Measurement, Verification and Additionality of Electricity Demand Reductions

Measurement, Verification and Additionality of Electricity Demand Reductions

Final report – recast

By: Isabelle de Lovinfosse, Luis Janeiro, Kornelis Blok, Julia Larkin
Date: 6 November 2012

ECOFYS UK Ltd. | 1 Alie Street | London E1 8DE | T +44 (0)20 742 309 70 | F +44 (0)20 742 309 71 | E info@ecofys.com | I www.ecofys.com
Company No. 4180444

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Introduction

This project supports the Electricity Demand Reduction (EDR) project in the Department of Energy and Climate Change (DECC). It was commissioned to explore the needs and requirements for a robust approach to measurement, verification and additionality (M&V and additionality) of electricity demand reduction projects in the context of providing financial incentives for electricity efficiency.

DECC defines financial incentives as incentives that provide direct payment to electricity efficiency projects in exchange for demand reduction (i.e. kWh saved). The focus of the financial incentive considered in this M&V and additionality advice is on large efficiency projects or efficiency programmes (aggregation of small projects) in order to reduce the administrative burden of the scheme. The purpose of an M&V and additionality approach is to filter the efficiency projects in order to pay only for permanent (long-term kWh saved) and additional (compared to a baseline) electricity demand savings.

This report presents Ecofys' analysis of issues raised by DECC to inform assessment of the feasibility of a robust M&V and additionality approach in the context of a new financial incentive for electricity efficiency in the UK:

Main issues

1. Needs and requirements for a robust approach to M&V and additionality in the context of a financial incentive for electricity efficiency
2. Risks of failure to address the M&V and additionality issues
3. Lessons from international comparators for feasibility of UK M&V and additionality
4. Key challenges for identifying an M&V and additionality approach in the context of a financial incentive for efficiency in the UK
5. Suitability of the International Performance Measurement and Verification Protocol (IPMVP) for the Electricity Demand Reduction Project

1 Requirements for a robust approach to M&V and Additionality

An effective and robust approach to M&V and additionality of electricity savings is always a trade-off between the costs of the approach and the certainty of the savings achieved. Electricity demand reduction projects where the expected savings of a single intervention are small but widely replicable require for pragmatic reasons an M&V and additionality approach at programme level (e.g. it would be out of proportion to monitor every single fridge). On the other hand, electricity demand reduction projects where a significant amount of electricity can be potentially saved in an individually designed project require a project based approach. The trade-off between high costs/high certainty vs. low costs/low certainty always exists, both in programme based and project based M&V and additionality approaches. M&V and additionality in electricity saving programmes or projects can be done in a very simple way (e.g. desk study, upfront analysis, rely on given information) or a very precise way (e.g. independent market research, measurements on a sample of projects, measurements on project sites).

An objective of M&V planning is to design the process to incur no more cost than needed to provide adequate certainty and verifiability in the reported savings. The issue is: “how much certainty is enough, and what is a reasonable cost?” The value of savings for a specific intervention places limits on the expenditure that can be justified for M&V. Conversely, the number, type and complexity of the energy saving measures increase the M&V effort and expenditure for a given level of savings certainty.

The aim of this chapter is to discuss the benefits and the risks of different approaches to M&V and additionality, to present advice on what a robust approach to M&V and additionality would require in the context of a financial incentive for electricity efficiency in the UK, and to identify the risks of failure to address the M&V and additionality issues.

1.1 Robust approaches to additionality

The concept of additionality has been extensively discussed for more than a decade in the context of the Clean Development Mechanism. However, its practical implementation is still contested in many cases. Additionality can be an elusive concept because proving it involves comparing real events against a hypothetic scenario.

The most common definition of additionality is the following: *‘Projects are additional if they would not have happened without additional policy intervention’*. This definition is used for instance in the Credit Development Mechanism (CDM), in the US energy efficiency programmes, and in the European examples of energy efficiency obligation schemes. In the case of the US programmes there is a variety of definitions of additionality (also called net savings) taking into account a range of spillover effects[1]. The difficulty under this approach is to identify the level of savings that are a result of the payment given under the financial incentive scheme. This risk can be mitigated by designing a robust additionality approach in the scheme. A clear set of factors influencing additionality have been identified: the regulatory framework affecting the project, current market penetration and market dynamics, technical innovation, financial feasibility, and non-economic barriers affecting the implementation of the project. To design a robust approach to additionality under this definition, we would advise to analyse additionality at the programme level[2] for widely replicable projects; also to use a case by case assessment of additionality for larger projects, using, for instance, the CDM tool as an inspiration.

1.2 Risks of failure and associated mitigation measures for additionality

Table 1 presents the risk of failure to address the additionality issues (sorted by types of risks), the consequences of the failure on the definition of additionality, and the measure to be considered to mitigate the risk. Some risks are generic but others are more relevant for project based approaches or for programme based approaches.

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[1] Spillover effects are externalities of economic activity (or in this case energy efficiency projects) that affect those who are not directly involved. Spillover effects are those variables in every economy that cannot be adjusted by a single policy monitored by the government.

[2] A programme here refers to a bundle of small energy efficiency projects that are managed together under a programme because they share similar characteristics (i.e. typically used in domestic sector). Programmes are used for widely replicable energy efficiency projects as opposed to larger projects that are tailored to specific conditions and therefore not replicable (i.e. typically used in industrial sector).

	Additionality Risk	Consequence	Mitigation Measure
Market & Technological changes	Fast technological evolution	Part of the calculated savings would not be additional due to technological improvements not accounted for when setting the baselines.	Periodic update of baseline calculations for the eligible efficiency measures.
	Eligible measures with large current or forecasted market penetration	Part of the calculated savings would not be additional because the technology does not require further policy support.	Periodic update of the list of eligible measures based on market studies.
Overlapping Regulation	Existing technical regulations & standards	Savings are not additional because they are already required by other regulation	Periodic update of technical standards and regulations affecting the eligible efficiency measures.
	Co-existing supporting policies	Savings are not additional or partly additional because they are (also) supported by other co-existing scheme.	Periodic review of potentially applicable overlapping schemes for the eligible measures. Clear rule on what schemes pay for to avoid double subsidies
Technical	Same technology may be used in different applications e.g. electric motors.	Additionality differs from application to application	List of eligible efficiency measures to consider the specific application of the technology.
	Same technology applies on different scales.	Additionality changes with the scale of the project e.g. heat pumps additional only for small scale projects.	Split programmes based on scale thresholds.
Fraudulent Information	Construction of unrealistic socio-economic barriers for implementation	Non-additional project obtains support.	Thorough project design audits
	Implementation budgets artificially high	Non-additional project obtains support.	Thorough project design audits

Table 1 Additionality risks and mitigation measures

1.3 Robust approach to M&V

There are two main approaches to measuring energy savings:

Ex-post approach (monitoring plans): The energy savings are calculated by comparing on site measurements of energy use before and after the implementation of the energy conservation measure. Used in the CDM (not for energy use but for emissions, but the principles are the same) and in Italian white certificate system under the category 'energy monitoring plan'.

It is critical to ensure that the calculations are adjusted to exogenous factors (e.g. weather conditions, production levels, etc.) in order to ensure that a reasonable comparison is made between the before and after situation. The monitoring period must be long enough to provide a representative measurement that avoids the effect of short term behavioural changes. In many cases it will be required to install specific equipment in the facilities affected by the efficiency measure. When using an ex-post approach the time delay between the installation of the measure and the validation of savings can be a problem for programme administrators. This approach is very robust because it measures the savings with a high certainty, but it may involve relatively high transaction and administrative costs in the case of small-scale equipment.

Ex-ante approach (deemed savings): The savings for an efficiency measure are assigned a priori based on equipment tests, the results of previous monitoring, or engineering calculations. Widely used in EU EEO (e.g. Italian white certificates, UK CERT)

The main advantage of this approach is the clear reduction in transaction and administrative costs. Measuring electricity consumption after the installation is not required (though verification is necessary). The availability of a priori data is also an advantage for the administrator of the programme. The main disadvantages are that the estimated ex-ante savings may not reflect the real savings achieved in practice, which reduces the certainty of the savings and that this technique is only feasible for certain types of measures that are widely replicable or predictable across different applications. This risk is mitigated when a large number of installations are realized in the programme, as the average value will tend to represent reality. Other risks include partial realisation of savings (e.g. when the measure is poorly installed or not installed at all), or poor additionality[3] (e.g. when baselines do not adapt to technological developments or when eligible measures are not revised following the evolution of the market). However, these risks can be mitigated by using the following best practices: calculation of savings based on as much real and updated data as possible, robust methodology for savings calculations, differentiated calculations for different technologies, regular updates of the calculation, deemed savings confirmed and updated by ex-post verification in a sample of projects.

