



Ministry of Power and
Energy Sri Lanka

WB Energy Efficiency Program Support in Sri Lanka



Sri Lanka Sustainable
Energy Authority

Implementation and Financing Mechanisms in Commercial, Public & Industrial Buildings Sectors

Capacity building on Measurement and Verification (M&V) Concepts for Energy Savings

Performance Contracts

November 10, 2022

Energy Efficiency “M&V” Objectives

- M&V role in financing and in energy efficiency projects (EPC)
- Overview of different M&V documents including IPMVP and others
- Developing an M&V plan, issues, methodologies, challenges in M&V, implementation steps
- Case studies of M&V (EPC projects in building sector US Navy and Tarshid in the Kingdom of Saudi Arabia)
- Certification / accreditation programs

COUNTERFACTUAL DESIGNS

Steve Kromer, P.E. CMVP

Pilot Program for ESPC in federal facilities 1992-93

Project Manager for FEMP/IPMVP 1993-1996

Director of Project Valuation – Enron 1999-2001

Chair of EVO 2003-2007

Chair of CMVP Board 2007-2022

- Short story – wanted to find a way to help people around the world communicate about important issues. Believe engineering can be that language.
- M&V has been that path. A winding path to be sure.

Pivotal Moments

- US DOE FEMP Offices – December 1993
- Dean Devine – “So you think you can **measure savings**?”
- Steve - “Yes, that’s my **assignment** for the next year”
- Dean – “But you know, **Savings can’t be measured ...**”
- Dean suggests that the term “measuring savings” is not accurate. And indeed, that’s proven to be true.
- Hence the adoption of a general term, “**counterfactual**”.

Pivotal Moments #2

- Delhi October 2005
- I was introduced by a high-level government official
- “Mr. Kromer is here to speak about M&V, which is just the **scientific method**, using different words”
- In a way, she was correct.



M&V Role in Financing and EPC

- Energy projects can lead to reduced energy consumption
- Reduced consumption can be valuable
- The accumulated value from EPC projects can be used to pay back a loan
- The method of determining the value is “M&V”
- \$uccessful \$ettlement requires good M&V

Origins of M&V

- 1992 US Energy Policy Act
- Authorization of ESPC – Federal Law 10 CFR 436.31
 - Provided very general language and definitions for
 - Energy Cost Savings
 - ESPC
 - Baseline

10 CFR 436.31 Energy Cost Savings

- *Energy cost savings* means a **reduction in the cost** of energy and related operation and maintenance expenses, from a base cost established through **a methodology** set forth in an energy savings performance **contract**, utilized in an existing federally owned building or buildings or other federally owned facilities as a result of—
 - (1) The lease or purchase of operating equipment, improvements, altered operation and maintenance, or technical services; or
 - (2) The increased efficient use of existing energy sources by cogeneration or heat recovery, excluding any cogeneration process for other than a federally owned building or buildings or other federally owned facilities.

See a video at www.counterfactual-designs.com

10 CFR 436.31 ESPC Definition

- *Energy savings performance contract*
- means a **contract** which provides for the performance of services for the design, acquisition, installation, testing, operation, and, where appropriate, maintenance and repair of an identified energy conservation measure or series of measures at one or more locations.

10 CFR 436.31 Baseline Definition

- ***Energy baseline*** means the amount of energy that would be consumed annually without implementation of energy conservation measures based on historical metered data, engineering calculations, submetering of buildings or energy consuming systems, building load simulation models, statistical regression analysis, or some combination of these methods.

The First “Modern” M&V Document

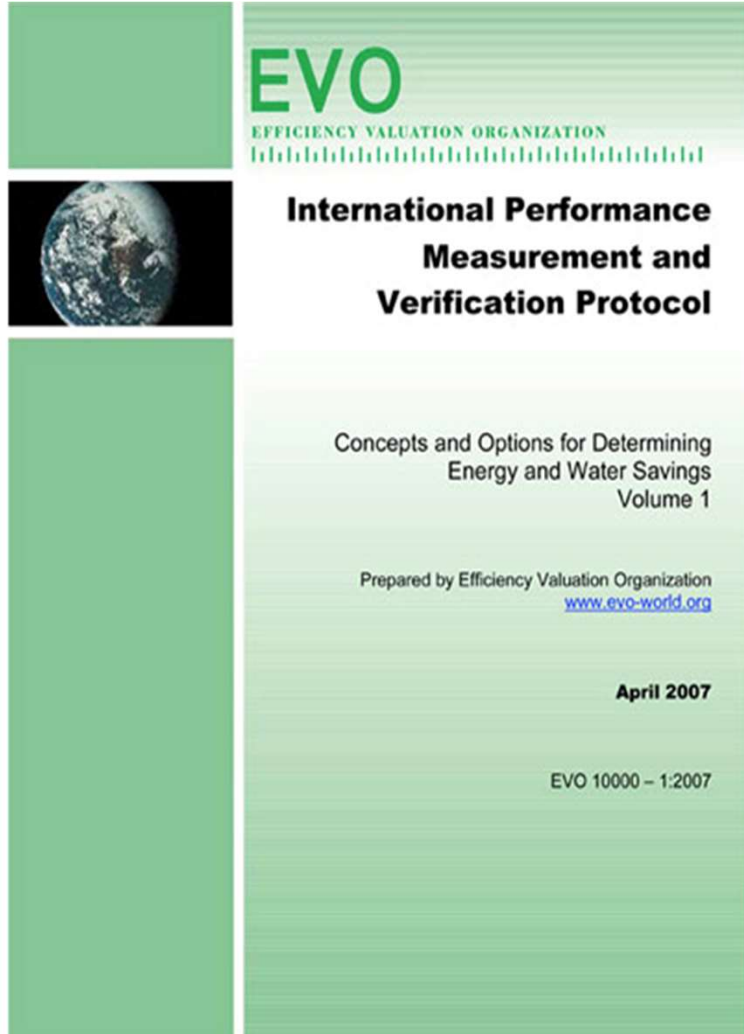
- The US DOE Federal Energy Management Program (FEMP) 1996
- Initiated implementation of the Energy Policy Act in the US Federal government
- Needed a full “methodology”
- [Spread the word, pre-internet](#)

History of M&V Protocols (partial listing)

- ⊃ 1970s: case-by-case measurements
- ⊃ 1983: International Energy Agency's "Guiding Principles for Measurement"
- ⊃ 1985: Oak Ridge National Laboratory's "Field Data Acquisition for Building and Equipment Energy Use Monitoring"
- ⊃ 1988: New Jersey Utilities M&V Plans
- ⊃ 1988: First NAESCO M&V Plan
- ⊃ 1989: Texas LoanSTAR Program M&V Guidelines
- ⊃ 1991: ASHRAE Handbooks Chapter 37 "Building Energy Monitoring" (revised in 1995 and scheduled for 1999)
- ⊃ 1992: California CPUC CADMAC M&V Protocol
- ⊃ 1993: New England AEE M&V Protocol
- ⊃ 1993: NAESCO M&V Guideline ver. 1.3
- ⊃ 1994: PG&E PowerSaving Partners "Blue Book"
- ⊃ 1995: EPA Conservation Verification Protocols
- ⊃ 1996: NEMVP (revised in 1997 to IPMVP)
- ⊃ 1996: FEMP M&V Guideline (revision in 1998)
- ⊃ 1998(?): ASHRAE 14-P
- ⊃ 2012 ISO 50015
- ⊃ 2000- 2022 IPMVP revisions

M&V Documents - IPMVP and others

- Many “standard” documents
 - Guidelines, Standards, Protocols, Manuals
- FEMP, IPMVP, ASHRAE, ISO – all adopt the **counterfactual** method.



