PN-ACQ-189

# ECO

## Energy Conservation and Commercialization Project

## A Program of USAID, Ministry of Power and ICICI

# Report On Executive Seminar on Measurement & Verification Protocol for Energy Efficiency Projects: Need and Issues

**December 2000**

**Activity 3**
**Milestone 3A**

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**Preface**

This report is part of the deliverable for Milestone 3A, Conduct 2 workshops on *international examples of Measurement and Verification* (M&V) protocols, of the ECO project. The report covers work done under this Milestone from September 2000 through December 2000.

The ECO project is being implemented by Bechtel National Inc (Nexant Inc) under a USAID contract, LAG-I-00-98-0000. This contract has been issued by the *USAID* Mission in New Delhi as a part of the IQC (Indefinite Quantity Contract) currently in place through USAID's Global Bureau. The project contract was signed on February 29, 2000, and continues through December 2003.

## Executive Summary

Two one-day workshops were held in Mumbai and Delhi. The purpose of these workshops was to provide an overview of existing M&V protocols and how the IPMVP might be adapted and applied to conditions unique to the Indian energy services industry.

Discussions at both workshops indicated that a more formal treatment of savings estimation was required to raise the industry status and promote industry growth. How such procedures were to be implemented was the topic of considerable discussion. Consensus opinion was that protocols adopted should be voluntary 'guidelines' and not regulated 'protocols'. This is essential to retaining flexibility so that the three interested parties in a project (ESCO, customer, FI) could use the most cost-effective approach that satisfies all parties. Discussions also indicated that participants preferred application of Protocol to be energy conservation measure, M&V approach, and fuel neutral.

The participants also realized that in order for the guidelines to be relevant, they need to be maintained and improved based on user feedback. This requires finding them a 'home', an organization that can be responsible for incorporating suggestions and revising them as needs are identified. Potential candidates included the Bureau of Energy Efficiency.

The main recommendation emerging out of these workshops was that the draft protocols being developed incorporate the suggestions and concerns indicated above. In addition, the recommendation was that the draft protocol being developed should attempt to address situations presently unique to the Indian energy-services industry, could be in the nature of voluntary guidelines, should attempt to remain neutral with respect to fuel source, technology application, M&V approach (not favoring one method over another), and market sector.

# Main Workshop Report

## 1.0 *Introduction*

A one-day workshop was held (at two different locations) within the context of the ECO project. The ECO project, in the main, aims to promote widespread commercialization of energy efficiency technologies and services in India by assisting stakeholders and institutions that are involved in developing, designing, constructing, implementing and operating energy efficiency projects ("Markets" component of ECO project), and by assisting government agencies and institutions in creating a supportive market environment for the commercialization of energy efficiency ("Policy" component of the ECO project).

The workshop forms an integral part of the larger activity which is under the "Markets" component of the ECO project, and which aims to provide support to energy efficiency service industry. The specific purpose of these two workshops was to provide an overview of existing M&V protocols and how the IPMVP might be adapted and applied to conditions unique to the Indian energy services industry.

The workshop, entitled "Executive seminar on M&V protocol for energy efficiency projects: need and issues" was held as scheduled in Mumbai on 5 December and in New Delhi on 11 December 2000, under joint responsibility of Nexant, Schiller Associates and local subcontractors Intesco Asia Limited. Both sessions of the workshop, which had identical content, achieved or exceeded the minimum attendance levels and were very well received by participants. The workshop participant profile, structure, conclusions and recommendations, and feedback from participants are summarized below.

## 2.0 Participant Profile

The workshop held in Mumbai was attended by 31 participants, while the workshop held in New Delhi had 30 participants. This met the target class size, which was intended to have a minimum of 15 at each location. While detailed list of participants is enclosed in Section C, summary profile has been provided in the Table below.

These workshop sessions were intended to attract a broad range of participants, including representatives from ESCOs, consulting firms, financial institutes, end-users, private utilities, and government ministries. It was felt that these were the people and decision-makers that would be most receptive to the ideas being promoted here. By including end-users and financial institutes, it was felt that all parties could see the benefit of increased measurement & verification standards.

Majority of the participants were either owners, CEOs or belonged to the top management team of their respective organizations. Others too were sufficiently experienced and belonged to the senior management level of their respective organizations. This participant profile helped in having lively and engaging discussions.

*Table Showing Participant profile*

| Category | Number of Participants : Mumbai | Number of Participants : New Delhi |
|---|---|---|
| ESCOs | 9 | 2 |
| Energy Efficiency Consultants/Auditors | 5 | 8 |
| Industry Associations | 0 | 2 |
| Policy Makers | 0 | 2 |
| Institutions/NGOs | 0 | 2 |
| Financial Institutions | 4 | 1 |
| End-Users | 8 | 5 |
| Utility | 2 | 2 |
| Others | 3 | 6 |
| **Total** | **31** | **30** |

Marketing of the workshop was by invitation. As mentioned earlier, the audience specifically targeted were: ESCOs, end-users, financial institutes, utilities, policy makers, and energy efficiency consultants. Invitee and attendance lists from previous ECO workshop and a Council of Energy Efficiency Companies (CEEC) database provided the initial contact point. Clients of major ESCOs, and firms/companies short listed under national energy conservation award scheme were also targeted to enhance end-user participation. In addition, individuals and firms from industry associations, academic/research institutions & NGOs, were also invited for the two workshop events. Nexant handled workshop marketing and logistical aspects.

## 3.0 Workshop Structure & Report on the Two Workshop Sessions

These one day workshop sessions in Mumbai and Delhi were scheduled to be conducted one day prior to three day training course on M&V protocols. The basic aim of these workshops and training sessions was to introduce the participants with the International Performance Measurement & Verification Protocols (IPMVP) and to provide initial training on established M&V approaches with a view to sensitize all interested parties into the benefits of more rigorous savings estimation in order to make energy-efficiency projects appear as attractive financial investments instead of construction-lending projects

Keeping in mind the proximity of the two events (workshop and training course), the workshop sessions were carefully structured to provide an overview of existing M&V protocols and how the IPMVP might be adapted and applied to conditions unique to the Indian energy services industry.

***Report on the Two Workshops***

The general presentation format offered in Mumbai was followed in New Delhi. Mr. Mark Stetz from Schiller Associates and Mr. R. Vasu and Mr. R. Kumar from Intesco Asia acted as the main resource persons.

Following topics were discussed in the workshop:

- Experience of Indian ESCOs on problems faced in Measurement & Verification (M&V) of savings.
- Overview of performance contracting and related risks, basic M&V methods, and the IPMVP
- International Experience of M&V Protocols: Case studies from Industrial, Residential and Commercial Sectors.
- Open Discussion on applicability IPMVP and adaptation possibilities.
- Concluding remarks.

The workshop(s) opened with a presentation by R. Vasu describing the problems Indian ESCOs face when estimating and reporting savings from energy-efficiency projects. Measurement and verification of savings is a nascent art in India, consequently, there is little emphasis on rigorously or accurately estimating project savings. This leads to uncertainty in the savings estimates and often reduces an energy-efficiency project to a design/build project despite the intentions of the ESCO or consultant. Clearly, ESCOs, consultants, and end-users will all benefit from more formal M&V approaches and education.

R. Vasu and Mark Stetz then presented case studies from the commercial, industrial, and residential sectors showing how existing M&V procedures and protocols in India and the U.S. can be successfully applied to a range of projects.

The workshop then shifted to a discussion of the International Performance Measurement & Verification Protocols (IPMVP) and how they might be applied to the India energy services industry.

## 4.0 Conclusions and Recommendations

From the presentations and comments offered during these two workshops, the following conclusions and recommendations have been drawn.

*Conclusions*

- Need for an M&V protocol was felt important by all the participants.
- Many members expressed that the India-specific protocol needs to be voluntary and holistic, providing guidelines but not dictating approach.
- Application of the protocol needs to be fuel neutral.
- Protocol needs to be energy conservation measure neutral.
- Protocol shall be M&V approach neutral.

The Indian energy-services industry model differs significantly from the American model whereby ESCOs provide both energy-efficiency services and capital funding. The Indian model provides the energy-efficiency services and arranges project financing on the strength of the customer's balance sheet. This shifts the performance (and financial) onto the customer as it reduces the ESCO's or consultant's financial stake in the project. This reduces the attractiveness of projects with simple paybacks exceeding three years. Further, it reduces the incentive for financial institutions to finance energy-service projects because it may not consider them attractive investments. The purpose of introducing M&V protocols was to sensitize all interested parties and stakeholders into the benefits of more rigorous savings

estimation in order to make energy-efficiency projects appear as attractive financial investments instead of construction-lending projects.

Discussions indicated that a more formal treatment of savings estimation was required to raise the industry status and promote ESCO-industry growth. How such procedures were to be implemented was the topic of considerable discussion. Consensus opinion was that protocols adopted should be voluntary 'guidelines' and not regulated 'protocols'. This is essential to retaining flexibility in order that the three interested parties in a project (ESCO, customer, FI) could use the most cost-effective approach that satisfied all parties. It was also felt that the establishment of more formal M&V methods and standards might open the door for the development of third-party M&V companies.

Most of the participants agreed that the IPMVP provided a framework, but added that it lacked specifics as to how to implement the protocol in energy-efficiency projects. Additionally, those who reviewed the IPMVP felt that it placed too much emphasis on electrical savings to the detriment of fuel savings and that it lacked applicability to the Indian industrial sector. These concerns are being addressed in the draft protocols by outlining M&V approaches for typical projects in each sector. Many of the examples have been borrowed from the FEMP[1] guidelines. Direction will be provided to show how to apply different methods to common projects in the industrial and residential sector. This will require continuing development and feedback from ESCOs, consultants, and any third-party M&V firms that might develop.

The participants also realized that in order for the guidelines to be relevant, they need to be maintained and improved based on user feedback. This requires finding them a 'home', an organization that can be responsible for incorporating suggestions and revising them as needs are identified. Potential candidates included the Bureau of Energy Efficiency.

### *Recommendations*

1. The India specific M&V protocols should be developed, it should preferably be in two volumes, with the first volume providing the basic approaches and the second volume focusing on application of basic approaches to various energy efficiency measures in different end-uses and sectors. Emphasis should be examples from industrial.

2. India specific protocols being developed should incorporate the suggestions and concerns raised at the workshop events, e.g. India-specific protocol needs to be voluntary and holistic, providing guidelines but not dictating approach

3. The India specific M&V protocol should attempt to address situations presently unique to the Indian energy-services industry, e,g. should bein the nature of voluntary guidelines, should attempt to remain neutral with respect to fuel source, technology application, M&V approach (not favoring one method over another), and market sector.

[1] Federal Energy Management Program, a U.S. Department of Energy publication describing M&V techniques to be used in federal-sector performance contracting. It is based on the IPMVP.

## 5.0 Participant Feedback

A combination of structured and open-ended questions was used to obtain feed back from workshop participants. While structured responses were sought on aspects such as, workshop content (relevance, coverage, structure), quality of resources persons/faculty, delivery methodology, venue, administrative arrangements, handout material and publicity and invitations; open ended responses were sought on reasons for attending the workshops/expectations from the workshops, extent to which expectations were fulfilled, and follow-up actions planned by the participant in the workshop focus area. A sample feedback form, along with summaries of the responses from each of the two workshops has been enclosed in Section D. The principal conclusions provided from these summaries include the following:

***Goals in attending the course.***

While good number of participants have indicated that the basic purpose for their participation in the workshop sessions was to understand M&V methodologies, their applicability and to know the issues involved, quite a few have indicated that their basic aim was to assess the importance and need for M&V. It was, however, interesting to find some of the participants indicating that they had attended the workshop sessions, basically to learn from and share with other participants the basic requirement of the M&V guidelines. This was perhaps an indication what large number of ESCO representatives present in the workshop sessions wanted from the workshops.

***Extent goals met by the course.***

Generally, the participants claimed that goals had been met.

