SPOTLIGHT ON VERMONT: MEETING STATE AND INDUSTRY NEEDS

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Utility Perspectives in Load Management and M&V

November 7, 2018

Jeff Monder
Green Mountain Power
To reduce GMP’s peak to a target level, tools need to handle the peak day(s)

- Deeper reductions require more frequent and longer utilization of storage/DER tools

- The requirements accelerate above roughly 50 MW >> requires new revenues/values to offset

- Some longer-duration resources will be needed
Other Value Streams

BUY LOW/SELL HIGH

Stored energy can be dispatched to take advantage of fluctuations in market costs, with clean, low-cost, renewable energy. This delivers value for all GMP customers.
GMP LOAD MANAGEMENT STRATEGY

- Utilize storage and controllable loads to redesign grid management in order to save Vermonters 10’s of millions of dollars in the coming decades
- Take GMP VT peak from 730 MW’s to no more than 600 MW’s year round
- Crush and flatten the peak to lower costs for customers
- Integrate distributed, intermittent generation resources
- Drastically improve the operational efficiency of the grid
TOU ALTERNATIVE - VOLUNTARY CURTAILMENT

Customers on commercial time-of-use rates can opt into a Curtailment Load Rider

GMP ‘shoots for peak’ several times every month
Customers agree to shed a % of load during events
Can save on peak demand charges, while tying demand to called peak
M&V is at the AMI meter
DEFERRED LOAD

- Direct management of customer-owned resources, like EV chargers, water heaters, and heat pumps during peak events
- M&V comes from DRMS, the charger, and the AMI meter
August 29, 2018 – All PowerWalls and Panton Battery (4MW Total)

Combined Value of RNS and FCM
As much as ~$200k / year / MW
HIDDEN RESOURCES

- What about controllable resources that could support DR, but don’t have a tariff that allows for operation?
  - Refrigeration
  - Air and water cooling and heating
  - Industrial processes
  - Multiple fuel sources

- Opportunities for Innovative Pilots
Flexible Load Management Pilot

- Demonstrate distributed, flexible load management for controllable assets that can ride through curtailments
- Create downward pressure on cost of service for all customers, while sharing value with customers hosting solutions
- Establish measurement and verification that feeds upstream operations and accounting systems
- Demonstrate security and integrity of all systems
- Work towards automation
- Work towards more granular, circuit-level action between controllable assets and local generation in the broader context of the regional grid
FLEXIBLE LOAD MANAGEMENT PILOT

Brattleboro Retreat Ice Storage Performance - July 5, 2018

Chiller System Performance on Peak Day
- Actual vs Model
- Baseline Performance Estimate from DO Model

- DO Modelled Chiller Performance (excluding pump load)
- Actual Metered Data of Chiller Performance (excluding pump load)

Retreat Chiller
Estimated Max Peak Hourly kW Demand
2018 FCM Peak Hour
July 5th Hour Ending 1800

120 kW

- Actual Max Pump Demand Peak Hour = 4.98 kW
- Actual Max A/C System Total Peak Hour = 6.12 kW
THANK YOU!
Building the Infrastructure and Skill Sets to put Advanced M&V into action!

November, 2018

Pierre van der Merwe
VEIC

- Mission-driven nonprofit
- Over 30 years reducing economic, environmental costs of energy
- Energy efficiency, renewable energy & transportation
- Consulting & implementation
- 3 energy efficiency utilities

Displacing 9,000,000 MT CO2e annually
Major Initiatives
Efficiency Vermont

- Founded in 2000
- Statewide energy efficiency utility
- Administered by VEIC, under appointment of Public Utility Commission
- Three-year performance cycle
Advanced Meter Infrastructure in Vermont

• 2009 ARRA Grant
• 17 utilities – five with AMI
• Over 300,000 meters
• Efficiency Vermont Data Infrastructure
  • Monthly data from all utilities
  • AMI data from Green Mountain Power
  • Supports data analytics tools and customer facing services

From 12 data point per home per year to 35040!
Its not just AMI data
It's not just AMI data… or any data.
VEIC Data Analytics

• Formed energy analytics support group in 2015
• Specialized expertise in data science, data visualization, software development, and automation
• Python and R
• Data-driven insights
  • Accurate
  • Repeatable
  • Scalable

