IEA-DSM Task XXI: Standardisation of Energy Savings Calculations

Task I: State-of-the-art

Results presentation

Paris, March 2010

This document summarizes the results achieved in the subtask I "State-of-the-art" of IEA-DSM TASK XXI "Energy Saving Calculation Methods", structured in four sections:

1. Introduction, describing the objectives and works carried out to reach them
2. International M&V protocols, analyzing the most applied international methods and its application in the Spanish market
3. Current Spanish situation, analyzing the situation and development of the ESCO market and the efficiency standards used in Spain
4. Prioritized energy efficiency techniques, analyzing the 25 selected energy conservation measures and considerations for their selection
5. Energy efficiency and demand response, highlighting the relationship between this two concepts through the analysis of practical experiences

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1. Introduction

General background

Currently there is no agreement between countries about how policies and measures in energy savings impact on the quantitative evaluation. **IEA-DSM Task XXI tries to respond to this lack of standards**, the aim of sub-task I is to evaluate the state-of-the-art on energy saving calculations:

1. Contextualizing the general **situation**, analyzing the **regulatory framework** and identifying the **most relevant key players** on energy efficiency
2. Identifying the **most applied international M&V** protocols worldwide, developing and exercise of technical comparison between them
3. Analyzing the **situation of the ESCO market in Spain**, regulatory framework, **usage of these protocols in Spain**, paying special attention to the application of other M&V methods (engineering calculations, etc.)
4. Evaluating the **application of M&V methods to a sample of selected Energy Conservation Measures**, by the development of practical examples
5. Analyzing the **relationship between Demand Response products and M&V** methods, specially those methods applicable to ECM highly related with demand response

Final Report Sub-task I: "State-of-the-art in Energy Savings Calculations"

The subtask I report "State-of-the-art energy savings calculation" deals with current situation of measuring and verification (M&V) methods applied for the evaluation of energy savings in Spain

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5. Energy efficiency and demand response

2. International M&V protocols

Identification and analysis of main international M&V protocols

Currently, there are **four international measuring and verification (M&V) protocols** that are the most deployed and applied worldwide in energy savings projects:

1. **IPMVP:** International Performance Measurement and Verification Protocol, developed by the **Efficiency Valuation Organization (EVO),** a worldwide organization exclusively dedicated to the development of measurement and verification standards and the evaluation of projects, that allows energy efficiency as a resource. IPMVP defines four measurement options based on the parameter measured and installation conditions

2. **ASHRAE guidelines 14-2002:** standard developed by the **American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)**. This guide defines three measurement schemes closed to those defined in IPMVP

3. **FEMP:** M&V guide elaborated by the US Department of Energy (DOE), establishes **the necessary methodology to implement energy efficiency projects** under the **Federal Energy Management Program (FEMP). It applies the same four IPMVP measurement options**

4. **Energy Savings Measurement Guide (ESMG):** elaborated by Australian Government for the application in energy efficiency projects, applies **four measurement schemes similar to the four of IPMVP**

Additionally to these international protocols, there are other M&V guides and methodologies, most of them with similar features as all they are based on IPMVP

These protocols have been deeply analyzed and compared according to their principle definitions and concepts, level of usage, calculation methods and methodology

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3. Current Spanish situation

M&V energy savings in Spain

The non existence of a broadly accepted M&V standard in Spain restrains the future development of this market for the next years. **M&V standards are fundamental to the development of an energy efficiency market** because their application in a project is guarantee of its success

Situation of the ESCO market

- Limited development in comparison with another countries
- Lack of awareness and confidence in energy services provided by companies, mainly due to deficiency in information
- Resistance to outsource energy management
- Difficulties to access to necessary funds and financial methods
- Market development promoted mainly by The National Action Plan For Energy Efficiency 2008-2011

Limitation of M&V international guides in Spain

- Limited technical knowledge of the guides and lack of formative processes
- Lack of endorsement and guidance by the public sector
- Lack of a real background in the Spanish ESCO industry, which means that many projects are developed without a clear methodology
- Non-adequate funding in the early phases of a project, which is when the M&V Plan is at its most critical phase
- Language barrier to the spread of the existent guides, even though the IPMVP has been translated, only one of its volumes it is available in Spanish

Possible solutions

- Training and formation for the ESCO professionals
- Development of a local standard, of compulsory application in the public sector contracts
- Endorsement of this standard by the key players of the market
- Financing entities becoming aware of this business model and how the appliance of standardization can reduce the risk involved in it

Need of standardized M&V methods

Any of the future solutions adopted regarding M&V standards for the Spanish market will be based in the experiences of more developed and mature markets, such as those of EU countries and USA

3. Current Spanish situation

Application of these methods in Spain

Given the lack of official consensus in Spain, ESCOs are either relying in their **own savings and measurements methods** or on foreign and **well proven international M&V protocols** to develop their projects:

1 **Engineering M&V methods (ad hoc solutions).** These methods can be classified :

Simple methods

- Utility bills reading, not taking into account some factors that modify the conditions
- The omission of these relevant factors may distort the real savings achieved, decreasing the accuracy of project's results and allowing the ESCO to make up them at its convenience

