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Renewable Energy and the International Performance Measurement and Verification Protocol

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RENEWABLE ENERGY AND THE INTERNATIONAL PERFORMANCE MEASUREMENT AND VERIFICATION PROTOCOL

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ABSTRACT

The Renewables Subcommittee for the International Performance Measurement and Verification Protocol (IPMVP) is developing a section of the IPMVP treating the special issues related to performance measurement of renewable energy systems. An industry consensus framework for measuring project benefits is important in realizing the promise of renewable energy. This work represents a voluntary, consensus-building process among sponsoring organizations from 21 countries and several disciplines.

Measurement and Verification (M&V) can provide a common tool for standardization to support performance-based contracting, financing, and emissions trading. M&V can ensure that savings and generation requirements in energy projects will be achieved accurately and objectively. The protocol defines procedures that are consistently applicable to similar projects, internationally accepted, and reliable. Actual M&V project results can demonstrate success and provide developers, investors, lenders, and customers with more confidence in the value of future projects.

1. PURPOSE AND SCOPE OF THE IPMVP

The IPMVP was created in 1997 to increase reliability and savings, cut efficiency investment costs, and provide the standardization required to secure lower cost financing for energy and water efficiency projects. The purpose of the IPMVP is to provide those involved in performance-based energy projects a basis for negotiating the contractual terms that will ensure that a project achieves or exceeds its goals of saving money, generating income, and improving the environment.

The objectives of the IPMVP include: to reduce transaction costs by providing an international industry consensus approach and methodologies; to replace multiple, incompatible protocols with a single consensus approach; to increase reliability and savings; to reduce financing costs by providing project M&V standardization, which facilitates project bundling and pooled project financing; and to provide a way to update the standard for future needs.

By providing greater and more reliable savings and a common approach to efficiency installation and measurements, widespread adoption of the protocol should make efficiency investments more reliable and profitable, fostering the development of new types of lower cost financing. The standardization of M&V should also lead to the development of a secondary market for efficiency investments. Increased global availability of low-cost and off-balance-sheet financing would allow the efficiency industry to grow more rapidly, resulting in widespread benefits in the form of increased employment, greater productivity, lower energy and water bills, and less damage to the environment and human health.

The Renewables Subcommittee hopes to extend the success of energy efficiency and water conservation in the IPMVP to include the special issues related to renewable energy systems worldwide. Similar to investments in efficiency and conservation, renewable energy system investments are more attractive if project performance can be measured and verified. In contrast, special considerations for M&V of renewable energy systems distinguish them from efficiency measures. Most notable is that renewable energy systems supply energy rather than reduce the amount of energy needed.

2. THE IMPORTANCE OF M&V AND RENEWABLE ENERGY SYSTEMS

If we are to realize the promise of renewable energy, it is important that we develop a protocol for measuring project benefits. Economic, environmental, and confidence factors all play a role in the success of a project.

Renewable energy projects provide an opportunity to significantly reduce the use of fossil fuels and to reap the resulting benefits. In addition to offsetting the cost of fossil fuels, renewable energy projects use more stable fuel suppliers and prices, which can reduce the risk of investing in projects. Installing and operating renewable energy systems, rather than paying for imported energy, also help to keep money and jobs in the local community.

While economic benefits generally depend on the amount and cost of energy delivered to a site, environmental benefits often involve a consideration of how that energy was generated and delivered. This site-versus-source difference is especially important in the case of electricity, which can be generated in several ways, each with its own environmental impacts. These range from hydropower with no atmospheric emissions to coal-fired power plants that contribute to acid rain, urban smog, and greenhouse gas emissions. Diversification of the energy supply and distribution of renewable energy generation around the power transmission system increases grid stability and availability while reducing downtime. The reduction of pollutant emissions associated with fossil fuel combustion improves air quality and human health. The environmental impacts of mining and fuel spills are also avoided. Several of these benefits are unique to renewable energy systems and require M&V techniques distinct from those of energy efficiency projects.

Regulatory bodies require a standard method of measuring progress and compliance with energy and emissions requirements in order to implement programs uniformly. The potential benefits of estimating the social costs associated with negative impacts on the environment, or environmental externalities, are extremely important in strategic energy planning and policy development purposes (8). One approach to addressing these impacts is to quantify and assign a value to the externalities associated with the resource consumed. Three common techniques for valuation of externalities include the Damage Cost Approach, the Control or Mitigation Cost Approach, and the Revealed Preferences Approach. Because each technique has its advantages and disadvantages yielding estimates which vary widely, reliable estimates of externalities are difficult to establish. Greater performance reliability inspires confidence among national and international bodies that the emissions offset allocation resulting from investments in renewable energy systems can be done with greater precision and in an internationally consistent manner. The IPMVP can serve as the framework from which benefits of renewable energy projects can be quantified.