Protocols Galore

- 25+ years of “modern M&V”
IPMVP, ASHRAE 14, ISO 50016
- All protocols are based on
modeling/counterfactual
- Each project gets a unique
M&V plan, a *counterfactual design*.

M&V Contexts

- M&V is applied two main contexts
 - Contracts
 - Energy Savings Performance Contracts
 - Agreements between parties/stakeholders
 - Emphasis on responsibility and risk
 - Research / Quasi-Scientific
 - Utility/Govt Energy Efficiency programs
 - Greater emphasis on scientific “accuracy”

M&V for Contracts

- Primary purpose is to set up rules that all parties can agree upon.
- All contractual terms are considered
- Maintenance, Effective Useful Life (EUL)
- Risk and Responsibility must be clearly defined
- “Savings” are defined in the M&V plan

(E)M&V for Programs

- Primary purpose is to assess the effectiveness of an overall program by studying a few projects
- Often involves sampling from a population of projects
- Often utilizes larger budgets allowing greater detail for any specific project
- Often includes different concepts such as “code baseline” or “dual baseline”

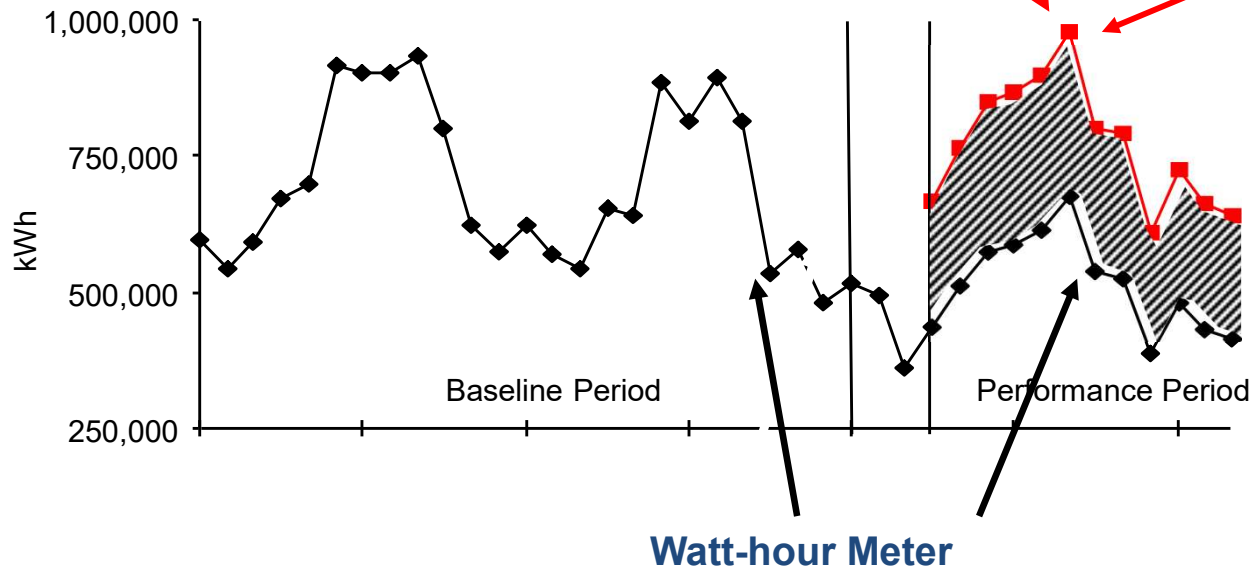
M&V options - IPMVP and other documents

- The M&V plan design for each project must be appropriate to the project/situation
- Whole Facility vs. Retrofit Isolation
- Continuous measurement vs. Occasional / Short term verification
- All projects must consider co\$t

Fundamental M&V

What **Would** Have Happened Meter

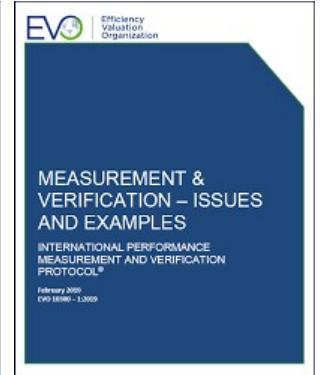
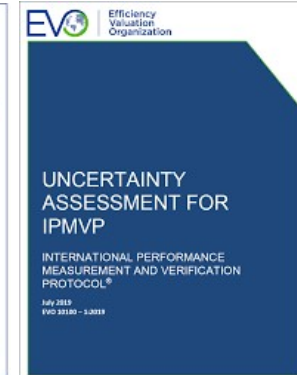
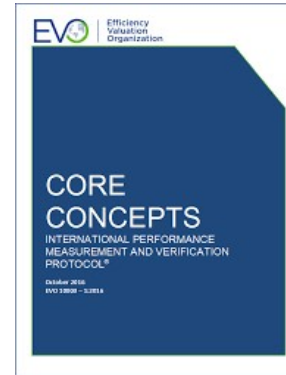
Also known as the
“Counterfactual”



**Watt-hour (Wh) meters &
What **Would** Have Happened
(WWHH) meters**

IPMVP (since 1996 and still going strong)

- ABCD's of M&V
- Flexible Framework
 - Built around the counterfactual (WWHH) method
- Fundamental language to create M&V plans
- Requires *field collected* **DATA**
- Data is used in **MODELS** (statistical and physical)



What Is M&V?

At its core, measurement and verification (M&V) is a **process** that (potentially) includes a wide range of measurement, verification, and analysis techniques for quantifying the results of resource efficiency and resource management activities.

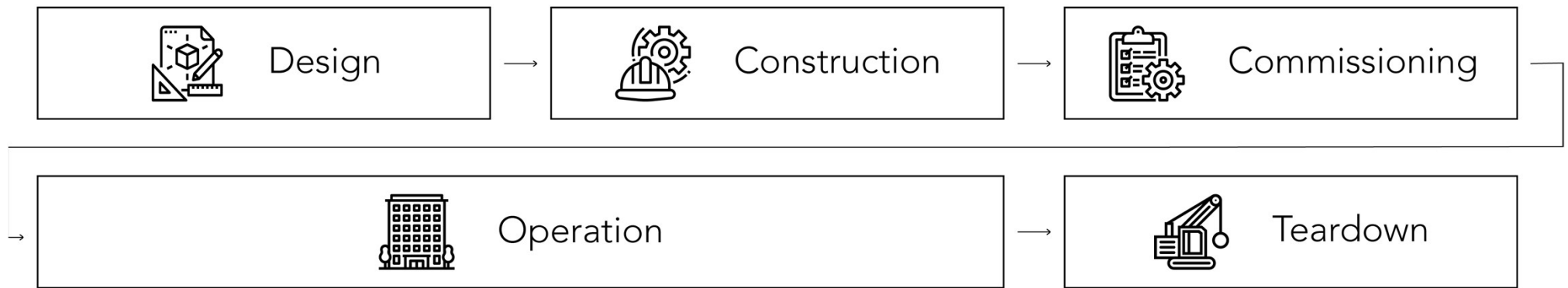
What Is M&V?

The M&V **process** requires participation from a range of stakeholders and professionals.