Complex methods

- Engineering calculations and estimations to determine the baseline period
- Comparing the previous consumption with the post-ECM situation

Lack of confidence by customers

2 **International M&V guides**, generally **IPMVP.** The use of IMPVP in Spain is justified by:

- **International spread** around the world
- **Some ESCOs** in the Spanish market are **subsidiaries of international companies**, already users of IPMVP
- **Other ESCOs**, in order to offer similar energy services, **use the same methods as their competitors**
- **Big Spanish utilities**, like Gas Natural Group, **use and promote IPMVP** in their energy efficiency projects
- **Training courses offered by EVO**, like the Certified Measurement and Verification Program (CMVP)

In a not well developed energy efficiency market, Spanish ESCOs are applying ad hoc solutions like engineering calculations and, to a large extent, IPMVP

3. Current Spanish situation

Other energy efficiency Spanish standards

Besides the M&V techniques for the evaluation of energy savings, there are some other mechanisms introduced by recent Spanish regulation that are aimed to the application of energy efficiency initiatives in buildings

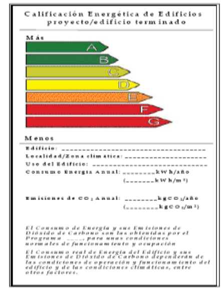
Introduction of mandatory ECMs in buildings

Mapa de zonas según el CTE

The Technical Building Code (CTE), in its last 2006 version introduced for the first time **one dedicated section to energy saving in buildings** due to their great savings potential, in some cases up to 25%:

- CTE establishes **rules and procedures** allowing fulfilling the basic needs of energy efficiency in buildings
- It is structured in five parts, according to **five areas of improvement:**
    - Limitation of energy demand
    - Thermal installation performance
    - Energy efficiency on lighting systems
    - Minimum contribution of DHW by solar heating
    - Minimum contribution of electricity by solar power

Energy efficiency labeling system for buildings



Since 2007 there is the obligation of **certificating energy efficiency in buildings** of new construction:

- Every new or refurbished building must have a **certification** showing the degree of efficiency in energy consumption, using an **energy efficiency scale** similar to the one used for electric devices
- Although currently this labeling system is only **mandatory for new and refurbished buildings**, for the next years it is considered to be **obligatory for all public buildings fulfilling certain conditions**

These methods can be considered a "standard" somehow, as they allow to compare energy performance of ECMs in facilities with similar features

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5. Energy efficiency and demand response

Starting from the initial list of ECMs, complemented with other initiatives identified that should be included because of their interest for the aims of the task, every energy efficiency initiative have deeply analyzed and categorized based on three criteria:

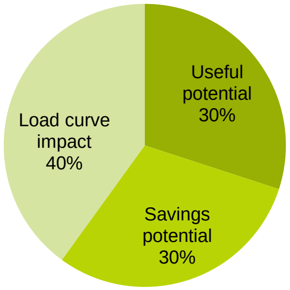
1. **Useful potential:** qualitative measure of the current penetration of an initiative in the Spanish market, also taking into account the perspectives for the next years and other criteria as profitability, complexity, barriers, etc.
2. **Savings potential:** qualitative measure of the savings reached by the implementation of this ECM, based on previous experiences and success cases
3. **Load curve impact:** qualitative measure of the impact of that ECM on the global energy demand curve, specially on those cases when the application of this measure can contribute to reduce energy demand on maximum peaks, and the contribution of this initiative to the control of demand response

Qualitative valuation for each ECM

○	Low
◔	Medium
◑	Medium – high
◕	High
●	Very high

Finally, for each ECMs a global valuation has been established taking into account the different weights considered for each feature

Weigh given to each feature



The choice of this three criteria and the valuation given to each one is based on practical experience, and also on the analysis of success cases on the implementation of these initiatives

4. Prioritized energy efficiency techniques

Additional considerations

Additionally to the qualitative criteria explained before, in the categorization and valuation of the initiatives some other criteria have been taken into account:

- **By sectors**, there are big differences in terms of quantity of energy used and savings potential:
  - **The household sector**, responsible of around 17% of total consumption, has a savings potential close to 10%(1)
  - **Commercial and industrial sectors**, both two represent more than 40% of total energy consumption in Spain; the savings potential can reach up to 18%(1) depending on the activity
- **By improvement areas**, heating systems, commercial lighting and industrial equipments are the areas with larger savings potential:
  - **Improvement of heating systems** has high savings potential on household sector, because more than 40%(3) of total energy consumption on a home is used on heating. The investments needed on this area have commonly a short payback, furthermore there are subventions to change heating systems
  - **On lighting systems savings potentials can reach up to 50%(2),** especially in workspaces and commercial areas where lighting consumption has an important weight in total energy consumption
  - **On industrial equipment**, the extra cost of the reactive energy can be removed by the use of capacitor banks, variable speed drives can also help to reduce outstandingly the energy bill
- **In terms of network impact**, there are several initiatives that can contribute to reduce the peaks on consumption curve, either reducing global energy demand or moving the demand to valley zone