“Squiggle Analysis”
AMI Analytics

AMI Explorer
Viper Peak Analysis Tool
Bullseye Portfolio Level Analytics & Filtering
AMI Exporter “Folder 8”
Standard Weather Modeling Algorithms
Submetering Platform

Meter Plan
Document Projects

Data Warehouse
Acquire, Organize & Store Data

Analytics Tools
Calculate Performance
Device Data – Smart Thermostats

Automated Analytics

Reports
Tables
Web

STAT - Smart Thermostat Analytics Toolkit
Device Data – Smart Thermostats

How it works

• “SCHWOOP” analysis correlating outside air temp against how often the home is heating or cooling

• Provides targeting opportunities for insulation, heating, and cooling
Device Data – Smart Thermostats

### Annual Savings Potential

Estimated savings potential is based on the weather-modeled heating and cooling energy use as well as the percent savings calculated from the thermal transmission rate.

#### Current

- **Total:** 9,476 kWh
- **Current Modeled Use:** $286
- **Estimated Savings:** $112

#### With Savings

- **Total Savings:** 60%

### Relative Envelope Performance

Compared to other homes in this group, there is minimal savings potential by improving this house’s envelope.

### Thermal Transmission Benchmarks

Each point represents a period of passive temperature drift. The rate of temperature change is plotted against the indoor-outdoor delta T at that time. The linear regression model for this house is compared to benchmarks.
Vermont Duck Curve

AMI Data
+ Program Tracking Data
  • EE impacts on loadshape
  • Seven individual measures tested
    • Cold-climate Heat Pump
    • Efficient Refrigerator
    • Efficient Freezer Early Replacements
    • LED Lighting
    • Efficient Clothes-Dryer
    • Efficient Clothes-Washer
    • Heat Pump Hot Water Heater
Common Themes & Challenges

• Access – privacy and availability
• Quality – errors, formatting, definitions
• Scalable – standardized methods
• Skillset – data science and software
• Value – new & improved programs, process efficiency
• Evaluation – coordination needed with existing evaluation processes and intended policy outcomes
• Traditional M&V is Summative and needs to shift to a Formative approach leveraging data in a dynamic real-time approach
Doing things differently!

### ANALYTICS-ENABLED EFFICIENCY

<table>
<thead>
<tr>
<th>EFFICIENCY PAST</th>
<th>EFFICIENCY PRESENT/FUTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Limited customer/building targeting</td>
<td>• Data-driven, segmented opportunity targeting</td>
</tr>
<tr>
<td>• Time-intensive, costly on-site</td>
<td>• Remote assessments at low cost/time</td>
</tr>
<tr>
<td>assessments</td>
<td></td>
</tr>
<tr>
<td>• Emphasis of capital-intensive</td>
<td>• Equal focus on retrofits and operational</td>
</tr>
<tr>
<td>retrofits</td>
<td></td>
</tr>
<tr>
<td>• Measure-by-Measure action</td>
<td>• Holistic, “whole building driven” EE</td>
</tr>
<tr>
<td>• Savings persistence unclear</td>
<td>• Savings persistence ensured</td>
</tr>
</tbody>
</table>

*Credit: Dian Grueneich*
“Insights using just your own data are just that, “insights”.
They fail to put your operations, your situation, or your future into the global context where it belongs. Even more valuable are “outsights” - Microscopes are great for diagnosing, but telescopes provide the ability to anticipate and plan”

Douglas B. Laney
Gartner, Inc
Thanks!

Pierre van der Merwe
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Director, Data and Technology
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Advanced M&V Methods to Drive Real-time Customer Feedback

Jeffrey Hullstrung, PE
Sandra LaFlamme, PE
Topics

- Vermont AMI & What VEIC Has Done
- Monthly Data Limitations
- 5 Schools Case Study Summary
- Our New Approach
- Resources We Use
- Customer Benefits
- Sample Output with Charts
Advanced Meter Infrastructure (AMI)

- In Vermont, > 80%
- >300,000 total installed
- 15-minute or 60-minute data intervals available

VEIC: Tools to Leverage High Frequency Data
Limitations with Monthly Electricity Data

Monthly energy models typically find savings only when they are greater than 10%
More Than a Month to See Possible Increase in Energy Use

6% savings at end of project

Energy use increases during summer so savings disappear until the fall
Other Ways to Obtain Data, But…

