Building More Knowledge About Whole Building EM&V

Tim Guiterman, EnergySavvy
Sarah Zaleski, US Department of Energy
Ethan Goldman, Vermont Energy Investment Corporation
Diane Duva, CT Department of Energy and Environmental Protection
Bill Norton, Opinion Dynamics

ENERGYSAVVY

What is M&V 2.0?

> “
>
> A defining criterion for automated M&V software is that it continuously analyzes data as it becomes available.
>
> New York Dept. of Public Service, EM&V Guidance, Nov 2016

Floating Names

M&V 2.0	EM&V 2.0	Advanced M&V (NY REV)	Automated M&V (NEEP)	ICT-Enabled EM&V (ACEEE)

RMI: The Status and Promise of Advanced M&V

Collaborative Study involved DOE, Utilities, Evaluators, and Analytics Firms

Automated analytics that can provide **ongoing, near-real time savings estimates**

Increased data granularity in terms of frequency, volume, or end-use detail

M&V 2.0 benefits evaluators, program administrators, regulators, grid operators and others.

" Advanced M&V can increase the value of evaluation, reduce costs through automation, enhance program targeting, allow for early adjustments to program designs and budgets, and increase accuracy of savings estimates to support EE as a resource."

New Demands Require New Approaches

“

Evaluation focuses on whether change has occurred, the nature and degree of change, and the factors that lead to change. Assessing, understanding and explaining change is at the center of evaluation. It is ironic then, that static thinking dominates evaluation, especially summative an impact evaluations.

MICHAEL QUINN PATTON
DEVELOPMENTAL EVALUATION: APPLYING COMPLEXITY CONCEPTS TO ENHANCE EVALUATION AND USE, 2010

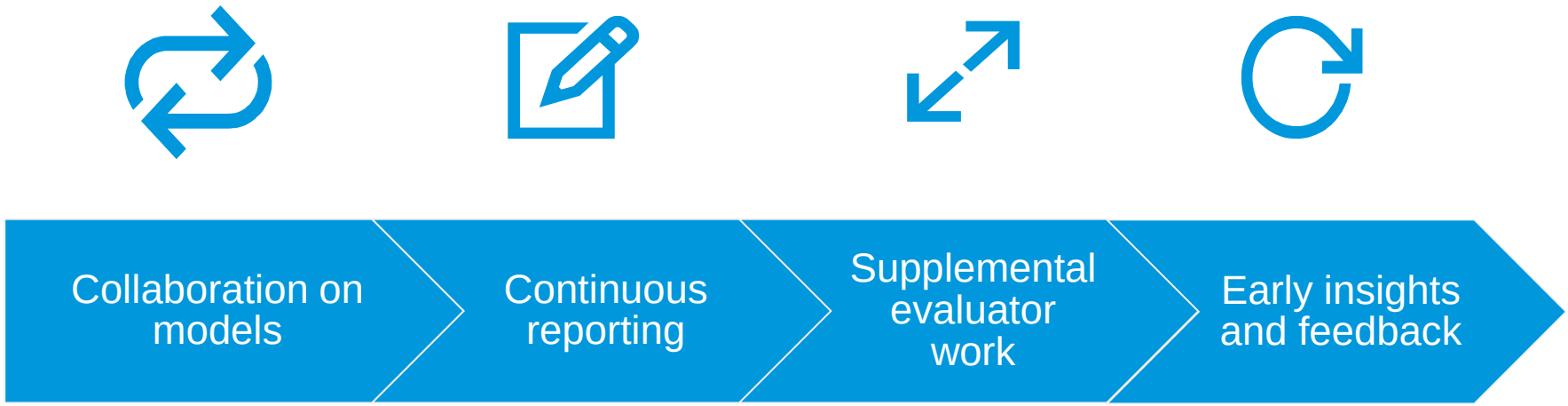
Developmental Evaluation

Traditional Evaluation	Developmental Evaluation
Roles & relationships: Positioned as an outsider to assure independence and objectivity	**Roles & relationships:** Positioned as an internal team function integrated into the process of gathering and interpreting data, framing issues, surfacing and testing model developments
Measurement: Measure performance and success against pre-determined goals and SMART outcomes	**Measurement:** Develops measures and tracking mechanisms quickly as outcomes emerge; measures can change during the evaluation as the process unfolds
Evaluation results: Detailed formal reports, validated best practices, generalizable across time and space. Can engender fear of failure	**Evaluation results**: Rapid, real time feedback; diverse, user-friendly forms of feedback. Evaluation aims to nurture learning
Complexity & uncertainty: Evaluator tries to control design implementation and the evaluation process	**Complexity & uncertainty**: Learning to respond to lack of control, staying in touch with what's unfolding and responding accordingly

Source: Patton, M. (2010). *Developmental evaluation: applying complexity concepts to enhance innovation and use.* New York, NY: Guilford Press

An Example of Integrated Evaluation

M&V 2.0 & EM&V firms jointly work together to evaluate programs



DOE's M&V 2.0 Demonstrations

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

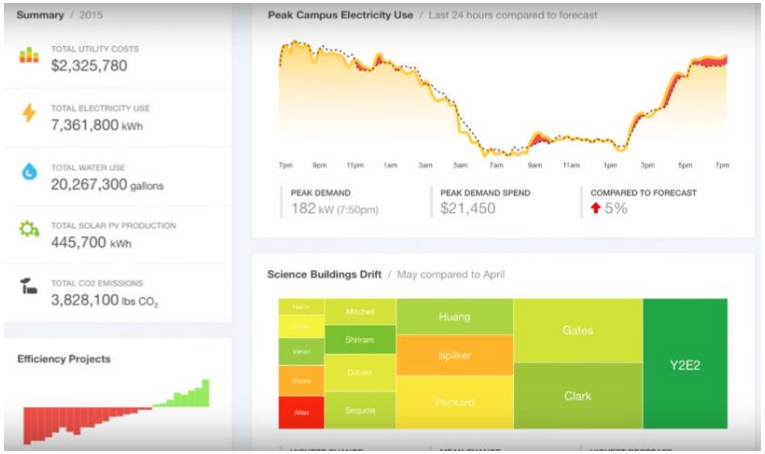
Sarah Zaleski
Sarah.Zaleski@ee.doe.gov
April 28, 2017

Purpose of M&V 2.0 Demonstrations

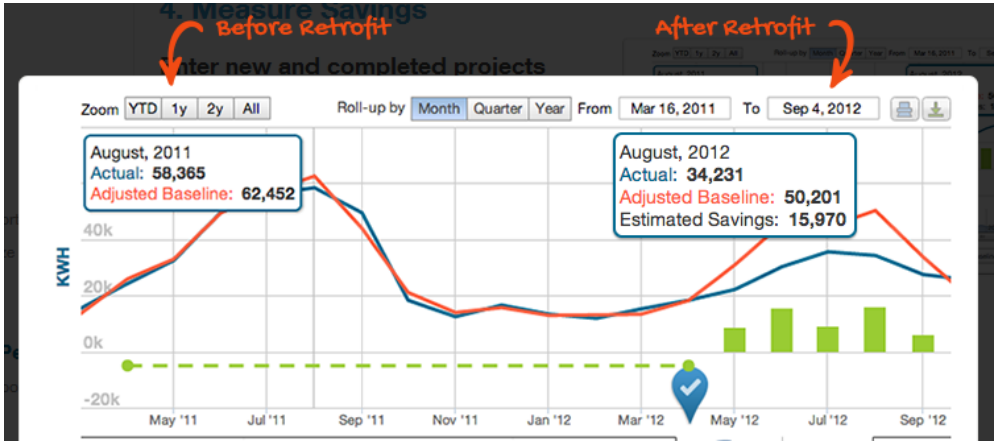
Problems - Verification and evaluation of efficiency savings is expensive, time consuming; spectrum of approaches are used and custom calculations and stipulated savings are most prevalent.

