# EVALUATION OF POLICIES TO REDUCE STANDBY POWER AND DEVELOPMENT OF A STANDARD METHODOLOGY

## AUSTRALIAN GOVERNMENT DEPARTMENT OF CLIMATE CHANGE AND ENERGY EFFICIENCY

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# ACRONYMS

| | |
|---|---|
| BAU | Business-as-Usual |
| DSM | Demand-Side Management |
| EPA | Environmental Protection Agency (USA) |
| GHG | Greenhouse Gas |
| IEC | International Electrotechnical Commission |
| IEC 62301 | International Standard IEC 62301: Household electrical appliances – Measurement of standby power |
| MEPS | Minimum Energy Performance Standards |
| SELINA | Standby and off-mode Energy Losses In New Appliances measured in shops (EIE project under the European Commission) |
| SPI | Standby Power Initiative |
| STB | Set-Top Box |

# GLOSSARY

| | |
|---|---|
| Active Mode | Defined by IEC 62301 as a Product Mode where a product is performing at least one primary function. It is also referred to as On Mode. |
| Functions | Defined by IEC 62301 as a predetermined operation undertaken by the product. Functions may be grouped into: Standby Mode (user-oriented secondary functions), Network Mode (network-related secondary functions), Active Mode (primary functions) and other functions. |
| Jurisdiction | A generic term representing any country or region (state, province, county, etc.) where a Standby Power Initiative (SPI) is implemented. |
| Low Power Mode | Defined by IEC 62301 as a Product Mode that falls into the Off Mode, the Standby Mode or the Network Mode. |
| Network Mode | Defined by IEC 62301 as a Product Mode where at least one network function is active but where the primary function is not active. |
| Off Mode | Defined by IEC 62301 as any Product Mode that is not providing any functionality other than indicating the user that the product is in the off position. |
| On Mode | Defined by IEC 62301 as a Product Mode where a product is performing at least one primary function. It is also referred to as Active Mode. |
| Product Mode | Defined by IEC 62301 as a mode where the performed product function depends on the particular product configuration. The appropriate terms to differentiate the Product Mode are established by a technical committee. Even if the term reflects the functions that are activated, IEC 62301 recommends not using the word “standby” or “network” even where the Product Mode falls into these categories to avoid confusion with IEC naming conventions. |
| Standby Mode | Defined by IEC 62301 as any Product Mode where at least one user-oriented secondary function or protective function is offered and active by the product. |
| Standby Power | Standby power refers to the power consumption of a product performing any Low Power Mode. |
| Standby Power Initiative (SPI) | A Standby Power Initiative (SPI) is a generic term used throughout this report to designate any policy, regulation, voluntary agreement, financial support programme and awareness campaign that could support the introduction of low standby power in a market and contribute to market transformation efforts in the long term. |

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# EXECUTIVE SUMMARY

Standby power refers to the energy consumed whenever the product is not performing at least one of its primary functions. End-usage studies conducted in different countries show that standby power can represent anything between 5% and 15% of household energy consumption. Therefore, there is a significant potential to improve product design or operation in order to reduce wasted energy while preserving the main functionalities. Governments and all stakeholders could then work together to design and implement various policies, regulations and programmes to capture this potential. These actions are designated as Standby Power Initiatives (SPI) in the report.

The objective of this study is to provide a uniform international methodology to evaluate the impact of SPIs in countries having their own set of activities to promote the reduction of standby power.

Various approaches could be used to design and implement SPIs aiming to reduce standby power. They are presented below to illustrate the diversity of initiatives possible, the context in which the impact evaluation methodologies could be applied and the challenges associated with each.

### Legislative informative:

Legislative initiatives could include the application of energy efficiency labels informing the consumers about the most efficient products on the market. However, energy labelling for standby power alone is rarely used in practice but standby power requirements are often included in an energy index used to define the efficiency of products.

### Legislative normative:

Legal requirements for the application of Minimum Energy Performance Standards (MEPS) in a market are set by a government.

### Cooperative measures:

Alternative to legislative initiatives include cooperative measures such as voluntary labelling and voluntary agreement schemes. These types of initiatives may initiate the transformation of the market through a close collaboration between the public and the private sectors.

### Financial incentives:

Financial support schemes are regularly used as part of Demand Side Management (DSM) initiatives and may be another approach that could be put forward to contribute to the reduction of standby losses. Financial incentives will be mainly offered to favour the purchase of products with low active power but these schemes can be modified to include low standby power requirements for eligible products.

### Fiscal initiatives:

Although not currently being used as a SPI, fiscal incentives are sometimes provided to reduce the fiscal charges on products with efficient active power characteristics. Again, it is unlikely that such a scheme could be viable only for the reduction of standby power. However, low power mode requirements could be combined with the active mode eligibility criteria of products to further promote market transformation toward low standby power products. Such fiscal initiatives could be tax, tariff and import duty reductions or exemptions.

### Information dissemination and awareness:

This category of initiatives could also contribute to the reduction of standby power. Such programmes could create awareness among consumers so that they favour more efficient models when purchasing new products or induce behavioural changes like the disconnection of equipment when not in use. They can also promote the installation of external devices like power bars (also called power strips or power boards) or timers that can overcome the poor standby characteristics of legacy stock. Although changes in behaviour and the use of external devices do not impact standby power product characteristics of the stock, they could impact the number of hours a product operates in standby mode.

All the above mentioned initiatives would impact standby power characteristics, the number of hours operating in standby mode, or both. The quantity and quality of data that could be made available to evaluate the impact of such initiatives may vary significantly from one approach to another, so in many cases special efforts are required to ensure that good data is specifically collected for evaluation purposes. Moreover, a single product can operate under several low power modes or even be disconnected, which makes it difficult to determine how many hours the product is operating under each given mode. User interactions mean that wide range of actual usage patterns will be present in the field. In addition, automatic energy management functions may automatically switch the product from one low power mode to another. Therefore, the impact evaluation of standby power initiatives represents a unique challenge when compared to traditional programmes targeting energy efficiency products.

Research in a limited number of industrialised countries have revealed that they have yet to evaluate the ex-post impact of their SPIs, in part because many of these initiatives are relatively recent. Some jurisdictions have put in place market research initiatives to measure standby power (and trends), determine the usage and expected life of existing stock and evaluate the energy saving technical potential (replacing all inefficient equipment with efficient appliances without consideration for the timeline). Some jurisdictions have conducted ex-ante projections to estimate expected savings from an SPI. These initiatives often contain data that is similar to those that will be needed for the impact evaluation of SPIs. However, they don’t specifically address the impact evaluation of SPIs. This report summarises some of the experiences in data collection from those countries.

The complexity of accurately evaluating the various standby modes power requirements and the number of hours of operation in these modes, including the effect of user behaviour and internal energy management strategies, need to be taken into consideration when designing a programme to evaluate the impact of SPIs.

The proposed impact evaluation methodology set out in this report is designed to be as generic as possible and could thus be applied to the evaluation of a wide variety of products for various implemented SPI schemes. As data availability and resources will likely differ from one SPI implementation scheme to another, the proposed methodology underlines these differences and offers a general framework while ensuring enough flexibility so that each jurisdiction can select the level of rigor that will be the most suitable for its own SPI impact evaluation. A preferred evaluation path that offers a reasonable balance of cost and effectiveness is also recommended associated with various options for the enhancement of specific elements with an associated increase in the resources required.

The first two steps of the proposed methodology involve identifying the product categories and the power modes that are to be assessed. The products would generally be the same or a subset of those covered by the SPI being evaluated. Some SPIs may target the standby power requirements, others may target the operating hours in each mode, or both, which would determine the type of impact we want to validate and what information is required to achieve this goal. At this stage, it is of paramount importance to accurately identify the type of information that should be included in the programme tracking system or the background research that should be conducted prior to programme launch. Planning for the evaluation requirements during the SPI design stage will facilitate and ensure that the information is collected at a lower cost during programme implementation.

The third step of the proposed methodology involves collecting sales data to determine the number of low- and high-efficiency products entering the market each year. Preferably, information will also be collected by specific brand and model to allow combining the sales data with the low power mode energy consumption to obtain a sales-weighted power average applicable to the market. In the absence of detailed sales data per model, simpler alternative approaches are proposed in the methodology to estimate the average standby power of products. For instance, market research can establish the approximate share of the market per brand and this information can be used for the weighting of the average product power in the market. If detailed information about the quantity of each model sold on the market is available, the evaluator may select a more precise sales-weighted average power model.

The fourth step consists in defining the baseline, which is a model of the standby energy usage for equipment sold in the market each year in a Business-as-Usual (BAU) scenario. Ideally, the research for the determination of the baseline characteristics should be conducted ex-ante as part of the analysis carried out to forecast the impact of an SPI as it is very difficult to retrospectively determine the baseline once the SPI has been launched (for a future ex-post evaluation). Part of the BAU scenario needs to include any autonomous[1] efficiency improvements that are occurring in any case without the SPI. It is important to take into account market anticipation of future SPI

[1] Also referred to as “baseline trend” or “market trend” in some jurisdictions.

requirements – if there is a lot of discussion and publicity about future SPI requirements and stakeholders believe that the requirements will come into force (or the implementation date is known well ahead of time), the market can anticipate these changes well in advance of any implementation date.

Before the energy savings can be quantified, it is necessary to define the SPI energy usage scenario. It is the energy consumed for standby power for the years under consideration in the impact analysis. This could be done by capturing the variation from the baseline scenario in terms of power demand and the number of hours of operation in each relevant power mode.

The fifth step consisted in quantifying the gross energy savings (i.e., the difference between the energy usage in the baseline scenario and the SPI scenario). They represent the direct impact observed in the market. As part of an ex-post evaluation, it is common practice to compare the ex-ante estimates of sales with the ex-post real sales evaluation to identify any deviation from the projected energy reduction impact that is due to sales variations. It is generally assumed that the SPI will have no effect on the quantity of products sold. As a result, any shortfall (or increase) in savings compared to objectives that is caused by sales variations is not considered as a programme design or implementation problem, rather it should be treated as an exogenous variable (or counterfactual). To assess the impact of an SPI over the product life, programme evaluators usually estimate life expectancy from supplier data, market actors or from information collected through household surveys.

The net savings that will be generated over the product life are based on the gross energy savings observed in the market. In general, the observed gross energy savings cannot all be attributed to the implementation of an SPI. The contribution of different global, regional and other national policies, programmes and technological changes can affect the natural market trend in standby power and must be taken into consideration. The base methodology presented in this report does not generally recommend that such effects be taken into consideration as they considerably increase the complexity of the evaluation and requires regional or global market research. In some cases, specific countries may want to do a more precise attribution evaluation to ensure that different programmes acting at the local, regional or international level will not each claim the same savings, which would eventually lead to double counting impacts in the same market. One of the usual approaches to performing a more precise attribution evaluation requires the organisation of meetings with manufacturers, suppliers or other knowledgeable market actors who have a regional or global vision of the market to try to determine what would have been their course of action and range of products offered in the absence of the SPIs introduced in the geographical areas where they supply products.