In some cases a *hybrid approach* may be the most appropriate and cost-effective. These hybrid methods are commonly known as engineering estimates of savings, which allows for a broader application of measures across different sectors. They are suitable for situations in which existing data from similar applications are available but it is difficult or too expensive to directly monitor project by project. Savings estimates depend on a limited number of identifiable parameters (e.g. in industrial motors number of working hours, load factor, etc.). With this approach, a specific calculation algorithm is defined, with pre-defined values for some parameters while other parameters have to be measured case by case.

[3] Euro WhiteCert Project WP4.1 Supply side: Measurement and verification of energy efficiency projects

There is no ‘best’ M&V approach for energy efficiency measures. A robust M&V strategy needs to consider the pros & cons described above in order to tailor the M&V requirements to the eligible efficiency measures considered in the EDR programme.

Actions where the expected savings of a single project are small but widely replicable, ask for simplified M&V approaches (deemed savings or engineering estimates) in order to keep the administrative costs of the programme reasonably low. On the other hand, actions where a significant amount of energy can be potentially saved in a single project may require thorough – and more costly – ex post M&V strategies capable of minimizing the uncertainty of the real savings achieved.

1.4 Risks of failure and associated mitigation measures for M&V

Table 2 presents the risk of failure to address the M&V issue (sorted by type of M&V approach), the consequences of the failure on the savings captured, and the measures to be considered to mitigate the risk.

Approach	M&V Risk Type	Risk Description	Mitigation Measures
Ex-ante (deemed savings)	Uncertainty of Savings Estimations	Real savings of individual efficiency measures will differ from the estimated ex-ante average savings	Ex-post statistical calibration and/or validation
			Larger samples so that real savings tend to the calculated value
	Partial Realization of Savings	Poor or ineffective installation	Improve training of Installation Companies; Verification of a sample
		Measure not installed	Verification on sample basis and appropriate penalization
		Measure installed, but old equipment is still running	Trade-in of old appliances
Ex-post (monitoring plans)	High M&V costs	M&V require the installation of equipment	Establish minimum project size
		Data gathering needs and techniques may differ greatly depending on the efficiency measure considered	Use of existing M&V protocols e.g. IPMVP

Table 2 M&V risks and mitigation measures

2 Lessons learnt from relevant M&V and additionality national and international comparators

The aim of this chapter is to describe key international and national experiences in M&V and additionality from which relevant lessons can be learned in designing the M&V and additionality for a financial incentive for electricity efficiency in the UK. We have selected a range of international and national experiences showing lessons for the design of M&V standards and approaches to additionality.

2.1 Clean Development Mechanism

The Clean Development Mechanism (CDM) under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) has been operating since the early 2000s. It enables the issuance of certified emission reductions. The projects are carried out in developing countries. Projects must qualify through a public registration and issuance process. Approval is given by the Designated National Authorities.

2.1.1 Additionality, Measurement and Verification under the CDM

Additionality

The UNFCCC considers a CDM project additional if *"anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity"*[4]. The UNFCCC has developed a methodological tool[5] for the demonstration and assessment of additionality that is applicable to a wide range of CDM projects. The tool defines the steps that project developers must follow to prove the additionality of their projects and also provides guidelines on the evidence to be demonstrated at every step (see Figure 1). The main steps defined in the tool are:

1. *Identification of alternatives to the project activity*, i.e. realistic and credible alternative(s) available to the project participants or similar project developers that provide outputs or services comparable with the proposed CDM project activity. These alternatives must be in compliance with existing mandatory legislation and regulations.
2. *Investment analysis*, in order to prove that the proposed project is not the most financially attractive or is not economically feasible without the sale of certified emission reductions.

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[4] UNFCCC (2006) Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its first session, held at Montreal from 28 November to 10 December 2005. FCCC/KP/CMP/2005/8/Add.1

[5] UNFCCC (2011) Tool for the demonstration and assessment of additionality. Report of the Executive Board meeting 65. Annex 21.

3. *Barrier analysis*, i.e. to prove that the project faces a number of barriers that prevent its implementation and do not prevent the implementation of at least one of the alternatives.
4. *Common practice analysis*, in order to evaluate the extent to which the practices, technologies proposed in the project have already diffused in the relevant sector/region.

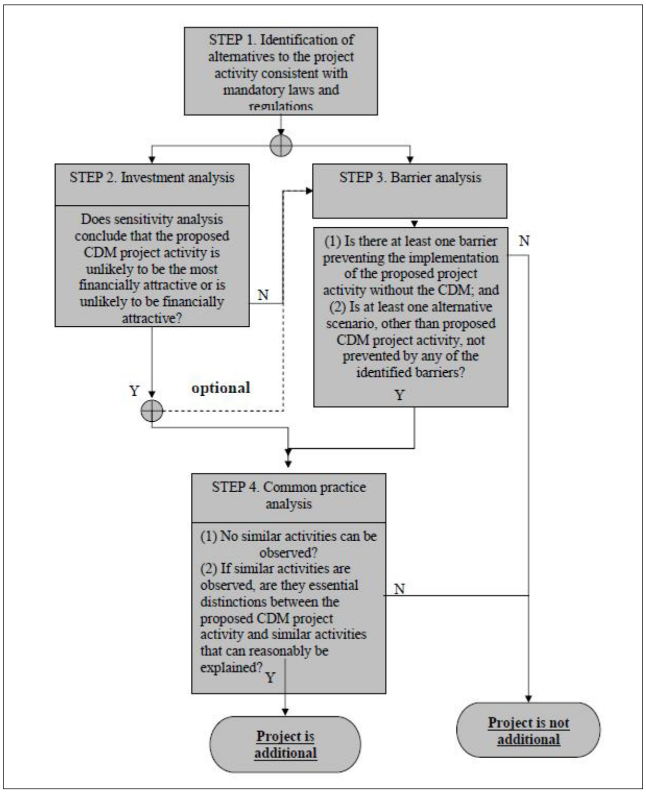

Figure 1 Additionality Tool Decision Tree. Source: UNFCCC

Steps 2 to 4 are additionality tests that the CDM project developers must prove in a so-called project design document (PDD). A project would need to be able to prove additionality under step 2 and/or 3 and 4 to be approved as additional and be eligible for CER. The logic behind these steps is illustrated in Figure 1.

Closely related to the issue of additionality is the definition of the baseline. The baseline defines the volume of GHG that would have been emitted in the most plausible alternative scenario to the implementation of the CDM project. The baseline is defined by project developers in the Project Design Document. CERs are accredited only for emission reductions beyond the baseline.

In addition to the general methodological tool discussed before, more specific and detailed instructions to assess additionality, set baseline scenarios and establish monitoring plans for a wide range of specific project types[6] have been proposed by project developers and adopted by the UNFCCC. These so-called "methodologies" usually make reference to the general tool but include specific parameters to evaluate the baseline for the specific project type. For instance, in the case of water pumping efficiency improvements (methodology AM0020[7]) baseline emissions are calculated by multiplying the pre-project efficiency ratio (kWh needed per litre of water pumped) with the total post-project water volume delivered and the carbon emission factor. Approved methodologies also define applicability criteria for the project. For instance, in the case of rehabilitation and/or energy efficiency improvements in existing power plants, the methodology (AM0061) requires at least 10 years of fuel consumption data for the existing power plant and imposes limits in terms of increase of generation capacity, among other criteria.

Measurement

Under the CDM programme, the process of measuring greenhouse gas emissions within the boundaries of a project is referred to as '*monitoring*'[8]. The aim is to determine the volume of emissions reduction that can be attributed to the project. Monitoring is implemented through the *monitoring plan*, which defines the data gathering required to calculate emission reductions and has to be included as part of the Project Design Document (PDD) developed by programme participants and submitted for approval by the Designated National Authority and registration by the CDM Executive Board.

Verification

Under CDM, the verification of authenticity of GHG reductions is performed periodically by an independent Designated Operational Entity (DOE). For the verification process the DOE applies standard auditing techniques which include desk reviews of submitted data, on-site audits, and interviews with relevant personnel. A detailed manual[9] defining the required parameters for the CDM verification process has been published by the UNFCCC.