Opportunity - Growth in interval data and analytics tools that automate meter-based measurement and verification ("M&V 2.0") promise to reduce cost and time requirements, but questions of accuracy and practical application remain.

Objectives - Increase confidence in energy savings, market adoption of meter-based approaches, reduction in costs.



Source: Lucid



Source: Noesis

Project Impact

Near Term

- Transparent, replicable test methods for M&V tools being used by industry
- Early demonstration of M&V 2.0 with utility partners
- Documentation of time and cost savings as well as accuracy

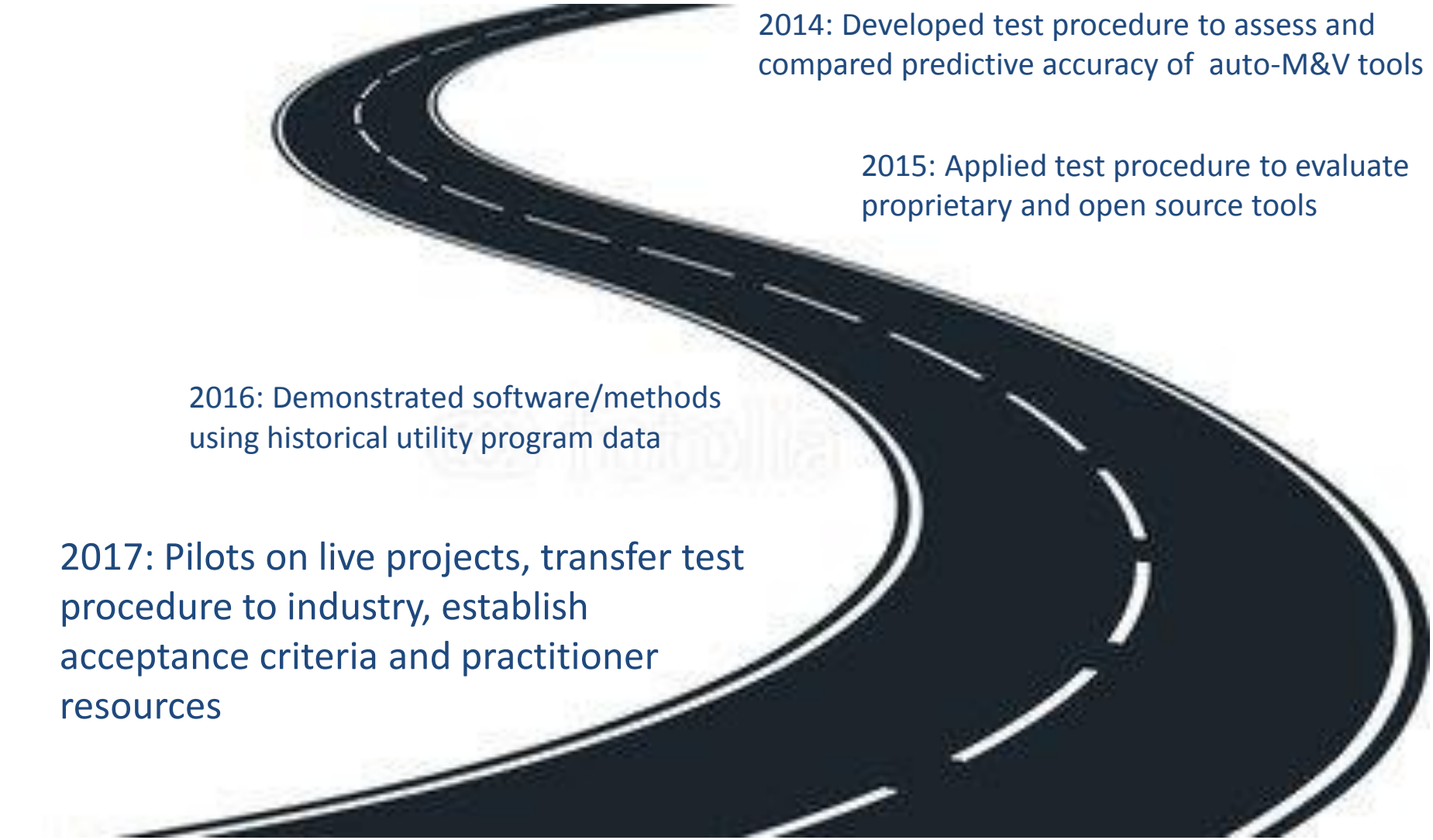
Mid Term

- Scaled demonstration and dissemination of results to industry at large
- Tools and resources created/adopted to standardize practical application of M&V 2.0 methods

Long Term

- Scaled adoption of cost effective, accurate, meter-based savings estimation
- Market growth from private capital injection, due to higher confidence in EE savings results

Evolution of Work



2014: Developed test procedure to assess and compared predictive accuracy of auto-M&V tools

2015: Applied test procedure to evaluate proprietary and open source tools

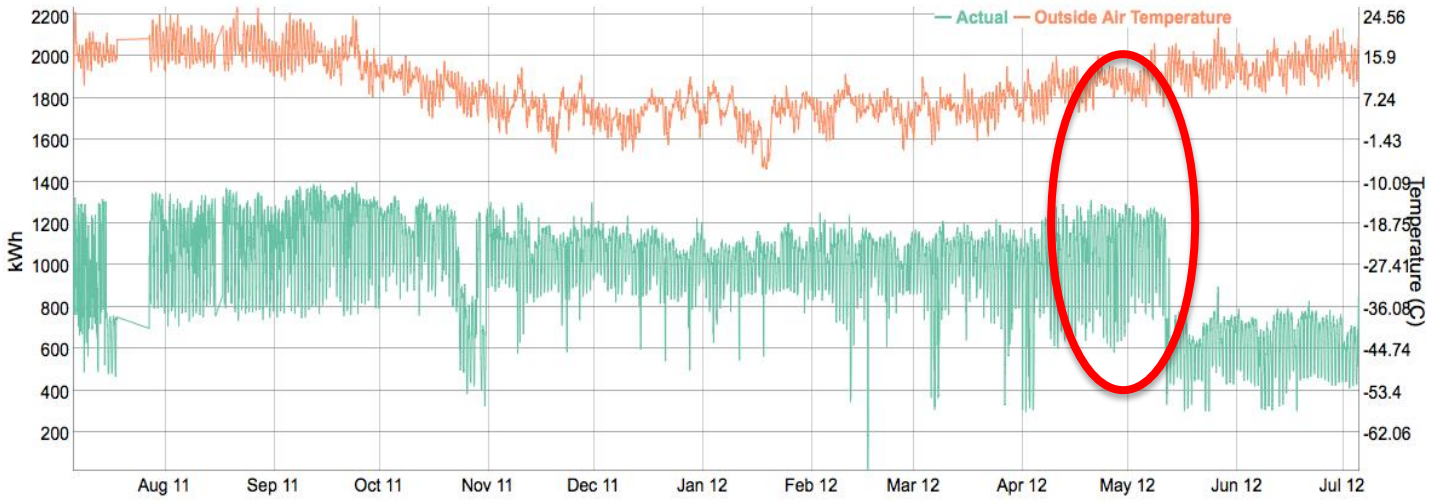
2016: Demonstrated software/methods using historical utility program data

2017: Pilots on live projects, transfer test procedure to industry, establish acceptance criteria and practitioner resources

Tool Testing Results

- Working with utilities, 70% of the buildings (n=77) were found to be well suited (statistical fitness) to automated characterization of baseline energy use
- Results indicated that M&V 2.0 can be used to accurately quantify whole-building savings, and that automation may offer time and cost savings advantages

Example of case where M&V 2.0 identified accurate measure implementation date



Findings and resources posted at: http://eis.lbl.gov/auto-mv.html

Pilot Design

Vs.

