How can IPMVP be "adopted" in a European country where M&V methods are not so widespread (France)? Illustration through the presentation of 2 case-studies

Isabelle Hita
EDF R&D
Département Eco-Efficacité et Procédés Industriels
France
isabelle.hita@edf.fr

Maxime Dupont
EDF R&D
Département Eco-Efficacité et Procédés Industriels
France
maxime-2.dupont@edf.fr

Xavier Romon
EDF DS3E
France
xavier.romon@edf.fr

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Abstract

Being for many years a stakeholder in energy efficiency, EDF, the major French electricity supplier, has recently made a strong decision regarding the development of energy efficiency services. Willing to provide quality services to its customers, EDF has committed itself into the Energy Efficiency Services Club (Club S2E) which includes five French main actors in the field (mainly professional associations) and with the support of the French energy agency, ADEME. The Club aims at contributing to the energy efficiency. Having led in 2006 and 2007 a wide study on Measurement and Verification (M&V) methods and tools for assessment of energy efficiency improvement, the Club elected IPMVP, International Performance Measurement and Verification Protocol, as its reference. The Club S2E is currently going a step further, intending to provide a guide for customers describing what is M&V and how it makes energy performance contracts reliable. This guide shall comprise case studies in order to illustrate the general principles depicted by IPMVP. EDF has finalised two case studies based on our practical experience, consisting in building up M&V plans fully consistent with IPMVP requirements. These examples deal with electrical base-load reduction for the first case and heat recovery from an industrial process for the second example. This paper concludes on the lessons learnt from this exercise and on the difficulties to fully adopt IPMVP and adapt current practices, in accordance with a future European standard on energy efficiency services.

Introduction: EDF, a new Services Integrator on the European market

EDF, major European energy supplier, has decided a strong commitment regarding the development of energy efficiency services. The reasons for it are multiple:

1. Energy market liberalization leads historical suppliers to seek new sources of development and innovative products and services close to their historical market;
2. End-use Efficiency and Energy Services Directive urges energy suppliers to offer energy services to their customers;
3. Evolutions of the markets and customers demand improved energy services to operate installations more efficiently, reduced energy bills and less CO2 emissions;
4. EDF strategy and strong belief that energy efficiency and greenhouse gas reduction are necessary to secure environmental protection and a more sustainable development.

The original approach in energy efficiency services led by EDF aims at advising and helping customers, in the industrial sector and also in the other markets, to help them optimise their energy consumption and reduce their CO_2 emissions. Willing to provide quality services to its customers, EDF has committed itself into the Club S2E works.

The federative approach in EPC proposed by the S2E Club

WHAT IS THE S2E CLUB?

The Energy Efficiency Services Club (Club S2E) was founded on November, 5th 2005 by five French main stakeholders in the field with the support of the French energy agency, ADEME. It gathers professional associations:

- FG3E, French Federation of Firms offering Services dealing with Equipment, Energy and Environment;
- GIMELEC, Group of Firms manufacturing electric equipment, control and related services;
- SERCE, Union of Companies dealing with electrical engineering;
- UCF, Union of Companies dealing with environmental engineering, as a part of the French Federation of Building;
- UFE, French Union of Electricity, Professional Association of the electric sector.

The Club aims at forming a working group to contribute to the energy efficiency market development. It is intended to be an information media to people working on utility, building and industry energy management. It reviews national public policies, and allows the French Energy Efficiency Service companies to express a common position and provide recommendations to French and international institutions.

A COMMON DEFINITION FOR ENERGY EFFICIENCY SERVICES

As a first task the Club agreed on common definitions and further to establish common practical references. Energy Efficiency Services are defined as follows:

The implementation of actions (equipment, works and/or services) leading to energy efficiency improvements and, whenever possible, to the introduction of renewable energy.

The improvement or saving brought to the customer must be measurable or verified, or else estimated in the case when measuring is not pertinent.

The contractor gives a guarantee of result in energy efficiency improvement and commits himself by contract to:

- Characterise accurately the reference/baseline situation, before action has been taken;
- Implement means of performance control and measurement;
- Achieve the objectives in terms of quality and energy savings announced.