Finally, the net impact of the SPI should be ideally assessed by taking into consideration distortion effects. One of the well-known distortion effects is the so called cross-effect, which is the impact that a reduction in power consumption for standby usage can have on other usages in a given household. The two most frequent interactions taken into account are the effect of reduced heat rejection by efficient products on heating requirements in a household or their effect on cooling requirements (or possibly both). The decision to include these effects (or not) is highly market specific. It depends on the climatic data and the percentage of households equipped with heating or cooling equipment. Such an analysis requires judgement about the level of waste heat from standby power and whether it is usefully contributing to overall heating (or negatively contributing to overall cooling). Wasted standby power will rarely be at a level, in a location and at a time that makes a significant contribution to space conditioning, especially as standby level for individual products decline. It also depends on the objective of the evaluation work. If the objective is to inform the policy makers about the market transformation trend at a higher level, this type of more refined calculation may be neglected.

Electronic products have a short development and market cycle, which means that there is a constant flux of products offering new and additional functionalities in the market. This creates a challenge both for any policy targeting standby power and for the associated market evaluation activity. The introduction of new features can make the attribution process more complex.

Policy makers and evaluators should allocate sufficient resources to track trends and changes in the market of electronic equipment and appliances to ensure that their policy or method of evaluation does not become obsolete because of natural changes in product designs and market trends.

The methodology presented in this report provides government and energy efficiency programme managers with a flexible set of guidelines and recommendations on how the impact of standby power initiatives should be assessed in a market.

# INTRODUCTION

The objective of this report is to present an internationally applicable methodology to assess the impact of various policies, regulations, programmes or initiatives designed to reduce the standby power consumption of products in the marketplace. These are designated as Standby Power Initiatives (SPI) in this report.

A substantial number of appliances, as long as they are plugged in, consume power even when not in Active Mode (i.e., where it is not performing any of its primary function). The energy consumption when not in Active Mode is referred to generically as Standby Power and includes the power consumed to maintain user and network-oriented secondary functions like internal clocks, timer modules, status displays, remote control sensing elements, battery recharge and indicator lights. Since Standby Power is continuously consumed as long as the product is plugged in, and not in active mode, the amount of energy consumed annually can be significant.

Studies conducted in different countries show that Standby Power can represent anything between 7% and 15% of household energy consumption. These studies also revealed that there was a large discrepancy in the power usage of various products, even among appliances offering similar functionalities. Needless to say, since Standby Power is not related to any of the product primary functions, there is a significant potential to improve product design in order to reduce wasted energy while preserving the main functionalities.

With the growing number of electronic products that rely on electronic circuits requiring Standby Power (e.g., televisions, DVD players, computers, peripherals, power supplies), there is a trend for governments and stakeholders to design and implement SPIs as a means to reduce the amount of energy wasted when not in Active Mode.

Tracking the impact of SPIs requires the development of a flexible and credible methodology to assist in the collection and analysis of data on Standby Power consumed by low-efficiency and high-efficiency products entering the market.

A comprehensive and universal impact evaluation methodology could be a useful guide for the design of ex-ante demand and energy savings estimates related to proposed initiative. It could also be used to design and conduct ex-post impact evaluation activities, including provisions to collect sufficient data as part of standard programme implementation to enable future ex-post evaluations to be conducted accurately.

A number of SPIs, such as MEPS, voluntary agreements, labelling programmes and awareness initiatives, are being implemented by an increasing number of jurisdictions. While a labelling programme that targets only standby power is unlikely, standby power can be incorporated with active power as a component of an energy index used to determine the efficiency class of products. We can therefore find some labelling programmes in the market that may have an impact on standby power level. Jurisdictions may use different approaches to select, develop, implement, monitor, enforce and assess SPIs. Whereas some jurisdictions decide to implement a single SPI, others may implement successive or concurrent SPIs. Designing a universal comprehensive methodology for assessing the impact on Standby Power losses for a wide variety of approaches and different implementation frameworks is a real challenge. Nevertheless, impact assessment is of paramount importance to track the effectiveness of a particular SPI, or a series of SPIs, within the implementation framework. Well-conducted impact assessments provide the feedback needed to determine required programme adjustments including more stringent requirements, determine if new SPIs are required and justify the continuation or abolishment of the SPI.

Section 1 of this report reviews some of the unique challenges related to the impact evaluation of standby power. Section 2 presents the various approaches that can be used to implement SPIs in order to reduce standby power with the objective of presenting the context in which the methodology could be applied. Section 3 presents a review of various market research initiatives already implemented in some countries to measure standby power, determine the usage and expected life of existing stock, and evaluate the technical potential of proposed SPIs. Those initiatives often contain some activities that are similar to the ones that will be needed for ex-ante and ex-post impact evaluation of SPIs. Section 4 describes the recommended generic methodology for assessing the impact of SPIs. Finally, Section 5 provides an introduction to sampling procedures that are required to ensure that good quality data is acquired for evaluation purposes.

# 1 UNIQUE CHALLENGES RELATED TO THE IMPACT EVALUATION OF STANDBY POWER

The impact evaluation of standby power initiatives presents unique challenges when compared to traditional energy efficiency programme impact evaluation for products in their active mode. These challenges arise from:

- The large number of products having standby power modes;
- The large diversity of functionalities within low power modes, which vary from product to product and within products from model to model;
- The rapid evolution of the products, with new functionalities and associated low power modes;
- The automatic energy management functions that may automatically switch the product from one low power mode to another without any external indication to the consumer;
- Communication between products that may induce automatic switching between different low power modes without end-user intervention.
- The difficulty to clearly define the hours of operation in each relevant mode, which is the result of the large quantity of low power modes mentioned above and the complexity of user interaction, which is highly variable from day to day and from site to site.

All these issues need to be taken into consideration while evaluating the impact of SPIs.

While certain products have only one low power mode, a large number have several. For instance, even a simple battery charger has at least two standby modes: plugged in with a fully charged battery or plugged in without a battery. Modern televisions may have several non-active modes such as a sleep mode and a higher consumption data acquisition mode triggered periodically by an external signal or internal clock (this could also be classified as a type of active mode). Computer networks have a variety of standby and inactive modes with interactions among components. Typically, products will operate under several low power modes and could also be disconnected. One of the objectives of the evaluator will be to define which of these multiple low power modes are relevant and should be taken into consideration in an impact evaluation and which should be excluded.

The standby power consumption of a product is generally not related to the efficiency level of the product in active mode. A product that is considered efficient in active mode may perform well, average or below average in low power modes. The standby energy consumption evaluation thus requires specific information on the power required and the duration of operation in each relevant low power mode. The standby energy requirements in individual households or sites may vary considerably for the same product based on user operational decisions defining the selected low power modes and the hours of operation in each mode. Standby energy requirements will also vary considerably for products exhibiting different standby power requirements under the same usage patterns.

The evaluation of hours of operation in each mode also presents unique challenges that are related to the number of low power modes and the difficulty to assess in a cost-effective manner their duration. The presence of energy management systems can also automatically affect the time spent in each mode for a given usage profile. The same is true for modern equipment that has the capability to communicate and switch modes of operation in response to a signal received from other equipment (e.g. via a network). Trying to identify an operation scenario that is representative of an average household in a market is not a trivial task.

The use of power strips that can be switched on or off by the end-user (some of these products provide more sophisticated controls that enable a master slave arrangement to switch off unwanted peripherals when the master device is not in use) also has an impact on hours of operation in low power mode and thus on standby energy. The same is true of an awareness campaign that suggests unplugging equipment while not in use. These types of initiatives offered in the market by DSM or government programmes will result in changes in operation time between the possible low power mode and the disconnected mode. The evaluation of these initiatives has its own set of complexities; for instance, the persistency of a household occupant’s behavioural change is something that is difficult to assess. Will the savings be maintained for several years or will the occupant return to former habits as soon as the awareness campaign is over?

In an ideal world, assessing standby power energy savings in the field would require recording energy consumption for a statistically representative sample of baseline and efficient products for a time duration that encompasses the various low power modes and which captures variations in hours of operation between modes (as well as persistence of behavioural change). This usually results in market research that is costly and that presents logistical challenges and thus not the preferred option for an evaluator that must deliver results as accurate as possible within limited budget.

Therefore, the challenge lies in determining how to deal with the complexity of standby impact evaluation without creating approaches that are impractical, expensive and cumbersome.

The methodology presented in this report addresses this challenge by presenting a robust base method that is not necessarily the most accurate that could be designed but that can nevertheless provide useful information to policy makers. The methodology also incorporates these elements while offering flexibility to SPI evaluators to increase the accuracy of one or several components if needed and if human and budget resources are available.

# 2 APPROACHES USED TO IMPLEMENT STAND POWER INITITIVES

Activities to limit standby power are being implemented using a variety of methods. Some are implemented via policies elaborated by government and applied by means of a regulation aiming to reduce standby power, with periodic revisions to increase the range of products covered or change the minimum performance requirements or energy efficiency classes of targeted products. Other activities are implemented via voluntary labelling schemes using endorsement labels to indicate products with superior performance. Being voluntary, this type of programme generally does not cover all products in a given market. Other methods of implementation can consist of providing financial incentives for efficient products or in creating consumer awareness. It is a good practice to incorporate programme impact evaluation as an integral part of the design and implementation plan of such programmes and initiatives. By planning the evaluation component prior to programme implementation, the programme manager can identify clearly which information will be needed for the ex-post evaluation and can organise data collection activities to determine the baseline trends before introduction of the programme and/or to collect the information as the SPI is implemented. Each type of programme requires attention in order to properly evaluate the results since the type of data that is normally available under each type of initiative and the additional data that must be collected to ensure a proper ex-post evaluation can vary widely for different SPIs. It will be necessary to analyse on a case-by-case basis the information available to the evaluator, additional data required and whether it should be collected through market research activities or product testing.

A recent report from the IEA[2] lists several policies implemented by various countries in the categories of Minimum Energy Performance Standards (MEPS), labelling, and voluntary agreements as shown in Table 1. The table also lists a few initiatives based on public sector purchasing rules for low standby power products (China and USA). These initiatives help to establish a solid market for energy efficient products and sends a clear message to all manufacturers interested in selling products to government agencies. Table 1 however does not mention some type of policies like information dissemination and awareness, incentives or the free distribution of power strips that can affect standby power consumption in the residential or commercial sector. Many countries have introduced or proposed a wide range of SPIs since this report was published.

[2] Gadgets and Gigawatts, Policies for Energy Efficiency Electronics, OECD/IEA 2009.