- 2.0 savings uncertainty, site and aggregate level
- Relative labor effort
- Benefit of continuous feedback from 2.0
- Open-source methods to advance commercial 2.0 products
  - Quantify model fitness and associated savings uncertainty
  - Auto-flag potential non-routine events
- Practitioner how-to application guidance
  - Where/how to use automation
  - When to use professional expertise
  - How to maintain a quality result

Seattle M&V 2.0 Pilot

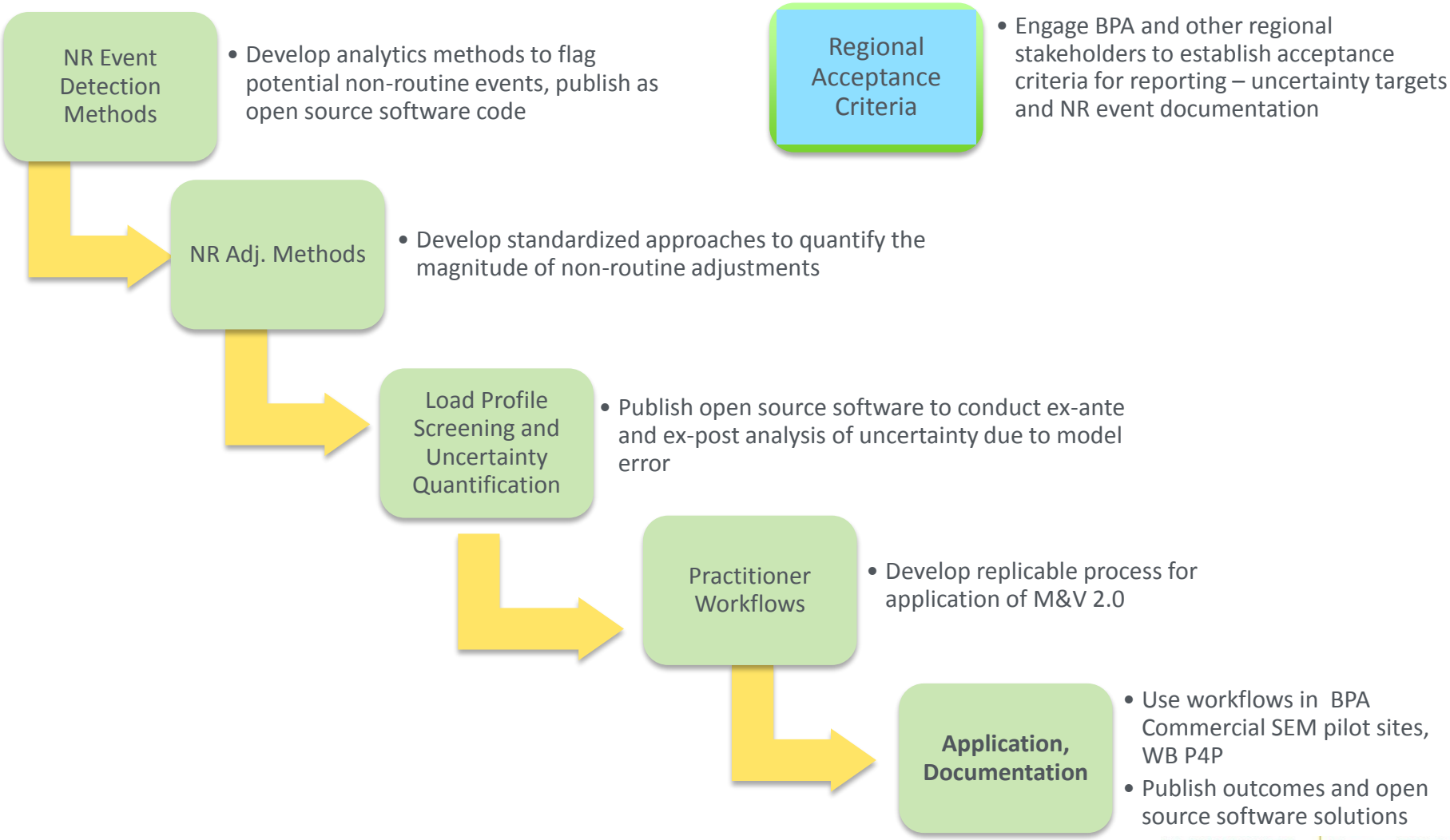
Partners

- LBNL
- Seattle City Light
- Bonneville Power Association

Activities

- Commercial investigation
- Develop end-to-end workflows to integrate M&V 2.0 into whole-building programs
- Apply solutions and evaluate efficacy
- Identify requirements for bar for rigor

Seattle Pilot Process



National Stakeholder Group

Poll Responses from Stakeholder Meeting

What are the top 3 critical needs for industry with respect to M&V 2.0?

Answer	Total Number	Total %
Pilots to demonstrate viability	10	59%
Standard requirements for accuracy/reports	9	53%
Non-routine adjustment methods	6	35%
Standard software testing	6	35%
Beyond existing conditions baseline	6	35%
Application guidance/ref materials	3	18%
Other	3	18%
Improving software tools	2	12%
M&V 2.0 vs. EM&V 2.0	2	12%

Poll Responses from Stakeholder Meeting

What will be the biggest challenge in executing successful pilots?

Answer	Total Number	Total %
ID/quantify non-routine adjustments	7	41%
Drawing conclusions (small sample)	4	24%
Other	3	18%
EE project delays (customer)	2	12%
Data access, QA, account mapping	1	6%
Recruiting pilot sites	0	0%

Next Steps and Future Plans

Next Steps:

- Monitor pilots and report on outcomes
- Continued industry outreach
- Document acceptability requirements
- Quarterly stakeholder group meetings

Future Plans:

- Scaled demonstration, market adoption to enable
  - Next generation holistic whole-building programs to deliver deep savings
  - Reliable cost effective savings estimation for increased confidence and investment in efficiency
  - With meter as foundation, ability to integrate energy, demand, cost savings, as EE, distributed energy resources, and transaction-based services converge

Connecticut Department of Energy and Environmental Protection

Connecticut Department of
ENERGY &
ENVIRONMENTAL
PROTECTION

Standardized, Sustainable and Transparent EM&V - Integrating New Approaches

CT M&V 2.0

Diane W. Duva, Director, Office of Energy Demand
Bureau of Energy and Technology Policy

April 27, 2017

Connecticut Department of Energy and Environmental Protection

Connecticut's Policy Framework

CT signs *NEG/ECP 2001 Climate Change Action Plan*

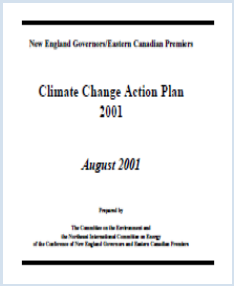
Governor's Steering Committee finalizes *CT Climate Change Action Plan*

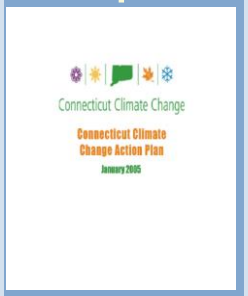
2007 Public Act 07-242 – Energy Efficiency and Expansion of the Renewable Portfolio Standard

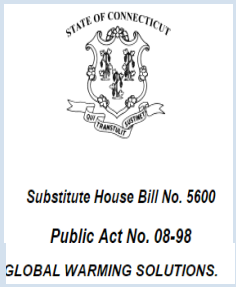
2013 Comprehensive Energy Strategy

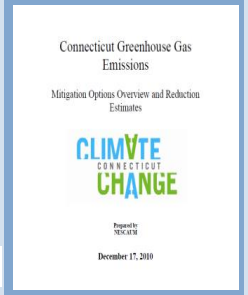
Executive Order 46 creates the Governor's Council on Climate Change(C3)

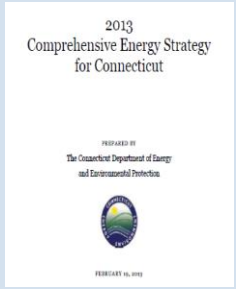
The GC3 releases it's *Exploratory report*