***Actions to be taken to follow-up the course.***

There was a wide variety of specific responses, some of the interesting ones have been produced below:

- Get the draft M&V protocol and then see how to use it in our own business; Get more information from the web sites discussed in the seminar; and check the possibility of involving 3rd party certification of M&V
- I would like to include the salient features in our energy audit program conducted in the textile mills all over the country
- Be active on the core group to develop the guidelines
- Use the M&V protocol/information gained for more effective energy study/saving study report
- Await M&V protocol document and then discuss with colleagues and implement. Very good tool for EE projects

# Program

## Executive Seminar on Measurement & Verification Protocol for Energy Efficiency Projects: Need and Issues

**Date:** **5, December 2000**
**Venue:** **Hotel President, Mumbai.**

| | | |
|---|---|---|
| 0930 | Registration | |
| | Inaugural Session | |
| 1000 - 1020 | Welcome, Participant and Faculty Introduction | Nexant, Inc. |
| 1020– 1045 | Overview of the ECO Project and Workshop Introduction | Nexant, Inc. |
| 1045 – 1100 | TEA BREAK | |
| 1100 - 1145 | Experience of Indian ESCOs on problems faced in monitoring and verification of savings | INTESCO Asia : Mr. R. Vasu & Mr. R. Kumar |
| 1145 - 1300 | International Experience of M&V Protocols: Case Studies from Industrial, Residential and Commercial Sectors | Schiller Associates: Mr. Mark Stetz |
| 1300 - 1400 | LUNCH | |
| 1400 – 1515 | Open Discussion on Applicability and Adaptation Possibilities | INTESCO Asia : Mr. R. Vasu & Mr. R. Kumar and Schiller Associates: Mr. Mark Stetz |
| 1515 – 1530 | TEA BREAK | |
| 1530 - 1700 | Concluding Remarks | INTESCO Asia : Mr. R. Vasu & Mr. R. Kumar and Schiller Associates: Mr. Mark Stetz |

# Program

## Executive Seminar on Measurement & Verification Protocol for Energy Efficiency Projects: Need and Issues

**Date:** **11, December 2000**
**Venue:** **India Habitat Centre, New Delhi**

| | | |
|---|---|---|
| 0930 | Registration | |
| | Inaugural Session | |
| 1000 - 1020 | Welcome, Participant and Faculty Introduction | Nexant, Inc. |
| 1020– 1045 | Overview of the ECO Project and Workshop Introduction | Nexant, Inc. |
| 1045 – 1100 | TEA BREAK | |
| 1100 - 1145 | Experience of Indian ESCOs on problems faced in monitoring and verification of savings | INTESCO Asia : Mr. R. Vasu & Mr. R. Kumar |
| 1145 - 1300 | International Experience of M&V Protocols: Case Studies from Industrial, Residential and Commercial Sectors | Schiller Associates: Mr. Mark Stetz |
| 1300 - 1400 | LUNCH | |
| 1400 – 1515 | Open Discussion on Applicability and Adaptation Possibilities | INTESCO Asia : Mr. R. Vasu & Mr. R. Kumar and Schiller Associates: Mr. Mark Stetz |
| 1515 – 1530 | TEA BREAK | |
| 1530 - 1700 | Concluding Remarks | INTESCO Asia : Mr. R. Vasu & Mr. R. Kumar and Schiller Associates: Mr. Mark Stetz |

# ECO PROJECT: MILESTYONE 3A
## Executive Seminar on M&V for Energy Efficiency Projects: Need and Issues
## 5, December 2000: Mumbai
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**ECOPROJECT: MILESTONE 3A**
**Executive Seminar on M and V Protocols for Energy Efficiency Projects: Need and Issues**
**11 December, 2000: New Delhi**

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## Participant Feedback

A combination of structured and open-ended questions was used to obtain feed back from workshop participants. While structured responses were sought on aspects such as, workshop content (relevance, coverage, structure), quality of resources persons/faculty, delivery methodology, venue, administrative arrangements, handout material and publicity and invitations; open ended responses were sought on reasons for attending the workshops/expectations from the workshops, extent to which expectations were fulfilled, and follow-up actions planned by the participant in the workshop focus area. A sample feedback form, along with summaries of the responses from each of the two workshops has been enclosed.

***Structured Responses:***

Following table shows participant feedback on Mumbai and New Delhi workshops to the question "What comments would you like to make about each of the following aspects of the event?" The figures indicated in the table show percentage of respondents saying 'poor' or 'satisfactory' etc.

**Mumbai Workshop Results:**

| Description | Percentage of Participants Saying | | | | |
|---|---|---|---|---|---|
| | Poor | Satisfactory | Average | Good | Excellent |
| Content (relevance, coverage) | | 11% | 16% | 63% | 11% |
| Content (Seminar Structure) | | 11% | 21% | 68% | |
| Resource person/Tutor (Indian) | | | 21% | 68% | 11% |
| Resource person/Tutor (US) | | 5% | 5% | 74% | 16% |
| Delivery, methodology | | | 11% | 72% | 17% |
| Venue | | 5% | 11% | 63% | 21% |
| Administrative arrangements | | 5% | 16% | 63% | 16% |
| Handout Material | | 5% | 26% | 53% | 16% |
| Workshop Publicity/Invitation | 5% | 11% | 21% | 53% | 11% |

**New Delhi Workshop Results:**

| Description | Percentage of Participants Saying | | | | |
|---|---|---|---|---|---|
| | Poor | Satisfactory | Average | Good | Excellent |
| Content (relevance, coverage) | | 6% | | 94% | |
| Content (Seminar Structure) | | | 6% | 94% | |
| Resource person/Tutor (Indian) | | | 6% | 59% | 35% |
| Resource person/Tutor (US) | | | 6% | 71% | 24% |
| Delivery, methodology | | 6% | | 88% | 6% |
| Venue | | | | 65% | 35% |
| Administrative arrangements | | 12% | 12% | 65% | 12% |
| Handout Material | | 6% | 18% | 71% | 6% |
| Workshop Publicity/Invitation | 6% | 6% | 18% | 65% | 6% |

*Responses to Open Ended Questions*

Given below are sample responses to open-ended questions.

**Mumbai Workshop Responses:**

| What were your goals in attending the seminar? | To what extent do you think these have been met? |
|---|---|
| To understand possible ways of M&V | We could get an overview of ESCO's M&V aspects. However, end-users were not available in sufficient numbers. Their view on M&V would have been very useful |
| To understand M&V methodologies | I am happy having attended this for it has given me insight to how the world addresses the same. I am happy that this important issue has been finally addressed |
| To get more information about IPMVP & its implementation procedures and constraints, etc. Also to share my experience in the ESCO field with other participants | Objectives met to a greater extent |
| To understand M&V methodology used in every conservation project. | I am satisfied with the contents of the seminar with practical examples |
| To understand M&V protocol | No response |
| To know the overall status of M&V protocol in the industry | No response |
| To get some additional information on M&V protocols, particularly in the area of standardization | The program has given the idea on above to a large extent |

| What were your goals in attending the seminar? | To What extent do you think these have been met? |
|---|---|
| To understand the issues related with EE projects; to understand ESCO concept better; and to understand issues related to M&V | No response |
| To get an overview of M&V and to understand issues of M&V in light of specific cases | Yes, they have been met |
| To know more about the subject of the seminar as we are in the EC area | The seminar was useful |
| To learn more about M&V protocol related to energy industry | Goal met to a good extent |
| To know about present trends in EC; and to assess the economic feasibility of EC projects in our plants | Goals met to a satisfactory level |
| To implement M&V protocol in textile industry | 50% |
| Having experienced the need for M&V as an energy auditor, I wished to know more about how this necessary approach is formalized and awareness is brought to users and ESCOs | No response |
| To learn about the M&V procedures for industrial EE projects | More or less, I was able to understand the risks involved |
| As in CPRI, we are planning take up implementation of EE in our power plants, and hence wanted to know about M&V | |
| To learn from and share with other participants the basic requirement of the M&V guidelines | Some success |
| To understand M&V protocol and how it is being applied in USA | Goals have been fairly met |
| To get ideas for standards and methods to measure quantified savings | No response |

| What Action Do You Plan to Take to Follow-up This Event? |
|---|
| As we have developed software for identification and quantification of energy savings, we would develop it further to take care of M&V function of ESCO companies |
| Down load all web sites. Present to clients the M&V for their appreciation and implementation, and buy some software |
| Study the procedures and practices generally applicable to the industry |
| Try to use these methods in our small EC projects, and to discuss with top management regarding feasibility study on this subject |
| Interact with Nexant |
| To study IPMVP in details |
| Get the draft M&V protocol and then see how to use it in our own business; Get more information from the web sites discussed in the seminar; and check the possibility of involving 3rd party certification of M&V |
| Help and develop ESCOs in our country |
| Get involved in helping to develop M&V protocol |

| What Action Do You Plan to Take to Follow-up This Event? |
|---|
| To interact as and when required with the team and keep the EC awareness in everybody as a routine |
| Keep in touch with the project team at Nexant and keep up with further steps towards M&V protocol |
| To discuss with top management about the feasibility of EC projects in our factory, and to try to implement the EC projects |
| I would like to include the salient features in our energy audit program conducted in the textile mills all over the country |
| To keep in touch with the activity and contribute from my experience |
| No response |
| No response |
| Be active on the core group to develop the guidelines |
| Try to convince our clients and get the projects |
| No response |

*New Delhi Workshop Responses*

| What were your goals in attending the seminar? | To what extent do you think these have been met? |
|---|---|
| To assess the importance and need of M&V protocol | These have been taken care of |
| To know latest know-how in M&V | To some extent |
| To collect information on the subject | Satisfied with the contents of the presentations |
| To have a feel of ECO/ESCO | It has been good |
| To understand IPMVP, to understand international experience on IPMVP, and to interact and share experience | No response |
| To understand the issues regarding M&V that ESCOs are facing in India and US | To a great extent |
| To know about the views of other consulting organizations about the need and issues related to M&V | No response |
| To know the process of evolving M&V protocol and its scope | No response |
| | Partly, 60% |
| To know about the salient points about M&V protocol, to know about the M&V requirements, its effects in ECM project formulation &calculation of energy savings. To listen to few case studies showing applicability of M&V in energy saving projects | The goals have been fulfilled to a large extent |
| To sharpen skills on M&V protocol | Understanding is achieved |
| To update the knowledge in the field of energy efficiency | Up to some extent |
| Learning protocols, business development, perceiving the energy efficiency market in India, perspective on challenges and opportunities | No response |

| What were your goals in attending the seminar? | To what extent do you think these have been met? |
|---|---|
| To know about the applicability of M&V protocols for the Indian situations, especially for government departments who have to deal with public accountability and vigilance angle. To know how to evaluate ESCOs. | No response |
| To understand how best to do M&V and resolve any dispute with ESCOs. How to know actual savings achieved after implementation of ECM | More clarification and details required for properly knowing M&V |
| To increase awareness/knowledge about M&V protocols | Attending seminar was beneficial |
| To understand the various M&V models and practices | No response |

| What Action Do You Plan to Take to Follow-up This Event? |
|---|
| I shall try to discuss with my co-related and counterparts in different section to deliberate further |
| To redefine all the work done so far. In the light of the event, as a user |
| I hope the protocol will be useful in eliminating disputes in savings achieved, and to know ESCO operations better. I am awaiting the protocol document |
| Watch the developments and then decide on opportunities |
| Contribute towards the development of PMV applicable in existing business environment |
| Go through IPMVP sites for more information |
| It is observed that a general feeling is to formulate a protocol suited for Indian situation |
| Discuss the need to include different areas/end-uses and measurement techniques |
| Would like to involve with commercial advantage |
| To go through the details of IPMVP and interact on the various issues of the same for application in Indian scenario with concerned organizations |
| To apply and make client understand M&V protocol |
| To keep in touch with concerned agencies |
| Personal meetings to participate in ECO projects |
| To be more familiar with ESCO activities from time to time, including NDMC agencies in India/abroad for seeing actual activities on ground |
| There should be some detailed training along with some practical demonstration in India and abroad |
| Use the M&V protocol/information gained for more effective energy study/saving study report |
| Await M&V protocol document and then discuss with colleagues and implement. Very good tool for EE projects |

## Vijay

**From:** vkaunni@THERMAXINDIA.COM
**Sent:** Monday, December 18, 2000 10:26 AM
**To:** India_m-v_cg@egroups.com
**Cc:** nexant@vsnl.com
**Subject:** M & V TRAINING AT MUMBAI

Dear Friends,
It was an excellent training session that we had between the 5th and 8th of December at Mumbai. The overall interaction of the group was excellent and encouraging free flow of information. We really got benefited with this training session and hope all the participants have the same feeling.
We thank each one of you for the success of this program. We look forward to more frequent interaction between the group for mutual benefits.
With warm regards

V.K.Anand Unni & S.K.Vichare
Thermax Energy Performance Services Limited
Pune

**ECO Project: Workshops Feedback Form**

**Executive Seminar on**
**Measurement & Verification Protocol for Energy Efficiency Projects: Need and Issues**

**11, December, 2000**
**India Habitat Centre, New Delhi**

**Dear Participant,**
We value your views on how you experienced this Seminar. Please take a few minutes to complete this form.

