



## Getting Your Money's Worth: Making Sure Retrofits Reach Expected Savings

Wednesday, July 10  
1:30 – 3:00pm



# Speakers and Moderator

- Speaker: Steve Morgan, Clean Energy Solutions
- Speaker: Matt Pesce, Facility Strategies Group, LLC
- Speaker: Ethan Goldman, Recurve
- Moderator: Josh Geyer, U.S. Department of Housing & Urban Development

**Steve Morgan**

Clean Energy Solutions



U.S. DEPARTMENT OF  
**ENERGY**



# The Value of M&V to Customers and Climate Protection

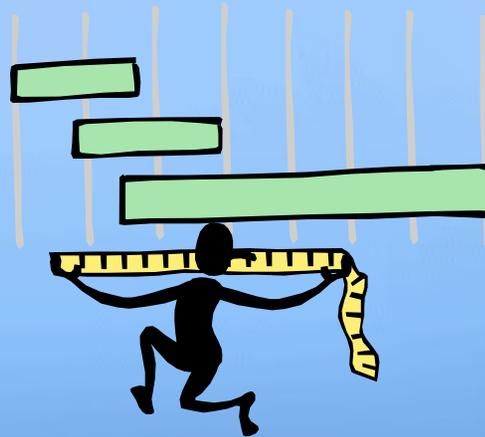
For Better Buildings Summit  
July 11, 2019 Crystal City  
Steve Morgan

# M&V Topics Covered: Getting Your Money's Worth

- What is M&V
- Why Bother with M&V
- How does M&V Work in Practice for Energy Performance Contracting
- The Key Dilemma for Building Owners: Valuing M&V properly
- Emerging Applications for M&V with Pay for Performance Programs, Battery Storage, Load Controls
- The New Technologies for M&V
  
- **Thanks to Dave Birr, Synchronous Solutions for some slides that follow**

# What Is Measurement And Verification (M&V)?

M&V is a process of tracking and verifying project energy savings as specified in the contractually agreed M&V plan



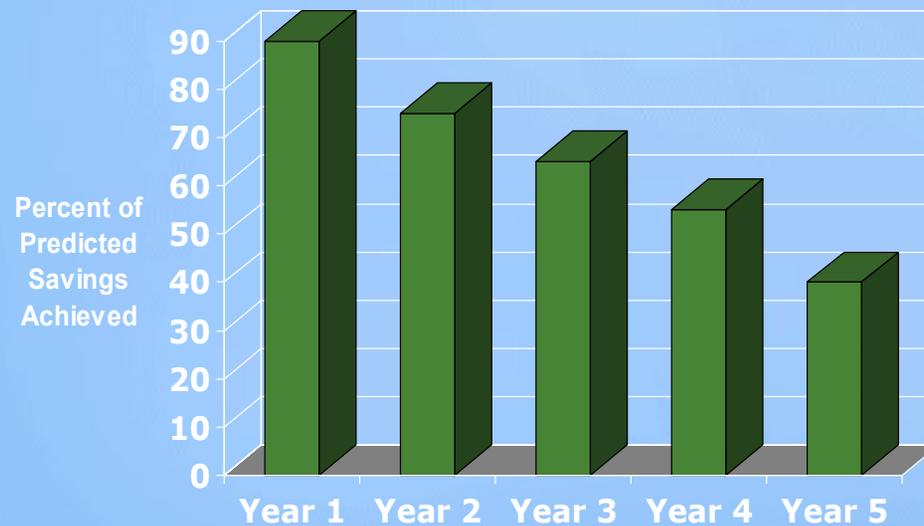
# What is a “Project” for M&V Purposes

- In energy performance contracting, a building or portfolio of buildings with single owner
- In a utility, Pay for Performance program, a portfolio of buildings, generally in same market sector, but a variety of owners and single vendor
- This presentation focuses on energy performance contracting, “guaranteed savings” projects

# Why Bother with M&V?

- Without it, Utility Savings Decline rapidly
- The Value of Energy Efficiency improvements correspondingly fall
- Energy Services Companies (ESCOs) can't get paid for their work
- Helps with Utility Budgeting
- Maintenance Staff cannot do their jobs properly and with highest value
- Climate Change Goals can never be realized

# Savings Erosion Over Time is Typical of Conventional Energy Projects



# How Does M&V Work in Practice?

- Develop M&V Plan
  - Target key project risks
- Establish Project Baseline
- Implement monitoring
- Periodic reporting

# M&V Plan Elements

- Key performance risks for this project
- Which M&V protocol(s) will be used to minimize these risks?
- What data will be measured, calculated, simulated, or estimated in the selected M&V methodology?
- Estimated annual costs for M&V program
- Sample savings report showing all data, calculations and summary results

# Standard M&V Protocols

- International Performance Measurement and Verification Protocol (IPMVP), [www.nrel.gov/docs/fy02osti/31505.pdf](http://www.nrel.gov/docs/fy02osti/31505.pdf) or [www.evo-world.org/index.php](http://www.evo-world.org/index.php)
- American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) guideline 14 (covers IPMVP options B, C, and D in more technical detail), go to: <http://www.ashrae.org>

# IPMVP M&V Protocols

- Option A – One time savings measurement as the basis for future stipulated savings
- Option B - Measured consumption by end use over time
- Option C - Whole facility analysis with utility meter measurements
- Option D - Calibrated simulation calculations

# M&V Protocols Match To Technology

- Option A – Lighting
- Option B – HVAC, DG/CHP, Controls
- Option C – Controls, Demand Response, Water
- Option D – Building Envelope, New Construction

# M&V Protocols Selection Factors

- Number and complexity of ECMS
- Value of projected ECM savings
- Uncertainty of savings
- Savings risk allocation
- Other value produced by M&V data
- Availability and capability of an EMS

# Project M&V

## Data Logging Equipment

- Isolates affected end-use from total building meter
- Quantifies parameters for engineering calculations and simulation models (e.g., temperatures, run times, control settings)
- Provides equipment operation diagnostic data
- Corrects catalog data estimates which can vary by application, design, quality of installation, and control

# Project M&V Data Sources

- Utility bills
- Facility sub-meter readings
- Weather data
- Outputs from building EMS
- Logs of building operation and maintenance data
- Reports on building changes from maintenance staff
- Special metering and benchmark measurements

# Why M&V is Undervalued by Customers

- It is costly: 2-3% of savings value annually
- It is often complicated
- Its absence does not immediately signal economic distress
- Organizational Disincentives: Budget Office pays for utilities; maintenance staff monitor performance

# Significant New Applications for M&V

- Utilities Pay for Performance Program
- HUD's Pay for Success Pilot
- Social Investment Portfolios: Pay for Success Programs Generally
- Load shedding in era of Distributed Generation
- Load Controls
- Battery Storage

# More Sophisticated Building, System Modeling, Load Controls: Examples

- Open source component whole building modelling software
- Adaptive controls (e.g. Nest Thermostats)
- Maximum Power Point Tracking
- Integrated Electrical Systems
- Artificial Neural Networks
- Sophisticated, building wide load controls

# The Energy System of 2030 Needs More and Better M&V

- Electric Utility of the Future is distributed
- Buildings are electricity generators, load shedders
- Electric vehicles are significant peak providers
- Balancing of Supply and Demand is the Challenge of Renewable Energy Future, and Efficiency a major part of that system
- M&V methodologies, technologies will assume more importance for buildings and utilities

**Matt Pesce**

Facility Strategies Group, LLC



U.S. DEPARTMENT OF  
**ENERGY**



# M&V as a Tool for Efficiency

Matt Pesce, P.E.  
Facility Strategies Group, LLC



# About the Speaker

- ▶ Matt Pesce, PE
  - ▶ Principal of Facility Strategies Group in Fort Mill, SC
  - ▶ Has 28 years of consulting engineering experience
  - ▶ Specializing in energy efficiency, renewable energy, and sustainability in buildings
  - ▶ Performs commissioning, design, and engineering consulting
  - ▶ Controls integration
  - ▶ Member AIA, ASHRAE, ASPE, USGBC, etc.



