

Compared to What?

The Continuing Challenges and
Developing Opportunities for
Quantifying Efficiency

Steve Kromer

May 24, 2017

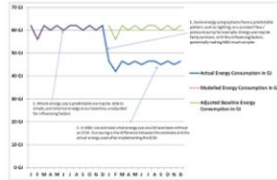


Compared to What? The Continuing Challenges and Developing Opportunities for Quantifying Efficiency

Steve Kromer, Principal, SKEE

- Standard tools and techniques for quantifying the results of energy efficiency and energy performance projects have been available for 20+ years.
- But new sources of data and better modeling tools are disrupting how practitioners perform "M&V".
- This talk will cover some of the recent developments in metering and modeling that promise to turn this art into a science.

Google Search for M&V (Images)

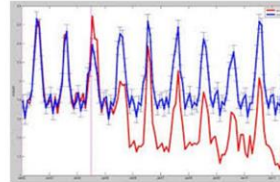
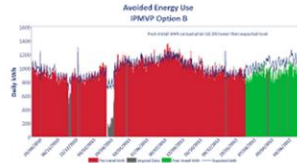


- Simplified VO M&V Protocols**
Approved May 4th, 2010
1. Simplified VO M&V Protocol can be applied to distribution systems with Residential and Small Commercial Loads to verify energy savings from reduced voltage operation.
 2. Protocol reduces use of historical data, system modeling, 5-day M&V 'on' and 7-day 'off' hourly measurements, and "Thermal" end-use VO Factors determined from NEA DEJ Study 2007 results.
 3. Protocol can be used with three Voltage Regulation Techniques: VTR, LDC, and AVTC.



ENERGY LEADER WEBINAR SERIES
The ABCs of M&V

Steve Helmer, P.E., CEM
Founder & CEO
EnergyCAP, Inc.



The WegoWise
Measurement and
Verification Report
In Pictures

By: Kelly Knoeland

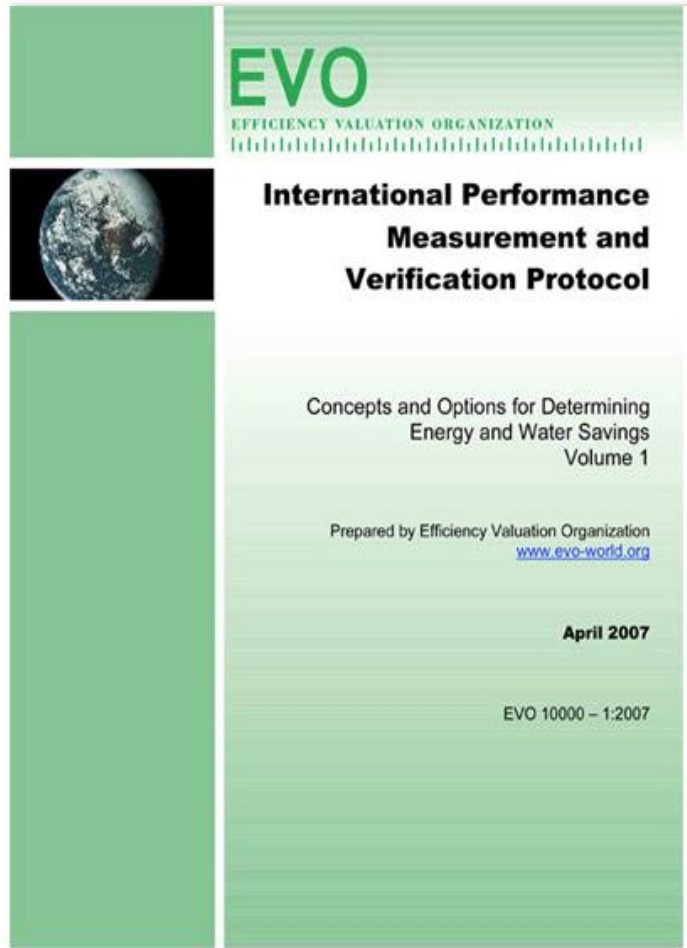


Part of the

Disruptions Driving Energy Management and M&V – a brief history

1. Oil Shock
 - Energy efficiency as a way to reduce overall loads
2. Deregulation Shock
 - Energy efficiency as a resource for offsetting investments in future power plants
 - Efficiency moves to “First in the loading order”
3. Data and Distributed Energy Resources (DERs)
 - Data
 - Proliferation of Sources
 - Analysis, a.k.a. “Big Data”, “M&V 2.0”
 - Distributed Energy Resources/Renewables
 - Where does energy efficiency fit into the new world?





Protocols

- 20+ years of “modern M&V”
 - Result of first Energy Efficiency “shock”
- Compared to What?
 - Control Groups
 - Modeling (AKA counterfactual)
- Most M&V protocols are based on modeling
 - IPMVP, ASHRAE 14, ISO 50016
- California legislature directing efforts back to “measured savings” using “Pay for Performance” programs

California Senate Bill 370 (Draft)

*(g) (1) (A) On or before September 1, 2018, the commission shall authorize electrical corporations or gas corporations to provide financial incentives, rebates, technical assistance, and support to their customers to increase the energy efficiency of industrial and agricultural facilities, systems, and equipment based on reductions in normalized metered energy consumption using a protocol such as the **International Performance Measurement and Verification Protocol (IPMVP)** or a simplified methodology for small-scale projects.*

Link to the current form of the draft bill; reference of IPMVP was removed in subsequent amendments:

https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB370

Compared to What?

#1/3 Compared to “Self” or “Others”?

Two main techniques:

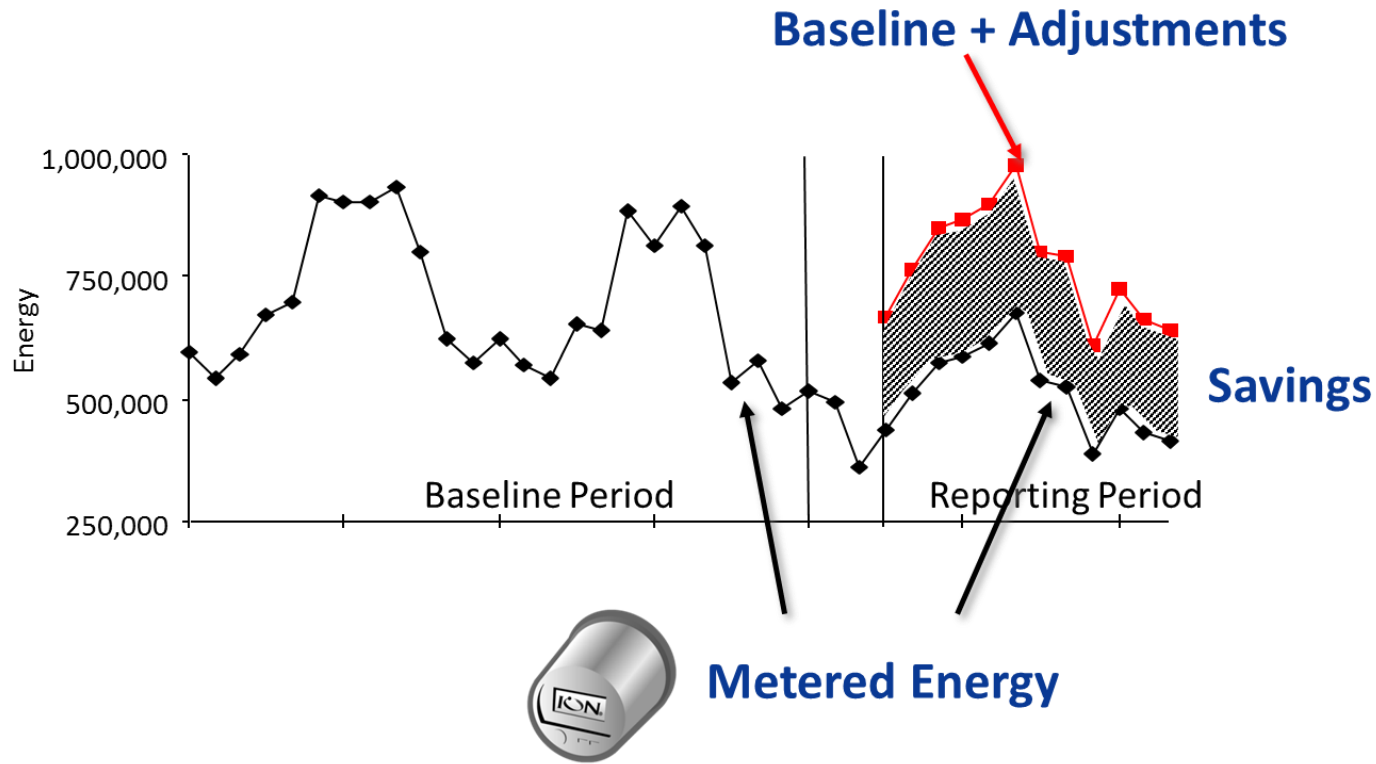
- Modeling – Compared to “Self”
 - Counterfactual
 - a.k.a. Longitudinal Benchmarking
- Control Groups – Compared to “Others”
 - a.k.a Cross-Sectional Benchmarking
 - Used in program evaluation



The terms Cross-sectional and Longitudinal benchmarking are from the Energy Information Handbook published by LBNL/DOE and available at: <http://eis.lbl.gov>

Compared to Self – the Counterfactual argument

“What would have happened without the project?”



Compared to What?

#2/3 Attribution

Compared to Code? Standard Practice?



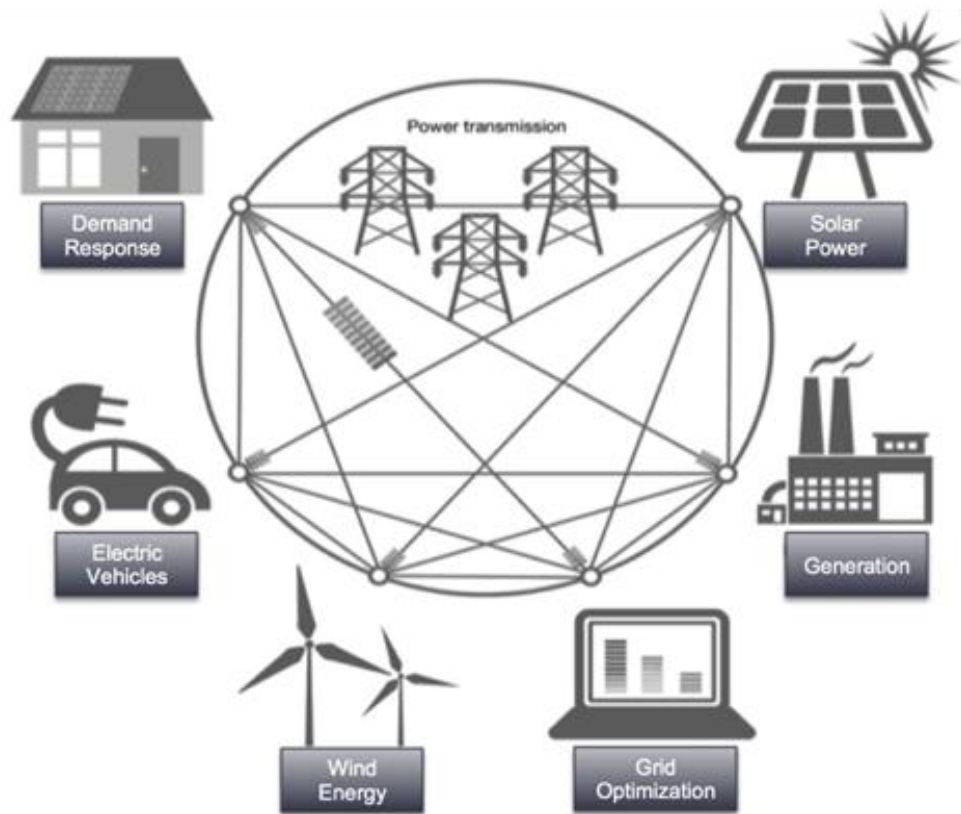
© Can Stock Photo

- Additionally
- Free Riders
- Business as Usual
- Market Transformation

Compared to What?

#3/3 Other energy sources and influences

- Greenhouse gas reduction activities/projects
- Grid -Integrated Resource Planning requirements
- Building on legislation adopted in California:
 - AB 32 – California Global Warming Solutions Act of 2006
 - SB350 - Clean Energy and Pollution Reduction Act of 2015



Disrupter #1 - Data



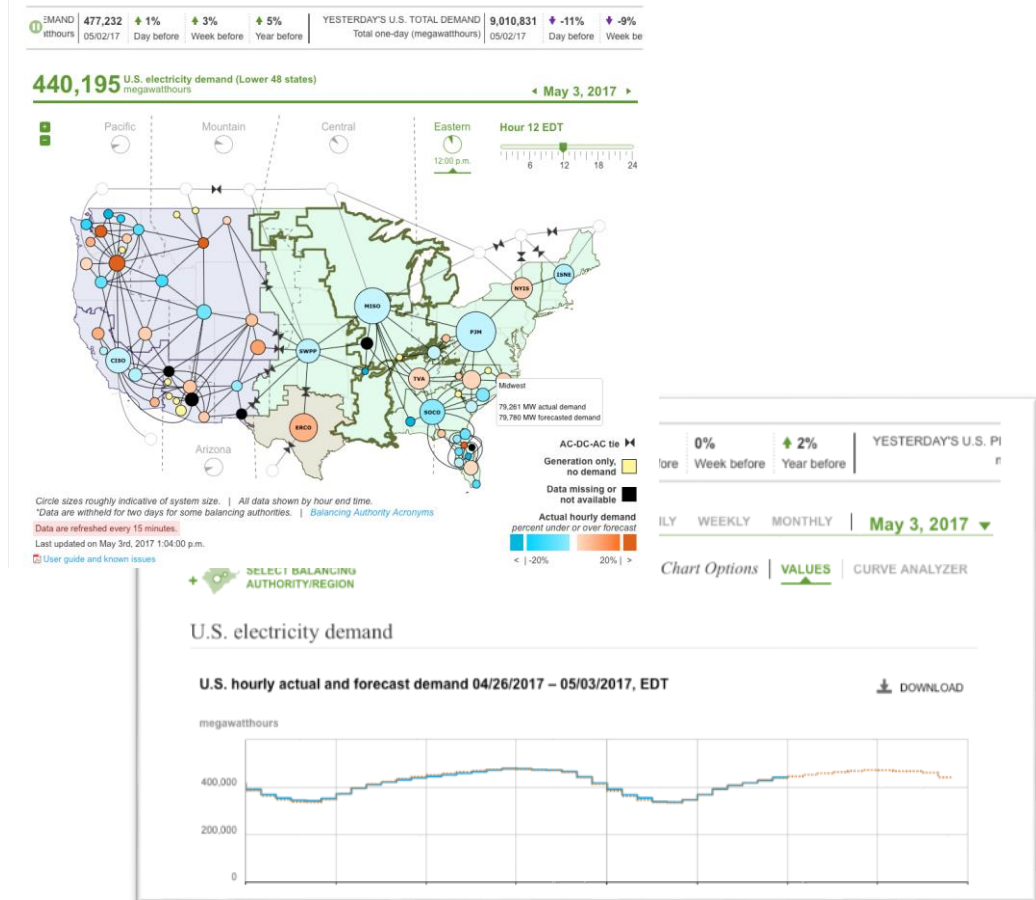
“Let’s shrink Big Data into Small Data ...
and hope it magically becomes Great Data.”