1. What were your goals in attending the Seminar? To what extent do you think these goals have been met?

2. What action do you plan to take to follow-up this event?

3. What comments would you like to make about each of the following aspects of the event? (Please indicate your choice on the five point scale below):

| | Poor | Satisfactory | Average | Good | Excellent |
|---|---|---|---|---|---|
| Content (relevance, coverage) | | | | | |
| Content (SeminarStructure) | | | | | |
| Resource person/Tutor (Indian) | | | | | |
| Resource person/Tutor (US) | | | | | |
| Delivery, methodology | | | | | |
| Venue | | | | | |
| Administrative arrangements | | | | | |
| Handout Material | | | | | |
| Seminar Publicity/Invitation | | | | | |

**ECO Project: Workshop Feedback Form**

**Executive Seminar on**
**Measurement & Verification Protocol for Energy Efficiency Projects: Need and Issues**

**5, December, 2000**
**Hotel President, Mumbai**

***Dear Participant,***
We value your views on how you experienced this Seminar. Please take a few minutes to complete this form.

1. What were your goals in attending the Seminar? To what extent do you think these goals have been met?

2. What action do you plan to take to follow-up this event?

3. What comments would you like to make about each of the following aspects of the event? (Please indicate your choice on the five point scale below):

| | Poor | Satisfactory | Average | Good | Excellent |
|---|---|---|---|---|---|
| Content (relevance, coverage) | | | | | |
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| Resource person/Tutor (Indian) | | | | | |
| Resource person/Tutor (US) | | | | | |
| Delivery, methodology | | | | | |
| Venue | | | | | |
| Administrative arrangements | | | | | |
| Handout Material | | | | | |
| Seminar Publicity/Invitation | | | | | |

# Workshop Plan: Outline

## *1.0 Workshop*

Basic purpose of the workshops would be to sensitize ESCO personnel and energy auditors on M&V protocols in countries where EE programs have been successful.

### *1.1 Session 1: Experience of India ESCOs with M&V Problems*

(R. Vasu, Intesco)

a) The energy performance contracting approach to energy efficiency projects
b) Measurement issues
c) Funding issues
d) Need for a Standard/ Protocol
e) Development of India specific M&V protocol

### *1.2 Session 2: International Experience of M&V protocols*

(M. Stetz, Schiller Associates)

a) M&V Overview- PC project risk and how M&V allocates risk among parties.
b) International Performance Monitoring & Verification Protocol (IPMVP).

### *1.3 Session 3: Case Studies from Industrial, Commercial, & Residential Sectors*

(M. Stetz, Schiller Associates)

Case studies from commercial, industrial, & residential sectors showing how current IPMVP M&V protocols are applied and the benefits that accrue.

Industrial Sector: Textile factory where VSDs were installed on ventilation fans to control internal humidity. Option B (continuous monitoring) was used to track performance.

Commercial Sector: Large office building with comprehensive project. M&V approach was hybrid of Options C (Utility Bill Analysis) and Option D (computer simulation). Case study incorporates weather adjustment, baseline adjustment, and energy-efficiency standards.

Residential Sector: Installation of ground-source heat pumps at military base housing as part of large performance contract. M&V approach was Option A (stipulation) after extensive performance monitoring. Case study shows how to monitor performance and stipulate usage to decrease M&V costs.

### *1.4 Session 4: Open Discussion on Applicability and Adoption Possibilities.*

(Moderator: R. Vasu, Intesco)

### *1.5 Session 5: Concluding Remarks*

( R Vasu, Intesco)

# Experience of Indian ESCOs on problems faced in Monitoring & Verification of Savings

## INTESCO Asia Limited



## Outline

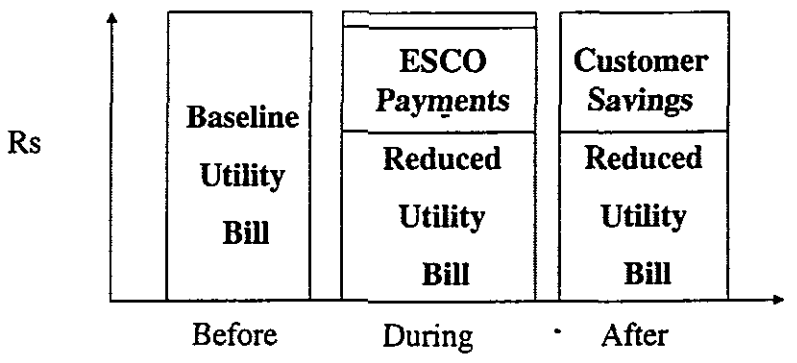
- Energy Performance contracting approach to energy efficiency projects.
- Measurement issues
- Funding issues
- Need for a Standard / Protocol
- Development of India specific M&V protocol

## Energy Performance contracting (PC)

- ESCOs - Energy Service Companies
- ESCOs provide performance contracting solutions



## Typical PC approach



## Common Issues

- Factors affecting energy saving performance
- Non-routine baseline adjustments due to
  - addition or deletion of machinery, loads etc.
  - set-point changes



## Measurement Issues

- How long to measure?
- Cases Option A or B.
- Expensive Calibration.
- M&V costs how much is justifiable?
- No formal procedures to identify levels of M&V that minimizes M&V cost plus uncertainty.

## M & V Issues
(Industries)

- Base-line development.
- Projection of post retrofit conditions.
- This results in need to use statistical regression techniques and makes the M&V complex and leads to expensive M&V costs.



## M & V Issues
(Industries - continued)

- M&V becoming complex when Energy Conservation Measures (ECM) for a central utility equipment in a multi-product facility is envisaged.
- Need for altering M&V procedures due to changes in top management / key personnel.

## M &V Issues

(Industries - continued)

- Expensive M&V costs towards calibration of meters, M&V efforts.
- Inability to appreciate benefits of M&V such as sustained savings- as it costs additional.



## M&V Issues

(commercial)

- Difficulties in the definition of system boundary line.
- Absence of separate distribution & /or meters for lighting & other loads.

## M&V Issues
(commercial contd.)

- Absence of standard M&V procedures leading to disagreement on establishing base line.
- Shift in baseline due to expansion/ modernization .
- Preferring whole billing analysis and a simple M&V procedure.



## M&V Issues
(residential)

- Metering common area benefits and apportioning benefits in apartments.
- Baseline determination issues due to variations in occupants & usage pattern for domestic solar water heating, lighting etc.

## Funding issues

- M&V can be used as a tool for defining and controlling risks.
- A standard M&V protocol shall provide credence to financing ESCO projects giving greater confidence to financial institutions (as risks are mitigated).



## Need for M&V Protocol

- Tremendous ESCO opportunities.
- Concept new relatively & therefore long selling cycle.
- In the absence of standard M&V procedures and desire to shorten this cycle, ESCOs try to close deals with simple M&V.

# Development of India specific M&V protocol

- IPMVP(International Performance measurement and verification Protocol) and FEMP(Federal Energy Management Program) have been reviewed for their suitability and applicability in Indian scenario to bring out India specific M&V protocol

# Measurement & Verification

An Overview

Mark Stetz
Schiller Associates

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# Outline

- Performance Contracting
- Financing
- M&V from Contracting Perspective
- M&V to Mitigate Risk
- Types of Risk
- How M&V Mitigates Risk and at What Cost

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# Performance Contracting

- Provides energy and $ savings to customer
- Actual savings are uncertain
- ESCO paid from savings
- Savings are often guaranteed
- How do we enforce guarantees?

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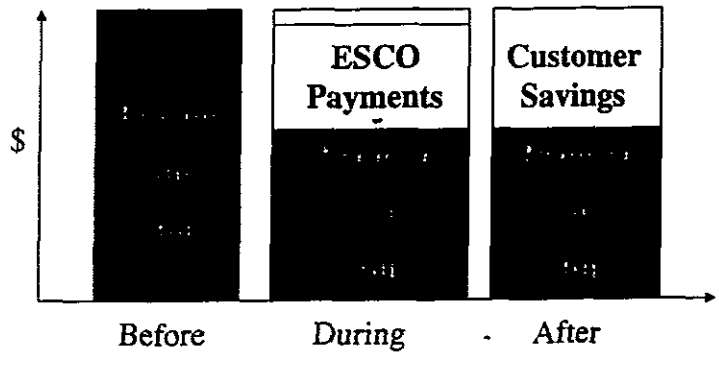
# PC Financing

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## What is M&V? Contracting Perspective

- Tool for defining and controlling risk
- Risk mitigation (*risk = need to verify*)
  - Value of project
  - Uncertainty about savings
- Risk allocation between the parties:
  - Who is responsible for performance?
  - Who is responsible for achieving long-term savings?

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## M&V Mitigates Risk

- M&V serves as project insurance by demonstrating that savings are real.

*Buy what you need,*
*get what you pay for.*

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## Types of Risk

- Uncertainty Risk (Measurement)
- Performance Risk (Equipment)
- Usage Risk (Hours, occupancy...)
- Financial (interest rates, energy costs...)

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## Uncertainty Risk

- Claimed savings are always <u>estimates</u> because *savings cannot be measured.*
- Uncertainty is introduced through:
  - Measurement error
  - Sampling error
  - Random variations
  - Simplifying assumptions
- *These are factors inherent in M&V*

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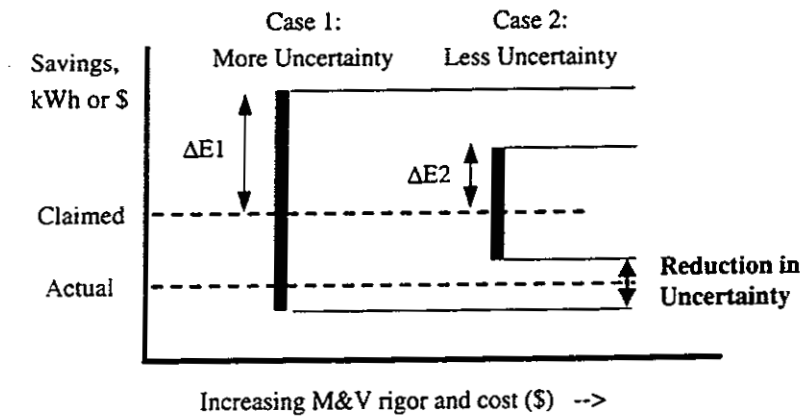
# Uncertainty Risk

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# Performance Risk

- Performance of an ECM may change over time due to equipment degradation and/or poor O&M practices. Performance may also be compromised by poor design or implementation.
- *These are factors that the ESCO normally controls.*

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## Performance Risks

| | Customer | ESCO |
|---|---|---|
| Equipment Performance | | X |
| Maintenance | x | x |
| Operation | x | x |

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## Usage Risk

- Savings are dependent on both performance and usage. Usage can be defined as:
  - operating hours (lighting, equipment)
  - occupancy or schedulēs
  - heating load (& setpoint)
  - cooling load (& setpoint)
- *These are factors that the customer controls*

