Practical Experiences in Applying Savings M&V

By

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Program

10:00-10:25 Introduction and Presentation of EVO

10:25-11:00 Overview of IPMVP

11:00-11:30 How to apply IPMVP's Options

Break

11:45-13:00 Project examples and Calculations

14:00-15:00 Q&A and Conclusion

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Introduction and Presentation of EVO

Introduction

Your Trainer:

Pierre Baillargeon p.eng.

- Professional Engineer (Energy Engineer)
- Vice President of Econoler International
- Certified Measurement and Verification Professional (CMVP) from the association of energy engineers

Introduction

Why Measure and Verify?

- Accurately assess energy savings for a project
- Reduce uncertainties to reasonable levels
- Allocate risks to the appropriate parties
- Monitor equipment performance
- Find additional savings, avoid savings deterioration
- Improve operations and maintenance (O&M)
- Verify cost savings guarantee is met
- Account for variances from energy budget
- Educate facility users
- Identify cash flow for financiers

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Introduction

- M&V is an evolving science, although common practices exist
- These practices are documented in several guidelines, including
  - The International Performance Measurement & Verification Protocol, (IPMVP Volumes I, II and III)
  - U.S. FEMP M&V Guidelines: Measurement and Verification for Federal Energy Projects Version 2.2 (2000)
  - ASHRAE Guideline 14: Measurement of Energy and Demand Savings (2002)

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EVO

Efficiency Value Organization (EVO)

www.efficiencyvaluation.org

- The home of IPMVP
- Formed in 2004, formerly IPMVP Inc, a non-profit U.S. based corporation
- Provides tools to help energy efficiency projects be valued on the same basis as new energy supply projects

EVO

- **EVO Vision**

  A global marketplace that correctly values the efficient use of natural resources and utilizes end-use efficiency options as a viable alternative to supply options

- **EVO Mission**

  To develop and promote the use of standardized protocols, methods and tools to quantify and manage the performance risks and benefits associated with end-use energy efficiency, renewable energy, and water efficiency business transactions

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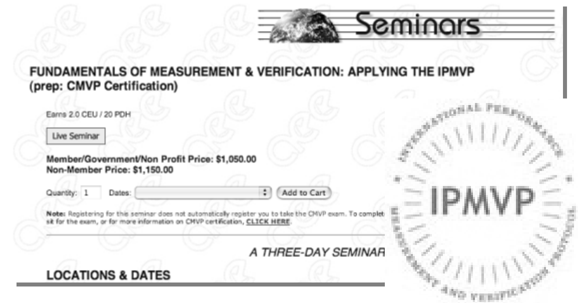
- **Protocols**
  - Industry Standards

- **Training, Certification**
  - In partnership with many organisations



- **Building Community, Promoting Efficiency**
  - USGBC - US Green Building Council - LEED
  - Metering International
  - Power Measurement - Webinars
  - APEC - IEEFP
  - **C*oming soon* - EVO subscriber services**

Overview of the International Performance Measurement & Verification Protocol (IPMVP)

IPMVP - Overview

- Created by an international committee to standardize the M&V approaches for owners and financiers of multiple ESCO projects
- Developed and managed by EVO Inc.

available free

www.ipmvp.org

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IPMVP - Overview

- IPMVP presents a **framework** and **defines terms** needed in determining energy savings after implementation of a project.
- IPMVP specifies the contents of the **M&V Plan** that must be prepared for each specific project.
- IPMVP **allows flexibility** in creating M&V Plans for individual projects, while adhering to the principles of accuracy, transparency and repeatability.

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IPMVP - Benefits

- Defines standard approaches to “measuring” “savings,” to reassure facility owners.
- Legitimizes ESCO projects though international recognition of their “cash register.”
- Enables logical discussion of the trade-off between measurement “accuracy” and measurement cost.
- Helps parties to create transparent, repeatable performance contract terms regarding savings settlement.
- Updates the definition of the state of the M&V art through constant evolution.

IPMVP – Other Characteristics

- Translated into more than 10 languages over the last five years
- First published in 1996, and updated periodically (update released may 2007)
- Broad international support and adoption
- The only world standard

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IPMVP

IPMVP does NOT cover in detail:

- Design of meter and instrumentation systems
- Cost estimating of M&V activities

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IPMVP - Documents

- IPMVP Vol. I - **Concepts and Options for Determining Energy and Water Savings.**
- IPMVP Vol. II - **Concepts and Practices for Improved Indoor Environmental Quality**
- IPMVP Vol. III - Applications
  - Concepts and Options for Determining Energy Savings in **New Construction**
  - Concepts and Practices for Determining Energy Savings in **Renewable** Energy Technologies Applications

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IPMVP Key Concepts

IPMVP stands for:

International Performance ***Measurement*** & Verification Protocol

So what do we ***measure***?

IPMVP Key Concepts
Measure?

- Savings are the absence of energy use.
- We can *not* measure what we do not have.
- We do ***not*** ‘measure’ savings!

- We ***do*** measure energy use.
- We *analyze* measured energy use to **determine** savings.

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IPMVP Key Concepts

More than Measurement

The Basic IPMVP Savings Equation:

Savings = Baseline period Energy

- Reporting period energy

+/- Adjustments

IPMVP Key Concepts

Adjustments

- An example of why we need Adjustments:

  An energy retrofit was performed but plant *production is lower* this year than last. How much of the raw 'savings' were due to the retrofit and not the production change?

- To identify the retrofit's effect we must adjust for unrelated changes so we have an "apples to apples" comparison.

- We adjust ("normalize") baseline and reporting period energy use data to a common set of conditions.

