January 2022 tech roundup

Customer Energy Solutions, E Source

E Source

POWERING WHAT'S NEXT

January 25th, 2022

Specific TAS content resources in 2022

Technology Assessment Service

1. Performance characteristics
   - Report: Impacts from the new Canadian Standards Association heat pump testing and rating system
2. Market potential
   - Report: Driving exterior energy retrofits forward in the US and Canada
3. Pilot recommendations
   - Presentations: Biannual tech roundup webinar and custom presentations
4. Emerging concepts
   - Report: EV load potential and integration strategies for demand response
5. Emerging technology development strategy
   - Event: Customer Energy Solutions Leadership Council (Roundtable summit for top utility emerging technology leaders)

Tech roundup ground rules

- This is a closed-door, vendor-neutral event for utilities
- We will cover 10 technology updates in a rapid-fire format
- Use Zoom's chat feature to ask questions and share comments throughout the presentation
- We'll publish this presentation for all Technology Assessment Service members

Today’s speakers

Luke Beckett

Kenneth Darisaw

Barend Dronkers

Michael Hartnack

Miles Hayes

Jesse Hitchcock

Bryan Jungers

Spencer Sator

Amy Schmidt

Jay Stein

Agenda

- Testing and rating heat pumps
- Prefabricated exterior energy retrofits
- Managed charging projects
- Heat pump controls for greenhouse gases
- Load profile data
- Variable-speed air conditioning
- Quadruple-paned windows
- Efficiency-as-a-service (EaaS) pilots
- Smart splitters for EV charging
- Spectrum control for greenhouses

EXP07: A new rating system for air conditioners and heat pumps

SEER and HSPF—the US Department of Energy ratings for heat pumps and air conditioners (AC):

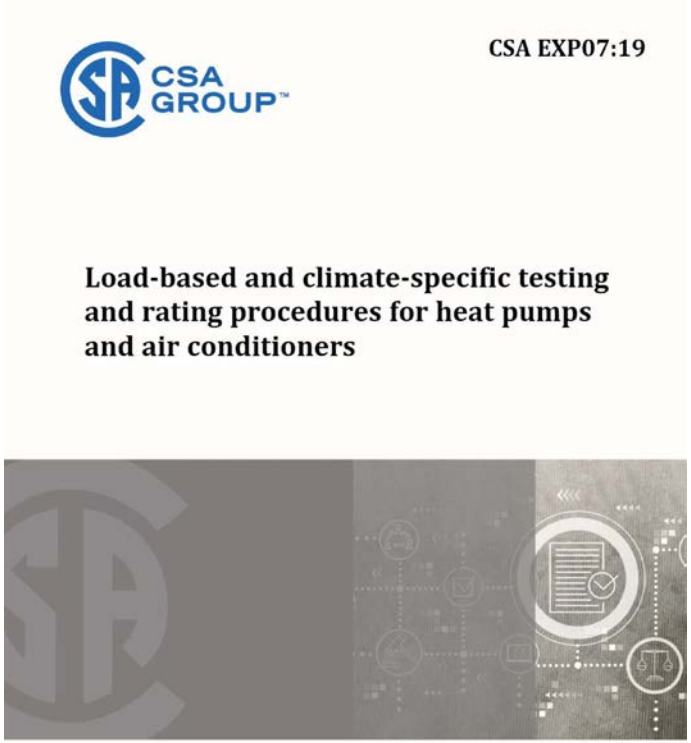
“Don’t get no respect”

Source: Public domain

Note: HSPF = heating seasonal performance factor; SEER = seasonal energy efficiency ratio.

Meet EXP-07

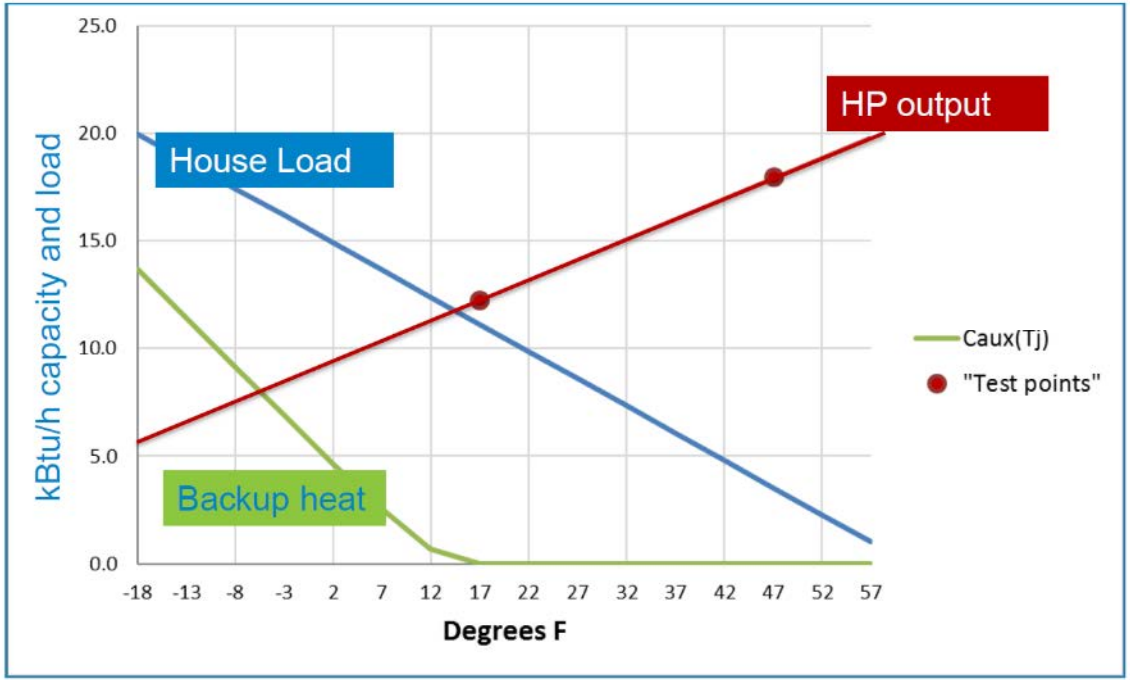
- Residential AC and heat pumps
- Air-air split systems
- ≤ 65,000 Btu-hours
- Both ductless and central
- Variable-speed control
- Eight climate zones
- More-accurate estimates



Source: CSA group

SEER and HSPF not effective for projecting annual energy consumption

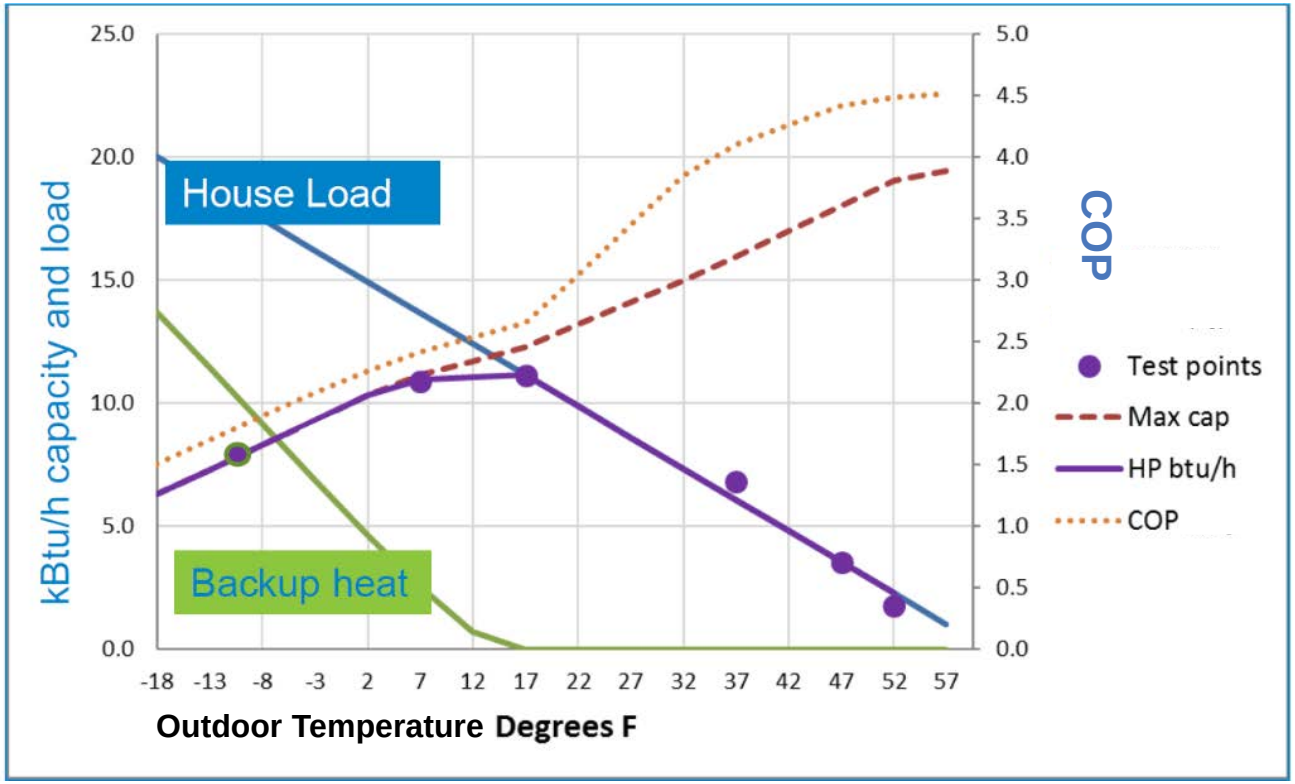
- Limited testing range
- No cycling
- Speeds set by standard, not onboard controls
- No climate



Note: h = hour; HP = heat pump; F = Fahrenheit; kBtu = a thousand British thermal units. Source: Northwest Energy Efficiency Alliance