# Agenda

- ▶ Introduction – Common Terms
- ▶ Using M&V
- ▶ Examples
- ▶ Conclusions



# Methods

- ▶ Option A - Retrofit Isolation, key variable
  - ▶ Draw a box around the equipment
  - ▶ Energy in, energy out; ignore everything else
  - ▶ Not tied to the meter; use engineering calculations
  - ▶ Key variables are well understood
  - ▶ Good for contractual agreement
  - ▶ Example – lighting replacement



# Methods

- ▶ Option B - Retrofit isolation, multiple factors
  - ▶ Similar to Option A except more variables at play
  - ▶ Not tied to the meter but can use a submeter or measure more than one variable
  - ▶ Key variables are well understood but secondary variables may need to be measured
  - ▶ Example – lighting controls



# Methods

- ▶ Option C – Main Meter Verification
  - ▶ Same as Option A except more variables at play
  - ▶ Not tied to the meter but can use a submeter or measure more than one variable
  - ▶ Key variables are well understood but secondary variables may need to be measured
  - ▶ Example – lighting controls



# Methods

- ▶ Option D – Calibrated Simulation
  - ▶ A variation to Option C; start with the model and adjust assumptions to allow the model to match actual data, then use the model for predictions
  - ▶ Use the main meter but also use other available measurements or submeter data
  - ▶ Start with an agreed upon model, then adjust assumptions
  - ▶ Example – model a campus of buildings under a single meter



# Methods

- Options A and B are good for contracts; the methods are good for estimating savings
- Options C and D can be used for more than just contracts; they can be used to evaluate pilot projects or to make much more accurate predictions for possible retrofits



# Using M&V

- ▶ Requires data
  - ▶ Equipment counts, pre and post
  - ▶ Equipment efficiencies
  - ▶ Equipment demand or use profile
  - ▶ Utility monthly or interval data
  - ▶ Logger or submeter data
  - ▶ Weather data
  - ▶ Occupancy schedules and building utilization
  - ▶ Construction dates – start and completion
- ▶ Many projects can drill down to an individual building or space



# Tools for Analysis

- ▶ Spreadsheets work well
  - ▶ Simple averages
  - ▶ Linear regressions
- ▶ Advanced tools are available (ASHRAE M&V toolkit methods)
- ▶ Automated software tools are available



# M&V versus Benchmarking

- ▶ Benchmarking is a global tool
  - ▶ Look for variations across a wide number of buildings or sites
  - ▶ Segment and prioritize potential sites
  - ▶ It can be used for simple M&V but doesn't typically have the analytical sophistication to remove confounding factors
- ▶ M&V is a targeted tool
  - ▶ Used after a retrofit to determine if it was successful
  - ▶ Can be used to determine if a pilot project was successful before rolling out an ECM to multiple other projects
  - ▶ Can be used to calibrate a model to make predictions



# M&V, Controls, and Data Analytics

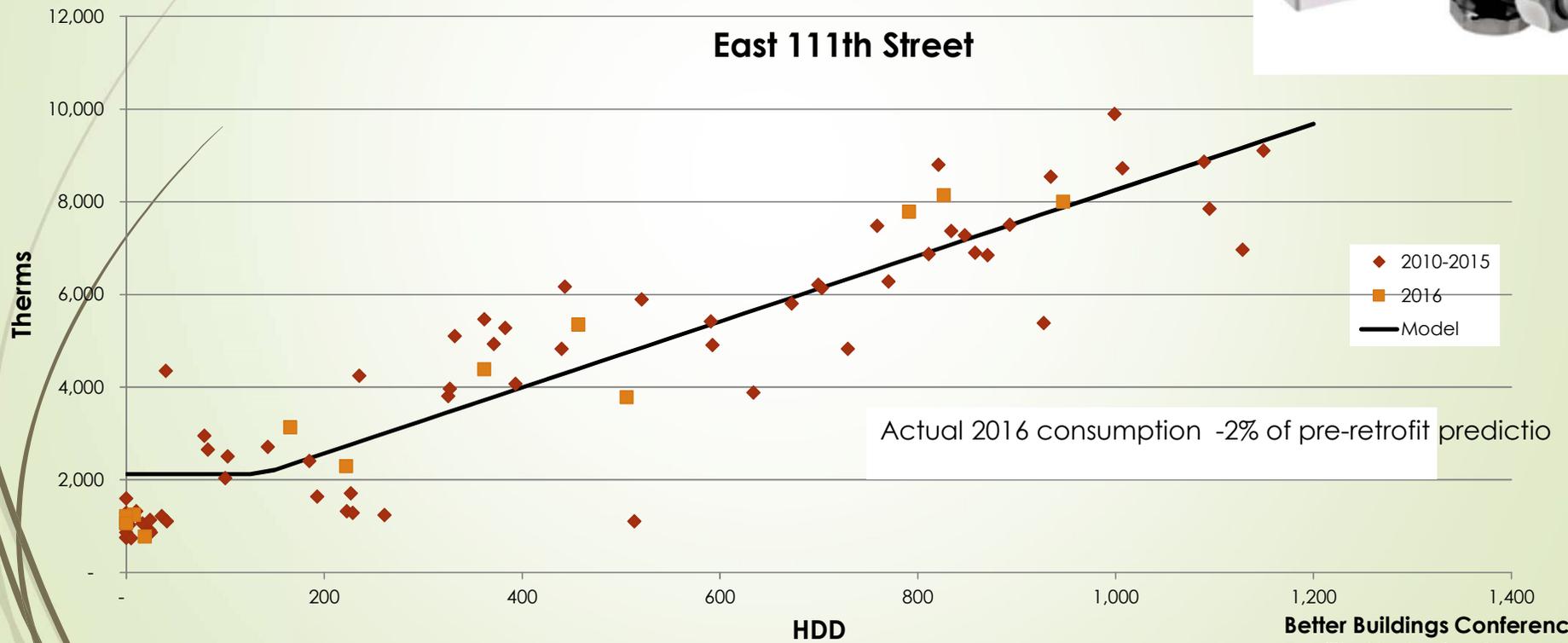
- Lower cost controls are bring intelligence to buildings
- Sensors on everything tied into wifi networks, Bluetooth, and other communications protocols (i.e., the Internet of Things) is bring more information into control systems
- This data is allowing for advanced real time analytics
  - Continuous commissioning
  - Pricing overrides, pricing equipment failures
- Coupled with the concept of M&V, we can use our building control systems to collect the data required to evaluate new equipment or operating sequences