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## Usage Risk

| | Customer | ESCO |
|---|---|---|
| Operating Hours | X | |
| Loads (occupancy, production...) | X | |
| Weather | | |
| Equipment Life | x | X |
| User Participation | X | |

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## Financial Risk

- Financial factors (such as interest rates and energy costs) affect cost and savings, but many are functions of market conditions. Typically, the effect of these unpredictable factors needs to be decided in advance.
- *These are factors that the market controls.*

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# Financial Risk

| | Customer | ESCO |
|---|---|---|
| Energy Prices | | |
| Interest Rates | | |
| M&V Costs | X | X |
| Construction Costs | | X |

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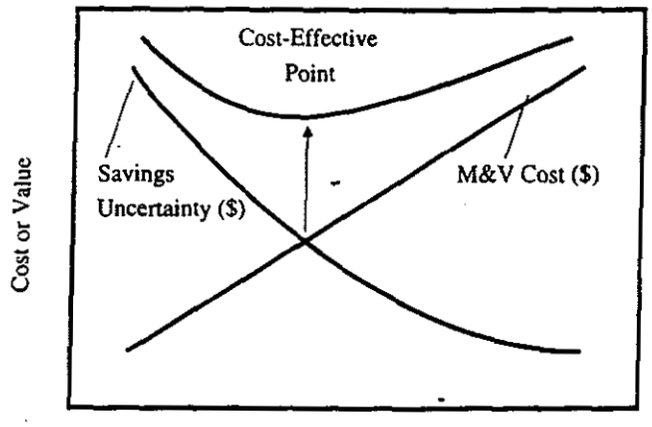
# Cost vs. Uncertainty

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Increasing M&V rigor -->





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# Measurement & Verification Resources and Training Opportunities

Prepared by

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**June 9, 2000**

for

## U.S. Department of Energy's Federal Energy Management Program (FEMP)

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# Measurement and Verification Resources and Training Opportunities

Measurement and verification (M&V) of energy savings, generated through building systems retrofits and upgrades, requires special project planning as well as unique engineering practices. Although several common practices exist for M&V of energy savings, it is not an exact science. There are many resources available that can be used to learn more about the engineering techniques and tools used for verification of energy savings. This document lists some of those resources. It is not intended to be a comprehensive listing of resources, but rather indicative of the types of tools that are available.

**Table 1: Overview of M&V Tools**

| Report Section | Includes | Purpose in M&V |
|---|---|---|
| M&V Guidelines | ❖ FEMP<br>IPMVP<br>ASHRAE 14P | Provide M&V standards based on accepted, proven strategies. |
| Utility & State Program M&V Guidelines | ❖ California SPC<br>Central Power & Light<br>NYSERDA<br>Texas Loan Star Program | Provide M&V standards based on accepted, proven strategies, which may be simplified and specified for certain applications. |
| Case Studies | California SPC Program<br>FEMP | Example applications of M&V strategies. |
| Software & Hardware Tools | ❖ Building energy simulation software<br>System performance simulation software<br>Utility cost management software<br>Software and hardware tools for data acquisition and management | Available tools that can be used to: model building and systems to estimate savings; track utility costs to verify savings; measure equipment operations; measure and recording of variable operating parameters; process recorded data. |
| Other Resources | Commissioning guidelines<br>Related papers | Other resources that could be utilized when preparing for and implementing the measurement and verification of energy savings. |



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# 1 M&V GUIDELINES

Several guidelines have been published on measurement and verification energy savings. Each of the Guidelines listed in this section are unique, albeit similar, and are intended for use in different instances. All of these documents provide standard M&V methods that are proven and accepted strategies.

## 1.1 FEMP M&V Guidelines Version 2.0

The Federal Measurement and Verification (M&V) Guideline provides procedures and guidelines for quantifying the savings resulting from the installation of energy conservation measures. Intended for use in Energy Savings Performance Contracting (ESPC) and utility program projects, the guideline provides the methodology for establishing energy cost savings called for in the ESPC rule. These guidelines are available at www.eande.lbl.gov/CBS/femp/MVdoc.html.

## 1.2 International Performance Measurement and Verification Protocol

The International Performance Measurement and Verification Protocol (IPMVP) is a document which discusses procedures that, when implemented, allow building owners, energy service companies, and financiers of buildings energy efficiency projects to quantify energy conservation measure (ECM) performance and energy savings. The IPMVP provides an overview of current best practice techniques available for verifying savings from both traditionally- and third-party-financed energy and water efficiency projects. These guidelines are available at www.ipmvp.org/.

## 1.3 ASHRAE PROPOSED GUIDELINE 14P

The ASHRAE guideline is called *Measurement of Energy and Demand Savings*, Advanced Working Draft #1, December 13, 1999 © ASHRAE. The proposed requirements in this draft are subject to change before final approval by ASHRAE.

ASHRAE Guideline 14P was developed by ASHRAE to provide guidance on the minimum acceptable level of performance in the measurement of energy and demand savings for the purpose of a commercial transaction based on that measurement.

ASHRAE Guideline 14P deals only with the measurement of energy and demand savings. Other tasks are needed in any energy performance contract. Review copy is available at http://www.ashrae.org/standards/availdft.htm.

# 2 M&V GUIDELINES FROM CURRENT UTILITY & STATE PROGRAMS

Many electric and gas providers in the U.S. offer incentive payments for verified energy savings. Each of these incentive programs has guidelines specifying their individual requirements for the measurement and verification of energy savings. This list of programs is not comprehensive, but includes programs that have M&V guidelines that are easily accessible.

## 2.1 California Utility SPC Program

This statewide energy-efficiency program is being offered by San Diego Gas & Electric, Pacific Gas and Electric Company and Southern California Edison (Utility Administrators) under the direction of the California Public Utilities Commission (CPUC). The Large Non-Residential Standard Performance Contract (LNSPC) Program is a performance-based program that offers incentive payments to Projects Sponsors who develop projects delivering verified energy savings at Host Customer facilities. This program offers fixed incentive prices to Project Sponsors for verified and documented energy savings achieved by the installation of specific, energy-efficiency measures. Energy savings will be measured and verified annually by the Project Sponsor over a two-year period following the approval and installation of the energy-efficiency equipment. Additional information about the individual utility programs can be found at www.pge.com/spc/large_nr/measurement.html, www.scespc.com/nonresidential.htm, and http://www.sdge.com/business/.

## 2.2 Central Power and Light

Central Power and Light in Texas is planning to introduce a new program for commercial and industrial facilities. This program is called the Non-Residential Standard Performance Contract (SPC) Pilot Program. SPC Program Manual, including M&V Guidelines, can be found at www.csw.com/About_CSW/default.htm.

## 2.3 NYSERDA

The New York State Energy Research and Development Authority offers the Energy $mart$^{SM}$ Standard Performance Contract (SPC) program. This program offers fixed-price incentives to energy service companies (ESCOs) that install cost-effective electric energy efficiency measures. Project-specific incentives will be calculated based on a per-kWh-of-annual-savings basis and paid out 40% upon installation and the balance over a two-year measured performance period as specified in an SPC Agreement. The M&V Guidelines for this program, along with sample M&V plans can be found at www.nyserda.org/499pon.html.

## 2.4 Texas Utilities

Information on TXU Electric's Energy Efficiency Markets (TEEM) programs can be found at http://www.txuefficiency.com/. TXU Electric's two energy efficiency pilot programs are: the Small Air-Conditioner Program and the Commercial and Industrial Retrofit Program, which includes measurement and verification requirements.



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## 2.5 Texas Loan Star Program

This program, which includes measurement and verification of savings, is used for Texas State Agency energy projects. *Overview of the Texas LoanSTAR Monitoring Program* was published in the *7th Annual Symposium on Improving Building Systems in Hot and Humid Climates 1990,* October 9-10, 1990, Fort Worth, Texas. The document and details about the program are available at www-esl.tamu.edu/loanstar/about_LoanSTAR.html.

Texas LoanSTAR Monitoring Workbook is intended to be a stand-alone survival guide to acquiring energy use and environmental data in buildings. It includes monitoring procedures and data analysis routines developed for the Texas LoanSTAR program and is available for $38.00

# 3 CASE STUDIES

One of the best ways to understand measurement and verification of energy savings is to learn from examples. Several sources of case studies and related materials are listed below.

## 3.1 California SPC Program Case Studies

Several example M&V Plans are included in Appendix D of the California Utility SPC Program M&V Guidelines. Included in this document are M&V Plan Template, VSD Installation M&V Plan, Constant Speed Chiller Replacement M&V Plan, Variable Speed Chiller Replacement M&V Plan, and Calibrated Simulation M&V Plan. It is available at www.pge.com/spc/large_nr/forms.html.

## 3.2 FEMP Case Studies

Demonstrations projects provide first-hand details on some of the latest federal projects at www.eren.doe.gov/femp/prodtech/successstories.html.

- **The Evaluation of a 4000-Home Geothermal Heat Pump Retrofit at Fort Polk, Louisiana**

Final Report, Report ORNL/CON 460 (1998), by P.J. Hughes and J.A. Shonder, Chapter 7 "Measurement and Verification of Energy Savings"

Additional information is available at http://www.eren.doe.gov/femp/financing/ghpresources.html#savings.



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# 4 TRAINING OPPORTUNITIES

Several organizations offer classes on measurement and verification of energy savings. Some upcoming courses are listed below.

## 4.1 AEE M&V Courses

The Association of Energy Engineers offers a course on measurement and verification of energy savings.

- **Management, Measurement & Verification For Performance Contracts**

November 30 - December 1, 2000, Buena Vista Suites, Orlando, FL, (800) 537-7737

With use of performance contracting to finance energy projects continuing to grow, it is important to be able to quantitatively assess results and project and measure payback. At this informative seminar, you will learn the skill and art of managing and monitoring a performance contract, to assure that you are getting the results you expect. You'll hear case studies illustrating how and why certain projects have "gone bad," and what steps you can take to avoid potential pitfalls. You'll also hear analysis of successful projects, and the factors contributing to their success. You'll leave the course with the tools you need to track your project along the way using M&V methods developed by leading experts with broad, hands-on experience in managing performance contracts. Regular Fee: $945, AEE Member Fee: $845*, Government & Nonprofit Fee: $845. Additional information is available at www.aeecenter.org/seminars/.

## 4.2 ASHRAE M&V Courses

The American Society of Heating Refrigeration and Air-conditioning Engineers offers a course on measurement and verification of energy savings.

- **Determining Energy Savings From Performance Contracting Projects - Measurement And Verification**

October 3, 2000—San Jose, CA. This course provides an overview of measurement and verification (M&V) procedures and methods for determining savings from energy efficiency projects. Four brief case studies will be presented to illustrate concepts and issues associated with M&V: a lighting project (using both estimates and long-term metering), a VSD project (using long-term metering), a billing analysis and a calibrated simulation. Additional information is available at www.ashrae.org/.

## 4.3 FEMP Courses

The federal energy management Program offers courses related to various aspects of performance contracting. A complete listing of courses is available at http://www.eren.doe.gov/femp/resources/training/femptraining.html.



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- **Water Resource Management**

How to assess, evaluate, resolve, and incorporate water efficiency into Federal project-assessment, planning and implementation programs. Additional information is available at www.eren.doe.gov/femp/resources/training/fy2000water.html.

- **Energy 2000**

August 21-23 Energy 2000 - Pittsburgh, PA

FEMP Symposia regarding all aspects of performance contracting, including measurement and verification of energy savings. Additional information is available at www.eren.doe.gov/femp/resources/training/femptraining.html.

# 5 TOOLS FOR DATA COLLECTION AND ANALYSIS: SOFTWARE & HARDWARE

Several types of software and hardware related to energy analysis are available. Some software is available at no cost, while other programs can be purchased. This is not intended to be a comprehensive list of all programs that are available nor a recommendation for any particular tool, but rather an indicator of the types of existing tools. The software is categorized as either: Building Energy Simulation, System Performance Simulation, Utility Cost Management, or Data Acquisition and Management. Information on additional energy software tools can be found at www.eren.doe.gov/buildings/tools_directory/ and eande.lbl.gov/CBS/eXroads/soft.html.