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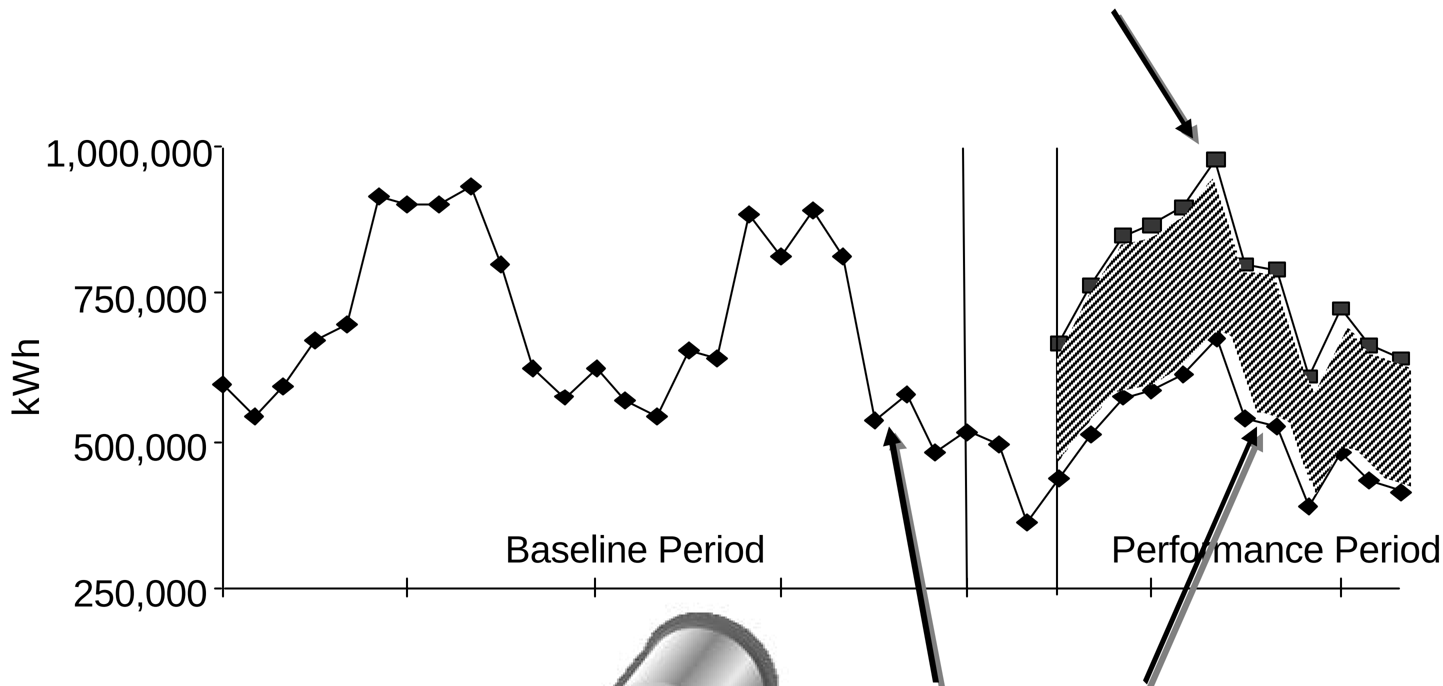
M&V Requires 2 Types of Meters

What Would Have Happened Meter



Watt-hour Meter

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IPMVP Key Concepts

"Cost Avoidance" not "Savings"

- Accountants only use meters and bills to report *Cost Savings.*
- Energy users usually wish to know how much their bills would have been if there had been no energy efficiency action. M&V engineers report such Cost Avoidance by making adjustments.
  - The extent of these adjustments depends on how much you are measuring.

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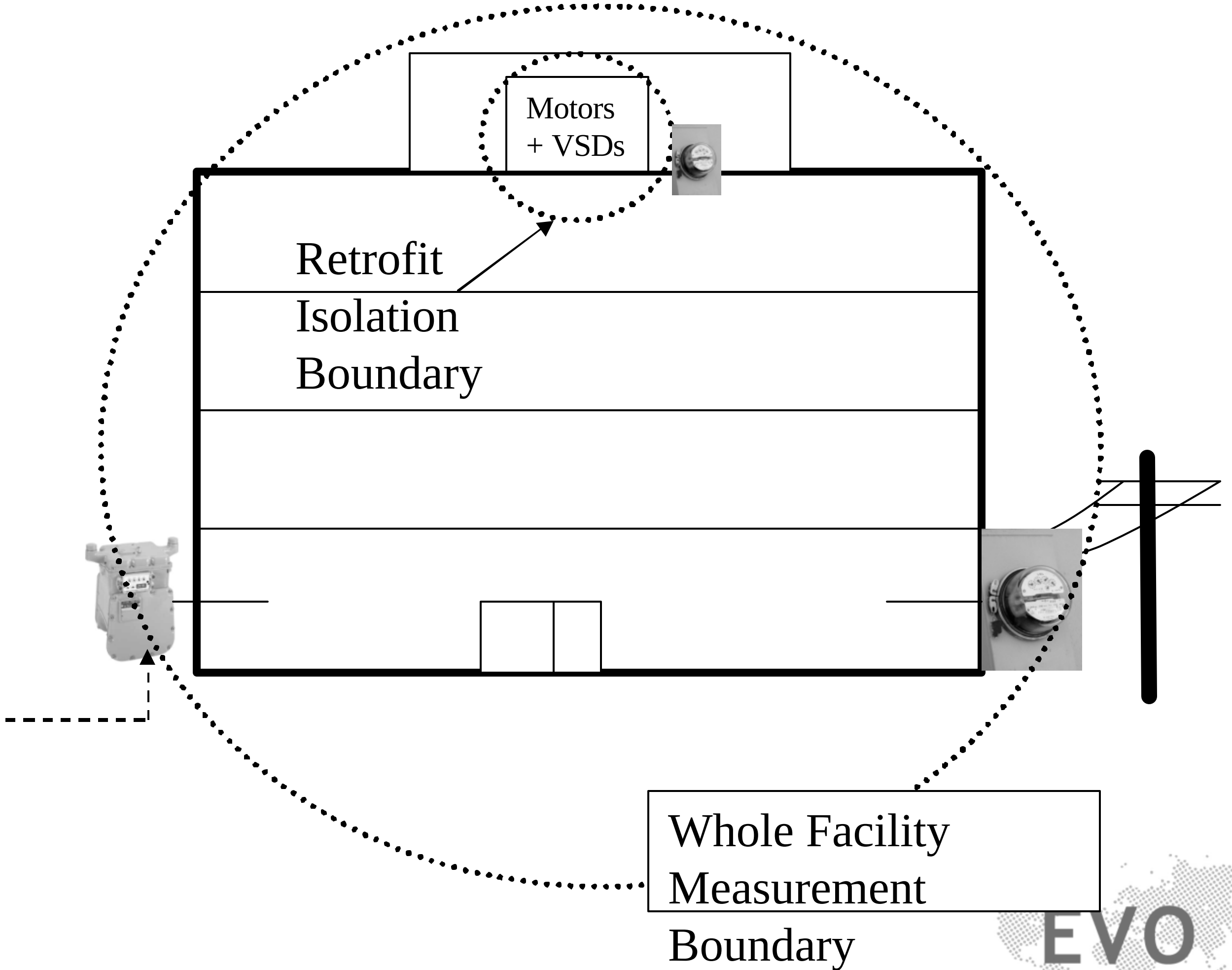
IPMVP Key Concepts