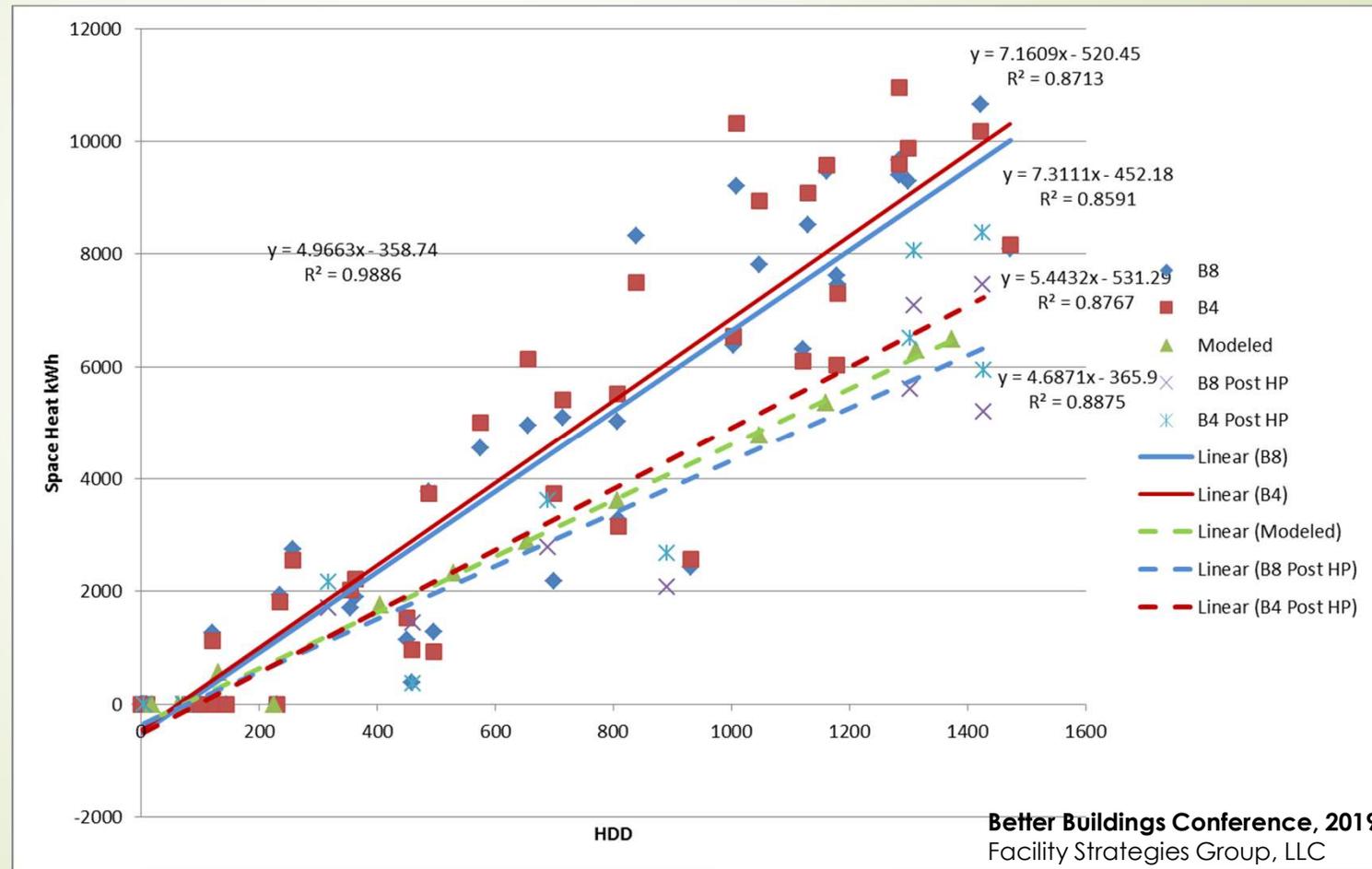
# Examples

- ▶ Temperature Reducing Valves
- ▶ Low Temperature Heat Pump

# TRV valve retrofit - Main meter verification



# Calibrated Model Low Temperature HP





## Q&A

- ▶ Open for any questions

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Recurve



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**RECURVE**  
SHAPE THE FUTURE OF ENERGY

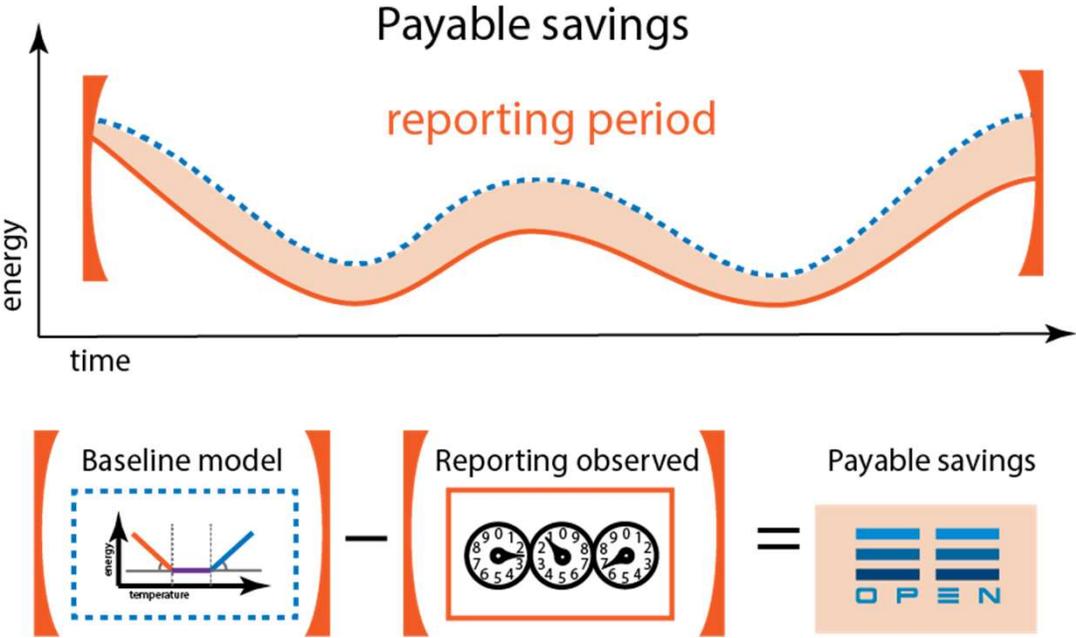
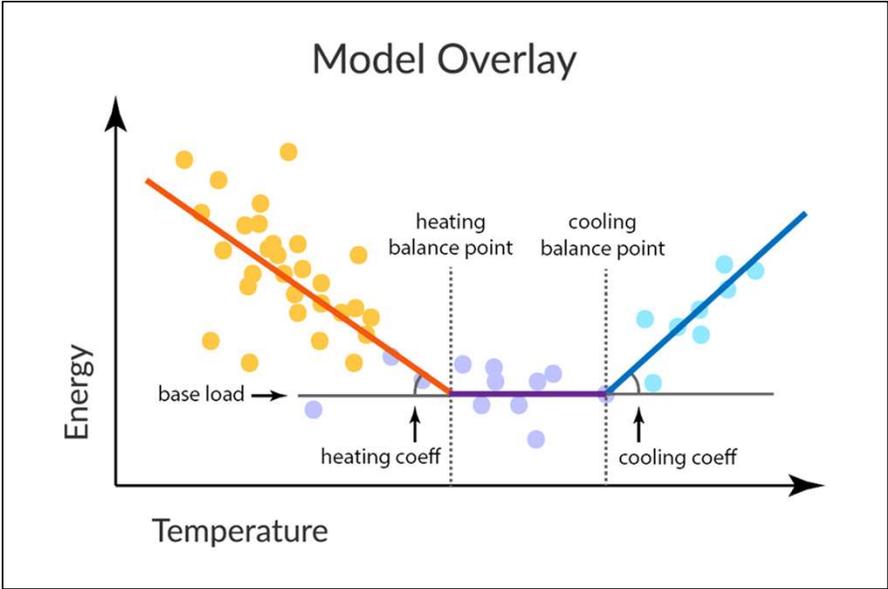
# Step One: Meter Your Savings

Measuring the Value of Efficiency

DOE Better Buildings Summit July 2019

Ethan Goldman  
Director of Customer Solutions

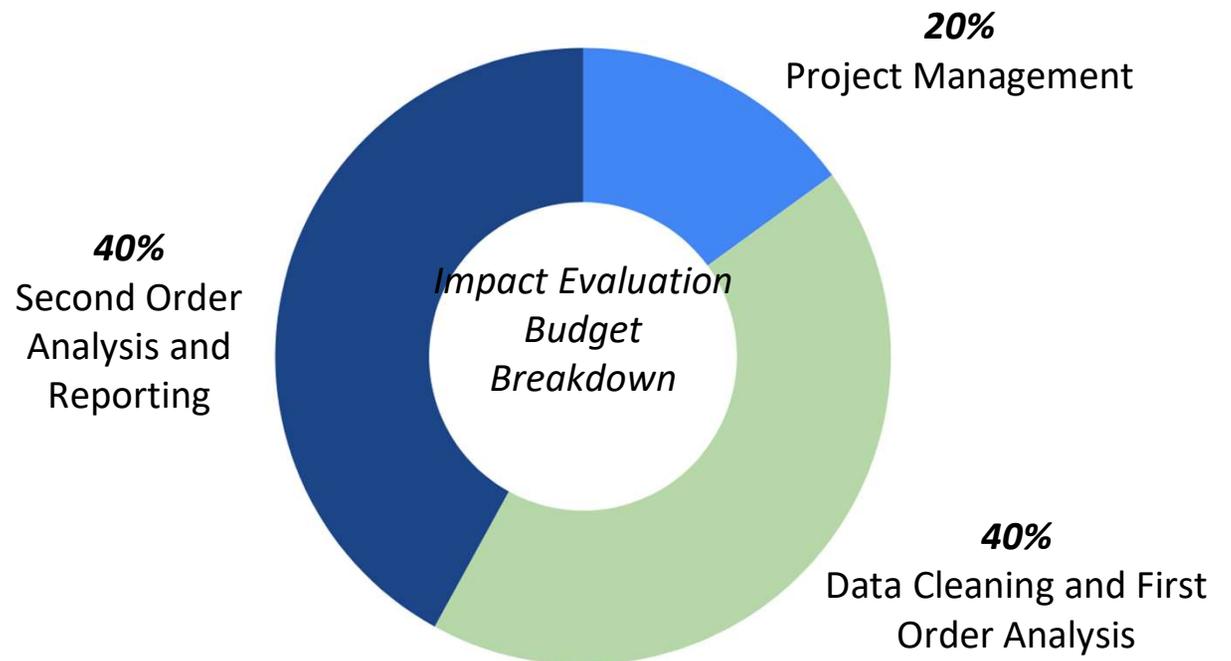
# How Do You Measure What Didn't Happen?