- Lawyers who write contracts
- Financiers who set terms for cash flow
- Engineers to perform audits and develop projects
- Statisticians to help with modeling and uncertainty



Facility Life Cycle



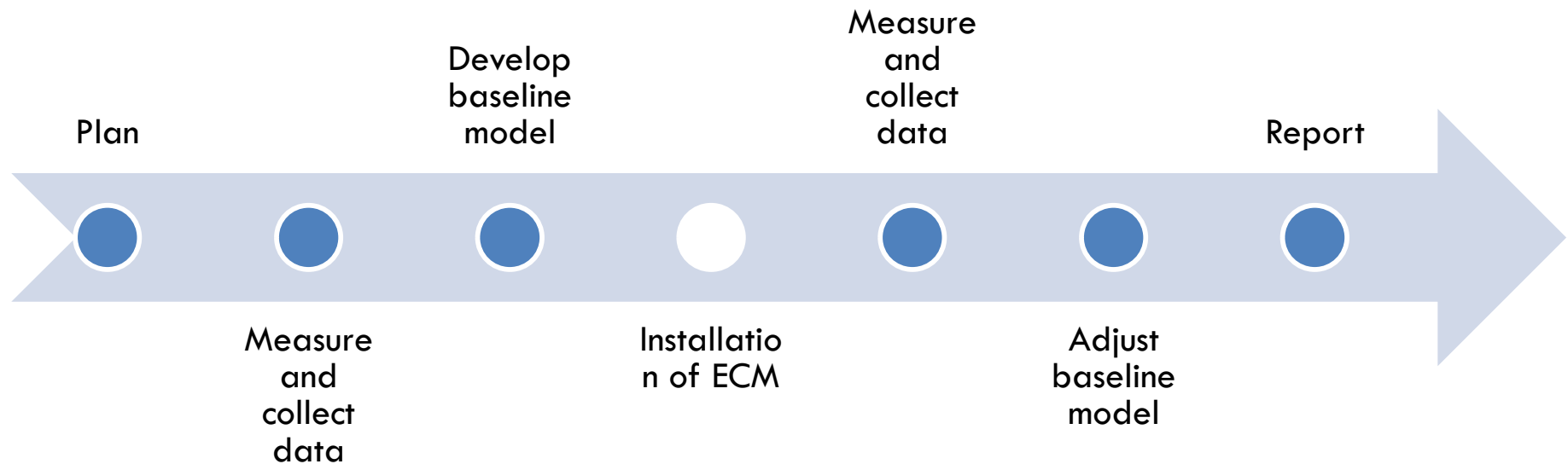
What can occur besides “typical operation”?

- Use changes
- Non-routine events
- Equipment optimization/replacement
- Large-scale renovation
- Degradation

M&V typically occurs at this point in a facility's life cycle.



M&V, Step by Step



What Is M&V? Two Main Methods

- Counterfactual Method

Build a **model** of the baseline

Update that model for the life of the project

- Performance Measurement

Short term measurements to verify/confirm an energy efficiency project is working properly

Compared to What? Terminology

Compared to “Self” or “Others”?

Two main techniques:

- Modeling – Compared to “Self”
 - a.k.a. Longitudinal Benchmarking
 - **Counterfactual** method
- 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:

<https://buildings.lbl.gov/sites/default/files/energy-information-handbook.pdf>

Compared to What?

Attribution Compared to Code? Standard Practice?



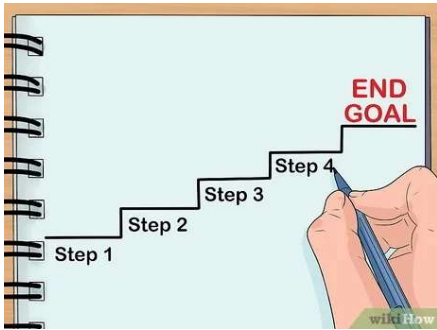
© Can Stock Photo

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

What Is M&V? Related Concepts

- Targeting
- Benchmarking
- Performance Measurement
 - KPI
 - Other?

Plan / Play / \$ettle



- Assemble your team
- Develop the M&V Plan



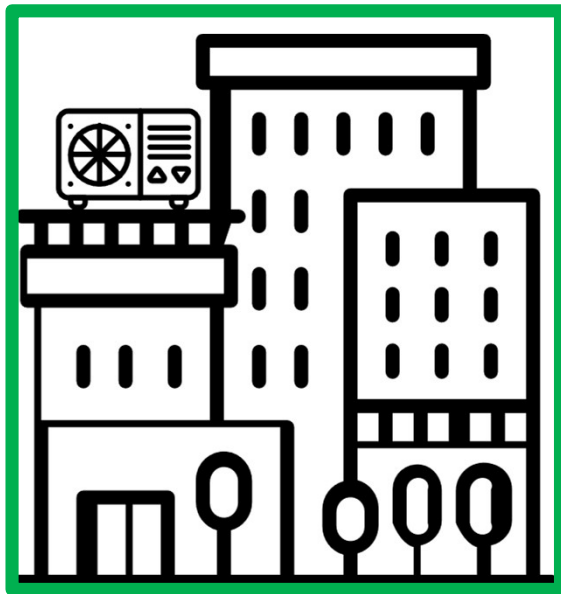
- Implement the project
- Perform the M&V



- Account for results
- Make \$\$ payments

Two System Boundaries

Whole Facility



Retrofit Isolation



IPMVP/FEMP Options A–D

Option A	Retrofit Isolation: Key Parameter Measurement
Option B	Retrofit Isolation: All Parameters Measurement
Option C	Whole Facility
Option D	Calibrated Simulation

- IPMVP: International Performance Measurement and Verification Protocol
- FEMP: Federal Energy Management Program

FEMP Original Definitions

Option A	Retrofit Isolation: Performance Measurement
Option B	Retrofit Isolation: Performance and Operation
Option C	Whole Facility: Statistical model
Option D	Calibrated Simulation: Physical model

- IPMVP: International Performance Measurement and Verification Protocol
- FEMP: Federal Energy Management Program
- I prefer these!!



Fundamental Methods of Measurement in Retrofit Isolation

Performance

- Snapshot measurements are taken of the key parameters of energy use in the system.
- Justified and auditable estimates provide the rest of the data.

Performance/Operation

- Continuous measurements are taken of the key parameters.
- No assumptions or estimates are made.

Communication / Judgement

Planning

- Planning ahead to avoid common issues.
- Develop guidance documents

Dispute Resolution

- Solving problems after they arise
- Develop a council to assist in mitigating disputes

Benefits of “Good” M&V (cont)

from Karel Steyn “Lessons Learned Energy Measurement and Verification

- M&V must assist in avoiding or resolving disputes between stakeholders!
- Good M&V reporting will also help with the proper and full implementation of projects - implementers usually do better work when results are checked by an independent party.
- Due to the aforementioned, M&V involvement will improve the design, operation and maintenance of existing and future projects.
- Good M&V helps to identify additional or existing focus areas for EEDSM and water-saving activities.
- M&V identify strengths and weaknesses in the (energy) performance of stakeholders, products or the EEDSM measures implemented.
- Good M&V creates accurate baselines with realistic saving projections while also predicting future requirements.
- M&V generates performance data that can be used in developing additional projects at the same, or similar, locations.
- Good M&V can result in the identification of new projects to further reduce energy, water

Benefits of “Good” M&V

from Karel Steyn “Lessons Learned Energy Measurement and Verification

The obvious response would be that M&V reports provide the reader with information on energy savings. Extremely good M&V reporting is however much, much more than that. The next are short statements but consider each:

- Good M&V reports provide key business insights to decision-makers. Often on facts that were unknown before.
- A report should educate facility users about their energy consumption and the impacts of Energy Efficiency and Demand Side Management (EEDSM) measures implemented - also referred to as Energy Savings Measures (ESM). This is because it establishes trends, identifies, quantifies, assesses and tracks the performance of any ESM (and/or water) project impacts against preset targets.
- It provides and makes current and future Tracking and Evaluation (T&E) of project performances and progress possible.
- M&V should enable an analysis of proposals, results and provide corrective action(s) where necessary. In other words, it must limit the risk of lost savings due to early identification of operational or maintenance problems.