EXP-07 closer to actual operating conditions

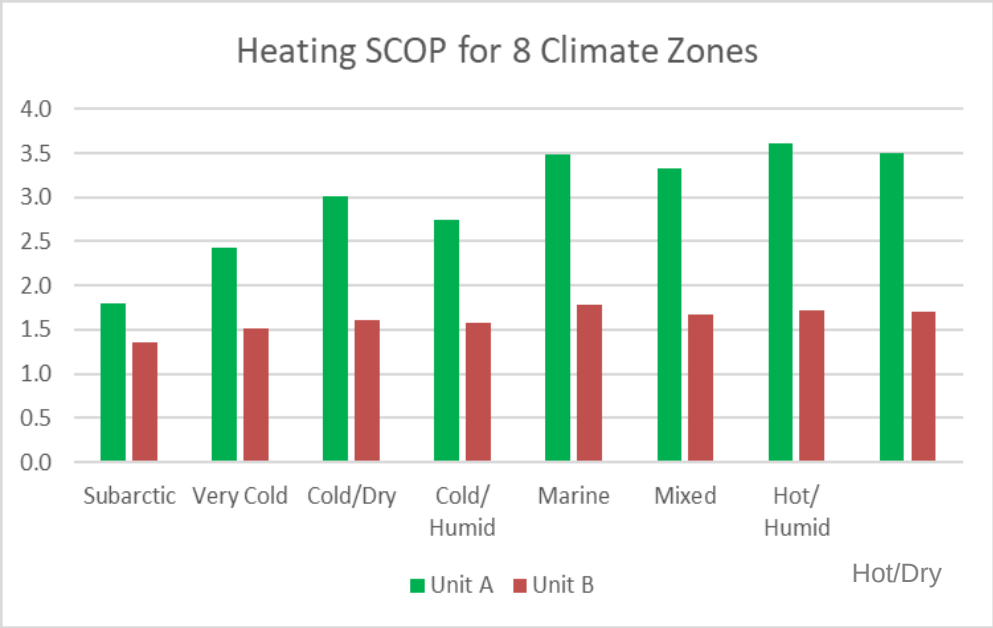
- Heating: 6 test points
- Cooling: 5 test points
- Includes
  - Fan energy
  - Defrost
  - Dehumidification



Note: COP = coefficient of performance; h = hour; HP = heat pump; F = Fahrenheit; kBtu = a thousand British thermal units. Source: Northwest Energy Efficiency Alliance

6 information products per unit

- Heating and cooling
- Capacity vs outdoor dry bulb temperature (ODBT)
- Coefficient of performance (COP) vs ODBT
- Sensible COP (SCOP) for at least 7 climate zones



Note: SCOP = sensible coefficient of performance. Source: Northwest Energy Efficiency Alliance

Better information is better

	Capacity (tons)	HSPH	SEER	SCOP heating	SCOP cooling
Unit A	1	12.0	20.0	3.0	4.8
Unit B	1	12.0	25.0	1.6	3.5

Note: HSPH = heating seasonal performance factor; SEER = seasonal energy efficient ratio; SCOP = seasonal coefficient of performance. © E Source; data from Northwest Energy Efficiency Alliance

- Based on HSPF and SEER two units appear similar
- SCOPs based on cold and dry climate
- Which unit would you rather pay incentives on?

Where things stand

- Representativeness project underway
- 2022 version in March
- Canadian accreditation expected in 2025
- Expected to remain voluntary
- Read more in our report Could EXP07, a new HVAC rating standard, replace SEER and HSPF for utility programs?

Prefabricated exterior energy retrofits: A huge residential savings opportunity?

Prefabricated exterior energy retrofits (PEER)

- The single largest untapped residential savings opportunity?
- Prefabricated panels that are built in manufacturing facilities then transported to the building site and glued or nailed to exterior walls
- Considered a deep energy retrofit because it’s most effective with other major systems upgrades

How PEER works

Source: Energiesprong

- No siding removal necessary
  - Because whole walls are fabricated, there is no break in waterproof barrier
- Makes most sense with interior upgrades
  - High-efficiency heat pump or other HVAC upgrades
  - Solar can be added to achieve net zero (more on this in a minute)
- Few pilots in US and Canada to date
  - Great zero net energy or deep energy pilot for existing homes
  - Great fit for low- and moderate-income programs
- Best applications
  - Best in colder climates and with older housing stocks
  - Most cost-effective in low-rise multifamily or row houses (less exterior wall area per unit)

Costs and benefits

Costs

- Cost ~$7 to $16 per sq. ft.
- $94k in Netherlands row houses (includes HVAC upgrades, solar)
- More cost-effective when siding replacements, asbestos mitigation, and water infiltration investigations is required

Benefits

- Brings R-values up by 10 to 20 points
- Can partially or fully eliminate energy bills
- A RetrofitNY pilot expects 60% to 80% total energy savings (when paired with additional improvements)

A home awaiting upgrades sits among completed neighboring properties in the Netherlands. Source: Energiesprong

Market maturing in Europe, nascent in US and Canada

Europe:

- Energiesprong has retrofitted 5,000+ homes in Netherlands
- Massive expansion plans across Netherlands and the European Union
- Initial cost is **free** to homeowners
- Includes installation of solar roof, PEER, and new HVAC
- Work typically takes less than one week
- 30-year warranty
- Netherlands has 6 PEER panel manufacturers

US and Canada:

- Only a few demonstration sites to date
- New York State Energy Research and Development Authority (NYSERDA) launched RetrofitNY in 2021, an low- and moderate-income initiative that includes PEER
- Limited panel manufacturing capability (~10 makers with capabilities for new construction panels who can retool for retrofits)

Modular home demonstration: Natural Resources Canada

Pilot Results

Performance Metric	Baseline	Retrofit	% Improvement / Reduction
Airtightness *(ACH@50Pa)*	7.62	0.82	89%
Normalized Leakage Area @ 10 Pa *(cm2/m2)*	1.84	0.20	89%
Heat loss – Walls (kWh)	4,118	1,102	73%
Design Heat Loss (@-25C) *(W)*	5,629.0	2,334.0	59%
Thermal Energy Demand Intensity *(kWh/m2a)*	229.0	54.2	76%

Note: ACH = air changes per hour; kWh = kilowatt-hour; m2a = square meter area; Pa = pascal; W = watt. Source: Natural Resources Canada

Many alternatives to prefabricated panels

Insulating the outside, then covered with siding or stucco

- Exterior insulation and finish systems (EIFSs)
- Exterior insulated sheathing, exterior super-insulation
- Thermal break shear wall assembly
- Spray foam outer shell retrofits

Insulating exterior finishes

- Insulated vinyl siding
- Masonry wall retrofit applications

Onsite cut-to-fit prefabricated panels

- Retrofit insulated panels (RIPs)

Layered scheme for exterior insulated sheathing

We need pilots in the US and Canada!

Pilot goals:

- Establish costs, savings, installation protocols
- Help establish supply chain, trained contractors, educate inspectors and municipalities
- Case studies can help convince homeowners of the performance

If you move forward:

- Rocky Mountain Institute is the leader in the US with its REALIZE program
- REALIZE seeks to make projects break even for customers through a long-term “energy service plan” (solar leasing model)
- REALIZE is already developing pilot sites in California (REALIZE-CA)

A few notes of caution

- Water protection is important
  - Especially important in brick and masonry buildings, where moisture can get trapped and cause extensive damage in freeze-thaw cycles
- Building wall weight loads
- Limited contractor or city inspector knowledge
- Very close-in buildings or landscaping can interfere
- No high-rise products
- Zoning or historical designations

Additional resources

- Prefabricated Zero Energy Retrofit Technologies: A Market Assessment (PDF), 2020
- Wall Upgrades for Residential Deep Energy Retrofits: A Literature Review, 2019
- Using Retrofit Nail Base Panels to Expand the Market for Wall Upgrades, 2016

Active managed charging: Is it right for you?

Active managed charging

- Allows the utility to take control of the charging load.
- Charging can be turned on or off during designated events, or continuously in response to daily peak, electricity mix, or other grid demands.
- According to SEPA's The State of Managed Charging in 2021, 29 utility programs exist with active control through the EV supply equipment (EVSE)—up from 17 in 2019

Examples of utility active managed charging

- Eversource's ConnectedSolutions EV
  - Charging is slowed down to 1.8 kW during demand response events
  - Guarantees 4 hours continuous charging between 6:00 p.m. and 6:00 a.m.
  - Bring your own charger with a $150 to $300 signing reward and $50 per year for 3-year term
- Xcel Energy's EV Accelerate at Home
  - Rent or purchase EVSE from Xcel Energy (installation included)
  - Turnkey solution—charger is preprogrammed to follow peak schedule
  - Customers can charge at other times (time-of-use rate applies)

Green Mountain Power (GMP)

EV Rate 72 manages charging on customers behalf during peak events

- 5 to 10 events per month
- 2 to 6 hours each

GMP provides a free charger and disables it during events

- Customers can opt out of an event but are charged an opt out rate

Active managed charging program	
Usage, peak opt-out	$0.71822 per kWh
Usage, off peak	$0.13969 per kWh

Passive managed charging program	
Usage, peak	$0.17650 per kWh
Usage, off peak	$0.13433 per kWh

Note: kWh = kilowatt-hour

The peak opt-out rate is higher than the peak rate during the passive TOU program.

"Early EVSE Demand Response (DR) pilots have shown promising potential, but **challenges related to equipment connectivity and asset availability** will need to be addressed before these programs can achieve the scale and dispatchability that utilities may ultimately want."

Source: Eversource, 2019 EVSE Direct Load Control Demonstration–Process Evaluation Findings

Evaluations

"Results from the evaluation of the EVCS pilot indicate there is minimal impact to System peak, in terms of additional load/potential DR savings, even as the kilowatt (kW) savings are projected across the estimated existing population of EVs in Colorado."