Vermont market for existing commercial buildings

- Vermont Buildings with Whole-Building Control Systems: 30%
- Vermont Buildings with Wireless Controls: 1%
- Vermont Buildings without Whole-Building Control Systems: 69%
High Frequency Data is a Game Changer!
## 5 Schools in Mt. Mansfield Modified Union School District

<table>
<thead>
<tr>
<th></th>
<th>Brown’s River Middle School</th>
<th>Camel’s Hump Middle School</th>
<th>Richmond Elementary School</th>
<th>Jericho Elementary School</th>
<th>Smilie Memorial School</th>
</tr>
</thead>
<tbody>
<tr>
<td>School floor area (sf)</td>
<td>88,760</td>
<td>88,760</td>
<td>40,800</td>
<td>49,500</td>
<td>17,400</td>
</tr>
<tr>
<td>Electricity savings (kWh /y)</td>
<td>30,000</td>
<td>15,650</td>
<td>33,680</td>
<td>10,800</td>
<td>12,580</td>
</tr>
<tr>
<td>Savings as percent of total site electricity</td>
<td>7.0%</td>
<td>5.2%</td>
<td>12.1%</td>
<td>5.3%</td>
<td>13.6%</td>
</tr>
<tr>
<td>RCx cost</td>
<td>$7,125</td>
<td>$0</td>
<td>$0</td>
<td>$3,207</td>
<td>$5,078</td>
</tr>
<tr>
<td>Annual savings</td>
<td>$4,400</td>
<td>$2,300</td>
<td>$3,000</td>
<td>$1,600</td>
<td>$1,800</td>
</tr>
<tr>
<td>Simple payback (years)</td>
<td>1.6</td>
<td>0</td>
<td>0</td>
<td>2.0</td>
<td>2.8</td>
</tr>
<tr>
<td>Average savings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.6%</td>
</tr>
</tbody>
</table>

Information used with permission from Jeff Forward, Facilities Coordinator and Project Manager for Mt. Mansfield Modified Union School District. Project team also included Cx Associates and Temperature Controls of Vermont.
All We Needed Was Already out There

- LBNL weather modeling guidance
- OpenEEMeter open source code
- Bonneville Power Administration model validation guidance
- ASHRAE Guideline 14-2014 *Measurement of Energy, Demand, and Water Savings*
Higher resolution

- Small savings can be identified
  - As low as 2% of total usage
  - Scales down to cover small projects

- Higher confidence in large savings
  - Reduces uncertainty
Customer Benefits

• Provide faster feedback
  • Monthly data takes 6+ months
  • ENERGY STAR® Portfolio Manager takes 12 months

• Contractors & customers can celebrate or troubleshoot quickly

• Become an engagement tool

• Provide motivation for future projects

• Save customer time through less data requests & on-site visits
Pre-Screening Tool

• Informs Pay for Performance (P4P) projects by eliminating surprises

• Provides an opportunity to address data challenges early
Streamlining the Process Saves Validation Costs

- Excel and Python-based solutions
  - No need to deploy submeters
  - No need to request building automation system data
Actual and Modeled Power: 96-period moving average

Model development (baseline)
Actual and Modeled Power: 96-period moving average

Number points total: 35,024
Number points used: 35,021
Start: 2016-01-01
End: 2016-12-31
Days: 365
R-squared: 85.0%
CV-RMSE: 21.4%
Average power (kW): 10.2
Actual Power, Modeled Power and Savings: 96-period moving average

Post-treatment savings evaluation
Estimated energy savings
Start: 2017-08-15
End: 2018-07-08
Days elapsed: 327
Days of data: 326
Number points: 31,330
Annualized predicted usage (kWh) : 92,500
Annualized savings (kWh) : 12,600 +/- 400
Percent savings: 13.6% +/- 0.4%
Thank you

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Towards a 21st Century Efficiency Program Toolkit

Dan Fredman, PhD
• Context
• Our Story
• Lessons Learned
• Going Forward
Context
And yet …

… according to a recent (2017) survey by Gartner, Inc. of nearly 10,000 online respondents … during the second half of 2016 … only about 10% of households currently have connected home solutions.
A Typical Program Lifecycle?