## 5.1 Building Energy Simulation Software

- **BLAST**

BLAST (Building Loads Analysis and System Thermodynamics) performs hourly simulations of buildings, air handling systems, and central plant equipment in order to provide mechanical, energy and architectural engineers with accurate estimates of a building's energy needs. The zone models are based on the fundamental heat balance method, are the industry standard for heating and cooling load calculations. BLAST output may be utilized in conjunction with the LCCID (Life Cycle Cost in Design) program to perform an economic analysis of the building/system/plant design.

Available through Building Systems Laboratory, University of Illinois, 1206 West Green Street, Urbana, Illinois 61801, telephone (217) 333-3977, facsimile (217) 244-6534 or www.bso.uiuc.edu. Software prices range from $450 for an upgrade package to $1500 for new installations.

- **DOE-2**

Performs hourly simulation of new and existing buildings based on the building's climate, architecture, materials, operating schedules, and HVAC equipment. Appropriate for use with Option D.

Available through LBNL, Buildings Technology Program, Kathy Ellington, fax: (510) 486-4089 or http://gundog.lbl.gov/.



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- **VisualDOE2.5**

VisualDOE is a graphical version of DOE2. Users can model complex buildings and HVAC systems. Provides results in graphical format. Software is available from Eley Associates, 142 Minna Street, San Francisco, California 94105. Phone: 415-957-1977, fax: 415-957-1381, email: info@eley.com. http://www.eley.com/.

- **Energy-10**

Energy-10 is a simple graphical building simulation program for evaluating buildings while still in the design stage. Good for residences and small offices. Can be used to evaluate different potential energy-efficiency measures including passive solar. Available through the Sustainable Buildings Industries Council (SBIC), 1331 H Street, N.W., Suite 1000, Washington, DC 20005, Phone: (202) 628-7400, fax: (202) 393-5043, email: sbic@sbicouncil.org, http://www.sbicouncil.org/

## 5.2 System Performance Simulation Software

- **CoolTool**

Software offers component level modeling of chiller plant, simulating performance of electric chillers & cooling towers. Provides hourly energy cost analyses of chiller water plant equipment and control alternatives. Appropriate for use with Option D. Electric chiller model is now in beta release.

Available through Pacific Energy Center, Mark Hydeman, 851 Howard Street, San Francisco, CA 94103, tel: (415) 972-5498, fax: (415) 1290, www.hvacexchange.com/cooltools.

- **QuickChill**

Designed to evaluate performance changes when converting from R-11or R-12 to another refrigerant. Can also be used to evaluate chiller staging strategies and condenser & evaporator water temperature reset. Software was developed by the US Environmental Protection Agency and is available at http://www.epa.gov/buildings/esbhome/tools/software.html.

- **Market Manager**

Simulation software using standard ASHRAE algorithms that allow modeling of building systems, sub-systems, and components. Appropriate for use with IPMVP/FEMP Options C and D.

Available through SRC SYSTEMS, INC., 2855 Telegraph Ave., Suite 410, Berkeley, CA 94705, tel: (510) 848-8400, fax: (510) 848-0788, www.src-systems.com.

## 5.3 Utility Cost Management Tools

- **Energy Accounting: A Key Tool in Managing Energy Costs**

Energy accounting is a system to record, analyze and report energy consumption and cost on a regular basis. This downloadable guide will discuss some of the reasons for energy accounting, go into background information needed to understand it, and explain how to get started with a program. With emphasis on computer software, this document will discuss some of the methods and means of energy accounting, focusing in on energy accounting software packages. The

appendix reviews and provides information on five of the most popular, commercially available energy accounting software packages. It is available at www.energy.ca.gov/reports/efficiency_handbooks/index.html.

- **FASER 2000**

Tracks, analyses, and reports utility billing data, as a result detects billing and metering errors, identifies electrical and mechanical problems, and highlights cost saving opportunities. Appropriate for use with IPMVP/FEMP Option C.

Available through OmniComp, Inc., 220 Regent Court, State College, PA 16801, tel: 1-800-726-4181, fax: (814) 238-4673, www.faser.com.

- **METRIX**

METRIX is software designed to track utility usage and costs in order to track operating cost savings or verify the impacts of utility performance measures. Metrix creates a historical baseline using a multi-variant linear regression to correct for weather and other independent variables that affect utility cost. It establishes performance targets and can track an unlimited number of sites, facilities, and meters. Appropriate for use with IPMVP/FEMP Option C.

Software prices range from $2,495 to $4,495 depending on the type of license purchased. See web site to download an evaluation version. Available through SRC Systems Inc., Suite 410, 2855 Telegraph Avenue, Berkeley, California 94705, telephone (510) 848-8400, facsimile (510) 848-0788 or www.src-systems.com.

## 5.4 Tools for Data Aquisition and Management

- **Abacus**

Provides wireless meter information that can be used to detect abnormal energy use and assess the impact of measures immediately. Use could include monitoring for IMPVP/FEMP Options B and C.

Available through Ameren (abacus.amerren.com).

- **ARC Systems**

Complete line of compact Information Loggers Small data loggers record temperature, relative humidity, electric current, pressure and other standard variables without plugs, power supplies, signal conditioning or complex in-field setups. Equipment can be used for monitoring for IPMVP/FEMP Option A, B, and D.

Information is available at www.acrsystems.com/menu.htm.

- **ACRx™**

ACRx acquires and processes technical data (air temperatures, refrigerant temperatures and pressures, etc.) to identify pending service needs, can be used for monitoring for Option A, B, and D.

Available through Field Diagnostic Services, Inc., North American Technology Center, 680 Jacksonville Road, Warminster, PA 18974, Tel: (215) 672-9600, Fax: (215) 672 9560, www.acrx.com.



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- **Analysis West**

Analysis West is a manufacturer and distributor of energy monitoring and software products for energy and HVAC professionals. Runtime DataWatcher datalogger records the runtime of fuel-fired heating systems, including hard-to-measure water heaters and millivolt heating systems. A separate sensor allows the unit to also log motors, air conditioners and other electrical appliances. Up to 11 months of data can be stored in the logger. Digital Power Meters allow you to measure the true power consumed (Watts) by plug-in electrical appliances and lights. Total kilowatt-hours used over an extended monitoring period are also recorded.

Information is available at www.energytools.com/.

- **Architectural Energy Corporation**

Architectural Energy Corporation's (AEC) MicroDataLogger® portable data acquisition system is a battery or line-powered, four-channel data logger and hand-held meter which records time-series data from virtually any sensor or transducer, including temperature, relative humidity, pressure,

electrical current, power, air flow, velocity or lighting levels. Made for use with Enforma™ software, which allows visualization and analyses of short-term data taken from portable loggers. Collect and analyze system-wide HVAC, controls and lighting performance data over time. Detect HVAC problems, determine energy use baselines, and verify savings of lighting retrofits, commission or re-commission building HVAC, control, and lighting systems. Use could include monitoring for IMPVP/FEMP Option A, B, and D. Available through Architectural Energy Corporation, 2540 Frontier Ave., Suite 201, Boulder, CO 80301, tel: (303) 444-4149, fax: (303) 444-4304, www.archenergy.com.

- **Boonton Test Solutions**

Products include test instruments & sensors, including power meters. Appropriate for short-term measurements associated with IPMVP/FEMP Options A & B.

Information is available at www.boonton.com/.

- **CellNet Online Meter Reader**

Real-time energy use tracking to detect abnormal energy use and assess the impact of measures immediately after installation. Use could include monitoring for Options B and C.

Available through CellNet Data Systems, 125 Shoreway Road, San Carlos, CA, www.myEnergyInfo.com.

- **Continental Control Systems**

Continental designs and manufactures AC power and energy meters. Available products include standard pulse-output watt-hour transducers and LonWorks interoperable power, energy, and demand meters. Applications include utility sub-metering, end-use metering, equipment performance monitoring, verification, evaluation, and diagnostics.

Information is available at www.ccontrolsys.com/.

- **E-MON Corporation**

Solid state electric meters and meter reading systems and software. E-MON D-MON electric meters install easily to meter KWH and/or demand of electricity. E-MON CE-MON systems and software can be installed on either E-MON meters or any manufacturer's meters for automatic meter reading and profiling. Information is available at www.emon.com/.



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- **Fluke Corporation**

Manufactures, distributes and services electronic test tools.
Information is available at www.fluke.com/.

- **Highland Technology**

Precision Electronic Instrumentation including energy measurement products.
Information is available at www.highlandtechnology.com/.

- **Measuring and Monitioring Services**

Services include end-use metering, load research, energy monitoring and analysis, water system monitoring as well as related hardware and software products.
Information is available at www.mmsinc.com/.

- **MeterTeck Inc.**

Data collection and management, including services, hardware, and software.
Information is available at www.metretek.com/.

- **Onset Computer Corp.**

Onset offers over 70 models of miniature data loggers and logger/controller engines. The popular HOBO & StowAway loggers, paired with BoxCar Pro software for Windows, allow you to quickly and easily record temperature, relative humidity, light intensity, lighting run time, rainfall, AC current, DC voltage, motor on/off, light on/off, open/closed states and events.
Available through Onset Computer Corporation, 536 MacArthur Blvd., Pocasset, MA 02559-3450, tel: (508) 563-9000, fax: (508) 563-9477, www.onsetcomp.com.

- **Pacific Science & Technology Inc.**

A variety of energy monitoring products, including tools designed to record the time-of-use and run-time of devices, current, temperature, and pulse counts, true RMS 3-phase recording power meter.
SmartLog is data analysis software for use with PS&T loggers. Tool provides graphs and results of the data. Tool can convert data to text format for further analysis with spreadsheet, etc. Works with PS&T loggers only. Use could include monitoring for IPMVP/FEMP Option A, B, and D. Available through Pacific Science and Technology, Inc., 64 NW Franklin Ave., Bend, OR 97701, tel: (541) 388-4774, fax: (541) 385-9333, web www.pacscitech.com/.

- **PowerFocus**

Forecasting of energy use by load using predicted models. Use could include assisting with building monitoring for Options B and C - analysis of utility bills, refrigeration and HVAC energy usage.
Available through Power Control Technologies, Tel: (410) 403-4000 www.powerfocus.com.

- **PSI Flow Instruments**

Process control and instrumentation, including a wide range of flow meters.
Information is available at www.psi-kc.com/html/products/flow.html.



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- **Texas A&M**

Various software programs designed to help users manipulate and analyze energy consumption data are available through Texas A&M at www-esl.tamu.edu/software/software.html

- **TimeFrame**

TimeFrame offers a database for data collection of lighting and motor projects. Consists of sensors (current or voltage types) that are hardwired at the site and remote computer for data collection and storage and analysis. Data retrieval is remote via modem. Use could include monitoring for Option A, B, and D.

Available through Measuring and Monitoring Service Inc., 620 Shrewsbury Ave., Tinton Falls, NJ 07701, tel: (800) 942-2703, fax: (732) 576-8067, www.mmsinc.com.

- **Veris Technology**

Veris offers a variety of energy automation sensors including power meters, remote energy reporting tools, and metering software.

Information is available at www.veris.com/.

- **Vistron**

Vistron offers products for energy measurement and remote meter reading. Products include run time meters for any intermittently operated electric device and a remote register of a utility meter.

Information is available at www.vistron.com/.

# 6 OTHER RESOURCES

There are many additional resources that could be utilized when preparing for and implementing measurement and verification of energy savings. Some of these resources are included here.

## 6.1 ASHRAE Guideline 1 on Commissioning

*Guideline 1-1996 - The HVAC Commissioning Process* describes the commissioning process that will ensure heating, ventilating and air-conditioning (HVAC) systems perform in conformity with design intent. Document is available through www.ashrae.org/ for $32.00.