### Table 1: Major existing national policies targeting standby power

| Country | Policy Type | Products Covered | Status |
|---|---|---|---|
| Australia and NZ | Comparison label | Standby in energy label for whitegoods | Current |
| | MEPS | Air conditioners, televisions, set-top boxes, computers | 2008-2010 |
| | MEPS | All electronic appliances and equipment | By 2012 |
| | Endorsement label (Energy Star) | Office equipment | Current |
| Brazil | Comparison label | CRT televisions (this comparative label is unique as it labels standby power only and not active power) | Current |
| Canada | Energy Star programme | Office and home entertainment equipment, external power supplies, household appliances. | Current |
| | Comparison label | Standby in energy label for dishwashers | Current |
| | MEPS | Home entertainment, external power supplies | 2008-2009 |
| China | Endorsement label (aligned with Energy Star) | Office and home entertainment equipment, external power supplies, household appliances. | Current |
| | Procurement policy | Office equipment | Current |
| | MEPS | External power supplies | Current |
| Chinese Taipei | Voluntary agreement | DVD players, desktop PCs, integrated stereos, microwave ovens, set-top boxes, ADSL modems, digital TVs | Current |
| Korea | Energy boy endorsement label | Office equipment | Current |
| | MEPS | External power supplies, battery chargers | 2008-2009 |
| | Comparison label | 1 watt | 2008-2009 |
| | Mandatory warning label | Appliances not meeting the 1 watt standby | 2008-2009 |

| Country | Policy Type | Products Covered | Status |
|---|---|---|---|
| EUROPE | Voluntary agreement (code of conduct) | set-top boxes (VA in framework Eco-Design and Code of Conduct), external power supplies (Eco-Design EC 278/2009 requirements coming into force in April 2011 supersede in practice the existing Code of Conduct version 4), broadband equipment | Current |
| | ENERGY STAR | Office equipment | Current |
| | EcoDesign directive | Electrical household and office equipment | Approved |
| JAPAN | Top Runner | Televisions, VCRs, DVD players/recorders, copiers, computers, microwave ovens, toilet seats, routers | Current |
| | Voluntary agreement | Gas and kerosene fired space heaters and water heaters | Current |
| | Endorsement label (ENERGY STAR) | Office equipment | Current |
| THAILAND | MEPS | All electronic appliances and equipment | By 2011 |
| UNITED STATES | Executive order 13221 & 12845 | Office equipment | Current |
| | Endorsement label (ENERGY STAR) | Office and home entertainment equipment, external power supplies, household appliances | Current |
| | Comparison label | Standby in energy label for dishwashers | Current |
| | DOE Standards | External power supplies, battery chargers | Current |

Source: IEA Gadget and Gigawatts, 2009

The main characteristics of each category of initiatives as well as the type of data that may be collected during implementation and used during impact evaluation are summarised below:

### Legislative, informative - labelling

Promoting a market transformation toward more efficient products can be done through regulations mandating the application of energy efficiency labels. Such labels inform customers about which products are the most efficient on the market and create a competitive environment for manufacturers as most of them seek to have at least some of their products range among the most efficient in the market. These labelling schemes can be mandatory, which means that all products in the market are covered, or they can be voluntary while still being part of a regulatory framework.

Usually, if a voluntary scheme is part of a regulatory framework, the government has the intention to make it mandatory after some years of operation. Most labelling programmes that include standby power requirements are vertical approaches that combine low power mode energy with active mode energy, as it is not cost effective to design a labelling scheme only for standby power. The evaluation methodology presented in the report however focuses only on the standby power component of labelling schemes that use a vertical approach.

These programmes involve testing the products using specific test standards and can be performed in manufacturer laboratories (self-declaration), independent laboratories or through a certification process where a third party assesses the conformity of the testing performed either by the manufacturer or laboratories. These tests will allow the determination of energy consumption in active and sometimes in low power modes for different products. Test results can be related to efficiency classes or an energy index in a mandatory comparative labelling scheme or compared against a minimum threshold required by a voluntary endorsement labelling scheme. This type of approach may or may not require setting up a database listing all products available in the market together with their consumption characteristics. Where databases are set up, collecting data on product performance and changes over time is an easy task with no additional cost over normal programme operational cost. When a database is prepared to support a labelling programme with vertical approaches including active and standby power, it is important to ensure that the energy characteristics of products in standby mode will be entered in specific fields in the database so that they will be available later for the impact evaluation of the standby component. Relevant sales data is still required in order to evaluate the impact of the implemented policy on energy use. In the particular case of standby power, it is not obvious that all relevant low power mode data will be available in the programme database and most of the time, there is no information about hours of operation.

### Legislative - normative

Regulations are also being used to mandate the application of MEPS, which may include active mode requirements and additional standby power requirements. These programmes work by eliminating the production or import of low-efficiency equipment on the market.

This type of programme usually has a database of products introduced in the market as the import authority needs a convenient tool to identify the products that are allowed to enter the market. The database should include information about active and standby power levels for all relevant modes to allow verification during enforcement activities. Similar to the mandatory labelling program, power consumption in standby mode can consist of a self-declaration from suppliers or can be supported by independent laboratory testing required under the regulation or via certification. These test results or declarations may be subject to a third party or government ongoing verification processes to further ensure the integrity of the MEPS scheme. A programme designed for a vertical integration of active and standby power must collect information related to the power usage of products in all relevant active and low power modes. Generally, the programme manager has estimates of operating time in each relevant mode coming from the programme design. These hours could be estimates derived from field test data, literature reviews or they could be estimates selected conveniently to normalise calculations of product consumption. They can also be arbitrarily selected by the government to achieve a particular programme objective such as sending a signal to manufacturers to modify products in a certain way. Thus, energy consumption calculated from the estimated hours of operation coming from the programme design may or may not reflect actual product usage in households. MEPS initiatives generally do not require a collection of information on quantity of products sold in the market but some jurisdictions may elect to mandate sales data reporting for market characterisation or market tracking purposes.

### Cooperative measures

Cooperative measures can include any type of voluntary activity that allows initiating a market transformation without the need for an elaborate regulatory framework and associated enforcement activities. We can include in this category of initiatives voluntary labelling schemes and voluntary agreements between governments and suppliers to improve the standby attributes of products supplied to market over time.

In a voluntary labelling scheme, manufacturers and importers are invited to participate in the initiatives. These types of programmes provide information to customers to allow them to make informed decisions when purchasing a product and help them select the most efficient ones. Suppliers show interest in joining these programmes in order to gain a marketing advantage by demonstrating their commitment to energy efficiency and the environment.

Several comparative or endorsement labelling programmes have been implemented in the past on a voluntary basis. Some of these programmes require commitments from manufacturers for participation (such as in the ENERGY STAR program) that include testing and certification of each product by an accredited body (a recent requirement), the verification of declarations on an ongoing basis and the submission of sales and product performance information. The ENERGY STAR programme covering certain types of products has been adopted by various countries and regions including the European Union, Japan, South Korea, Canada and Australia.[3]

The voluntary nature of this type of labelling programme means that it is most likely that only incomplete market data will be available. For instance, only information about efficient products that comply with programme requirements may be available, which means that only a portion of the market information will be readily available for impact evaluation work. The hours of operation for each standby mode will likely not be available from the programme design. Sales information may (as is the case with the ENERGY STAR scheme) or may not be a requirement under the programme.

These initiatives are also being used successfully in several countries to create a market “pull” for more efficient products. Most of the time, they cover the active mode but they can also cover the

[3] Details of the Partner Commitments are found on the ENERGY STAR website at: http://www.energystar.gov/index.cfm?c=manuf_res.pt_manuf.

low power mode and the off mode power. A small number of manufacturers may initially agree to voluntarily change the type of products offered in the market but the objective in general is to enrol most of the major market actors.

Voluntary agreements are another form of policies. They take the form of government and private sector discussions and commitments on the introduction of a certain market share of efficient products or on the voluntary commitment to a minimum performance standard. These initiatives work by introducing better equipment in the market or by removing the worst products altogether.

There is generally a form of monitoring in these types of initiatives so that the market transformation effect can be assessed by partners. In these cases, some information about energy consumption may be available from participating suppliers and could be used for impact evaluation.

### Financial

Another method being used to encourage the purchase of energy-efficient products (programmes offered usually over a specific period of time) is the use of financial incentives such as grants or low-interest loans towards the purchase of highly-efficient products. These programmes try to convince customers, through financial incentives, that they should purchase the most efficient products when they are considering acquiring a new unit. It is unlikely that a financial incentive would be offered only to support the introduction of low standby power products in the market as the value of savings for individual products is relatively small compared to the purchase cost of those devices. It will thus be difficult to find an incentive level that is, at the same time, attractive for customers while being cost-effective for programme managers (given that there are significant transaction costs). As a result, most of the time, the financial incentive will target in priority the active mode power consumption that offers the largest savings (i.e. as part of a vertical approach). However, if requirements are added to the effect that to be eligible to participate in the programme products should also have low standby power characteristics, this type of financial incentive can contribute to the reduction of standby power in the market. The challenge here will be to ensure that the programme captures the information needed to estimate the standby power saving component.

There are also specific cases such as programmes promoting the use of products (power bars/boards and controls) that may reduce the standby consumption of several products with significant standby losses (entertainment systems and network components). Some social-oriented programmes go as far as to freely distribute, provide and install energy efficiency items like power bars/boards in households. In this case also, financial incentive programmes may have an effect on standby power that can be measured during impact evaluation.

For these initiatives, an accurate and reliable method is used to identify highly-efficient products in order to determine whether they are eligible for grants or low-interest rates. In order to evaluate the impact (costs/benefits) of this type of policy, which is often referred to as a resource acquisition scheme, the programme manager tracks the number of products supported by the policies so that this information is readily available in the programme database. Tests and marking (such as endorsement labels) or a simple list of products eligible will be required to classify the products that meet the criteria for financial incentives. Standby power should be available in a product database if the programme is designed vertically to include active and low power mode requirements. Sometimes, programme managers define their own threshold of efficiency, which may end up being different from an existing labelling scheme.

Generally, this type of programme uses estimates of hours of operation in each relevant mode that are derived from testing campaigns, literature reviews or selected by the programme designer for normalisation or to achieve specific programme objectives. These hours may or may not reflect actual hours of operation in households, but ideally to estimate actual programme savings, a reasonable estimate of typical hours by mode is required.

### Fiscal - Tariffs

This method uses tax reductions/exemptions as well as tariff and import duty reductions/exemptions to encourage the purchase of energy-efficient equipment. Historically, product requirements were focussing on high efficiency active mode but as the interest for standby power develops, government can also include an additional requirement concerning low standby losses for the eligibility of products. This type of initiative reduces the fiscal charges on product imports or sales and thus the cost to end-users for the most efficient products.