In June 2007, the Club has published a guidebook in cooperation with ADEME, aiming at defining what an energy performance contract should be.

OBJECTIVES OF THE WORK LAUNCHED BY THE S2E CLUB ON M&V TOPICS

A study was led from late 2006 (first part) to the beginning of 2007 (second part). The study realised a two-stage benchmarking study:

- a first part based on an expert review of American and European standards, tools and methods, with a description of the market they address;
- a second part using interviews with experts employed by members of the Club.

According to the content of the results, the study has inspired the Club to write an addendum to the guidebook related to good practices in M&V, mainly recommending the use of IPMVP as a reference. This new guide targets customers, public procurement purchasers, but also service suppliers and public authorities. It describes what is M&V, it explains why a customer should have an interest in M&V and what are the advantages of buying an "IPMVP-inside" energy efficiency service. It aims at convincing purchasers of energy efficiency services that M&V makes energy performance contracts reliable. This guide is accompanied by case studies devoted to the illustration of the general principles depicted by IPMVP. The case studies are detailed M&V plans for a variety of "classical" situations met both in industrial and tertiary sectors. With a view to inform all stakeholders (customers, public authorities, energy services companies etc), the Club found that M&V plans constitute a holistic illustration of what measurement and verification consist in, they show customers what they should ask from their contractors.

Quick overview of IPMVP

WHAT IS IPMVP?

The development of the International Performance Measurement and Verification Protocol (IPMVP) was launched in 1995 by the U.S. Department of Energy (US DOE). The main objective was to provide standardized methods to quantify energy savings occasioned by ESCO projects in particular. The following explanations directly stem from IPMVP Preface:

IPMVP is a guidance document describing common practice in measuring, computing and reporting savings achieved by energy or water efficiency projects at end-user facilities. The IPMVP presents a framework and four measurement and verification (M&V) options for transparently, reliably and consistently reporting a project's saving. M&V activities include site surveys, metering of energy or water flow(s), monitoring of independent variable(s), calculation, and reporting. When adhering to IPMVP's recommendations, these M&V activities can produce verifiable savings reports.

Each user must establish its own specific M&V plan that addresses the unique characteristics of the project. The IPMVP is not a standard and thus there is no formal compliance mechanism for this document. Adherence with the IPMVP requires preparation of a project specific M&V plan that is consistent with IPMVP terminology. It must name the IPMVP option(s) to be used, metering, monitoring and analysis methods to be used, quality assurance procedures to be followed, and person(s) responsible for the M&V.

In 2002, IPMVP Inc. was incorporated as an independent non-profit corporation in order to include the international community and relieve the U.S. Department of Energy of its responsibilities as the organizer. In 2004, IPMVP Inc. was renamed Efficiency Valuation Organization as it expanded its fo-

cus. IPMVP is actually sponsored by the Efficiency Valuation Organization (EVO), a non-profit private corporation. EVO's mission is to develop and promote standardized methods to quantify and manage the risks and benefits associated with business transactions on end-use energy efficiency, renewable energy, and water efficiency.

IPMVP KEY-IDEAS

An accurate determination of energy savings is a key-condition for long-term success of energy management projects.

Savings are determined by comparing measured energy use before and after implementation of an energy savings program. In general:

Energy savings = (Base-year Energy Use) – (Post-Retrofit Energy Use) ± « Adjustments »

The "Adjustments" term in this equation brings energy use in the two time periods to the same set of conditions. Conditions commonly affecting energy use are weather (temperature, humidity etc.), occupancy, plant output, and equipment operations required by these conditions. The difficulty of M&V lies in the determination of realistic rules for the Adjustments term: if for heating distribution a relation between energy consumption and degree-days is easily settled, how to model a whole production plant consumption?

IPMVP proposes four options for the M&V Plan according to the system boundaries of the contract:

- Option A: isolation of a "simple" system and partial measurement, only of key-parameters, including stipulations of the other parameters,
- Option B: isolation of a "simple" system and exhaustive measurement , all parameters,
- Option C: whole facility approach,
- Option D: computer simulations using a software calibrated on a data collection.