“Lessons Learned South Africa”

Karel Steyn’s newsletter, assembled into an Book

- Can be obtained from Yolanda at IEPA
Yolanda@iepa.org.za

Alternative Dispute Resolution

- <https://www.courts.ca.gov/3074.htm>
- <https://www.ronkelly.com/pg5.cfm>

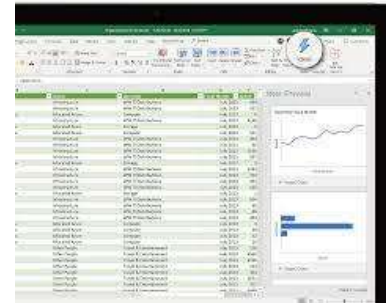
Benefits of a local Council

- South Africa
- <https://iepa.org.za/mvca/>



M&V Toolkit

- Ruler
- Excel / Spreadsheets
- Academia package
 - Dozens of “EE” calculation tools and models



Academia	Today at 9:57 AM
Academia Summary - Review of Existing Energy Retrofit Tools.pdf	Today at 9:57 AM
Review of Existing Energy Retrofit Tools.pdf	Today at 9:57 AM
most_recent_projects_summary.pdf	Today at 9:57 AM
DOCS Commercial_Bidding_Energy_Ann_Mark.pdf	Today at 9:57 AM
A Low Order Thermal_Zone_Energy_Model_for_H.pdf	Today at 9:57 AM
Low_order_Variable_Performance_Vol_2.pdf	Today at 9:57 AM
A Systematic Approach_to_Quantifying_Ene.pdf	Today at 9:57 AM
Basic_Studies_and_Numerical_Analyses_of_Heat.pdf	Today at 9:57 AM
Development_and_Validation_of_the_Green_Risk.pdf	Today at 9:57 AM
Efficient_Windows_Calculations.pdf	Today at 9:57 AM
Improving_the_accuracy_of_energy_base.pdf	Today at 9:57 AM
Testing_the_Performance_and_Dynamic_Con.pdf	Today at 9:57 AM
The_Impact_of_External_Windings_in_Heat.pdf	Today at 9:57 AM
Annex_A_Report_of_Commissioning_Tools_2p.pdf	Today at 9:57 AM
Data_analysis_for_simulating_thermal.pdf	Today at 9:57 AM
Energy_performance_analysis_of_a_low.pdf	Today at 9:57 AM
Intelligent_System_for_Building_Energy.pdf	Today at 9:57 AM
Plug-and-Play_Modular_Facade_Construction.pdf	Today at 9:57 AM
Review_of_Existing_Energy_Simulation_Techn.pdf	Today at 9:57 AM
Simplified_Building_Simulation_Tool_App.pdf	Today at 9:57 AM
Summary_and_early_finding_from_a_se.pdf	Today at 9:57 AM
Unit-by-unit_integrated_simulation_and.pdf	Today at 9:57 AM
Beyond_DOE_2_and_ELAST:EnergyPlus_the_Ne.pdf	Today at 9:57 AM
BuildingPA_Future_tool_for_building_1.pdf	Today at 9:57 AM
Comparing_Building_Performance_Trends.pdf	Today at 9:57 AM
Establishing_Benchmark_for_DOE_Comm.pdf	Today at 9:57 AM
Low_carbon_heating_and_cooling_of_reside.pdf	Today at 9:57 AM
Minimising_the_Duration_between_Pred.pdf	Today at 9:57 AM
Potential_Benefits_of_Combining_Building.pdf	Today at 9:57 AM
Technical_Subtopic_2_1_Modeling_Variable.pdf	Today at 9:57 AM
Use_of_the_IBM_Planetarium_in_Testing_Con.pdf	Today at 9:57 AM
Validation_of_Transaction_Simulation_Fin.pdf	Today at 9:57 AM
Assessment_of_Energy_Impact_of_Windings_2p.pdf	Today at 9:57 AM
Comparison_of HVAC_system_modeling_in_E.pdf	Today at 9:57 AM
ENERPLUS_NEW_CAPABLE_AND_INEXPENSIVE.pdf	Today at 9:57 AM
KEY_FACTORS_METHODOLOGY_OF_ENR_ENHANCEMENT.pdf	Today at 9:57 AM
MODELING_AND_SIMULATION_OF_HVAC_RULES.pdf	Today at 9:57 AM
MULTI_OBJECTIVE_OPTIMIZATION_OF_HVAC_RULES.pdf	Today at 9:57 AM
Performance_of_Building_Energy_Simulation.pdf	Today at 9:57 AM

M&V Toolkit

- Contracts for Lawyers
- Utility Rate Structure for Accountants
- Engineering / Audits for Engineers
- Community of Practice? Meetings?

Tools - Models

- Many can be useful
- None is perfect
- Local community develops and adopt a standard practice

Statistical Modeling

Frequentist

- If you have data
- Can you “fit” a model to the data?
- Typically uses GLM or OLS methods
- Causality is always a question

Bayesian

- [Why?](#)
- Starts with estimates of the parameters
- Causal
- Don't give up “additional power”

Tools, Models, Predictions

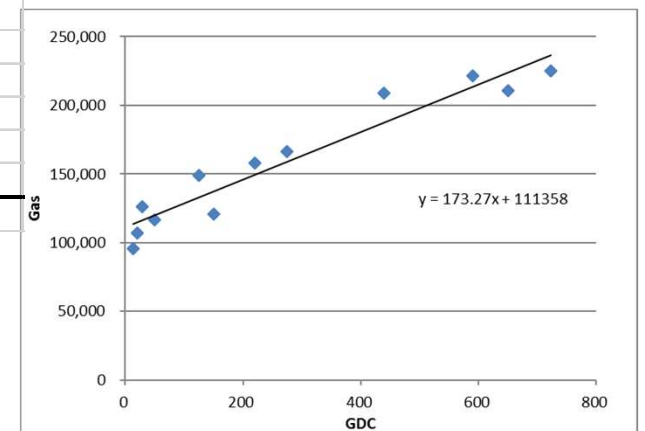
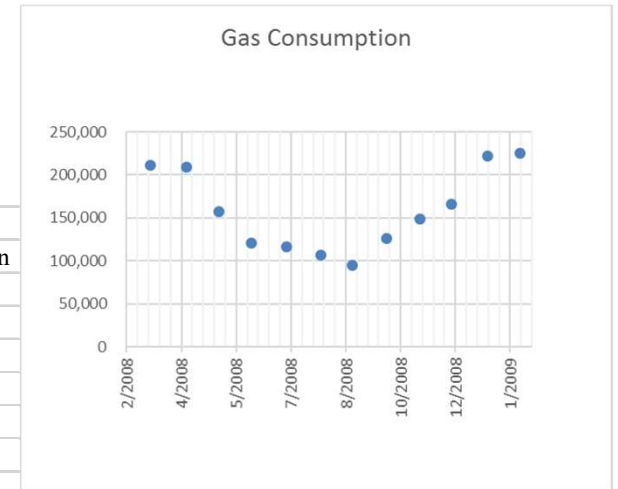
- Audit
- Understand
- Characterize
- Predict
- Update prediction tool (model)

“Classic M&V”