## 6.2 DOE Building Commissioning Guide: Version 2.2 (Draft)

DOE's Federal Energy Management Program (FEMP), in cooperation with the General Services Administration, developed the Building Commissioning Guide. This Guide was originally released for comment on June 16, 1997. Since that release date, comments have been received and incorporated into the Draft Building Commissioning Guide: Version 2.2. The Guideline is available at www.eren.doe.gov/femp/techassist/bldgcomgd.html.



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## 6.3 NEBB Procedural Standards for Building Systems Commissioning

This publication contains uniform and systematic procedures for the commissioning of building systems developed by national and international NEBB commissioning firms. In addition to the general procedures, there are specific procedures for HVAC systems, sample forms, checklists, and a 23-page glossary of building systems and engineering terms in a loose-leaf binder with tabs. Publisher: NEBB; Pub year: 1993. Document is available through www.ashrae.org/ for $52.00.

## 6.4 Predicting and Verifying Energy Savings for Energy Service Companies Using Short-Term Monitoring 3.25

This study by W.Mark Arney, Stuart S. Waterbury, Matthew J. Ossi was published in 1998 ACEEE *Summer Study On Energy Efficiency In Buildings Proceedings.* It can be ordered through www.aceee.org/pubs/pan398.htm.

## 6.5 The Energy Efficient Project Manual

This book is published by national Association of Energy Services Companies (NAESCO) and the Department of Energy fro the Energy Fitness Program. It is sub-titled *The Customer's Handbook To Energy Efficient Retrofits: Upgrading Equipment while Reducing Energy Consumption And Operating And Maintenance Costs.* This overview of performance contracting has a chapter on measurement and verification, and can be downloaded from http://www.ornl.gov/EFP/efp.htm.



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# Case Study: Industrial Sector

Variable Speed Drives on Ventilation
& Humidification Fans

## Project Goals and Objectives

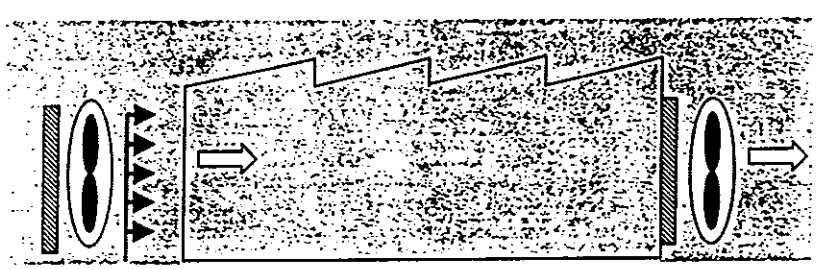
- Project goal: Obtain energy cost savings by installing 15 VSDs on fan motors that are used for ventilating at a fabric factory's production area
- M&V goal: To determine the energy savings during a 10-year performance contract

# Facility Characteristics

Facility:

- Large cotton cloth manufacturing facility
- Need to keep facility's humidity constant for the production process
- Humidity and ventilation rates controlled by 15 supply and exhaust fans (total 550 hp) and air wash systems
- Before VSDs, manual (and hard to use) inlet and outlet vanes were used to regulate air flow
- Vanes have 7 different positions and apparently were adjusted seasonally

# System Description





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## ECM Characteristics

Install VSDs on fan motors to provide:

- Savings by more efficiently controlling fan speed
- Better process control by making it easier to change ventilation rates

## Data Products and Output

Information required:

- Verification
  - Motor nameplate data
  - VSD nameplate data
  - Annual inspection results
- Determining savings
  - Baseline motors' kW draw (as a function of ?)
  - VSD controlled motors' kWh draw per year.
  - Baseline kWh was to be based on a model of fan motor kW as a function of air flow.
  - Measurements showed constant kW more realistic.

## Approach, Data Analysis Procedures and Algorithms

- Savings = (annual **post-installation kWh**) minus (annual **baseline kWh**)
- Post-installation frequency metered continuously, then converted to kW.
- For QC, data would be checked first daily, then weekly, then monthly. Independent spot power measurements for calibration.
- Baseline calculation data:
  - calibration data
  - VSD parameters (e.g., speed, operating hours)
  - independent variables?

## Approach, Data Analysis Procedures and Algorithms

- Baseline model defined with fans in each damper position. Air flow rates monitored and a correlation developed, power = f (flow).
- However, no clear correlation between the dampers' position to the power draw or flow (the dampers leaked).
- In addition, using measurements taken randomly over a nine-month period showed that the baseline could be considered constant (Table 1).

# Table 1. Baseline Fan Load Information

| FAN | 8/22/94 | 10/24/94 | 11/6-18/94 | FAN FULL LOAD POWER, KW | PERCENT LOAD | AVERAGE | MINIMUM | MAXIMUM |
|---|---|---|---|---|---|---|---|---|
| RF-2 KW | 14.1 | 18.9 | 20 | 19 | 89% | 17.7 | 14.1 | 20.0 |
| RF-3 KW | 19.2 | 20.1 | 20 | 19 | 89% | 19.8 | 19.2 | 20.1 |
| RF-4 KW | 11.1 | 11.7 | 13 | 12 | 87% | 11.9 | 11.1 | 13.0 |
| RF-5 KW | 12.7 | 12.6 | 13 | 12 | 87% | 12.8 | 12.6 | 13.0 |
| RF-6 KW | 20.2 | 23.4 | 23 | 22 | 77% | 22.2 | 20.2 | 23.4 |
| RF-7 KW | 21.2 | 23.7 | 22 | 25 | 74% | 22.3 | 21.2 | 23.7 |
| RF-8 KW | 13.4 | 13.2 | 14 | 13 | 94% | 13.5 | 13.2 | 14.0 |
| RF-9 KW | 14.4 | 15.8 | 16 | 21 | 71% | 15.4 | 14.4 | 16.0 |
| SF-2 KW | 23.5 | 23.1 | 23 | 23 | 77% | 23.2 | 23.0 | 23.5 |
| SF-3 KW | 32.9 | 21.6 | 22 | 25 | 74% | 25.5 | 21.6 | 32.9 |
| SF-4 KW | 33.8 | 33.3 | 34 | 37 | 91% | 33.7 | 33.3 | 34.0 |
| SF-5 KW | 30.4 | 30.3 | 25 | 37 | 67% | 28.6 | 25.0 | 30.4 |
| SF-7 KW | 12.5 | 12.6 | 14 | 21 | 63% | 13.0 | 12.5 | 14.0 |
| SF-8 KW | 31 | 29.1 | 32 | 41 | 71% | 30.7 | 29.1 | 32.0 |
| SF-9 KW | 38.7 | 36.9 | 37 | 33 | 99% | 37.5 | 36.9 | 38.7 |
| SUM | 329.1 | 325.3 | 328 | 360 | | 327.8 | 307.4 | 348.7 |

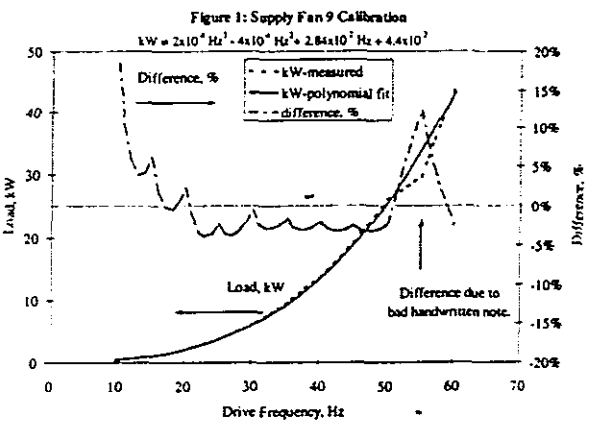
# Approach, Data Analysis Procedures and Algorithms

- Thus, a constant baseline kW value was used based on averages of measurements taken continuously over a two-week period.
- For QC, independent spot power measurements were taken.

# Data Monitoring

- VSD has a power output indicator, but it is not accurate.
- Speed was a direct indicator of kW.
- VSD could output speed (Hz) and that was recorded via modem at a central computer.
- Calibration curves were created by recording the readings from a power meter while the drive was run through its range from 10-60 Hz (Figure 1).
- Each drive/motor was monitored continuously. Every 15 minutes, the frequency was recorded. Data were converted to kWh using calibration curve.

# Figure 1: VSD Calibration Curve



## Baseline and VSD Calibration

- Contractor calibrated data loggers with factory calibrated and certified meter.
- Owner spot checked the contractor's power measurements with calibrated power meter.

## Results

- Analysis showed:
  1) The calibration curves showed a flaw in one motor's power meter calibration (Figure 1).
  2) The power readings vary so slowly that the recording interval could be lengthened to once a week.
  3) Frequency was more reliable indicator of energy than kWh output, but system would require recalibration if fans changed.
- Table 3 lists the first year estimated and actual energy savings.

# Table 3. Estimated and Actual Energy Savings

| Fan | Baseline Demand, kW | Post-Retrofit Demand, kW | Energy Savings, kWh | Savings, kWh | Actual Savings / Estimated Savings |
|---|---|---|---|---|---|
| SF-2 | 23 | 1.8 | 170,986 | 185,581 | 109% |
| SF-3 | 23 | 9.9 | 76,848 | 114,398 | 149% |
| SF-4 | 34 | 23.2 | 113,601 | 94,588 | 83% |
| SF-5 | 30 | 23.7 | 83,530 | 57,932 | 69% |
| SF-7 | 14 | 2.5 | 67,826 | 100,867 | 149% |
| SF-8 | 32 | 18.7 | 106,918 | 116,589 | 109% |
| SF-9 | 37 | 5.3 | 188,527 | 277,649 | 147% |
| RF-2 | 20 | 5.1 | 66,824 | 130,313 | 195% |
| RF-3 | 20 | 9.3 | 101,907 | 93,891 | 92% |
| RF-4 | 13 | 6.2 | 33,663 | 59,381 | 176% |
| RF-5 | 13 | 6.8 | 66,239 | 54,426 | 82% |
| RF-6 | 22 | 5.9 | 112,506 | 141,204 | 126% |
| RF-7 | 22 | 5.5 | 73,506 | 144,352 | 196% |
| RF-8 | 14 | 0.9 | 71,335 | 114,331 | 160% |
| RF-9 | 16 | 1.0 | 105,582 | 131,551 | 125% |
| Total | 333 | 126 | 1,439,798 | 1,817,054 | 126% |
| | | | $ 71,990 | $ 90,853 | $ 18,863 |

# Conclusions

- Long-term monitoring provided accurate savings estimates.
- Rigorous M&V revealed 26% more savings than originally estimated.
- M&V costs reduced by reducing data collection interval without sacrificing reliability.

# Case Study: Commercial Sector

Comprehensive Office Building Project

## Project Description

- Large office building in California of large aerospace contractor. Project included:
  - Lighting efficiency upgrades
  - Constant-Volume Dual-Duct air handlers converted to Variable-Air Volume w/ VSD
  - Chiller replacement
  - Efficient motors on chilled water pumps
  - New cooling tower

## Project Goals

- Reduce total Energy consumption
- Reduce 10,000,000 kWh energy consumption by 20% ($100,000 or Rs 3.8 million per year)
- Improve air distribution to offices
- Replace R-11 chiller with R-134a
- Replace old cooling tower

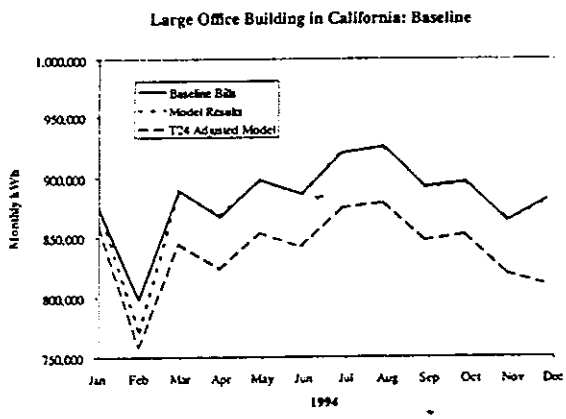
## M&V Approach

- Combination of Option C and D used.
- Building simulation model (Option D) used to establish baseline conditions.
- Annual post-retrofit utility bills (Option C) used to determine post-retrofit performance.
- Difference is savings
- Savings to be tracked for 3 years.