All these considerations have been taking into account for the selection and prioritization of energy efficiency initiatives for this study

(1) Source: Study "Indicadores de la Eficiencia Energética", Unión Fenosa, 2008
(2) Source: Energy Savers. US Department of Energy
(3) Source: IDAE, Guía Práctica de la Energía, 2nd Edition 2007

4. Prioritized energy efficiency techniques

Additional premises

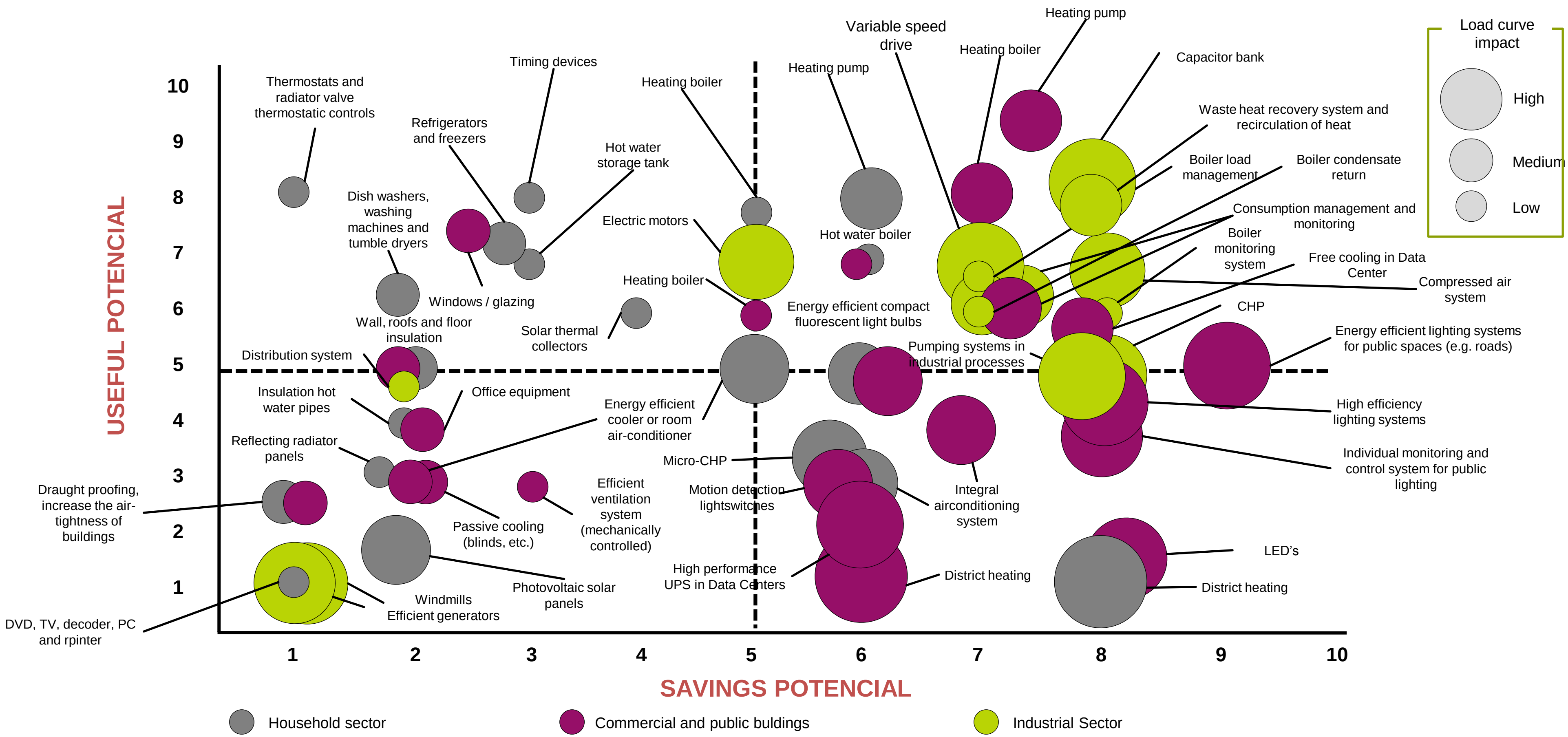
For every group of initiatives, some additional premises have been considered before giving a quantitative evaluation of each attribute:

- **Insulation building envelope:** Due to legislative restrictions (Spanish Technical Building Code) there is reduced potential in new constructions. In legacy housing exists some potential, where glazing is the most critical aspect especially in office buildings
- **Hot water heating equipment:** Domestic Hot Water (DHW) is one of the main consumptions in the residential sector. There is great potential to reduce energy consumption at a reduced cost, however DHW demand is generally lower in office and public buildings
- **Heating:** Heating is one of the main energy consumption in the Spanish residential sector. There are synergies with DHW production. For commercial uses usually heating is lower than cooling demand, nonetheless, there is enough potential to warrant attention
- **Cooling**: Not as important in energy volume as heating, but it has big effect in the electrical system. Cooling is a critical aspect of energy consumption in commercial sector, with big savings potential
- **Ventilation:** Due to current regulatory issues there is not a big potential in most cases
- **Electrical appliances:** The energy savings potential in household sector is reduced. For commercial uses, except in CPD installations, there is not a big field of application as an energy efficiency product
- **Lighting:** One of the most easily applied and measured energy efficiency products, with better payback periods and with great potential to be integrated in Demand Response Control schemes
- **Power Generation:** strategic group, with the potential to greatly increase the overall efficiency of energy usage, combined with mature technology. On industrial environment, these measures are highly effective
- **Energy Management:** Energy Management systems are critical in the implementation of energy efficiency measures, as well as a measure to save energy in itself, with great profitability
- **Energy efficient industrial equipment:** Depending on the specifics of the industrial process involved, a mix of these measures delivers maximum efficiency
- **Steam:** Steam production and usage is a key aspect of energy efficiency in the industrial sector
- **Public lighting:** Is the main energy consumption in municipalities, easy to integrate in demand response control systems

4. Prioritized energy efficiency techniques

Categorization of energy efficiency initiatives

As a result, all the initiatives have been prioritized as its shown in the next prioritization map:

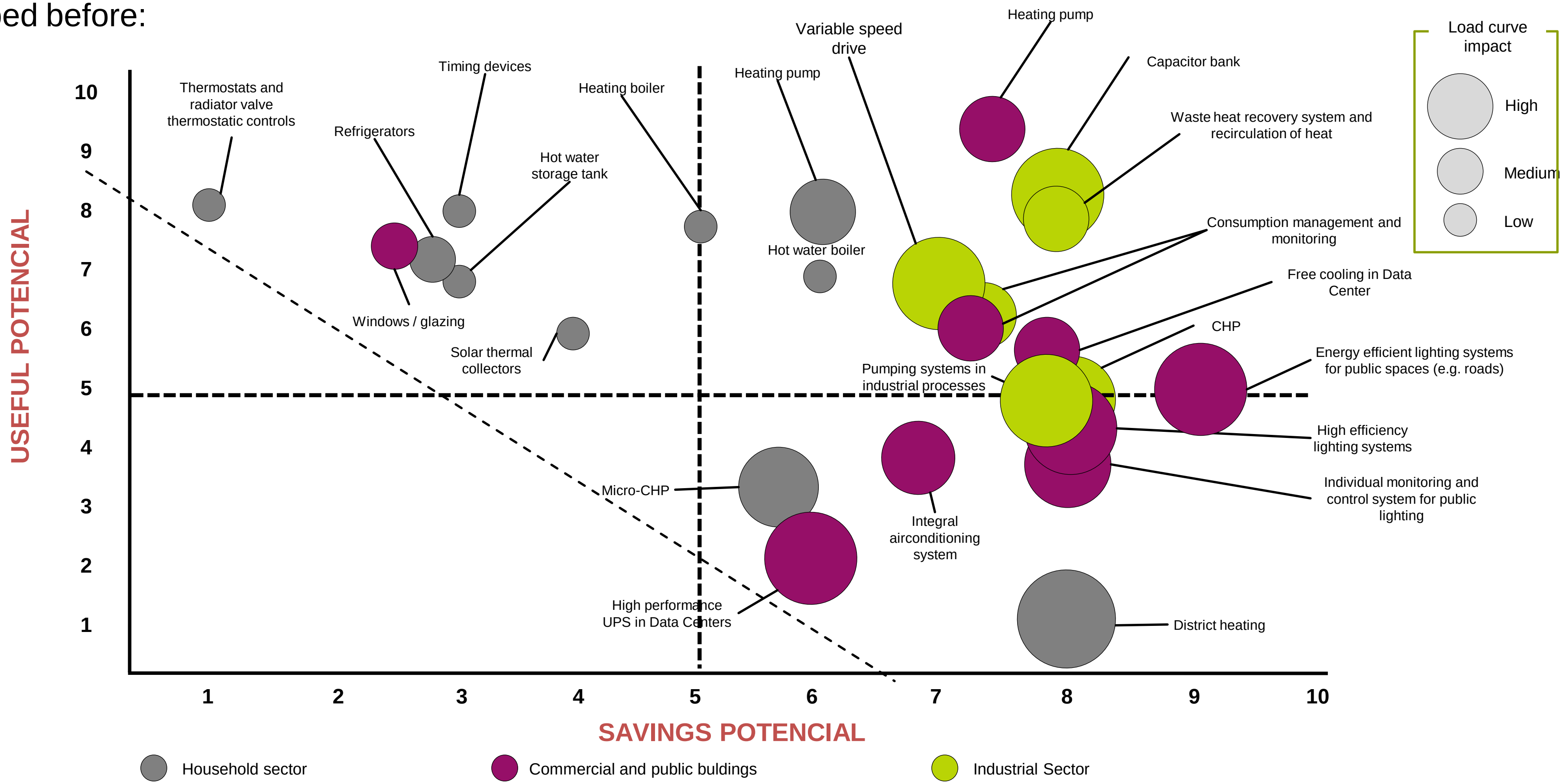


These initiatives have been positioned on the matrix based on its level of useful potential, savings potential and impact on the electric mains

