Better Buildings Residential Network Peer Exchange Call Series: *Algorithm-based Home Energy Assessments*

July 26, 2018

Agenda and Ground Rules

- Agenda Review and Ground Rules
- Opening Poll
- Residential Network Overview and Upcoming Call Schedule
- Featured Speakers:
  - **Greg Hopkins** and **Jacob Corvidae**, Rocky Mountain Institute
  - **Chris Tholstrup**, SkyCentrics
  - **Joe Medosch**, Energy Education Curriculum
- Open Discussion, Closing Poll, and Announcements

Ground Rules:

1. **Sales of services and commercial messages are not appropriate** during Peer Exchange Calls.
2. Calls are a safe place for discussion; **please do not attribute information to individuals** on the call.

Better Buildings Residential Network

Join the Network

Member Benefits:

- Recognition in media and publications
- Speaking opportunities
- Updates on latest trends
- Voluntary member initiatives
- Solution Center guided tours

Commitment:

- Members only need to provide *one number*: their organization's number of residential energy upgrades per year

Upcoming calls:

- August 9th: The Sustainability of Energy Efficient Products

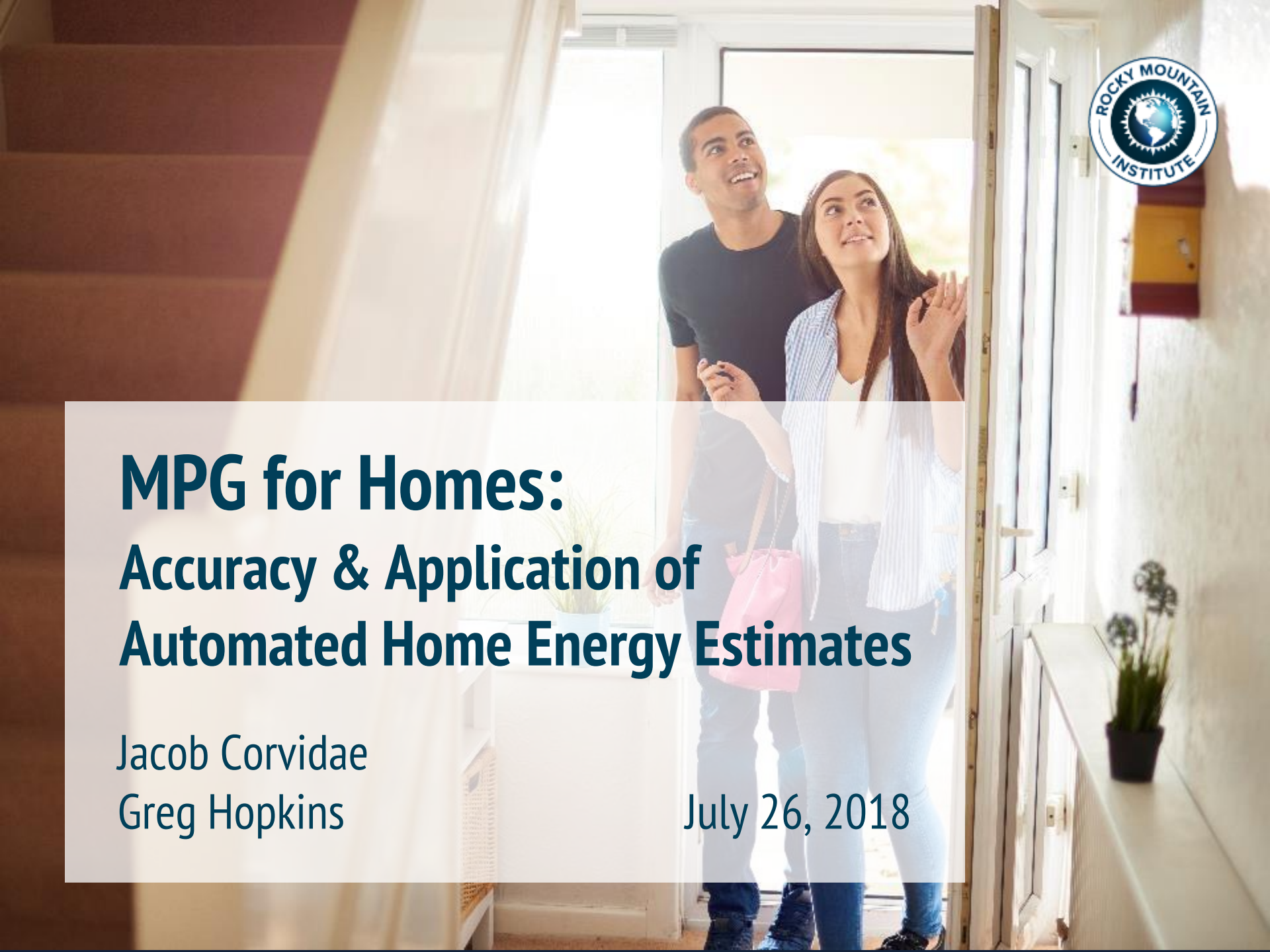
Peer Exchange Call summaries are posted on the Better Buildings website a few weeks after the call

For more information or to join, for no cost, email bbresidentialnetwork@ee.doe.gov, or go to energy.gov/eere/bbrn & click Join

Jacob Corvidae
Rocky Mountain Institute

Greg Hopkins
Rocky Mountain Institute

U.S. DEPARTMENT OF ENERGY



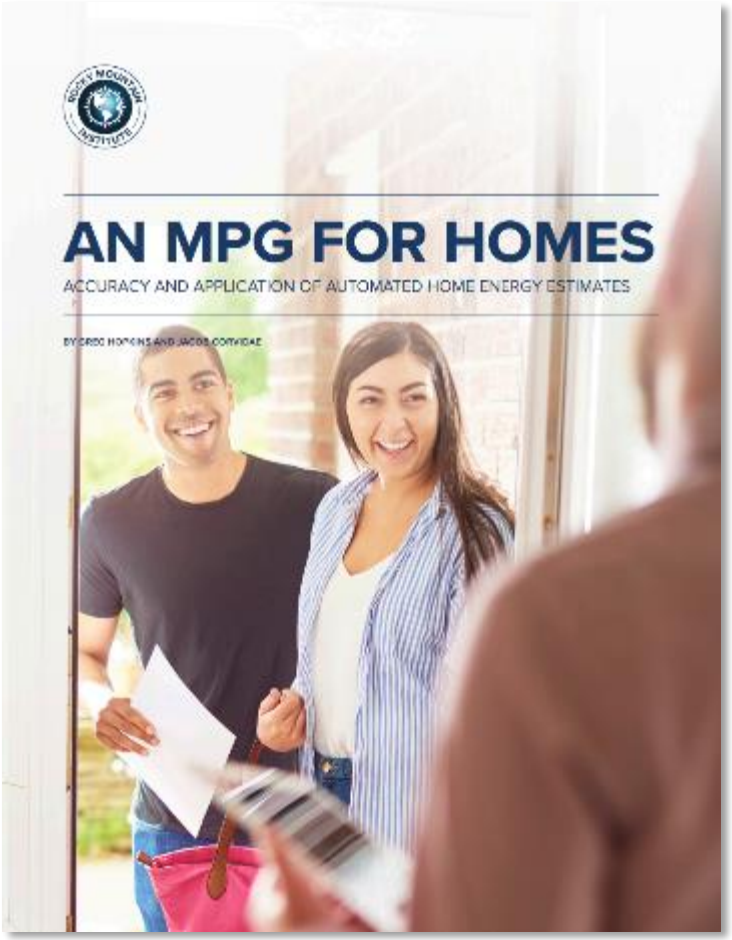
MPG for Homes:
Accuracy & Application of Automated Home Energy Estimates

Jacob Corvidae
Greg Hopkins

July 26, 2018

Agenda

- Context
- Analysis Scope & Methodology
- Key Findings
- Viable Use Cases
- Final Thoughts
- Q&A



Access the report at: info.rmi.org/MPG_for_Homes

Automated Energy Models (AEMs) at a Glance

Find Savings | Costs

Understanding energy costs can help you save

Get Cost Report

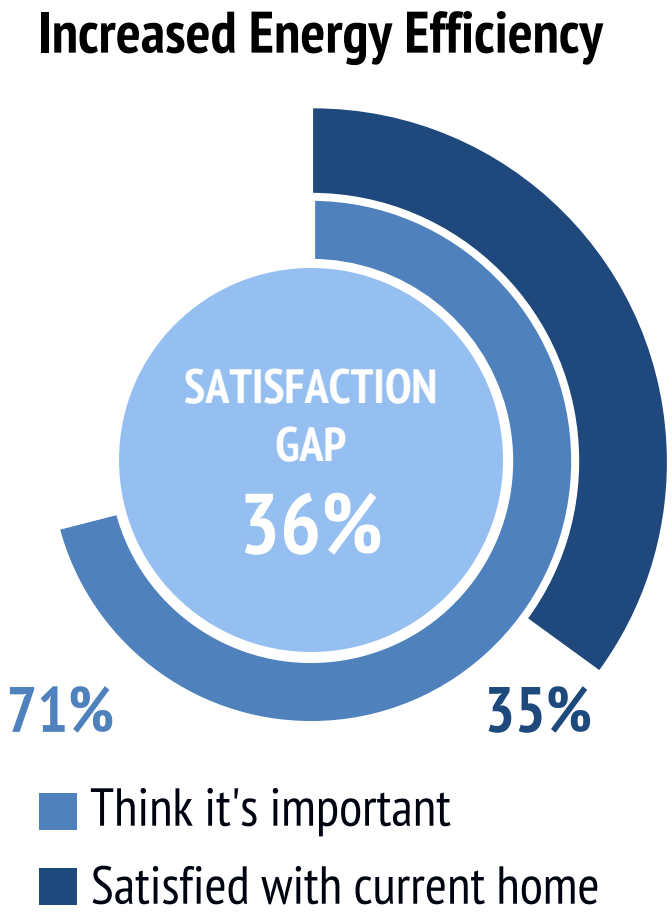
Estimated

$2748/Year

$1269 Most Efficient — $5082 Least Efficient

Sources: clearlyenergy.com (top), myutilityscore.com (bottom)