2.1.2 Project based CDM vs. Programmatic CDM

In classical CDM, the registration and verification process needs to be done on a project by project basis. This approach may for small projects result in relatively high transaction costs. In order to reduce transaction costs in CDM and expand the reach of the mechanism to smaller projects, the CDM Executive Board approved the Guidelines and Procedures for Programme of Activities in 2007. The main advantage of programmatic CDM is that many individual activities scattered over space and time can be brought together under the framework of a single Programme of Activities. Additionality, baselines as well as measurement and verification requirements need to be approved only once at

[6] An updated list of approved methodologies can be found in this site: http://cdm.unfccc.int/methodologies/PAmethodologies/approved

[7] UNFCC (2012) CDM Methodology Booklet. Report of the Executive Board meeting 66.

[8] UNFCCC (2012) Glossary of CDM terms. Report of the Executive Board meeting 66. Annex 63.

[9] UNFCCC (2008) Clean Development Mechanism Validation and Verification Manual. Report of the Executive Board meeting 44. Annex 3.

the programme level by the Executive Board of the UNFCCC. Then, an unlimited number of projects can be included in the programme provided that they meet the eligibility criteria. For instance, fifty projects have been registered under a single programme of activities for the implementation of CFL lighting in the residential sector of India[10] (PoA 3223).

Additionality requirements for programmatic CDM are not different from traditional single CDM projects as far as the conditions of the single projects under the ‘umbrella’ of the programme are comparable to those assumed. It is worth noting that so far the CDM perspective on additionality is black-or-white: a project is additional or it is not. Programmatic CDM is still relatively new and evaluations on the *actual* additionality are not available.

2.1.3 Lessons learnt from evaluations of UNFCCC CDM

The accumulated experience with the UNFCCC CDM shows that proving real emission reductions at the project level is feasible but requires a relatively high amount of effort in terms of defining baselines, demonstrating additionality as well as monitoring and verification. The administrative costs associated with these processes are usually only justifiable with large projects and the CDM approach - assessing additionality on a project by project basis - would therefore only be likely to be successful for large electricity saving projects that can offset the bureaucracy costs needed to demonstrate the additionality. This inconvenience has been partially addressed by the UNFCCC with the concept of Programme of Activities. A similar approach could potentially be used in the UK in the context of an electricity demand reduction programme. Specific definitions of additionality, as well as measurement and verification methodologies could be implemented for a number of energy efficiency projects of the same type. This approach enables bundling a large number of projects around a common ‘programme’ structure, therefore reducing the administrative costs.

Independent analyses of extensive samples of CDM projects have evaluated their likeliness of additionality ranging from 50% to 95%, with an overall 60% of projects unquestionably additional for the whole scheme[11]. This wide range is mostly dependent on the weight that the certified emission reduction revenues have on the economic feasibility of the projects. When certified emission reductions are the only source of revenue, projects are very likely to be additional (95%).[12] This percentage drops when the project has other economic benefits apart from the certified emission

[10] An updated list of registered Programme of Activities can be found in this site: http://cdm.unfccc.int/ProgrammeOfActivities/registered.html

[11] Schneider, L (2007) Is the CDM fulfilling its environmental and sustainable development objectives? An evaluation of the CDM and options for improvement. Öko-Institut – Institute for Applied Ecology.

[12] This means that when the money for carbon credits is the only income for the project, then the chances of additionality are higher because there is no other economic motivation to carry out the project than the financial help from the programme itself. In the CDM context this is for example the case for end-of-pipe N_2O capture projects, in contrast to renewable energy projects, where the income is a combination of carbon credits and electricity sales revenues.

reductions. The likeliness of additionality is estimated at around 70% for projects when certified emission reductions are a significant part of the income and at 50% for projects where the revenue from certified emission reductions plays only a secondary role. In terms of costs, however, it is important to note that CDM projects with questionable additionality (40%) accounted only for 20% of the generated certified emission reductions. Note that these data are from a report dating back to 2008 and that since then there is a feeling among CDM practitioners that additionality has improved. However, no new evaluations are available to quantitatively support this statement.

In CDM the M&V and additionality requirements are not distinguished by project size. In practice the differences between small-scale and regular projects are limited and there are no indications that there would be differences in additionality. In CDM, a specific category “small-scale project” exists. This is for instance the case for electricity conservation projects that save less than 60 GWh electricity per year, renewable energy project with a capacity smaller than 45 MW, or in general projects that avoid less than 60,000 ton CO_2-eq. per year. The aim is to reduce transaction costs for these small-scale projects. E.g. for small-scale projects one independent auditor can do both validation (before implementation) and verification (after implementation), whereas for regular projects this can be different. Also the number of measurements in the monitoring phase can be more limited. This is all arranged in the methodology and can differ by project type. It is worth noting that the rules of CDM are still developing, e.g. a new category ‘micro-scale’ will be introduced and certain small-scale projects will be automatically considered additional.

2.2 Energy Efficiency Obligations/White Certificates Schemes

The functioning principle of an Energy Efficiency Obligation (EEO) is that some actor in the energy supply sector (usually energy retailers or distributors) has an obligation to save energy in eligible end use customers. If the established savings are not met at the end of the obligation period, the company pays a penalty. Several EEO schemes are currently in place within the European Union. These show considerable variation with regard to the obligated actors, the eligible customers and the eligible energy conservation measures. There is also considerable diversity in how the targets are set and how companies chose to achieve those targets. Some schemes go beyond the target setting and have established a market for energy efficiency reductions via a tradable white certificate market (e.g. Italy).

In this section we will briefly discuss how the issues of additionality, measurement and verification have been dealt with in the context of EEO schemes in Europe.

2.2.1 Additionality in EEO schemes

The EEO schemes have mainly (but not only) targeted energy efficiency measures that are highly replicable on a large number of projects. Additionality is a big concern for the cost-efficiency of these policies and therefore it is intrinsically dealt with when choosing the portfolio of energy efficiency measures and technologies eligible for the scheme upfront. The solution adopted in most EEO schemes is that additionality is defined ex ante at the programme level and reviewed on a regular basis to account for technology, market and policy changes.

The administrator of the **Italian** white certificate scheme applies an 'additionality coefficient' in the calculation of the energy savings delivered by eligible efficiency measures. Baselines are defined ex-ante according to data on average energy performance of the eligible technologies and their level of market penetration. In order to ensure that savings remain additional to business as usual, these baselines are periodically reviewed. For example, from 2005 to 2008, energy savings from compact fluorescent lamps were considered fully additional (additionality coefficient = 1). From 2008 to 2011, an additionality coefficient was applied (0.42 for the E14 type; 0.22 for the E27 type). Since 2011 compact fluorescent lamps are no longer included as an eligible measure in the scheme. It must be noted that currently all eligible measures have an additionality coefficient of 1 (fully additional).

The **Danish** scheme has also mitigated the risk of non-additionality by accounting for it in the overall target of the policy. The target was set 15% higher than the nominal expected savings with this purpose.

Under the **French** white certificate system additionality is assessed ex-ante for a group of measures for which a standardised procedure is designed by the Ministry in technical documents (over 100 standardised measures are eligible). The decision on additionality of standardised measures is based on technology and market analysis of the savings expected for these measures. Project developers can also suggest new measures and guidelines are available for the so-called non-standardised measure.

Regarding the lists of eligible technologies, there is a lot of variability among countries in the measures supported, even within relatively similar EEO schemes in Europe. As EEO schemes rely to a large extent on *standard* measures, the selection of measures is typically done ex-ante by the Ministry and/or its advisory bodies. Project specifics on site measurements are not possible at this stage. The French scheme uses a relatively rigorous approach for the acceptance of *non-standardised* measures: 1) Auditing the energy use before the measure; if the measure concerns a specific site, an on-site energy audit is required; otherwise, the energy use is to be documented by other means; 2) Based on the energy audit (step 1) the energy consumption before the measure must be established; 3) A reference scenario ("situation de reference") must be established, often based on the state of the product/technology specific market; 4) Estimating the situation after the implementation of the measure; 5) Calculating the amount of certificates requested.

2.2.2 Measurement and Verification in EU EEO schemes

The majority of EEO schemes in Europe have chosen ex-ante deemed approaches for the measurement of energy savings. This seems appropriate given that most of the energy measures considered are widely replicable.

The **Italian** strategy to M&V allows for three different approaches to assign energy efficiency credits to energy efficiency projects[13]:

1. The deemed savings or '*standard'* approach. The programme administrator provides data sheets of standardised evaluations in which the amount of energy saved is defined ex-ante for each installed unit. An example of application of deemed savings is the substitution of incandescent light bulbs with compact fluorescent lamps. The deemed savings are calculated by multiplying the difference in energy consumption of the two alternatives by the estimated average hours of use during the lifetime of the measure.