Source: Xcel Energy Colorado, Electric Vehicle Charging Station Pilot Evaluation Report 2015

"Almost no customers were charging during demand response events which shows that just planning a DR event incentivizes customers not to charge during that time, or that customers were not plugged in at that time anyway."

Source: Pepco Demand Management Pilot for Plug-In Vehicle Charging in Maryland 2016

"The implementation costs remain highly uncertain due to lack of scale, and many questions remain about the ability for managed charging to produce reliable cost benefit analyses."

Source: National Renewable Energy Laboratory's Assessing the value of electric vehicle managed charging: a review of methodologies and results 2022

Food for thought

Passive managed charging can also produce results

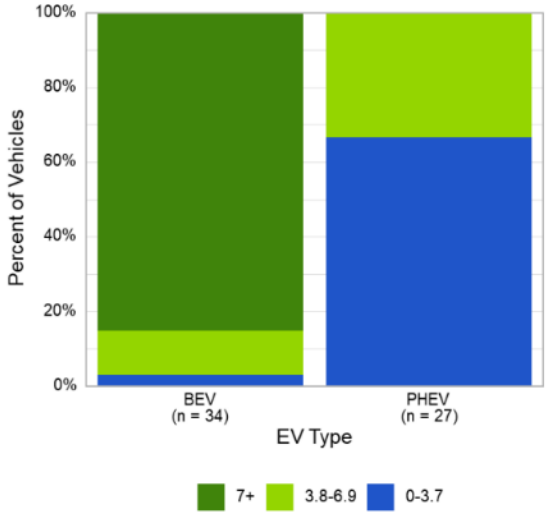
Upfront EVSE cost can be a barrier

- 72% of active managed charging projects offer a subsidy for the EVSE

Knowing your customers (vehicle type, charging preferences)

Asset availability and connectivity

Figure 18. Onboard Power Draw (kW) by EV Type



Note: BEV = battery electric vehicle; kWh = kilowatt-hour; PHEV = plug-in hybrid vehicle. Source: Guidehouse

Food for thought

Local load conditions

- Xcel Energy evaluation noted that it "doesn't expect significance on distribution feeder capacity until 4% EV penetration" and that the company is "10+ years away" from that point

Fleets or workplace charging may provide opportunities

We need more evaluations!

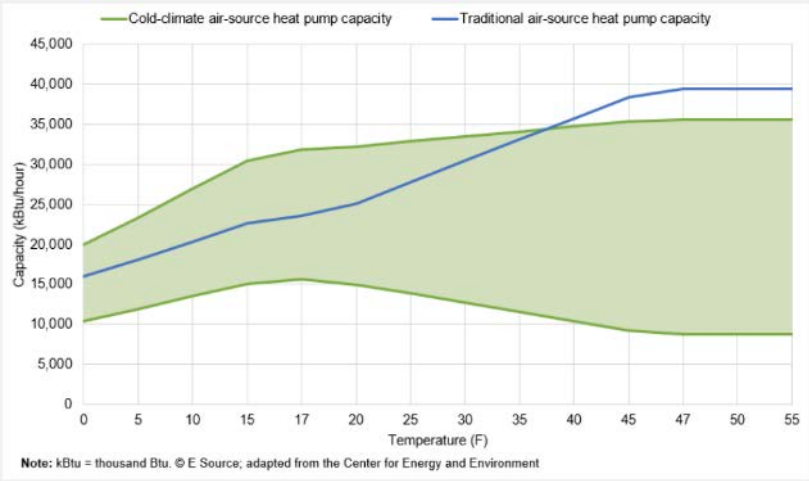
New greenhouse gas controls for dual-fuel heating

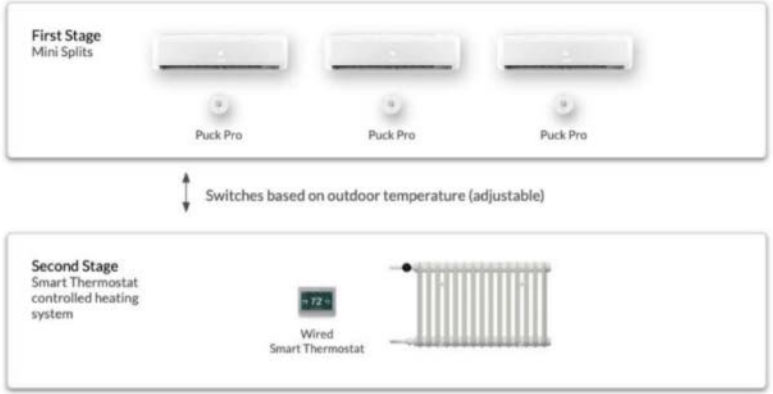
Where we've been and where the industry is going

- Real-time greenhouse gas (GHG) reporting isn't a new topic to E Source, see our 2020 Forum Session Driving decarbonization with demand flexibility
- New research that has emerged in 2021
- Data centers driving the demand for real-time GHG monitoring in recent years
- An ongoing debate surrounding real-time GHG reporting
- New technologies and strategies that offer some solutions

2021 E Source recap

Last year we focused on heat pumps and dual-fuel controls





Source: Flair

- Cold-climate heat pumps are ready to bolster your decarbonization efforts
- Spring 2021 tech roundup

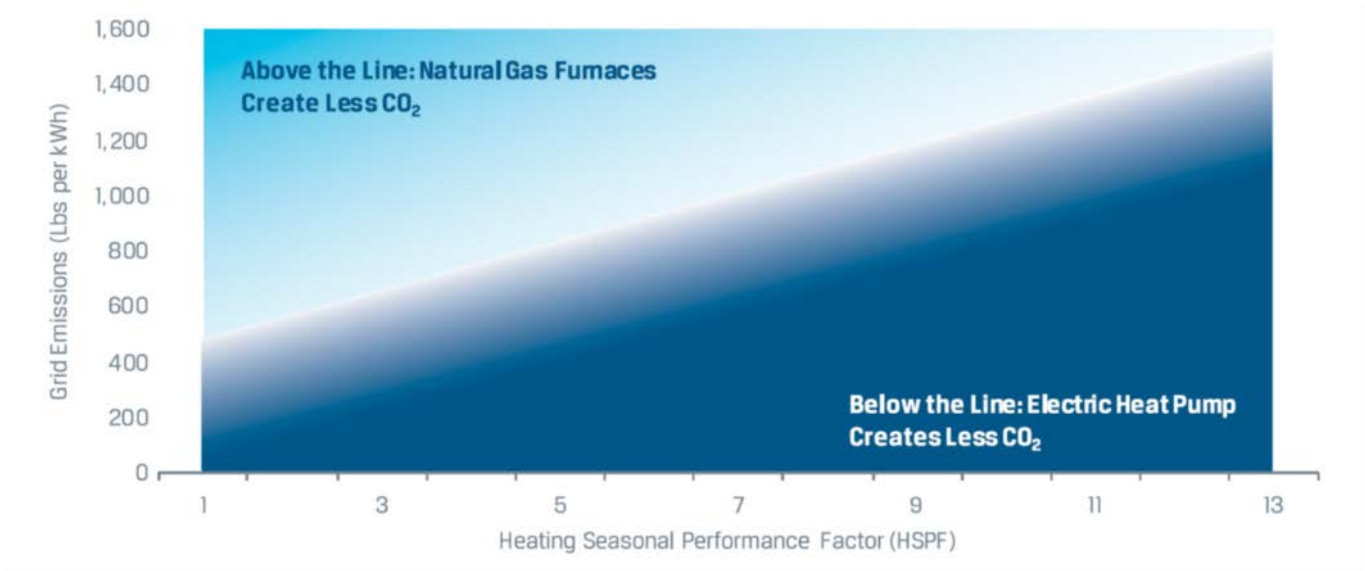
Recent research reveals a challenging balancing act

- 233 locations simulated
- Many locations will require dual-fuel solutions for the near term
- Balancing act as more renewable generation comes online
- How will we optimize the control of dual-fuel homes for the best outcome?

Heat pump system types	Carbon dioxide improves today
Single-speed all electric	4 states
Variable-speed all electric	8 states
Single-speed dual fuel	9 states
Variable-speed dual fuel	15 states

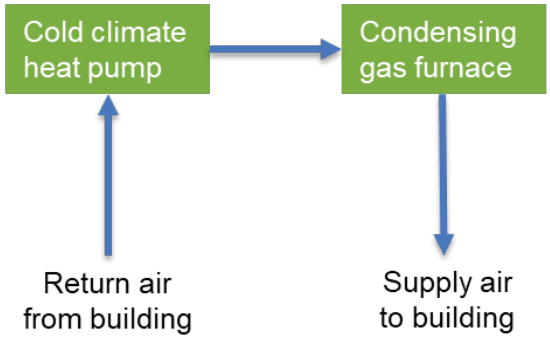
Source: Western Cooling Efficiency Center UC Davis, Analysis of Greenhouse Gas Emissions from Residential Heating Technologies in the USA (PDF)

Which releases fewer CO_2 emissions: Gas or electric space heating?