Why This Matters



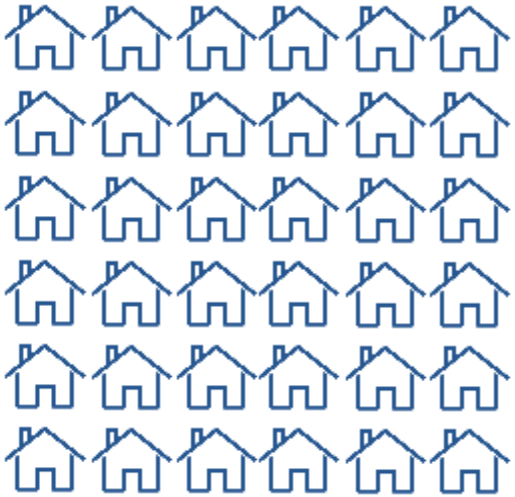
Source: Demand Institute, "The Housing Satisfaction Gap" 2014

Why This Matters

Increased Energy Efficiency

Information Availability

On-Site Assessor	AEMs
Labor intensive & customized	*Automated & widely available*
3 million	110 million



Source: Demand Institute, "The Housing Satisfaction Gap" 2014

But are AEMs at all accurate?

Subjects of Comparison

Participating AEMs

CLEARLYENERGY

UtilityScore
Better Home. Better World.

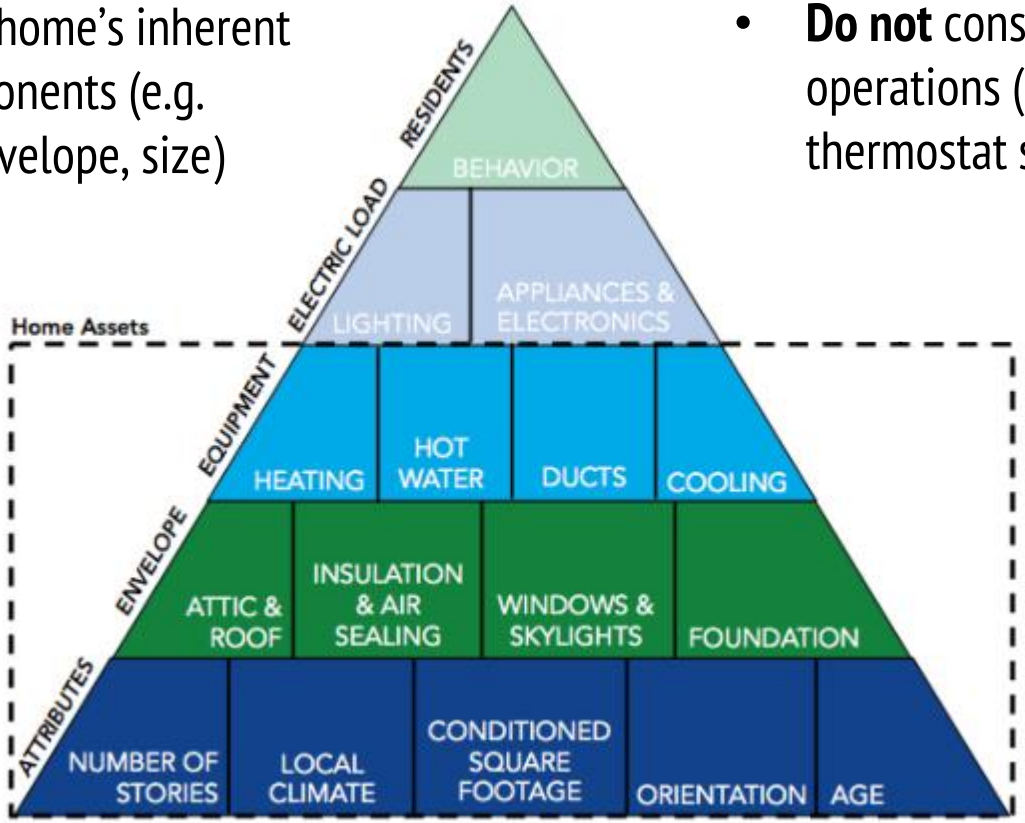
Baseline

U.S. DEPARTMENT OF ENERGY
Home Energy Score

Actual utility data was NOT considered;
asset rating estimates were compared instead

Asset Ratings

- **Do** consider a home's inherent physical components (e.g. equipment, envelope, size)



- **Do not** consider a home's operations (e.g. # occupants, thermostat settings, plug loads)

Asset ratings allow for apples-to-apples comparisons of the components that will stay with homes when their ownership changes

Source: US Department of Energy Better Buildings

Analysis Scope & Methodology

- 2017 HES data for ~8,000 homes across 27 states
- AEMs generated their own energy use and cost estimates
- Differences between AEMs and HES were evaluated in terms of:

Absolute value: indicator of **variance**; useful for **individual** homes

Nonabsolute value: indicator of **directional bias**; useful for **aggregated** sets of homes

Key Findings: Energy Use Estimates

Set 1

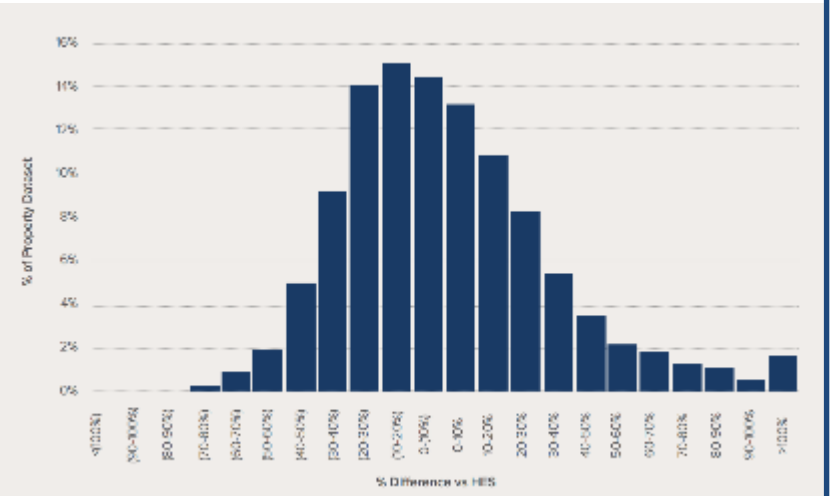
Given: only property addresses

20-30% avg absolute difference vs HES

65-75% of homes <30% different

25-30% of homes <10% different

+/-10% avg nonabsolute difference



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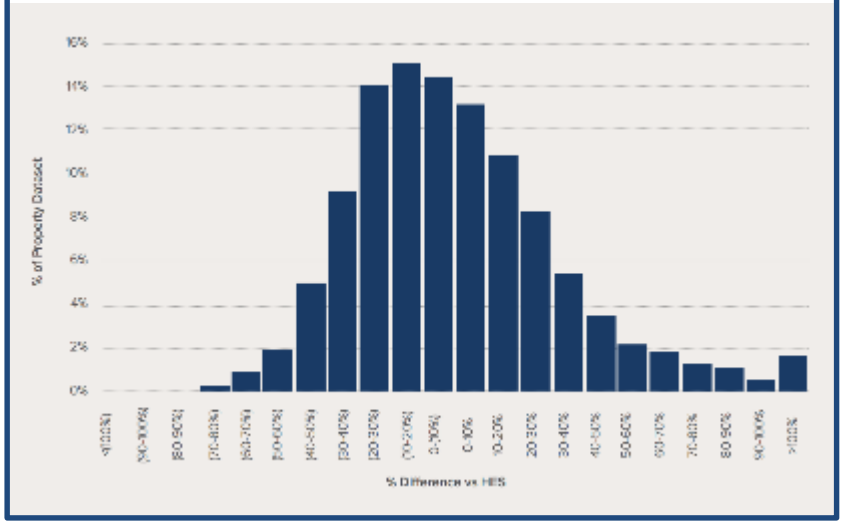