How Much to Measure?



IPMVP Key Concepts

How Much to Measure?

The Whole Facility Method:

Measures **all** effects in the facility:

- Retrofits AND other changes (intended and **un**intended)
- Often uses the utility meter

The Retrofit Isolation Method:

Measures only the retrofitted system

- Unaffected by other changes
- Ignores interactive effects beyond the boundary
- Usually needs a new meter

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IPMVP Key Concepts

How Much to Measure?

Decide what you are concerned about

If you want to assess a particular retrofit:

- use the Retrofit Isolation Method.

If you want to manage your total energy use:

- use the Whole Facility Method.

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IPMVP Key Concepts

How Much to Measure?

Terminology:

- Retrofit Isolation – Option A or B
- Whole Facility – Option C or D

Two flavours of each – to allow flexibility for various situations

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IPMVP Key Concepts

Retrofit Isolation

Select Option A over B based on responsibilities:

A – Retrofit Isolation – key parameters measurement

Allows measurement of just the parameter of performance concern, estimate the other.

B – Retrofit Isolation – All parameters measurement

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IPMVP Key Concepts

Retrofit Isolation

	Option A	Option B
Baseline **measurement**	400 kW	200,000 kWh
Reporting period **measurement**	300 kW	150,000 kWh
Estimated operating hours	500 hrs	
Avoided Energy	100 x 500 = 50,000 kWh	50,000 kWh

A – measure only part of the energy computation, for example:

- a contractor is only responsible for a load reduction (or only responsible for a reduction in operating hours, but not both)

B – measure all factors governing energy use, for example:

- a contractor is responsible for controls which optimize both load and operating hours.

IPMVP Key Concepts

Retrofit Isolation

Option A (Retrofit Isolation – Key parameters measurement) allows a possible reduction in measurement cost, but introduces some inaccuracy.

All parties must accept the inaccuracy associated with the estimate.

The choice between A and B allows flexibility to suite the situation.

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IPMVP Key Concepts
Whole Facility?

Select Option C over D based on availability of data.

C – Whole Building
Need both baseline period and reporting period data

D – Calibrated Simulation
When there is no meter in the baseline (or no building), baseline data can be manufactured under controlled circumstances. We will not discuss this option further.

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IPMVP Key Concepts

Whole Facility - Example

• Baseline Electricity Bill	
July 1999	800,000 kWh
• Reporting per. Electricity Bill	
July 2001	600,000 kWh
Gross difference	200,000 kWh
• Adjustment for meter reading period length and weather	+100,000 kWh
• Avoided Energy =	300,000 kWh

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IPMVP – Summary of Options

- The IPMVP has four M&V methodologies: Options A, B, C, and D
- The options are generic M&V approaches for energy and water saving projects.
- Four options provide a range of approaches to determining energy cost avoidance, depending on the characteristics of the ECMs being implemented, and balancing accuracy in reporting with the cost of conducting M&V.

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How to Apply IPMVP's Options in Practical Ways

M&V Options - Practical Application

Regardless of the Option followed, similar steps are taken to “measure & verify” “savings:”

- Step 1: Gather the baseline data (energy and operating conditions).
- Step 2: Develop a Project Specific M&V Plan.
- Step 3: Verify the proper equipment/systems were installed and are performing to specification. Calibrate meters.
- Step 4: Gather reporting period measured data and compute Cost Avoidance as defined in the M&V Plan.

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M&V Options - Practical Application

Step 1 Gather Baseline Information

- Set the measurement boundary to determine what to monitor, and for how long. Consider factors such as the complexity of the ECM, stability of the baseline data, variability of equipment loads and operating hours, and impacts beyond the boundary.
- Gather physical information within the measurement boundary (equipment inventory and operations, occupancy, energy/demand data, control strategies, and so on). This is part of a normal energy audit.