The Status Quo  
does not help solve  
our problems

**6-18 Months**  
Average completion time for  
one impact evaluation

**∞**  
Number of potential  
evaluation methods





- Standard Calculation Methods for Energy Efficiency and Electrification
- Monthly, Daily, and Hourly
- Public 60 Stakeholders Empirical Process
- [www.CalTRACK.org](http://www.CalTRACK.org)



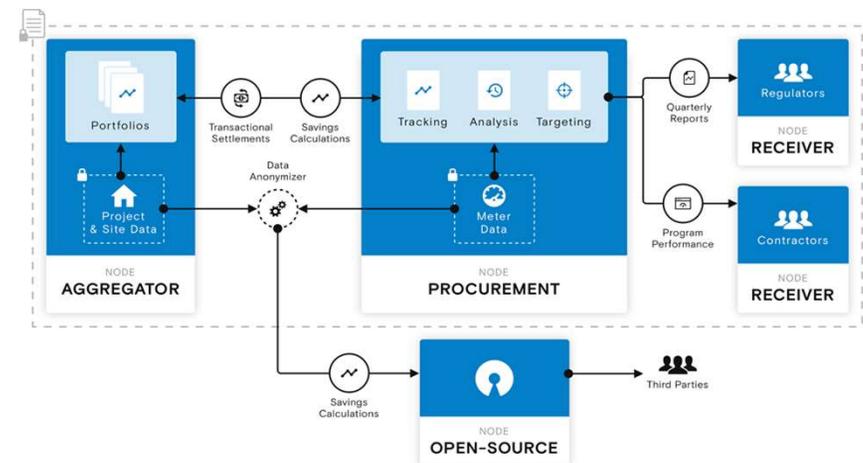
- Python CalTRACK Engine
- Open Source [Apache 2.0](#)
- How It Works: <https://goo.gl/mhny2s>
- Code Repo: <https://goo.gl/qFdW4P>



## Recurve SaaS Platform

- Telemetry, Targeting, and Analytics
- CalTRACK Compliant
- SaaS “OpenEEmeter Inside”
- Data Pipeline (ETL)
- Secure, Encrypted, and Scalable

## Distributed Nodes



# Near Real-Time Telemetry

RE

FILTERS (0) ▾ No filters selected

①  
**8,570**  
Total Projects

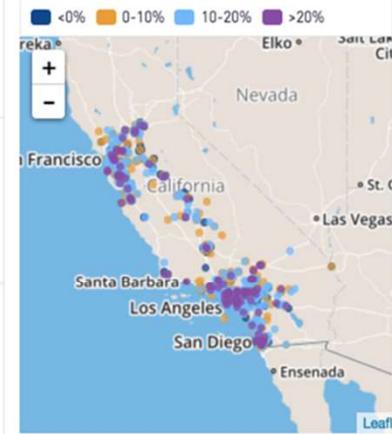
Projects Enrolled Per Month



①  
**45**  
Contractors

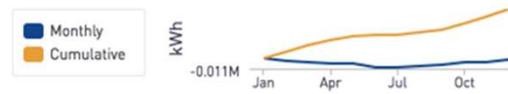
**55 Years**  
Average Building Age

① Projects and Savings % [Click to Drill]



①  
**2.19M**  
Total kWh Savings

Electricity Savings per Month

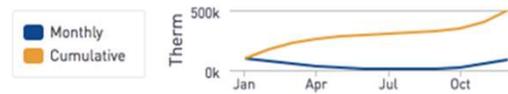


①  
**438**  
kWh Project/Year

①  
**5.9%**  
Electricity Savings

①  
**595k**  
Total Therm Savings

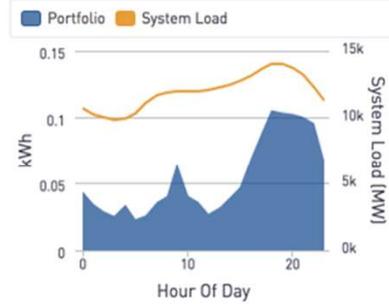
Natural Gas Savings per Month



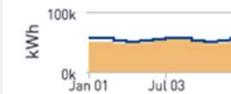
①  
**108**  
Therms Project/Year

①  
**19%**  
Gas Savings

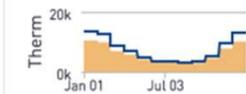
Resource Curve (hourly savings)