To be consistent with IPMVP, the service must settle a M&V Plan, as part of the contract. IPMVP recommands that average annual savings determination costs do not exceed 10% of the average annual savings being assessed.

EDF participation in the French approach on M&V

STANDARDIZATION WORKS

EDF considers M&V as a confidence-raising tool and a facilitating method in the long-term relationship with its customers. M&V is a necessary tool to make the development of the energy efficiency market become a reality. EDF has been a co-driver in the decision-making for raising IPMVP awareness of the French market, but also at a European level in the context of European works for standardisation of energy management topics. Mandated by AFNOR (French standardisation organisation), EDF is indeed fully involved since its launch in the CEN/CENELEC (CEN is the European Committee for Normalization, CENELEC is the European Committee for Electrotechnical Standardization) Task-Force 189 on Energy Management, and more particularly within the Project Team on Energy Efficiency Services (PT EES), administrated by Italy. EDF participates actively both in our mirror-committee and in the European Project Team. France has warmly supported the idea that M&V is a requirement in the definition of such a service. Nevertheless the PT EES finally decided not to make M&V compulsory, but optional.

PARTICIPATION IN CLUB S2E WORKS

As a representative of UFE (French Union of Electricity) EDF is part of the Club S2E from the beginning and fully supports the adoption of IPMVP as a reference in energy performance contracting. EDF has played an active part in the Club S2E benchmarking study on M&V methods (specification and follow-up of the study), and has been a co-driver in the decision-making for raising IPMVP awareness of the French market. EDF has provided two case-studies based on its practical experience of energy efficiency improvements led on industrial customers sites. The first one deals with electric base-load reduction, the second one concerns heat recovery on a process line.

M&V Plan Contents

A complete M&V plan should include discussion of the following thirteen topics, as described in 2007 IPMVP version chapter 5:

1. Project Intent: describe the Energy Efficiency Improvement Project, its intended result, and the commissioning procedures that will be used to verify successful implementation of each action. Identify any planned changes to conditions of the baseline, such as unoccupied building temperature settings.
2. Selected IPMVP Option and Measurement Boundary: specify which IPMVP Option will be used to determine savings. Identify the measurement boundary of the savings determination. The boundary may be as narrow as the flow of energy through a pipe or wire, or as broad as the total energy use of one or many buildings. Describe the nature of any interactive effects beyond the measurement boundary together with their possible effects.
3. Baseline: Period, Energy and Conditions: document the facility's baseline conditions and energy data, within the measurement boundary. An energy audit used for establishing the objectives of a savings program or terms of an energy performance contract usually provides most if not all of the baseline documentation needed in the M&V Plan. This baseline documentation should include:
    a. Identification of the baseline period;
    b. All baseline energy consumption and demand data;
    c. All independent variable data coinciding with the energy data (e.g. production rate, ambient temperature…);
    d. All static factors coinciding with the energy data: e.g. occupancy type, density and periods.
4. Reporting Period: this period may be as short as an instantaneous measurement during commissioning of an action, or as long as the time required to recover the investment cost of the program

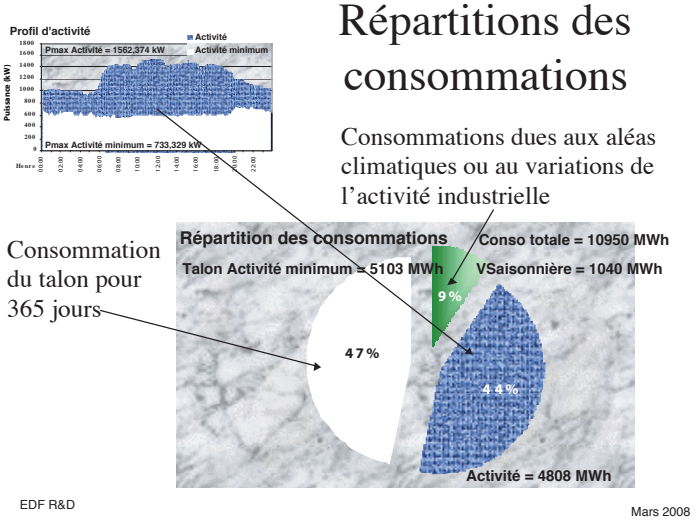

Figure 1. Breakdown of consumption into weather and activity parts. Translation: "répartitions des consommations" = "breakdown of consumption", "consommations dues aux aléas climatiques ou aux variations de l'activité industrielle » = « consumptions due to weather or production variations », « consommation du talon pour 365 jours » = « base-load consumption for 365 days », « talon activité minimum » = « minimum base-load due to activity », « Vsaisonnière » = « seasonal variation ».

