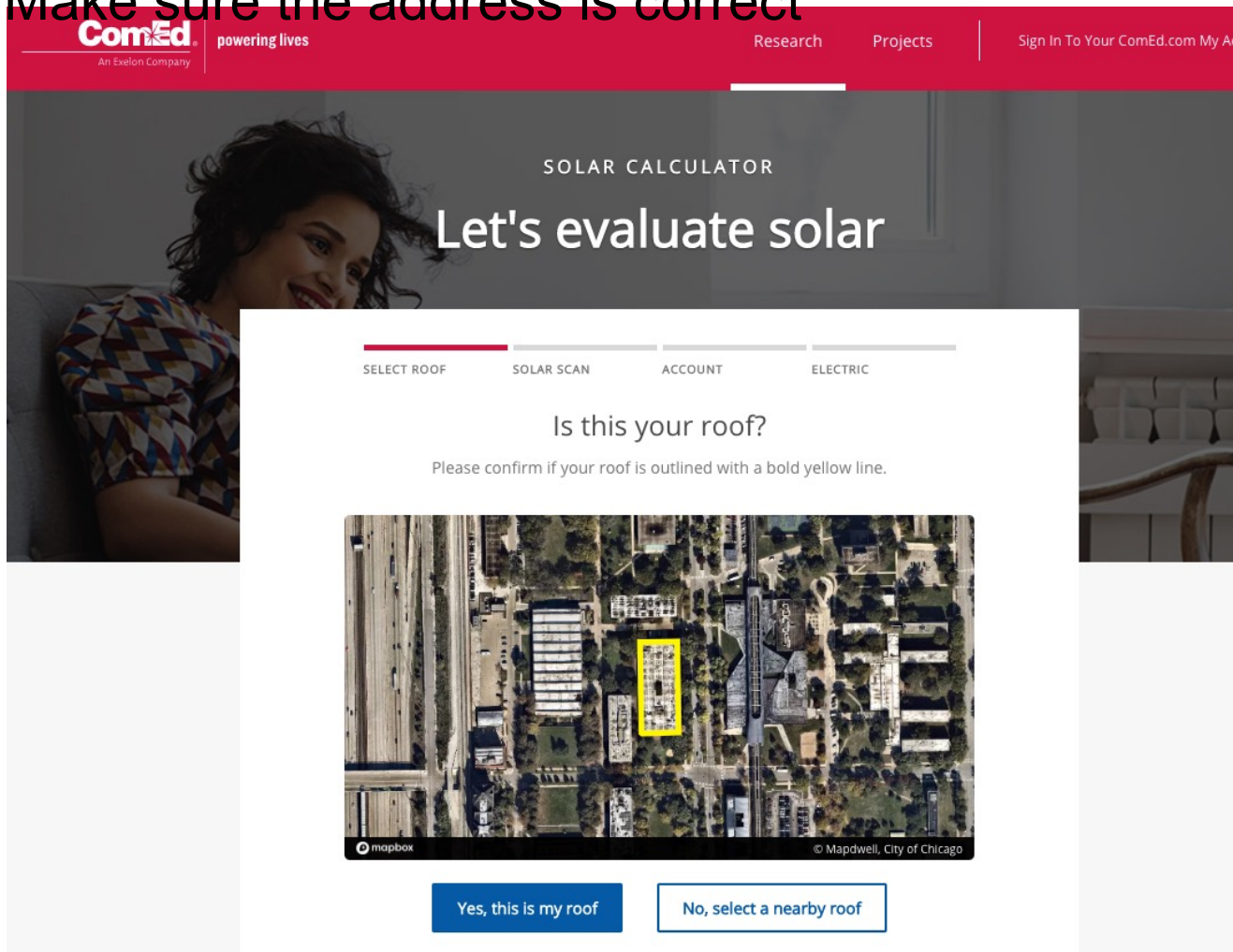
Get started with your home or business solar evaluation.

Enter a street address [Start My Evaluation](#)

[Sign In](#) for a personalized solar evaluation.

Renewable Energy (Solar)