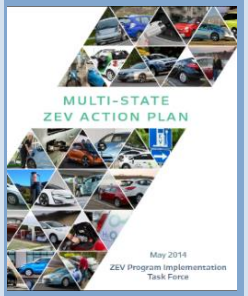


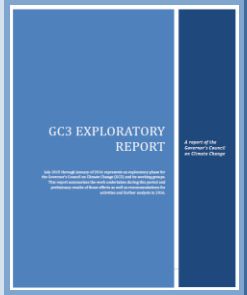












2001 2005 2008 2010 2013 2014 2015 2016

CT 's implementation of 1990 Amendments to Federal CAA continues

CT 's implementation of The RPS continues

2004 Public Act 04-252 — An Act Concerning Climate Change sets GHG goals that align with NEG/ECP regional goals

CT Global Warming Solutions Act (Public Act 08-98) reaffirms commitment to GHG targets for 2020 and 2050

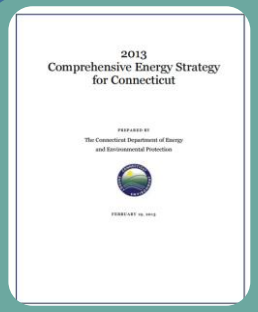
Regional Greenhouse Gas Initiative

Gov. Malloy signed a Zero Emissions Vehicles Memorandum of understanding with 7 other states to deploy 3.3 million ZEVs by 2025.

CT joined 12 jurisdictions from around the world to create the International ZEV Alliance

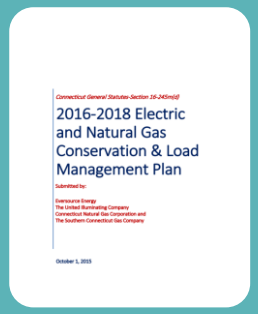
Through Public Act 15-107 & Public Act 13-303 CT selects renewable energy and energy efficiency projects equal to approximately 1,092 GWhs

Energy Plans



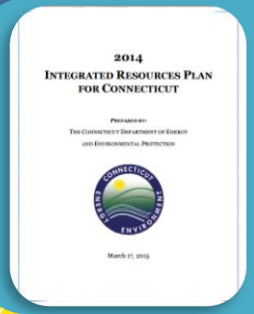
Comprehensive Energy Strategy

The Department of Energy and Environmental Protection (DEEP) developed the first-ever Comprehensive Energy Strategy for the State of Connecticut – an assessment and Strategy for all residential, commercial, and industrial energy issues, including energy efficiency, industry, electricity, natural gas, and transportation.



Conservation & Load Management Plan (C&LM Plan)

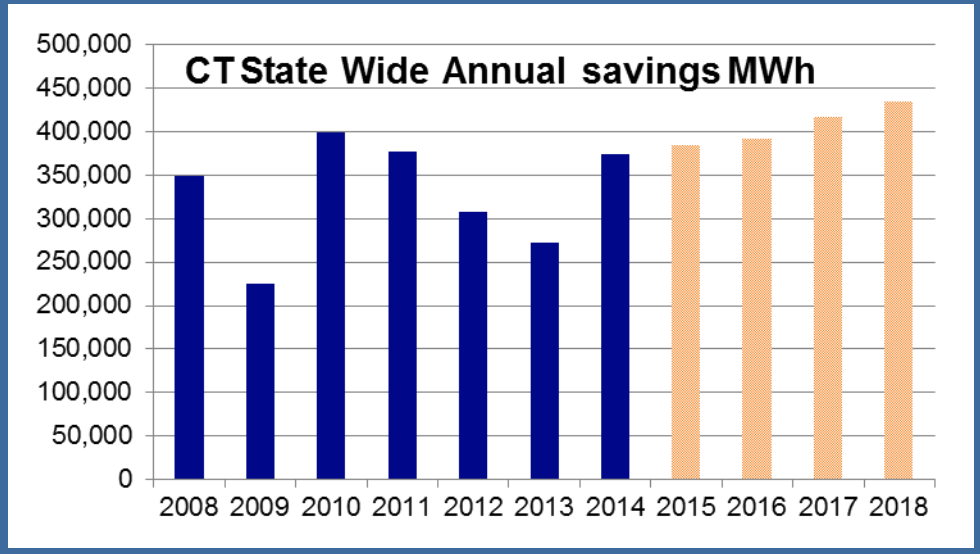
Every three years, Connecticut's utilities develop and implement an energy efficiency investment plan for the CT Energy Efficiency Fund (CEEF). The CEEF is funded by various sources, including customer contributions, the Regional Greenhouse Gas Initiative (RGGI) and the ISO New England Forward Capacity Market. The CT Energy Efficiency Board (EEB) advises and assists the utilities in the development of the plan. DEEP then reviews and approves or modifies the CEEF's plans and budgets in order to achieve cost-effective energy savings across the state.

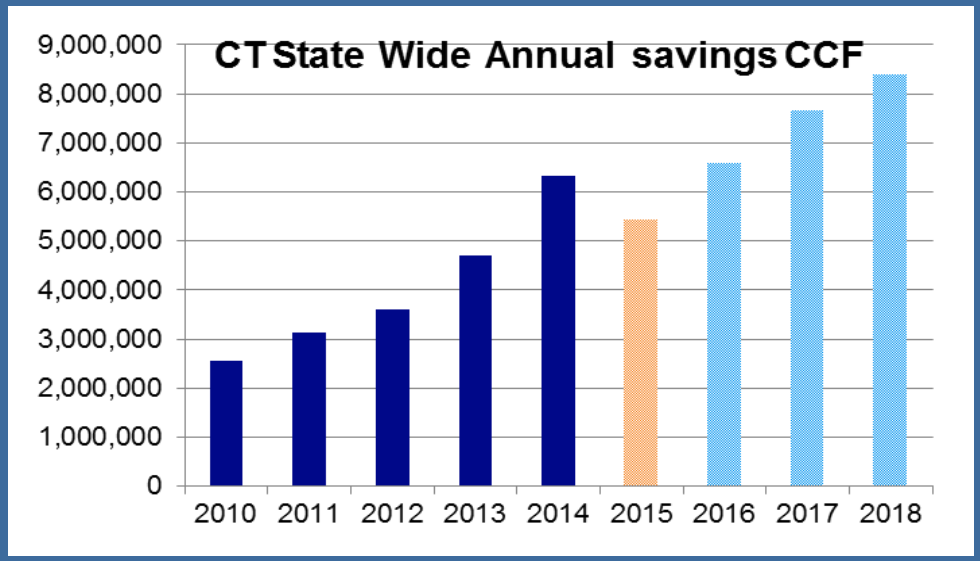


Integrated Resource Plan

The Integrated Resource Plan is a biennial assessment of Connecticut's future electricity needs, and a plan to meet those needs through a mix of generation and energy efficiency.