2. The engineering or '*analytic' approach*, where the energy saving impact of the efficiency measure is well understood but varies depending on a limited number of identifiable parameters (e.g. capacity factor). This methodology is commonly used for commercial or industrial applications. For each project type a specific evaluation algorithm is defined, with pre-defined values for some parameters while other parameters have to be measured case by case. An example of application of this methodology is the implementation of variable speed drives in industrial pumping applications. The energy savings that can be claimed with this measure depend on parameters like the absorbed power of the motor and the working hours of the actual pumping installation.

3. An *energy monitoring plan*, in which measurements before and after the implementation of the project are required. This is an ex-post methodology and is applicable for larger commercial or industrial projects.

The **Danish** scheme also uses 'standard values' (equivalent methodology to the Italian deemed savings approach) for most of the eligible efficiency measures. The Danish EEO scheme also allows for the use of specific calculations in cases in which no 'standard value' is available e.g. large integrated projects.

Table 3 presents an overview of the M&V approaches used in the white certificate schemes in Europe. It is interesting to see that the deemed savings approach with the use of standard values and an ex-ante accreditation of savings has been the most popular M&V approach in Europe, with the exception of Denmark.

[13] ENEA Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (2011). I Titoli di Efficienza Energetica: Guida Operativa. ISBN 978-88-8286-244-2

	Italy	France	Denmark
Measurement and Verification Options	Standard values (19 measures) Engineering approach (5 measures) Metered baseline method	Standard Values (around 240 measures) Case by case approval for other measures	Standard values for approx. 200 measures. Specific engineering calculation
Dominant Measurement and Verification Choice	Deemed Savings	Deemed Savings	Specific engineering calculations
Accreditation of Savings	Ex-ante (majority)	Ex-ante	Ex-ante (adjusted first year savings only)

Table 3 Overview of M&V strategies in EU EEO schemes[14]

2.2.3 Lessons learnt from evaluations of EU EEO schemes

Lessons on M&V

Ex-ante methods have been proved successful for energy efficiency measures that can be widely replicable. However, they are only appropriate for a limited set of measures where the savings will be similar in many different building types or where they are only being implemented in a narrow sector. Ex-ante methods require no on site measurement and the uncertainty of the assigned value of energy savings per measure can be mitigated to a great extent when averaged over a large number of installations. These strategies require from the administrator of the programme:

- A priori analysis of additionality and the definition of baselines (which requires a thorough understanding of the state of technology, the market dynamics, and coexisting regulations in place)
- The ex-ante calculation of savings for the eligible measures
- A periodic update of the eligible efficiency measures, accounting for changes in costs, market penetration and new regulations, in order to ensure additionality
- A periodic update of the energy savings calculations for eligible measures, in order to account for technological developments

The Italian experience with hybrid methods (engineering estimates based on case by case parameters) shows that the reach of relatively simple ex-ante approaches can sometimes be extended to larger industrial applications e.g. implementation of variable speed drives, without increasing M&V costs substantially.

[14] Adapted from: Bertoldi, P. 2012. Introduction to Suppliers Obligation and White Certificate Schemes in the European Union. Institute for Energy and Transport. Joint Research Center. European Commission.

Lessons on additionality

In European Energy Efficiency Obligations and White Certificate Schemes additionality has certainly been a concern in the design of the programmes as well as for the choice of eligible measures. However, there is clear lack of systematic quantitative evaluation of the additionality of the schemes, but there are still some interesting evaluations that can be useful to consider. Building provisions for the evaluation of additionality in the design of the scheme from the start would be critical for an effective ex-post evaluation of the certainty of additionality achieved.

An evaluation of the Danish energy efficiency policies[15] - based on surveys with energy efficiency measure adopters - indicated that the percentage of additional savings was very low: 50% estimate from savings in energy companies and 40% in households with building energy labels.

Togeby et al. (2009) present the result from another evaluation of the Danish energy efficiency policy[16]. "As part of the Energy Analysis evaluation 26 energy companies were asked to deliver information about their largest energy efficiency projects. To make the basis for an evaluation of the balance between costs and benefit the contact person was asked to state "with what probability the project would have been realised within the next year – without the help from the utility?" It is recognised that this is a hypothetical question, and that answers should be considered with care. Based on 88 cases in our interviews the weighted average of the additionality factor is indicated to be 45%. The same question, but with a three years horizon, indicated 33% additionality. Out of the 88 cases, 42 have indicated a low additionality factor (between 0 and 10%) and 13 indicated a high additionality (between 90 and 100%). A review of the statements that each person gave after answering the probability question supports the result: For some the utility help was essential and for others it did not change anything. Although the method is not accurate, it is concluded that about half of the recorded saving would not have been realised without the intervention from the energy utility"

The evaluation of the Danish energy efficiency policies tend to show that only a limited degree of additional savings was achieved, but it also shows that a high degree of additionality (90-100%) is observed in a number of cases. This demonstrates that by targeting the financial incentive to the appropriate measures a high additionality degree can be secured.

2.3 US National Action Plan for Energy Efficiency (NAPEE)

[15] Kirsten Dyhr-Mikkelsen (2010) Evaluation of Danish energy efficiency policies. Keeping it simple, presentation at IEPEC 9-10 June 2010.

[16] Mikael Togeby, Kirsten Dyhr-Mikkelsen, Anders Larsen, Morten Juel Hansen, Peter Bach (2009) Danish energy efficiency policy: revisited and future improvements, paper presented at the ECEEE 2009 Summer Study.

2.3.1 Additionality, measurement and verification in US energy efficiency programmes

In the US, there is a long history of demand side management programmes, often run by utilities. The National Action Plan for Energy Efficiency was a private-public initiative facilitated by the EPA (Environmental Protection Agency) and the US Department of Energy from 2005 to 2010 to create a US wide commitment to energy efficiency through the collaborative efforts of gas and electric utilities, utility regulators, and other partner organisations. The ambition of the action plan was to save on customer energy bills, and reduce the need for new power supplies.

The term additionality is not usually found in the US context. Instead, efficiency programmes in the US distinguish between gross and net savings. Gross savings are defined[17] as *'the change in energy consumption and demand that results directly from programme-related actions taken by participants in an efficiency programme, regardless of why they participated'*. Net savings are defined as the *'total change in energy consumption and demand that is attributable to an EE programme or efficiency standard'*. The difference may include, implicitly or explicitly, the effects of free-riders[18], free-drivers[19], state or federal energy efficiency standards, changes in the level of energy service and natural change effects, and spillover effects[20]. The concept of 'net savings' is very close to the concept of 'additional savings' used in many other programmes. However, the distinction between gross savings and net savings can be analytically clarifying. Furthermore, it is important to note that the 'net savings' definition can include programme impacts outside the programme boundaries, like free-drivers and spillover effects. Evaluation strategies across the US show wide variation in the factors considered for the estimation of net savings achieved by a programme. Some states, e.g. the State of California have developed their own evaluation protocols[21] for this purpose. The evaluation protocols of the California Public Utilities Commision (2006), define three different levels of rigor (basic/standard/enhanced) for the estimation of net savings.

Like in the EEO schemes, the deemed savings approach has been widely used for mass market measures across US efficiency programmes. However, practices differ widely across the US in terms of the M&V and additionality protocols in place and whether deemed savings are verified, ex-ante or ex-post, by independent parties.

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[17] Messenger et al. (2010) Review of Evaluation, Measurement and Verification Approaches Used to Estimate the Load Impacts and Effectiveness of Energy Efficiency Programmes. Ernest Orlando Lawrence Berkeley National Laboratory.

[18] Free-riders: parties that would implement efficiency measures even in the absence of the scheme and take direct advantage of it.

[19] Free-drivers are the opposite of free riders: parties that implement efficiency measures inspired by the policy but do not take direct advantage of it.

[20] Spillover effect: Reductions in energy consumption caused indirectly by the presence of the programme, beyond programme related gross or net savings of participants, e.g. actions that programme participants take outside the programme as a result of having participated.

[21] California Public Utilities Commision (2006). California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals

Vile, Hall and Keating (2010)[22] present a summary of the approach to additionality in the US energy demand reduction programmes with a comparison of how different States define and measure additionality, or rather 'net energy savings' as they call it. The concept of net energy savings is fairly simple: "What were the true effects produced by a program or intervention in terms of energy savings, separated out from what would have otherwise occurred absent the program or intervention?" The definition of what constitutes net energy impacts can be state-specific, in some cases program-specific, requiring the measurement approach to be tailored to meet the applicable definition for a specific regulatory jurisdiction. The difference in definitions can have a substantial impact on the estimate, as well as on the evaluation method that is used. For example, in California (2004-2009), net energy savings are defined by the California Public Utilities Commission to be gross energy savings minus the energy savings from free riders. In this case, the gross energy savings are reduced to account for what a specific evaluation methodology can identify as a program-induced installation, subtracting out savings from instillations that are driven by other factors. The following formula represents the current California definition: Net savings = gross savings – free riders.