For evaluation purposes, this type of policy would require performance testing and/or appropriate labelling that identifies the products qualifying for the fiscal benefit as well as a method for verifying transactions and properly tracking tax or customs reductions as part of the programme cost of implementation. The fraction of the market affected could be, generally, readily determined from a programme database. Because of the relatively high cost of this type of policy, as in the case of financial incentives, it is not likely that this type of implementation strategy will be used for standby power performance alone but low power mode requirements may be included in a programme that targets mainly active power mode characteristics.

### Information - education

These types of programmes and activities are being used to create awareness for consumers of electrical and electronics products. This in turn will create a demand for more efficient models or will induce behavioural changes toward more efficient energy usage. These programmes generally target the active mode energy consumption but some of them can also target low standby energy consumption. For instance, encouraging consumers to unplug appliances when not in use or promoting the use of power strips in order to save energy. The impact on energy consumption, which depends on consumer behavioural change, is not only difficult to determine, but it may vary over time as well. As for providing information about products with low standby power, the message is often focused on the benefit of energy efficiency in general or on the environmental benefits rather than on monetary savings. A single product with efficient standby modes will often produce only modest gains compared to normal equipment, which will in turn be considered negligible by most individual users if they were used as the main rationale for changing behaviour. The approach of promoting small gestures towards better efficiency is more appropriate in this particular case. In most types of information programs, there is very little information available on the number of products sold in the market, product efficiency and hours of operation. Because it does not collect information about the market, this type of initiative is usually the most difficult to measure. It is also the one that raises the most questions with respect to the sustainability of savings among policy makers or market actors engaged in DSM programme implementation.

**Cross-cutting measures:**

These types of initiatives can affect a number of areas (e.g., climate change levy with sector-specific characteristics, energy and carbon dioxide taxes, ecological tax reform). These types of actions are usually not specific to standby power and thus of less interest for this report. They may however be used to raise funding that will then be applied to the financing of various energy efficiency initiatives with some of them resulting in standby power reductions.

Readers interested in more information about the various policies and programmes that can be implemented to support energy efficiency in general and standby power reduction in particular can consult the MURE database (www.mure2.com) where policy measures taken at the EU level and in all member states are listed. Included in the database are up-to-date policies involving the various market sectors (household, transport, industry, tertiary and general/cross-cutting – including office equipment in the tertiary sector). The database also contains descriptions of the evaluation methodologies used in various types of initiatives. These methodologies can be searched by country, market segment, programme type, etc. The evaluation methodology is described through case studies.

By observing the wide variety of programmes and initiatives introduced in the market to support energy efficiency improvement and standby power reduction, we can conclude that one of the priority tasks which an evaluator must perform when preparing an evaluation plan is to carefully assess what information is available from the programme database (if any), what hypothesis has been made and what was the support for selection of each of them during programme design (e.g., hours of operation per low power mode). The data requirements will include the number of efficient products entering the market compared to a baseline scenario, the power requirements while the equipment is in standby mode and the hours of operations for each low power mode.

# 3 INTERNATIONAL ACTIVITIES TO EVALUATE CHARACTERISTICS OF STANDBY POWER

Assessing the impact of initiatives aiming to reduce standby losses presents a number of challenges such as small amounts of energy standby losses by a large number of individual units, a large variety of products and product functionalities, a large, diverse and growing market as well as difficulties collecting field energy use data with expensive and invasive processes. This topic, amongst others, was discussed by the Expert Group on Energy Efficiency and Conservation under the Energy Working Group of APEC, at an international conference in Tokyo, Japan in October 2010 (Alignment of Standby Power Approaches Moving Towards 1 Watt and Beyond). The conference brought together experts on standby power, manufacturers and suppliers of electronic equipment. The purpose was to get a better understanding of the feasibility of reducing the standby power requirements of products. The evaluation of initiatives was discussed and key issues were identified, as stated in the conference overview. Some of the discussions concerned more specifically the impact evaluation or will result in policies, activities or processes that can help collect information required for evaluation:

- Agreed approaches to the preparation of energy estimates and energy impacts
- “Shared evaluation approaches and methodologies.”
- “Use of Common measurement and evaluation approaches to support policy development and implementation”
- Ongoing measurement of new products (stores, labs, manufacturer data)
- Information sharing between APEC economies to facilitate policy development and enforcement (where applicable)
- Longitudinal measurements to obtain information on user interactions and to evaluate more advanced energy management approaches
- Clearing house and repository for data and shared resources

The value of collecting information in a standardised format, sharing it with others and defining common impact evaluation methodologies all contribute to moving the agenda forward and building on the knowledge and experience of others at a reduced overall cost.

A review of current status of work on standby power was conducted as part of this mandate for Australia, Canada, the USA and Europe. The research revealed that most of these jurisdictions conduct market research initiatives to measure standby power, determine the usage profile, existing stock characteristics and the expected life of products. Many of them have also prepared ex-ante projections of savings. Such research informs policy makers, helps evaluate the total end usage for standby power and the energy saving technical potential (replacing all inefficient equipment by efficient appliances without consideration for the timeline). On the other hand, few countries have conducted ex-post evaluations to date, in part because they haven’t had a programme in place for a sufficient historical period. One notable exception is the ENERGY STAR programme, for which numerous ex-post evaluations have been conducted. Those initiatives often contain some activities that are similar to the ones that will be needed for ex-ante and ex-post impact evaluation of SPIs. Therefore, this section presents examples of various market research initiatives and the activities that could be applied to assess the ex-ante potential or the ex-post impact evaluation of SPIs.

## 3.1 REVIEW OF COUNTRIES EXPERIENCE ON MARKET RESEARCH AND ANALYSIS OF STANDBY POWER

A combination of literature reviews and direct communications with stakeholders were conducted to locate examples of recent work in the field of market research and analysis related to standby power. This field of interest has received considerable attention in several industrialised countries over the last 10 years. Gradually, other countries are showing interest or are planning initiatives to address the standby issue as they realise the importance of the energy saving opportunities offered by standby power initiatives. Examples of initiatives from industrialised countries to support research on standby power current usage or reduction are reviewed below. These examples are not impact evaluation activities but they contain activities that are similar to those that will be required for impact evaluation. They can thus provide interesting insight on the approaches that are the most applicable and cost-effective to be included in a generic methodology for impact evaluation.

### 3.1.1 Initiatives in Australia

In Australia, standby power has been on the government's policy agenda for over 10 years[4]. Their initiatives include data collection in support of policy development as well as support for international standards development in this area.

Early work includes a comprehensive quantification study of standby power carried out in 2000[5]. Through an intrusive survey, the power consumption of 2,500 appliances in 64 households in Brisbane, Melbourne and Sydney and 531 new appliances in retail outlets were measured. This measurement campaign was complemented by a telephone survey of 801 households. This study revealed that 11.6% of household electricity consumption could be attributed to standby mode. This research has provided the baseline data required to support the introduction of standby power policies.

In 2002, the Ministerial Council of Energy initiated a 10-year national strategy, "Money Isn't All You're Saving." This policy set out the goal that by 2012 all appliances would only use one watt in their lowest standby mode. To provide the critical data required to quantify the magnitude of standby power of products offered for sales in Australia, the 2000 study was followed by five in-shop surveys of new appliances. The energy consumption of 635 appliances was measured in

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[4] *Lloyd Harrington, Jack Brown, Paul Ryan;* Quantification of Standby in Australia and Trends in Standby for New Products.
[5] Quantification of Residential Standby Power Consumption in Australia, Energy-Efficient Strategies and EnergyConsult, 2001.

2002, whereas 573 appliances were measured in 2003, 1,431 in 2004, 1,313 in 2004/05 and 946 in 2005/2006.

Under the 10-year strategy[6], detailed product profiles were determined and published in 2005. The profiles include an assessment of the current market, ownership levels, product attribute and the range of standby powers typically found in new products.

The survey methodology of 2005/2006 is of particular interest as a similar approach could be used for the collection of the information required to evaluate the impact of an SPI[7].

For the 2005/2006 survey, more than 946 products segregated into 40 categories were measured in seven Melbourne participating retail stores. The products' power consumption in normal use and standby mode was measured using a portable metering device that was plugged into the products. For the purpose of the study, four standby modes were defined: off mode, passive standby, active standby and delay start. Products with external power supply had the external power supply measured separately.

The study reveals a few challenges in measuring power consumption in stores. One example being cited is the integrated stereo equipment. The active standby power of these units varied depending on the type of unit. For instance, when the stereo unit is searching for a disc in the CD mode, it doesn't consume as much as when the unit is set to an auxiliary input. Another notable challenge worth mentioning with respect to the design of an SPI evaluation programme is the fact that multi-function devices have replaced some single function devices. Such is the case with facsimiles that are no longer sold as standalone units but rather included in multi-function devices. This market transformation adds complexity to the comparison of standby power consumption from one year to another.

An example of the methodology used to collect market information about the effect of an SPI in Australia and New Zealand prior to deciding which initiative to pursue was described in a document entitled: "Consultation Regulatory Impact Statement: Minimum Energy Performance Standards and Alternative Strategies for Set-Top Boxes"[8] (STBs). As part of this work, impacts on energy use and GHG emissions were calculated from market studies that integrated a forecast of sales and projected savings in energy use. Energy and GHG emissions are estimated for the business-as-usual scenario and the modelled MEPS scenario in order to calculate the difference over time.

In 2009, a report was issued to update the projected impact of the Equipment Energy Efficiency (E3) program, an initiative that belongs to the National Framework for Energy Efficiency of Australia. This report mentions that standby power will be included as part of the ENERGY STAR 4.0 for TV sets as a voluntary programme. The report also highlights that MEPS will be introduced in 2013 for the standby power of a range of equipment. A global figure of approximately 1,000 GWh pa at the horizon 2020 is expected from the combined initiative for active mode and

[6] Standby Power – Current Status. Energy Efficiency Strategies, 2006.
[7] Appliance Standby Power Consumption Store Survey 2005/2006, EnerConsult, 2006.
[8] Report 2007/11, Issued by the Equipment Energy Efficiency Committee Under the Auspices of the Ministerial Council on Energy, Australia/New Zealand, October 2007.

standby mode. While the report doesn't provide details on the underlying model, it indicates that an ex-ante model exists for these impact forecasts.

### 3.1.2 Alignment of National Standby Power Approaches Project

Another interesting project that could provide insight for the design of an SPI impact evaluation activity is the Alignment of National Standby Power Approaches Project[9] of the Asia Pacific Partnership on Clean Development and Climate Change (APP). One of the objectives of this project was to facilitate standby power measurements between jurisdictions. In order to normalise the type of equipment measured, a basket of products consisting of 14 core products and 29 secondary products was defined. The survey method is based on the IEC 62301 principles and the experience Australia has gained since the inception of its initiative on standby power. This survey strategy consists in measuring products offered for sale in stores and complementing the research with individual household surveys where all electronic products are measured. This database has, as of 2010, nearly 8,000 measurements, a valuable tool for policy makers involved in SPIs.