# Baseline Definition

- Building simulation model developed and calibrated to monthly utility bills.
- California has minimum energy-efficiency standards called Title 24.
- New model developed incorporating energy-efficiency standards.

# Building Model Comparison



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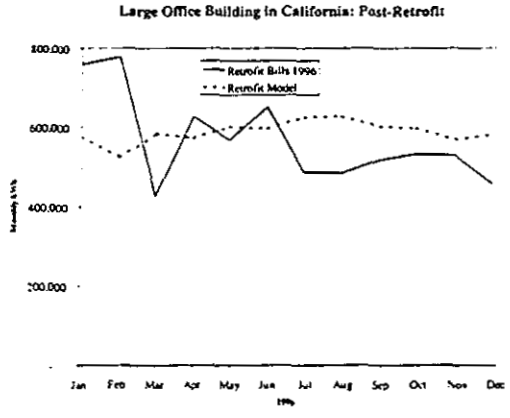
## Savings Calculations

- Results from Title 24 model adjusted for weather.
- Title 24 model adjusted for other factors.
- Actual utility bills subtracted.
- Difference is savings.

## Model Verification

- Retrofit model developed and adjusted.
- Utility bills compared to retrofit model
- Significant difference indicate problem

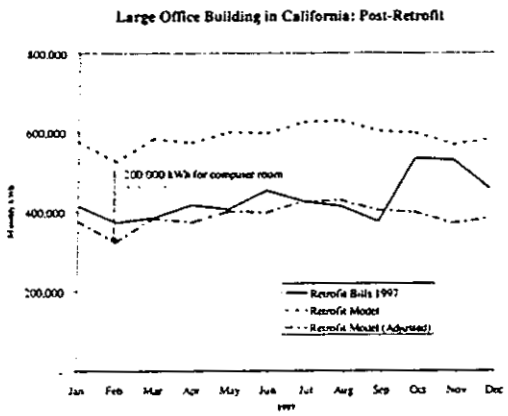
# Post-Retrofit Performance



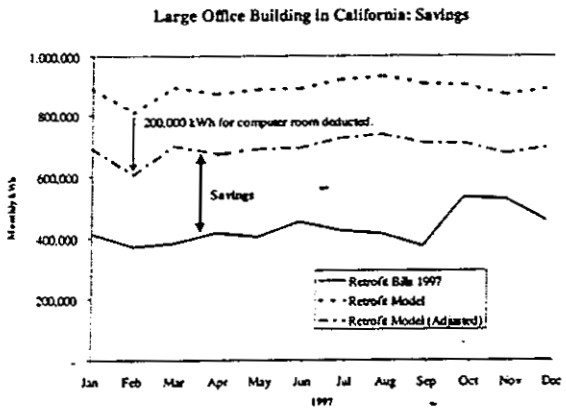

# Problems Noted

- Construction completed January 1996.
- Project being commissioned through early 1996.
- Large computer room removed (loss of load)- accounted for 200,000 kWh/mo.
- Computer room required baseline adjustment.

# Baseline Adjustment




# Savings Calculations



## Conclusions

- Options C and D successfully combined
- Simulation model could be used to estimate baseline case
- Model was adjusted for weather, facility changes, and energy-efficiency standards
- Continued comparison of actual utility bills to post-retrofit model assures long-term performance.

# Case Study: Residential Sector

Replacement of air conditioners and furnaces with ground-source heat pumps at military housing.

# Project Description

- Replace old DX air conditioners and furnaces (gas & oil) with ground source heat pump.
- Savings come from significantly increased cooling efficiency in summer (COP 4-6.5) and heating cost savings.
- Savings also from reduced maintenance efforts.

## Facility Description

- Military District of Washington comprises five military bases near Washington, D.C.
- Multifamily housing for soldiers and their families.
- Housing built in 1940's and has historic value that needs to be preserved.

## Project Financing

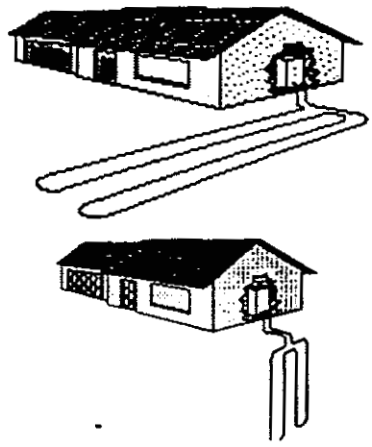
- Performance contract with U.S. Department of Defense will provide $67 million (Rs 2.5 billion) of capital investment.
- 18 Year contract- paid from savings.
- GSHP measure is one of a dozen being installed at the five bases. Investment is $2.65 million (Rs 100 million).

## Ground-Source Heat Pump

- Similar to central air-conditioning system in that system uses refrigerant (R-22) and mechanical compressor.
- Can provide both heating and cooling by reversing refrigerant flow.
- Heat is extracted or rejected to soil instead of atmosphere.

## GSHP Configurations

- Ground-source heat pumps exchange heat with the soil.
- Usually PEX tubing circulating glycol.
- Either just below surface or deep wells (30-100 m).



## M&V Approach

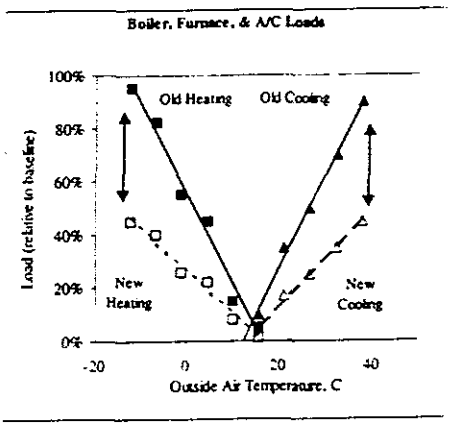
- Hybrid of Option B and A
- Use short-term metering (one season) to characterize a sample of heating and cooling equipment (Option B).
- Normalize results to typical weather.
- Install GSHPs

## M&V Approach (cont'd)

- Monitor performance for one year. (Option B)
- Normalize to typical weather conditions.
- Compare differences.
- Stipulate weather conditions (Option A).
- Remonitor heat pumps every three years to verify performance.

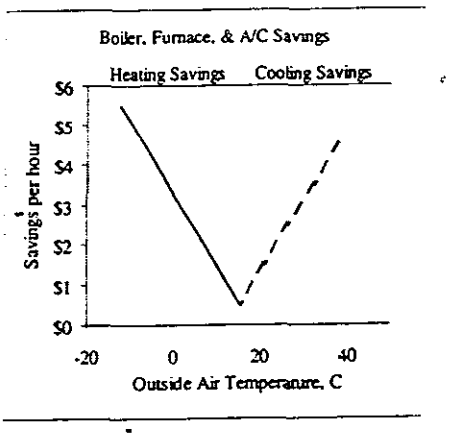
# Furnace & A/C Performance

- Short-term measurements to define run-time as function of OSA temp.
- Repeat on heat pumps.
- Savings are the difference.



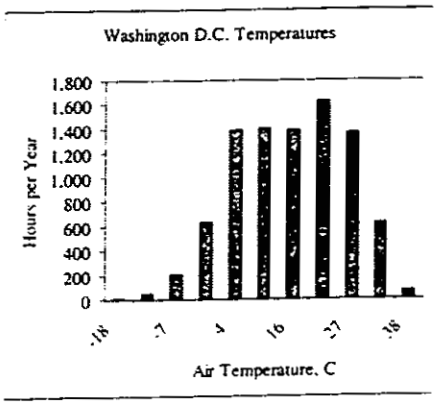

# Furnace & A/C Savings

- Convert savings to dollar amounts because of fuel switching.
- Develop equations for savings as a function of temperature.



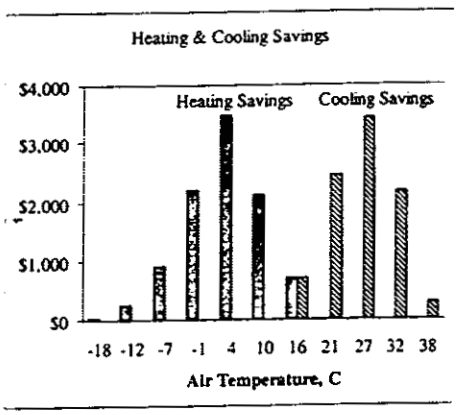
# Weather Data

- Need to apply savings to weather data.
- Use TMY data to find hourly temperature distribution.
- Then apply distribution to savings.




# Bin Analysis

- For each temperature range, find savings in dollars/hour.
- Multiply savings by number of hours.
- Total savings are sum of bin savings.



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## M&V Issues

- Need to ensure that sampling periods are sufficient for both heating and cooling.
- Need to use correct fuel prices for oil, gas, and electricity.
- Demand savings apply to summer only.
- Savings not based on real weather data but typical weather data.

## Conclusions

- Method could could be considered hybrid Option A & B, or simply Option A with measurements.
- Savings based on *measured* performance and *stipulated* weather data. *Actual* savings will fluctuate every year but *claimed* savings will not.

# Open discussions on applicability and adaptation possibilities

# INTESCO Asia Limited



## Outline

- Application of M&V (sample ECMs)
- Issues for Discussion
- Composition of Indian ESCOs
- Experience of Indian ESCOs
- Potential ESCO Customers

# Application of M&V

## Sample ECMs

- Variable Speed Drive
- EE motors Vs std. motors
- Chiller upgrades
- Building Control systems
- Process/Technology upgrades
- Lighting efficiency / controls
- Cogeneration



# Issues for Discussion

- Urgent need felt for M&V protocols.
- Applicability of option A&B possible in most of the areas, especially for retrofit isolation cases.

## Issues for Discussion (continued)

- The 'whole billing and computer simulation' approaches are viewed as a complex exercise to comprehend.



## Composition of Indian ESCOs

(as understood by us)

- Full Service ESCOs
- Lighting service ESCOs
- Energy services providers
- Others

## Composition of Indian ESCOs
(contd.)

Others based on types

- equipment / vendor promoted
- solely for private utilities

Others based on end-use sector

- main focus on industrial
- main focus on commercial buildings and hotels
- main focus on residential (mostly solar & renewable)



## Experience of Indian ESCOs

- Present focus of many ESCOs is on industrial sector.
- Also moving towards commercial and residential sectors.
- Huge opportunities are also forecast in agricultural sector.
- Benefits of M&V rigors not understood by all concerned.