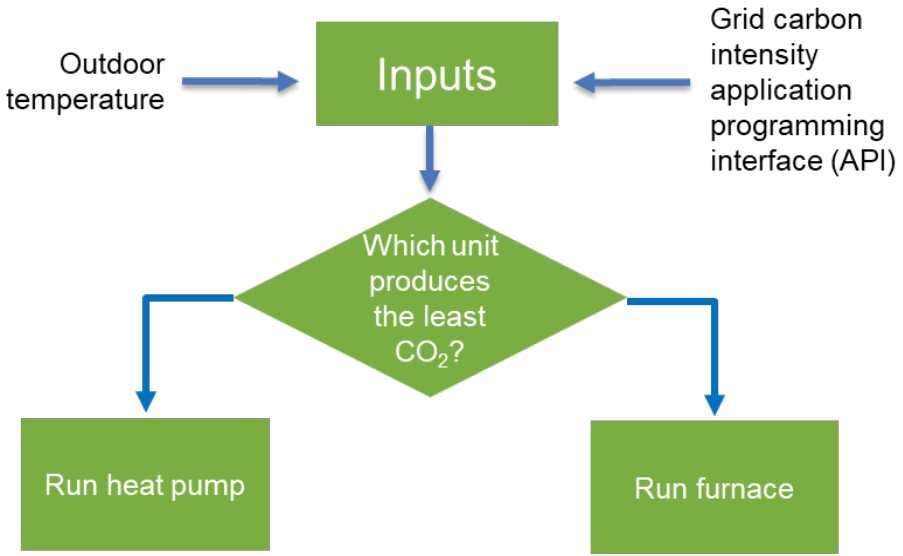


Notes: Co_2 = carbon dioxide; kWh = kilowatt-hour; Lbs = pounds. Source: American Gas Association

Dual-fuel carbon responsive HVAC



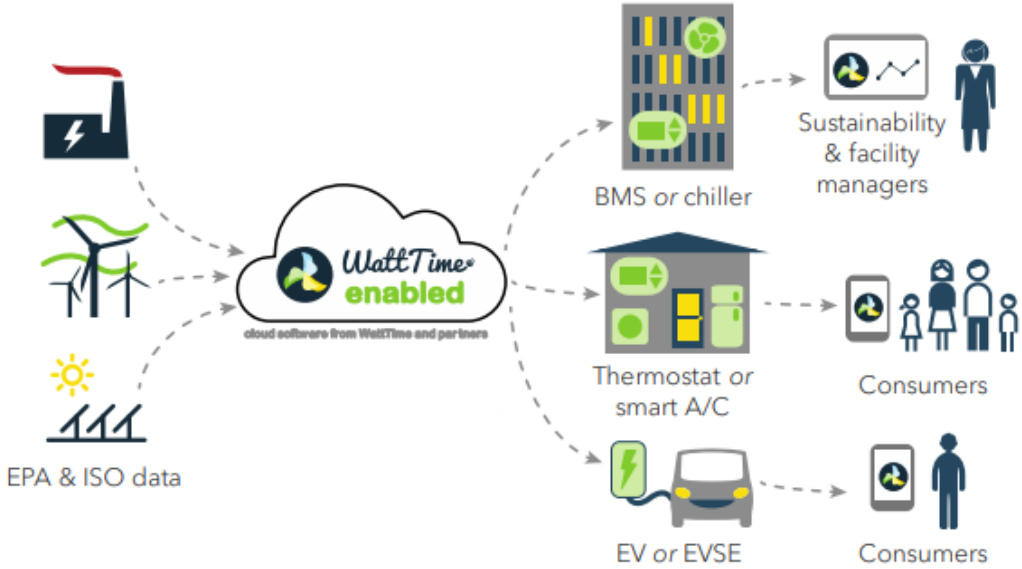
Physical system



Controls

Potential solutions entering the market

- Google Nest Renew
- WattTime
- EnergyTag
- Carbonara by Singularity
- electricityMap
- Kevala



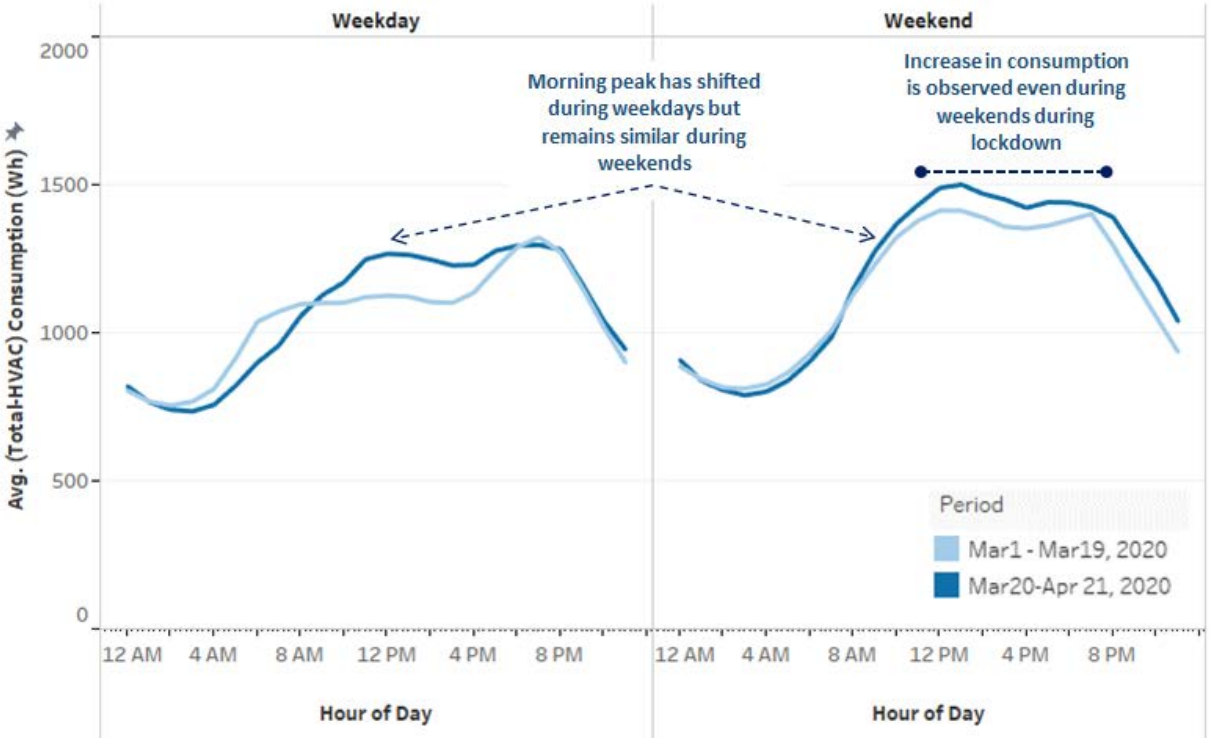
Source: WattTime

Additional research

- 2021 Northwest Energy Efficiency Alliance (NEEA) report, Variable Speed Heat Pump Smart Thermostat Findings
- 2021 NEEA report, Northwest Smart Thermostat Research Study
- 2021 NEEA report, Maximizing Mini Split Performance Report
- Zero Lab, System-level Impacts of 24/7 Carbon-free Electricity Procurement
- 2020 Western Cooling Efficiency Center UC Davis report, Analysis of Greenhouse Gas Emissions from Residential Heating Technologies in the USA (PDF)
- 2019 SlipStream report, Dual Fuel Air-Source Heat Pump Monitoring Report (PDF)
- 2018 ACEEE report, Energy Impacts of Smart Home Technologies

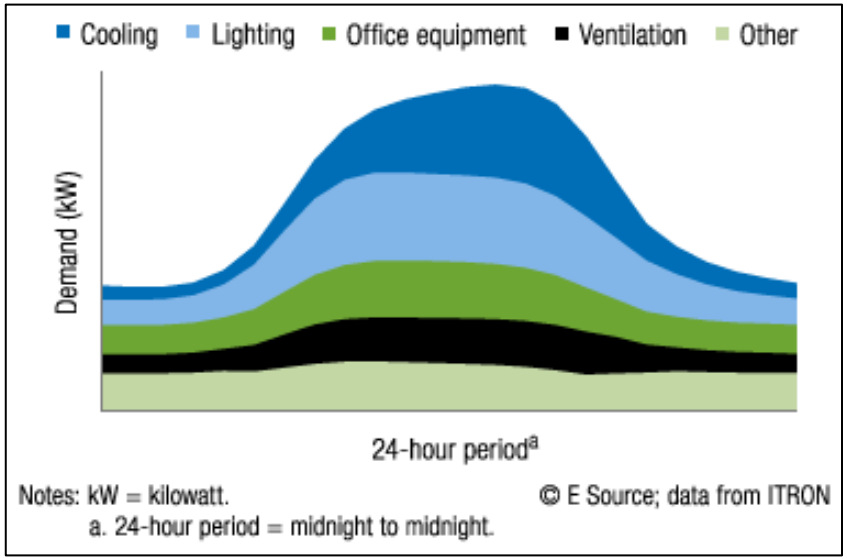
NREL end-use load profiles for all US building stock

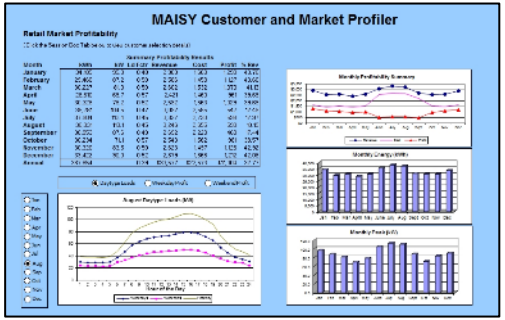
Load profiles: Who needs ’em?



Note: Wh = watthour. Source: Bidgely; How do you measure energy savings during and after the COVID-19 pandemic?