Once the products included in the basket of products were listed, a data collection Excel tool was developed to minimise data entry errors while allowing for maximum flexibility. The 2010 version of the tool was updated so that readings from the metering device could be directly input into the Excel spreadsheet. The survey process was also updated to help make the test procedure more robust. Both the updated tool and process were distributed to the APP partners in May 2010. A website[10] supports the project and allows for information exchanges between interested stakeholders. It provides graphs allowing comparison by country and summary graphs looking at products over time and across modes. Seven APP project participants (Australia, Canada, Korea, China, India, Japan and the USA) and four other jurisdictions (Europe through SELINA, which also includes Switzerland) have collected store data and allowed APP partners access to this information. The international survey methodology was based on Australia's experience. Therefore the following modes were defined: in-use mode, active standby, passive standby and off mode. The report contains product standby power trends per jurisdiction and standby mode but provides no insight on how to evaluate the impact of a particular SPI.

Energy and GHG emissions are estimated for the business-as-usual scenario and the modelled MEPS scenario in order to calculate the difference over time.

### 3.1.3 EU Initiatives – SELINA

Another initiative conducted by the EU was the *Standby and off-mode Energy Losses in New Appliances measured in shops (SELINA)*[11] project. As the name implies, the methodology of the SELINA project was designed to measure the standby power consumption of new equipment in shops.

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[9] APP Alignment of National Standby Power Approaches Project, Enerconsult, 2010.
[10] www.energyrating.goc.au/standbydata"app
[11] *Centre for Energy and Processes, Armines/Mines ParisTech, **S**tandby and off-mode **E**nergy **L**osses **I**n **N**ew **A**ppliances measured in shops (SELINA), June 30, 2010.*

Measurements were undertaken in shops using a small portable wattmeter to which the equipment to be measured was plugged into. This equipment was developed for standby power measurement purposes, which implies that it is designed to capture small power and is particularly well adapted to this type of measurement campaign. An energy consumption calculation tool was also developed under this initiative to facilitate the analysis and computation of standby power based on field measurements undertaken.

The SELINA project also supported the development and operation of an online database of standby power measurements that can be used by any interested party to gather information about the various markets tested or for benchmarking purposes.

The main activity of the project was the in-shop measurement effort and the methodology and results of this activity were summarised in a report issued in 2010[12]. This report describes how the products to be measured were identified from an initial list of 269 products which was then reduced to 140 products that could be practically measured in shops. A basket of 45 products was finally retained to ensure that results could be compared with other initiatives put in place by the EU (regulation EC 1275/2008) or by the Asia Pacific Partnership (APP). The products selected were organised into 18 categories to facilitate the analysis.

An interesting finding under this project was that sufficient resources should be planned for the enrolment of shops. The shops can either be contacted directly (the most efficient method) or through their head office to get the authorisation for measurement. Evaluators should be prepared to answer legitimate concerns expressed by shop managers about the disturbance that the measurement campaign would produce. Shop managers are also sensitive to potential equipment damage during the test. Ideally, measurement should be conducted during periods where there are less customers shopping. The size of the measurement equipment could also be an issue as bulky equipment will create more disturbances in shop alleys. As a result, the selection of small portable equipment (plug-in type) is recommended.

Each test performed in the course of the SELINA project was performed for a period of 1 to 10 minutes to ensure a steady state operation in each relevant standby power mode. The operator makes the final decision about the test duration and an average power measurement during the test is taken as final result. The measurement included the voltage, power and power factor.

The accuracy of the wattmeter selected was ±0.4%. The testing setup included additional devices like a safety breaker to avoid electrical shock and a short extension cord to avoid plugging equipment directly in the power meter, which can cause a rapid wear down of the integrated plug.

In order to maximise the efficiency of the measurement process, an Excel tool based on the work carried out in Australia was adapted to the SELINA project. Additional functionalities were integrated into the tool to provide for automatic data acquisition from the measurement equipment to the Excel sheet to fasten the process and reduce the possibility of manual input errors.

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[12] Consumption Monitoring Campaign of Standby and Off-mode Energy Losses in New Equipment, SELINA, June 30, 2010.

The different modes defined for the measurement were the off-mode, the passive standby mode, the network mode and the active standby mode. The study focused on the passive standby mode and off-mode but did try to perform measurement in other modes. It was noted that measurement in standby mode was particularly difficult.

Other practical aspects of in-shop surveys were noted like the importance of doing a first screening of equipment in shops to enter them in an overall database. This allowed saving time during the measurement campaign and identifying equipment that had already been measured in other shops and which did not have to be measured once more.

The report summarises the results of 5,844 products measured in 15 countries.

One of the main recommendations from the SELINA project was that governments that are implementing SPIs should consider in-shop measurement as a first stage of screen tests for compliance surveillance. A side benefit of using in-shop measurement as part of the enforcement scheme is that it will bring real market data on low power requirements of products in different modes that can then be used as part of an impact evaluation effort. It should be noted that the SELINA project field data collection was initiated only after the coming into force of the tier 1 of the Eco-Design directive one year after its official publication on December 18, 2008. As a result, the data collected under the SELINA initiative cannot be used as a baseline to measure the impact of this new regulation. Evaluators interested in determining the energy impact of the Eco-Design directive would thus need to set up an alternative strategy to develop an appropriate baseline. For instance, they could use field test results from other projects performed in the EU before the implementation of the directive or use as a control region a country that is not part of the European Union and which could help determine what would have been the market without the regulation.

One of the important factors to consider in this study was the accuracy of the standby consumption measurement data. Since product consumption characteristics were measured in *situ* in stores during this study, the measurement results were not particularly accurate. Comparison of products where a duplicate measurement has been done in different stores showed that they were deviating from an average of +/-15%[13]. This would be in the case where data was automatically transferred to the worksheet, which eliminated any possibility of transcription error. Other measurements with manual data entry resulted in even larger differences (28%) between measurements of the same products in different stores. This level of precision was considered sufficient for market trend evaluation but could be an issue in an evaluation context as we will be interested in determining a differential power level between the baseline and the SPI scenario. If the differential between these values is small then the error in each measurement can result in a larger overall error on a sample by sample basis. This will thus require a sufficient sample of products to be sure that the results are accurate enough for impact evaluation purposes.

Work under the SELINA initiative resulted in a summary of the range of off power consumptions, including the average, 25th and 75th percentile and the minimum and maximum values found in the market.

[13] Consumption monitoring campaign of standby and off-mode energy losses in new equipment, SELINA, page 27.

While this market research effort was interesting, it was not intended and did not allow collecting other data required for impact evaluation such as annual sales data of corresponding models in order to calculate an average power in standby mode for each product of interest in the market. Hours of operation for each mode where not part of this study.

### 3.1.4 Natural Resources Canada Study

In a study[14] carried out for Natural Resources Canada, estimates of total energy consumption related to the standby power of various products were developed. The standby power was estimated both for the equipment sold in 2007 and for the overall stock of equipment.

While this study was not aimed at impact evaluation, there were activities that could also have been used in an impact evaluation context. For instance, in-shop measurement of standby power of specific products offered for sale were measured, which is also an activity frequently used as part of impact analysis. Other important information for impact evaluation is the annual sales data that were also collected in this particular study. Finally, hours of operation in houses were estimated from an earlier study and used to determine the standby energy usage. This information was collected as follows:

- A measurement of standby power of consumer electronics, small household appliances, white goods and computer equipment was conducted using measurement equipment in several stores across Canada. A total of 884 products (25 categories) were tested in five retail stores.
- The selection of products to be measured followed the standby power measurement protocol proposed by Energy-Efficient Strategies of Australia in the “Basket of Products” white paper.
- The corporate office and the individual stores were contacted to obtain the authorisation needed to perform in-store testing.
- Stores were contacted and visited prior to the measurement campaign. A list of products on display was requested from the shop manager of each site.
- Two high-precision Wattmeters specifically designed to measure small loads were purchased. They offered a ± 0.1% accuracy on measurement. This equipment was relatively bulky and needed to be put on a cart for easy moving in stores with the associated laptop for data entry. An extension cord provided power to the equipment on the cart and the setup was protected against potential electrical faults.
- A data gathering tool using an Access database was developed to facilitate the in-store data collection of products.
- Individual protocols for measurement were developed for each product. This work was in large proportion inspired from the Australian experience in this field.
- Measurements were done for 8 seconds after stabilisation of the reading, which takes less than one minute generally with a few notable exceptions. The measurement sampling rate

[14] Navigant Consulting Inc., Canadian Retail Store Survey, March 31, 2008.

was 4 readings per second for a total of 32 readings per product. Results were averaged. An average of 125 products could be measured in a shift of 8 hours by a team of two.

- Data entry was done manually and only one reading was taken by product except for products falling outside of a predefined acceptable range. For products falling outside of that range, a second test was conducted to confirm results. The fact that there was no automatic entry required a team of two to conduct the test. One person was reading the meter and calling out the results while the other was entering data in the Access tool.
- All measurements were verified for quality and data that were doubtful or missing were removed. Duplicate entries were retained as a way to partially reflect the popularity of some models in the market.
- Market sales data were obtained from industry associations and *Appliance Magazine*, and collected by a private survey company. Data could not be broken down by brand and model and therefore could not be used to calculate the sales-weighted average of the standby power level.
- Energy use characteristics of Canadian homes, collected from a household energy use survey conducted in 2003, were used. The survey data included the hours of use of domestic electronic products, the product penetration in Canadian homes as well as the appliance saturation. For certain products for which detailed consumption data was not available, estimates of active use and standby hours of operation were developed. Using this set of data, standby energy consumed by these products in Canada in 2007 was calculated.

As a follow-up to this study, the University of Alberta is finalising (June 2011) the latest campaign of in-shop measurement. While the results of this project were not publicly available at the time of writing this report, the project manager confirmed that:

- The objective is mainly to collect current market data on standby power in Canada in 2011.
- The current work still uses the basket approach that was used in 2008 for the previous study.
- The disconnected mode will be explored as well as the standby mode.
- 360 products were measured in the following categories: TVs, microwaves, video equipment, audio equipment, washing machines, computers, laptops, monitors and printers. In addition, 160 products of smaller importance were measured to have an indication of their standby power requirements.
- For some products, the results will be analysed by technology or by size. This is notably the case for TVs.
- Measurements try to adhere as much as possible to IEC 62301. Stabilisation time of 2 minutes for equipment before reading. No voltage stabilisation equipment used but voltage is recorded during the test.

While most of the data collected above could have been used for impact evaluation, this was not the objective of the work. Furthermore, if this effort had been undertaken specifically for impact evaluation purposes, the projects could have explored additional dimensions of standby power usage.