- More data is available at every level
- Demand and energy data at every level
- Geographic data on grid/systems and prices

United States Electricity Demand

- National Level Planning and Reporting
- Not for management

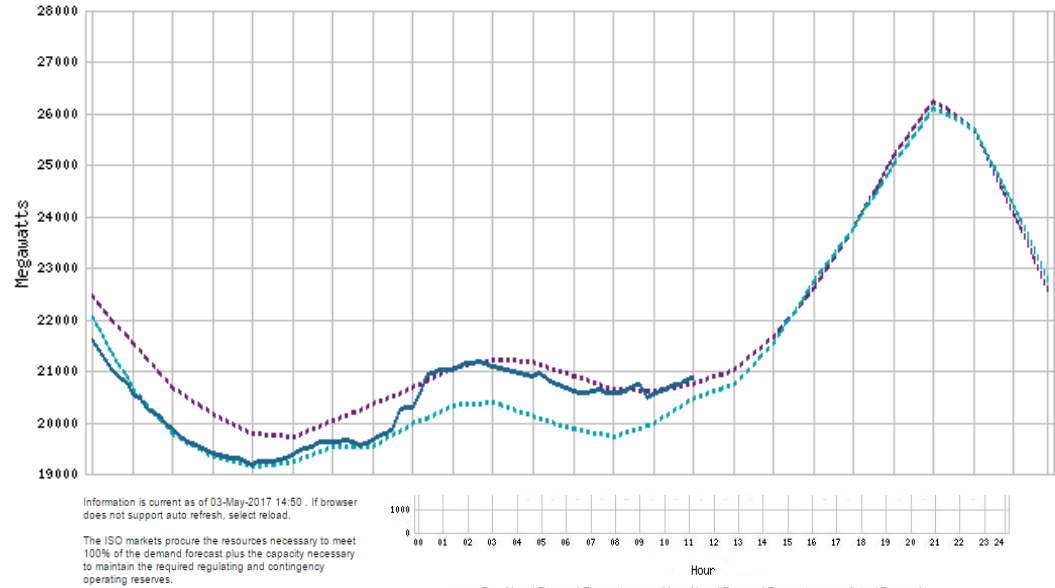
https://www.eia.gov/beta/realtime_grid/#/status?end=20170310T11



California Electricity Demand

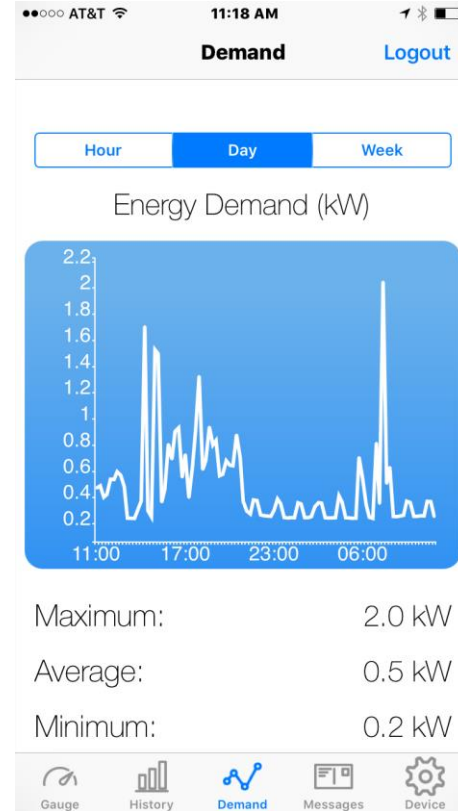
- California Independent System Operator (ISO)
- Used by planners and market participants
- Active management