Set 2

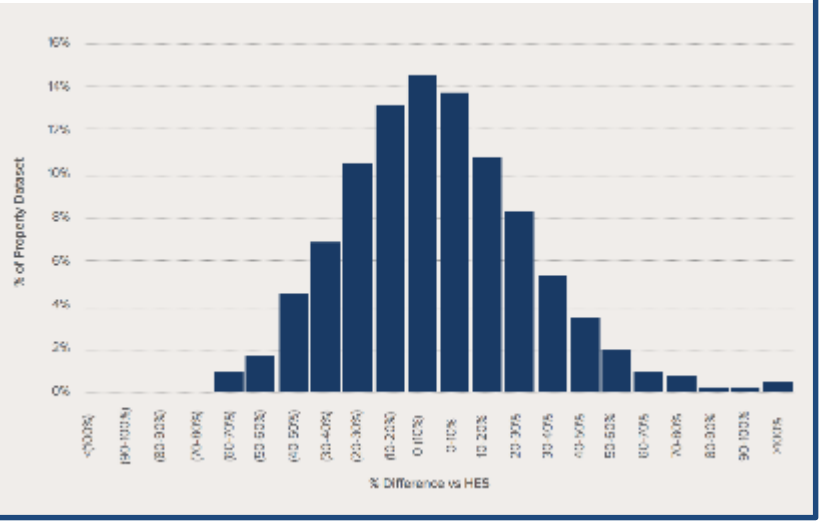
*Given: six HES inputs**

20-25% avg absolute difference vs HES

70-75% of homes <30% different

25-30% of homes <10% different

+/-10% avg nonabsolute difference

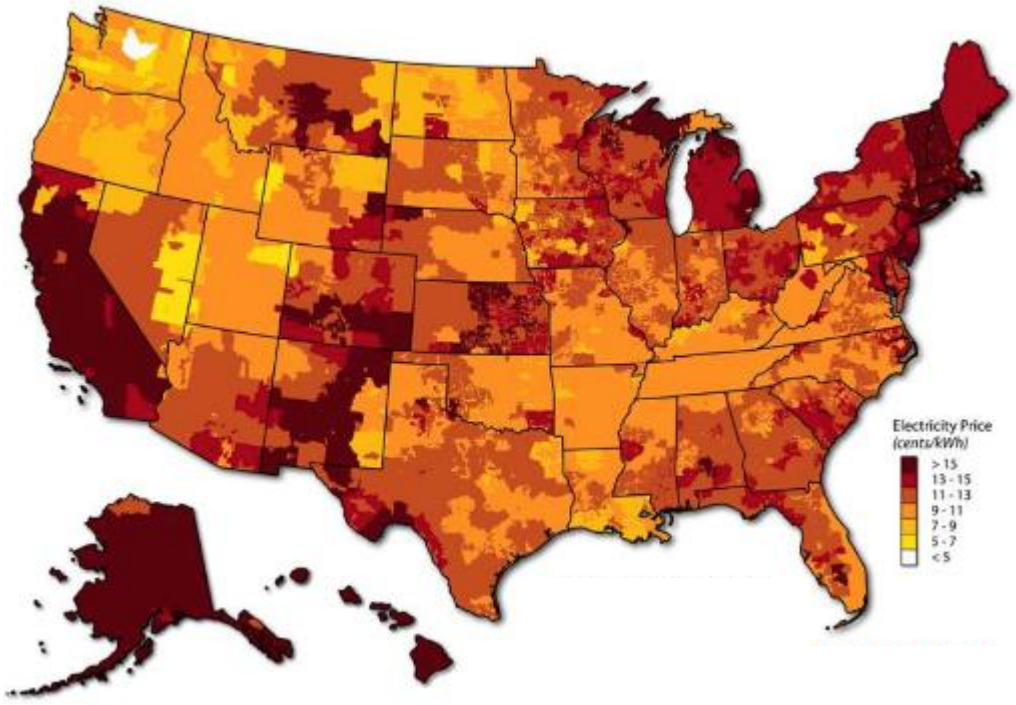


* Six HES inputs provided for Set 2 were zip code, year built, conditioned floor area, # bedrooms, heating/cooling system type and fuel type.

Key Findings: Energy Cost Estimates

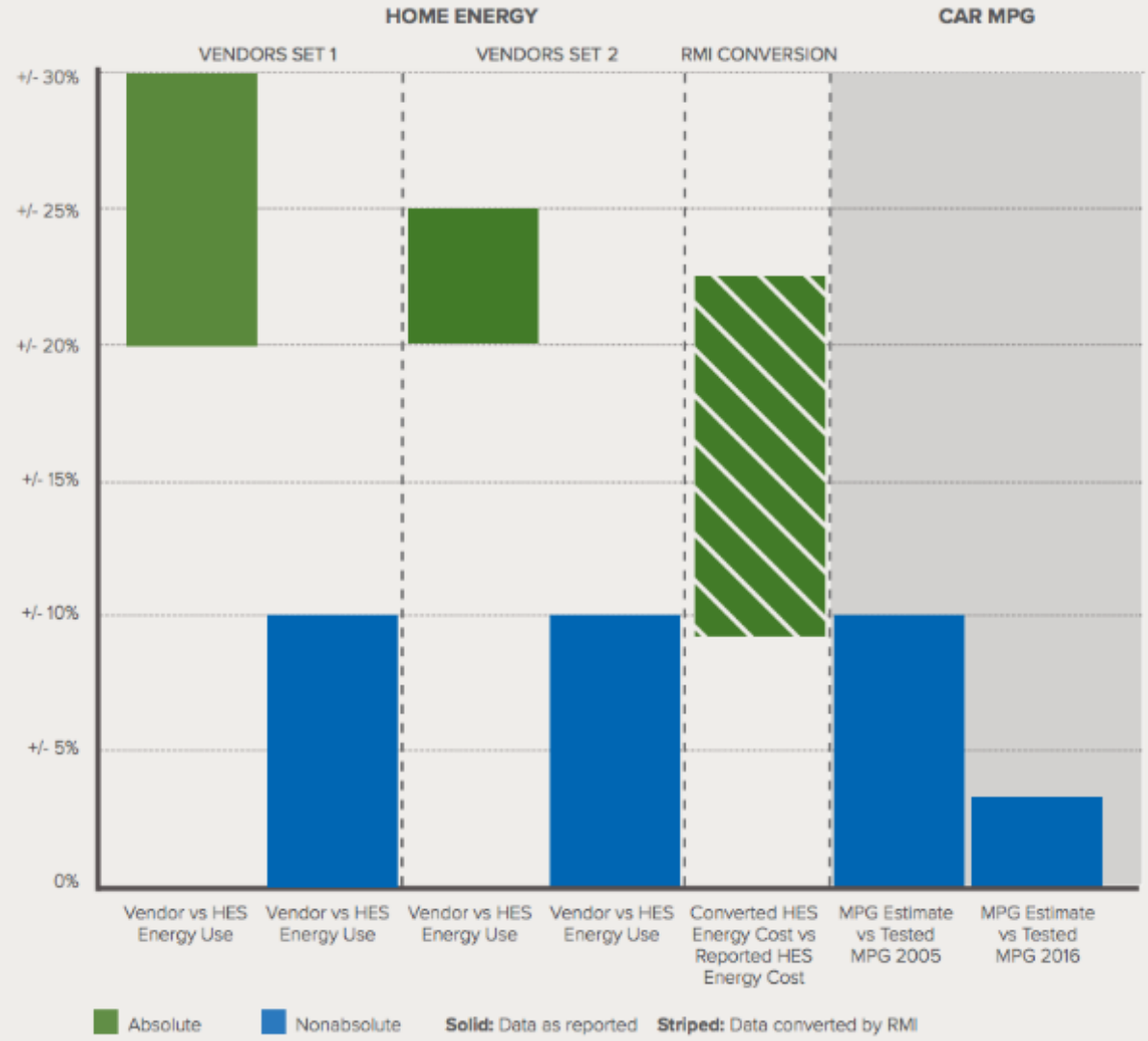
AEMs can outperform given their ability to pull more granular utility rate data

- HES currently relies on statewide average rates
- RMI *converted* HES cost estimates using implied AEM utility rates
- They were **9-22%** different than *reported* HES cost estimates



Source: National Renewable Energy Laboratory 2013 Residential Electric Rates

Key Findings in Context



Viable Use Cases for Key Stakeholder Groups

Homeowners / Homebuyers: greater awareness of home energy performance; more conservative budgeting for homeownership costs

Real Estate Portals: higher customer retention on sites that provide more robust information (e.g. affordability calculators)

Energy Service Contractors: higher sales of products / services by leveraging personalized home profiles; targeted marketing efforts

Mortgage Lenders / GSEs: avenues to address energy cost risks at a local level; easier identification of candidates for special products

Local Governments: ability to prioritize investment of public funds toward higher energy burden areas; community engagement

Final Thoughts

+

- Readily available ‘first look’
- Cheaper, faster than audits
- Raise consumer awareness
- Offer transparency at scale
- High-level insights (e.g. neighborhood level)

Final Thoughts

+	▲
• Readily available 'first look' • Cheaper, faster than audits • Raise consumer awareness • Offer transparency at scale • High-level insights (e.g. neighborhood level)	• Less comprehensive than on-site assessments • Limited insight into root causes of performance • Accuracy can improve over time

Final Thoughts

+	▲	?
• Readily available 'first look' • Cheaper, faster than audits • Raise consumer awareness • Offer transparency at scale • High-level insights (e.g. neighborhood level)	• Less comprehensive than on-site assessments • Limited insight into root causes of performance • Accuracy can improve over time	• Differences between inputs pulled by AEMs vs collected on-site • Accuracy of AEM cost estimates vs a reliable cost baseline • Accuracy of AEM upgrade recommendations vs HES

As an emerging tool, AEMs are helping to close the information gap in the residential energy performance market.

Thanks for listening!

Questions?