- ComEd's Solar Calculator
 - ❑ Make sure the address is correct



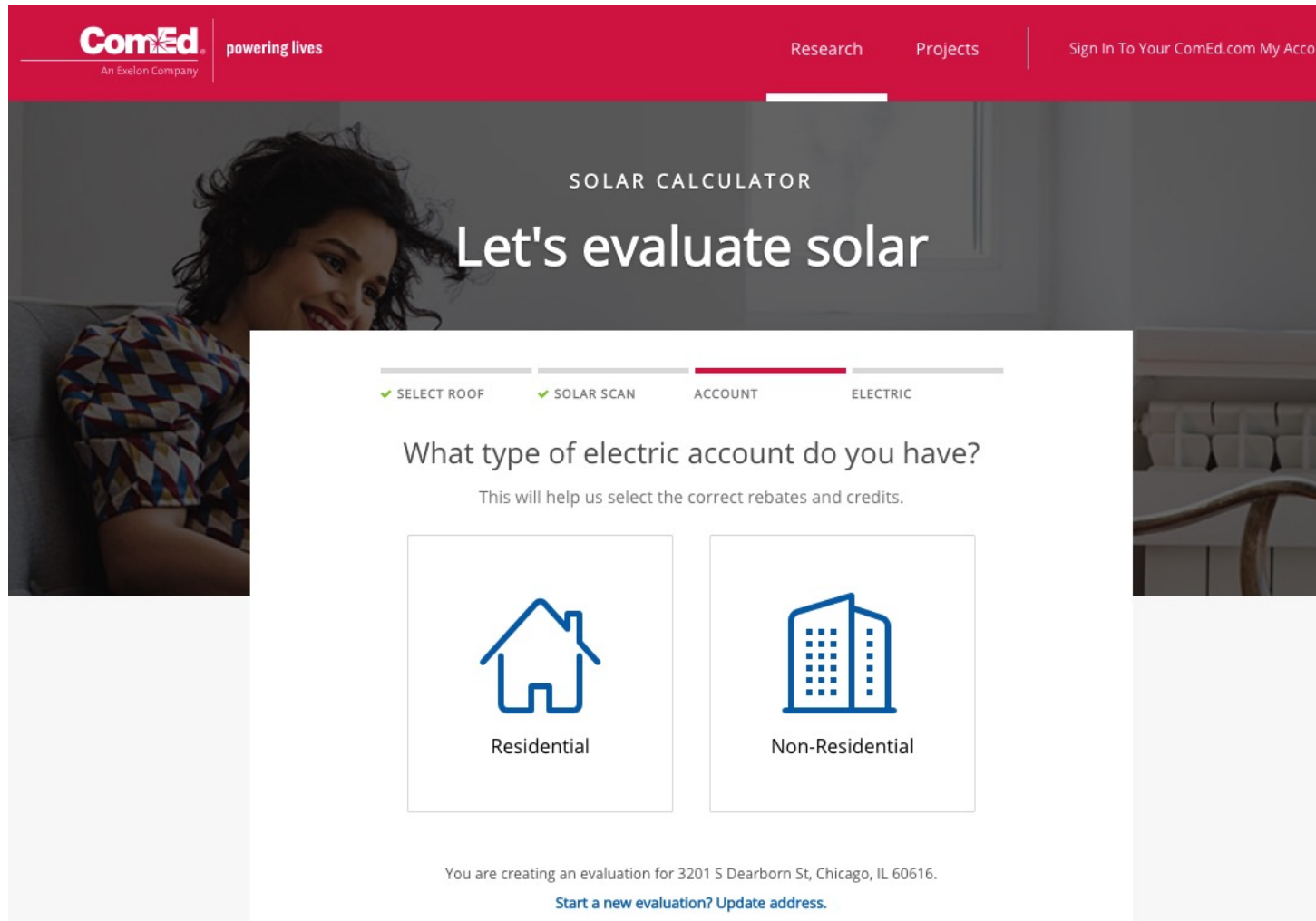
Renewable Energy (Solar)

- Review the solar potential

The screenshot shows the ComEd website's solar calculator interface. At the top, the ComEd logo is on the left, and navigation links for 'Research', 'Projects', and 'Sign In To Your ComEd.com My Account' are on the right. The main heading reads 'SOLAR CALCULATOR' and 'Let's evaluate solar'. Below this is a progress bar with four steps: 'SELECT ROOF' (checked), 'SOLAR SCAN', 'ACCOUNT', and 'ELECTRIC'. The current step is 'SOLAR SCAN', which displays the text 'Here's your roof's solar potential' and 'Continue with a few simple questions to determine your solar options.' Below the text is an aerial satellite image of a residential area with a central house highlighted in yellow, indicating high solar potential. A color scale legend below the image shows 'None' (dark brown), 'Feasible' (orange), and 'High-Yield' (yellow). The ComEd logo is also present at the bottom right of the image area. At the bottom of the interface are two buttons: 'Continue as a guest user' and 'Sign in for a more accurate report'.

Renewable Energy (Solar)

- Select building type



The screenshot shows the ComEd website's solar calculator interface. The header includes the ComEd logo (An Exelon Company) and the tagline 'powering lives'. Navigation links for 'Research' and 'Projects' are visible, along with a 'Sign In To Your ComEd.com My Account' link. The main heading is 'SOLAR CALCULATOR' with the sub-heading 'Let's evaluate solar'. A progress bar at the top of the form shows four steps: 'SELECT ROOF', 'SOLAR SCAN', 'ACCOUNT', and 'ELECTRIC'. The 'ELECTRIC' step is currently active. The question asks, 'What type of electric account do you have?' and explains that this helps select correct rebates and credits. Two options are presented: 'Residential' (represented by a house icon) and 'Non-Residential' (represented by a building icon). At the bottom, it states the user is creating an evaluation for '3201 S Dearborn St, Chicago, IL 60616' and provides a link to 'Start a new evaluation? Update address.'

ComEd[®] powering lives
An Exelon Company

Research Projects | Sign In To Your ComEd.com My Account

SOLAR CALCULATOR

Let's evaluate solar

✓ SELECT ROOF ✓ SOLAR SCAN ACCOUNT ELECTRIC

What type of electric account do you have?
This will help us select the correct rebates and credits.

Residential Non-Residential

You are creating an evaluation for 3201 S Dearborn St, Chicago, IL 60616.
[Start a new evaluation? Update address.](#)

Renewable Energy (Solar)

- Enter the estimated monthly electric bill

ComEd powering lives
An Exelon Company

Research Projects | Sign In To Your ComEd.com My Account

SOLAR CALCULATOR

Let's evaluate solar

✓ SELECT ROOF ✓ SOLAR SCAN ✓ ACCOUNT **ELECTRIC**

What is your estimated monthly electric bill?
[Pull real usage data for greater accuracy? Sign in.](#)