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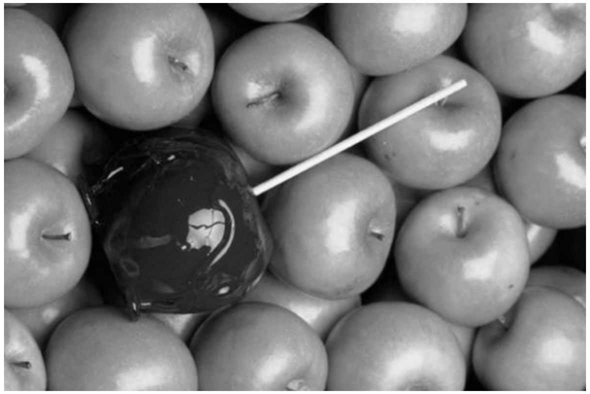
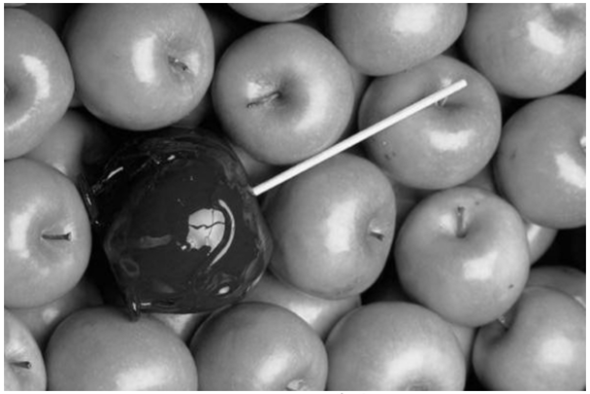
M&V Options - Practical Application

Step 1 Gather Baseline Information (continued)

Baseline information is needed to **adjust** for any changes that may occur during the performance period so we can make an “Apples to Apples” comparison.





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M&V Options - Practical Application

Step 1 Gather Baseline Information (continued)

In almost all cases, after the ECM has been installed, you cannot go back and re-evaluate the baseline. It no longer exists!

It is very important to properly define and document all baseline conditions before the measure is implemented.

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M&V Options - Practical Application

Step 2 Develop Project Specific M&V Plan

The project specific M&V plan includes project-wide items as well as details for each ECM, including:

- Details of baseline conditions and data collected
- All assumptions and sources of data
- What will be verified
- Who will conduct the various M&V activities
- Schedule for all M&V activities
- Analysis of baseline information
- Cost avoidance calculation method to be used

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M&V Options - Practical Application

Step 2 Develop M&V Plan (continued)

- Utility rates and how changes in rates are accommodated
- Expected M&V cost and accuracy
- Responsibilities for reporting facility changes
- Content and format of all M&V reports
- Nature of any expected “baseline adjustments”

M&V Options - Practical Application

Step 3: Verify the proper equipment/ systems were installed and are performing to specification.

- After commissioning, the post-installation activities specified in the M&V Plan are implemented.
- Verification methods may include surveys, inspections, spot measurements, and short-term metering.
- The results of the commissioning and M&V activities are presented in a *Post-Installation M&V Report*

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M&V Options - Practical Application

Step 4: Compute Cost Avoidance

- Monitor the facility (within the measurement boundary) to identify any changes from baseline conditions.
- Gather all data, as defined in the M&V Plan.
- Make all routine or special adjustments needed, as defined in the M&V Plan.
- Compute Cost Avoidance and report, as defined in the M&V Plan.

M&V Options - Practical Issues

Key Variables for M&V Cost Management:

- Meter quality
- Number of independent variables to be monitored
- Frequency of measurement and reporting
- Length of the reporting period
- Sampling, if a lot of equipment to measure
- Other uses of meter information to share costs

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M&V Options - Practical Issues

M&V Cost vs Uncertainty

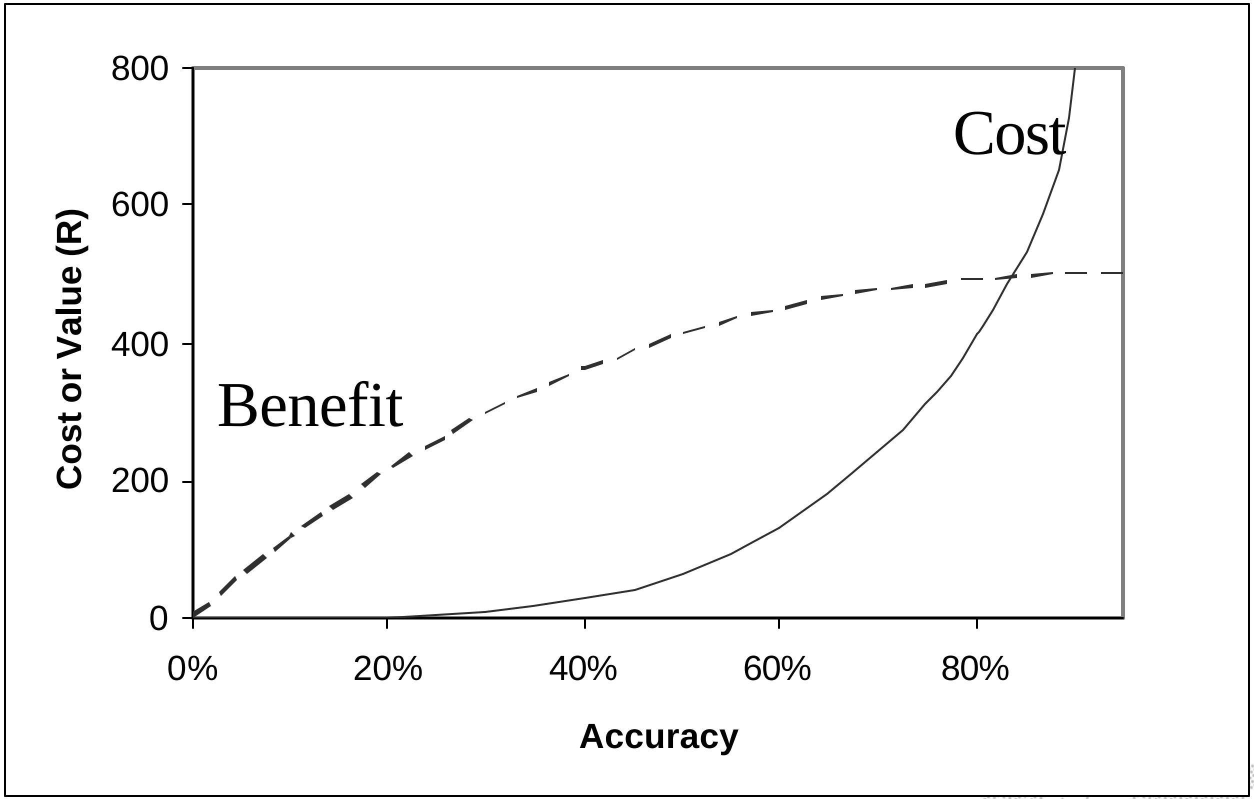
How much Accuracy do you want – or can you afford?