To show another approach, in New York, net energy savings are defined by the New York Public Service Commission as gross energy savings, minus savings from free riders, plus energy savings due to participant spillover and market effects. Participant spillover is the savings from program participants who, as a result of the program, installed additional energy efficiency measures, but who did not obtain a program incentive for those additional measures. Market effects are the market level savings that resulted from program influences on the market and the operations of that market (sometimes referred to as nonparticipant spillover, since these end users did not participate in the program and did not obtain a program incentive for those measures), but the market for energy efficiency was affected by the program. The following formula represents the New York definition: Net savings = gross savings –free riders + participant spillover + market effects.

In some states, market effects are not equivalent to nonparticipant spillover, since program participants as well as nonparticipants are affected by market effects. For example, in Wisconsin, depending on the program, the evaluation of net savings may focus either on:

- free riders only,
- free riders and participant spillover only,
- free riders, participant spillover, and non-participant spillover, or
- total market-level net impacts, without any effort to disaggregate by spillover type.

Because the market effects of a program can be as large as or larger than the program's gross savings, the resulting quantification of net effects from one state to another can be very different for the same program, rebating the same measures, targeting the same customers.

[22] Vine, E., N. Hall, K. Keating. M. Kushler and R. Prahl. 2010. "Emerging Issues in the Evaluation of Energy Efficiency Programs," Proceedings of the 2010 International Energy Program Evaluation Conference, Paris, France: IEPEC. Available at: http://www.iepec.org/2010PapersTOC/2010TOC.htm

In conclusion, the definition difference alone makes comparing a net effect from one program to the next problematic, particularly if the evaluation approach varies from state to state.

2.3.2 Lessons learnt from evaluations of US energy efficiency programmes

M&V

The US experiences vary widely by state with the majority of states implementing hybrid methods such as those used in Italy, for as many measures as feasible, yet adding programme elements with inspections and/or ex-post M&V to cover a broader class of more complex measures that can deliver significant savings.

Additionality

In the US context there is an abundant literature on the evaluation of the energy savings program attribution (additionality).

The State of California has a long tradition of leadership in energy efficiency policies and practices and is ranked 1st by the American Council for an Energy Efficient Economy in its latest comparison of energy efficiency policies across the US[23]. The California Public Utilities Commission (CPUC) uses net-to-gross ratios (NTGR) to estimate free-ridership occurring in energy efficiency programs. These ratios are applied to gross programme savings to determine the programme's net impact. Over the years of implementation of energy efficiency programmes, the CPUC has accumulated an extensive database of studies[24] estimating NTGR for a wide number of residential, non-residential and industrial energy efficiency measures[25]. Net-to-gross ratios are usually estimated by carrying out surveys on programme participants and vary widely depending on the programme considered. For instance the latest update of the NTGR for the implementation of door gaskets in commercial refrigeration is 0.19 while duct sealing of residential HVAC is estimated as 0.78. The upper range of net-to-gross ratios is found for commercial lighting applications such as the installation of T8 lamps or the implementation of lighting controls (0.89). Net-to-gross ratios are updated regularly based on data obtained during the programme evaluation[26]. Overall, for the ratepayer funded energy efficiency investments carried out by the four largest IOU (Investor Owned Utilities), the CPUC estimated in its latest evaluation report for the 2009 funding period that ‘approximately 60% of the savings achieved would not have

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[23] American Council for an Energy Efficient Economy. The 2010 State Energy Efficiency Scorecard. 2010

[24] California Public Utilities Commission. NTG Values and Literature Review. Available from: http://deeresources.com/index.php?option=com_content&view=article&id=65&Itemid=57

[25] California Public Utilities Commission. DEER 2011 Update Net to Gross Table. Available from: http://deeresources.com/index.php?option=com_content&view=article&id=68&Itemid=60

[26] Itron Inc. DEER Database 2011 Update Documentation. Available from: http://deeresources.com/DEER2011/download/2011_DEER_Documentation.pdf

happened without the program intervention[27]'. More specifically, the programme obtained gross lifecycle electricity savings of 30,119 GWh of which 19,023 GWh were fully attributable to the programme (63% additional). This relatively low ratio of additional savings, however, did not prevent the programme from paying back an additional $.28 in net benefits for the state for every dollar invested in energy efficiency.

The accumulated experience in evaluating net savings in California may be valuable for DECC to strategically choose a portfolio of efficiency measures to be funded, while minimizing the risk of payments for non-additional activities.

DECC's main objective with a new financial incentive is to support electricity savings that will displace new generation and avoid building additional generation capacity. The Californian efficiency obligation scheme shares DECC's objective of focussing on programs that serve as resource alternatives to supply-side options.[28] In this sense, programme evaluations not only report on energy saved but also on avoided new capacity. For instance, the evaluation[29] of the 2009 funding period estimates that the program resulted in 542 MW gross capacity, reduced to 342 MW when corrected to net programme impact. In such an evaluation the load pattern (time dependency) of the electricity savings needs to be taken into account.

Skumatz and Vine (2010)[30] have been evaluating the additionality of energy savings in several US states.
They reviewed state and regulatory practices or guidelines, showing the diversity of approaches in place in different states. Several states use the California Standard Practice Manual, or large portions of it, for estimating energy savings, free ridership, non-energy benefits, and benefit-cost regulatory tests, including Oregon, Washington, Idaho, Montana, Wyoming, Utah, Iowa, Kansas, Missouri, New Mexico, and Colorado. Several studies specifically examined state and utility practices regarding free ridership and net-to-gross. These studies find that utilities treat the issue of net to gross differently. In some cases, there is no regulatory agreement on the estimation of net to gross, and they historically treat free ridership only in the calculation of the net to gross ratio: 15 states (69%) did not use free ridership in estimating net savings, some states say net to gross is too costly and biased. Massachusetts prefers to have utilities focus on market transformation programs and correct for factors affecting net to gross savings in program design. California requires deemed free ridership values in the calculation of the net to gross, but excludes spillover. Several other states say

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[27] California Public Utilities Commission. Energy Efficiency Evaluation Report for the 2009 Bridge Funding Period. January 2011

[28] See for example California Energy Commission, Implementing Calfornia's Loading Order for Electricity Resources. July 2005.

[29] California Public Utilities Commission. Energy Efficiency Evaluation Report for the 2009 Bridge Funding Period. January 2011

[30] Lisa A. Skumatz, Edward Vine (2010) A National Review of Best Practices and Issues in Attribution and Net-to-Gross: Results of the SERA/CIEE White Paper.
Available from: http://eec.ucdavis.edu/ACEEE/2010/data/papers/2078.pdf

estimating net to gross is not a priority – they feel free ridership is balanced by spillover and make no further efforts, argue that measurement of free ridership and spillover is unreliable, or say that when they did measure it the value was close to one. In Illinois, net to gross ratios of 0.8 are assumed for low income programs and are lower for appliance efficiency programs. Washington reportedly doesn't support savings from behavioural changes or NTG allowances or disallowances.

Skumatz and Vine (2010)[31] also examined patterns in net to gross values, results, or methods across programs and regions. Table 4 presents the main conclusions from this analysis. It shows that measure-level net to gross performance varied, presumably depending on elements of the underlying program design and possibly due to measurement techniques as well.