\$25 \$600

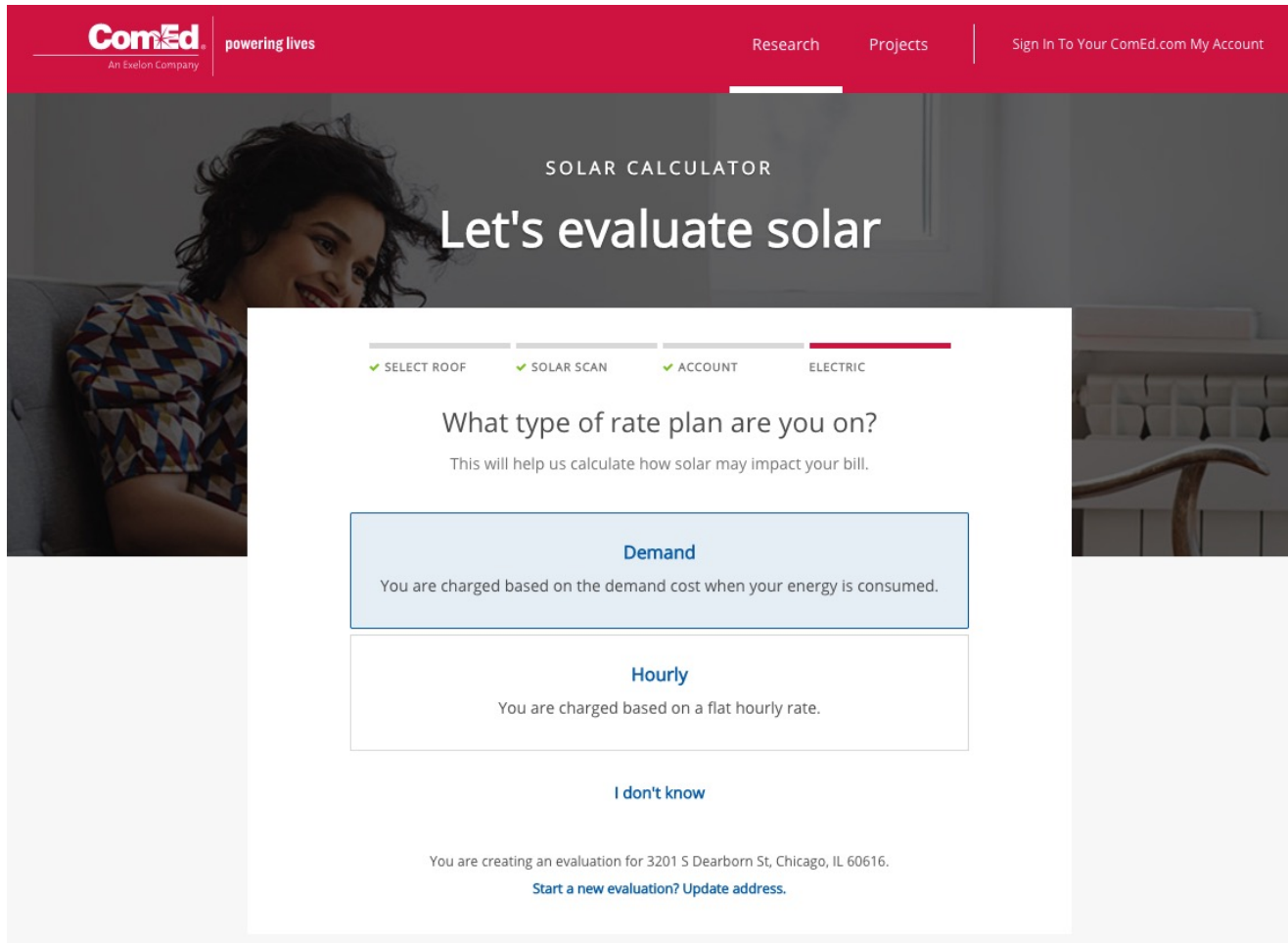
[Enter custom amount?](#)

[Continue](#)

You are creating an evaluation for 3201 S Dearborn St, Chicago, IL 60616.
[Start a new evaluation? Update address.](#)

Renewable Energy (Solar)

- Select the utility rate structure



ComEd powering lives
An Exelon Company

Research Projects | Sign In To Your ComEd.com My Account

SOLAR CALCULATOR

Let's evaluate solar

✓ SELECT ROOF ✓ SOLAR SCAN ✓ ACCOUNT **ELECTRIC**

What type of rate plan are you on?
This will help us calculate how solar may impact your bill.

Demand
You are charged based on the demand cost when your energy is consumed.

Hourly
You are charged based on a flat hourly rate.

I don't know

You are creating an evaluation for 3201 S Dearborn St, Chicago, IL 60616.
[Start a new evaluation?](#) [Update address.](#)

Renewable Energy (Solar)

- Review the estimated installation cost, incentives, and payback period



Here's what solar can mean for you

Why? ▾



ESTIMATED UPFRONT INSTALLATION COST

\$161,800-\$197,800

Why? ▾



ESTIMATED COST AFTER INCENTIVES

\$83,000

Why? ▾



ESTIMATED PAYBACK PERIOD

11 years

Why? ▾

Find a Contractor

Download My Report

Street Address

3201 S Dearborn St, Chicago, IL 60616

The data used to evaluate your roof's solar potential was last updated on: April 30, 2017.



© Mapdwell, City of Chicago, Mapbox, DigitalGlobe

Solar Potential: None Feasible High-Yield


powered by Mapdwell

Renewable Energy (Solar)

- Review the incentives and rebates in detail:

System Size & Cost

[Want a personalized estimate? Sign In.](#)



Offset 110% of my usage

0% 110%

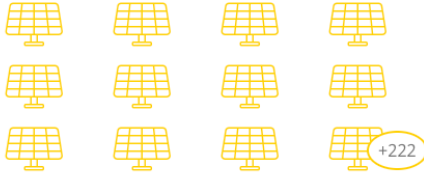
You will need **234** Solar Panels with an upfront cost of **\$161,800-\$197,800**.