There is no *absolutely* correct savings number.

M&V Options - Practical Issues

The Law of Diminishing Returns

Spend more on M&V for improved accuracy?



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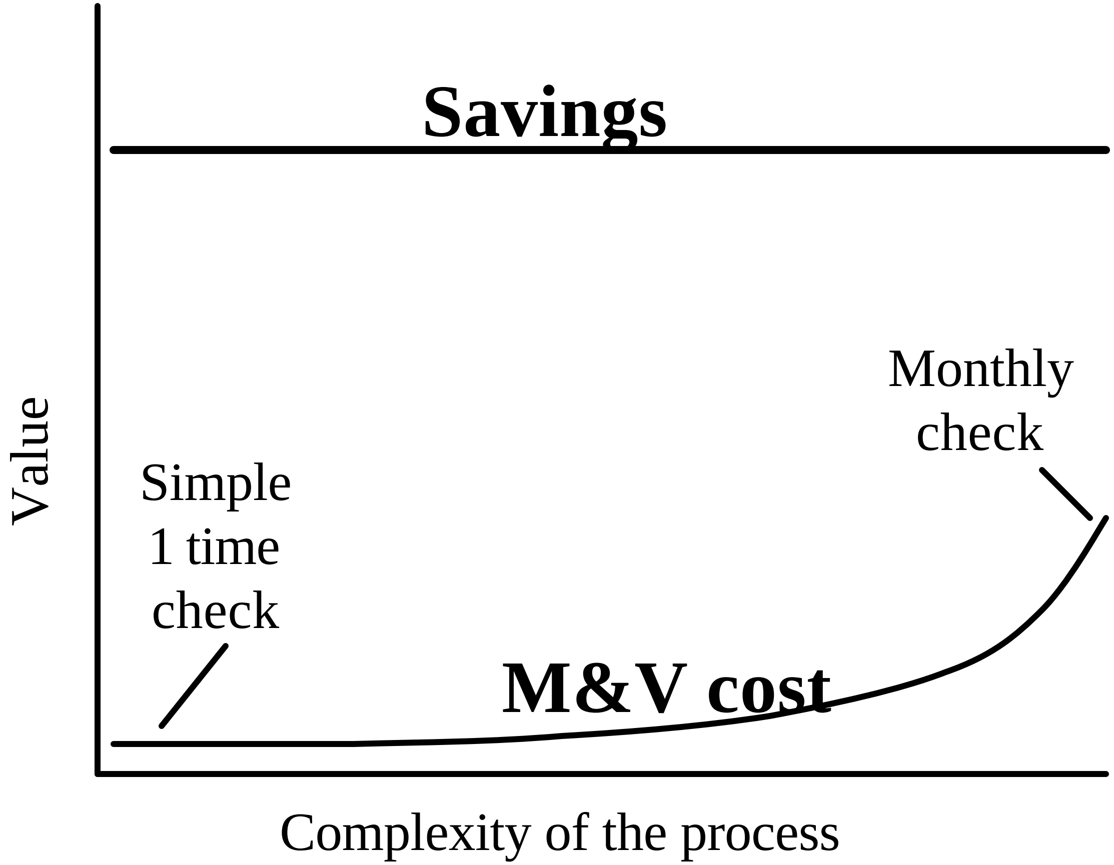
M&V Options - Practical Issues

Limits to M&V Cost



M&V Options - Practical Issues

How Much M&V Is Enough?

Total cost to determine savings should normally be less than 10% of the savings.

M&V Options - Practical Issues

Performance Contracts

- In performance contracts, risks are allocated between the ESCO, Owner and Financier.
- M&V is critical to the success of a contract:
  - maximizes the savings and the persistence of savings over the contract term
  - verifies what savings were achieved and acts as the cash register for the exchange of value
- So design your M&V well, using recognized methods.

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Project Examples in Applying IPMVP

Sample M&V Project

Commercial Building

Energy Conservation Measures	Simple Payback (years)
Lighting retrofit	4.5
Energy efficient motors	5.6
HVAC modifications	5.4
Control system	3.4
Building leakage reduction	2.1
Training and awareness	0.5

Sample M&V Project

Commercial Building

M&V Approach - OPTION C

- Whole facility approach using data from utility gas and electric meters.

- We will analyze baseline gas meter data and compute savings for two months.