IPMVP Option C

- 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



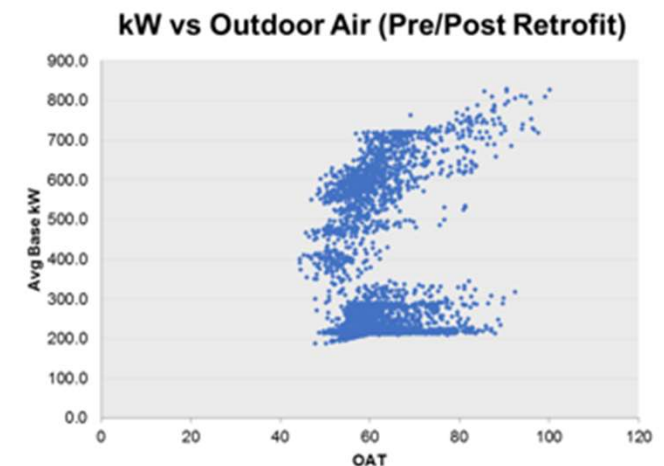
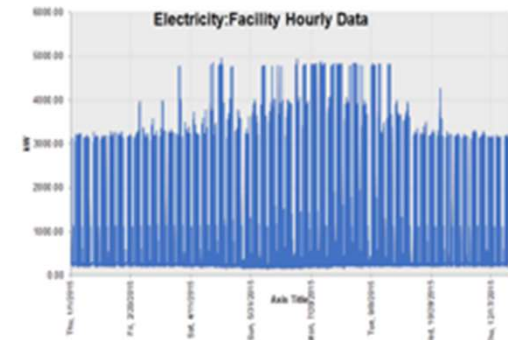
INTERVAL DATA M&V – Statistics Models

Modern Times

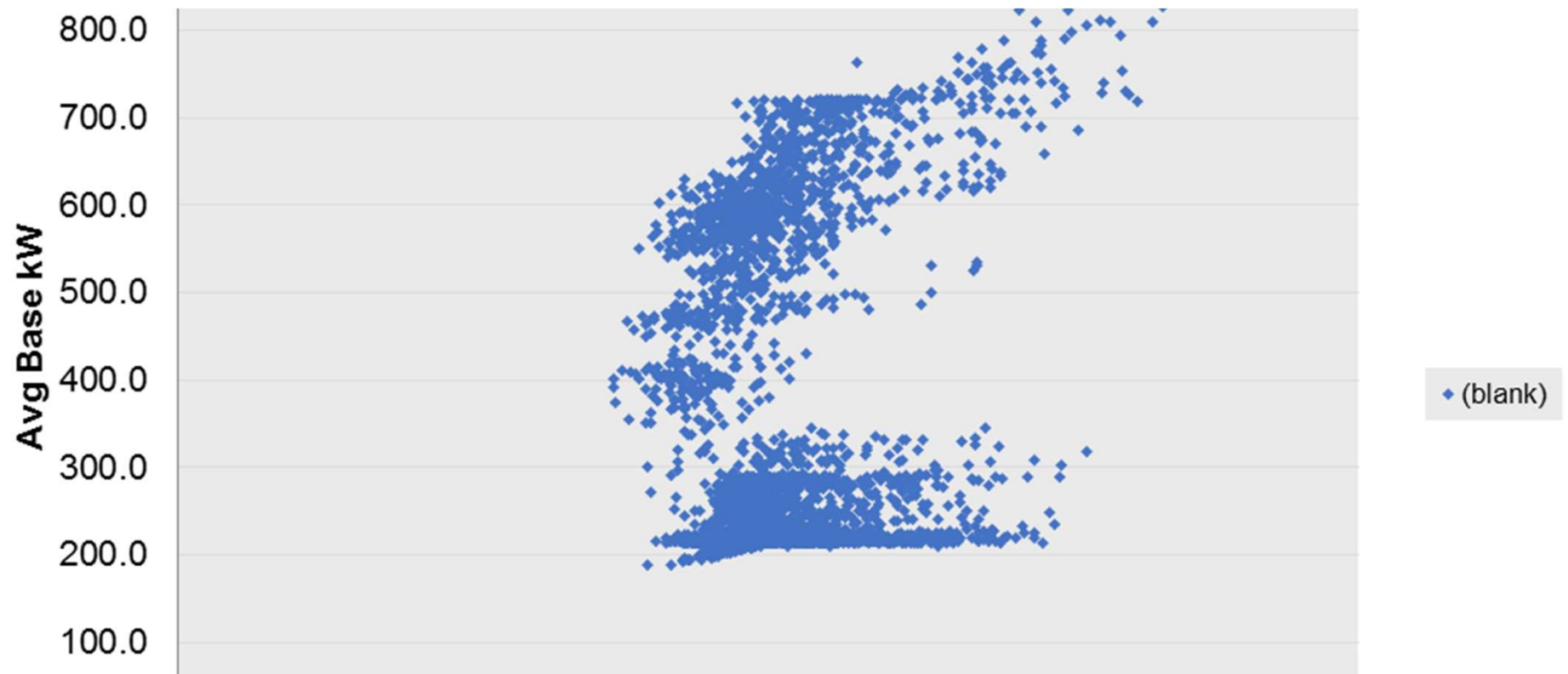
- Interval meter data
- Other sources of (granular) data

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
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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
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3/1/04 7:00 AM	2004	March	Mar 2004	1	7	3/1/2004

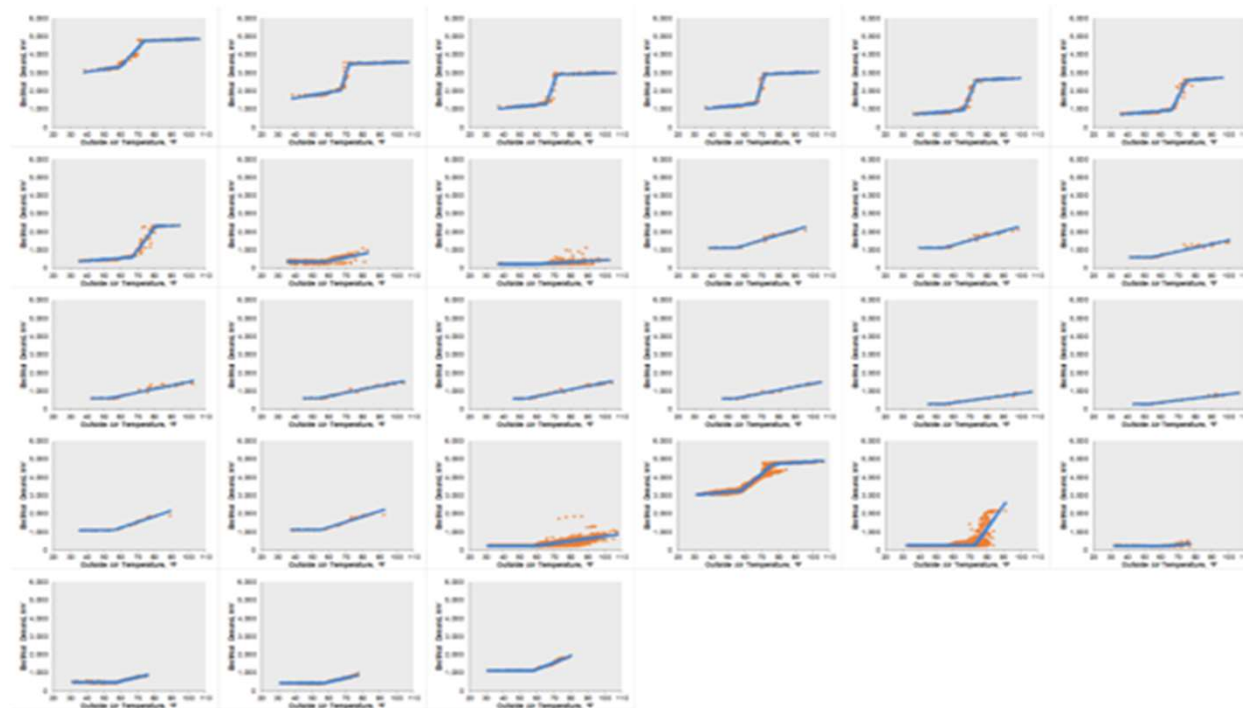
8760 records



How many models do you see in this data?