<http://www.caiso.com/Pages/TodaysOutlook.aspx>

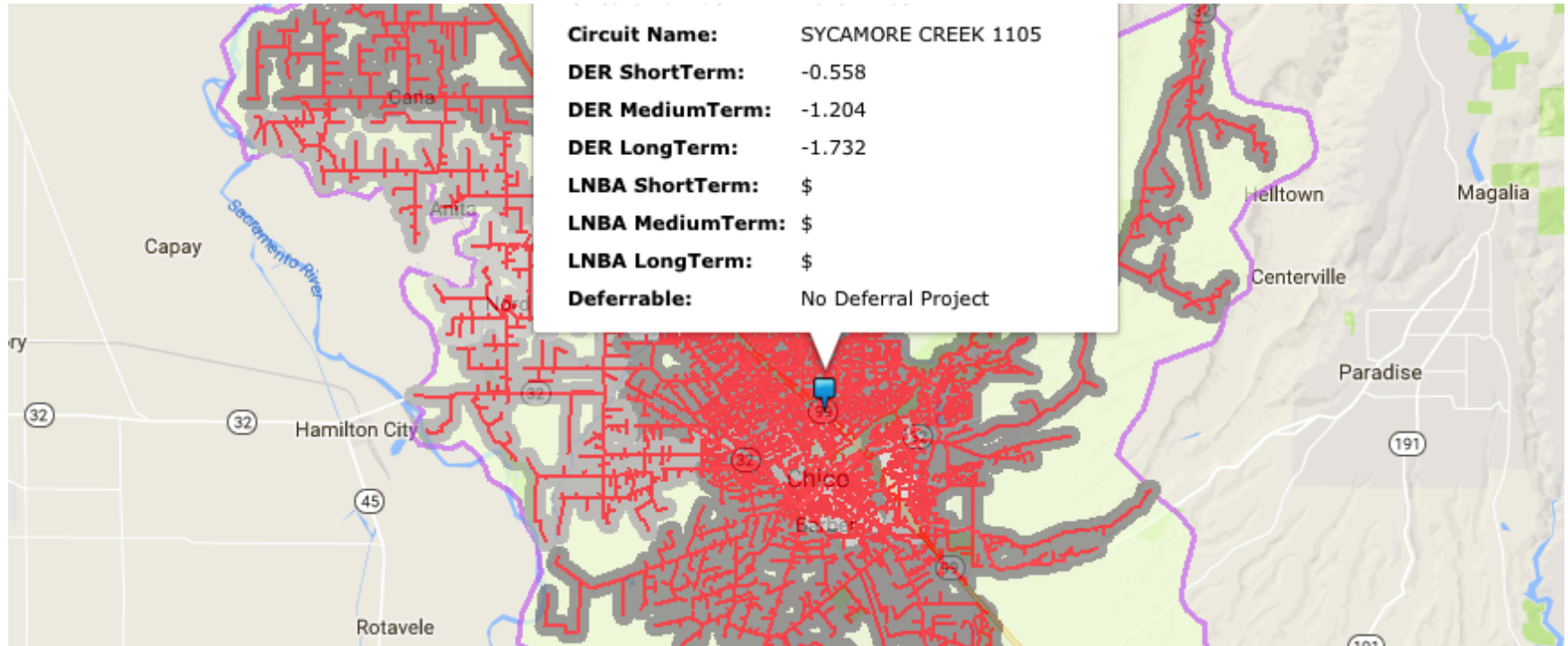


1911 9th Street Berkeley - Energy Demand

- Individual meter level data
- Home energy management

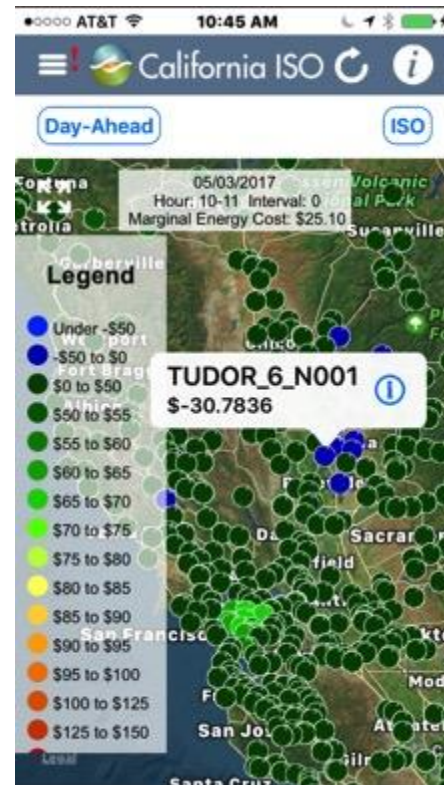


Distribution Level Data - Maps



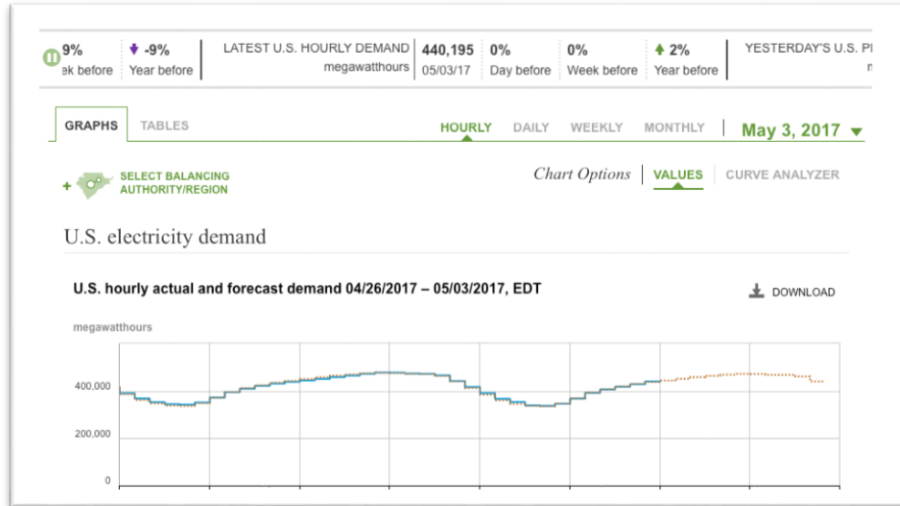
Price of Power = Value of Efficiency

- Saving Energy is the means to some goals
 - First in the “loading order”
 - GHG emission reduction
- But there is also a Cost Effectiveness test
 - The price of power is becoming more volatile
 - The timing of the delivery of efficiency is becoming more important

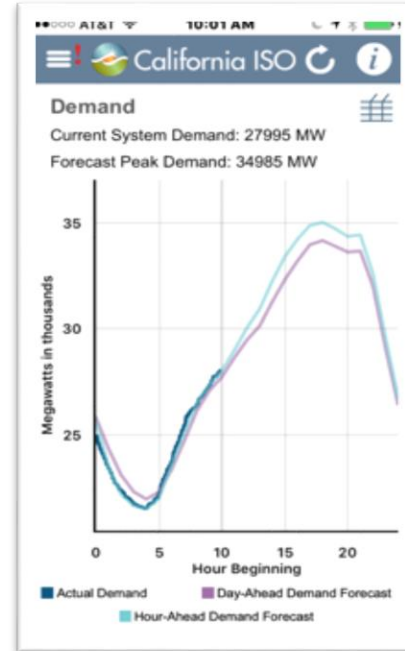


Load Shapes at Three Levels

Increasing volatility with increased granularity



National



State



Household

Disrupter #2 – Data Analysis

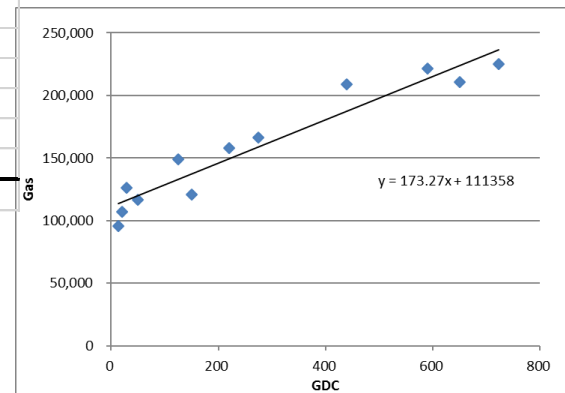
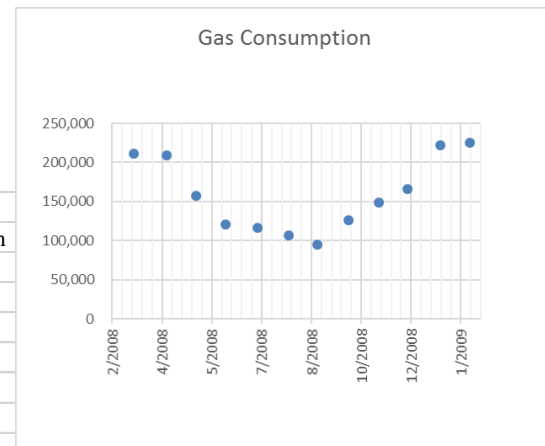
- ***More data*** can be ***analyzed*** in ***more ways***
 - Tools to build Statistics models (based on measured data)
 - Excel – ECAM
 - Universal Translator
 - LBNL Time of Week and Temperature Model (ToWT)
 - R Code
 - Other research on “Advanced M&V”

“Classic M&V”