[Why? ▾](#)

Incentives & Rebates

Estimated Upfront Installation Cost	\$179,800
What's This? ▾	
Distributed Generation Rebate	\$(14,600)
What's This? ▾	
Solar Renewable Energy Credit*	\$(82,200)
What's This? ▾	
Cost After Incentives and Rebates	\$83,000
	Save up to 54%

Your Solar Energy System



+222

Your 81.7 kW DC solar energy system is a total of 234 panels capable of generating 101850 kWh of electricity per year based on your desired percentage offset.

[Not ready to invest? Learn about community solar.](#)

Renewable Energy (Solar)

- Review the incentives and rebates in detail:

Incentives & Rebates

Estimated Upfront Installation Cost **\$179,800**

[What's This? ^](#)

We provide a range associated with this installation cost, and in the remainder of the solar calculator report, use the mid-point of that range in calculating other costs and benefits. We calculated your installation cost by multiplying your system size by the cost per kilowatt (this is the midpoint). Installation Cost = 81.7kW DC x \$2200/kW.

Distributed Generation Rebate **\$(14,600)**

[What's This? ^](#)

This is an optional ComEd rebate that non-residential customers qualify for by installing a smart inverter and allowing ComEd to control it for purposes of grid reliability. Its initial value is \$250/kW of installed solar capacity. Our calculator reflects the fact that this is an incentive which is subject to tax, and assumes that the rebate is received in the year of installation.

Solar Renewable Energy Credit* **\$(82,200)**

[What's This? ^](#)

REC's are a state incentive, whose value is equal to the solar energy you produce over 15 years times the price set by the Illinois Power Agency for REC's. For commercial customers, our calculator assumes this is paid out over 4 years, and the REC value varies based on the size of the solar system. Our calculator reflects the fact that this is an incentive which is subject to tax. *Please note: The RECs for systems 10 kW and larger have been fully allocated through the Illinois Power Agency's Adjustable Block Program. The Illinois Power Agency has created a wait list. The price used for this calculation is 4% lower than Block 4 pricing. For more information visit www.IllinoisABP.com

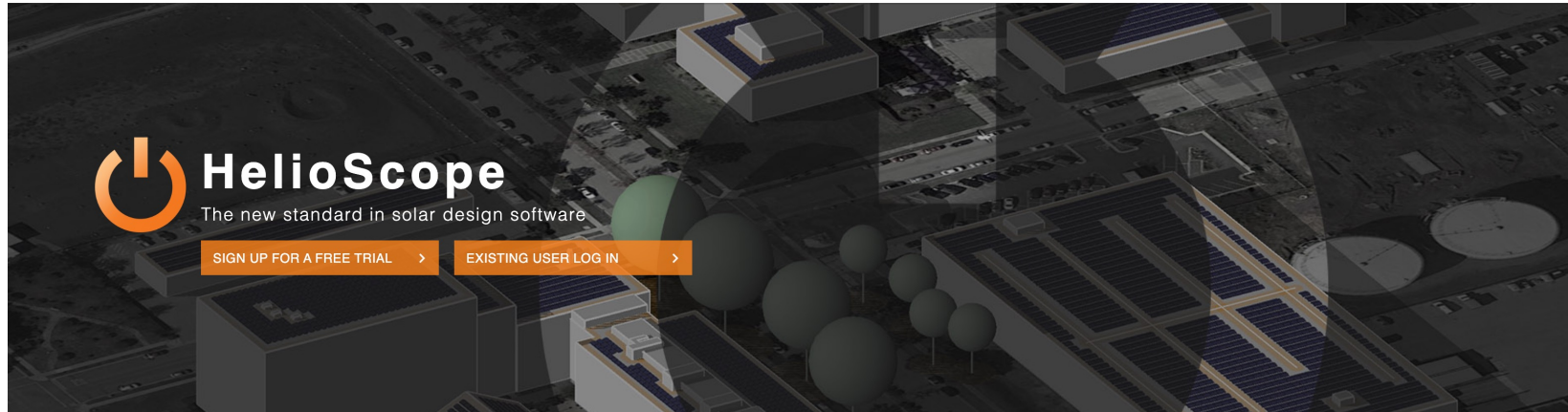
Cost After Incentives and Rebates **\$83,000**

Save up to 54%

Renewable Energy (Solar)

- Review the incentives and rebates in detail:

HelioScope



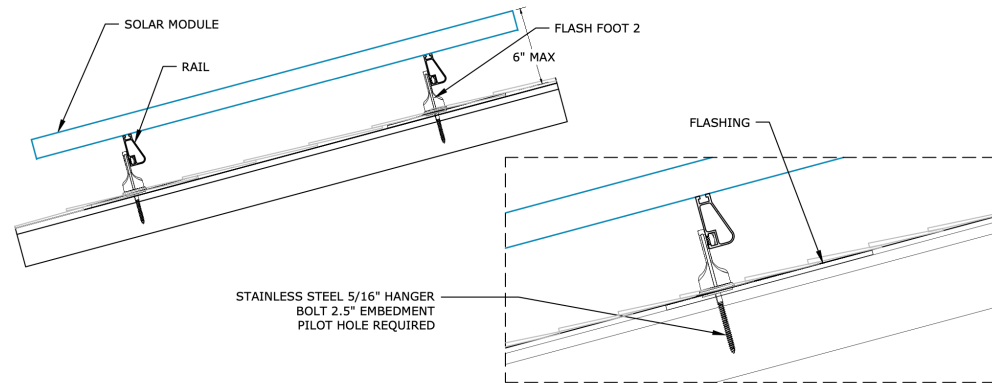
Meet HelioScope

A web-based sales and design tool for solar professionals with the power to completely reshape your proposal generation process. From its robust 3D design engine and bankable energy yield simulator to its detailed financial calculator and drag-and-drop proposal editor; HelioScope makes responding to customer requests fast, easy, and bankable. [Sign-up for a free 30-day trial](#) and find out why installers who use HelioScope wonder how they ever survived without it.