Where to get end-use load profiles (EULPs)

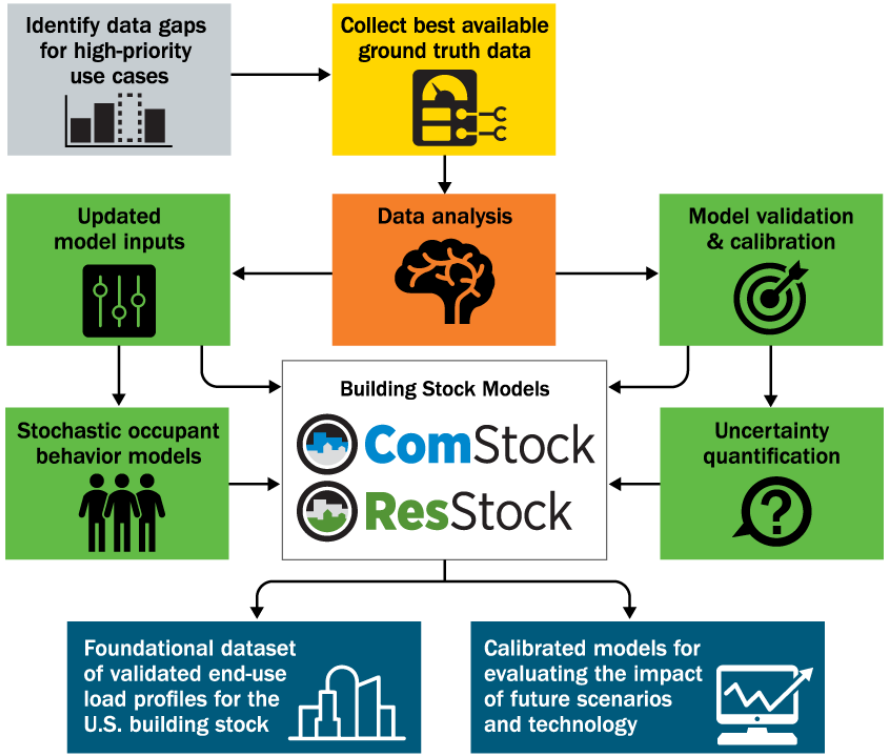




Source: MAISY

Source: EPRI

Responding to the need for better EULPs



Source: NREL

NREL Transforming ENERGY

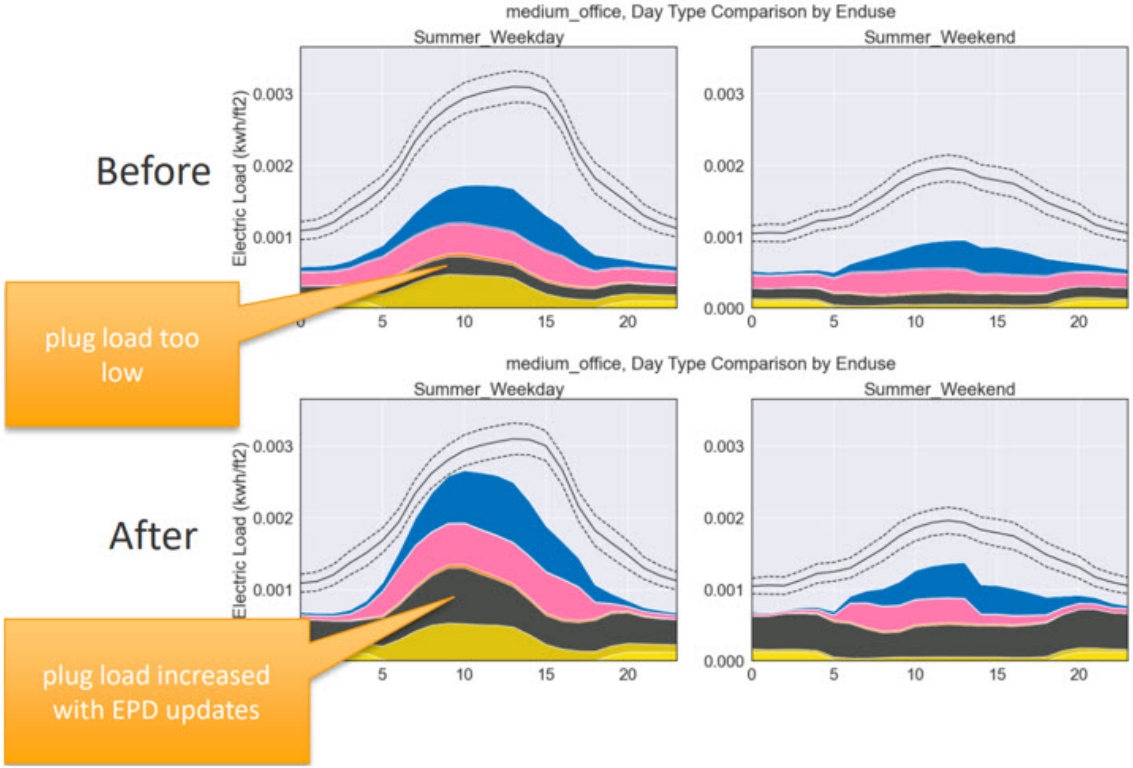
BERKELEY LAB

Argonne NATIONAL LABORATORY

EPRI ELECTRIC POWER RESEARCH INSTITUTE

E Source

Most of the work—calibration and validation



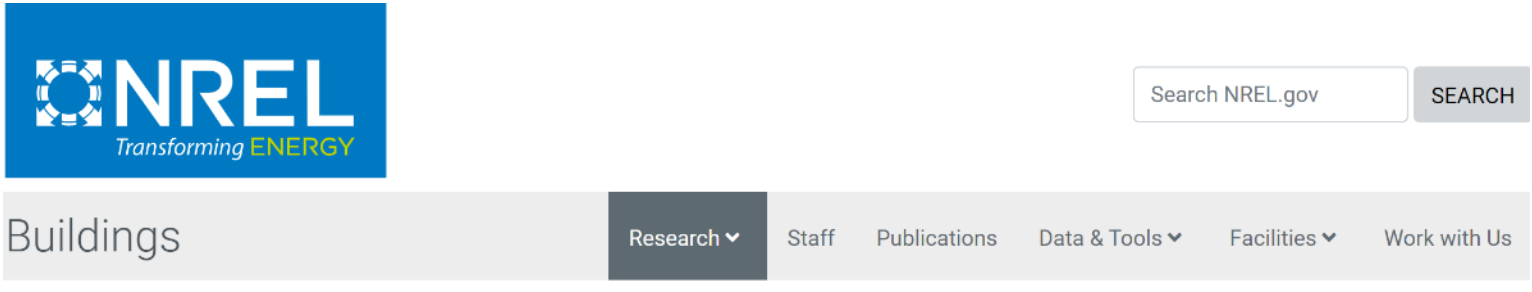
Region 1 – Fort Collins, CO

Note: kWh = kilowatt-hour. Source: National Renewable Energy Laboratory

Final deliverables

- Full dataset = 17 terabytes
- Downloadable spreadsheets of preaggregated data
  - By climate region, census tract, and other slices of the dataset
- Using ComStock and ResStock
- Web-based data viewers

Where to get the goods



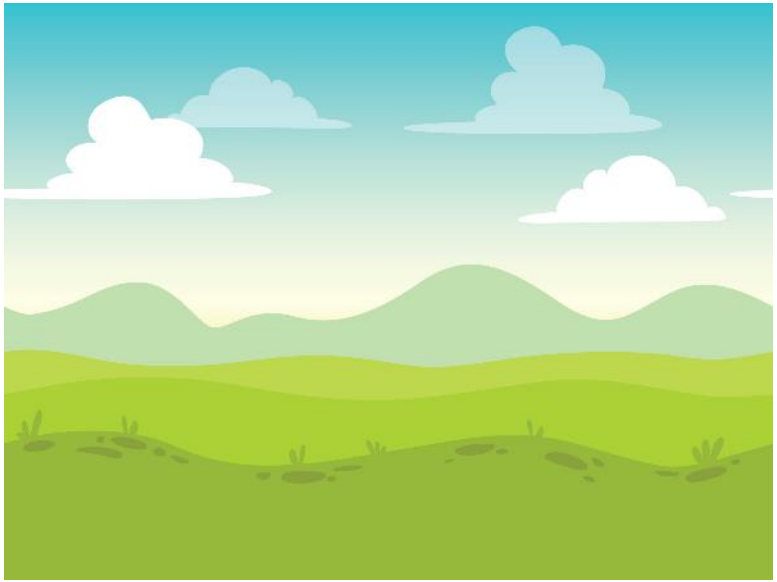
Source: NREL, End-Use Load Profiles for the U.S. Building Stock

Variable-speed air conditioners and demand response

A new kind of cooling load

What if we no longer have jagged peaks and valleys, but instead have rolling hills?

Single-speed AC



Variable-speed AC

Variable-speed air conditioners in the HVAC landscape

Instead of running compressor at 100% or 0% (simple on-off function), a variable speed AC compressor can run anywhere between 100% to 30% when on.

- Single speed? Think digital
- Variable speed? Think analog

Variable-speed AC response to temperature setback event

- Load profile of each unit matches the aggregate load so there's less variety in load shapes compared to single-speed compressors
- Different models have different performance!
  - Internal cycling control systems differ, so models have different average and peak loads
  - Focus on top performers in eligible product lists

Source: Berend Jan Christiaanvan Putten, An Analytical Model for Demand Response of Variable-Speed Air Conditioners

Why does this matter?

- Fewer units running at 100% capacity at a given time

Critical peaks are less common

Customer experience improvements

More benefits than just peak shaving

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- Units don’t need to turn off during events
- Temperature changes are more gradual

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Why does this matter?