IPMVP Option C

- Monthly Bills
 - Monthly bills smooth out some noise (remember the earlier graphs)
 - Show general trends when:
 - *Savings impacts are large enough*
 - *“other” changes behind the meter are small (non-routine adjustments)*

Days	Heating Degree Days	Gas Consumption mcf
29	650	210,692
33	440	208,664
29	220	157,886
30	150	120,793
32	50	116,508
31	20	107,272
29	14	95,411
31	29	126,423
31	125	149,253
28	275	166,202
33	590	221,600
30	723	224,958
366	3,286	1,905,662



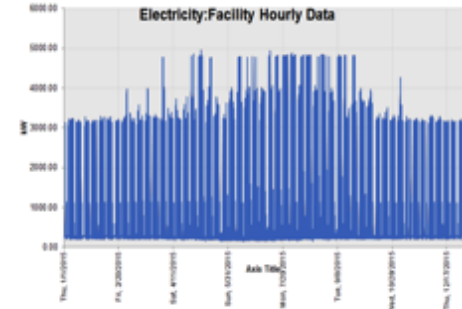
Disrupted M&V – Statistics Models

Modern Times

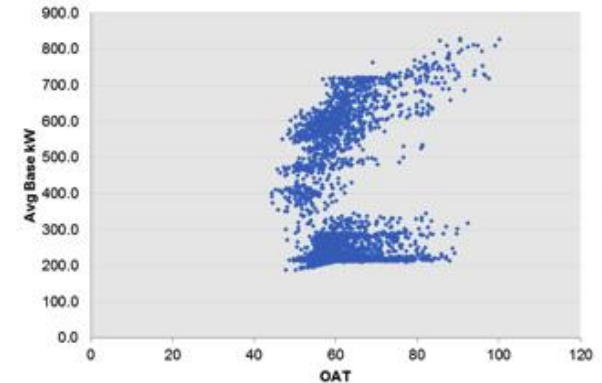
- Interval meter data
- Other sources of (granular) data

DateTime	Year	Month	MonthYr	Day	Hour	Date
2/29/04 12:00 AM	2004	February	Feb 2004	29	0	2/29/2004
2/29/04 1:00 AM	2004	February	Feb 2004	29	1	2/29/2004
2/29/04 2:00 AM	2004	February	Feb 2004	29	2	2/29/2004
2/29/04 3:00 AM	2004	February	Feb 2004	29	3	2/29/2004
2/29/04 4:00 AM	2004	February	Feb 2004	29	4	2/29/2004
2/29/04 5:00 AM	2004	February	Feb 2004	29	5	2/29/2004
2/29/04 6:00 AM	2004	February	Feb 2004	29	6	2/29/2004
2/29/04 7:00 AM	2004	February	Feb 2004	29	7	2/29/2004
2/29/04 8:00 AM	2004	February	Feb 2004	29	8	2/29/2004
2/29/04 9:00 AM	2004	February	Feb 2004	29	9	2/29/2004
2/29/04 10:00 AM	2004	February	Feb 2004	29	10	2/29/2004
2/29/04 11:00 AM	2004	February	Feb 2004	29	11	2/29/2004
2/29/04 12:00 PM	2004	February	Feb 2004	29	12	2/29/2004
2/29/04 1:00 PM	2004	February	Feb 2004	29	13	2/29/2004
2/29/04 2:00 PM	2004	February	Feb 2004	29	14	2/29/2004
2/29/04 3:00 PM	2004	February	Feb 2004	29	15	2/29/2004
2/29/04 4:00 PM	2004	February	Feb 2004	29	16	2/29/2004
2/29/04 5:00 PM	2004	February	Feb 2004	29	17	2/29/2004
2/29/04 6:00 PM	2004	February	Feb 2004	29	18	2/29/2004
2/29/04 7:00 PM	2004	February	Feb 2004	29	19	2/29/2004
2/29/04 8:00 PM	2004	February	Feb 2004	29	20	2/29/2004
2/29/04 9:00 PM	2004	February	Feb 2004	29	21	2/29/2004
2/29/04 10:00 PM	2004	February	Feb 2004	29	22	2/29/2004
2/29/04 11:00 PM	2004	February	Feb 2004	29	23	2/29/2004
3/1/04 12:00 AM	2004	March	Mar 2004	1	0	3/1/2004
3/1/04 1:00 AM	2004	March	Mar 2004	1	1	3/1/2004
3/1/04 2:00 AM	2004	March	Mar 2004	1	2	3/1/2004
3/1/04 3:00 AM	2004	March	Mar 2004	1	3	3/1/2004
3/1/04 4:00 AM	2004	March	Mar 2004	1	4	3/1/2004
3/1/04 5:00 AM	2004	March	Mar 2004	1	5	3/1/2004
3/1/04 6:00 AM	2004	March	Mar 2004	1	6	3/1/2004
3/1/04 7:00 AM	2004	March	Mar 2004	1	7	3/1/2004