Sample Option C

Baseline period Data

Meter Reading	Gas	Heating
Date	Consumption	Degree
February 5, 1991	mcf	Days
March 5, 1991	210,692	650
April 7, 1991	208,664	440
May 6, 1991	157,886	220
June 5, 1991	120,793	150
July 7, 1991	116,508	50
August 7, 1991	107,272	20
September 5, 1991	95,411	14
October 6, 1991	126,423	29
November 6, 1991	149,253	125
December 4, 1991	166,202	275
January 6, 1992	221,600	590
February 5, 1992	224,958	723
Total	**1,905,662**	**3,286**

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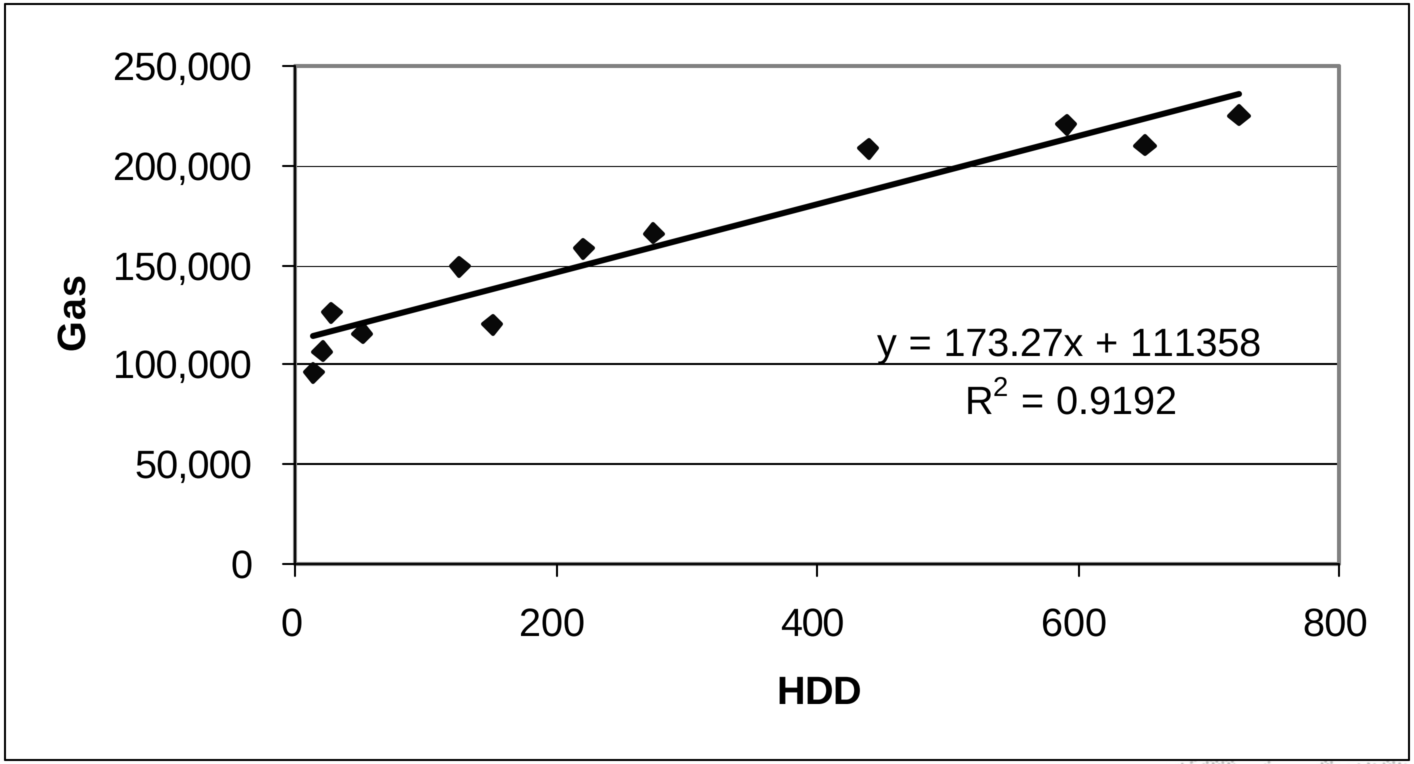
Sample Option C

Baseline Model

Find Gas vs Heating Degree Day relationship:



Sample Option C
Method

For each month after retrofit predict what the baseline gas use would have been under conditions of the current month's weather.