As an example of the importance of a protocol for project benefits, the U.S. Initiative on Joint Implementation (USIJI) includes monitoring and verification as a component of the guidelines for a project proposal. The USIJI is a pilot program encouraging organizations in the United States and other countries to implement projects that reduce, avoid, or sequester greenhouse gas emissions. The United States announced the USIJI pilot program in October, 1993 as part of the U.S. Climate Change Action Plan.

Finally, an established M&V protocol provides a systematic foundation for greater confidence that the predicted economic and environmental benefits of a renewable energy project investment will be realized. This is important to project investors, who bear the financial risk of non-performance.

3. SPECIAL M&V REQUIREMENTS OF RENEWABLE ENERGY SYSTEMS

Renewable energy systems are diverse in terms of resources and conversion technologies. Nevertheless, aspects that are common to all renewable energy technologies distinguish supply-side measures from energy efficiency measures. Measuring this supply offers a simplified approach to system performance that is not possible with energy efficiency projects. However, barriers such as capital cost, intermittent resources, and backup systems call for special consideration in designing an M&V program.

The principal barrier to wide implementation of most renewable energy technologies is the high capital cost. The associated opportunity is low operating cost (resulting largely from low or no fuel costs). High initial cost requires that special consideration be given to the ways that other properties of renewable energy technologies impact finance issues. They require an investment term for payback that is often longer than efficiency projects. The associated M&V program must verify that benefits are sustained over a longer time period, favoring M&V approaches that may cost more initially, but have lower annual operating costs.

Renewable energy systems often rely on intermittent resources requiring special procedures to measure effects on the integrated energy system. The performance of renewable energy systems is a function of environmental conditions, such as solar radiation and wind speed, which are outside the control of project developers. The capacity to deliver power on demand may indeed be as valuable as the amount of energy supplied over time. Resources must be taken into account in any M&V approach.

A renewable energy system rarely displaces the cost of a conventional system since it is required when the intermittent resource is not available. It is also difficult to compare renewable resources to fossil fuels in terms of cost, emissions, land use impacts, and other criteria because they operate very differently. This makes increased capacity and redundancy an added value in a carefully structured M&V approach. A sound protocol for measuring performance and quantifying benefits unique to renewable energy systems can help counterbalance these barriers.

4. OBJECTIVES OF THE RENEWABLES SECTION

M&V for renewable energy systems may suggest several project objectives, from the earliest stage of project development through operation of the completed system. Objectives may be based on performance data, performance contracting, financing, and emissions trading.

Daily, weekly, and annual load profiles are measured initially to establish the energy use baseline and to ascertain the size of the system, energy storage requirements, and other design characteristics of the project. These load profiles also provide load information needed to establish project feasibility. Directly after a project is installed, M&V serve as a commissioning tool to confirm that systems were installed and are operating as intended. Data from a well-designed M&V program provide ongoing diagnostics and help to sustain system performance and resulting benefits over time.

A standard M&V framework provides guidance on obtaining information needed to reduce and manage performance risk in order to structure project financing contracts. M&V results may serve as the basis for payments to a financier over the term of a performance contract. Payments can be directly tied to measured performance, in which case the payment would vary from month to month. Alternatively, or perhaps in addition to this, M&V results could be used to verify a minimum level of performance guaranteed in the contract.

Different investments require different measures of performance. Accordingly, the IPMVP provides four options to accommodate a variety of contractual arrangements. The protocol provides guidance on which options to choose and helps clarify the relationship of various M&V options to the risks assumed by relevant parties. The value of measuring performance ranges from useful to absolutely critical, depending on the financing method and which party has accepted the contractual risk. For example, an energy service company typically will not be concerned about operating hours if the owner takes responsibility for equipment operation.

In the drafting of a financing contract, a defined, accepted, and proven M&V approach helps increase customer comfort and reduce transaction costs by facilitating negotiations. For project developers, financiers, and large customers (such as government agencies), there are additional M&V objectives extending beyond the scope of an individual contract. M&V programs can be designed to validate or improve computer simulations or other predictions of system performance, thus increasing confidence in project benefits and reducing project risk.

Actual M&V project results provide developers, investors, lenders, and customers with more confidence regarding the value of future projects than engineering estimates. A previously defined and accepted M&V protocol can help reduce transaction costs by pooling projects and facilitating negotiations. By helping investors to understand and mitigate risk, a well-established protocol for measuring the benefits of a project will help obtain lower-cost financing for the project.