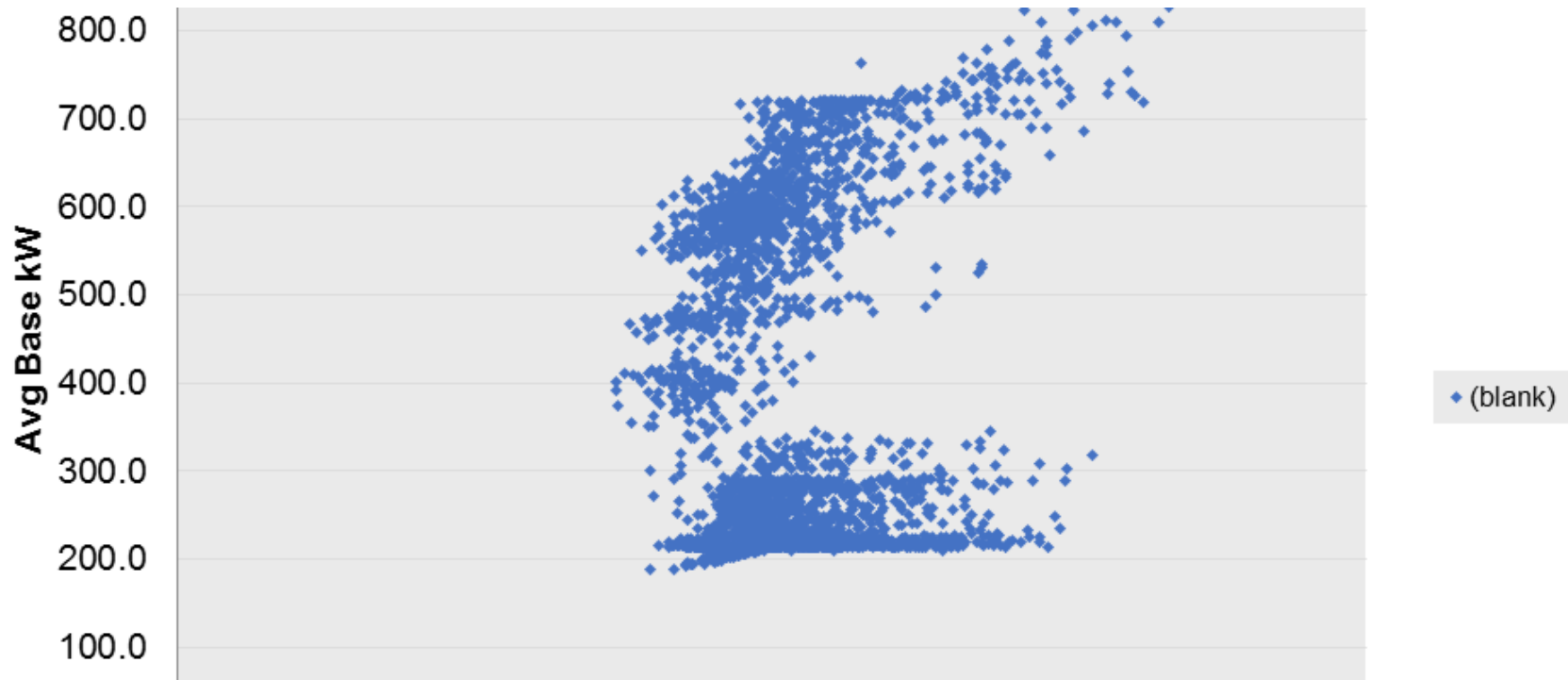
8760 records



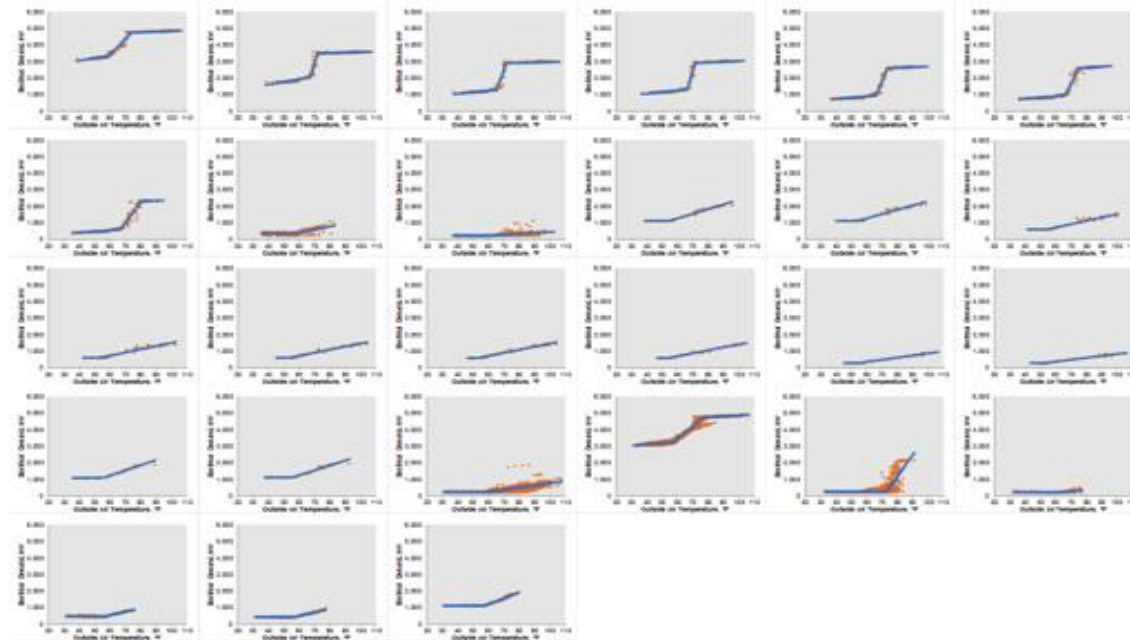
kW vs Outdoor Air (Pre/Post Retrofit)



How many models do you see in this data?

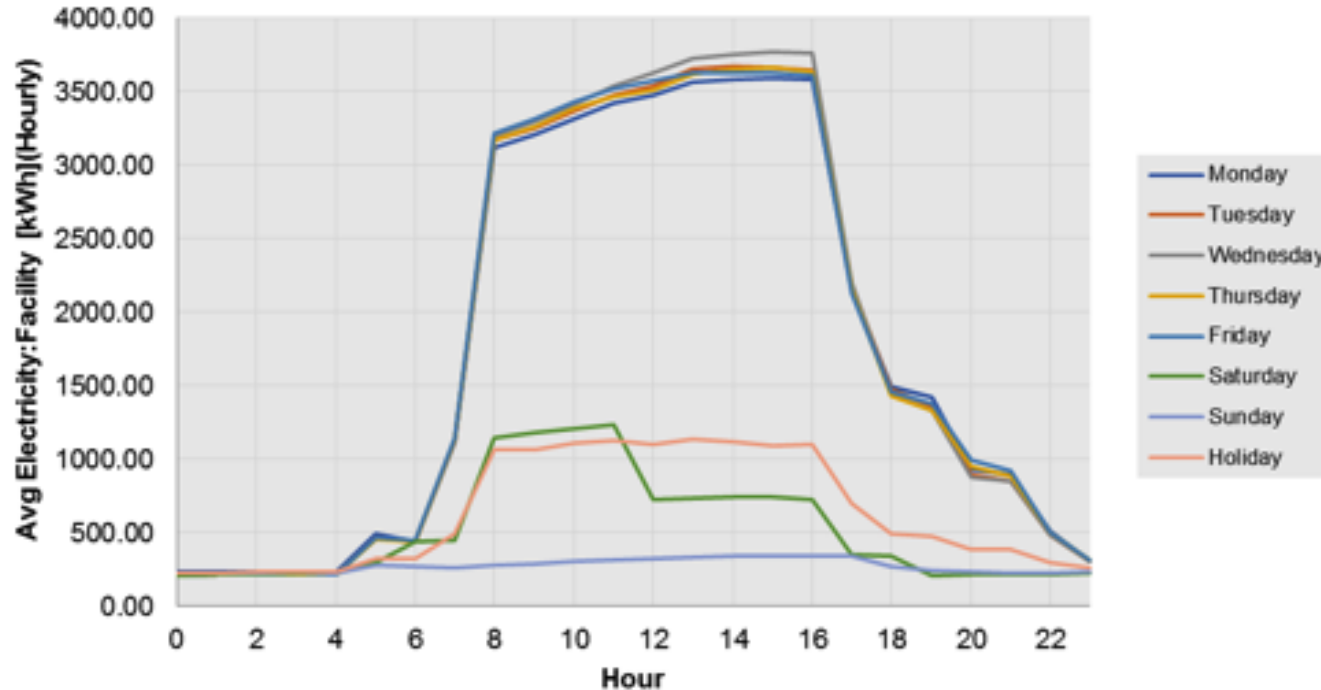


Some people see 27 models (hourly plus 3)