https://www.helioscope.com/?gclid=Cj0KCQiAm5ycBhCXARIsAPldzoUr2ubRDvduY8SI4duKsyGHPT1uvpVmZ0rSrkvBz3MgSTNnLexahiwaApYvEALw_wcB

Renewable Energy (Solar)

- A real-world installation



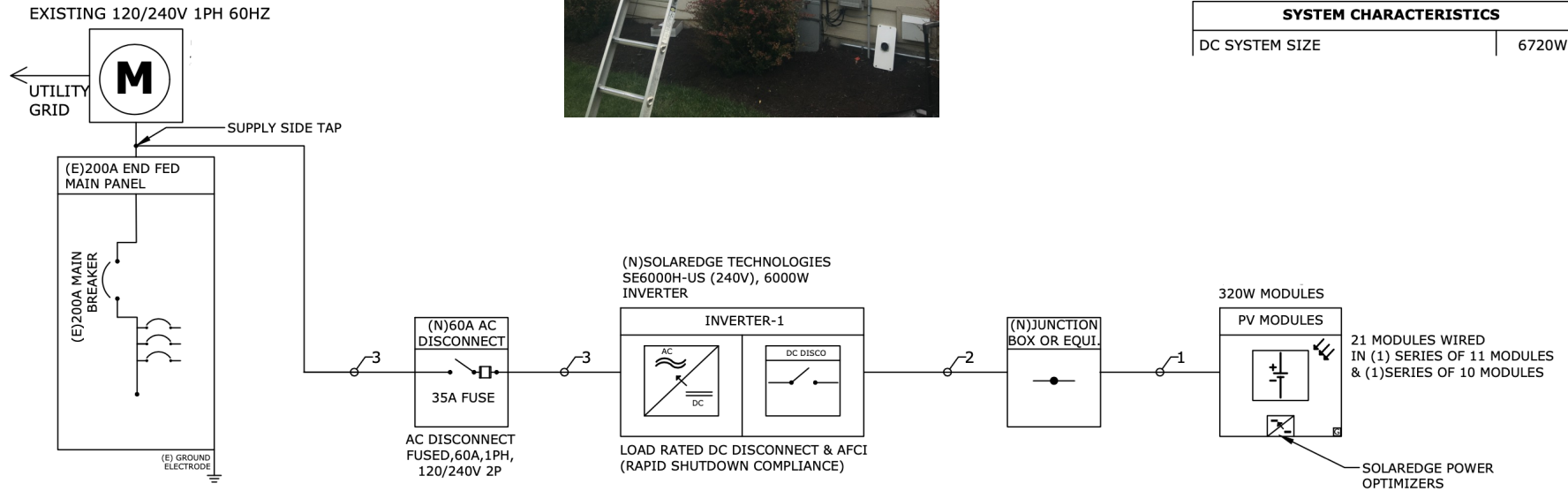
Renewable Energy (Solar)

- A real -world installation



Renewable Energy (Solar)


- A real-world installation



HOW TO HARDSIZE YOUR MODEL

How to Hard Size Your Model

- Method 1:
 - ❑ Find from EnergyPlus results



The screenshot shows a software window titled "Results Summary". At the top, there is a "Reports:" dropdown menu currently set to "EnergyPlus Results". Below this is a "Table of Contents" section with a list of hyperlinks to various summary reports. A vertical toolbar on the left side of the window contains various icons for navigation and analysis.