An accepted protocol is helpful to secure the full financial benefits of emissions reductions, such as emissions trading. In order to establish compliance with emissions reduction targets, a regulating body will need to adopt a protocol for measuring emissions reductions. A protocol common to all projects would be required for claiming and trading emissions credits.

5. PERFORMANCE CLAIMS

An M&V protocol is an agreement adopted between a supplier and a consumer. In a performance contracting arrangement, measurement of performance is all-important. It is, in fact, what the consumer is buying. A protocol designed to measure performance must start by clearly articulating what the supplier is claiming to deliver. The performance claims for renewable energy will depend on the conversion technology, the application, and the business arrangement between the supplier and the consumer.

The design of an M&V program should be one that measures and verifies the specific performance claims of the deal. To borrow a concept from the International Standards Organization, "First state clearly what it is that you do, then state how you measure your success at it." An example of a performance claim may be to deliver a certain amount of energy (kWh) per year, while another claim might be to provide a capacity to deliver power (kW) on demand.

6. M&V OPTIONS

The protocol affords a great deal of flexibility in choosing between M&V options to best suit the needs of the project participants. The options to measure and verify the performance of a renewable energy system may be classified into four general categories:

Option A: Measured Capacity, Stipulated Performance -- *using engineering estimates based on system specifications to stipulate savings, inspecting the system initially to ensure that equipment was installed according to those specifications and periodically inspecting to ensure the system is operating properly.*

If the supplier and the customer can agree on the values, energy and cost savings may be stipulated based on engineering calculations of the performance of a renewable energy system. Even then, inspections must be conducted to ensure that the systems are installed as specified and are operating as expected, and to satisfy any statutory or regulatory requirement that the level of savings be verified periodically. This is the least-cost M&V option, and it is often suitable for small systems in which cost savings are not sufficient to justify the expense of instrumentation and analysis. To avoid a conflict of interest, the energy service company and the customer may retain a third party to conduct the inspections.

As an example of stipulated performance of a specific system, the American Society of Heating, Air Conditioning and Refrigeration Engineers have prepared manuals on installation and operation/maintenance of active solar heating systems (1,2).

Option B: Measured Production/Consumption – *long-term measurement of energy delivery directly by metering plant output, or indirectly by determining savings based on an analysis of end-use electric or gas meters.*

Since renewable energy systems deliver, rather than conserve energy, a distinguishing feature over efficiency measures is that the performance (energy delivery) can be measured directly with a meter. Metering has the potential to simplify an M&V program, but the way in which metering fits into the M&V plan depends on the performance claims. A program can be designed either to directly meter the system output (with a Btu meter or kWh meter), or meter the gas or electric use and infer savings indirectly by subtracting the data from the baseline. The numbers of channels and type of measurements taken distinguish metering strategies.

Option C: **Utility Bill Analysis** -- *inferring savings by the statistical analysis of whole-facility energy consumption without end-use metering of the renewable energy system.*

Utility bill or whole-facility metering involves identifying computer driving forces (independent variables) and relating them to whole-facility energy use by using a model. Then post-retrofit energy consumption is subtracted from energy consumption calculated with the model to estimate savings. Since the accuracy of this method is not better than +/-20%, it may be appropriate for applications in which renewable energy systems contribute to a large fraction of the load. Measuring all the independent variables needed to model energy usage (temperature, humidity, solar radiation, occupancy, etc.) generally exceeds the measurements required to directly measure renewable energy system output. Despite these drawbacks, this option would be well suited for M&V for renewable energy systems as part of a larger suite of energy efficiency measures in which load modeling and measurement of the driving functions is done routinely.

The Sacramento Municipal Utility District offers solar water heating as an example of Utility Bill Analysis of a specific system (7).

Option D: Calibrated Models -- *predicting the long-term performance of a system by calibrating (renormalizing) a computer model based on data from a short-term test.*

This method offers a tremendous amount of information from a short-term test. A model provides the form of the correlation between measured independent variables and measured system performance. The independent variables (ambient conditions such as solar radiation, wind speed, temperature, etc. and load) are measured and recorded simultaneously with the system performance over a short time period. Coefficients of the model are adjusted to provide the best fit between the model and the measured performance. This calibrated model then becomes a valuable source of information. The deviation of model coefficients from their expected value provides information for diagnosing system problems. Running the model with annual weather and load data provides an estimate of annual performance.

An example of Option D is dynamically measuring solar storage tank temperatures, effectively making the solar storage tank a calorimeter to measure the energy flow in a solar system (5). A simple collector model combined with integrated data analysis is based upon the tank energy balance, identifying solar gain during the day and tank losses at night.

These options are not necessarily listed in increasing order of complexity or cost. For example, inspection can be more or less costly than metering, depending on the application.