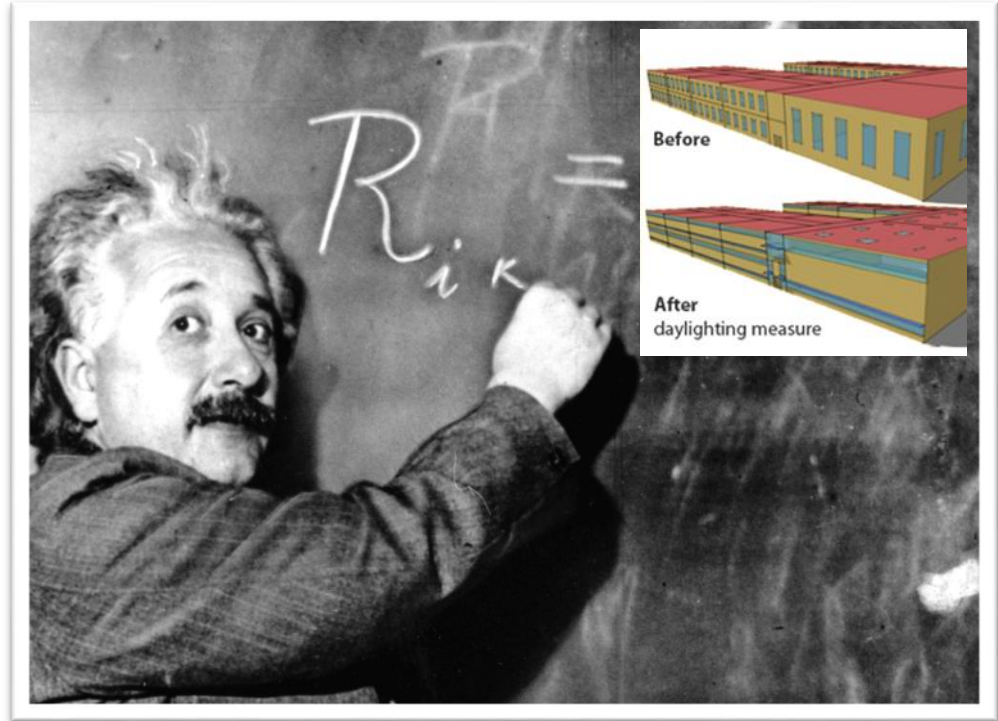
Or maybe a simplified “typical” load shape?

Avg kW by Daytype

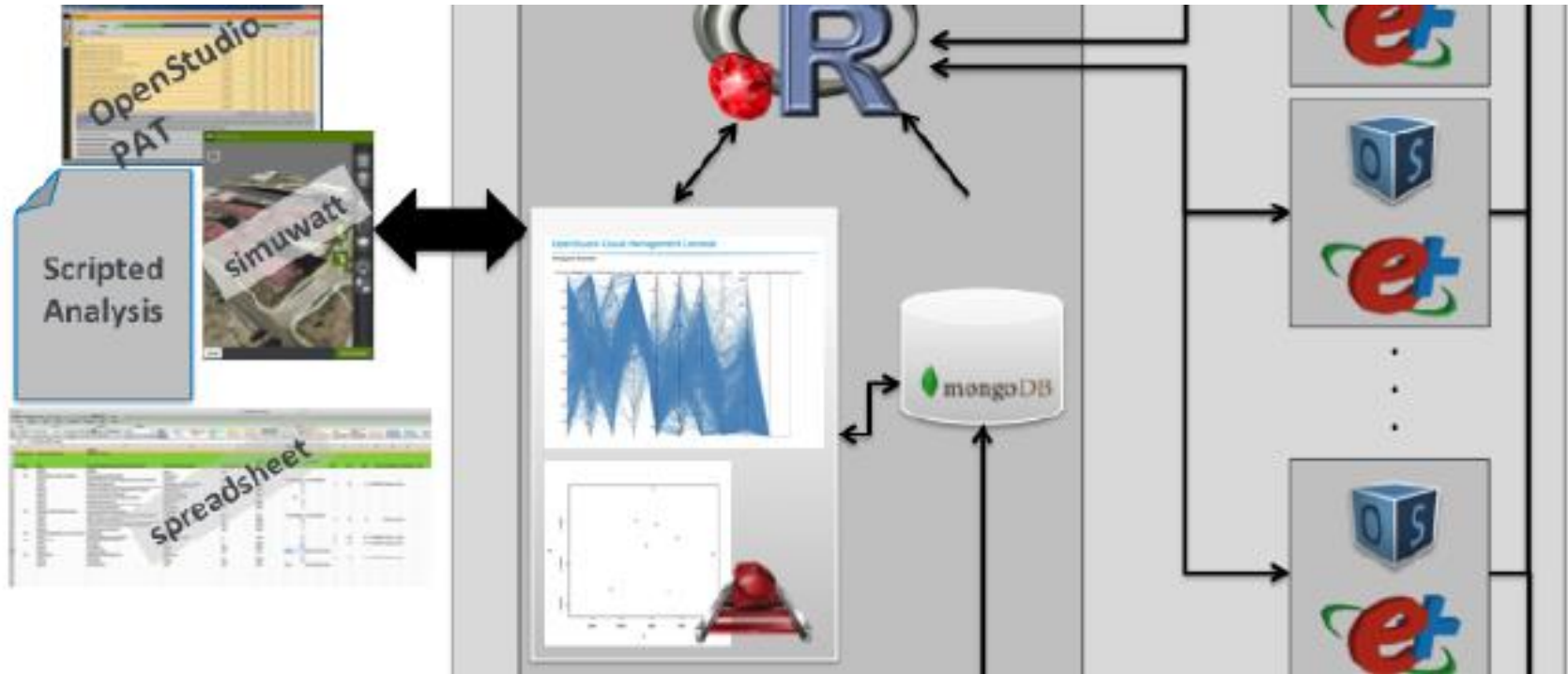


Disrupted M&V - Better Physics Modeling

- IPMVP “Option D” = Energy Simulation
- Used to compare to
 - Code
 - Industry Standard
- Can use Prototypes
- Faster, more powerful models on the way



Energy Models leveraging cloud computing



Energy Modeling has some issues

Recent article (May 2) in The Telegraph fires up conversation in building modeling community.

<http://www.telegraph.co.uk/science/2017/05/02/energy-scandal-misleading-efficiency-claims-leading-huge-bills/>

The Telegraph

HOME | NEWS | SI

Science

Science

Energy scandal: misleading efficiency claims leading to huge bills for homeowners



New homes are often not as efficient as older houses CREDIT: IVAN SMUK / ALAMY

By Sarah Knapton, SCIENCE EDITOR

2 MAY 2017 • 10:00PM

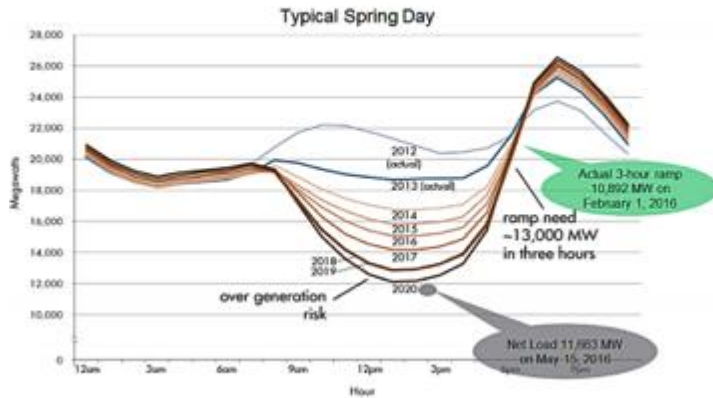
Disrupter #3 Grid Issues in California (and beyond)

- Renewables are coming fast
 - Duck Curve
 - Prices (negative and volatile)
- Distributed Energy Resources
 - Micro Managing the Grid
 - Locational Net Benefits Analysis



Ducks in Theory and Practice

Figure 2: The duck curve shows steep ramping needs and overgeneration risk



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Today's Outlook

Get an at-a-glance view of supply and demand, renewable energy production, emergency notifications and requests for energy conservation. These displays are provided for information only and do not represent real-time system operating conditions. [Click here](#) for more information about this page.