Results Summary

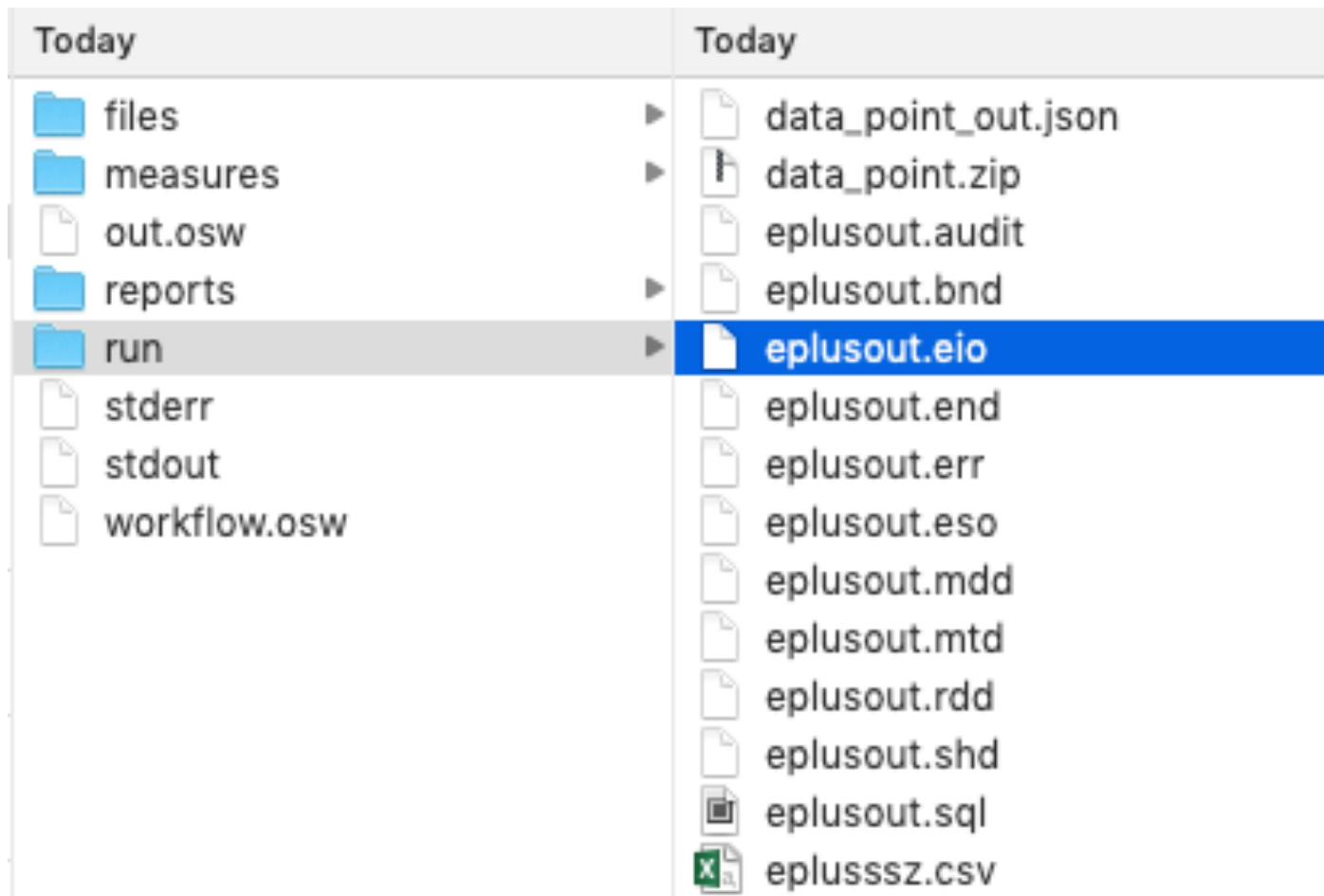
Reports: EnergyPlus Results

Table of Contents

- [Top](#)
- [Annual Building Utility Performance Summary](#)
- [Input Verification and Results Summary](#)
- [Demand End Use Components Summary](#)
- [Source Energy End Use Components Summary](#)
- [Component Sizing Summary](#)
- [Surface Shadowing Summary](#)
- [Adaptive Comfort Summary](#)
- [Initialization Summary](#)
- [Climatic Data Summary](#)
- [Envelope Summary](#)
- [Shading Summary](#)
- [Lighting Summary](#)
- [Equipment Summary](#)
- [HVAC Sizing Summary](#)
- [Coil Sizing Details](#)
- [System Summary](#)
- [Outdoor Air Summary](#)
- [Object Count Summary](#)
- [Energy Meters](#)
- [Sensible Heat Gain Summary](#)
- [Standard 62.1 Summary](#)
- [LEED Summary](#)

How to Hard Size

- Method 2:
 - ❑ Open the EIO extension file



How to Hard Size

- Find the component that you would like to hard size

The screenshot displays a software interface for a building simulation. The main window shows a schematic diagram of a 'Packaged Rooftop VAV with Reheat' system. The diagram is divided into 'Supply Equipment' (top) and 'Demand Equipment' (bottom) by a horizontal dashed line. The supply side includes a fan, a reheat coil, and a control valve. The demand side consists of three zones, each with its own reheat coil and control valve. A red dashed box highlights the 'Packaged Rooftop VAV with Reheat' component in the schematic. To the right, a properties panel for this component is visible, showing various settings such as Name, Controller List Name, Availability Schedule, Availability Manager List Name, Design Supply Air Flow Rate (set to 'Autosized'), Branch List Name, Connector List Name, Supply Side Inlet Node Name, Demand Side Outlet Node Name, Demand Side Inlet Node A, and Supply Side Outlet Node A.

How to Hard Size

- Open the EIO file:

```
water heating coil capacity information, coil heating water, coil heating water 0.3100720  
Component Sizing Information, AirLoopHVAC, PACKAGED ROOFTOP VAV WITH REHEAT, Sum of Air Terminal Maximum Heating Flow Rates [m3/s], 4.41869  
Component Sizing Information, AirLoopHVAC, PACKAGED ROOFTOP VAV WITH REHEAT, Sum of Air Terminal Minimum Heating Flow Rates [m3/s], 4.41869  
Component Sizing Information, AirLoopHVAC, PACKAGED ROOFTOP VAV WITH REHEAT, Sum of Air Terminal Maximum Flow Rates [m3/s], 14.72897  
Component Sizing Information, AirLoopHVAC, PACKAGED ROOFTOP VAV WITH REHEAT, Adjusted Heating Design Air Flow Rate [m3/s], 10.80620  
Component Sizing Information, AirLoopHVAC, PACKAGED ROOFTOP VAV WITH REHEAT, Adjusted Cooling Design Air Flow Rate [m3/s], 14.72897  
Component Sizing Information, AirLoopHVAC, PACKAGED ROOFTOP VAV WITH REHEAT, Adjusted Main Design Air Flow Rate [m3/s], 14.72897  
Component Sizing Information, AirLoopHVAC, PACKAGED ROOFTOP VAV WITH REHEAT, User Heating Air Flow Ratio [], 0.30000  
Component Sizing Information, AirLoopHVAC, PACKAGED ROOFTOP VAV WITH REHEAT, Calculated Heating Air Flow Ratio [], 0.73367  
Component Sizing Information, AirLoopHVAC, PACKAGED ROOFTOP VAV WITH REHEAT, Design Supply Air Flow Rate [m3/s], 14.72897
```