5. Basis for Adjustment: declare the set of conditions to which all energy measurements will be adjusted.
6. Analysis Procedure: specify the exact data analysis procedures, algorithms and assumptions to be used in each savings report. For each mathematical model used, report all of its terms and the range of independent variables over which it is valid.
7. Energy Prices: specify the energy prices that will be used to value the savings, and whether and how savings will be adjusted if prices change in future
8. Meter Specifications: specify the metering points, and period(s) if metering is not continuous. For non-utility meters, specify: meter characteristics, meter reading and witnessing protocol, meter commissioning procedure, routine calibration process, and method of dealing with lost data
9. Monitoring Responsibilities: assign responsibilities for reporting and recording the energy data, independent variables and static factors within the measurement boundary during the reporting period.
10. Expected Accuracy: evaluate the expected accuracy associated with the measurement, data capture, sampling and data analysis. This assessment should include qualitative and any feasible quantitative measures of the level of uncertainty in the measurements and adjustments to be used in the planned savings report
11. Budget: define the budget and the resources required for the savings determination, both initial setup costs and ongoing costs throughout the reporting period.
12. Report Format: specify how results will be reported and documented. A sample of each report should be included.
13. Quality Assurance: specify quality-assurance procedures that will be used for savings reports and any interim steps in preparing the reports.

EDF case studies

As said before, we have produced two case studies, based on real field experience and real operations. Nevertheless these projects have not been conducted under IPMVP precepts, so we built up "fake" M&V plans, trying retrospectively to write plans as we would have done had we followed IPMVP. These cases, along with the ones provided by other Club S2E stakeholders, are available on ClubS2E website (in French only): http://www.clubs2e.org

CASE STUDY 1: BASE-LOAD REDUCTION

This project consists in reducing the electric power of a manufacturer during non-activity periods, typically at week-ends. An energy audit identifies the main consuming equipment during these periods, allowing to define targeted actions (on lighting, pumps, compressors, fans etc.).

The site taken as a case study presents a 600 kW base-load during week-ends. Our objective was to reach 400 kW, thus realising more than 1 GWh/year savings. The adopted option is C, a whole facility approach, as base-load consumption mainly concerns many diffuse energy uses. Power is measured by the Utility billing meter.

In order to calculate the savings, we estimate the mean week-end power that we multiply by the out-of-production duration (hours). We state that no adjustment is necessary, provided the site does no change its perimeter over the reporting period. We observe that the climatic conditions do not affect industrial load-curves significantly. The out-of-production hours is considered as constant, because the contractor is not responsible for industry uncertainties leading to variations in manufacturing rhythms. We calculate a production-time of 5 760 hours during the reference year, thus the duration for the saving calculation is 2 976 hours/year.

The budget for M&V amounts to 9 k Euro for a 3-year follow-up, essentially composed of time spent by the contractor for data collection and reporting to the customer. Compared to an estimated 215 k Euro savings for the same 3-year period, it makes a ratio M&V cost/saving of 4%, which is highly acceptable.

CASE STUDY 2: HEAT RECOVERY ON A PROCESS LINE

The industrial site we consider here belongs to the metals industry linked to the car manufacturing sector. One of its combustion processes generates hot exhaust gas, which are cooled through an air/thermal oil heat exchanger. The oil temperature is controlled thanks to the use of cooling towers. The excess-heat produced by the process is then lost in the air. Our project consist in installing an oil/water exchanger in place of the dry cooling towers, connecting the water loop to heating devices as well as domestic hot water network.