Energy Savings as an Energy Resource Progress and Targets: 2016-2018



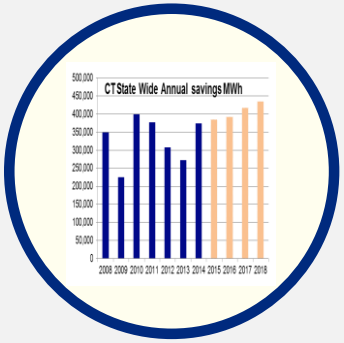


Source: 2016-2018 Conservation and Load Management Plan

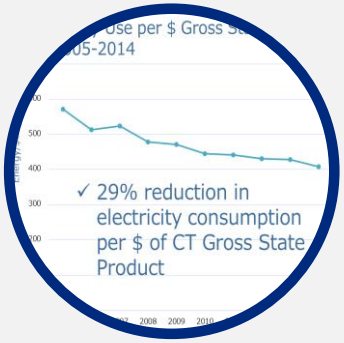
Highlights of 2016-2018 C&LM Plan Targets:

- $700M portfolio for customers
- 129k residential homes weatherized
- 9.7 M residential products distributed
- All 169 communities actively engaged
- 28k businesses more efficient
- Energy as a resource: Energy savings equivalent to the output of a 262 MW power plant

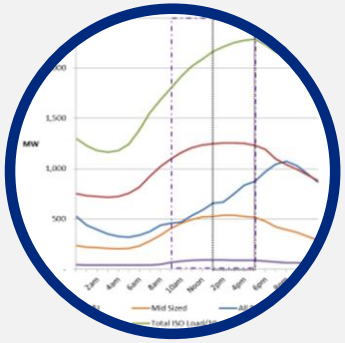
Key Strategies for Better Buildings



Prioritize energy savings as a financing resource and as an energy resource



Improve energy performance of existing buildings; Increase productivity of processes



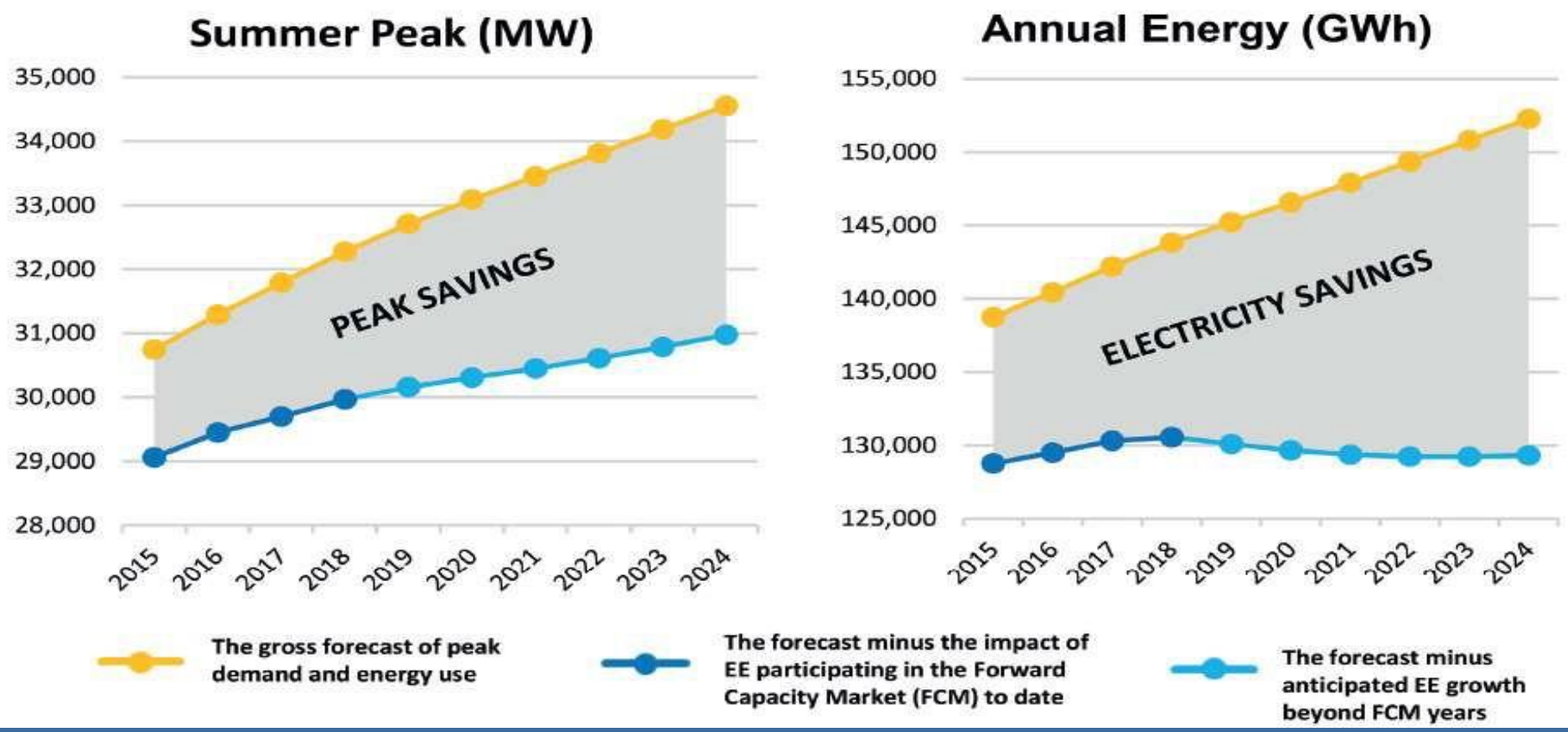
Integrate efficiency, storage, rates, and renewables to reduce peak demand

Ensure interoperability of demand response communications between grid and buildings

Energy Planning Priorities

- ✓ Advance tailored energy efficiency and demand reduction solutions to achieve cost savings for all
- ✓ Continue to drive down energy supply costs
- ✓ Support grid modernization initiatives
- ✓ Continue focus on resiliency initiatives including microgrids and energy security
- ✓ Continue progress towards 2020 greenhouse gas reduction goal (GHG) to provide a foundation for achieving transformational 2050 GHG reduction goal.

Check Demand Growth & Reduce Peak



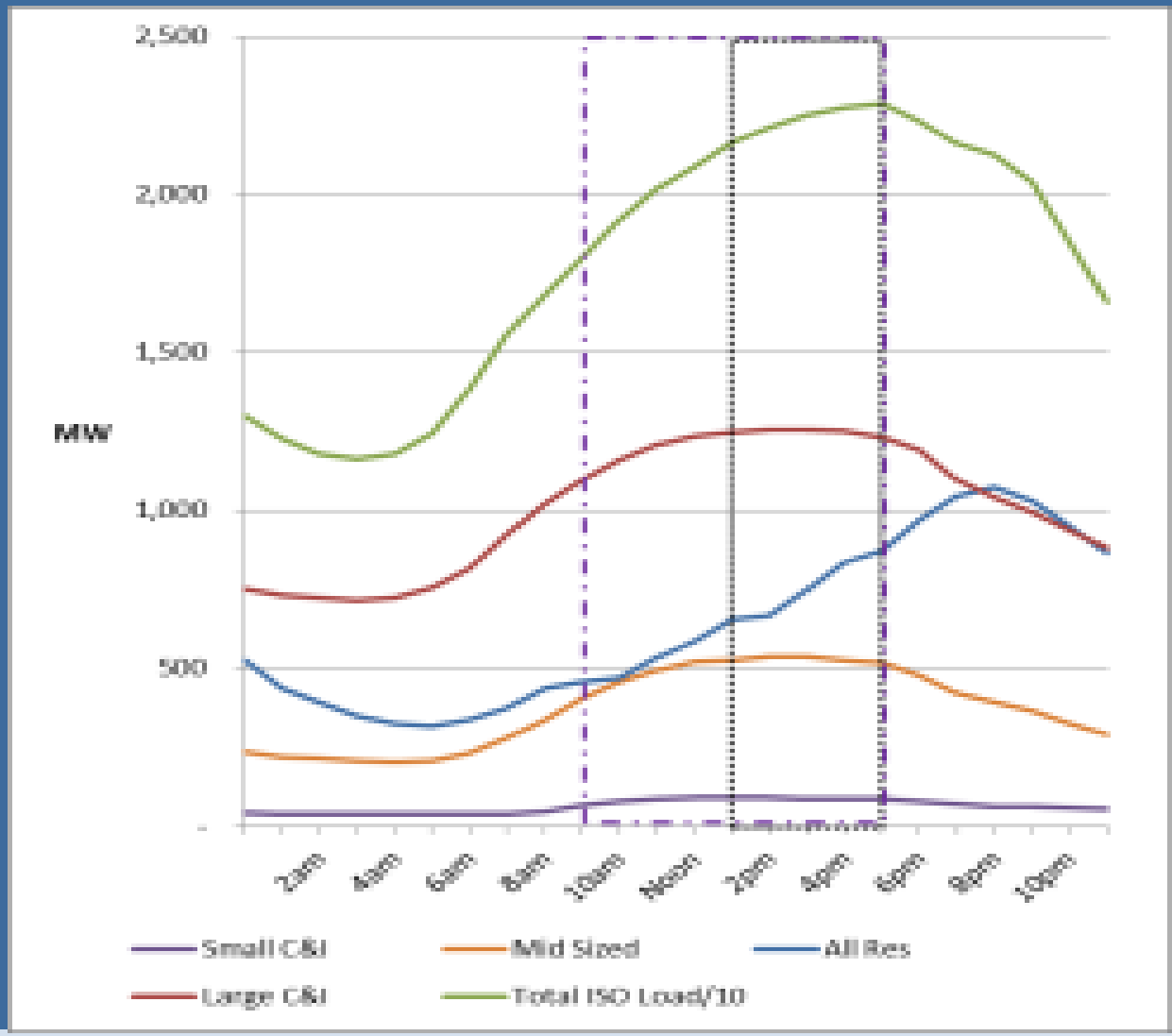
Source: ISO-NE RSP 15 Final ISO New England Energy-Efficiency Forecast 2020-2025 (May 2016)