How to Hard Size

- Let's look at another example

Thermal Zones

HVAC Systems Cooling Sizing Parameters Heating Sizing Parameters Custom

Name	All	Rendering Color	Turn On Ideal Air Loads	Air Loop Name	Zone Equipment	Cooling Thermostat Schedule	Heating Thermostat Schedule	Humidifying Setpoint Schedule	Dehumidifying Setpoint Schedule	Multiplier
Thermal Zone 1	<input type="checkbox"/>		<input type="checkbox"/>	rooftop VAV with Reheat 4	HW Baseboard Single Duct VAV Reheat 21	Medium Office ClgSetp	Medium Office HtgSetp			1
Thermal Zone 10	<input type="checkbox"/>		<input type="checkbox"/>		HW Baseboard 18 PTAC DX Clg Gas Htg	Medium Office ClgSetp	Medium Office HtgSetp			1
Thermal Zone 11	<input type="checkbox"/>		<input type="checkbox"/>		HW Baseboard 23 PTAC DX Clg Gas Htg 8	Medium Office ClgSetp	Medium Office HtgSetp			1
Thermal Zone 12	<input type="checkbox"/>		<input type="checkbox"/>		HW Baseboard 21 PTAC DX Clg Gas Htg 6	Medium Office ClgSetp	Medium Office HtgSetp			1
Thermal Zone 13	<input type="checkbox"/>		<input type="checkbox"/>		HW Baseboard 9 PTAC DX Clg Gas Htg 9	Medium Office ClgSetp	Medium Office HtgSetp			1
Thermal Zone 14	<input type="checkbox"/>		<input type="checkbox"/>	Rooftop VAV with Reheat	HW Baseboard 48 Single Duct VAV Reheat 3	Medium Office ClgSetp	Medium Office HtgSetp			1

My Model Library Edit

Name: HW Baseboard 21

Availability Schedule Name: Always On Discrete hvac_library

Heating Coil Name: Baseboard HW Htg Coil 21

OS:Coil:Heating:Water:Baseboard

Name: Baseboard HW Htg Coil 21

Heating Design Capacity Method: HeatingDesignCapacity

Heating Design Capacity: Hard Sized 20000 W Autosized Autosize

Heating Design Capacity Per Floor Area: 0 Btu/ft²·h

Fraction of Autosized Heating Design Capacity: 0.800000000000000004

U-Factor Times Area Value: Hard Sized 1137.3805443759809 Btu/h·R Autosized Autosize

Maximum Water Flow Rate: Hard Sized 0.620000000000000055 gal/min Autosized Autosize

Convergence Tolerance: 0.001

How to Hard Size

```
DX Cooling Coil Standard Rating Information, Coil:Cooling:DX:SingleSpeed, ELEC PTAC 1 SPD DX CLG COIL, 3392.7, 2.51, 8.56, 9.08, 8.70
Component Sizing Information, Coil:Heating:Electric, PTAC ELEC HTG COIL, User-Specified Nominal Capacity [W], 0.00000
Component Sizing Information, Fan:ConstantVolume, ELEC PTAC FAN, Design Size Maximum Flow Rate [m3/s], 0.21503
Component Sizing Information, ZoneHVAC:Baseboard:Convective:Water, HW BASEBOARD, Design Size Maximum Water Flow Rate [m3/s], 6.71983E-005
Component Sizing Information, ZoneHVAC:Baseboard:Convective:Water, HW BASEBOARD, Design Size U-Factor Times Area Value [W/K], 72.02346
Component Sizing Information, ZoneHVAC:PackagedTerminalAirConditioner, PTAC DX CLG ELEC HTG 4, Design Size Cooling Supply Air Flow Rate [m3/s], 0.21641
Component Sizing Information, ZoneHVAC:PackagedTerminalAirConditioner, PTAC DX CLG ELEC HTG 4, Design Size Heating Supply Air Flow Rate [m3/s], 0.21641
Component Sizing Information, ZoneHVAC:PackagedTerminalAirConditioner, PTAC DX CLG ELEC HTG 4, User-Specified Heating Supply Air Flow Rate [m3/s],
1.04793E-019
Component Sizing Information, ZoneHVAC:PackagedTerminalAirConditioner, PTAC DX CLG ELEC HTG 4, Design Size No Load Supply Air Flow Rate [m3/s], 0.21641
Component Sizing Information, ZoneHVAC:PackagedTerminalAirConditioner, PTAC DX CLG ELEC HTG 4, Design Size Outdoor Air Flow Rate During Cooling Operation [
m3/s], 6.85799E-003
Component Sizing Information, ZoneHVAC:PackagedTerminalAirConditioner, PTAC DX CLG ELEC HTG 4, Design Size Outdoor Air Flow Rate When No Cooling or Heating
is Needed [m3/s], 6.85799E-003
```

How to Hard Size

Thermal Zones

Name	All	Rendering Color	Turn On Ideal Air Loads	Air Loop Name	Zone Equipment	Cooling Thermostat Schedule	Heating Thermostat Schedule	Humidifying Setpoint Schedule	Dehumidifying Setpoint Schedule	Multiplier
102A	<input type="checkbox"/>	■	<input type="checkbox"/>		PTAC DX Clg Elec Htg HW Baseboard	SecondarySchool ClgSetp	SecondarySchool HtgSetp			1
102B	<input type="checkbox"/>	■	<input type="checkbox"/>		PTAC DX Clg Elec Htg 4 HW Baseboard 4	SecondarySchool ClgSetp	SecondarySchool HtgSetp			1
103	<input type="checkbox"/>	■	<input type="checkbox"/>		PTAC DX Clg Elec Htg 9 HW Baseboard 9	SecondarySchool ClgSetp	SecondarySchool HtgSetp			1
103A	<input type="checkbox"/>	■	<input type="checkbox"/>		PTAC DX Clg Elec Htg 7 HW Baseboard 7	SecondarySchool ClgSetp	SecondarySchool HtgSetp			1
111	<input type="checkbox"/>	■	<input type="checkbox"/>		PTAC DX Clg Elec Htg 13 HW Baseboard 13	SecondarySchool ClgSetp	SecondarySchool HtgSetp			1
					PTAC DX Clg Elec Htg 2					