- Design
- Implement
- Evaluate
- Measure & Verify
Measuring Changes in Energy Behavior

Control Group

Energy Cultures before

Have
Think
Do

Energy Cultures after

Have
Think
Do

Natural Changes

User Experience Technology Interaction

Intervention

Treatment Group

Energy Cultures before

Have
Think
Do

Energy Cultures after

Have
Think
Do

IEA-DSM Task 24 & Karlin et al. (2015)
Our story
The Challenge  (w/ remaining 2014-17 Behavior R&D funds)

Develop behavior programs that …

• Won’t rely on HERs (neighbor comparisons)
• Will account for:
  • “Program uplift”
  • “Non-routine events”
  • ‘Outlier’ disruptors of consumption, e.g. Solar or HPWHs
• Maintain satisfactory customer experience
• Deliver savings via satisfactory M&V methods
Our approach: ARIES

Advanced
Residential
Integrated
Energy
Study → Services
ARIES pilot overview

**Driving Factors**
1. Customer satisfaction
2. Rich data collection
3. Rapid deployment (free)
4. Maximize Effect
5. Maximize Measurability
6. Ongoing Assessment

**Tools & Resources**
- Aligned Vendor/Partner
- AMI Billing Data
- Contractor Network
- Survey & Data & Program Team

(Convenience Sample)
- Recruitment
- Installation
- E-mails & Surveys
- Ongoing Analysis
- Savings Assessment

3 cohorts
N ~ 400
How it works
(In practice)

1. Participant Intake Form
2. Utility Data (Monthly / AMI)
3. Contractor Match + Installation
4. High-Resolution Home Energy Monitor Data
5. Email Campaigns + Surveys
6. Implementation Feedback, Eval + Adaptation
Finding a new way?

Method: Off-the-shelf “virtual sub-metering” product

- In-panel hardware + App + ‘cloud’
- Measure mains current and voltage
- Very high frequency sensing (Mhz)
- Pattern recognition, device detection
- ‘Edge’ Computing + Human-aided ML
Lessons Learned (so far)
**Energy-saving changes at home since monitor installation**

- **None**: 63
- **Small**: 90
- **Major**: 6
- **Both**: 9

### Small Changes
- Open text response → NLP
- Could be anything: e.g. “Behavior”
- Focus of communications

### Major Changes
- Structured responses (checkbox)
- Weatherization, solar, EV, heat pump, etc.
- Drives non-routine event (NRE) handling in savings assessments
VERY Early Savings Estimates?

- “M&V 2.0”
- Segmenting on ‘anomalies’ revealing
- Passes “is something here” pilot test
Learning in context

• Different service areas: Different priorities
  • Peak-related demand response
  • Concerns about DER expansion
  • Technology reliability & non-AMI solutions

• Same pattern, different data streams:
Device Diversity

Example only. Labels have been randomly shifted!
Monitor Uptime
Monitor Uptime
Grid Impacts?

- Demand response
- Rate guidance
- Pay-for-performance
- Custom messaging
- Anomalous loads
Going Forward
Some (New?) Obstacles

• Data source diversity (+ management)
• Complex programs + time spent recreating:
  • Program designs
  • Implementation approach
  • Analyses and Evaluation
• Interpretation of data feeds
  • Accuracy + Validation
• Fast turnaround time required
If you learn something today:

1. Changing EE needs + new technologies require new ways to create and ID savings

2. Implementers need new tools to get this done → there’s something here (and needs more work)

3. Innovative programs need a coordinated, open science initiative → You should contribute!
Thank you!

Dan Fredman
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vtd_f
Regulatory Perspective EM&V 2.0

November 7, 2018
Burlington, VT
EM&V 1.0

- **EM&V 1.0 +**
  - Well defined best practices and methodologies
  - High levels of confidence in its results
  - Deemed Savings
  - Accepted and understood by Regulators

- **EM&V 1.0 –**
  - Time-consuming
  - Expensive
  - Additional equipment required
  - Potentially disruptive to the participant
  - Not particularly responsive to program needs
EM&V 2.0

- More accurate deemed savings values
- Lower cost of EM&V
- Real-time energy performance of new equipment
- Ability to evaluate measures and programs within a shorter time period
- More uniform methods of determining energy savings in certain areas
- Help to understand measure persistence.
But…. 
Data Sources

- Large-scale Data Analysis
- Interval Meter Data
- Nonintrusive Load Monitoring
- Embedded Sensors in Equipment
Context Matters
What the Regulator Needs

- Education on what EM&V 2.0 is and how it works.
- Best practice guidelines for these tools
- Empirical evidence that results from EM&V 2.0 are statistically similar to those from EM&V 1.0
Convince Me

I WANT TO BELIEVE