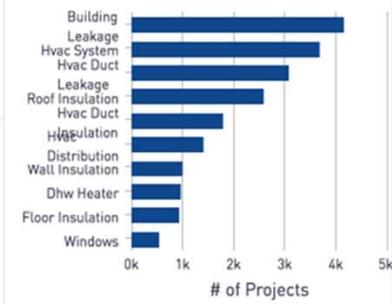
Electricity Use vs. Baseline



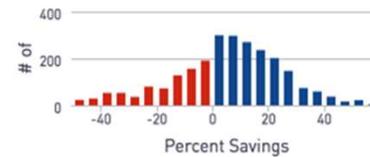
Gas Use vs. Baseline



Energy Conservation Measure Distribution



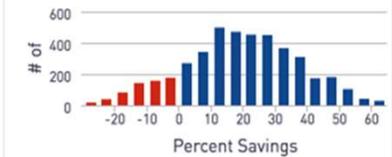
Electricity Savings Distribution



①  
**78%**  
Electric Realization Rate

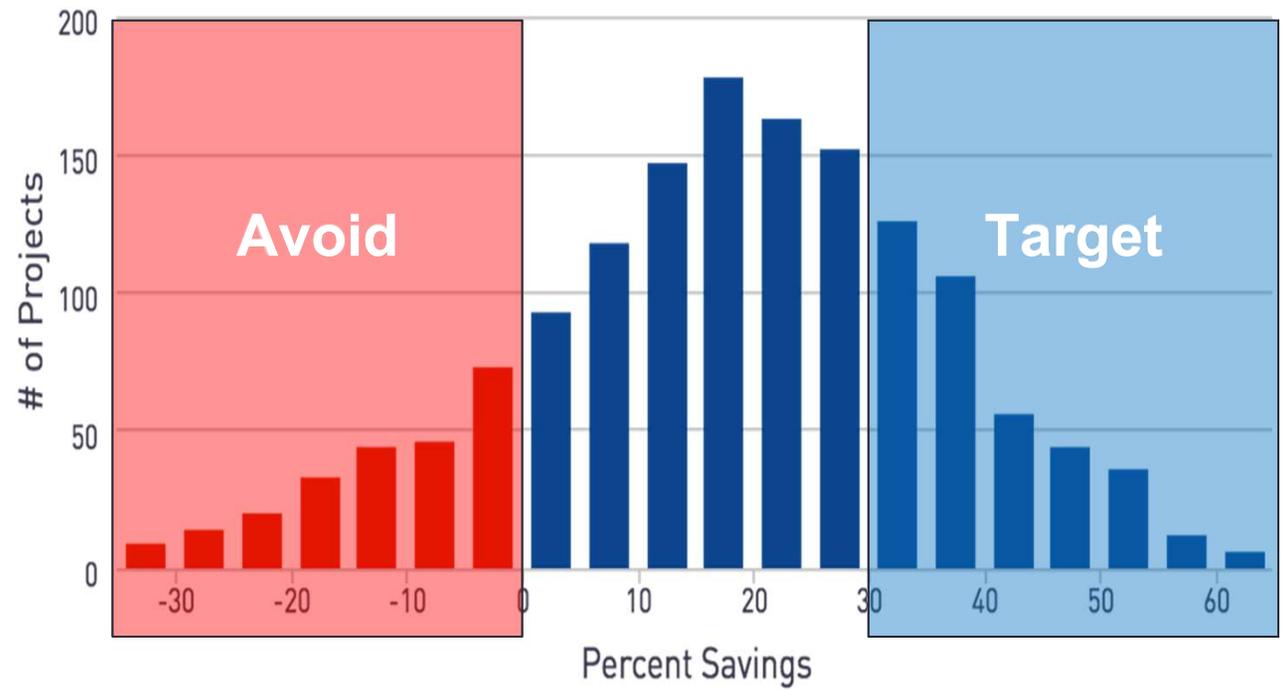
①  
**80%**  
Gas Realization Rate

Natural Gas Savings Distribution



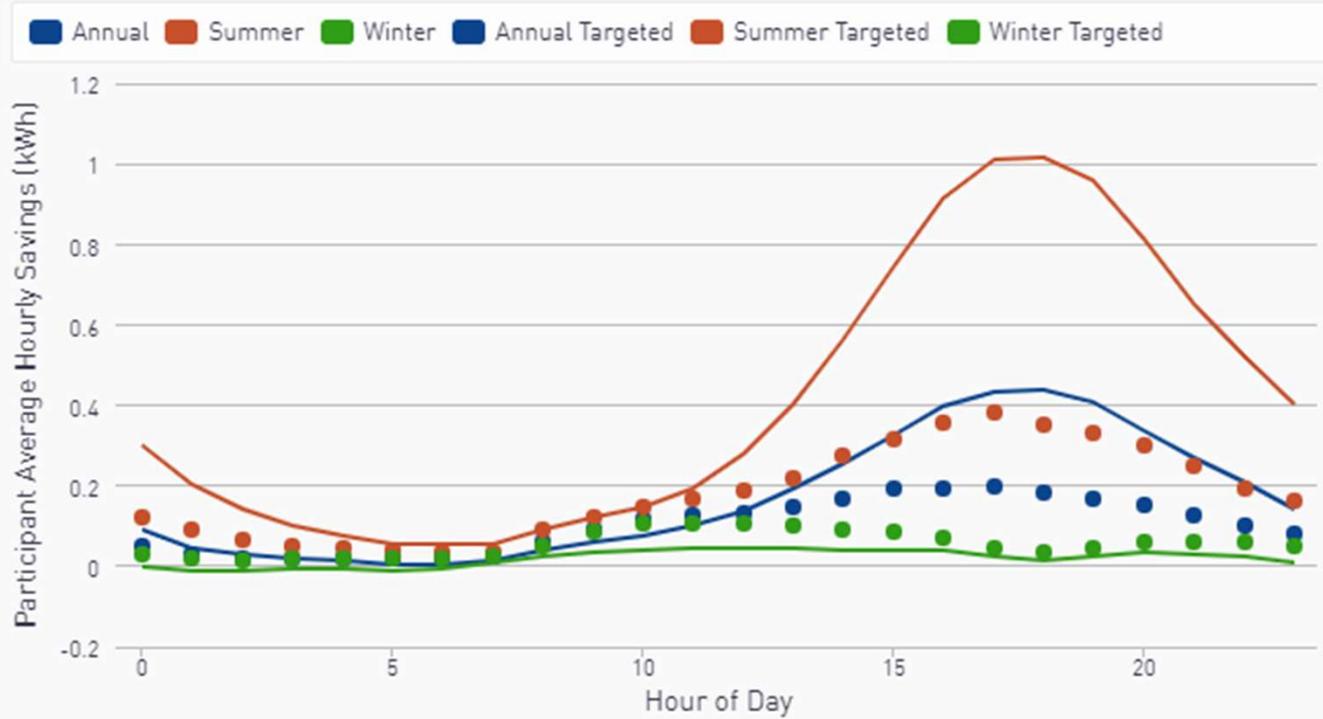
# Target the Most Valuable Projects

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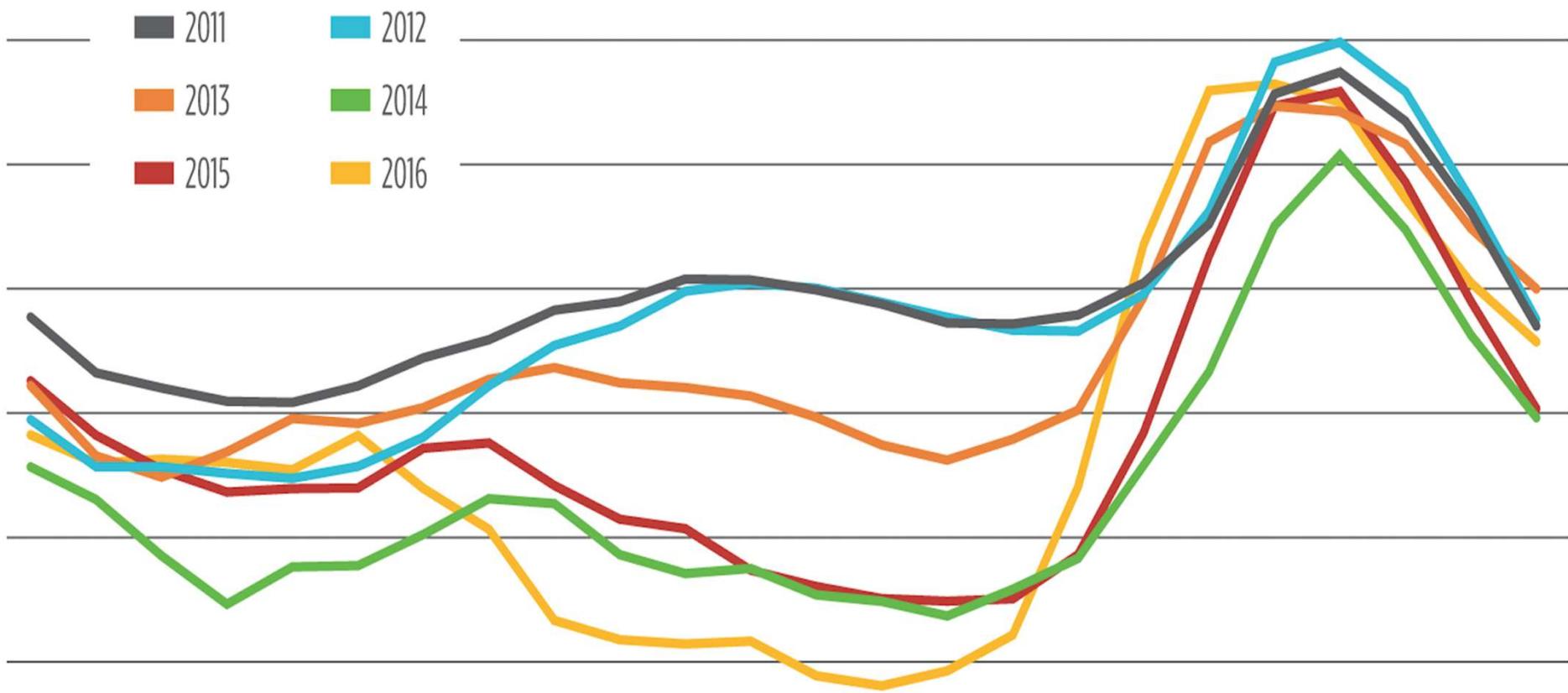