Contact us:
jcorvidae@rmi.org
ghopkins@rmi.org

Additional Resources

- Rocky Mountain Institute MPG for Homes: Accuracy and Applications
- Rocky Mountain Institute MPG for Homes: Driving Visible Value
- Rocky Mountain Institute MPG for Homes: The Quest for the Best
- Rocky Mounty Institute MPG for Homes - other resources

Three Key Take-Aways

- Automated Energy Models (AEMs) are an emerging alternative/complement to in-person efficiency audits such as Home Energy Score (HES).
- Given only the property address, AEM assessments differed from HES scores on the same properties by an average of 20-30%.
- There is room for improvement in accuracy, but AEMs can offer quick, high-level assessments right now, and do so cheaply and quickly.

Chris Tholstrup
SkyCentrics

U.S. DEPARTMENT OF ENERGY

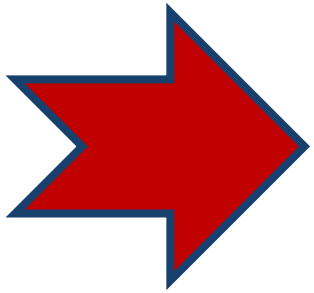
SkyCentrics

Better Buildings Residential Network | July 2018

What does it really cost?

SkyCentrics

From the lab to the lot to the road performance changes



Multiple pieces multiple issues

SkyCentrics

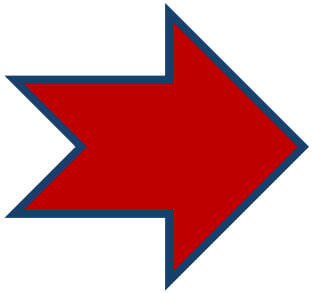
What do you change to improve performance?

Building Standards

Architects

Construction

Appliance Ratings

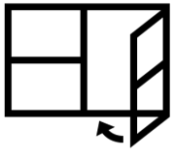


Appliances

Water Heaters

Building Envelope

Thermostats



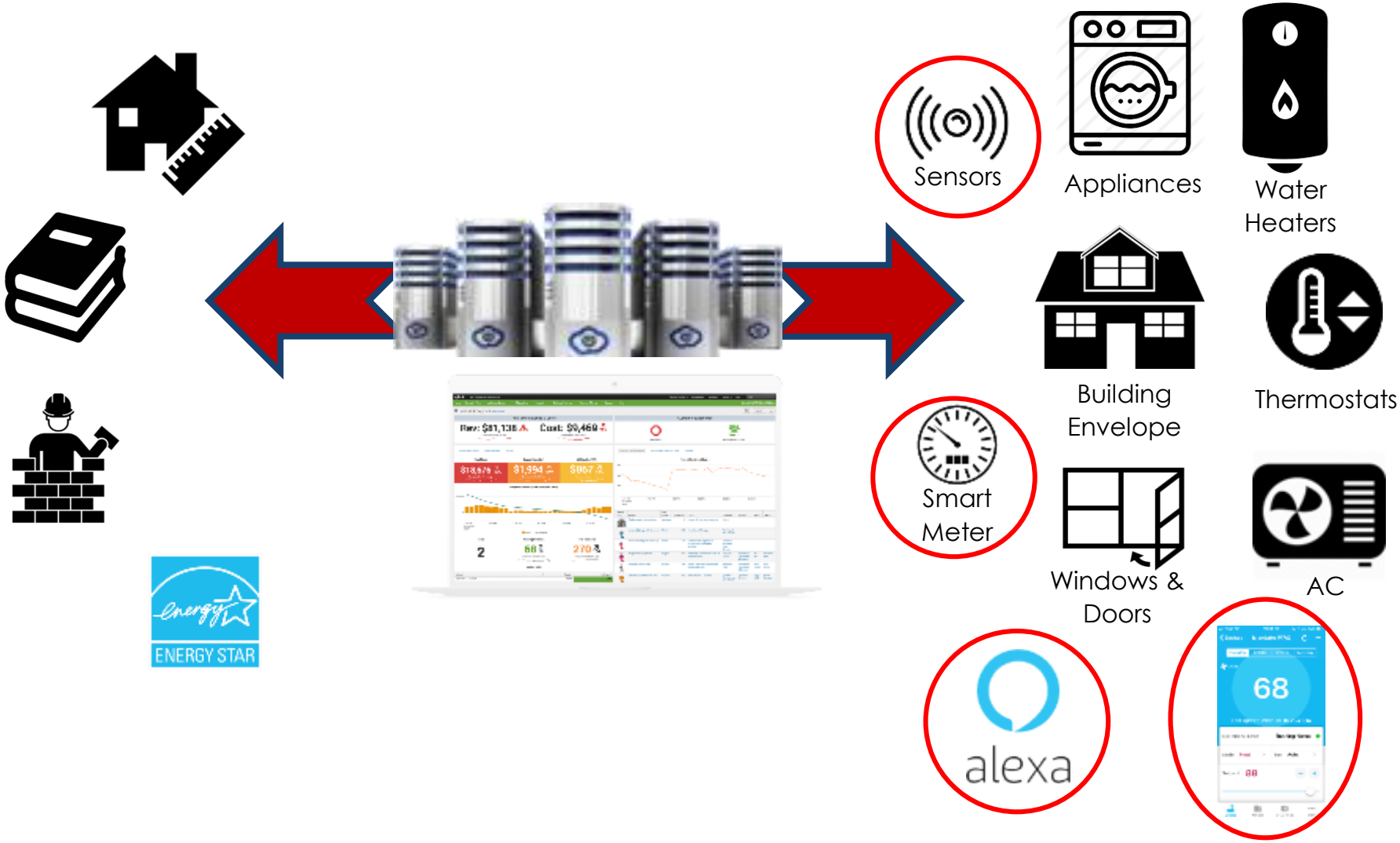
Windows & Doors

AC

Real Data, Real Answers

SkyCentrics

Data-driven performance management and investment decisions



Lifetime Optimization

SkyCentrics

Thinking starts before construction and scales with needs

Pre-commissioning

Continuous Monitoring

Benchmarking from Day 1

- Data-driven construction design and procurement

Build to Plan

- Install as you go targeting high-risk areas
- Easy tweaks not big repairs

Sensors & controls installed alongside building envelope and appliances

Whole-building perspective

- Consumption balanced for comfort and efficiency
- Intelligent scheduling
- Predictive maintenance & fault detection
- DR/DER integration

Multiple data users

- Utilities
- Manufacturers

Scalable sensor/control platform

Periodic Review

- Target problem areas
- Evaluate investments

"Sensor briefcase" – self-install or set & forget

One Platform, Many Connections

SkyCentrics

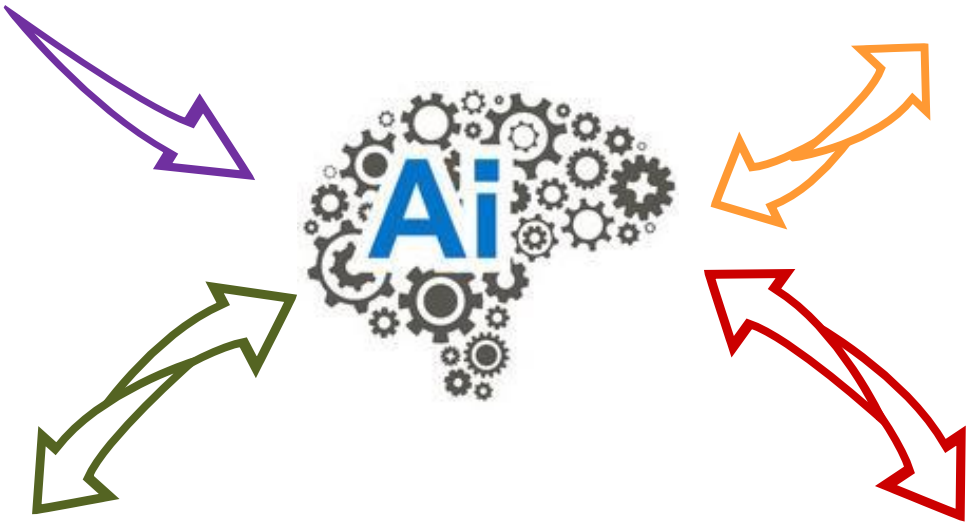
Real-time data-driven environment and asset management