	Net To Gross , Free Ridership, Spillover
General results	• Most utilities and regulators exclude NTG or assume values that incorporate only free riders and range from about 0.7 to 1.0 (*ex ante*). *Ex post* results have been measured for many programs; spillover is measured much less often than free ridership (and spillover is more commonly reported in the Northeast than in California). • Most studies rely on self-report surveys using variations in questions incorporating partial free ridership/likelihoods; only a small percent used logit/ranking/discrete choice modeling. • Some studies included both *ex ante* and *ex post* NTG figures for the same program. The *ex post* values were generally 10-20% lower than the *ex ante* values. The most obvious exceptions were some cooking measure programs (*ex post* was about half the *ex ante* value), and some refrigerator programs that reported spillover values greater than 0.5. • Gaps included: Fewer than 10% reported confidence intervals; only a small subset covered NTG for gas savings; and very few studies identified free ridership for electricity savings; most considered only kWh effects.
Variations by measure type, program type or region	• Clear patterns for free ridership, spillover, or NTG results by measures, program types, and regions have not been demonstrated to date. The assumption is that variations in specific program design and measure eligibility definitions are important to results. NTG results in the literature are also affected by whether or not spillover is included in the assessment. • *Ex-post* free ridership clustered around 0.1-0.3 but ranged as high as 0.5 to 0.7 for some commercial HVAC / motors and refrigerator initiatives. *Ex-post* NTG clustered around 0.7-1.0, but dipped as low as 0.3 and as high as 1.3. The lowest free ridership was low income programs (as low as 0.03). • NTG for whole homes and home retrofits tended to be high (0.85 to 0.95), but ranged from 0.5 to more than 1.0. • Net realization rates were provided for about one-third of the programs, and the values averaged about 0.7 to 1.0. A number of values exceeded 1.0, including commercial HVAC rebate programs (1.07) and refrigerator rebate programs (1.15). Several programs showed net realization rates between 0.3 and 0.5 including several CFL programs, some refrigerator programs, some gas cooktop rebate programs, and some energy management system initiatives.
Variations for behavioral vs. measure-based programs	• Studies addressing NTG, free ridership, or spillover estimates associated with strictly behavioral programs were not found, and if available, are probably too few in number to lead to overarching conclusions or patterns.

Table 4 Evaluation of US net to gross performance. Source: Skumatz and Vine (2010)

Regular updates of the net-to-gross ratios are key to ensuring that the measurement of additionality is adapted to the technology, market and behaviour changes. In California, major updates of the Database of Energy Efficiency Resources including deemed energy savings, peak impact, technology

[31] Lisa A. Skumatz, Edward Vine (2010) A National Review of Best Practices and Issues in Attribution and Net-to-Gross: Results of the SERA/CIEE White Paper.
Available from: http://eec.ucdavis.edu/ACEEE/2010/data/papers/2078.pdf

costs, net-to-gross ratios, etc. were carried out in 2008 and 2011. In the Pennsylvania scheme, the Technical Reference Manuals are updated every year[32].

3 Challenges for M&V and additionality in the context of a financial incentive for electricity efficiency in the UK

A challenge for the M&V of a financial incentive scheme for electricity efficiency is to *tailor the M&V requirements to the targeted electricity savings applications in the targeted sectors* because as we indicated above there is no such thing as a 'one size fits all' approach. Based on the information provided by DECC on savings potentials and the main applications considered at this stage in the Electricity Demand Reduction project, Table 5 suggests some general preliminary guidelines for an M&V approach.

Sector	Applications	Guidelines for an M&V approach for a financial incentive
Residential	Electric appliances, building improvements	Ex-ante deemed savings
Services	Building improvements, lighting controls, HVAC and controls	Largely ex-ante deemed savings, ex-post monitoring required above a project size threshold to be defined
Industrial	Motor & pump systems, Boiler insulation and optimisation	Ex-ante parametric engineering estimations, ex-post monitoring required above a project size threshold to be defined

Table 5 M&V guidelines for a financial incentive for energy efficiency

One of the challenges identified by DECC with regards to M&V and additionality is the potential existence of *rebound effects*[33] i.e. behaviour changes that can partly offset electricity demand as an effect of the energy efficiency measures. In order to evaluate this effect it is necessary to measure operational parameters (e.g. room temperature in heating and cooling projects) before and after the implementation of the measure. However it is worth mentioning that in general, rebound effects are only a small fraction of the total savings.

[32] Audit Plan and Evaluation Framework for Pennsylvania Act 129 Energy Efficiency and Conservation Programs. 2011. Available from: http://www.puc.state.pa.us/electric/pdf/Act129/SWE-Audit_Plan_Update_Nov11.pdf

[33] We do not enter into the details on the different types of rebound effects here, but we only raise the issue on how M&V and additionality can be impacted.

Nadel (1993)[34] still serves as the best comprehensive review of rebound studies in EE programs. From his review of 42 studies, he concluded that rebound could occur but that it was not a widespread phenomenon. Instead, he noted that rebound was more likely a localised phenomenon, largely limited to specific end uses (e.g., residential lighting (10% increase in operating hours due to the installation of CFLs), and industrial plant production (2% increase due to the installation of EE process measures)). For other end uses, he found no data or inconclusive data supporting the rebound effect.

In principle, M&V ex-post approaches based on monitoring are expected to be able to identify the existence and size of a rebound effect. On the contrary ex-ante deemed savings approaches would not be able to capture direct rebound effects; however, the following solutions could be implemented to limit the rebound effect:

1. Take the rebound effect into account when estimating the savings (for instance applying a 'rebound coefficient'). Research would be required to gather statistically relevant data quantifying typical rebound effects for the eligible efficiency measures.
2. Complement the financial incentive with other non-financial incentives such as educational and information programmes to induce long-term behavioural changes.

[34] Nadel, S. 1993. The Takeback Effect: Fact or Fiction? Washington, DC. American Council for an Energy-Efficient Economy.

4 Conclusions on M&V and Additionality challenges and lessons learnt

Can we have certainty (close to 100%) that electricity savings funded under a financial incentive for electricity efficiency in the UK are additional and predictable so that they will displace new generation and therefore avoid building new generation capacity?

- Experience in energy efficiency schemes shows that 100% certainty and additionally cannot be guaranteed. In the best cases a 90-80% certainty can be achieved very predictably (well-designed schemes with stringent M&V and additionality requirements taking advantage of best practices), but if the design is not detailed enough and M&V and additionality requirements are modest, this can easily drop to below 50%.

- It is probably reasonable to accept a certain degree of non-additionality to balance cost, predictability and administrative complexity upfront. The savings targets and the selection of eligible efficiency measures can be adapted accordingly (e.g. if the objective is to guarantee 10 TWh savings then the scheme will target 12-15 TWh paid- savings, only measures with high additionality rate are remunerated). In this sense, expert voices with wide experience in the field of energy efficiency programmes in the US have questioned an extreme focus on avoiding non-additional measures: *'if urgent and comprehensive efforts are needed, and the efforts by everyone need to be encouraged and noted (including free-riders), then it may be necessary to live with the 'extra costs' of paying people to reduce their energy use and emissions, even if they were already planning to do so[35]'*. The alternative, a 100% additionality requirement, will narrow down the available choice of efficiency measures compromising the potential overall impact of the programme. The accumulated experience in evaluating net savings in California may be valuable for DECC to strategically choose a portfolio of efficiency measures to be funded, while minimizing the risk of payments for non-additional activities. A recent comparative study[36] analyzing 19 different energy efficiency obligation schemes implemented around the world – including Europe, Australia, Korea, China and US – concludes that *'none of the schemes have established robust procedures to verify whether the savings are additional'.* This conclusion is probably over-pessimistic especially in the light of the results achieved in US cases like California, but it confirms the result of our analysis that setting up robust additionality procedures is not yet common practice. Most countries adopt a less stringent approach to additionality than DECC is considering for its financial incentive for electricity efficiency to address their own needs to balance of cost,

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[35] Vine, E., M. Sullivan, L. Lutzenhiser, C. Blumstein and B. Miller. 2011. Emerging Issues in the Evaluation of Energy Efficiency Programs. Proceedings of the 2010 International Energy Program Evaluation Conference. Paris, France: IEPEC. Available from: http://www.iepec.org/2010PapersTOC/2010TOC.htm.

[36] Regulatory Assistance Project. Best Practices in Designing and Implementing Energy Efficiency Obligation Schemes. June 2012

predictability, additionally, and equity across sectors. Some policy makers also examine the uncertainty of an energy efficiency scheme being considered with the error bounds of the demand forecast for that region to assess acceptable levels of certainty versus predictability.

- We do not know how the market, technologies and behaviours will change in the future with certainty. The decision on what is additional is based on our knowledge and predictions at a certain time. The best solutions to increase the certainty of no overpayment to measures that would have happened without the support of the financial incentive that are used in the comparators we have presented in this report are: 1- regular update of the measures supported (based on market, technology and policy analysis); and 2- regular update of the level of payment (in financial incentives or capacity market schemes) or quota and number of credits allocated (in obligation scheme), to closely follow the cost gap to be funded.

- The Californian efficiency obligation scheme focuses0 on programs that serve as resource alternatives to supply-side options. This type of evaluation of net to gross evaluation not only of energy savings but of electricity generation capacity saved is a very interesting example for DECC to follow.