Some people see many Models (hourly)



Whole Facility Approaches

Statistical (aka Option C)

Strengths

- All the metering you need is often already installed: utility billing meter
- Sometimes cheaper
- Captures interactive effects

Weaknesses

- Can you identify the factors that influence energy use and create a model?
- Cannot determine ECM level results
- Can you see the savings at this level?
- Possibly complex non-routine adjustments

Whole Facility Approaches

Physical (Option D)

Strengths

- Whole Facility AND ECM level impacts determined
- Allows for 8760 impact curve
- Captures interactive effects
- Can perform M&V on complex ECMs and new construction
- Can be used for ongoing energy management

Weaknesses

- Can you identify the factors that influence energy use and create a model?
- Complex to build and calibrate adequate models
- Requires specific skills
- All parties must understand the model

Example 1 – Situation

- Hotel / Resort
- M&V Plan Included Energy Model
- "Option C" selected for contract
- Baseline data on end uses (HVAC)

Example 1 - Issues

- Baseline period was pre COVID
- COVID altered guest
- Contractor did not
- “Savings” appear, due to reduced operation

Example 1 - Resolution

- Detailed post –audit operations
- Update the Energy Model
- Change from Option C to Option B

Example 2 - Situation

- Schools and mosques
- HVAC replacement and lighting
- "Option B" selected for contract
- Small savings for each project
- Requires dedicated sub-metering

Example 2 - Issue

- Sub-metering expensive
- Cost prohibitive for every site

Example 2 - Resolution

- Measure only a sample
- Apply sampling rules to hit target for confidence level and confidence interval

Example from longtime M&V

DON's New Approach to Measurement and Verification

Federal ESPC Steering Group Meeting
May 11th, 2016

Daniel T. Magro
DON ESPC Team Lead

DON's Historical Approach to M&V



- Stipulated savings in many cases
- Assumed most of the Operations and Maintenance Responsibilities
- Set up M&V procedures that make it nearly impossible for the contractor to fail
- Incorporated contractor's full DES into final task order
- Does this sound familiar?



DON's Historical Approach to M&V



- Has this happened to you?
 - An ECM breaks, and upon further review of the incorporated DES you discover that the O&M responsibilities are either very limited or unclear.
 - Like a set number of PMs, or
 - R&R limited to just one failure per part, or
 - Only good until the warranty expires, or
 - Different sections conflict with each other.



DON's Historical Approach to M&V



- How about an ECM that breaks and the contractor informs you that they don't need to repair it because they are meeting the contracted savings from the other 5 ECMs they installed.



Navy ESPC M&V

- Our Gov't-drafted task orders are set up in two sections, one for construction and one for performance period services.
- We (usually) do not allow models for M&V purposes
- We do not allow adjustments to baselines
- We no longer stipulate savings

US NAVY M&V Lessons Learned

The guarantee must address both efficiency and availability

We now require a non-monetary, measurable performance guarantee for each ECM.

The guaranteed performance (and thus M&V) is then tied to the key parameter affecting the savings

We then remove all weather, operations and other third party effects from the M&V process / methodology

So we now measure the contractor and not chase savings
(because you can't measure savings anyway)

And we penalize for failure (non-availability) without allowing other excess savings to cover the "breakage."

And we limit the M&V report to 50 pages.

M&V Experience – KSA / Tarshid

- Five-year-old Super ESCO program
- Adopted Saudi M&V Guide
 - Based on “standard” FEMP/ IPMVP options
- Implemented now in > 100 projects
- Learning curve for all participants
- Similar issues to US NAVY – **non-routine** adjustments can be costly to implement

Lessons Learned from Dispute Resolution

The Standard Methods

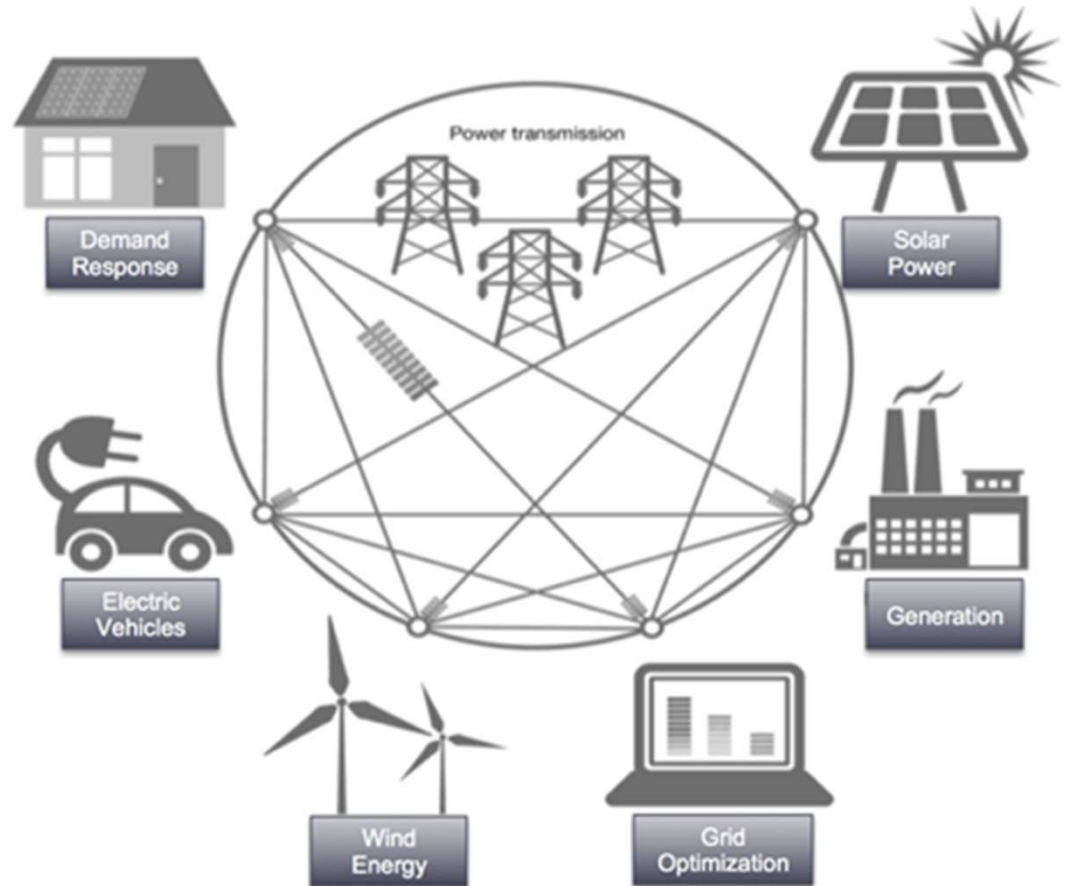
- Negotiation
- Mediation
- Arbitration
- Litigation
- And a side note on Dispute Resolution Boards

Typical Causes of Disputes in ESP Contracts

Issue	Contractor	Host/Owner/Facility
Scope of work - technical	Vague specifications for how to integrate with existing equipment	Existing systems not up to code or not amenable to adaptation
Scope of work – M&V	Full baseline data not collected or archived	Full M&V process not specified and/or followed
Scope of work – O&M	Does not perform routine maintenance	Does not perform routine maintenance!
Non-Routine Events	Does not perform regular audit	Responsibility for reviewing conditions not specified in contract=

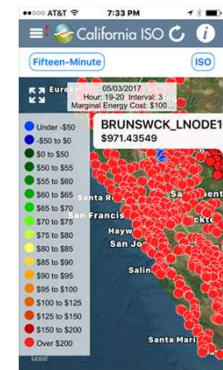
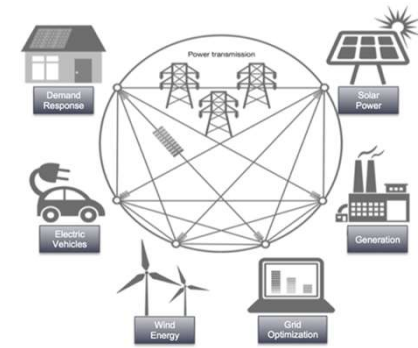
How does M&V account for a changing world?