4. Prioritized energy efficiency techniques

Selection of energy efficiency initiatives

After this prioritization, it is possible to determine which of the initiatives will be selected based on the criteria described before:



For the selection of these 25 initiatives, as well as the criteria of useful and savings potential, has been taken into account the sector and the IPMVP scheme applicable in order to have a varied sample of measures

4. Prioritized energy efficiency techniques

Selected energy efficiency initiatives (1/2)

For these 25 initiatives, the next two tables indicate the valuation of each parameter, IPMVP scheme applicable and a brief comment regarding its selection. On the first table, the initiatives on household and commercial sector……

Id.	**Household sector**	Useful potential	Savings potential	Load curve impact potential	**Global Valuation**	IPMVP Scheme	coments
2.	Hot water heating equipment						
2.1.1	Boiler	◕	◑	○	◑	B/C	High efficiency boilers, combined with small thermal energy accumulation vessels
2.1.2	Solar thermal collectors	◑	◔	○	◔	B	Solar energy for Domestic Hot Water (DHW)
2.2	Hot water storage tank	◕	◔	○	◑	B	Hot water accumulacion, improves the performance of production system
3.	Heating						
3.1.1	Boiler	◕	◑	○	◑	B	Condensation and low-temperature boilers
3.1.2	Heat pump	◕	◑	◔	◑	B	Depending on the climate zone, the heat pump represents a significant energy save over boilers, specially where DHW consumption is minimal or null
3.1.3	**District heating**	◔	◕	●	◕	B/C	Centralized hot water production: reduces the unitary costs and improves efficiency, as well as reduce the net impact caused by electric heating devices on peaks
3.2.1	Timing devices	◕	◔	○	◑	B	Control devices that allow for optimal strategies in boiler and terminal units operation
3.2.2	Thermostats and radiator valve thermostatic controls	◕	○	○	◔	A	Control 2-way valves in terminal units, thus reducing electrical and fuel consumption
5.	Electrical appliances						
5.1.1	Refrigerators	◕	◔	○	◑	A	High energy efficiency class refrigerator
7.	Power Generation						
7.1	Micro-CHP	◔	◑	◑	◑	B	Local Combined Heat and Power production, in the lower electrical power band
	Commercial, industrial and public buildings	Useful potential	Savings potential	Load curve impact potential	**Global Valuation**	IPMVP Scheme	
8.	Insulation building envelope						
8.3	Windows / glazing	◕	◔	○	◑	D	Thin film to reduce solar loads, complete overhaul of glazing systems, including low-E and high reflection layers
11.	Heating						
11.1.2	Heat pump	◕	◕	◔	◕	B/C	Depending on the climate zone, the heat pump represents a significant energy save over boilers, specially where DHW consumption in minimal or null
12.	Cooling						
12.2	Integral airconditioning system	◑	◑	◑	◑	B/C/D	Centralized system has lower cost and better efficiency
14.	Lighting						
14.1	**High efficiency lighting systems**	◑	◕	◕	◕	A/C	Low consumption lightings, TL5 fluorescent, high pressure sodium, LED, motion detection lightswitches, etc.
15.	Energy Management						
15.1	**Consumption management**	◔	◕	◕	◕	B/C	Real-time energy consumption measurement, recording and control, and load control on the energy distribution system

4. Prioritized energy efficiency techniques

Selected energy efficiency initiatives (2/2)

… and on the second table, the initiatives for public spaces, industrial sector and the new initiatives proposed:

	Industrial sector	Useful potential	Savings potential	Load curve impact potential	**Global Valuation**	IPMVP Scheme	
16.	Power Generation						
16.1	**CHP**	◑	◕	◕	◕	B	Combined Heat and Power production in industrial scale, helps to manage de demand response (distributed generation)
17.	Energy Management System						
17.1	Monitoring	◕	◕	◔	◕	B/C	Real-time energy consumption measurement, recording and control, and load control on the energy distribution system
17.2	Waste heat recovery system and recirculation of heat	●	◕	◔	◕	B/C/D	Recovery of residual thermal energy and usage in pre-heat systems
18.	Energy efficient industrial equipment						
18.2	**Variable speed drive**	◕	◕	◕	◕	B	Decrease the speed drive (and so the energy consumption) based on the current needs
18.4	**Pumping systems in industrial processes**	◑	◕	◕	◕	B	Variable flow hot water pumping systems
	Public sector	Useful potential	Savings potential	Load curve impact potential	**Global Valuation**	IPMVP Scheme	
20.	Public lighting						
20.1	**Energy efficient lighting systems for public spaces (e.g. roads)**	◕	●	◕	●	A/B	High efficiency lamps, LED streetlights, automatic intensity regulation, etc.
	Additional measures	Useful potential	Savings potential	Load curve impact potential	**Global Valuation**	IPMVP Scheme	
21.1	**Individual monitoring and control system for public lighting**	◑	◕	◕	◕	B	Remote control of public lighting: data bus connection or wireless networks with integrated "intelligent" systems
21.2	High performance UPS in Data Centers	◔	◑	◑	◑	A	Static bypass on UPS, load transfers systems, delta topology, etc.
21.3	**Capacitor bank**	●	◕	●	●	A	Real time or static control of the Power Factor in the electrical loads, helps to reduce electric load
21.4	Free Cooling on Data Centers	◕	◕	◑	◕	B/D	Rejection of heat generated by the CPD to the ambient without usage of compressors, when low external temperatures allow to