# Target the Most Valuable Projects

Resource Curve

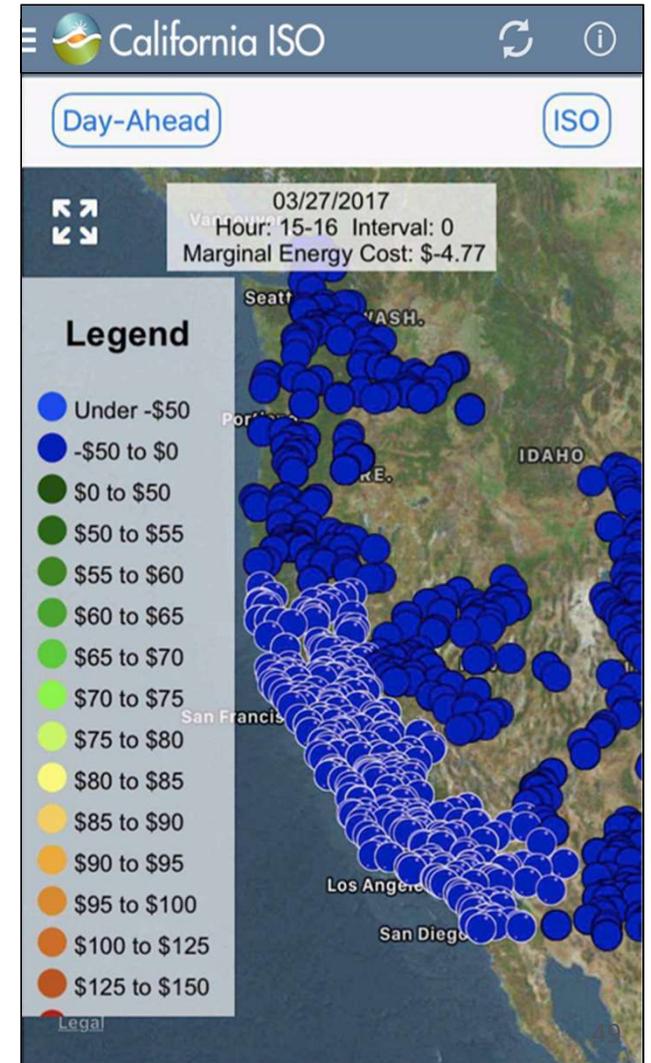
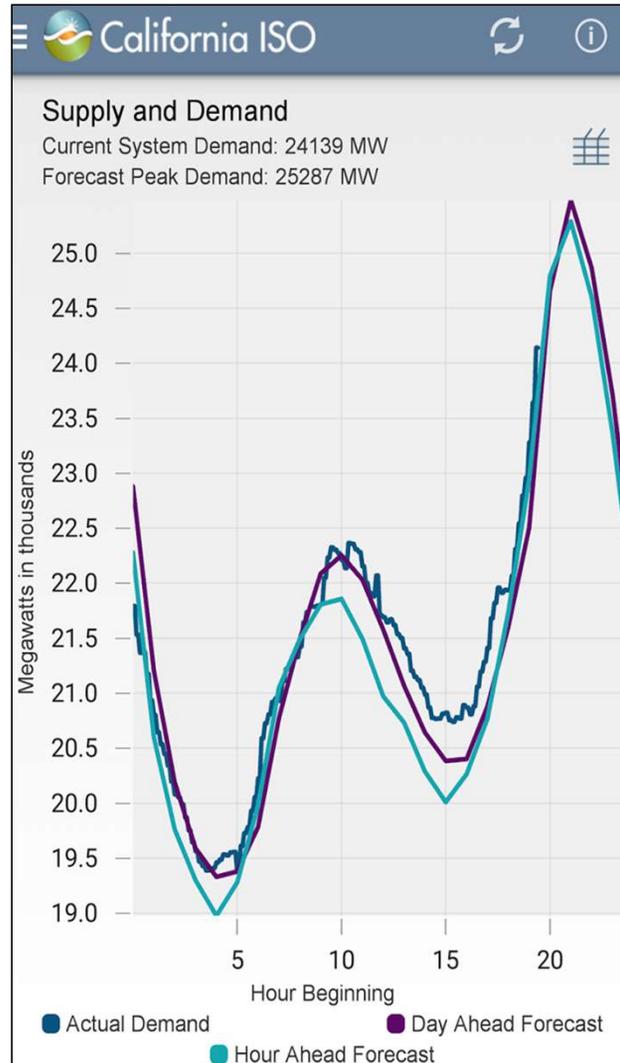


# The Duck is Four Years Ahead of CAISO Projections

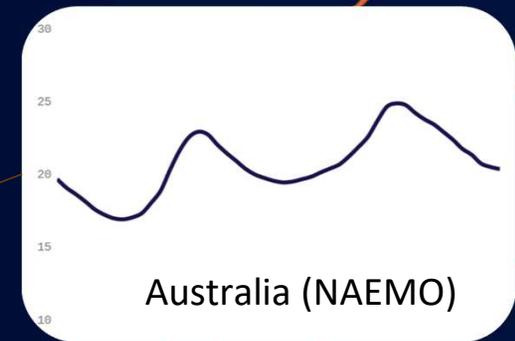
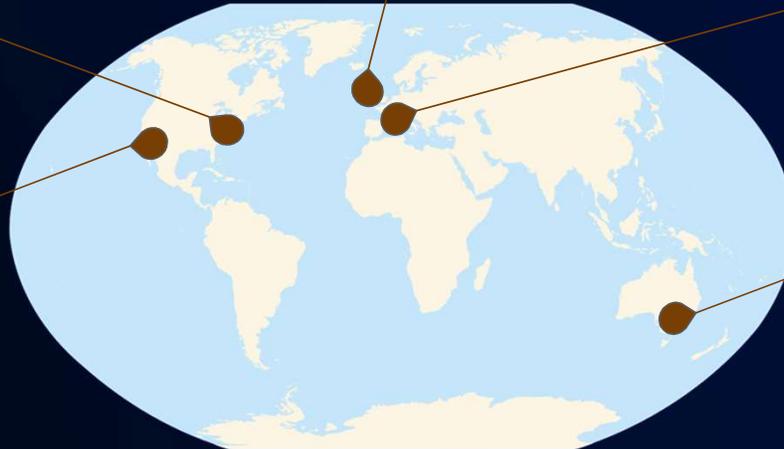
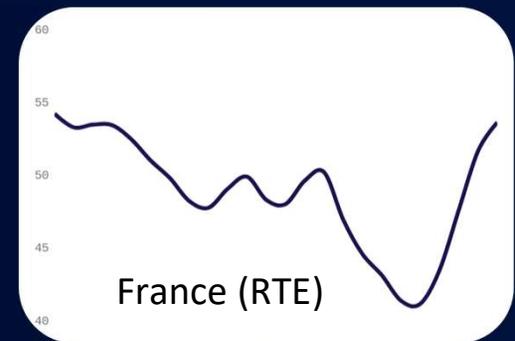
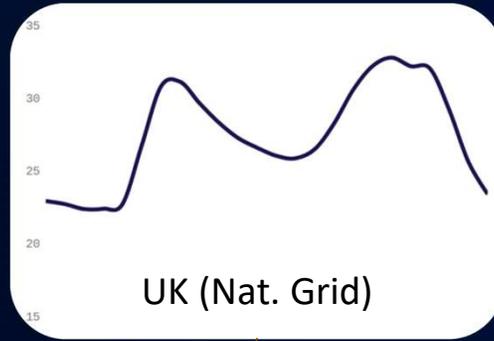