For instance:

- Collection of sales data per product to identify the most popular ones and allow a sales-weighted average of standby power consumption.
- Measurement of more low power modes or in-house measurements to confirm energy usage in a real context.
- Expected life of products in use and of replacement products.

**Box 1 - Lessons Learned from Field Measurement Activities:**

- **The normalisation of a basket of products for market research facilitates the exchange of information and benchmarking between jurisdictions.**
- **In-store measurement of products is technically and logistically feasible. It offers a good ratio of products measured for a given budget.**
- **The evaluator should allow sufficient resources for the initial discussion and the enrolment of shop owners or chain headquarter representatives.**
- **Off, passive standby, active standby and delay start are all modes that were considered relevant to measure.**
- **Automatic transfer of data between the power meter and the computer used for data collection can enhance the accuracy of the campaign and reduce the human resources required.**
- **Small portable equipment is preferable to large equipment as it creates less disturbances during in-store measurement.**
- **Screening of store products prior to the measurement activity is important to avoid multiple testing of the same model of equipment.**
- **Electrical equipment protection and auditor safety are primary concerns when designing a measurement campaign.**

## 3.2 MAIN VARIABLES THAT NEED TO BE CAPTURED FOR IMPACT EVALUATION AND STRENGTHS AND WEAKNESSES OF DATA GATHERING OPTIONS

To date, there is no universal, well-established approach for evaluating the impact of standby power initiatives. Depending on the type of initiative, the nature of the product, the use pattern and interconnections with other products via networks, the requirements and opportunities to collect the type of data required to undertake a proper evaluation may differ widely from one proposed type of initiative to the next.

The barriers to the establishment of a universal methodology are related to the relatively small amount of energy that needs to be measured on individual products, the high cost of collecting sufficient field data to establish the breakdown between the various relevant low power modes and disconnected modes and the relatively short life of the majority of products of interest, which requires frequent updating of the market data.

In-home energy audits and the calculation of energy usage by end-use can be a useful activity to collect market statistics (before and after SPIs) and to provide trends in energy usage patterns of the products of interest. Although these are expensive and invasive activities, they can yield useful data if undertaken for other purposes.

Determining the use pattern of interconnected equipment and separating the power consumption corresponding to standby use from the total consumption is complex and highly variable from one user to the next (and from one context to another). This implies that a relatively large sample size must be measured to assess the variation from one installation to the next, as well from one user to another. These facts make data collection very expensive if a high degree of precision is required.

The precedent sections have presented country initiatives led to gather information about standby energy usage in the market. These initiatives allowed gathering information that can be used for impact evaluation. However, because these initiatives were not designed or intended to measure programme impact, these studies failed to gather information that was paramount for impact evaluation. The information required for evaluating the impact of efficient standby power products in a market can be categorised as follows:

- Quantity of efficient products sold in the market;
- Standby power characteristics in relevant low power modes and disconnected modes;
- Hours of operation in each relevant low power mode and disconnected mode;
- Attribution to the programme (i.e., the fraction of efficient product sales that could be directly attributed to the introduction of the SPI);
- The life expectancy of the products.

**Each of these categories of information are discussed below.**

### Quantity of Efficient Products Sold in the Market

In virtually all cases of small appliances, computers, audio-visual equipment and white appliances, hardly anyone would replace a product in working order with a new one just to save on standby power consumption. Therefore, for standby power initiatives, the programme designer has to rely entirely on natural replacement and market growth to achieve energy savings. As a result, the quantity of products sold in the market each year is an essential piece of information for impact evaluation. More specifically, the quantity of efficient products sold in the market is of the upmost importance as the SPI cannot claim savings for the portion of the market where low efficiency products are still sold after the introduction of the initiative. However, it is good practice to track both the quantity of efficiency and inefficient products in the market to be able to assess the increase in market share of efficient products over time and the efficiency of the SPI to transform the market. Knowing the market share of efficient products is of particular interest to programme designers and operators as it can provide an indication of when an SPI has effectively transformed a market and requires adjustments in order to adapt the efficiency requirement to a new, higher threshold.

Market data for individual products can be collected most effectively and at the lowest cost when an industry association is engaged in collecting data from its members and in producing summary results that can be made available to the evaluator. However, this may lack the required level of detail as very often the information cannot be disaggregated by model sold, which precludes the calculation of sales-weighted standby power characteristics.

In situations where manufacturers participate in a voluntary programme such as ENERGY STAR, programme participants are required to report (confidentially) on the volume of sales of each individual product along with the actual performance data. This particular type of programme makes product performance and energy savings tracking particularly convenient and accurate. Tracking the sales of non-complying products is more difficult but, as mentioned above, not essential for impact evaluation.

Finally, data collection can be undertaken directly through surveys and meetings with manufacturers and suppliers. In general, this is more difficult unless we can secure the collaboration of the largest market actors. In this type of research, only a partial vision of the market is usually achieved.

### Standby Power Characteristics in Relevant Low Power and Disconnected Modes

The standby power level in all relevant low power modes is another critical piece of information for impact evaluation. Measuring the standby loss component in actual use is expensive, invasive if made in houses and needs to be repeated periodically, as product types and consumer usage profiles may vary over time. This is especially true for electronic equipment that tends to have a relatively short useful life.

As far as standby power is concerned, it is important to assess both the baseline (i.e., what would have been the standby power of products sold in the market without the SPI – this is best established before the SPI is implemented) and the SPI scenario power (what is estimated to occur for ex-ante projections or what actually did occur for ex-post evaluations). The standby power should be assessed in the most relevant low power mode only as the objective of an impact evaluation is to achieve the maximum precision for a given cost.

Ideally, the establishment of the baseline would require accurate historic data on standby power characteristics in the market during the year prior to SPI introduction using approaches similar to the one used in Australia, the EU, Canada, the USA and other countries over the last 12 years. Having access to several years of history would be ideal as it would allow determining the natural trend in standby power in products. However, for several countries, it will be practically impossible to have access to such type of historical information especially for countries that are just starting to design or implement their first SPI and which want to launch it rapidly after having conducted an initial market survey.

In the absence of accurate historic data, the evaluator will have to estimate the baseline using other methods. In some cases, a jurisdiction that is considered similar is used as a baseline but comparisons of standby power from different countries show that this will be a challenging endeavour as we can observe large variations in standby power characteristics from market to market. Another option can be used for SPIs that only partially transform the market. In this case, it is possible to use as baseline proxy the efficiency of equipment in the market that doesn't achieve a certain threshold. Assumptions will need to be made to account for autonomous improvements over time from that proxy baseline.

Standby power characteristics can be obtained from field measurements in households, field measurements in shops and from laboratory testing under normalised conditions. Laboratory testing is the most precise yet the most costly approach, which makes it difficult to apply to large, statistically representative samples. Field measurements in shops are the easiest way to achieve the measurement of a large quantity of samples at a reasonable cost and could be sufficient for many impact evaluations even if it lacks the precision of other methods. In-house measurement is intrusive but has the potential to provide the most precise information about the duty cycle of products in different on-modes, low power modes and disconnected modes especially if carried out with data logging equipment. Data loggers also provide the information required to understand how standby power varies with time (e.g., in conditions where automatic power management logic triggers operational mode changes in products).

### Hours of Operation in Each Relevant Low Power Mode and Disconnected Mode

Hours of operation are also required for impact evaluation. According to the type of SPI and its potential effect on the hours of operation, the evaluation team can either assume that the hours will not change before and after the introduction of the SPI or it may want to add data collection activities to assess any change in the hours of operation. SPIs that aim to change user behaviour will need to be carefully assessed with respect to the changes that occur in behaviour. Products that have energy management as part of an SPI will also put the product automatically into different modes irrespective of usage patterns and behaviour, so assessing this aspect can also be important in some cases.

Hours of operation can be collected from end-user surveys but are known to be unreliable as household occupants often have only limited knowledge of the time spent in each mode of operation. A more precise estimate can be derived from direct in-house equipment measurement. Measurement of hours of operation in households requires intrusive measurement campaigns using logging equipment (both expensive and costly, but may be undertaken for other purposes). In the absence of more precise information, hours of operation in each mode can be estimated from literature reviews of research conducted in other jurisdictions.

### Attribution to the Programme

The fact that we observe changes in standby power in the market does not imply that an SPI is entirely responsible for the changes. There may be other regional and global effects that make the market move toward higher (or lower) efficiency products (including programme spillover effects from other regions). For several evaluators, the determination of attribution, which is the causal link between the SPI activities and the market changes observed, is a critical component. Usually, the determination of attribution requires information and opinions from several well-informed market actors to be able to confirm that a programme is responsible for a portion or for the totality of an observed market change. Interviews, focus groups or a Delphi approach are often used to gather the information needed for attribution.

### Life Expectancy of Products

The life expectancy of products is needed in an impact evaluation to project savings for each new efficient product introduced in the market over its service life. End-user surveys, manufacturer and supplier surveys as well as maintenance company surveys are often used to get a realistic estimate of a product's life expectancy.

**Box 2 - What is Needed to Evaluate the Impact of an SPI**

- **The quantity of products entering the market at any given year. For some SPIs, the quantity of products improved through the SPI could be sufficient.**
- **Standby power of products in all relevant low power modes for the baseline scenario, including effects of autonomous improvements.**
- **Standby power of products in all relevant low power modes for the SPI scenario.**
- **Hours of operation of products in all relevant low power modes and in disconnected mode.**
- **Fraction of the changes in efficiency observed in the market that can be attributed to the SPI.**
- **The expected life of the efficiency products introduced in the market due to the SPI.**

# 4 METHODOLOGY RECOMMENDED FOR IMPACT EVALUATION

The proposed methodology includes different steps to assemble and analyse market and product technical data as well as customer behaviour information that will help quantify the impact of an SPI on energy demand and consumption in a given market.

The methodology is designed to be as generic as possible and could thus be applied to the impact evaluation of a wide variety of products for various SPI schemes, taking into consideration variations in available human resources and budget.

The proposed methodology uses an impact evaluation method consistent with a "natural replacement" context that is also referred to as a "loss opportunity." In evaluation terminology, a loss opportunity relates to a situation where a buyer has to make the decision to invest in a new product and select either a standard efficiency product or a more efficient product (in this case with lower standby power characteristics). The impact of the SPI will thus be the difference between the power consumption of a standard low-efficiency product at the time of purchase and that of a high-efficiency product also offered in the market at the time of purchase.

This approach is quite different from a "retrofit" or "early replacement" scheme where we assume that the SPI will provide sufficient incentives or rationale to end-users so that they will prematurely change an existing product that has not yet reached the end of its useful life for a more efficient product. In a retrofit scheme, the energy impact of a programme or initiative is the difference between the efficiency of the existing stock and the efficiency of a brand new product[15]. It would be unusual to be able to justify a programme based on early replacement that covers standby power alone.