1. Record the current weather (HDD)
2. Plug HDD into the baseline model:

   Gas = 173.27 * HDD + 111,358

3. Compare baseline model's gas with actual post-retrofit gas, to determine avoided gas.

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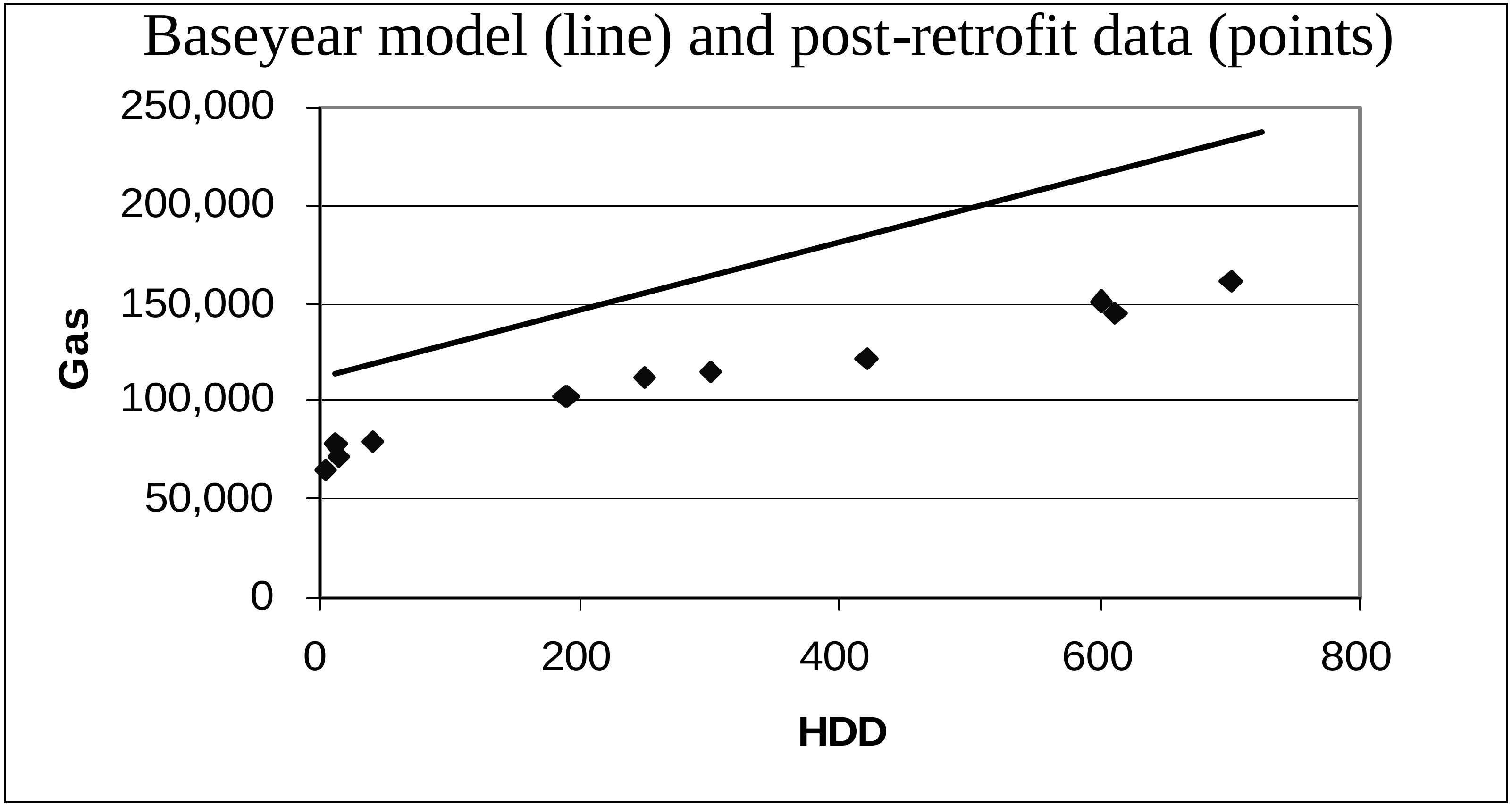
Sample Option C

Graphical Savings



Sample Option C
Computations

Meter Reading Date	Actual Post-Retrofit Data		Projected Baseyear (Wouldavbin)			Savings	
			Baseload	Weather Sensitive	Total	mcf	Value
	Consumption	HDD	Factors				Price
	mcf		111,358	173.27			$ 6.232
March 6, 1994	151,008	601	111,358	104,135	215,493	64,485	$ 401,871
April 4, 1994	122,111	420					?
May 6, 1994	102,694	188	111,358	32,575	143,933	41,239	$ 257,001
June 5, 1994	111,211	250	111,358	43,318	154,676	43,465	$ 270,874
July 5, 1994	80,222	41	111,358	7,104	118,462	38,240	$ 238,312
August 6, 1994	71,023	15	111,358	2,599	113,957	42,934	$ 267,565
September 8, 1994	65,534	5	111,358	866	112,224	46,690	$ 290,972
October 9, 1994	77,354	12					?
November 4, 1994	103,000	190	111,358	32,921	144,279	41,279	$ 257,251
December 10, 1994	115,112	300	111,358	51,981	163,339	48,227	$ 300,551
January 7, 1995	160,002	700	111,358	121,289	232,647	72,645	$ 452,724
February 4, 1995	145,111	612	111,358	106,041	217,399	72,288	$ 450,499

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Sample Option C
Best Applications

- Significant energy saving (10% or more of consumption on the utility meter)
- All parameters significantly affecting energy usage can be clearly identified (baseline and after implementation)
- Adjustments factors are simple
- Individual ECM measurement not required
- Multiple ECMs
- Complex ECMs
- Soft savings measures included (training, awareness)

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Option C summary

Whole Facility

Advantages:

- Evaluates performance of the entire facility
- Interactive effects between EE measures

Disadvantages:

- No separation of the impact of different ECMs
- Not a saving control method, since normal unexplained total facility energy variations may obscure individual months' savings. However the method provides annual reconciliation.

Sample M&V Project

Textile Mill in India

Energy Conservation Measures	Simple Payback (years)
Ventilation pre-heat	2.2
Pumping power reduction	2.8
Compressed air leakage reduction	3.3
Waste water aeration optimization	3.3
Steam condensate optimization	2.2
On-site power generation upgrade	2.9

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Sample M&V Project

Textile Mill

ECM	Item Measured	Level Measured	How often Item Measured
Ventilation pre-heat	Steam	100%	Continuous
Pumping power reduction	kW, kWh	100%	Continuous
Compressed air leakage reduction	kW, kWh	100%	Continuous
Wastewater aeration	kW, kWh	100%	Continuous
Steam condensate	Steam	100%	Continuous
On-site power generation	kW, kWh	100%	Continuous