- Electric Vehicles
- Electrification
- Greenhouse gas reduction activities/projects
- Grid -Integrated Resource Planning requirements



The Future - 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



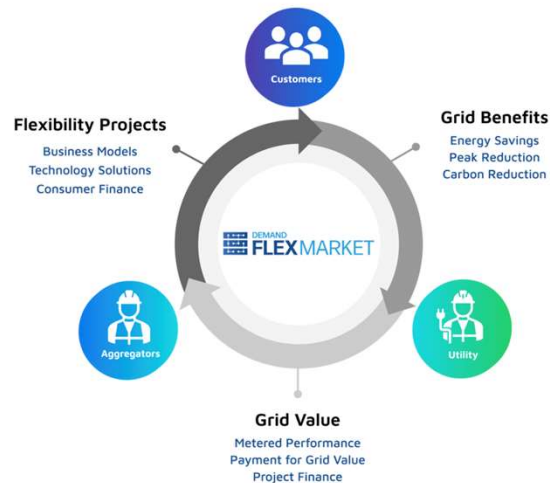
Flexibility is the Future

- California, other US States, EU and elsewhere
 - Adopt a “Whole Facility” method.
 - Collect baseline data for one year (hourly)
 - Compare to one year post project
 - Determine hourly savings (load shape)
- Provides financial incentives for reducing AND shifting loads (hence, Flexibility)

Flex Markets – Future of M&V?

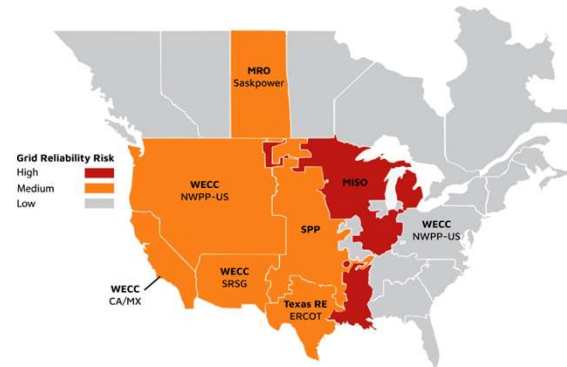
What is FLEXmarket?

FLEXmarket is a user-friendly demand flexibility platform that pays aggregators for the virtual power plant and value being delivered to the grid. Rather than focusing on traditional "measures," FLEXmarket determines outcomes at the meter using transparent open-source M&V and pays aggregators for those delivered outcomes helping them capture more revenue for the work they're already doing. [Find a FLEXmarket in your region and get started.](#)



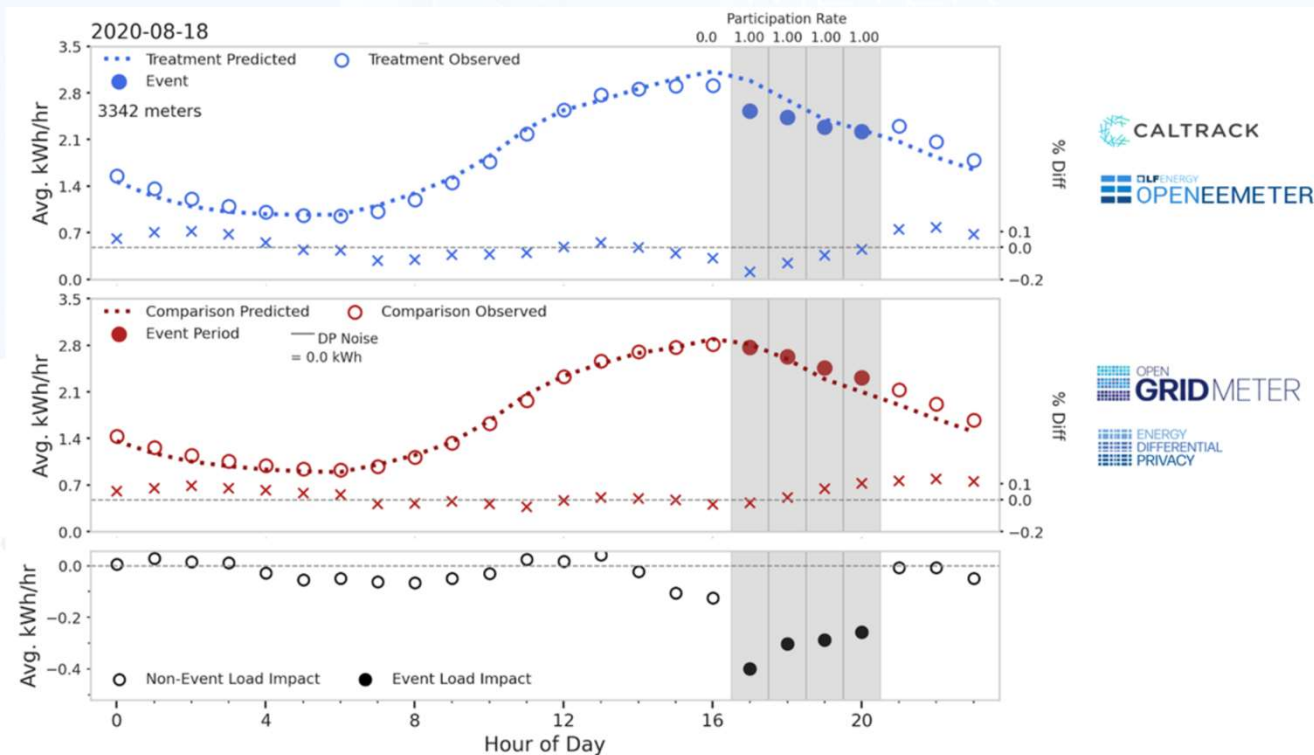
The Virtual Power Plant Solution

Grid reliability is a growing problem affecting millions across the globe. As we accelerate towards decarbonization, the balance between supply of energy and demand is becoming increasingly difficult to manage. A virtual power plant pools the collective power of smaller distributed energy resources. Managing demand through virtual power plants can help both stabilize the grid and enable cost savings for end use customers. [Learn more about our virtual power plant solution.](#)