As it is assumed that a natural replacement context would prevail, the proposed methodology does not aim to provide a measure of the impact associated with SPIs that promote the early replacement of products. Providing that a programme promoter would like to implement an SPI targeting early replacement and evaluate its impact, it would be necessary to modify the baseline product characteristics to reflect the installed stock and its remaining useful life instead of the standard low-efficiency products offered in the market in the years where the SPI was implemented.

A programme promoter can also use the proposed methodology to determine the ex-ante objective of a new SPI. The proposed methodology can also be used for the design of an ex-ante impact potential evaluation of a new SPI with the purpose of providing decision makers with the rationale to support the adoption of the standby policy. In addition, the proposed methodology can provide the basis for an ex-post impact evaluation, with the objective of quantifying the real impact of

[15] Even this is a simplified approach as some impact evaluations of retrofit schemes sometimes consider two baselines for a product. The first baseline is the stock efficiency and applies to the remaining life of the existing product. The second baseline, which is the current market efficiency for standard low-efficiency products, applies to the rest of the evaluation period.

implemented SPIs in a given market. There will be specific recommendations when a portion of the methodology has to be adjusted to take into consideration ex-ante or ex-post evaluation specificities.

One of the main challenges of an impact evaluation methodology for standby power is related to the diversity of the low power modes that can be found in a single product. This difficulty of evaluating these various low power modes is further complicated by the wide variety of products in the marketplace. IEC 62301, which proposes an international standard for the measurement of standby power, provides clear indications on how a low power mode should be measured but does not identify and classify all the low power modes that can be found in specific products. It is up to a programme designer or operator who wants to use IEC 62301 as a testing standard for an SPI to specify the low power modes that should be included in the SPI requirements. For instance, a jurisdiction could decide to create a simple low power mode structure for DVD players including only two modes (e.g., one mode when the DVD player is off and one for standby mode). Other jurisdictions could decide to specify additional low power modes such as one when the DVD player is waiting for a remote control signal. It clearly gives individual jurisdictions the flexibility to define, categorise and measure low power modes. Including additional low power modes is only justified where the product spends a significant period of “normal use” in these modes.

Low power modes specified in SPI requirements would not necessarily be the same low power modes assessed for the purpose of evaluating the impact of the SPI. This is particularly true if the low power consumption tests for the baseline and the actual product sold in the market are performed under IEC 62301 normalised test conditions. Whereas IEC 62301 requires that all relevant low power modes be measured, the administration rules of a given SPI may involve only a few of the lower power modes covered by IEC 62301. A similar situation can be found while estimating the hours of operation of products in an SPI. It is quite possible that the programme designer elects to combine several low power modes and estimates a global number of hours of operation for these modes while preparing an ex-ante forecast of savings. An evaluator on the other hand could decide that end-use measurement is required to verify the hours of operation in each individual low power mode. This could allow determining real use savings and help compare the ex-ante and ex-post evaluation results to identify any source of discrepancy.

The power mode variations from product to product will also create challenges for data collection and could increase the cost of any field surveys, field testing or laboratory testing activities required to determine the baseline and the characteristics of current energy-efficient products.

Each jurisdiction will have its own particular context for SPI implementation. Data availability will likely differ as well as the budget and human resources available to perform the impact evaluation. The proposed methodology recognises these differences and offers a general framework while ensuring enough flexibility so that each jurisdiction can select the level of rigor[16] that will be used for its own SPI impact evaluation, based on the size and importance of its program.

The Box 3 presents the impact evaluation steps proposed in this methodology.

**Box 3 – Standby Power Evaluation Steps**

1 **Identifying product categories and types**
2 **Defining product power modes based on functionality, design and usage**
3 **Determining the quantity of products sold in a market**
4 **Defining baseline standby power and trend**
5 **Defining the SPI standby power and trend**
6 **Calculating gross energy savings over time**
7 **Estimating savings over product expected life use**
8 **Determining attribution to the SPI**
9 **Evaluating distortion effects**
10 **Calculating the net impact.**

**The proposed methodology follows the above steps and identifies the various data required assessed to determine the SPI energy impact. Some of the data collected at the various above could change over time, which needs to be considered while preparing the impact evaluation plan. Evaluation activities should allow capturing the evolution of the various affecting savings over time. The various data collection methods that could be used are at each individual step but it is important to keep in mind that the data collection activities at different steps of the methodology will often be combined in a single field research instance, a field visit of households can be an opportunity to collect information about the penetration and saturation of different products but also the hours of operation, the history purchase and other related information. Evaluators should pay attention to the fact that the information they try to collect in a single survey or field visit activity, the more likely large will be required to provide the targeted statistical precision of results on all data collected. instance, if in the same field visit targeting 120 households, an evaluator wants to gather products with a high penetration like televisions and data for products with a lower Blu-ray disk players, he will achieve a different level of precision on data collected.**

Table 2 shows the precision that will be achieved considering the different penetrations of televisions and Blue-ray disk players assuming that he wants to obtain accuracy with a 90% confidence interval and that the coefficient of variation of the variables to be measured is 0.50[17].

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[16] This approach using various levels of rigor is found in other impact evaluation protocols. One of the most widely known is the *California Energy Efficiency Evaluation Protocols: Technical, Methodological and Reporting Requirements for Evaluation Professionals*, California Public Utilities Commission, April 2006.
[17] A discussion on sample size determination is presented in Section 5.

**Table 2: Effect of Penetration on Precision of Data Collection**

| Products | Penetration | Number of Samples Found During Visits (n=120 households) | Expected Accuracy |
|---|---|---|---|
| Televisions | 97% | 116 | 7.6% |
| Blu-Ray Disk Players | 23% | 28 | 15.5% |

From the results above, we can see that the precision achieved on the television data will be better than the one on Blu-ray disk players due to the fact that a lower number of samples will be assessed during the survey. If, for instance, the evaluator wanted to maintain a minimum accuracy of 10% on all variables collected, he would have to increase the number of households visited to 292 to account for the lower penetration of Blu-ray disk players. However, lower precision may be acceptable for products that generally have low penetration, for example, so the impact of such uncertainty needs to be considered and assessed on the overall result.

For each particular application of this methodology, the analyst will have to select the market and field research activities that will be required to assemble all the data needed in the most economic and efficient way.

**Box 4 – Recommended Base Approach**

**For each step of the methodology discussed in the following sections, a recommended base approach is clearly identified.**

**The recommended base approach offers the path that is considered the most widely applicable and the most cost-effective in a large number of SPI impact evaluations. It is not intended to offer the ultimate in terms of precision but instead aims to provide policy makers with information that is useful to support the decision-making process relative to SPIs.**

## 4.1 OVERVIEW OF THE METHODOLOGY

When considering a single product, the main steps of the methodology that will allow calculating the gross savings in the market are schematised in Figure 1. The figure lists all data that will be required and their relationship in the evaluation process.

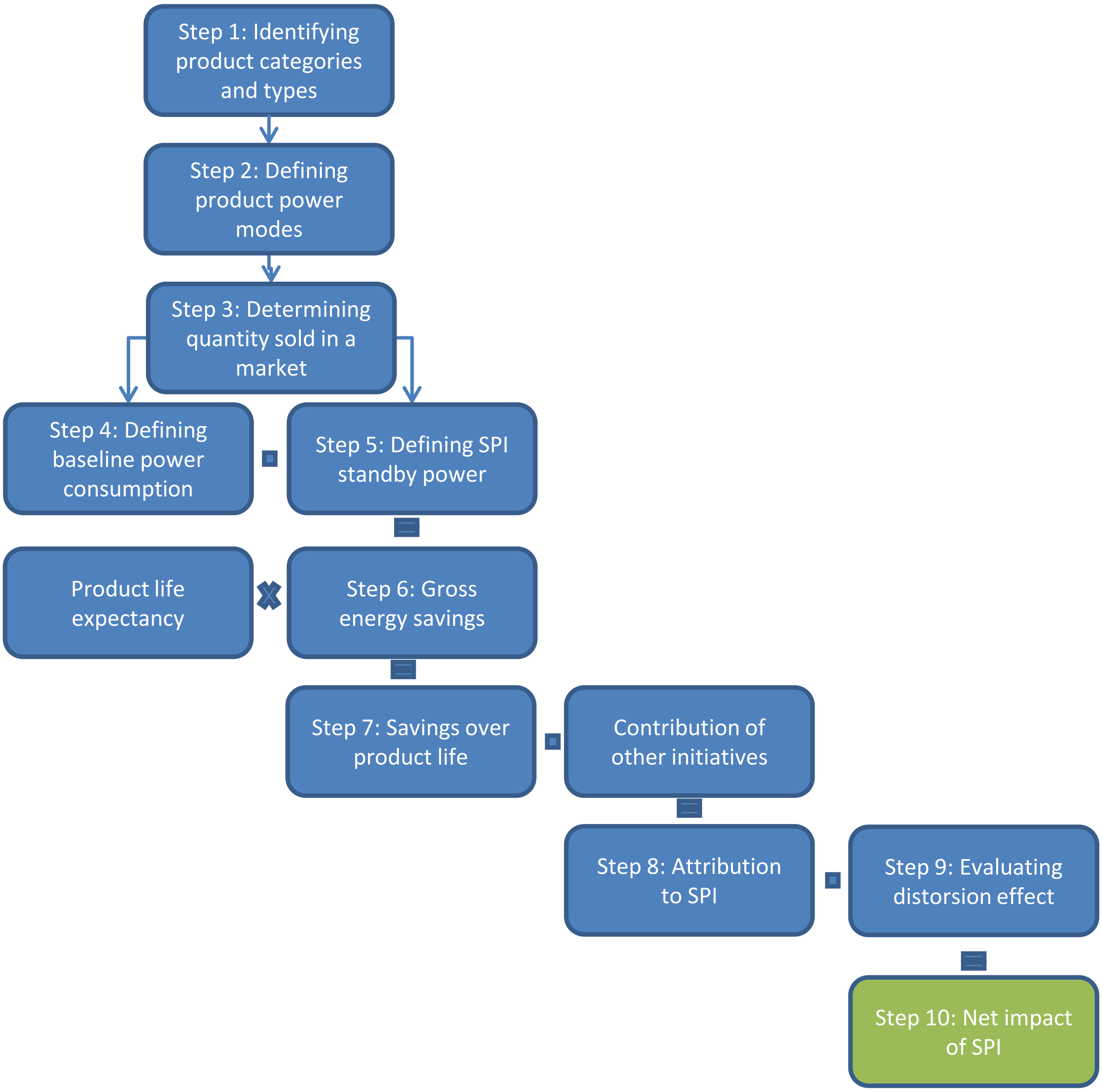


**Figure 1: Model for Gross Savings Calculation of a Single Product**

The following text presents a summary of the main elements that need to be considered in each step of the evaluation.