# Load Balancing Renewable Energy

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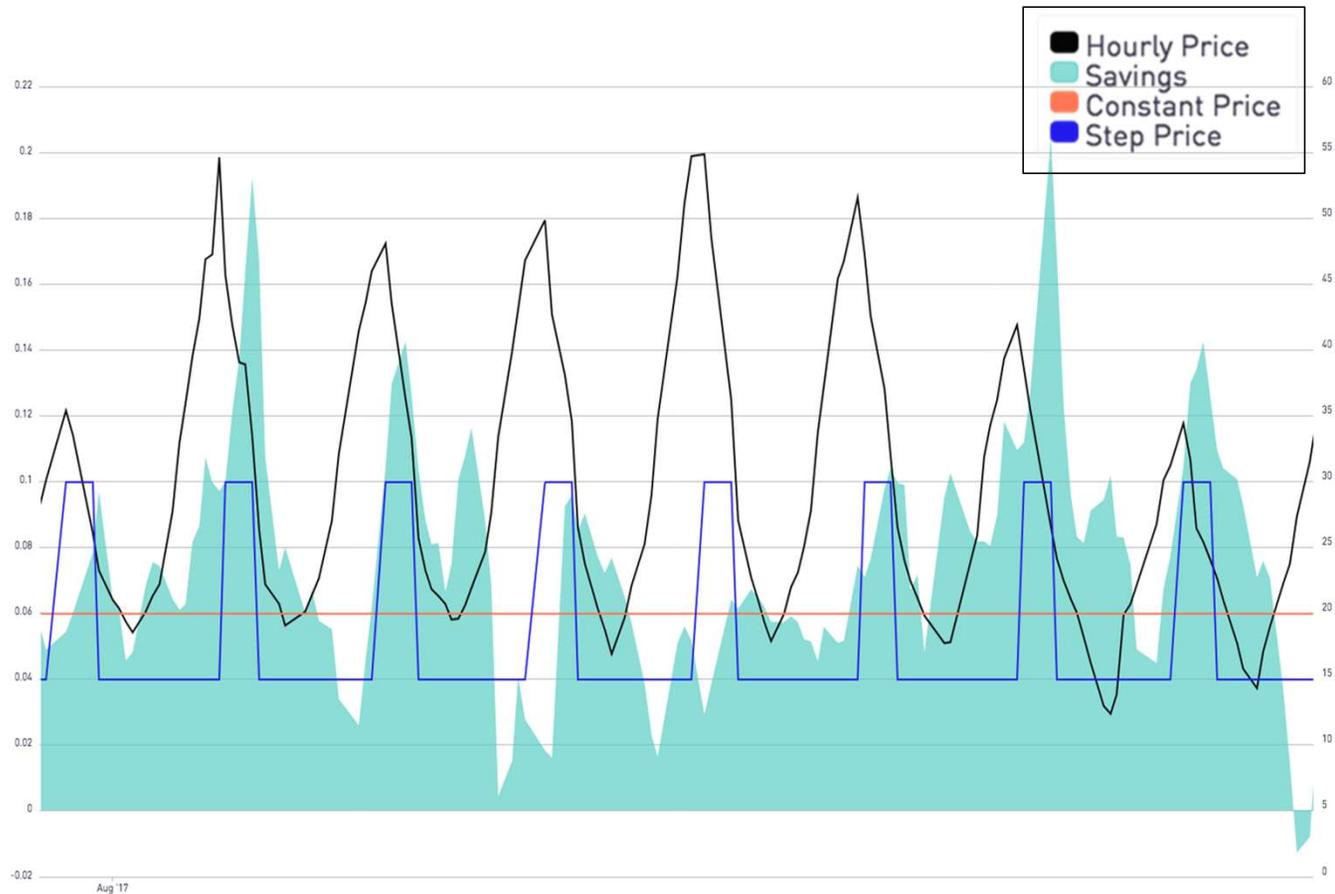


# The Duck is Coming



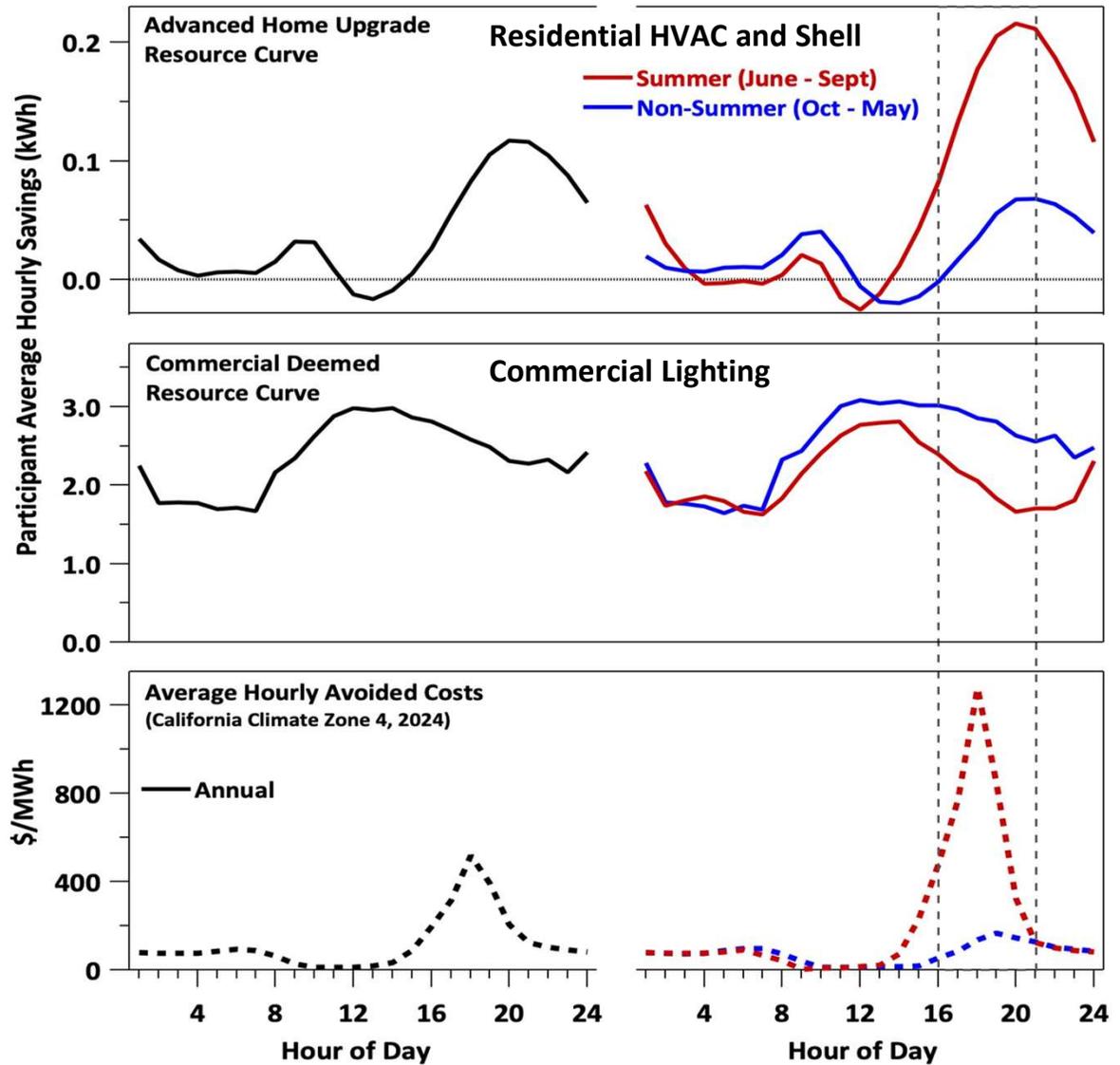
# Paying for Performance When it Matters Most

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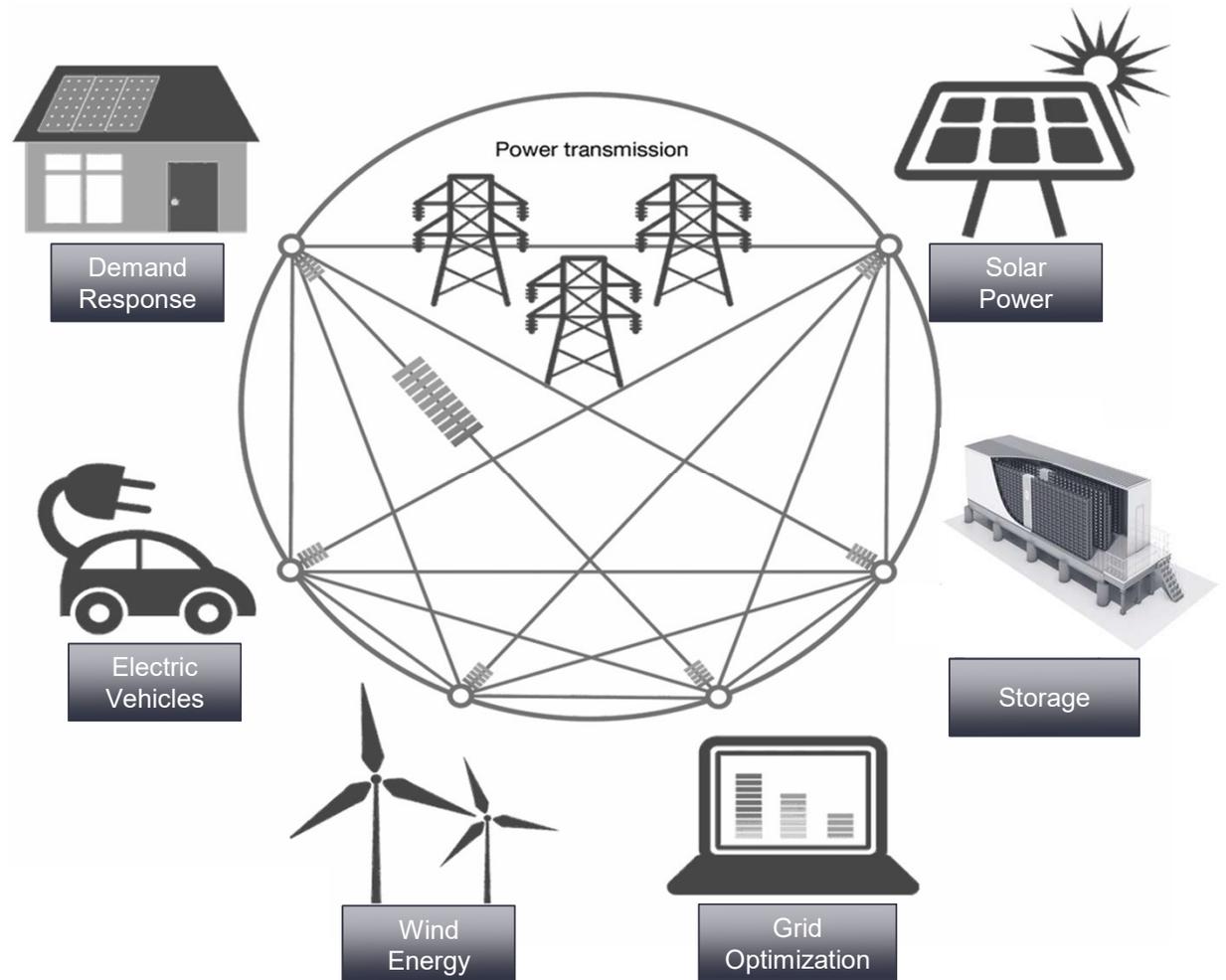