- Fewer units running at 100% capacity at a given time

Critical peaks are less common

- Units don't need to turn off during events
- Temperature changes are more gradual

Customer experience improvements

- Smaller adjustments over the course of the day to control for emissions intensity and energy prices

More benefits than just peak shaving

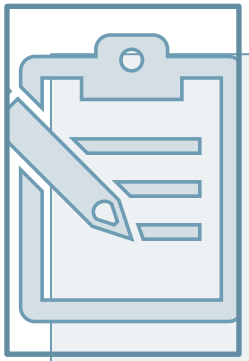
Potential advantages

Next steps

Next steps

Start tracking variable-speed AC installations separately from single-speed AC installations

Next steps



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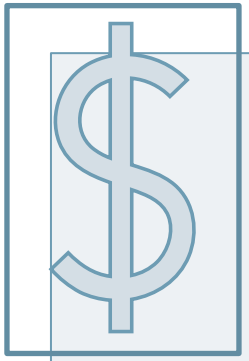
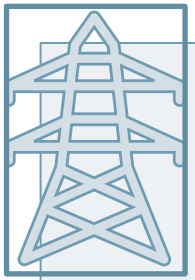


Consider offering greater incentives for variable-speed vs single-speed units

Next steps

Start tracking variable-speed AC installations separately from single-speed AC installations

Consider offering greater incentives for variable-speed vs single-speed units



Design new demand-management programs for customers with variable-speed units

Thin quadruple-paned windows show promising energy savings and costs

Thin quad-paned windows

The windows

- Two very thin sheets of internal glass
- Krypton gas in each chamber
- Fiberglass frames
- Six to eight (measured vs rated) times better insulation than single-paned windows
- Weight and thickness is about the same as double-paned
- Same footprint and installation as average double-pane window

Only one known pilot

- Completed in November 2021 by US General Services Administration at the Denver Federal Center
- Significant savings compared with even high-performance double-paned windows

Manufacturer

- Alpen High Performance Products
- Andersen likely to follow soon (pioneers of thin triple technology)

Source: US General Services Administration

Traditional windows

Single-pane windows are the weakest link in the building envelope

34% energy loss

20% exterior air

30% building stock

Note: Data is from General Services Administration.

Suffering is optional

Savings

- The 2021 GSA study found 23% HVAC modeled energy savings compared with high-performance double-paned windows.
- Payback period for quad windows average 1.8 years across US climate zones (compared with high-performance double-paned windows common with new construction)

Costs

- <10% cost increase: Cost of thin quad windows is $34.87 per square foot, compared with $32.38 for high-performance double-paned windows

Source: US General Services Administration

More pane, more gain

Savings potential	**High**
Cost-effectiveness	**High**
Estimated useful lifetime	**30+ years**
Applications	▪ New construction ▪ Existing buildings with single- or double-paned windows that are due for replacement
Fuel	**Dual**
Benefits	▪ Greater thermal comfort ▪ Good sound attenuation ▪ Low interior condensation ▪ Allows high visible light transmittance with no tinting ▪ Identical thickness to double-paned windows

Economies of scale

	Double pane	Triple thin	Quad thin
Glazing	2	3	4
Insulating gas	Argon	Krypton	Krypton
Footprint	NA	Equal to double	Equal to double
U-value (Btu per h·ft^2·°F)	0.32*	0.2*	0.13*
R-value	Up to 3.7	Up to 5	7 to 8
Cost	$	$$	$$

Notes: h = hour; ft^2 = square foot; F = Fahrenheit; NA = not applicable. *Simulated results from EnergyPLUS modeling or Lawrence Berkeley National Laboratory, High-Performance Window Demonstrates Berkley Lab-to-Market Success.

In conclusion …

- Excellent candidate for pilots
  - Suitable for both fixed and operable window applications
- Permanent solution
- Lightweight, cost-effective alternative to double-pane windows
- Approximately 10% more expensive than high-performance double pane windows
- **Significantly increase measure cost-effectiveness with little risk or downside**

EaaS: Driving deep energy savings for hard-to-reach customers

Why efficiency as a service (EaaS)?

Removes top energy-efficiency barriers

- **Removes split incentive** between tenants and owners
- **Targets hard-to-reach customer segments** with long-term, deep energy saving contracts
- **Avoids rate-base erosion** by adding EaaS payments on utility bills

EaaS = M&V 2.0 + Pay-for-performance (P4P)

Measurement and Verification (M&V) 2.0

Uses advanced metering infrastructure (AMI) to accurately measure when and where buildings save energy

- Achieves granular savings in time and by end-use
- Improves accuracy (10% error or more as opposed to 5%)

P4P contracts

Contracts that pay for energy savings as the building owner and tenants realize them

- Customers pay only for energy savings the building achieves
- Utility pays energy service provider (ESP) for contracted energy savings

EaaS = M&V 2.0 + Pay-for-performance (P4P)

Measurement and Verification (M&V) 2.0

Uses advanced metering infrastructure (AMI) to accurately measure when and where buildings save energy

- Achieves granular savings in time and by end-use
- Improves accuracy (10% error or more as opposed to 5%)

P4P contracts

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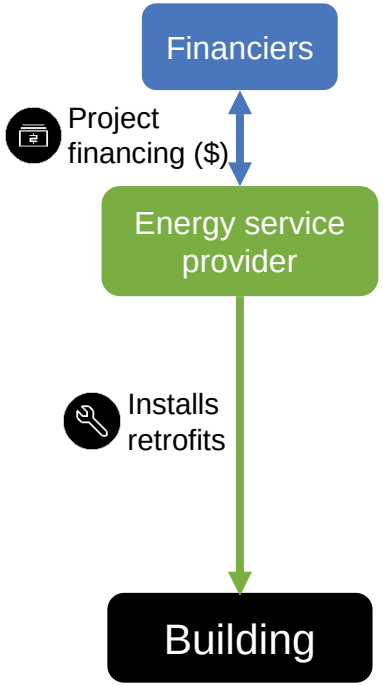

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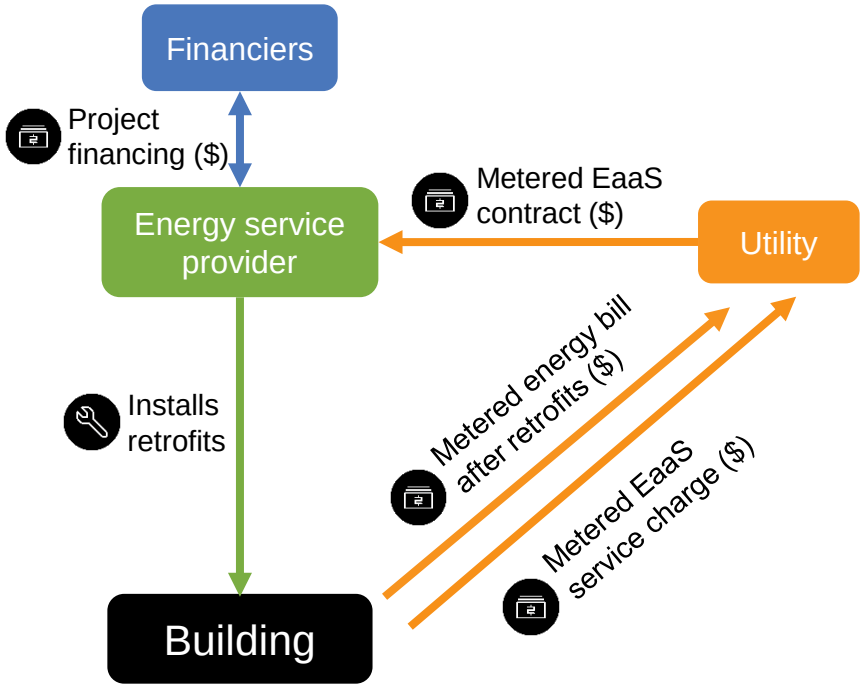


EaaS pilot program momentum

Demo project

2016. Seattle's Bullit Center uses the Metered Energy Efficiency Transaction Structure (MEETS) in first pilot project.

Pilot programs

2020. Seattle City Light launches MEETS-styled pilot program: The first EaaS utility program

2021. City Light EaaS program has first building under contract and five approved applications

Scaling up!

2021 to 2022. National Grid, Hawaiian Electric Co., Con Edison, and NYSERDA engage with financiers and project developers to develop utility pilots.

- National Grid's Efficiency as a Resource
- Con Edison and NYSERDA's EaaS pilot

First Seattle EaaS project (2021)

$7 million retrofit
+ 30% energy savings
+ **$0 incentives**

Metering energy savings needs baseline

Approach needs to be

- Reliable
- Flexible
- Transparent
- Transferable

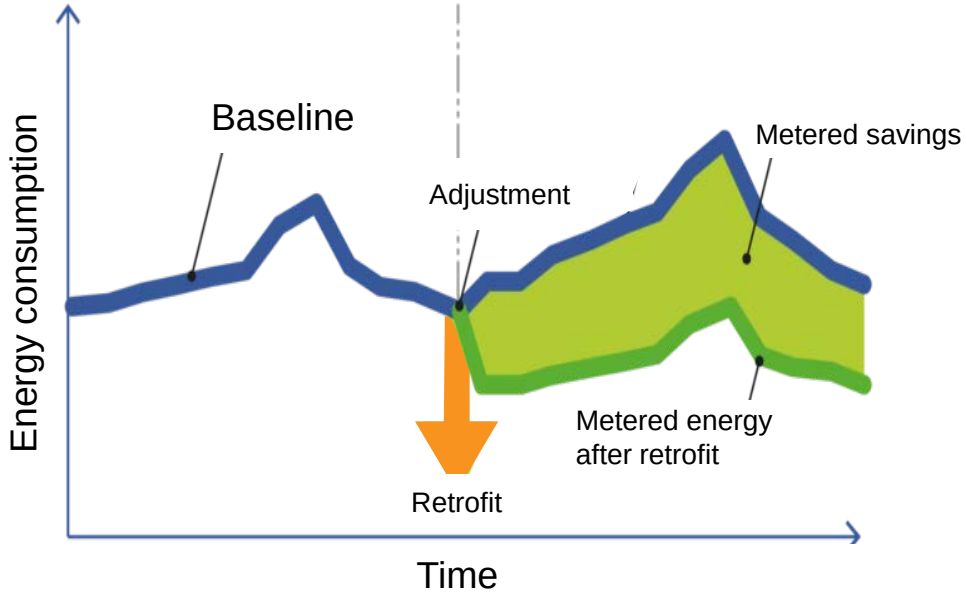
International Performance M&V Protocol (IPMVP) Option C:

Whole building metered data

or …

IPMVP Option D:

Calibrated simulation



© E Source; data from Efficiency Valuation Organization

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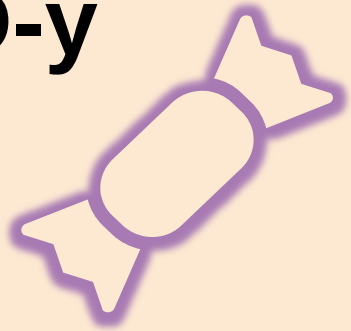
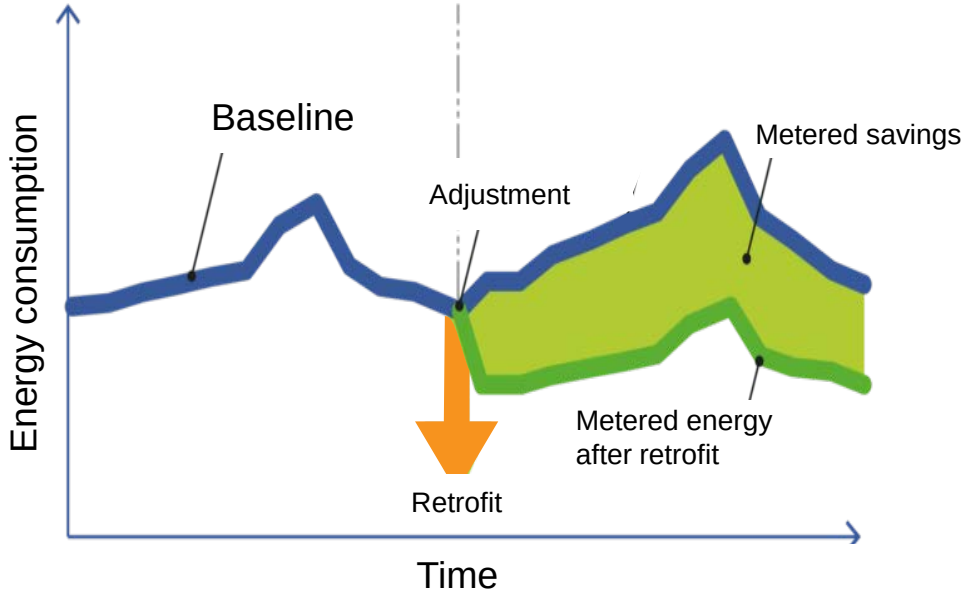
C-an-D-y

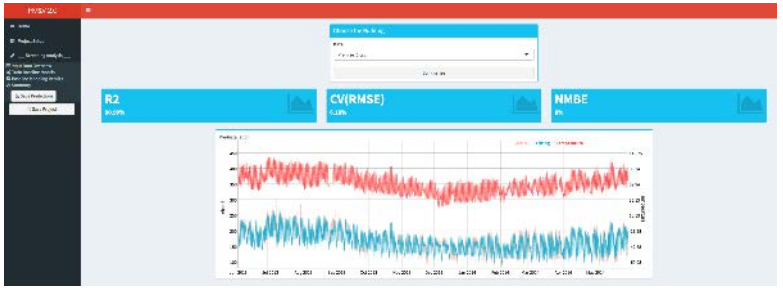




Which vendors can meter EaaS?

EnergyRM's DeltaMeter

- Combines IPMVP Options C and D to produce a baseline that can be adjusted for routine and nonroutine events
- Challenge is dealing with nonroutine events
  - New tenants and change in occupancy levels
  - New or change in equipment (e.g., HVAC, medical equipment)
  - Changes in building controls strategies



Source: LBNL RMV2.0

Open source tools offer platform for efficiency metering

- Lawrence Berkeley National Laboratory's RMV2.0
- kW Engineering's nmecr

EV charging with the NeoCharge Smart Splitter

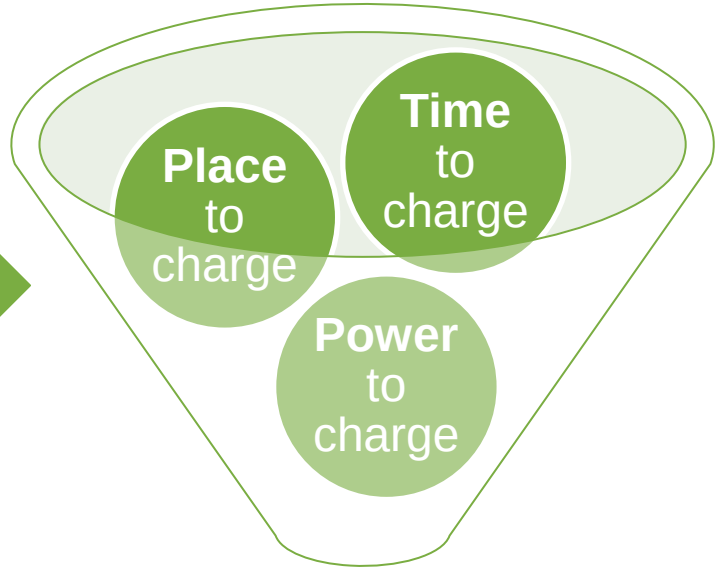
To run an electric vehicle, you need…

To run an electric vehicle, you need…

to charge it

To run an electric vehicle, you need…

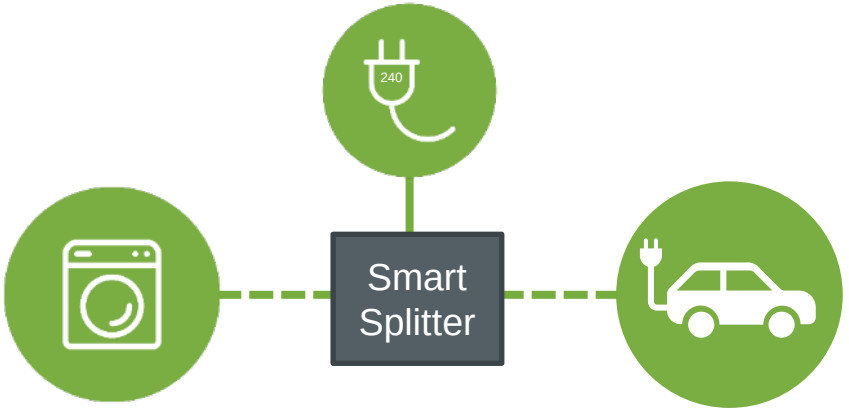
to charge it



Charged EV

What is a smart splitter?

A smart splitter is a device that allows you to share your dryer's 240 volt (V) outlet with your EV charger



Charging benefits

Smart Splitters:

- Prevent the need for expensive dedicated 240 V circuits or panel upgrades
- Significantly increase charging speeds over household 120 V outlets
- Can provide safety mechanisms including breakers for current and heat safety without an electrician
- Allow renters to charge at 240 V without installing new circuits

So, what’s the catch?

- Most homes don’t have dryers in the garage
- Many newer-construction homes come ready for a Level 2 charger for the same price as a smart splitter
- Safety concerns: Dryer outlets, especially in older homes, may not have been designed for an always-on EV load

Source: NeoCharge

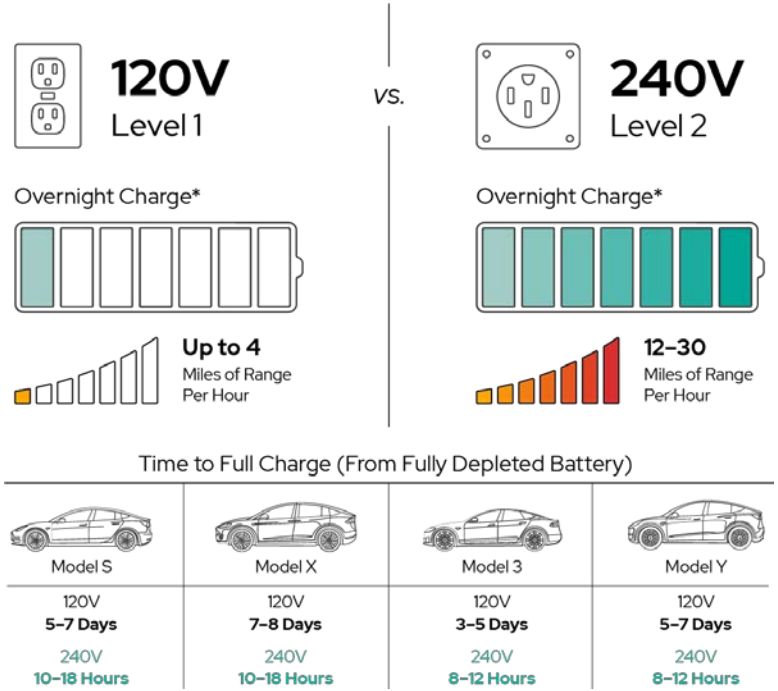
Typical 240 V home charging

Includes the following estimated costs:

- Charging station……..$300 to $500
- Permit……$150 to $200
- Electrical materials……..$400 to $700
- Electrician labor……..$200 to $1,200

- Total Costs: $1,050 to $2,600

Charging benefits



Source: NeoCharge

- Smart splitters give EV owners the opportunity to charge at Level 2 speeds from their home without upgrading or modifying their electrical infrastructure.
- These also enable innovative load management opportunities and EV rate structures.