These 25 initiatives selected are composed by 10 initiatives for household sector, 5 for commercial sector, 5 for industrial processes, 1 for public sector and 4 new additional measures

4. Prioritized energy efficiency techniques

Example of IPMVP application for these initiatives (1/2)

For the selected ECMs, all four IPMVP options have been explored, since IPMPV is the most general and used standard in Spain. **One example exercise for each IPMVP Option** have been developed, measuring the individual energy savings caused by one or more ECMs (not their impact on load shape). Firstly for options A&B….

Example of Option A (retrofit isolation partial measurement)

With option A only one parameter is measured, in this example Option A has been applied for measuring energy savings in an office after **the improvement of lighting system** (selected ECM "High efficiency lighting systems")

ECM example: retrofitting of lighting in a public office

- **Interactive effects:** HVAC system, nonetheless, for this example are not included in the analysis
- **M&V Option justification:** sufficient degree of accuracy, since the interaction effects have been determined as not significant
- **Measurement equipment and process**: portable wattmeter, with an accuracy of 2% (overall accuracy over 10%)
- **Baseline consumption**: considering total power, mean power per lamp and number of lamps (active and burned)
- **ECM energy savings**: considering consumption before and after ECM

Example of Option B (Retrofit Isolation, all parameters measurement)

With option B only all parameter are measured, in this example Option B has been applied for measuring energy savings of a **new, more efficient air to air heat pump** (selected ECM "Heat pump")

ECM example: substitution of an electrical heating with a more efficient air to air heat pump

- **Interactive effects:** there are not with other consumptions
- **M&V Option justification:** the level of savings expected is more than 20% of the annual consumption
- **Measurement equipment and process**: three phase power meter with capacity to register up to 32.000 measurement points
- **Baseline consumption**: taking into account daily heating load, inside and outside temperature
- **ECM energy savings**: comparing the energy measured with the baseline energy

For the application of IPMVP Options A&B to the rest of selected ECMs, the procedure followed to each measurement options would be similar

4. Prioritized energy efficiency techniques

Example of IPMVP application for these initiatives (2/2)

….and examples of energy savings calculation of ECMs using options C&D:

Example of Option C (Whole building)

With option C the energy consumption in the whole building is measured, in this example Option C has been applied for measuring energy savings in an office after **the installation of a new control and monitoring system** (selected ECM "Consumption management")

ECM example: Consumption control and monitoring system in a office building for HVAC system, lighting system, and chiller water

- **Interactive effects:** strong interactive effects between these three measures
- **M&V Option justification:** interactive effects
- **Measurement equipment and process**: consumption for a period of 12 months prior to the implementation of any Energy Conservation Measure, with a frequency of 15 minutes
- **Baseline consumption**: modelization taking into account variables selected
- **ECM energy savings** : comparison, taking into account necessary adjustments

Example of Option D (Calibrated simulation)

With option D the energy savings are calculated by the development of a calibrated simulation, in this example a Variable Refrigeration Volume system is going to be replaced **by centralized, water condensed chillers** (selected ECM "Integral air conditioning system")

ECM example: installation of centralized, water condensed chillers in a building

- **Interactive effects:** refitting of the HVAC system shall have a significant effect in the comfort temperature of the building
- **M&V Option justification:** only possible for measuring energy savings before the installation of the new system
- **Measurement equipment and process**: simulation software, feed by actual real data corresponding to the last year available of billing data from the utility
- **Baseline consumption**: determined with regression equation
- **ECM energy savings** : comparing the baseline adjusted with the registered hourly temperature with the actual monthly consumption

For the application of IPMVP C&D to the rest of selected ECMs, the procedure followed to each measurement options would be similar

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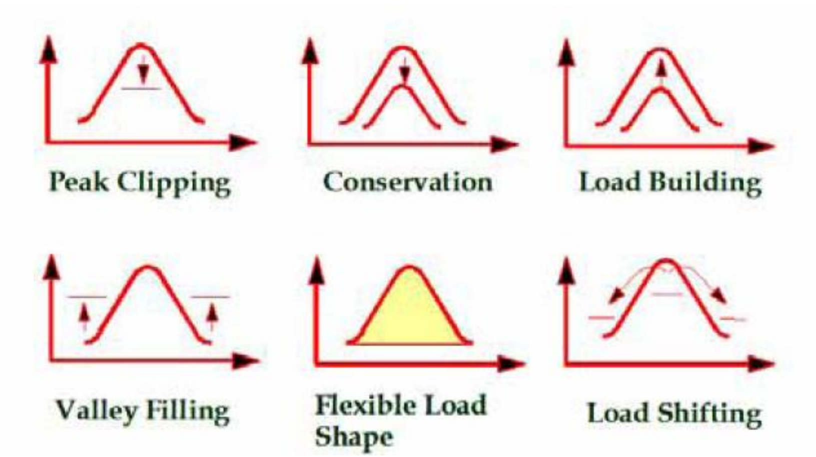
5. Energy efficiency and demand response