7. AN EXAMPLE OF OPTION B

Option B deserves special consideration in evaluating M&V options for a renewable energy system since the energy delivery of most renewable energy systems can be measured directly. This means that baseline and energy savings required for energy efficiency measures do not need to be determined.

As one example of direct Btu metering in a performance contract, consider a 1,670-square meter parabolic trough system valued at $650,000, which Industrial Solar Technology (IST) is installing at Phoenix Federal Correctional Institution in Arizona (3). Monthly payments from the prison to IST are equal to the monthly solar energy delivery (kWh) as measured by the Btu meter, multiplied by the average cost of utility power, and multiplied again by an 85% discount. The discount guarantees that the prison will realize a 15% savings over utility power.

In order to verify demand savings, the M&V program includes a time-of-use meter for the whole facility and a Btu meter that logs solar energy delivery every 15 minutes (the utility demand billing period). The data from these two meters are analyzed to verify demand savings. The sum of the utility meter and Btu meter establishes when the peak would have occurred without solar power. The solar power delivery for this 15-minute period is the amount of peak shaving. Adopting a simple energy-plus-demand rate structure, the ratio of peak shaving (kW) to monthly energy delivery (kWh) must be at least that of the overall utility bill. If it is less, the set-point of the temperature control that bypasses the solar preheat tank is increased to increase the peak shaving, albeit at the expense of monthly energy delivery (a higher temperature preheat tank results in more thermal losses).

Two Btu meters are used in series so that metering continues if one is removed for calibration. Each meter is +/- 7%, and the meter reading high is sent for calibration. The large size and cost of this system justifies two meters for the performance measurement, but such redundancy is usually not required.

8. QUALITY AND COST OF RENEWABLES M&V

The cost of an M&V program consists of the cost of purchasing, installing, and maintaining the instrumentation (including periodic calibration), and the cost of the labor needed to design the program, install the instrumentation, and periodically collect, reduce, and present the results of the program. Overly detailed or poorly designed M&V programs can be very expensive, so the amount of money that should be spent on M&V should be determined by the value of the benefits to be realized by the M&V program. The value of project benefits is determined by the negotiation for each project.

The objective is to minimize the cost of the M&V program and the cost of uncertainty in the savings. The cost of uncertainty would most often be realized by a higher interest rate. In general, the allowable relative error in an M&V program will be negotiated between parties, with all parties trying to minimize total cost. As a rule of thumb, M&V costs should fall within 3% to 10% of typical project cost savings.

9. SUBCOMMITTEE STRUCTURE

The Renewables Subcommittee is composed of leading experts from around the world whose goal is to strengthen and foster the rapid growth of renewable energy technologies. Members are of diverse affiliations, including governmental agencies, non-governmental organizations, private firms, and academia. A database was created of prospective members and contact information. It is regularly maintained with a record of correspondence. Invitations to participate were sent to contacts early September 1998. Members, by joining, agree to contribute to the stated purpose of the IPMVP, to contribute to its development, and to work cooperatively within the consensus method. They also commit to promoting the adoption of the IPMVP through the organizations and professional communities in which they serve. Members are encouraged to identify topics that they think need attention and offer examples of effective M&V approaches. Other contributions include providing draft language and commenting on that developed by other committee members. The consensus method is encouraged from the start and on a continual basis to ensure a high-quality product that represents a broad consensus.

10. A CONSENSUS-BASED APPROACH

The IPMVP is the product of thousands of volunteer hours from hundreds of individuals in the United States and abroad. Through an open, consensus process, as governed by the Committee Guidelines, members have discussed, written, and reviewed the protocol. Because it involves individuals from a broad range of backgrounds, interests, and professions, the IPMVP is quickly becoming the international standard for M&V.

Because of its speed and convenience, the primary avenue of communication among members is the Internet. In October 1998, the IPMVP Renewable Energy Article Review Web Site was launched. It provides a convenient way to review the current draft section. The site is interactive and provides members a convenient method of communication. The postal service and facsimile machines supplement electronic communication as needed.

The IPMVP is revised every year and is maintained under the sponsorship of the U.S. Department of Energy by a broad coalition of facility owners and operators, financiers, contractors, energy service companies, and other stakeholders. As a living document, it incorporates changes and improvements reflecting new research, improved methodologies, and better data. Extending the protocol to address major new topics involves assembling a substantial body of international experts who develop a recommended methodology on a volunteer basis. They use the Internet to access evolving documents to ensure broad and open participation and review.

11. CONCLUSION

The members of the Renewables Subcommittee trust that this new section of the IPMVP provides the renewable energy community with a valuable tool for M&V of renewable energy system performance. As innovative renewable energy financing increases worldwide, so will the need for the IPMVP and its internationally standardized framework.

12. ACKNOWLEDGMENTS

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