Data Integration

Weather | Utility Pricing | Occupancy

Transactive Energy

Micro-transactions between devices
balance loads to support grid



Device Connections

CTA-2045 | Modbus | BACnet | SEP2

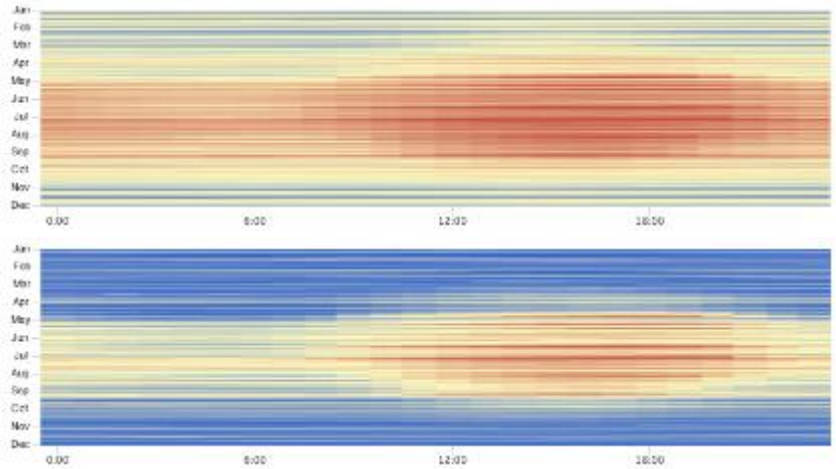
Control Automation

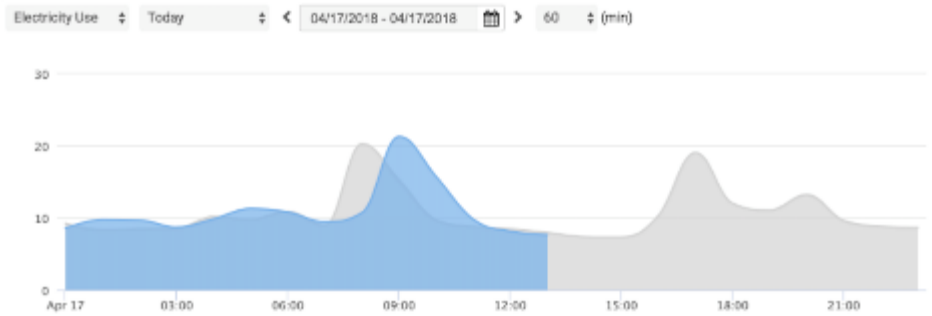
Optimized schedules
Quick response for tenant comfort

Scalable AI Models – Fast Results

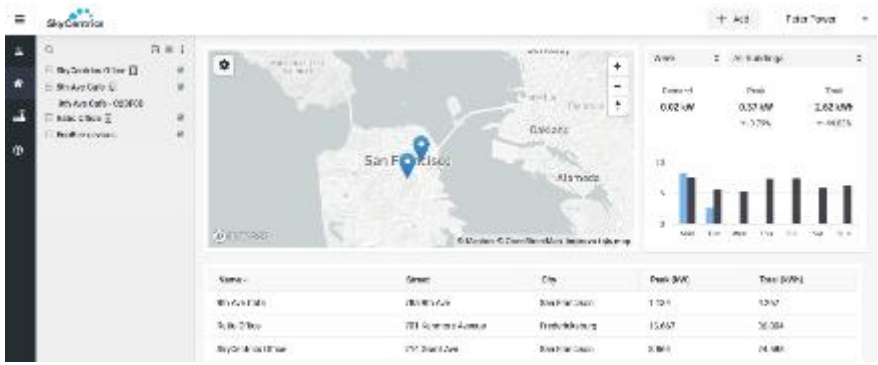
SkyCentrics

Benchmarking starts immediately





PG&E Share My Data



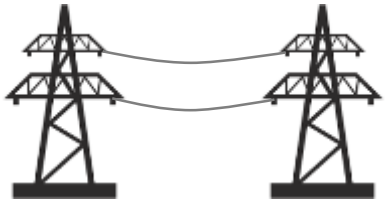
IoT Tools Making a Difference

SkyCentrics

Open source tools and commitment from leading manufacturers

Making Everyone Happy

SkyCentrics



Utilities

Real-time Control

- Demand response
- Time-of-use pricing
- Reduce infrastructure cost

Lifetime Data

- Demand forecasting
- Capacity planning
- Real time measurement & verification

Homeowners

Lower cost

- "On when you need it, off when you don't"
- Grid-responsive
- More durable appliances
- Utility incentives

Always comfortable

- Pre-heating & cooling
- Occupancy responsive

Builders & Operators

Data driven design

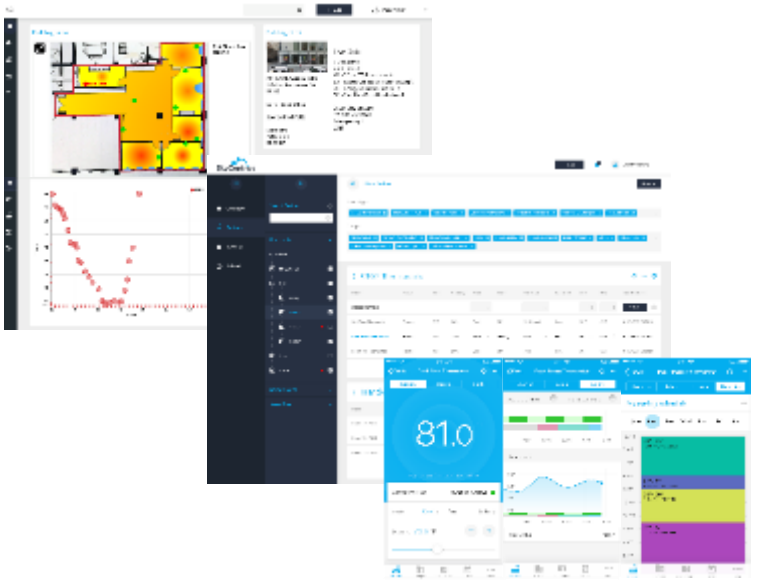
- Cost/performance optimization
- Pre-commissioning review

Real-time management

- Remote troubleshooting
- Predictive maintenance
- Continuous commissioning

About SkyCentrics

- Easily deployable, turnkey, low-cost, open platform:
  - Sensors, device and appliance controls
  - AI and machine learning optimization
  - Predictive analytics and fault detection
  - Cloud, web and mobile apps
  - Modular and scalable to millions of devices
- Reduces lifecycle cost of building and real estate by 30%
- Allows buildings to automatically participate in the Smart Grid
- Platform proven with Duke Energy, Con Edison, AO Smith, Mitsubishi

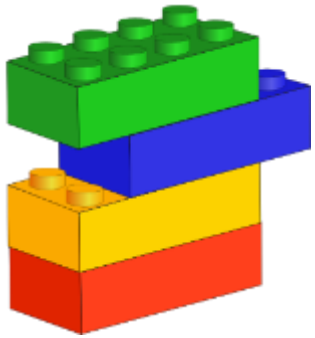


VOLTTRON™

What to ask from your vendors

SkyCentrics

- Rest API?
- Play nice with other vendors?
- Data Access and portability?
- Multiple communication paths?
- Modular? – buy only what you need
- Modern architecture? - easy to add features
- Enterprise features? – grouping, permissions, low latency at scale



Why Open Standards?

SkyCentrics

- One standard, multiple devices
- Drives Innovation
- Builds a community of developers
- Avoids vendor lock-in
- Scales quickly
- Easy to add devices
- Avoids stranded assets

http://

HI-SPEED CERTIFIED USB

Wi Fi™

The Home of the Future

SkyCentrics

Homeowner-centric

- Controllable
- Programmable
- Responsive
- Adaptive

Money Saving

- Low-cost connected devices
- Energy efficient
- Utility-connected

What it Needs

- Connected devices that play nicely together
- Single co-ordination platform
- Open standards
- Scalable IT platforms
- Big Data & Artificial Intelligence
- Major manufacturer adoption

More About Open Standards

SkyCentrics

- CTA-2045 Demand Response (SkyCentrics)
  https://www.youtube.com/watch?v=baPmqPgQhDE
- EPRI CEA-2045 Field Demonstration Project (EPRI)
  https://www.youtube.com/watch?v=BHMssq6_R94
- Alexa voice control of PTAC (SkyCentrics)
  https://youtu.be/YSQaxz2tzUM
- Water heaters, as sexy as a Tesla? (Rocky Mountain Institute)
  https://www.rmi.org/news/water-heaters-sexy-tesla/
- What is the Volttron™ Platform? (DoE)
  https://transactionalnetwork.pnnl.gov/volttron.stm
- Economic Sizing of Batteries for the Smart Home (NREL)
  https://www.nrel.gov/docs/fy18osti/70684.pdf

Questions?

chris@skycentrics.com

Three Key Take-Aways

- Integration of smart data monitoring and management systems with IoT components offers great potential for residential energy efficiency.
- Think “lifetime optimization,” with smart management systems, considering them in design, construction and ongoing monitoring phases.
- IoT security concerns are still paramount; the continued development of widely-used, open-source standards can address them.

Joe Medosch
Energy Education
Curriculum

U.S. DEPARTMENT OF
ENERGY

Smart Meters

- Hourly usage rates / Real-Time Feedback
- Learn individual appliances including
  - Heating /cooling, refrigerator, TV, cooking, toaster, ventilation
- Learn your habits / can provide personal incentives
- Minimal or zero cost to occupant
- Potential privacy concerns / Can they sell my usage!
- Can determine if your heating the basement and cooling upstairs. Is your refrigerator “dying” ?
- Can be combined with other monitors ie PM 2.5 and ventilation usage.