ISO-NE: Investment in energy efficiency will decrease overall load growth, but peak demand continues to grow, spreading costs over fewer units.

Managing Peak Demand is Key

Managing peak demand means customizing solutions for different customer classes. Why?

Because solutions require understanding varied energy profiles at the ISO level, distribution level, and customer level.



Source: Eversource

Advanced Controls and Two-Way Communications

- Empowering individuals and businesses to recognize the opportunity and receive value of demand response, distributed generation, and energy storage

<u>Benefits:</u>

- Reduces capacity needs
- Reduces transmission & distribution investments
- Contributes to a more resilient electrical grid

M&V 2.0 Research Objectives

- Gain experience with advanced data collection and analytic tools while developing automated M&V software protocols.
- Test the use of advanced data analytics and collection tools (M&V 2.0), and compare to traditional EM&V practice in terms of savings certainty, timeframe, and other aspects;
- Assess how M&V 2.0 tools are best integrated or coordinated with supplemental evaluation and analysis (more broadly referred to as 'EM&V 2.0);
- Support efforts to build transparency of EM&V methods used by states, through the use of standardized EM&V methods reporting forms;
- Inform and coordinate EM&V 2.0 learning and pilot results with other Regional EE Organizations and national efforts (e.g., US DOE Uniform Methods Projects).

Potential Key Outcomes

- Demonstrated extent to which M&V 2.0 can help to improve and streamline EM&V practices
- Increased understanding and use of M&V 2.0 based on the CT M&V 2.0 pilot results, and from other developments and information gathered and disseminated by NEEP States and other key stakeholders in the region (e.g., utilities, evaluators, system planners)
- Standardized protocols for automated M&V software tools are developed at the national level, informed by experience in region and with input from regional stakeholders through a facilitated regional process.

TEAM

- CT DEEP (Applicant)
- NEEP
- LBNL
- Eversource-CT and United Illuminating/AvanGrid
- US DOE

Home Envelope Pre-audits with Smart Thermostats

Ethan Goldman
NEEP M&V Forum
2017 Spring Meeting

Vermont Energy Investment Corporation

What is Smart Thermostat Data Good For?

- Set points
- Setback schedule
- Duty cycle
- Envelope performance!

Timeline

- 2012: Efficiency Vermont R&D project (schwoops)
- 2013: AESP National Meeting paper & presentation
- 2014: Launched Nest pilot (600 homes)
- 2014: Smart tstat data standard (with EPRI & Eversource)
- 2016: Energy Star connected thermostats metric
- 2016: DOE research paper – uses for smart tstat data
- 2016: Complete Nest pilot, data collection
- **2016: Smart Thermostat Analytics Toolkit (STAT)**
- 2016: USPTO awards patent for schwoop algorithm

STAT Home Performance Reports

- Smart Thermostat Analytics Toolkit
  1. Pre-audits from indoor temp. trends
  2. From cheap temperature loggers, or
  3. Smart thermostats provide continuous data

Analysis Flow

Raw data
(csv, xls)

Data parsing
and
Data cleaning

Data store

Cleaning
report

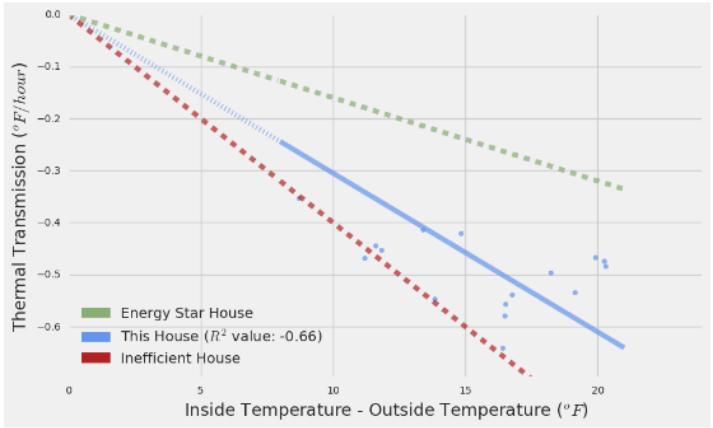
Report
generation
script

```
from src.metrics import pipeline
                        Pipeline
# ------------------------------------------------------------------------
# --- Pipeline Functions
@pipeline.result_numeric('DeltaTemperatureTimeseries')
def delta_temperature(device):
    results = pipeline.make_results()
    results.add_value_result('DeltaTemperatureTimeseries', None)
    return results
           Input objects
@pipeline.result_numeric('AvgDeltaTemperature', depends_on=['DeltaTemperatureTimeseries'])
@pipeline.result_numeric('StdDeltaTemperature', depends_on=['DeltaTemperatureTimeseries'])
def delta_temperature_statistics(device):
    results = pipeline.make_results()
    results.add_value_result('AvgDeltaTemperature', None)
    results.add_value_result('StdDeltaTemperature', None)
    return results
```