Demand Response as a tool for Energy Efficiency

- **Demand Response (DR)** can be considered as a particular set of **Demand Side Management (DSM) policies**, where the final customer receives whether economic incentives or penalties according with the changes in energy behavior reached
- The **final intention** of DSM and DR programs is to control energy demand in order to **grade the load curve in the system**, by different mechanisms:

Mechanisms to grade load curve



Source: Tata Power

- **Peak clipping**: aims at reducing the load, primarily on periods of peak demand
- **Valley filling**: increasing the load during the hours of minor utilization of the system.
- **Load shifting**: redistribution of the daily system load, moving part of the consumption in peak hours to valley hours
- **Conservation**: reducing the load homogeneously over all hours of the day
- **Load building**: increasing the load homogeneously over all hours of the day
- **Flexible load shape**: these are programs that seek to provide tools to the utilities to modify the load curve in real time

Demand response is related to energy efficiency, as there are ECMs that can contribute to move non-critical electrical loads from peak to valley zones, helping to grade the aggregated system load curve

5. Energy efficiency and demand response

Demand response products: some practical examples

In the last years several **demand response pilot programs** have been conducted by utilities throughout the world, achieving good results in short-term. In this sub-task I, some of them have been analyzed:

Demand response product	Consumers' benefits	Utility's benefits	Pilot program	Main results
In-Home Displays: small household devices that provide real-time energy consumption and costs information to customers	Less energy consumption as been aware of real-time consumption, it directly translates into a lower electricity bill	Keep the consumption growth under check, avoiding incremental capacity, transmission, and distribution investments	Distribution of IHDs to 3.512 customers in Massachusetts (2007)	63% of the participants changed their electricity-use behavior (switching-off not used lights, replacing bulbs, unplugging unnecessary devices, etc.)
Dynamic pricing in the mass market: utility can change prices dynamically according to load system needs	They have the choice to decide which consumption will be shifted to cheaper hours, keeping in the peak the ones that consider of high priority, depending on how much are willing to save or pay as a surcharge	Utility can increase energy prices at demand peaks, taking into account several changing factors (weather, social events, etc.)	Statewide Pricing Pilot in California (2003-2005), with several different rate structures	Consumers reduced peak-period energy use on critical days between 8% and 16%
Direct load control: utility can control and even switch-off user's appliances	Reduction in the electricity bill in exchange for allow the utility to control some appliances	Reduce load peaks by switching-off non critical user's appliances	In Ontario (2006), Hydro One provided customers with a free smart thermostat allowing participants and the utility to control the setting on their central air conditioning remotely over the Internet	Significant reduction of peaks on demand curve
GAD: research programme in active demand side management	Improve energy efficiency in final consumers, increasing the information of energy consumption provided to customers	Increase the efficiency of electrical mains use, by reducing load peaks and better gauging the capacity of the nets	Project formed by a consortium of 15 Spanish entities and research centers, in current development	Research on new strategic technology lines on R+D

These pilot programs have shown good results reducing peaks in load curve. Big part of this success have been determined by customers' commitment , based on the economic incentives they receive

5. Energy efficiency and demand response

Interaction between demand response and M&V

In the design of a demand response program, one of the aspects to be taken more into account is **the way the results are going to be measured**. This is a key issue to the success of the initiative because it identifies and quantifies the benefits obtained

- **Information requirements of demand response programs** are not always equally demanding than those of other energy efficiency initiatives discussed in this document
- **Besides the comparison of total consumption before and after** implementation of the initiatives, some other aspects related must be considered:
  - Feedback from users about the initiatives
  - Financial commitments to each customer
  - Behavior monitorization of each individual client, not to evaluate the results but as a part of the DR process
- **When demand response products are related to a group of initiatives** but not to a specific one, bottom-up calculation methods like international M&V guides are not applicable, hindering the individual measurement of the results achieved:
  - In these cases, top-down approaches can be more suitable, measuring the initiative results directly on the electrical network.
  - This measurement can be made at different levels, from the measurement of the load curve on a single home or small sample group of homes in a neighborhood, to the measurement of this curve in a whole district area

When measuring the performance of DR products is possible to see how the different products are contributing to change the load curve, and how the global effect is the sum of individual results achieved

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Annex: analysis of international M&V protocols

Annex: analysis of international M&V protocols

Comparative analysis with different M&V guides

As the analyzed M&V protocols in this subtask are based on IPMVP, there are **several features shared among them**. However, there are some characteristics in relation with IPMVP that differ from one guide to another:

- **IPMVP vs. ASHRAE 14-2002:** this one applies **three measurement options instead of four**, having condensed options A and B of the IPMVP into one, although the possibility of a partial measurement, remains. ASHRAE stands apart in its thoroughness and **level of detail** when analyzing the different **metrological and statistical aspects** of M&V Planning. Thus it is closer to an **engineering handbook** than to a conventional guide, although the principles that guides it are underlying in the IPMVP

- **IPMVP vs. FEMP:** this one can be considered as a **development of IPMVP for Federal Super ESPC projects**, detailing very clearly all the steps and procedures to develop and apply the M&V Plan. This approach is **necessary in Federal Projects**, where the Building Manager often does not have a technical background, nor has the resources to develop the project; thus, an easy to apply, **standardized method of contracting** is necessary, as well as a guarantee of transparency

- **IPMVP vs. ESMG:** ESMG, is a **development of IPMVP with focus in estimating energy savings before the actual application** of the measures. There are **no methodological differences** of note in both protocols regarding how to determine the actual savings

ASHRAE 14-2002 complements IPMVP with more metrological and statistical details, while FEMP and ESMG are adaptations of IPMVP for specific energy savings programs

Annex: analysis of international M&V protocols

Comparative of methodologies

Each one of the four presented M&V guides follow their **own methodology divided in different steps**, but the general content of all of them is very similar. It can be stated that there are three **common parts** in which all the methodologies are divided:

METHODOLOGY FOR SAVINGS CALCULATION	EVO IPMVP	ASHRAE 14-2002	DOE-FEMP	ESMG
BEFORE PROJECT IMPLEMENTATION	1. User´s need consideration on the planned M&V report 2. IPMVP Option selection 3. Baseline period energy data gathering 4. M&V Plan preparation (step 1 and 2 can be integrated in the M&V plan preparation)	1. Measurement and verification plan preparation 2. Previous energy use measurement	1. Allocate Project Responsibilities 2. Develop a Project-Specific M&V Plan (step 1 can be integrated in this step) 3. Define the baseline	1. Establishing your energy baseline (step 2 can be integrated in define the baseline) 2. Completing an energy mass balance 3. Measuring, metering and capturing energy data
DURING PROJECT IMPLEMENTATION	5. Design installation, calibration and Commissioning of any special measurement equipment 6. Installed equipment inspection 7. Reporting period energy data gathering	3. Post energy measurement 4. Baseline projection (this step only appears in this methodology)	4. Install and Commission Equipment and Systems 5. Conduct Post-Installation Verification Activities	4. Estimating the energy savings from an opportunity 5. Accuracy in energy savings analysis 6. Evaluating an energy efficiency opportunity
AFTER PROJECT IMPLEMENTATION	8. Savings computation in energy and monetary units 9. Savings report in accordance with the M&V plan	5. Savings calculation 6. Uncertainty determination (This step only appears in this methodology)	6. Perform Regular-Interval Verification Activities	7. Measuring and tracking your implemented opportunities 8. Energy monitoring and reporting

The three general parts in which all methodologies can be spitted correspond with the three stages of the M&V process: before, during and after implementation

Annex: analysis of international M&V protocols

Comparative of methodologies

Taking into account the different steps of each protocol, it is possible to outline a **common methodology in 8 steps containing** all steps of each one of the individual methodologies:

COMMON METHODOLOGY FOR SAVINGS CALCULATION	EVO IPMVP	ASHRAE 14-2002	DOE-FEMP	ESMG
1. M&V Plan preparation	1. User´s need consideration on the planned M&V report 2. IPMVP Option selection 4. M&V Plan preparation	1. Measurement and verification plan preparation	1. Allocate Project Responsibilities 2. Develop a Project-Specific M&V Plan	3. Measuring, metering and capturing energy data
2. Define the baseline	3. Baseline period energy data gathering	2. Previous energy use measurement	3. Define the baseline	1. Establishing your energy baseline (step 2 can be integrated in define the baseline) 2. Completing an energy mass balance
3. Reporting period energy data gathering	7. Reporting period energy data gathering	3. Post energy measurement		
4. Baseline projection		4. Baseline projection		
5. Installation, calibration and commissioning of the measurement equipment	5. Design installation, calibration and Commissioning of any special measurement equipment		4. Install and Commission Equipment and Systems	5. Accuracy in energy savings analysis
6. Installed equipment inspection	6. Installed equipment inspection		5. Conduct Post-Installation Verification Activities	6. Evaluating an energy efficiency opportunity 7. Measuring and tracking your implemented opportunities
7. Savings calculation	8. Savings computation in energy and monetary units	5. Savings calculation		4. Estimating the energy savings from an opportunity
8. Savings report in accordance with the M&V plan	9.Savings report in accordance with the M&V plan	6. Uncertainty determination	6. Perform Regular-Interval Verification Activities	8. Energy monitoring and reporting

This general methodology reflects all individual steps, adjusting the order the steps are in each one to a common order

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