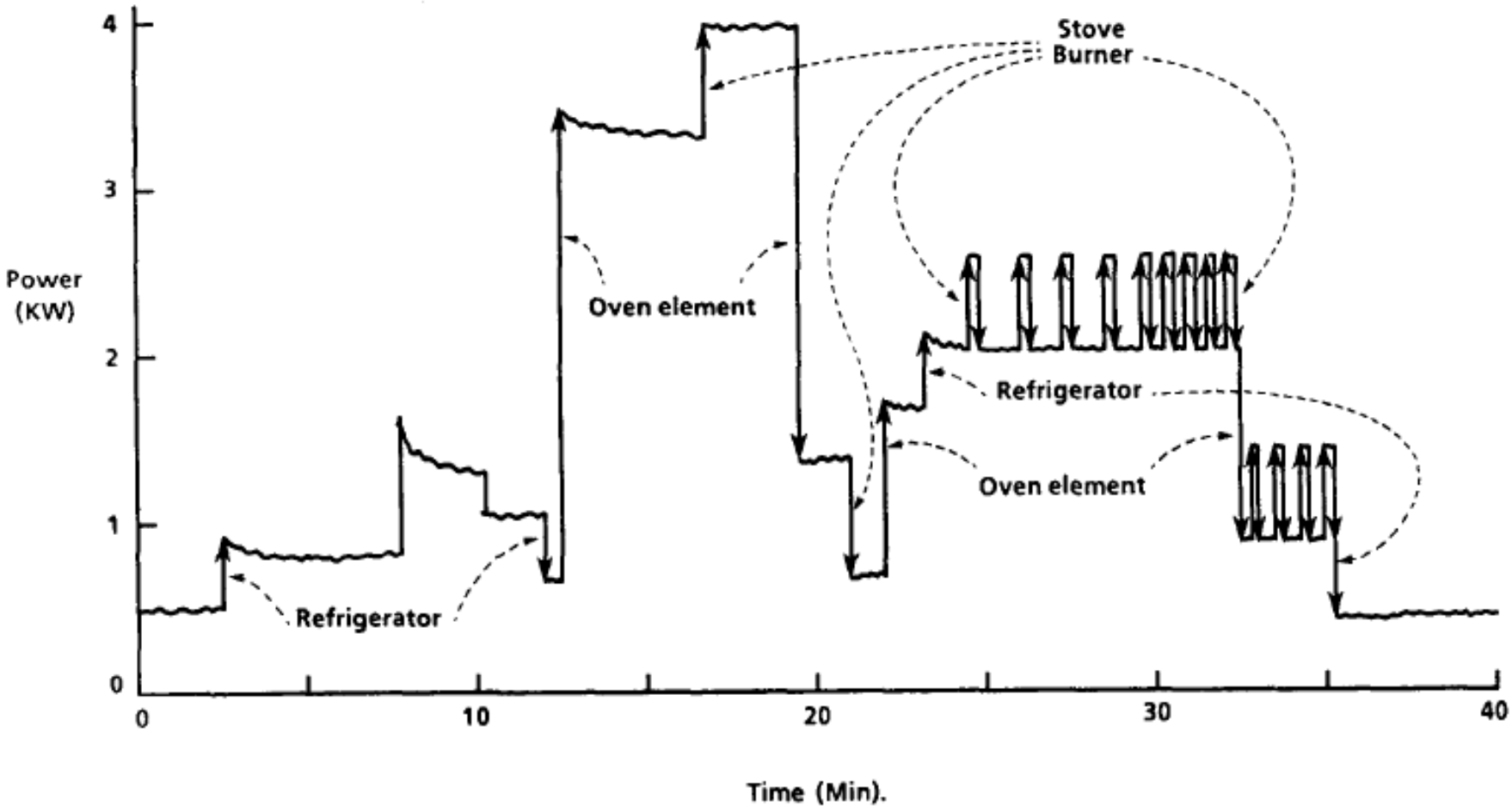
Smart Meter vs. Consumer options

	Sensing Technology	Cost to Consumer	Installation Effort	Adoption
Hardware Disaggregation	Plug Level Hardware Monitors (e.g., Kill-A-Watt, EnergyHub)	$30-$50/plug; $300-600/home	Most plugs – Med 240V plugs - Hard	Low; in existence for past 7-8 years
	Smart Appliances	$100+ additional compared to non-Smart appliances	Easy	10-15 years after introduction for mass adoption
Software Disaggregation	House Level Current Sensor (example - TED, Blueline, Egauge etc.)	$200+/house	Very Hard	Low (high cost + high effort)
	Smart Meter	None	None	Very High & fast (installed by utilities)

Source
Energy Disaggregation - 2011
Carrie Armel
Precourt Energy Efficiency Center, Stanford

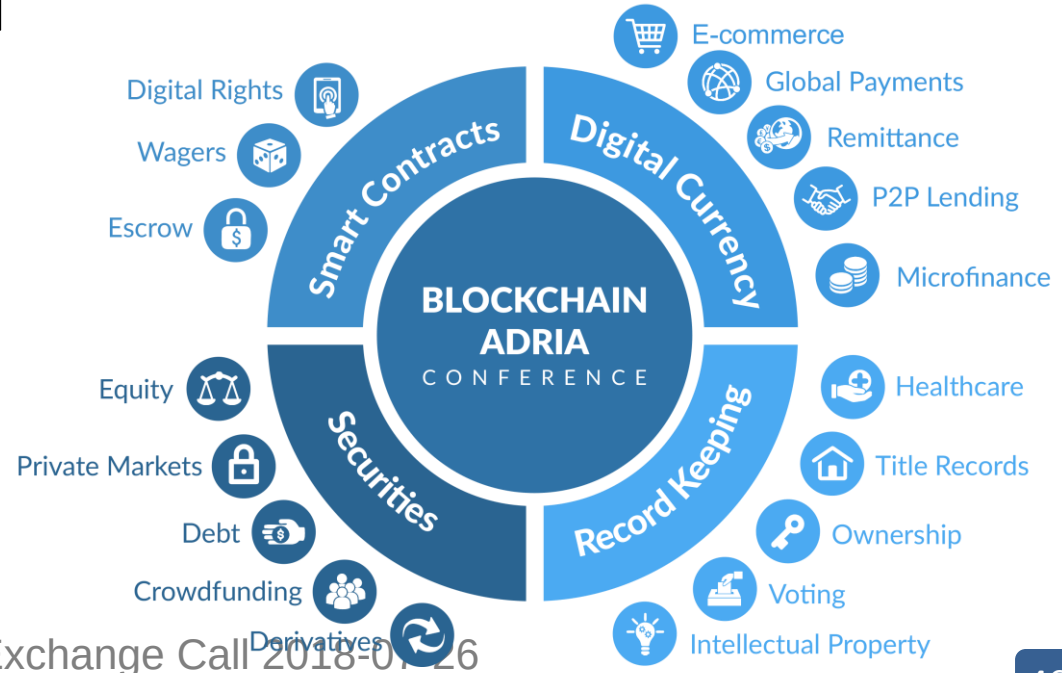
https://stanford.io/2A8Vjzq

Energy Disaggregation



Blockchain storage – accurate recording

- Smart monitors with algorithms
- Provide true “Pay for Success”
  - Block Chain records the reduction agreement
  - “x” wattage reduction = success = recorded in Blockchain
  - Contractor is paid



Smart Home ≠ energy efficient

- Devices have high connectivity requirements
  - information and communication technology (ICT)

Smart Home ≠ energy efficient

- Devices have high connectivity requirements
  - information and communication technology (ICT)
- Home automation = Convenience, not energy reduction
- Standby Loads are greater than energy savings
- Energy reduction can occur from:
  - turning Heating / Cooling systems and ventilation off while windows are open
  - 'smart' use of blinds to optimize solar energy gains
  - centrally switch off all (predefined) appliances and lights when leaving the home
- Visual consumption can cause conservation

Smart Home ≠ energy efficient

- Code requirements reduced traditional energy loads
  - Increased R-value and tighter homes
- Plug loads are generating higher energy consumption

"Smart buildings allowing electricity management in households decrease peaks in the daily load profile of the house, but electricity consumption increases as monitoring systems increase in houses."

"The implementation of smart technologies requires active involvement by end users, through raising awareness, to reap the benefits."

Source: Jean-Nicolas Louis - 2016
DYNAMIC ENVIRONMENTAL INDICATORS FOR SMART HOMES
ASSESSING THE ROLE OF HOME ENERGY MANAGEMENT SYSTEMS IN ACHIEVING DECARBONISATION GOALS IN THE RESIDENTIAL SECTOR