OS:ZoneHVAC-PackagedTerminalAirCo

Name
PTAC DX Clg Elec Htg

Availability Schedule Name
Always On Discrete hvac_library

Supply Air Flow Rate During Cooling Operat
 Hard Sized
 Autosized Autosize

Supply Air Flow Rate During Heating Operat
 Hard Sized 2.2204460492502988e-16
 Autosized Autosize

Supply Air Flow Rate When No Cooling or H Needed
 Hard Sized
 Autosized Autosize

Outdoor Air Flow Rate During Cooling Oper
 Hard Sized
 Autosized Autosize

Outdoor Air Flow Rate During Heating Oper
 Hard Sized 0
 Autosized Autosize

Outdoor Air Flow Rate When No Cooling or H is Needed
 Hard Sized
 Autosized Autosize

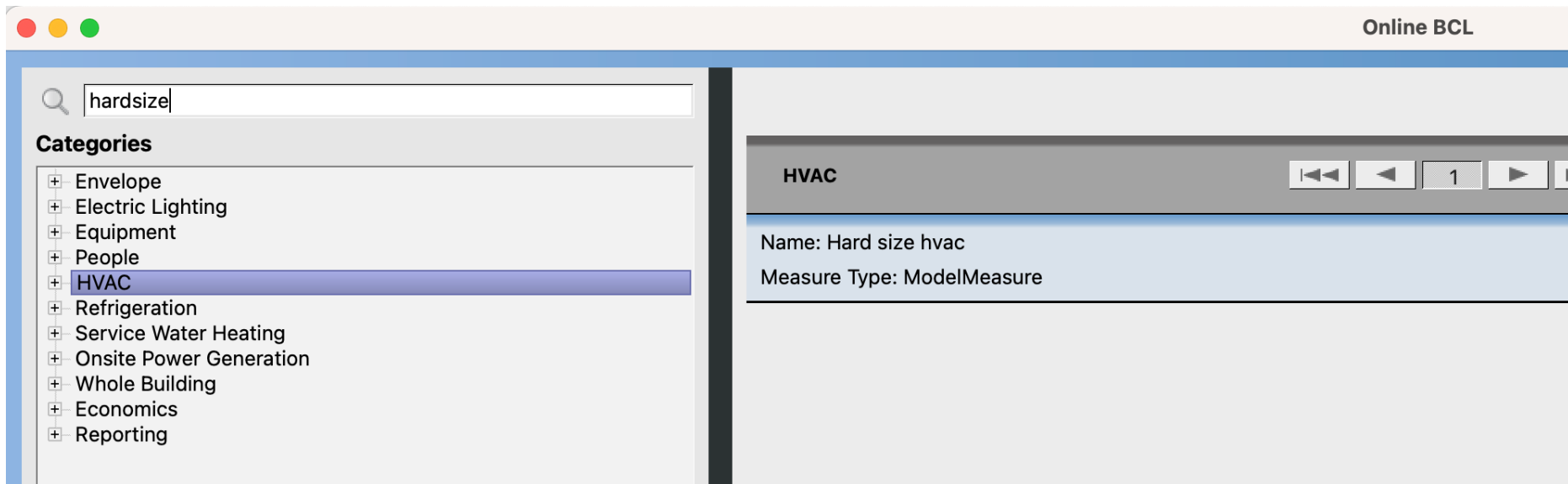
Fan Placement

How to Hard Size

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DX Cooling Coil Standard Rating Information, Coil:Cooling:DX:SingleSpeed, ELEC PTAC 1 SPD DX CLG COIL, 3392.7, 2.51, 8.56, 9.08, 8.70
Component Sizing Information, Coil:Heating:Electric, PTAC ELEC HTG COIL, User-Specified Nominal Capacity [W], 0.00000
Component Sizing Information, Fan:ConstantVolume, ELEC PTAC FAN, Design Size Maximum Flow Rate [m3/s], 0.21503
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Component Sizing Information, ZoneHVAC:PackagedTerminalAirConditioner, PTAC DX CLG ELEC HTG 4, Design Size Heating Supply Air Flow Rate [m3/s], 0.21641
Component Sizing Information, ZoneHVAC:PackagedTerminalAirConditioner, PTAC DX CLG ELEC HTG 4, User-Specified Heating Supply Air Flow Rate [m3/s],
1.04793E-019
Component Sizing Information, ZoneHVAC:PackagedTerminalAirConditioner, PTAC DX CLG ELEC HTG 4, Design Size No Load Supply Air Flow Rate [m3/s], 0.21641
Component Sizing Information, ZoneHVAC:PackagedTerminalAirConditioner, PTAC DX CLG ELEC HTG 4, Design Size Outdoor Air Flow Rate During Cooling Operation [
m3/s], 6.85799E-003
Component Sizing Information, ZoneHVAC:PackagedTerminalAirConditioner, PTAC DX CLG ELEC HTG 4, Design Size Outdoor Air Flow Rate When No Cooling or Heating
is Needed [m3/s], 6.85799E-003
```

How to Hard Size

- Method 3:
 - Using OpenStudio measure:



<https://github.com/NREL/openstudio-calibration-gem/tree/develop/lib/measures/HardSizeHvac>

How to Hard Size

- Should the energy change before and after hard sizing your model?