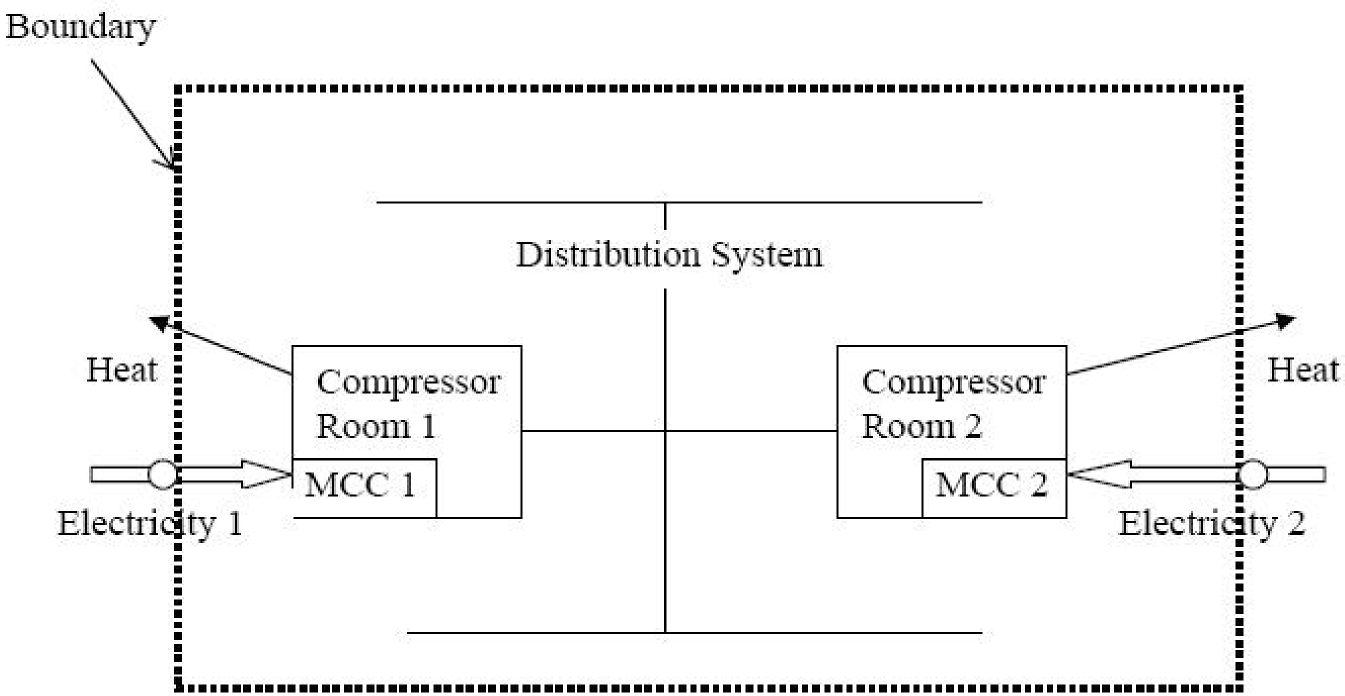
Sample M&V Project

Retrofit Isolation

- Many aspect of the plant are changing and not relevant to the performance of an ESCO – so retrofit isolation is needed.
- Determine savings in the compressed air system:
  - Continuous measurement needed to demonstrate continuous performance, so use **Option B.**

Sample M&V Project

Measurement Boundary



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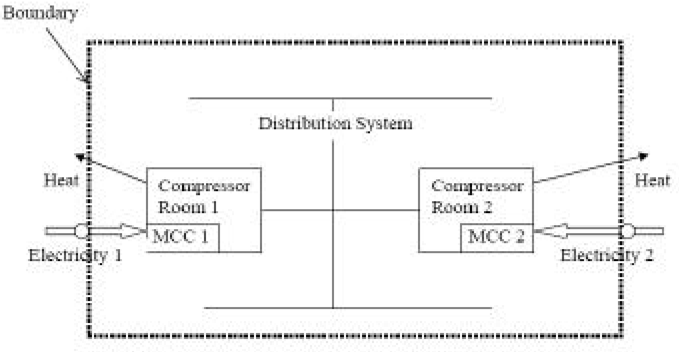
Sample Option B
Measurement Boundary



To set the measurement boundary, decide:

1. What affects energy use *inside* the Boundary?
   – Mill operating hours (mill either operates steadily or is shut down)
   – Leakage in compressed air distribution system
2. What energy effects happen *outside* the boundary?
   – less heat rejected from compressor room

Sample Option B

M&V Plan

Baseline period:

1. Measure compressor plant electricity consumption (kWh) continuously for a month
2. Determine mean energy use per operating hour and non-operating hour.

Reporting period:

a) Measure compressor plant electricity consumption (kWh) continuously

b) Model baseline energy for each hour from baseline test (2)

Cost Avoidance

Compute the difference between a) and b)

Sample Option B

Baseline Test

Averaged over the one month period of baseline test:

Mode	Energy Use (kWh/hr)
Mill ON (operating)	140.3
Mill OFF (not operating)	102.3

* Energy use is constant in each mode.

Baseline Energy = (140.3 * ON hrs) + (102.3 * OFF hrs)

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Sample Option B

2003 Reporting period Data

	Plant Hours		Actual
	On	Off	Energy (kWh)
January	496	248	61,005
February	448	224	52,321
March	496	248	61,987
April	480	240	59,921
May	496	248	60,111
June	480	240	60,191
July	200	544	50,345
August	496	248	62,255
September	480	240	58,765
October	496	248	61,178
November	480	240	59,232
December	150	594	48,822

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Sample Option B

2003 Energy Avoidance

During 2003, no new machines were added and no modifications were made to existing machines affecting their use of compressed air.

Test: What is the Energy Avoidance for January?

Sample Option B
Best Applications

- Contractor is responsible for all aspects of energy use in the system that was retrofitted.
- On-going measurement required to verify savings methodology is still in place.
- Meter maintenance cost insignificant relative to savings.
- Few changes are expected from baseline conditions.

Option B
Retrofit Isolation

Advantages:
- Savings correlate with process changes
- Actual savings verified with metered usage
- Provides operational feedback

Disadvantages:
- Can be expensive to install and maintain meters
- Not reconciled to total energy costs
- Difficult to establish baseline loads for varying process and energy consumption levels

Conclusions

- Carefully crafted M&V Plans are a key tool in demonstrating performance in risky projects.
- The M&V approach selected should balance the desire for accuracy with cost to install and maintain M&V activities.
  - More complex ECMs may require more complex and expensive M&V methods to determine energy savings
  - M&V costs should not normally exceed 3-5% of project cost

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Conclusions

- M&V is the only approach that shows the return on energy efficiency investments ("ROI").
- EVO's IPMVP can play an important role in the development of the ESCO industry because it provides credibility for M&V activities.
- EVO also provides training and certification to help develop M&V expertise.

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