Drones – (UAV) Unmanned Aerial Vehicle

Aerial Thermal Imaging

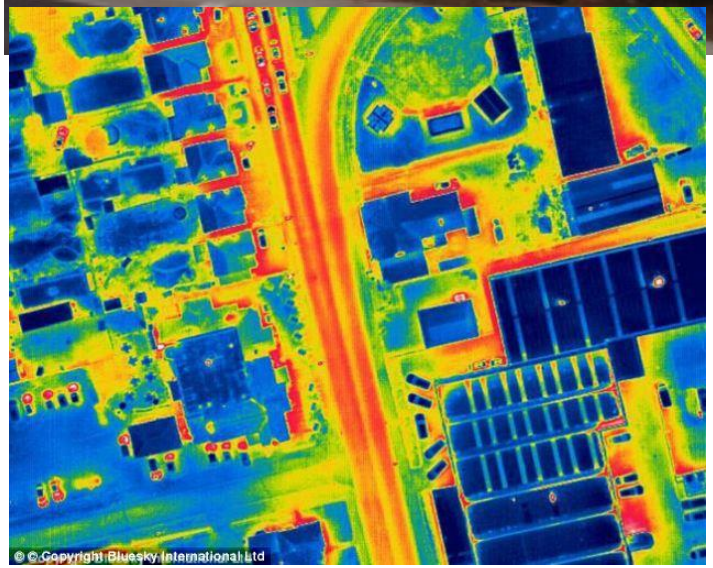


Image source In Sky Aerial Services

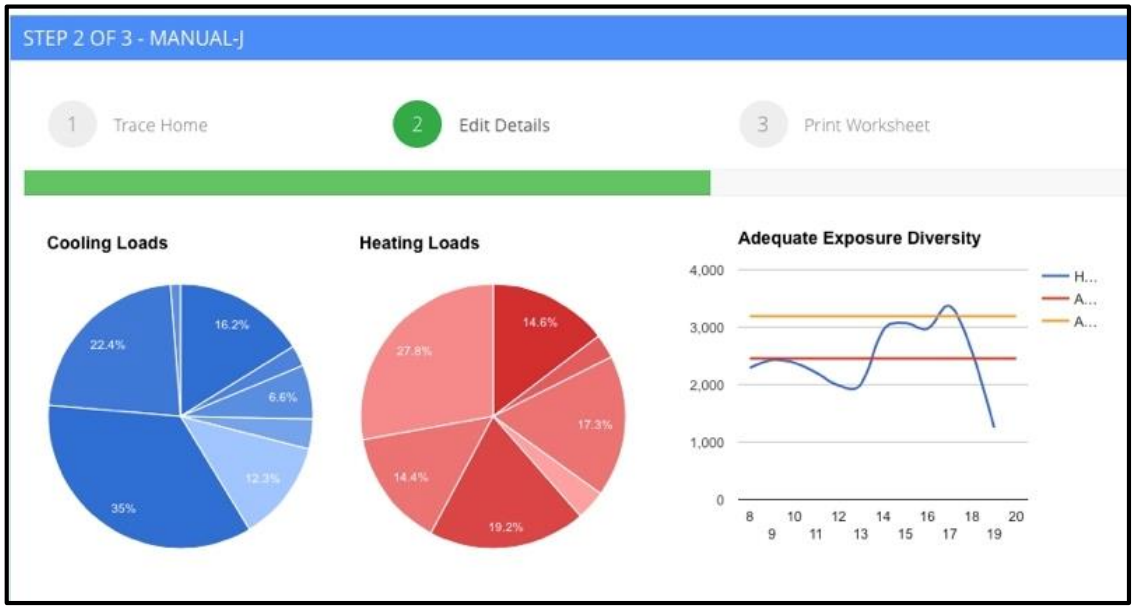
Bluesky International

Cool Calc

1967 sq ft

1803 sq ft

Manual J from satellite image!



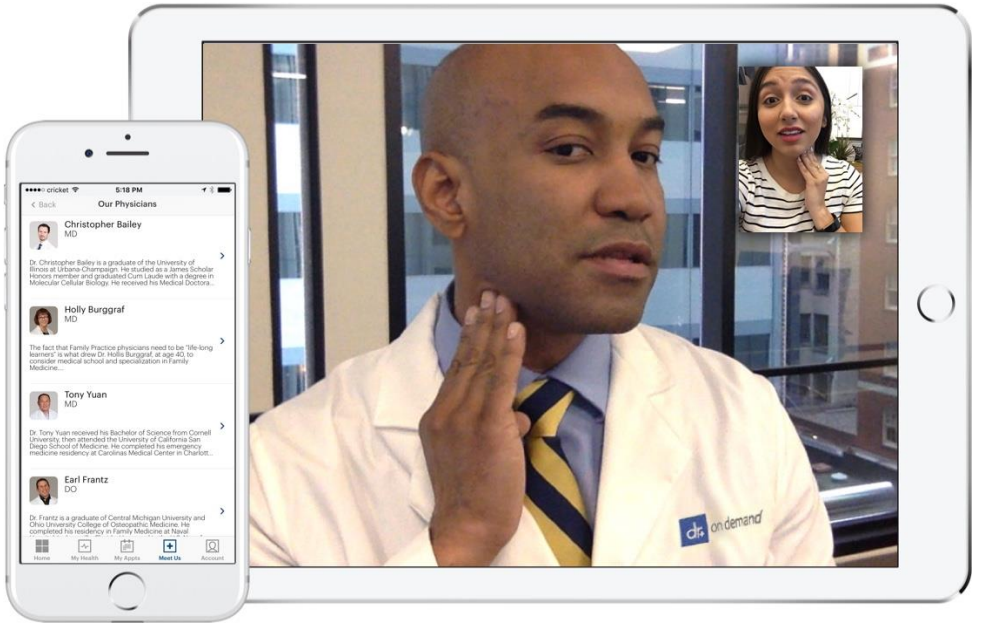
Sensible Cooling Load 10856.19

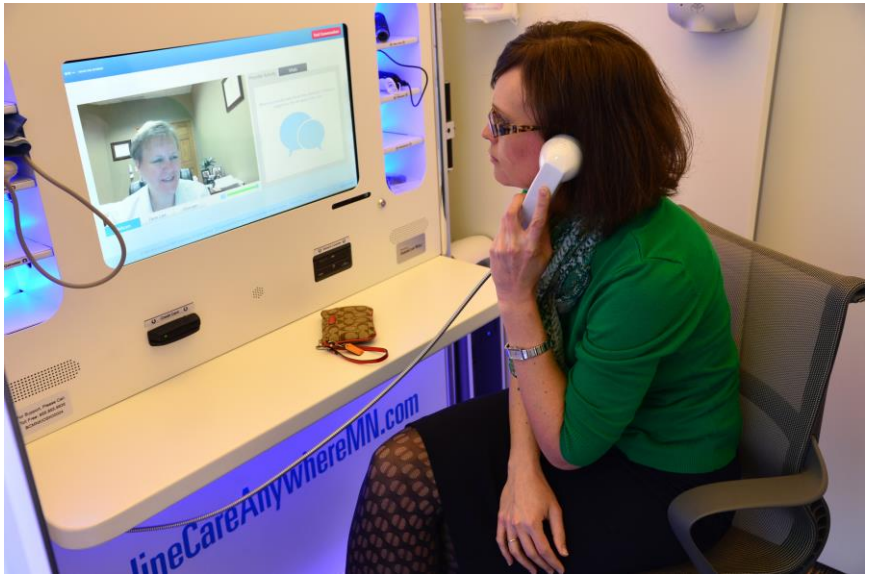
Latent Cooling Load 3357.65

Heating Load 20445.47

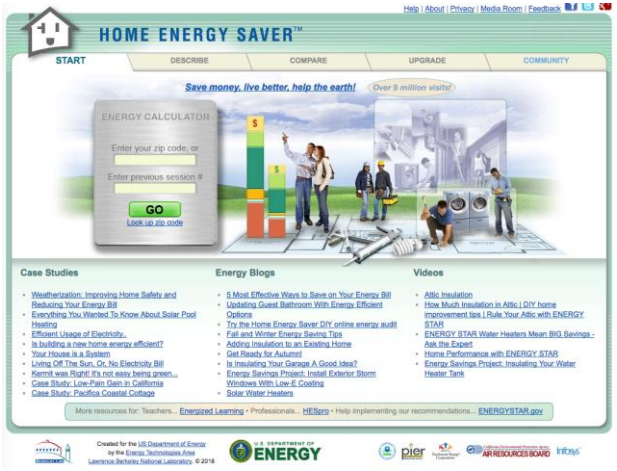
Futurology: the ability to imagine, anticipate and integrate future technologies.

Telehealth
Telecare
Telemedicine





Tele-assessments



Example of Calculator:

Pre-WX Inspection ASHRAE 62.2-13 for KS

Pre-WX Auditor:
Homeowner:
Address:
Date: today is: 6/22/2016

Location: N-factor:

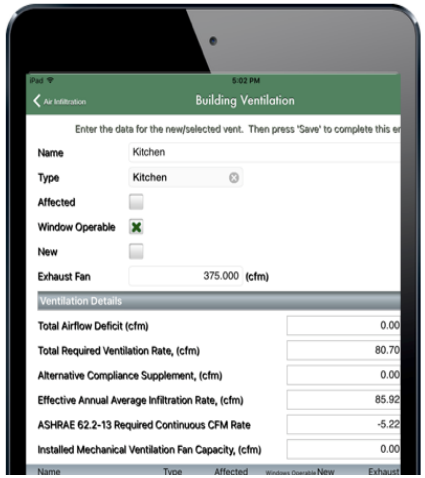
Number of stories: (above the lowest window or door)
Number of bedrooms: (include all rooms that could be bedrooms)
Number of full bathrooms: (full baths have a tub or shower)
Number of occupants: (used only if greater than #bedrooms + 1)
Conditioned, finished, above grade FLOOR AREA: ft² ?
Volume: ft3 Average ceiling height: ft ?
Estimated Post WX Q50 CFM@50
CFMnat = CFM

Base formula: (7.5 cfm × #occupants) + (3 x A floor / 100) = CFM

Existing home infiltration credit: CFM

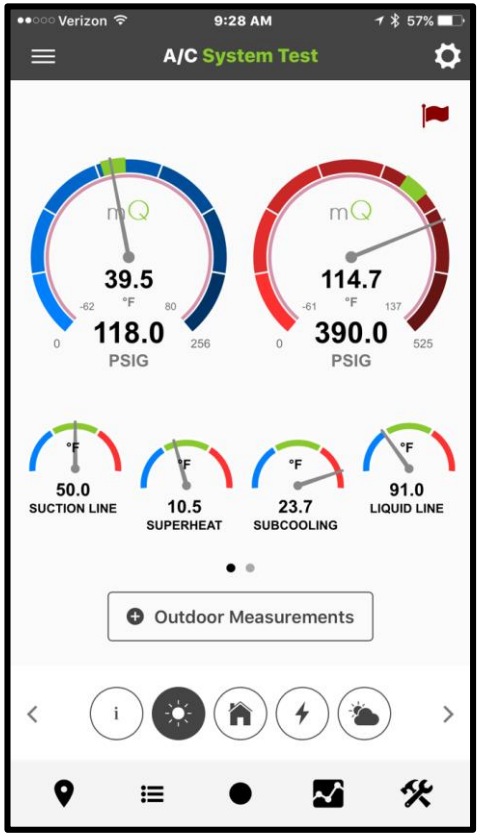
NEW HOME Ventilation requirement = 0 CFM