- Whether the financial incentive will lead to the benefit of avoided generation or transmission capacity will not only depend on the robustness of the design of the scheme but also on the confidence that the electricity actors will have in the M&V and additionality approach. There are solutions to build confidence in the system, starting with designing a robust and stable approach and engaging with the market actors early in the process.

- The trade-off between the predictability, certainty of additionality and the administrative cost of the scheme is a political decision. An effective and robust approach to M&V and additionality of electricity savings is always a trade-off between the costs of the approach and the certainty of the savings achieved. Electricity demand reduction projects where the expected savings of a single intervention are small but widely replicable require for pragmatic reasons an M&V and additionality approach at programme level (e.g. it would be out of proportion to monitor every single fridge), this is the approach followed in programmatic CDM and energy efficiency schemes in the US and in Europe. On the other hand, electricity demand reduction projects where a significant amount of electricity can be potentially saved in an individually designed project require a project based approach, this is the approach followed in project CDM and in some large scale white certificate projects. The trade-off between high costs/high certainty vs. low costs/low certainty always exists, both in programme based and project based M&V and additionality approaches. M&V and additionality in electricity saving programmes or projects can be done in a very simple way (e.g. desk study, upfront analysis, rely on given information) or a very precise way (e.g. independent market research, measurements on a sample of projects, measurements on project sites).

- Rebound effects occur and cannot be avoided, but they are small. Also, rebound effects are not widespread but limited to specific end uses and can therefore be solved with specific calculations for the most affected end uses.

Can we have certainty that electricity savings will save money for consumers compared to cost of new generation capacity?

- This is only worth answering if the answer to the 1st question is 'yes', i.e. there is certainty that paid for scheme with robust M&V and additionality can guarantee savings and avoid new generation. To answer this question we need to compare the costs and predictability of a financial incentive with robust M&V and additionality versus cost of building new generation and grid upgrades. At this stage of the project there is too much uncertainty on the first one to provide realistic cost estimates.

- Some elements of answers can be found in a study released in 2009[37] by The American Council for an Energy-Efficient Economy (ACEEE) where they reviewed the cost-effectiveness of 14 energy efficiency programs from different US states. The costs of electricity saved through utility ratepayer-funded energy efficiency programs ranged from \$0.016 to \$0.033 per kWh. According to these results the cost of electricity saved is around one-third of any source of electricity supply in the US.

[37] American Council for an Energy-Efficient Economy. 2009. Saving Energy Cost-Effectively: A National Review of the Cost of Energy Saved Through Utility-Sector Energy Efficiency Programmes.

Annex I: Suitability of the IPMVP protocol for the Electricity Demand Reduction project

There is relatively little guidance available on the practise of M&V internationally. Of primary significance is the IPMVP, which is a guidance document that represents an international professional consensus on acceptable M&V practices for developing reliable savings estimates for water- and energy efficiency projects.

We consider that the IPMVP is suitable for DECC's stated objectives in the Electricity Demand Reduction programme. The IPMVP is a protocol, rather than a standard. As such, it is most effective as a framework for estimating energy savings for programme interventions at a specific measure or building level when the savings will be measured by the programme implementer or other DECC subcontractor. Therefore, it is only applicable for some of the interventions being considered.

We advise that DECC should consider using the IPMVP framework in conjunction with other indicators as appropriate. In which case the effort spent on designing an appropriate M&V strategy can focus on tailoring the overall evaluation to meet specific programme needs or which other indicators, such as participation rates are important) in combination with techniques to address market effects and program processes.

The IPMVP is a guidance document because, rather than prescribing how to perform M&V, it delineates the components and activities that constitute an acceptable degree of M&V in proportion to the level of risk and uncertainty for the savings expected from a water- or energy efficiency project. It defines common terminology, identifies documentation requirements and reporting periods, and describes high-level practices in quantifying savings based on energy measurements and analysis. It presents a framework of four M&V Options that allow broad flexibility in applying the fundamental M&V concepts to calculate and report a project's savings. All four paths require monitoring and/or consumption data.

An important distinguishing feature of IPMVP-adherent M&V is that savings are determined and reported well after the project has been installed, as compared to engineering calculations, which are determined prior to project implementation. Another distinguishing feature is that the IPMVP methods provide the means to determine the project's savings uncertainty.

4.1 IPMVP: level of certainty, reliability and cost

Since the IPMVP is a protocol, the implementer must make numerous decisions during the evaluation that will impact the overall cost, level of uncertainty and reliability of the results. This increases the flexibility and applicability of the IPMVP, but makes it impossible to predict in advance what level of certainty DECC's use of the IPMVP would provide. However, it does provide a solid framework that DECC can use to balance acceptable costs compared to certainty levels.

The IPMVP is widely used internationally, such as throughout the US, Canada, and Australia, for estimating energy savings at a project or a programme level. Each jurisdiction must balance the M&V costs with acceptable levels of uncertainty as indicated by their policy priorities. In practice 80-90% certainty is common.

4.1.1 Tailoring the IPMVP Protocols

The overwhelming majority of protocols customized for local needs use the IPMVP as a basis. However, it is only required in certain jurisdictions, and should not be thought of as a true national standard for the US or other countries. Also, some jurisdictions follow its guidelines strictly, while other jurisdictions allow more flexibility.

In practice, these protocols and guidelines tailored to specific jurisdictions or schemes that are based upon the IPMVP are more directly useful because they provide additional examples and practical discussions on how to deal with the unique issues that arise. Note, several ISO and EN standards used IPMVP as a basis as well.

See, for example, the following selection of guides based upon the IMPVP protocols:

1. *Centre for Energy Advancement through Technological Innovation (CEATI), 2008. Energy Savings Measurement Guide using the* International *Performance Measurement and Verification Protocol.* Notes: General M&V guide based upon the IMPVP from a Canadian consortium. Available online: http://www.hydro.mb.ca/pop/guides/energy_savings_measurement.pdf
2. Energy Efficiency Services Club (ClubS2E). *Energy Efficiency Services Measurement and Verification Guide.* Note: From France, this document is easy to follow, and essentially duplicates relevant *information* from other sources, such as the IMPVP in a more user-friendly format. Also provides sample M&V plans; additional supplemental materials are available in French. Available online: www.clubs2e.org
3. Haberl et al, 2005. *ASHRAE's Guideline 14-2002 for Measurement of Energy and Demand Savings: How to determine what was really saved by the retrofit.* Proceedings of the Fifth International Conference for Enhanced Building Operations. Note: This conference paper provides a good and brief summary of the resources available in the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Guideline 14-2002 – Measurement of Energy and Demand Savings. We suggested reading this free document first, before reading Guideline 14 (available for a small charge at www.ashrae.org). Available online: http://www-esl.tamu.edu/docs/terp/2005/ESL-IC-05-10-50.pdf
4. U.S. Department of Energy Federal Energy Management Program (FEMP), 2008. *M&V Guidelines: Measurement and Verification for Federal Energy Projects: Version 3.0.* Notes: Like the ASHRAE Guideline 14-2002 this document is consistent with, but provides more specific guidance and *suggestions* for dealing with particular data issues than the IPMVP e.g. calibrating to weather data, issues with new construction, and specific examples of several major technologies. Available online: http://www1.eere.energy.gov/femp/pdfs/mv_guidelines.pdf

5. Intelligent Energy Europe, 2006. *Guidelines for the Monitoring, Evaluation and Design of Energy Efficiency Policies: How Policy Theory can Guide Monitoring & Evaluation Efforts and Support the Design of SMART Policies*. Note: The document provides an overview of theory-based evaluation at a program level. Chapter 5 focuses on Monitoring and includes an overview of the positives and negatives of top down and/or bottom up evaluation and common monitoring challenges. Available Online: http://www.aid-ee.org/documents/000Guidelinesforthemonitoringevaluationanddesign.PDF

No system we were able to uncover provides 100 percent certainty of savings. However, as discussed above, the IPMPV provides a good framework to design an evaluation scheme that most appropriately balances cost considerations with different levels of uncertainty.

4.2 Choice of IMPVP options

As discussed above, we believe that the IPMVP is valuable, yet is only part of the framework needed for evaluation with behavioural programme. Options A or B (described below) are only appropriate for a subset of the measures with significant savings potential in the UK. The accuracy will depend on what data is available per the scheme design as well as the specific choices made by DECC and are not proscribed in the protocol. For example a behavioural program may not have direct measure installations that can then be measured using the IPMVP framework. Essentially, how measurable the savings will be depends on the particular design of the scheme and the evaluation strategy developed before the scheme is implemented.