The amount of heat recoverable varies, in terms of power, between 6 and 9 MW, the exchanger is sized for 5 MW. The

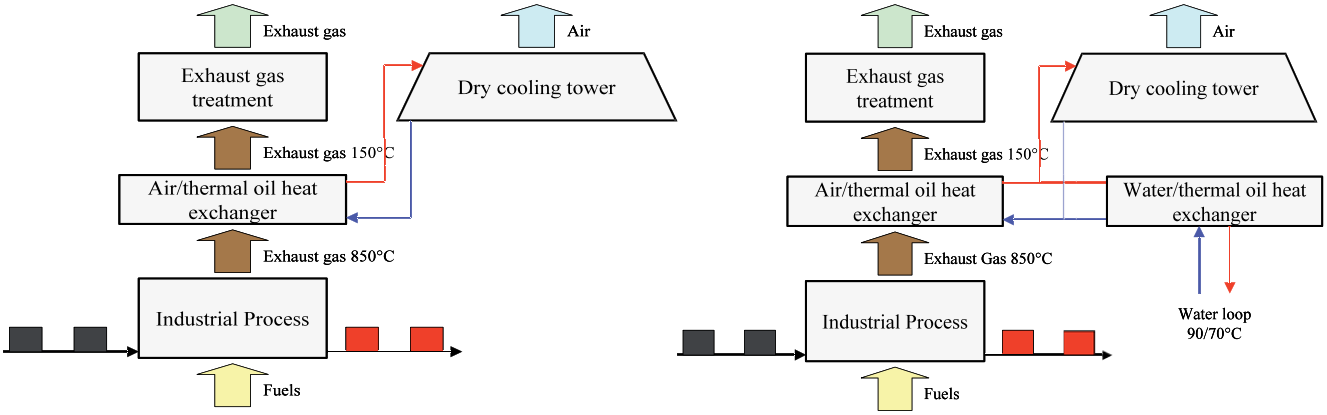

Figure 2. The industrial process before and after implementation of heat recovery

Table 1. Detail of case 2 M&V costs. The ratio M&V/savings is only 1.5%. M&V cost.

	Metering	Data collection and analysis	Reporting
Reference period	3 k€ (man-power and material)		
Reporting period	3 k€ every third-year (sensor calibration)	500 €/year	2 k€/year
15-year total	15 k€	7,5 k€	30 k€
Total 52,5 k€ for the 15-year period			

savings concern gas consumption for space heating, roughly 9 GWh/year, and hot water generation, 237 MWh/year.

The M&V option chosen is B: measurement of all parameters. We need to add a few sensors to the already existing metering (mainly gas consumption and ambient temperatures). Hot water flow rate, inlet and outlet water temperatures sensors were installed.

The process is constant throughout the year, but the use of recovered heat for space heating is dependant on weather conditions, while domestic hot water usage is constant. Thus we consider no adjustment for the amount of recoverable heat, neither on domestic hot water use. On the contrary, we need to take into account outside temperature for space heating : for low outside temperatures all the recoverable heat is used, on the contrary for a mild winter the heat demand is reduced. Fortunately past data are available on the customer supervision system, we use the previous heating period to elaborate a model for the heating of premises. Indeed the problem is not as simple as it may seem, as part of the site set point is 18°C (offices) and the rest is 14°C (workshops).On the basis of historian data we calculate different loss coefficients for the site, relative to different heating degree-days according to different temperature setpoints.

During the contract (lasting 15 years), the hot water flowrate is measured at the exchanger outlet. It is variable according to the energy needs of the site. A verification of ambient temperatures is made, in order to check that no degradation in the personnel comfort nor over-heating is happening. The valorised heat is adjusted according to the heating degree-days.

The error is again due more to consumption modelling than to sensors accuracy… The approach of the energy need according to heating degree-days is quite complex considering the extent and number of the buildings. In order to estimate the precision of our model, we draw a graph with daily gas consumption (measured) and energy needs (calculated). A regression analysis shows the model is correct ($R^2 > 0.8$). The relative accuracy, based on standard deviation, is 8%.

Cost of M&V operation is estimated to reach 52 k Euro over the 15-year period, for more than 3.5 million Euro savings on the same period of time. The M&V cost breakdown is detailed in table 1.