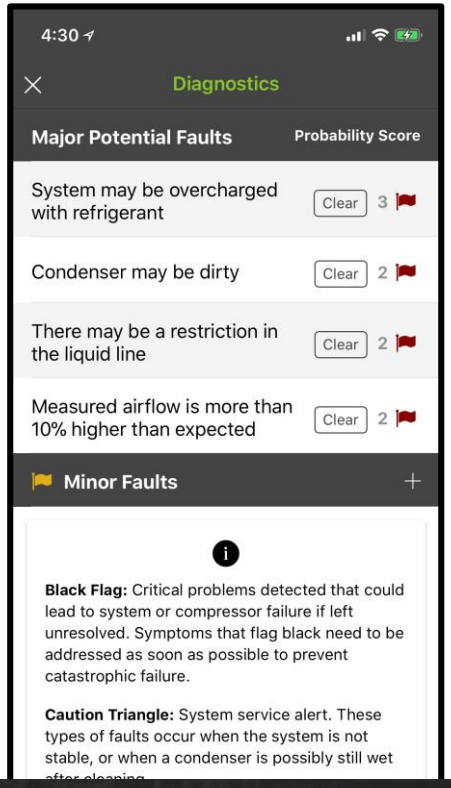
Example of Calculator Embedded in HEAT:

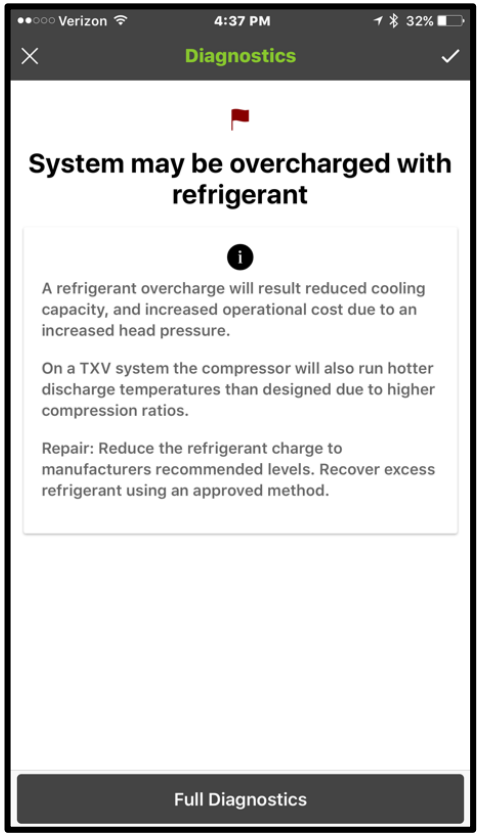


Assessments with Intelligent Tools

Diagnose the technicians results







measureQuick

Self-Aware HVAC units (SAH)

Sensors & Reporting

- Vibration
- Wattage / voltage spikes / amp draw
- Static pressure in. wc
  - Filter status
  - Date changed

Proactive maintenance

House system sends email, text and states out loud

"Alert filter needs replacing"

Provides solutions

"order a new filter" or

"Schedule service call with

- A-Plus HVAC & Plumbing"

Manufacturer Integrated Diagnostics

Alert Smart Device

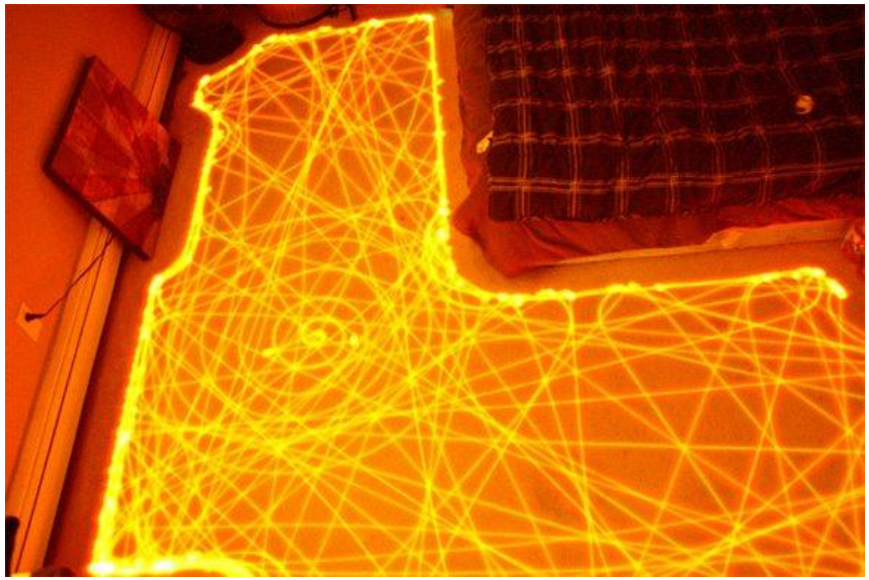
Notification:
"Exhaust fan is low and needs to be Serviced."

"Shall I schedule a professional to evaluate the fan?"

Programmable & Self-Diagnostics

Alert Smart Device

IR Roomba



Algorithms - do not visually evaluate environment attic, crawl space, exterior or anomalies

Are energy assessor jobs being replaced by technology?

Thank you

Joe Medosch
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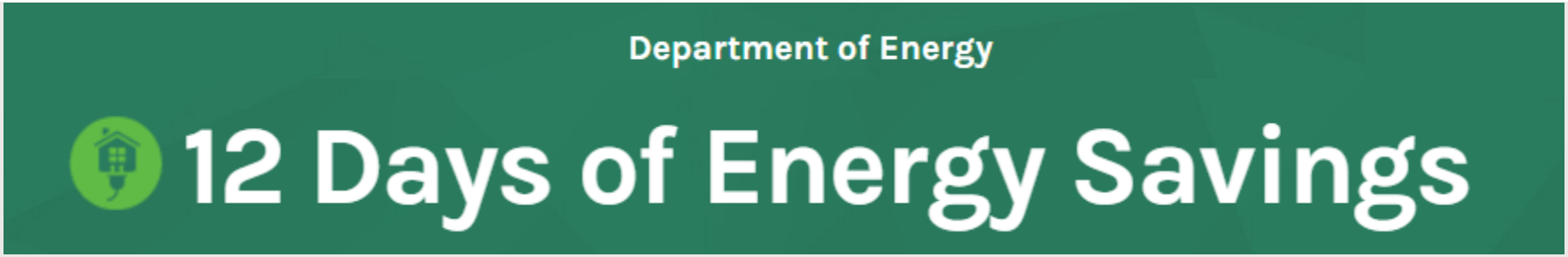
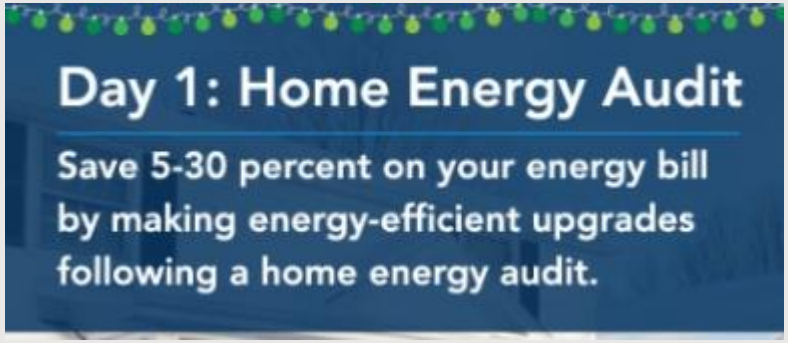
Three Key Take-Aways

- Smart monitoring of data, and its storage via blockchain technology, will enable true pay-for-performance.
- Remote assessment tools (thermal imaging with drones; Manual J calculations via satellite) are emerging technologies which forward-thinking contractors can take advantage of.
- Algorithms do not visually inspect the environment; expect a continued role for human assessors.

Upcoming Seasonal Messaging Opportunities

Make connections to the holidays





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- August 21st-23rd in Cleveland, OH
- Register today!
- Highlights include:
  - Panel sessions and technical trainings (earn CEUs)
  - Peer-to-peer discussions
  - Ask-an-Expert/FEMP Lounge
  - Networking opportunities
  - Pre- and post-conference workshops
  - Better Buildings Partner sessions
  - Building Tours

For more information and to register:
2018energyexchange.com

Explore the Residential Program Solution Center

Resources to help improve your program and reach energy efficiency targets:

- Handbooks - explain *why* and *how* to implement specific stages of a program.
- Quick Answers - provide answers and resources for common questions.
- Proven Practices posts - include lessons learned, examples, and helpful tips from successful programs.
- Technology Solutions NEW! - present resources on advanced technologies, **HVAC** & **Heat Pump Water Heaters**, including installation guidance, marketing strategies, & potential savings.

https://rpsc.energy.gov

Thank You!

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Please send any follow-up questions or future call topic ideas to:
bbresidentialnetwork@ee.doe.gov