In cases where the intervention is a specific measure, or set of measures within a building, the IPMVP provides four Options for determining savings:

- Option A: Retrofit Isolation (partially measured)
- Option B: Retrofit Isolation (all parameter measurement)
- Option C: Whole Facility
- Option D: Calibrated Simulation

Having four options provides a range of approaches to determine energy savings with varying levels of savings certainty and cost. A particular Option is chosen based on the specific features of each project, including[38]:

- Type and complexity.
- Uncertainty of the project savings.
- Potential for changes in key factors between the baseline and reporting period.
- Value of project savings.

[38] National Action Plan for Energy Efficiency, 2007. *Model Energy Efficiency Program Impact Evaluation Guide.* Prepared by Steven R. Schiller, Schiller Consulting, Inc. Note: This document was commissioned as a resource to support the U.S. National Action Plan for Energy Efficiency. Available online: www.epa.gov/eeactionplan.

This is because the Options differ in their approach to the level, duration, and type of baseline and reporting period measurements. If it is decided to determine savings at the facility level, Option C or D may be favoured. However if only the performance of a single energy saving measure is of concern, a retrofit-isolation technique may be more suitable (Option A, B or D).

For example, in terms of measurement levels:

- M&V evaluations using Options A and B are made at the end-use, system level (e.g., lighting, HVAC).
- Option C evaluations are conducted at the whole-building or whole-facility level.
- Option D evaluations, which involve computer simulation modelling, are also made at the system or the whole-building level.

In terms of type of measurement:

- Option A involves using a combination of both stipulations and measurements of the key factors needed to calculate savings in engineering models.
- Options B and C involve using spot, short-term, or continuous measurements in engineering models (Option B) or regression analyses (Option C).
- Option D may include spot, short-term, or continuous measurements to calibrate computer simulation models.

4.3 Limitations of the IPMVP Protocol

The IPMVP protocol is most widely used to estimate electricity savings but the approaches can be adapted for other fuels, water etc. In general, the IPMVP is appropriate for any programme intervention where specific buildings or measures where savings can be measured or modelled. Use of the IPMVP does not directly address other issues that are often important for evaluators such as program costs, participation rates or persistence.

Therefore, a comprehensive evaluation strategy would also include components addressing market effects and processes to test the program theory and overall cost-effectiveness at a programme level. The components needed would depend on the particular scheme. Only some schemes would benefit from the use of a control group to establish a baseline from which to estimate savings, for example, interventions focused only on education and behavioural changes, and some new construction interventions may benefit from a control group.

Information policy measures and programmes cover a wide range: from general information campaigns and information centres to labeling, education and training, and energy audits. In most cases, especially for general information campaigns and for information centres and education and training schemes, it is difficult (or almost impossible) to make a good estimation of the energy efficiency improvements (impacts). Most hypotheses dealing with general information use some kind of causal model whereby knowledge, attitudes and behaviour are the main features. Sometimes there are no baselines included in the evaluation, especially for information campaigns, while this could be done.

The design of some information programmes might preclude or complicate estimates of net adoptions and/or unit energy savings. Examples of such situations include instances where the programme[39]:

- Broadly promotes a label or concept without calling for specific actions or purchase of specific items.
- Promotes actions such as turning off unnecessary lights, where it is difficult to estimate unit energy savings.
- Works in coordination with fiscal policy measures (rebates), which provide a much stronger incentive for consumers to adopt efficient products and practices.

Due to the extreme variation, it is beyond the scope of the current assignment to provide comprehensive guidelines addressing the appropriate evaluation approaches for all different programme interventions DECC may be considering. However, DECC can benefit from manuals already available describing evaluation techniques for different program types that incorporate the IPMVP with other evaluation approaches, such as to address overall cost-effectiveness, behavioural changes, process issues or market effects, see for example:

- International Energy Agency (IEA), 2005. Evaluating Energy Efficiency Policy Measures & DSM Programmes: Volume I Evaluation Guidebook : Based on National Case Studies & National and International Experiences. Available online: www.ieadsm.org
- California Public Utilities Commission, 2006. California Energy Efficiency Evaluation Protocols: Technical, Methodological and Reporting Requirements for Evaluation Professionals. Available online: www.calmac.org/events/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf

As a rule of thumb 8-10% of the overall programme budget would be set aside for evaluation. However, this is often not feasible in practice. The examples cited above also provide scenarios for different levels of evaluation, based upon the funding available.

4.4 Further Considerations

The preparation of an M&V strategy prior to implementation of the programme is critical. It is central to proper savings determination, and forms the basis of verification. A plan is essential to manage costs and to assure the transparency of processes as well as the quality and credibility of achieved outcomes.

An objective of M&V planning is to design the process to incur no more cost than needed to provide adequate certainty and verifiability in the reported savings. The issue is: “how much certainty is enough, and what is a reasonable cost?” The value of savings for a specific intervention places limits

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[39] International Energy Agency (IEA), 2005. Evaluating Energy Efficiency Policy Measures & DSM Programmes: Volume I Evaluation Guidebook : Based on National Case Studies & National and International Experiences. Available online: www.ieadsm.org

on the expenditure that can be justified for M&V. Conversely, the number, type and complexity of the energy saving measures increase the M&V effort and expenditure for a given level of savings certainty.

Option A[40] normally has the lowest cost although, for multiple measures, sometimes the cost of using measurement equipment required for Options A or B may make Option C less costly. It may also be less costly to use Options C or D than to isolate and measure each ECM with Options A or B. Development and calibration of an Option D simulation model is time consuming, but it may have other uses such as designing the energy saving intervention itself.

It is difficult to generalise about costs for the different Options. However, typically, the cost ranges from 1% to 10% of annual savings, depending on the project objectives and constraints. The acceptable level of uncertainty in a savings calculation is a function of the value of expected savings and the cost effectiveness of decreasing uncertainty through additional time, effort and cost. The M&V process itself introduces uncertainties such as through:

- Measurement and Instrumentation Errors
- Modelling Errors
- Sampling Errors
- Planned and Unplanned Assumptions.

Finding the best balance between savings uncertainty and M&V cost is ultimately a question of risk management based upon the given policy priorities; there is no one 'right' balance.

4.4.1 Calculating Baselines

The method used to calculate the baseline is one of the most important decisions to make at a programmatic level. There is a great deal of literature available addressing baseline calculation for different measures/interventions. Generally, it is best to follow the most typical industry practice for that region for that type of intervention – unless the unique characteristics of the programme(s) suggest an alternative method that would be more appropriate.

Typically, the appropriate baseline for refurbishment or replacement schemes is easier to determine, e.g.:

- Consumption data for the building, or particular equipment being modified
- Current standards relating to that type of equipment or intervention

For new construction, there are three basic approaches to calculating the baseline. The most appropriate will depend on the project and the data available. Note that each approach often requires adjustments based upon project characteristics to increase the accuracy:

- National (or other relevant) standard for new construction for that building type

[40] A quick reminder of what the different options are referring to: Option A: Retrofit Isolation (partially measured); Option B: Retrofit Isolation (all parameter measurement); Option C: Whole Facility; Option D: Calibrated Simulation

- As designed (e.g. as documented in EPC model)
- As built, typically requiring actual consumption data

4.5 Conclusions

The IMPVP is widely used internationally for estimating energy savings at a project or a programme level. Given that 100 % certainty is prohibitively expensive, we advise that the IPMVP provides a solid foundation for DECC to design an evaluation scheme that most appropriately balances cost considerations with acceptable levels of uncertainty. We advise that DECC can then focus on designing programme interventions and related evaluation strategies that most effectively address the policy priorities.

Given DECC's desire to have a high degree of certainty of savings and maximise additionality, we advise that it will be important to focus on interventions with savings that are clearly measureable or estimable. DECC may also wish to focus on interventions with a record of very high additionality inherently, or where the programme rules can be set to maximize additionality, and/or where the cost-effectiveness of the program is so high that the targets can be set to achieve the overall savings goal with an acceptable level of non-additionality. Since the evaluation approach and associated cost varies by intervention type, it is also important to set the evaluation strategy and budget available at the same time the programme intervention(s) are established to ensure that acceptable levels of certainty can be achieved.

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ECOFYS UK Ltd. | 1 Alie Street Suite 208-209 | London E1 8DE | T +44 (0)20 742 309 70 | F +44 (0)20 742 309 71 | E info@ecofys.com | I www.ecofys.com

ECOFYS

sustainable energy for everyone

ECOFYS UK Ltd.

1 Alie Street Suite 208-209
London E1 8DE

T: +44 (0) 20 742 309 70
F: +44 (0) 20 742 309 71

E: info@ecofys.com
I: www.ecofys.com