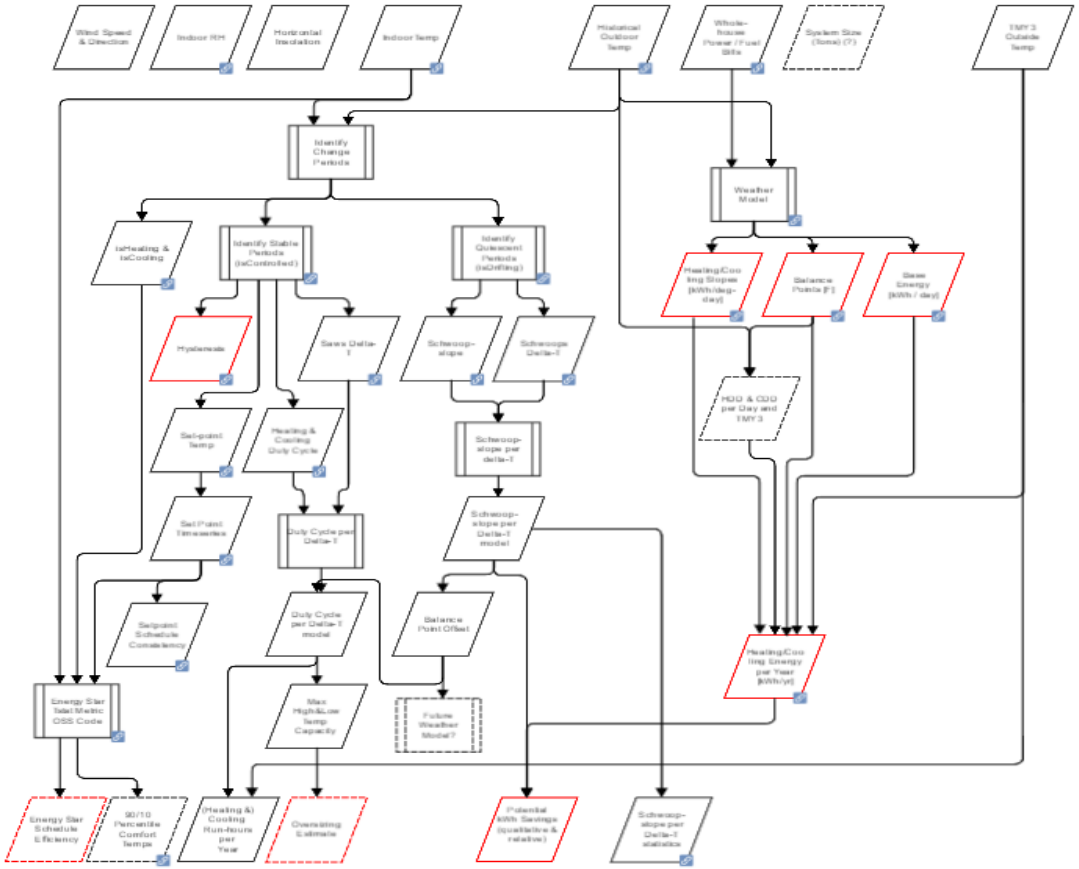
Result Declarations

Dependencies

Result Values



Iterative Analysis



Group-level Report

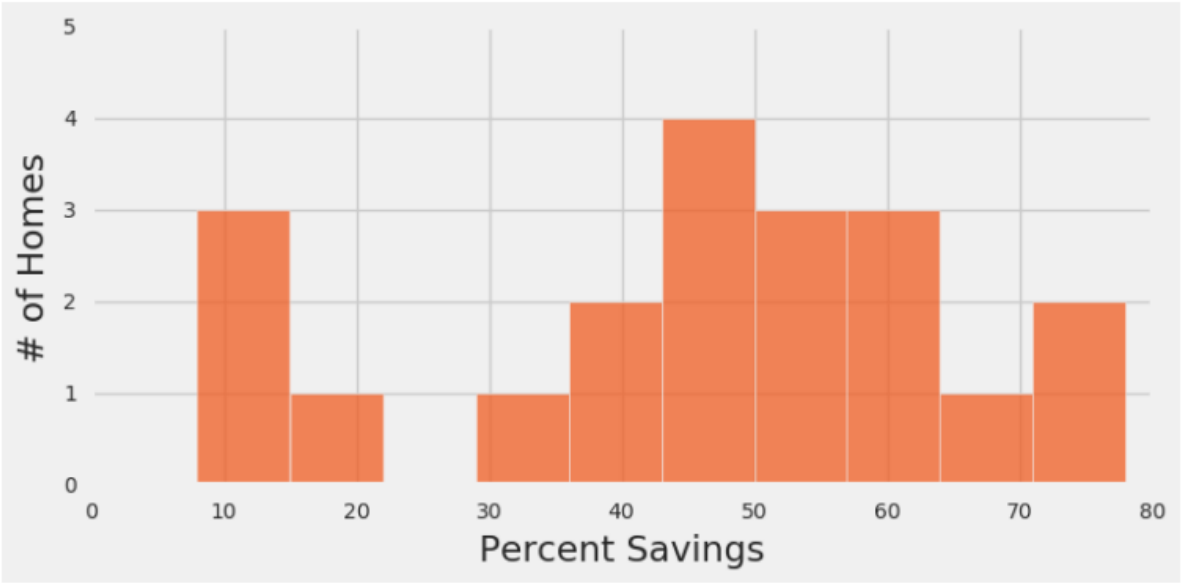
Introduction

Home envelope performance reports are generated using data from indoor temperature loggers and smart meters. By comparing energy use and rates of temperature change to local weather data, the annual heating and cooling costs and savings potential are estimated. These estimates rely on measurements of how the building performs under different conditions, and some data sets may not capture the full range of building performance; in these cases the estimates will be less reliable and will be noted as such. Savings estimates assume that the building is improved to a modeled benchmark, and actual savings will depend on the level of improvement to the envelope.

Data Snapshot

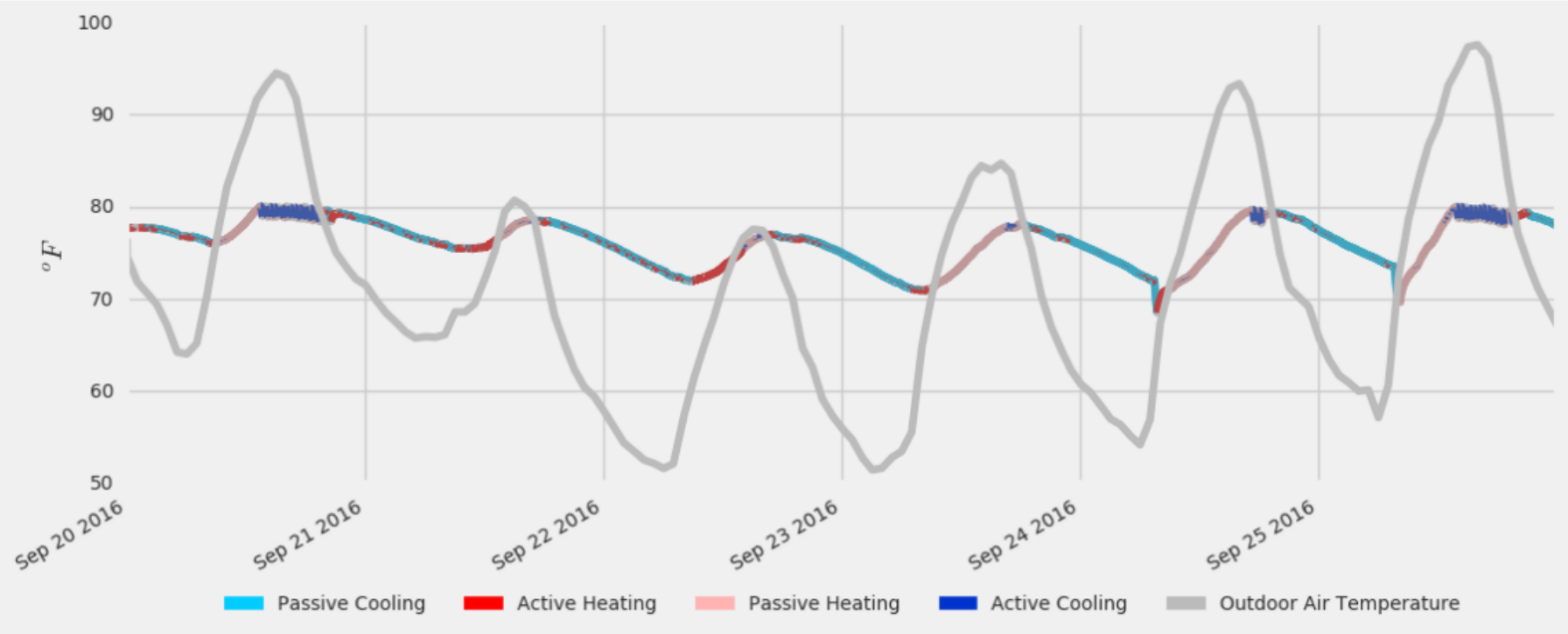
- group contains 20 homes
- data was found for 100 devices
  - 20 devices of type IntervalPowerMeter
  - 80 devices of type TempLogger

Distribution of Estimated Percent Savings



Temperature Trends

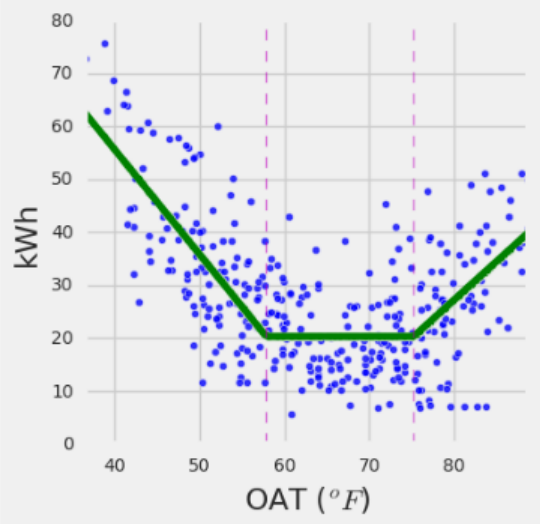
A sample week of indoor and outdoor temperature illustrates the typical thermal response for this house. The analysis is most reliable when outside weather is consistently warmer or colder than indoor temperature, and both periods of stable control (caused by active heating or cooling) and long periods of passive temperature drift are observed.