## Potential ESCO customers

- Buildings & Hotels
- Cement
- Chemical process
- Pharmaceutical
- Steel
- Textile
- Fertilizer
- Refineries

# IPMVP

Presentation develop by:

Satish Kumar

of the

Lawrence Berkeley National Laboratory

(and edited by Mark Stetz of Schiller Associates)

IPMVP World Wide Web site: http://www.ipmvp.org

## IPMVP - Objectives

- **Reduce transaction costs by providing international, industry consensus approach and methodologies**
- **Replace multiple, incompatible protocols with single consensus approach**
- **Increase reliability and level of savings**
- **Reduce financing costs by providing project M&V standardization, thereby allowing project bundling and pooled project financing**
- **Provide a way to update the standard for future needs**

## IPMVP - Scope

- Addressing the M&V needs of participants in energy and water efficiency projects
- Defining the role of verification in third-party financed efficiency projects
- Providing industry consensus options, with varying levels of accuracy and cost, for verifying:
  - Baseline and project installations conditions
  - Long-term energy and water savings performance
- Providing techniques for calculating "whole-facility" savings, *individual technology savings* and stipulated savings
- Defining procedures which are:
  - Consistently applicable to similar projects
  - Internationally accepted, impartial and reliable

## IPMVP - Target Audience

- Facility Energy Managers, *particularly public buildings*
- ESCOs (Energy Service Companies)
- WASCOs (Water Service Companies)
- Development Banks
- Finance Firms
- Utility DSM Managers
- Building Managers
- State and Municipalities

## Uses of M&V

- Determine energy savings
- Integrated with commissioning can provide feedback on performance of ECMs
- Long term feedback for on-going fine-tuning of ECMs
- Documentation for evaluating (and justifying) future ECMs
- Enhances Indoor Environmental Quality
- Basis for documenting emissions reductions and securing credits

## IPMVP as Basis for International $CO_2$ Trading Regime

- Allow credits to accrue at the project level
- Industry consensus
- Measurement as cost savings, not added cost
- Standardization allows bundling

## M&V Efforts in U.S.

- 1970's — Case by case measurement plans
- 1983 — IEA's "Guiding Principles for Measurement"
- 1985 — First utility sponsored large scale programs
- 1988 — New Jersey Utilities M&V plan
- 1988 — First NAESCO M&V plan
- 1992 — California CPUC M&V Protocol
- 1992 — New Jersey Standard Offer Protocol
- 1993 — NAESCO M&V ver 1.3
- 1994 — PG&E PowerSaving Partners "Blue Book"
- 1995 — *EPA Conservation Verification Protocols*
- 1995 — LoanSTAR (Texas) Protocols
- 1996 — North American Energy Measurement & Verification Protocol
- 1996 — FEMP application
- 1997 — International Performance Measurement & Verification Protocol
- 2000 — IPMVP 2000, FEMP 2.2, ASHRAE 14-P (draft)

## M & V Methods

| | IPMVP | FEMP | ASHRAE 14-P |
|---|---|---|---|
| Retrofit Isolation | A | A | - |
| Retrofit Isolation w/ continuous metering | B | B | Retrofit Isolation |
| Utility Bill Analysis | C | C | Whole building metered approach |
| Building Simulation | D | D | Whole building calibrated simulation |

# M&V Options in the IPMVP

- Option A: Stipulated Baseline and Performance
  - Verified equipment performance potential
- Option B: Stipulated Baseline, Verified Performance
  - Estimating tool calibrated with end-use data

Measure

- Option C: Comparison of similar buildings with and without ECMs using whole building data (hourly or monthly)
- Option D: Stipulated Baseline, Verified performance
  - Estimating tool calibrated with whole building data

Building

# Option A

- Properly defined baseline conditions
- Projects where verifying the *potential* to generate savings is the major concern (or the risk to be mitigated)
- Actual energy or cost savings are not verified
- They are *predicted* using engineering or statistical methods
  - Using historical data for operational factors (occupancy schedule etc.)
  - May use spot or short-term (but not long-term) measured data to estimate performance factors
- Option A includes primarily verification activities such as physical assessment of equipment changes

## Option B

- Properly defined baseline conditions
- Projects where actual savings (energy and cost) during contract need to be determined, based on end-use
- Involves long-term measurements for both *Performance* and *Operational* factors
- A "Retrofit Isolation" method
- M&V can be performed at the equipment or system level and goes on for the term of the project
- Same procedures as Option A plus measurement of pre- and post-installation energy use

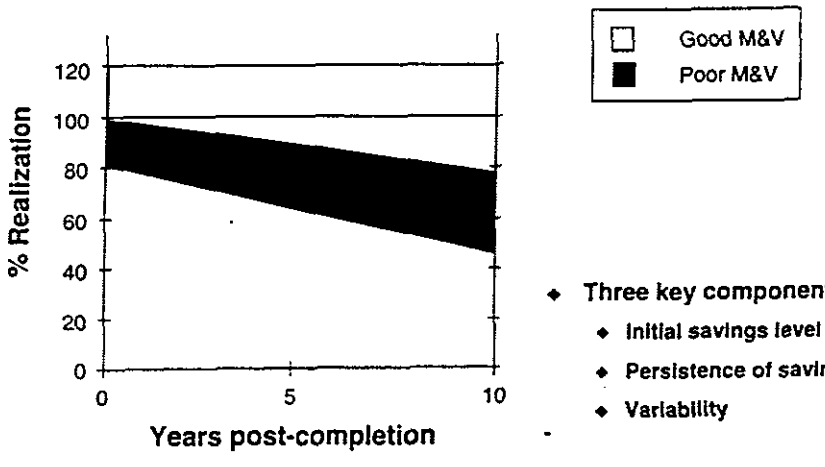
## Option C

- Properly defined baseline conditions
- Projects where actual savings (energy and cost) during contract need to be determined, based on end-use
- Utility whole-facility meter analysis calibrated with utility billing data
- Savings are determined by "whole facility"
- Same procedures as Option A plus measurement of pre- and post-installation energy use

# Option D

- Use of a calibrated simulation tool to estimate "before" and "after" energy use
- Simulation of whole building or just end use
- Building simulation model (e.g. DOE-2), or a spreadsheet, or VSD estimating program, etc.
- Calibration is done by:
  - Linking simulation inputs to actual operating data, and
  - Comparing the results with end-use or whole building data
- Used for new buildings and complex existing building systems

# Project Comparison




- Three key components
  - Initial savings level
  - Persistence of savings
  - Variability

## Useful Web Sites

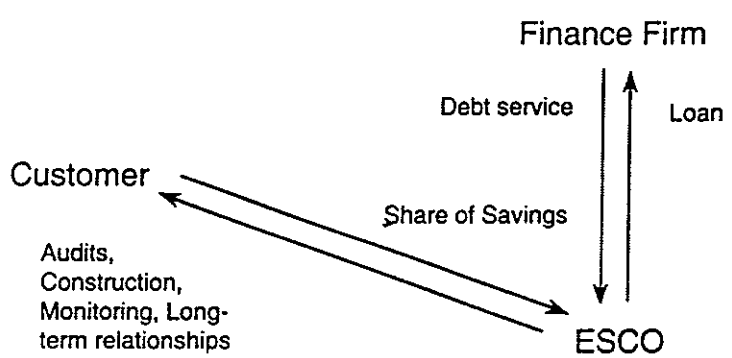
Industry Protocols

- IPMVP www.ipmvp.org
- FEMP www.eren.doe.gov/femp/financing/measguide.html
- LBNL ateam.lbl.gov/mv/
- ASHRAE www.ashrae.org

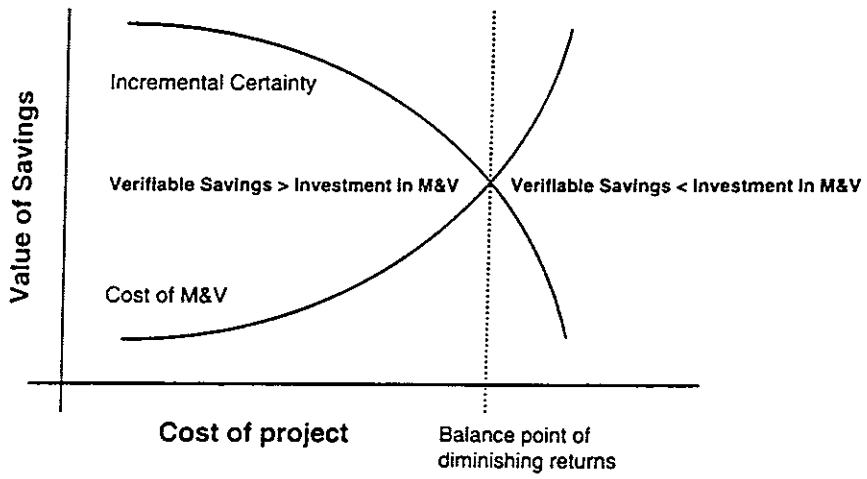
Utility Protocols

- Standard Performance Contract (CA)
  - **PG&E** **www.pge.com/spc**
  - **SCE** **www.scespc.com**
  - **SDGE** **www.sdge.com/spc/bus/**

## Full Recourse Project Financing



## Trade-off Between M&V and Cost




## Common Energy Cost Savings Measure

- Lighting Improvements
- Electrical Motors and Drives
- Boiler Improvements
- Chiller Improvements
- Improving Control Strategies
  - Building Automation Systems (BAS)
  - Energy Management Control Systems (EMCS)
  - Utility Monitoring and Control Systems (UMCS)
- Heating Ventilating and Air Conditioning
- Building Envelope Modifications
- Water and Sewer Conservation Systems
- Renewable Energy Systems

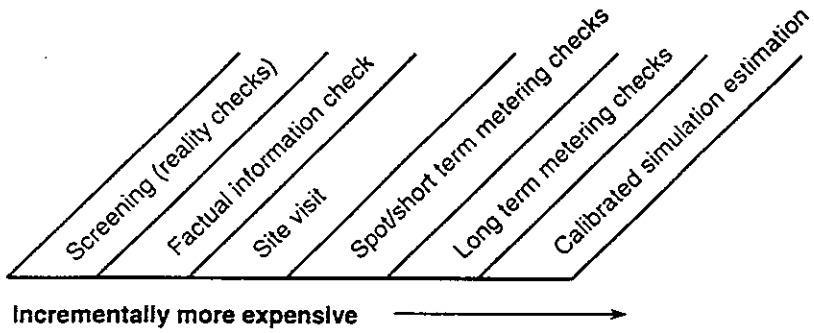
## Overview of M&V Options - 1

- Option A (1-5% of project construction cost)
  - Properly defined baseline conditions
  - Focuses on physical assessment of equipment changes
  - Reliance on historical data for *operational* factors (occupancy schedule etc.)
  - Use of spot or short-term measured data to estimate *performance* factors
- Option B (3-10% of project construction cost)
  - Properly defined baseline conditions
  - Verifying energy and cost data obtained during term of agreement
  - Use of long-term or continuously measured data for both *performance* and *operational* factors
  - M&V can be performed at the equipment or system level and goes on for the term of the project

## Overview of M&V Options - 2

- Option C (1-10% of project construction cost)
  - Properly defined baseline conditions
  - Savings are determined at the *"whole-building"* level
  - Reliance on a combination of utility billing analysis and sub-metered data (for calculations.
- Option D (3-10% of project construction cost)
  - Properly defined baseline conditions
  - Savings are determined through *simulation* of individual system or "whole-building"
  - Simulation model is *calibrated* with hourly or monthly utility billing data and/or end-use metering
  - Used for new buildings and complex existing building systems

## Layers of Measurement & Verification




- Option A - End use, measured capacity, stipulated consumption
  - Option B - End use, measured capacity, stipulated consumption
    - Option C - Whole building or main meter approach
      - Option D - Calibrated simulation approach

## How to Get a Copy of IPMVP

- For hard copies, call Energy Efficiency and Renewable Energy Clearing House (takes 2-4 days to receive a copy)
  - 1-800-DOE-EREC
- Electronic Download (in MS Word and Acrobat)
  - www.ipmvp.org/download.html
- For miscellaneous information
  - s_kumar@lbl.gov
  - 1-202-484-0884 x110

## How to Specify Compliance

- State the document to be referenced
- State which option and method will be used
- Indicate who will conduct the M&V
- Define the details of how calculations will be made
- Specify the metering
- Define key assumptions
- Define the level of accuracy
- Define quality assurance methods
- Define reporting contents and schedule

## IPMVP Uses - 1

### In the United States

- ESCO industry standard
- Federal buildings through FEMP
- State-wide adoption
  - California
  - Florida
  - Iowa
  - New York
- Basis for innovative, large scale financing initiatives
  - NYSERDA
- To achieve and demonstrate state compliance with Federal Clean Air Act Requirements under State Implementation Plans (SIPs)
  - New Jersey (preliminary)

## IPMVP Uses - 2

### Currently (or beginning to be) used

- by Multi-lateral Development Banks as a key design element in large scale energy efficiency loans
  - World Bank
  - International Finance Corporation
  - Inter-American Development Bank (IDB)
  - European Bank for Reconstruction & Development (EBRD)
- for determining reduction of greenhouse gases
  - Inter-Governmental Panel for Climate Change (IPCC)
  - Global Environment Facility

## IPMVP - International Participation

### Countries with National Participating Organizations

- Brazil
- Bulgaria
- Canada
- China
- Czech Republic
- India
- Japan
- South Korea
- Mexico
- Nepal
- Poland
- Russia
- Ukraine
- United Kingdom
- United States