Smart splitters market

Two major providers of smart splitters

Source: SplitVolt

Source: NeoCharge

NeoCharge Smart Splitter

NeoCharge Smart Splitter:

- Launched in September 2020
- Has a companion app for tracking power usage and costs across both connected devices
- Allows the switch to be used for prioritized autoswitching charging of two EVs on one 240 V outlet
- Is UL listed

Source: NeoCharge

SplitVolt Smart Splitter

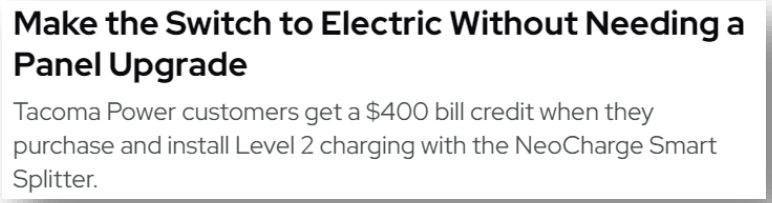
Source: SplitVolt

- Debuted in January 2021
- Provides an on-device display screen with voltage, current, kWh and status indicators
- Contains an integrated 25 amp circuit breaker
- Is compatible with chargers ranging from 24 to 40 amps and with EVs from FCA, Ford, GM, Honda, Tesla, VW, and Volvo

Smart splitter utility pilots and partnerships

- In June 2021, NeoCharge submitted a proposal for consideration as part of the California Energy Commission's EPIC plans.
- Tacoma Power—$400 rebate
- Silicon Valley Clean Energy—$125 discount. Developing pilots for load shifting functionality
- Central Coast Community Energy—full rebate

Source: NeoCharge



Source: NeoCharge

Smart splitter strategies

- Educating customers about options
- Engaging directly with smart splitter vendors and provide direct-to-customer purchase options
- Pilot and learn from other pilots
- Use to overcome EV charging barrier
- Build EV rates that use smart splitters

Getting smart splitter out to your customers:

- Incentives
- Rebates
- Partnerships
- Pilots

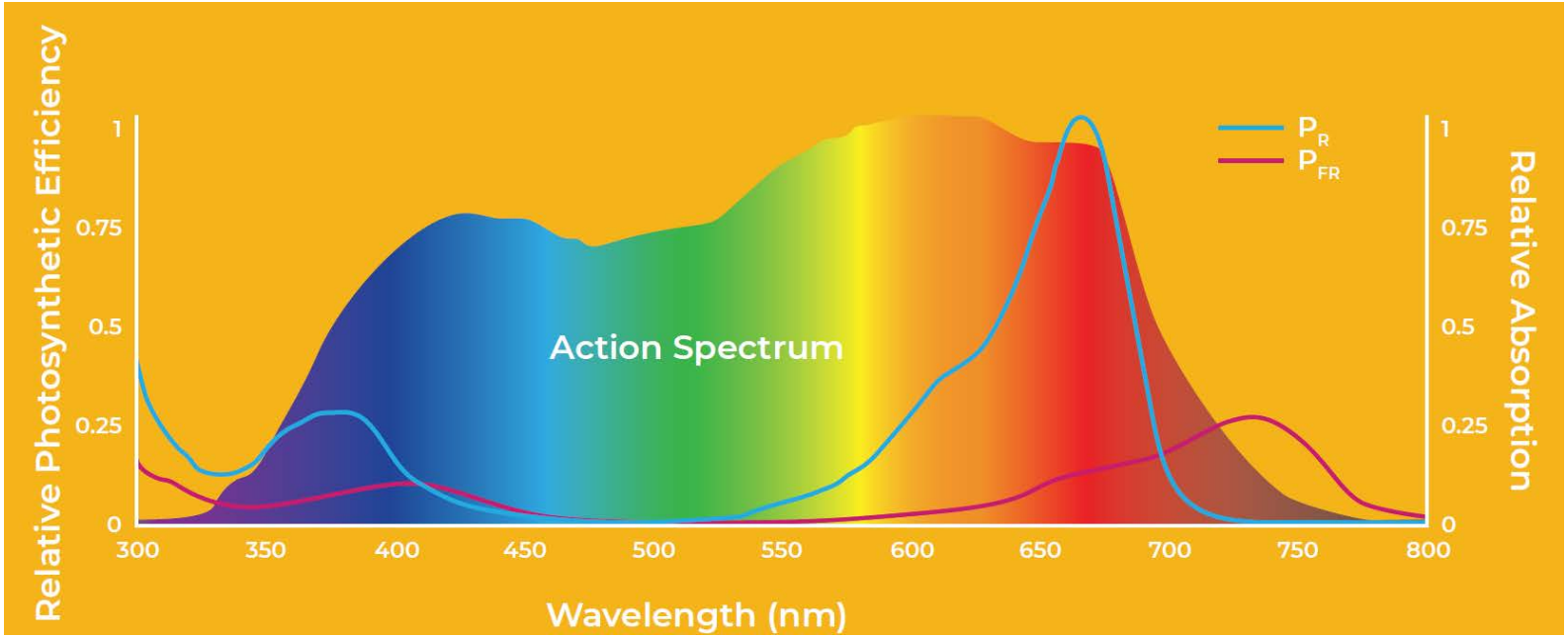
UbiGro: Energy efficiency for greenhouses

Greenhouse energy consumption growing

- Better control
  - Water
  - Pests
  - Temperature
- Higher
  - Yield
  - Quality
  - Access to markets
  - Energy consumption

Sunlight isn’t perfect

“Let’s improve sunlight.”
Hunter McDaniel, founder and CEO of UbiQD



Note: nm = nanometer; P_{fr} = far red absorption; P_r = red absorption. Source: UbiQD

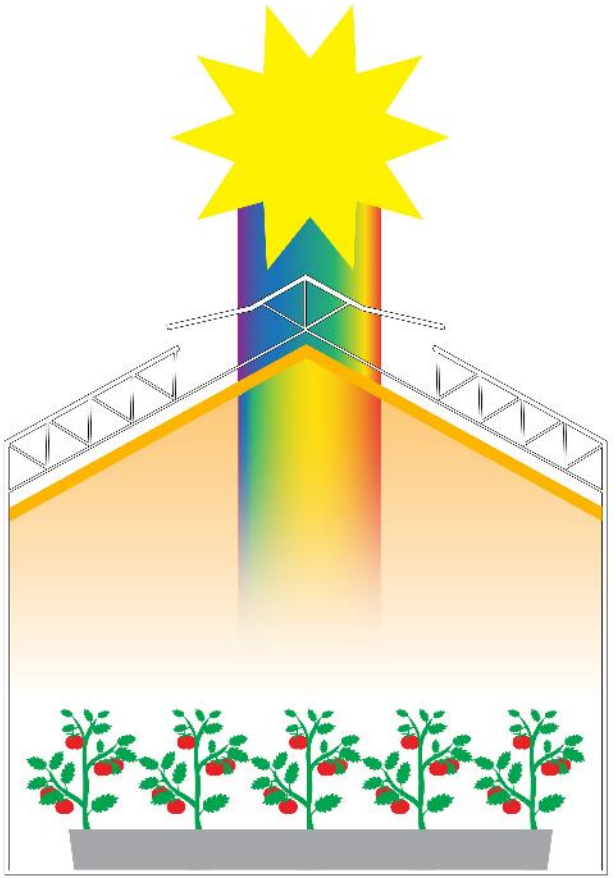
Quantum dots are a big deal

- Semiconductor crystals
- About 5 nanometers
- About 95% of photons absorbed re-emitted
- Used in TVs and monitors

Source: Nicholas Brawand

Less blue, more red

- Quantum dots injected between plastic sheets
- Suspended between greenhouse cover and plants
- Converts ultraviolet and blue light to red



Source: UbiQD

Boosts yields by 5% to 20%

Source: UbiQD

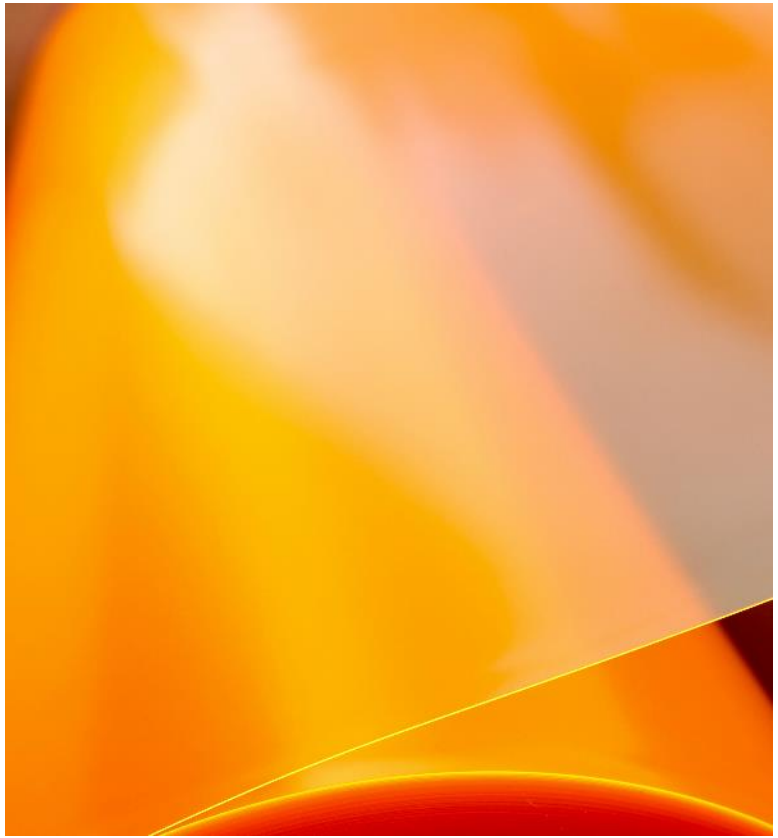
Two ways to estimate energy savings

- Avoided additional greenhouse space
  - 2.5 to 10 kWh per sq. ft. per year pumps and fans
  - 5 to 10 times more for heating
- Avoided lamp and fixture installation
  - 22 kWh per sq. ft. per year for high-pressure sodium or metal halide

Source: UbiQD

About one-year simple payback period

- Cost: $3 per sq. ft.
- 5-year lifetime
- No utilities paying incentives yet



Source: UbiQD

Thank you! Questions?

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