Discussion on the difficulties we identified through the exercise

As a first impression, and according to our former commercial experience, the feeling was that M&V would be too costly to be accepted by our customers. However, from the exercise on the two case studies, we revised our initial judgment by realizing that the cost of M&V was low compared to the potential energy savings at stake.

We found difficulties in:

1. Creating a satisfying model for energy consumption: to relate heating consumption to outside temperature seems easy, though our second case revealed difficulties for a set of heterogeneous buildings. Further, how can we build the baseline adjustment equation when we deal with industrial utility or process usage ? Moreover, how to deal with a whole facility when we have to establish a model in Option C (as for the base-load case) ?

2. Estimating the error committed in the saving calculation: calculating an error due to meters is quite easy, we felt the difficult part of this chapter of M&V relates to the energy consumption modeling (adjustment equation)…

a. In the case of the base-load reduction, we based our calculations on the mean of all Sunday 10-minutes power after a cleaning phase (elimination of rare though periodic events such as refrigeration units starting for ice-storage…). This average power is calculated on "quiet" parts of Sundays, the error does not derive from measurement itself (IPMVP states that billing meters present no error) but from the statistic dispersion around the calculated average power. We quantify it through calculation of coefficient of variation of root-mean squared error (CVRMSE) on the observed values during the reference period.

b. In the case of heat recovery, we had to build a model based on exploitation of daily climatic data and gas consumptions, the error is derived from the standard deviation on the residuals (difference between observed value and calculated through model value).

3. Making sure of the permanency of the site perimeter when a C option is used: in the base-load reduction case, we regularly calculate a power used by the customer. The comparison with the reference period is valid only if the site keeps the same configuration over the years (no extension nor closure of buildings). We said we would control the perimeter comparing the power called during activity periods with the Sunday average power, this ratio should remain constant… but we are not certain of the relevance of this indicator and even though, how could we deal with a change of perimeter apart from re-negotiation with the customer?

All these difficulties can be mastered, but there is a risk to spend more time and money to elaborate a satisfying M&V plan…

In France we feel the need for M&V to enhance confidence of the customers regarding EPCs, for such big projects it is a powerful means to guarantee results. M&V also represents a beneficial tool to clarify discussions with customers as savings are established on a commonly agreed method adapted to the customer's situation. At last we regard it as a facilitating tool for project financing, both for inner finance services and for bank credit-seeking (third-party financing).

French energy efficiency stakeholders, as far as we could understand from our experience in Club S2E, tend to believe that IPMVP could be adopted in France, provided all actors are informed of its existence and benefits they could get using it, if necessary even trained to it. In order to raise awareness and knowledge both in French energy services companies and on customers' side, communication actions are taken (e.g. by Club S2E). Lastly, we do believe that R&D is necessary to come over the obstacles above-mentioned.

Prospects

Given the stakes on M&V in energy efficiency services, EDF has decided to invest resources in M&V topics to contribute to the introduction of IPMVP in France:

- **Raise in competency**, up to certification (to have Certified Measurement and Verification Professionals among our experts) and IPMVP integration within our energy efficiency services
- **Further investigation in option D**: this option allows the use of simulation software tools, which is precious in the case of a lack of former data, before the project is defined (e.g. creation of a new building). IPMVP makes reference to public software issued by US Department of Energy which are not easy to transfer to French stakeholders… This point is subject to debate within the ClubS2E and we can foresee the undertaking of future works led by the work group. The result might be guidelines in the recognition of software tools. For its part, EDF has developed its own simulation tools primarily aiming at studying energy efficiency actions. We need to assess in which conditions we can use them for M&V purposes.
- Use of EDF automatic Monitoring & Targeting (aM&T) tools for M&V operations. These tools already allow smart data collection, creation of consumption models, automatic reporting to the customer…We need to modify them slightly to be fully adherent to IPMVP and make a direct use of them.

EDF ambitions in M&V matters is to fully contribute to IPMVP dissemination among customers, in the public sector as well as in the industry. Thus EDF will remain active within Club S2E to help make IPMVP better known from service purchasers and is integrating M&V practices within its offers.

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