Go to...

- [Supply & Demand](#)
- [Power Mix by Fuel Type](#)
- [Renewables](#)
- [Alerts, Warnings & Emergencies](#)
- [Net Demand](#)
- [Flex Alerts](#)

Demand

Graph displays current system demand plotted against forecast demand.

Actual Demand displays instantaneous maximum MW amount over previous 10 minute period. Forecasts are hourly average MW.

Current System Demand:
(Actual Demand at this point in time)
33361 MW

Today's Peak Demand:
(Highest point thus far today)
33361 MW

Today's Forecast Peak Demand:
(Highest point expected today)
34792 MW

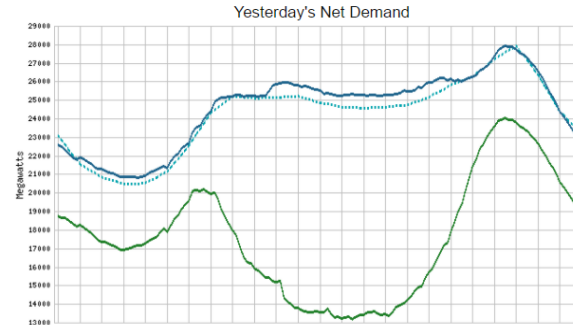
Tomorrow's Forecast Peak Demand:
(Not included on graph)
33303 MW

Historical Peak Demand:
(Set on Jul 24, 2006)
50,270 MW
[Click here to see history](#)

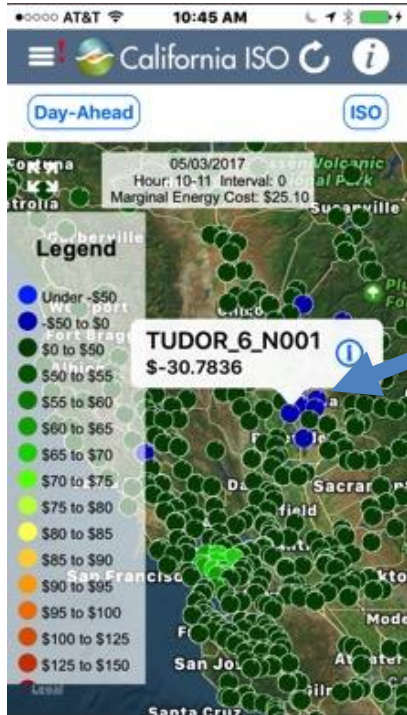
Information is current as of 03-May-2017 14:50. If bro does not support auto refresh, select reload.

The ISO markets procure the resources necessary to 100% of the demand forecast plus the capacity needed to maintain the required regulating and contingency operating reserves.

••• Hour-Ahead Demand Forecast — Actual Demand — Net Demand



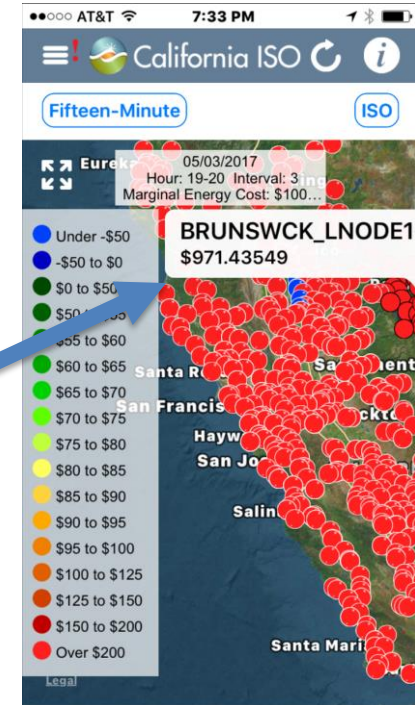
Price Volatility in California (last week)



Negative prices?

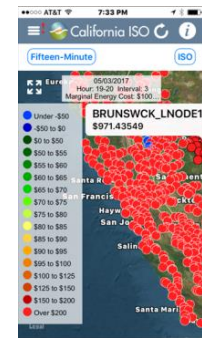
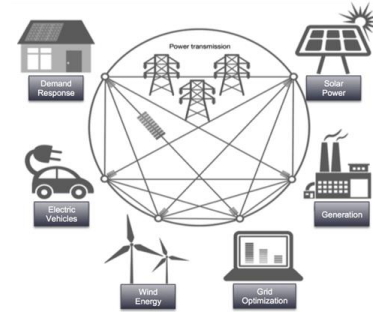
What is
efficiency worth
at these times?

What is efficiency
worth now?



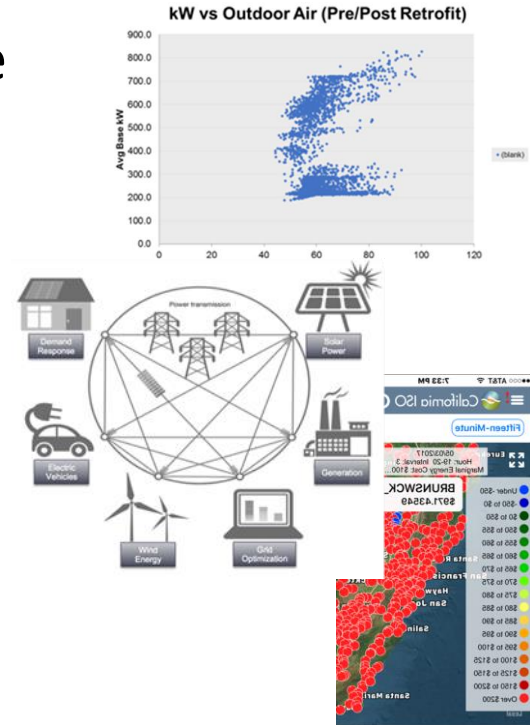
M&V must move to hourly reporting

- Both **Interval data models** and **simulations** are needed to allow efficiency to play in the new world of volatile prices and alternative load management capabilities
- Savings need to be demonstrated and reported at an hourly (or sub-hourly) level



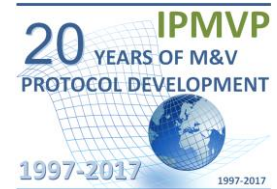
Conclusions

- Efficiency opportunities are abundant, but simple methods for quantification are elusive
- Data is abundant, but more and better **modeling** is still required.
- New modeling capabilities under development but not yet standardized
 - Statistics Models – M&V 2.0
 - Physics Models - M&V 3.0??



Conclusions

- New data, models and the need for hourly savings models will disrupt “classic” M&V
- The global M&V community has a strong foundation in using modeled baseline methods for quantifying efficiency
- We all need to build on this foundation to develop innovative M&V solutions to address our disrupted energy world



Thank you

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