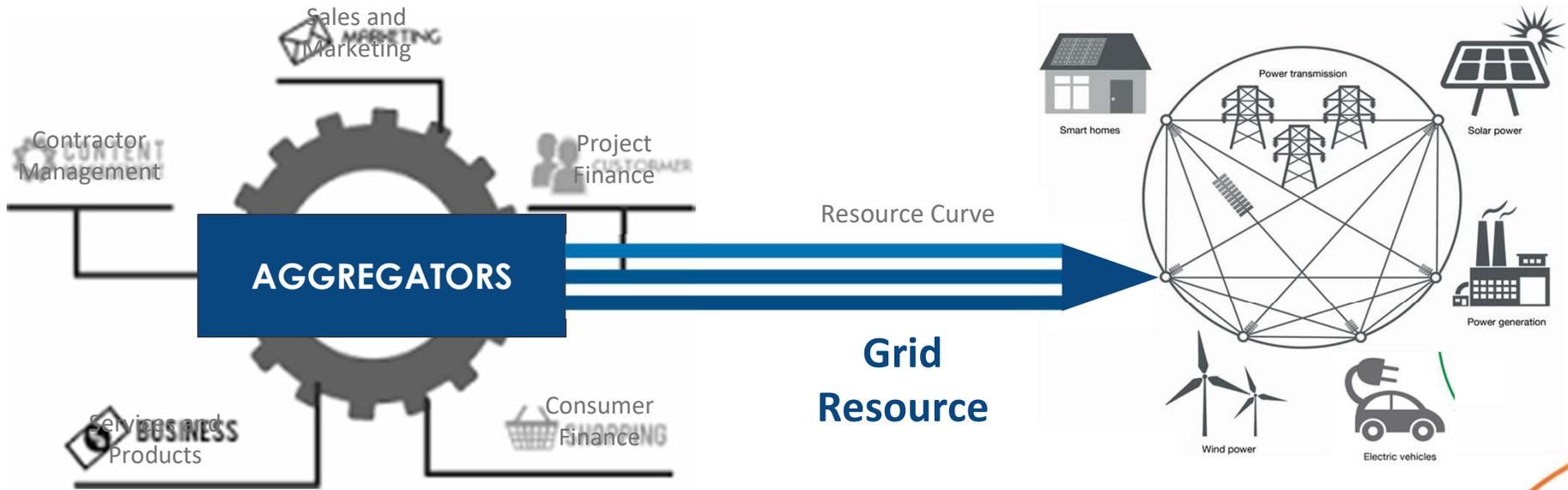
- Savings Purchase Agreement (SPA)
- 3x Kicker for summer savings from 4pm to 8pm
- Payments based on CalTRACK / OpenEEmeter

Not All Energy Efficiency is of Equal Grid Value



# Turning Demand Flexibility into a Grid Resource





**Business Models**

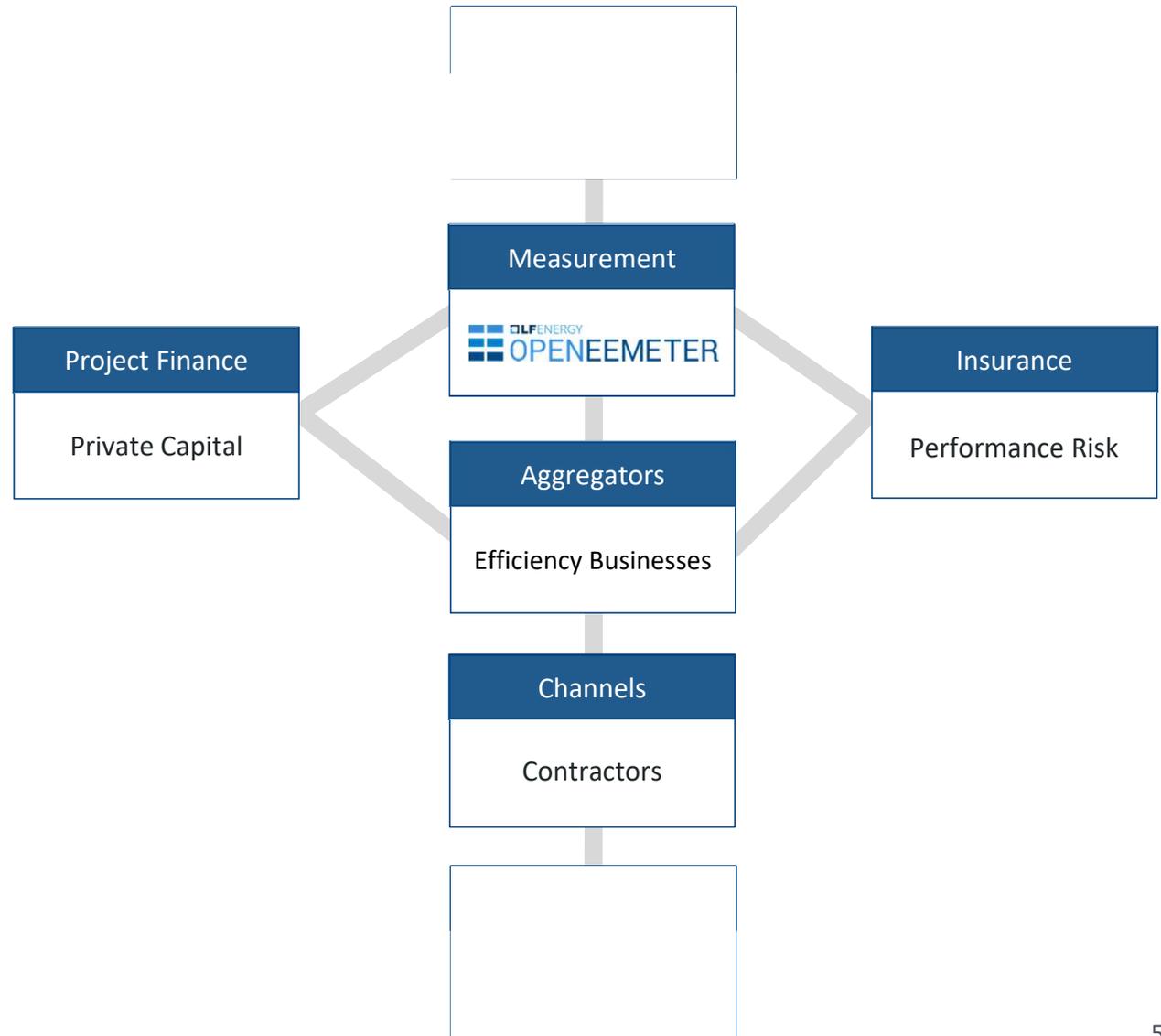
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**Savings Comfort Health**



# Scalable Structures and Private Capital

RE



# RECURVE

SHAPE THE FUTURE OF ENERGY



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