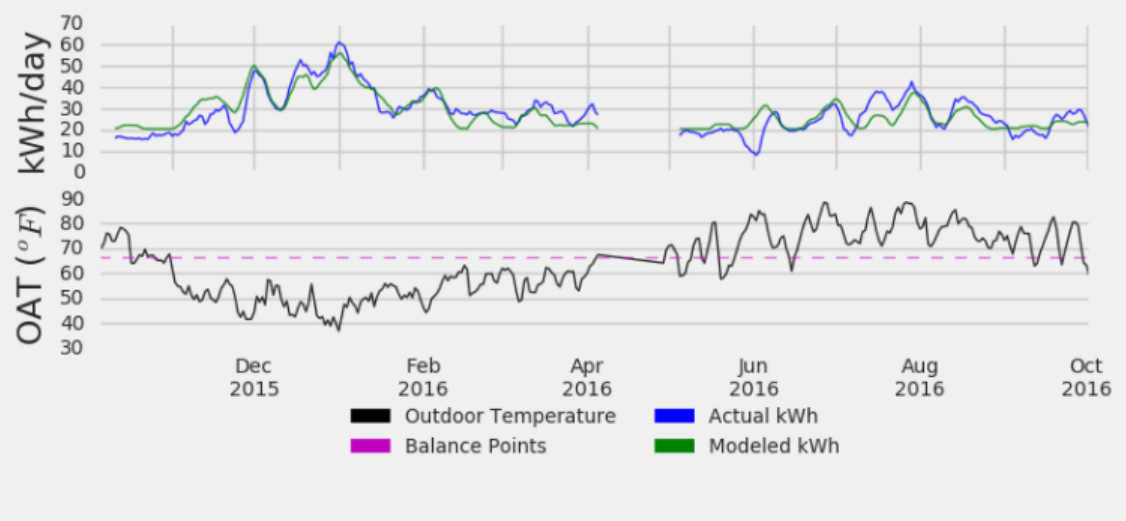


AMI Weather Modeling

Heating and Cooling Energy Model

Heating and cooling components of electricity consumption are derived from the relationship between daily average outdoor temperature and kWh; if actual energy measurements are tightly clustered around the modeled values, that indicates a more reliable model.





Applications

Assess potential Home Performance projects

Verify completed Home Performance projects

Home labeling

Pay-for-performance

Customer engagement

DIY weatherization

EM&V 2.0

An Evaluator's Perspective

NEEP EM&V Forum

April 27, 2017

Opinion **Dynamics**

M&V 2.0 vs. EM&V

- There is no consistent definition of M&V 2.0
- However, there are key differences between M&V 2.0 and EM&V

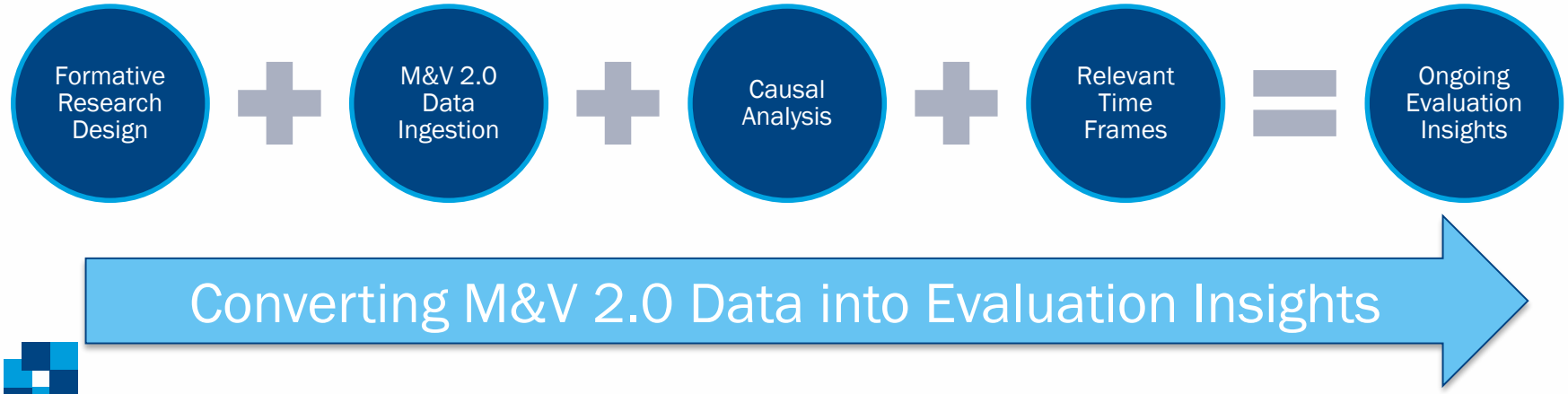
Features	M&V 2.0	EM&V
Goal	Monitor and characterize energy use to quantify savings and/or identify O&M and other strategies to optimize energy consumption	Quantify energy savings that are attributable to program interventions and generalizable to a broader population of participants
Unit	End-use or whole building level	Aggregate or program level
Data	AMI Meter + Smart Device	AMI Meter + Smart Device + Survey + Market
Approach	Assess **gross** changes in energy use prior to, during and after project implementation	Assess **net** changes in energy use attributable solely to program activity
Validity	Internal	External
Timeframe	Real-Time	Over-Time

Moving from EM&V to EM&V 2.0: Is Enhanced M&V the Holy Grail or Another Tool in the Evaluator's Toolbox?

- Analysis of energy consumption and metering data has been in the EM&V tool kit for years – one of many approaches
- Choice of approach is determined by several factors
  - Some programs are better suited to this approach than others
  - Baseline: Standard efficiency vs. existing conditions
- To apply M&V 2.0 we must have confidence in our ability to find the 'signal in the noise' by isolating other meter-level changes
- M&V 2.0 data streams enhance an evaluator's back-office:
  - Automaticity
  - Predictive analytics
  - Data presentment

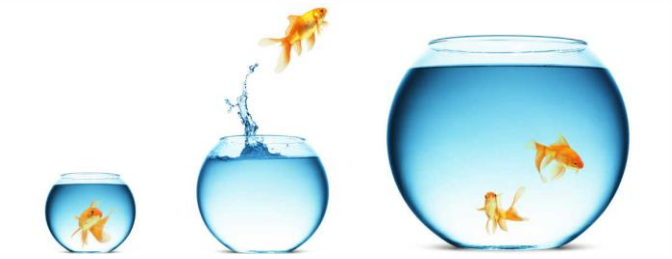
How Can We Increase the Value of M&V 2.0 to Evaluation?

- Developers of M&V 2.0 tools can consider how to support evaluation objectives
- How can we leverage these tools to establish relationship between energy use and other parameters (e.g., attribution)?
  - Thoughtful research design
  - Skilled causal analysis
  - M&V 2.0 data ingestion and frequency



New Approaches Bring New Practical and Policy Challenges

- Implementation and policy framework is still nascent, and may support or stall adoption
  - What policy changes are needed to embrace real-time dynamic flow of information regarding program performance?
  - Do we want to estimate what comes off the grid? Or, do we want to reconcile what was planned?
  - What are we trying to measure? And what risks are we trying to mitigate?
  - How can we facilitate data access and frequency for faster results?



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