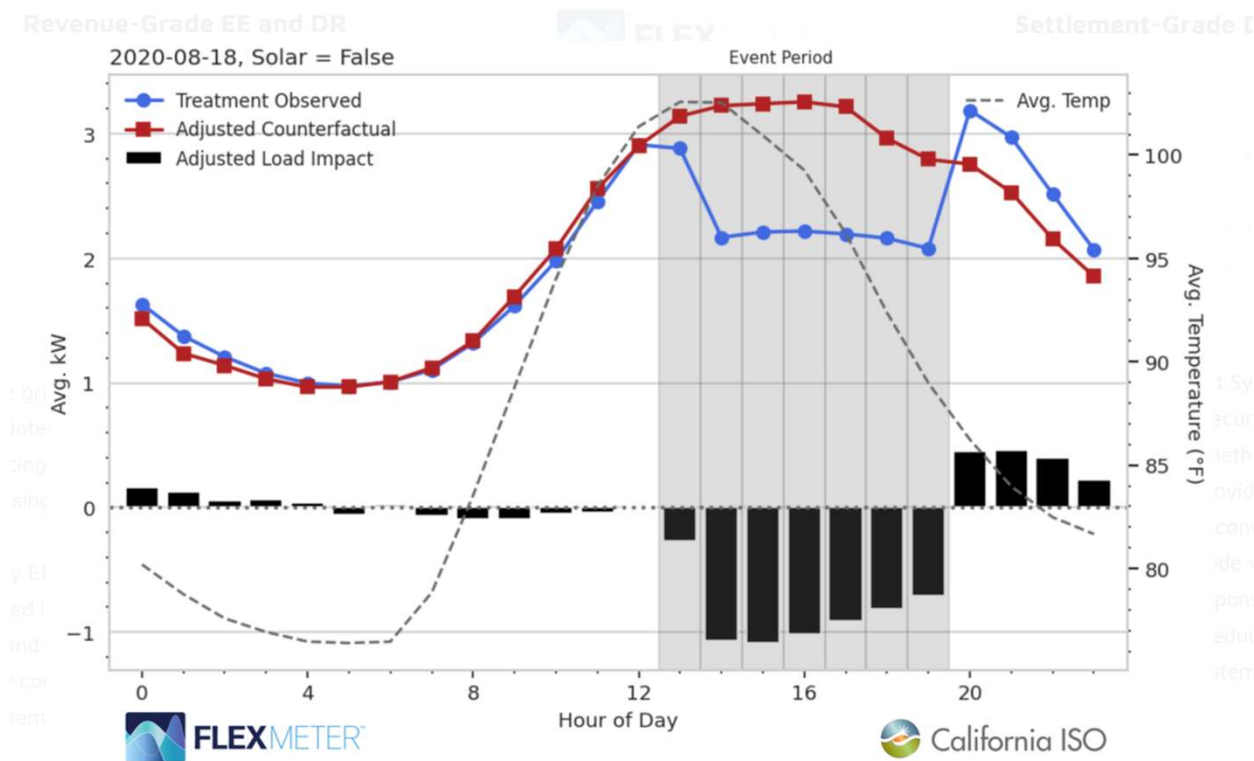


"Why are blackouts looming? Blame extreme weather, not wind and solar" Canary Media 2022

Flex Markets – Future of M&V?



Flex Markets – Future of M&V?



Best Practice of EPC M&V

- Program develops or adopts a **specific M&V application**
 - Detailed definitions of “savings” per contract terms
- **M&V Plan** written by a **certified professional** CMVP/PMVA
- M&V Plan reviewed by CMVP/PMVA for **each stakeholder**
- M&V requirements are coordinated with the:
 - Contract – all terms
 - Program – all requirements
- M&V activities and reports reviewed by **all stakeholders**

Certification of M&V Personnel

- The best defense against “issues” in M&V is having all parties utilize trained professionals
- Currently two main “M&V” Certifications
 - AEE / CMVP
 - EVO / PMVA, PMVE



Training Goals

To raise the professional standards of those engaged in measurement and verification (M&V)

To enable you to quantify the energy usage impacts of energy management activities.

To prepare you for the certification examination.

Day 1

- Fundamental Concepts
- Contextual Considerations
- Fundamental Performance Measurement Approaches

Day 2

- Basic Concepts in Statistics
- Defining a Baseline and Incorporating Adjustments
- Whole Facility Approaches
- Retrofit Isolation

Day 3

- Planning
- Metering Considerations
- Rounding and Significant Digits
- Reporting



Study Guide/Body of Knowledge

Topic	Percentage of Exam
Fundamental Concepts in Measurement and Verification	10–15%
Contextual Considerations and the CMVP	5–10%
Fundamental Performance Measurement Approaches	5–10%
Defining a Baseline and Incorporating Adjustments	10–15%
Whole Facility Approaches	10–15%
Retrofit Isolation Approaches	10–15%
Planning	5–10%
Metering Considerations	5–10%
Savings Reporting	5–10%



CMVP Scheme

8	Modeling Concepts and Application (9-13%)
801	Counter-factual method
802	Types of modeling and simulations
803	Applications of modeling and simulation
804	Sampling
805	Uncertainty
806	Rounding



CMVP Scheme

9	The CMVP® - Contextual Considerations (6-10%)
901	Professional judgment
902	Wider world of professionals
903	Guiding principles
904	Contractual considerations
905	Contextual considerations



CMVP Scheme

2	Fundamental Performance Verification Approaches (9-13%)
201	Introduction to retrofit isolation and whole facility
202	Periodic verifications
203	Commercial
204	Residential
205	Metering considerations
206	Uncertainty issues for savings determination
207	How to define savings



CMVP Scheme

Body of Knowledge / Duties and Tasks (% Exam)	
1	Basis for Adjustments (10-16%)
101	Defining the measurement boundary
102	Considerations for developing a valid baseline
103	Identification of significant parameters for measurement
104	Impact of external requirements
105	Defining a common set of conditions for determining savings
106	Applying routine adjustments
107	Non-routine events and non-routine adjustments
108	Utility programs



CMVP Scheme

3	Retrofit Isolation Approach (11-17%)
301	Simplified Measurement approaches
302	Identifying & defining parameters for estimation
303	Interactive effects to Section 3
304	Enhanced measurement approaches
305	ID significant parameters for retrofit isolation measurement
306	Advanced modeling methodologies for retrofit isolation
307	Use of calibrated simulations and physics-based models
308	Appropriate applications
309	Uncertainty Issues for savings determination



CMVP Scheme

4	Whole Facility Approach (10-16%)
401	Identifying and measuring significant parameters
402	Identifying and monitoring Static Factors
403	Advanced modeling methodologies for whole facility
404	Metering issues
405	Uncertainty assessment for savings determination
406	Facility interactions
407	Use of calibrated simulations and physics based models
408	Appropriate applications



CMVP Scheme

5	M&V Planning (12-18%)
501	Methods for developing M&V plan contents and requirements
502	M&V protocols & guidelines
503	Cost benefit comparison – contextual considerations
504	Contractual requirements
505	Baseline development
506	M&V plans and adherence
507	IPMVP® – adherent process
508	Industrial applications – roll up to planning?
509	Operational verification
510	Determining plan requirements



CMVP Scheme

7	Metering and Considerations (6-8%)
701	Methods of measuring – electrical / thermal / flow
702	Planning
703	Accuracy
704	Systems
705	Calibration
706	Costs of Data
707	Safety



CMVP Scheme

6	Savings Reporting (6-10%)
601	Deviation from M&V plan
602	Valuations, tariff calculations
603	Methods for evaluating emissions
604	Maintenance savings
605	Identifying & implementing non-routine adjustments
606	CO ₂ credits



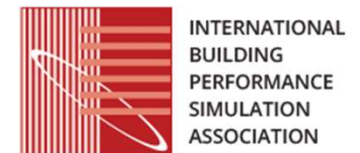
Typical CMVP Job Titles

- Strategic Energy Management Specialists
- Energy Engineers and Managers
- Energy Efficiency Consultants
- Sustainability Managers
- Resource Efficiency Managers
- Project Development Engineers



Conclusion

- M&V is based on science, engineering and evidence. But..
- M&V is a process which requires professional judgment for each specific project.
- The global M&V community has a strong foundation in using counterfactual and performance methods for quantifying efficiency project results
- Experience has shown that proper preparation, including utilizing certified M&V professionals can help avoid conflicts
- Careful attention to M&V will lead to successful settlement of project results



Thank you

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COUNTERFACTUAL
DESIGNS