Step 1 – Identifying Products Categories and Types

- Determine which products are to be included in the evaluation.
- Determine if it is intended to take advantage of the evaluation work to undertake some additional parallel market research on products not covered by the SPI.
- Consider applying the basket of product approach to have a normalised data set that can be compared to other jurisdictions.

Step 2 – Defining Product Power Mode

- Determine which product low power mode will be included in the evaluation.
- Ensure that the whole is based on a review of product characteristics and relevant functions.
- Consider in priority the active standby mode, passive standby mode, off-mode and the, delay start mode.

Step 3 – Determining the Quantity of Products Sold in a Market

- Determine the total number of products sold in the market for each product selected in step 1.
- Obtain data disaggregated by brand and model if possible.

Step 4 – Defining Baseline Energy Consumption

- Collect or measure information about average power of products in each relevant low power mode.
- Estimate trend in low power level including autonomous improvement.
- Calculate the model sales-weighted power average, the brand- weighted average or the simple arithmetical average of all products.
- Estimate or measure the number of hours of operation in each mode.
- Calculate the resulting energy usage in standby mode or off-mode for the baseline scenario.

Step 5 – Defining SPI Scenario Energy Consumption

- Collect or measure information about the average power of products in each relevant low power mode.
- Calculate the model sales-weighted power average, the brand- weighted average or the simple arithmetical average of all products.
- Estimate or measure the number of hours of operation in each mode.
- Calculate the resulting energy usage in standby mode or off-mode for the SPI scenario.

Step 6 – Calculating Gross Energy Savings

- Calculate the gross savings from the difference between the baseline energy usage and the SPI scenario energy usage.

Step 7 – Estimating Savings over Product Life

- Estimate or obtain data about the expected life of each product considered in the study.
- Calculate energy savings over the product life.

Step 8 – Determining Attribution to the SPI (optional)

- Evaluate the proportion of the gross savings that could be attributed to the SPI compared to other programmes or initiatives implemented nationally, regionally or on the globally market.

Step 9 – Evaluating Distortions Effects (optional)

- Evaluating cross-effect.
- Evaluating free-ridership if the SPI is a resource acquisition programme.

Step 10 – Net Impact Evaluation

- Apply the net-to-gross ratio and the attribution ratio from the previous steps to the gross savings to determine the net savings.

## 4.2 METHODOLOGICAL STEPS

This section of the report details each step that should be implemented for an impact evaluation.

### Step 1- Identifying Product Categories and Types

The first step is to determine the various types of equipment that will be included in the impact evaluation effort. This usually corresponds to the equipment targeted by the SPI.

Figure 2 presents an indicative list of equipment that has been included in past standby power projects in different jurisdictions and that could be considered for impact evaluation. This classification includes a higher-level classification by domain. Each domain includes different classes of products and each class comprises a comprehensive list of equipment. In some cases, a single equipment has been broken down by technology, as shown for television where individual entries exist for LCD, plasma, LED and CRT (in the case of televisions, for example, the display technology should not (in theory) have an impact on low power modes, but this is not always true in practice, because product development will affect both on mode and low power modes and the rate of change in these different technologies in each is quite different). This structure was adopted in the recent SELINA project carried out in the EU (2009-2010). This is only one example of the comprehensive classification of various appliances that consume energy in low power modes.

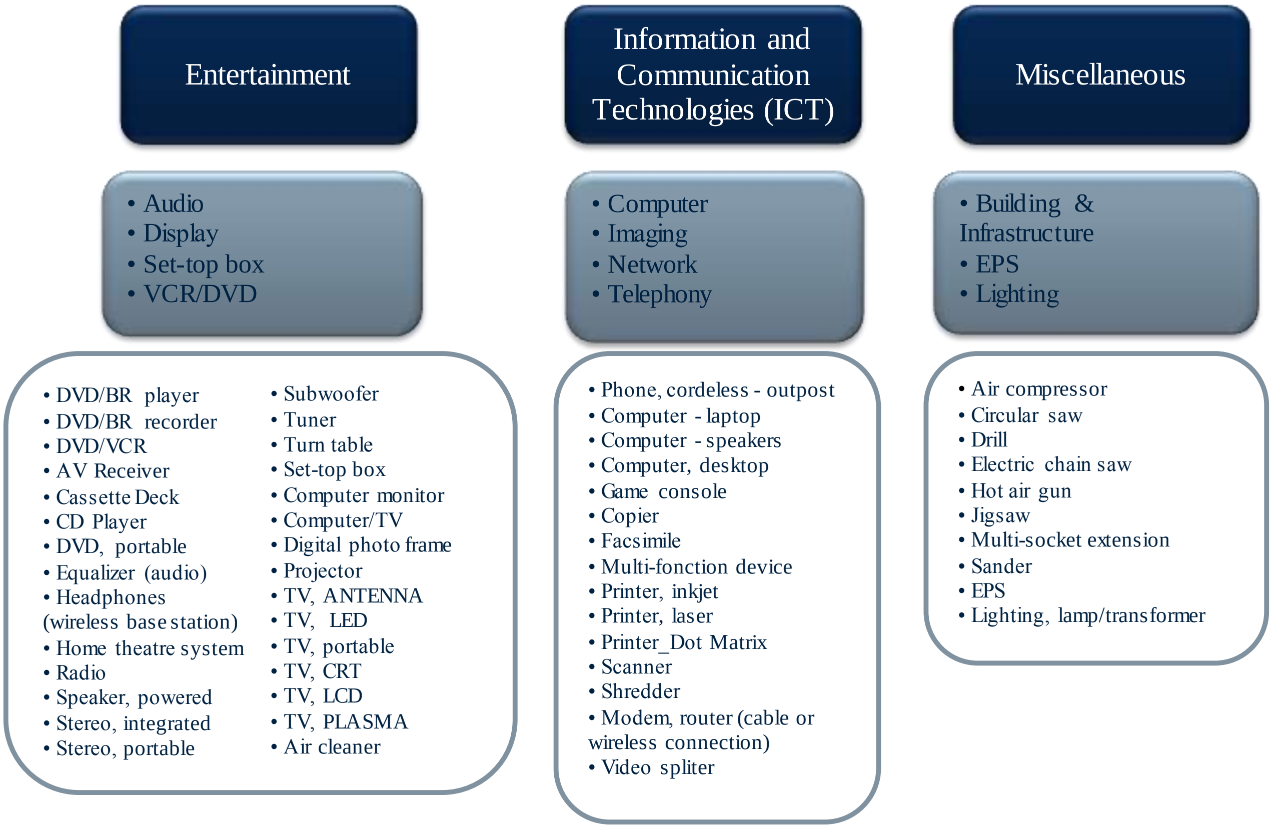


**Figure 2: List of Equipment**

An element that needs to be considered for the planning of the evaluation work is the products offering several primary functions. For instance, a single unit can combine a tuner, a cassette deck and a DVD reader. While it is not possible to provide definitive recommendations on how to approach the classification of products, the evaluator must balance the number of categories and types to be selected for evaluation with the complexity and cost added to the data collection activities. Indeed, for each category and type of products selected, it will be necessary to quantify the number of units sold in the market by model and determine the baseline and actual energy consumption characteristics for a statistically valid sample of units.

**Box 5 – Recommended Base Approach for Step 1 – Identification of Product and Type**

**The minimum requirement here is to include all products that are affected by the proposed SPI in the market.**

**However, if a field measurement campaign is envisioned, it may be more appropriate to select a basket of product approach to combine the market research activity with the impact evaluation activity.**

From this point on, the discussion will focus on individual products and how we can determine impact attribution for each of them. Steps 2 to 10 of the methodology will need to be applied separately for each of the products that are included in the SPI under evaluation.

### Step 2 - Defining Product power Modes based on Functionality, Design and usage

For each product selected in step 1 above, it will be necessary to determine a classification of products present in the market on the basis of their low power modes and the associated functionality that is provided. This is an important step as we will be interested in determining for each of the relevant low power mode, the characteristics of energy usage before and after SPI implementation. The energy usage is determined by both the power drawn in the various low power modes and the hours of operation in each mode.

### Selecting Only the Relevant Modes of Operation

The variety of low power modes to be included in any impact evaluation needs to be carefully considered. While it is tempting to create a large number of low power modes to reflect the increasing complexity of electronic equipment, it must be weighted with the increasing cost and difficulty of gathering information on power usage in each mode including information on how people use and programme their equipment. The evaluation should focus on the modes that are the most used and which represent the largest portion of standby energy usage of products. As a general rule, the evaluator should define the minimum number of power modes that will capture the largest portion of the energy used (or an approximation of that value) while in standby mode.

In addition, it is important to consider the feasibility of collecting information about hours of usage in each mode as this information is required for each of the power mode that will be included in the study. In several cases, end-users may not be aware of the various modes featured by products they use. Consequently, end-users may be unable to provide reasonable estimates of time of usage for each mode, thus affecting the accuracy of any self-declaration method of data collection (telephone surveys, internet surveys, face-to-face surveys). Even field data collection by experienced auditors may be difficult due to the large diversity of brands, models and functionalities available. For this reason, the definition of power modes for evaluation work should be limited in number and include characteristics that can be easily identified during field data gathering activities. For instance, active standby, passive standby, off mode, delay-start and disconnected mode could be included as an initial check list of the most relevant modes as the experiences of the International Standby Power Data Project and the SELINA project suggest.

**Box 6 – Recommended Base Method for Step 2 – Defining Product Power Mode**

**It is recommended to limit the standby power mode to the following categories for most impact evaluations:**

- **Active Standby**
- **Passive Standby**
- **Off**
- **Delay Start.**

The three recommended low power modes are defined as follows in the International Standby Power Data Project[18].

### Active Standby

Active standby is when the appliance is on but not performing its main function. For example, the DVD may be on but is not playing or recording. This mode is usually only present in devices (a) where there is a mechanical function which is not active (e.g. DVD drive or motor) but where power circuits are on, or (b) where a device has a battery and the device is charging

### Passive Standby

When a product or appliance is not performing its main function (sleeping) but it is ready to be switched on (in most cases with a remote control) or is performing some secondary function (e.g. has a display or clock which is active in this mode). This mode also applies to power supplies for battery operated equipment (portable appliances which are intended to be used when disconnected from the base station) when the appliance is not being charged (disconnected).

### Off

The product must have a power switch located on the product. Off mode is when a product or appliance is connected to a power source but does not produce any sound or picture, transmit or receive information or is waiting to be switched "on" by the consumer. If the product has a remote control, it cannot be woken by the remote control from off mode – it can only be activated via the power switch on the product. No display should be active in off mode. While the product may be doing some internal functions in off mode (e.g. memory functions, EMC filters) these are not obvious to the user. An LED may be present to indicate off mode. Generally the power consumption in off mode is quite low, but this is not always the case (depending on product design).

[18] http://www.energyrating.gov.au/standbydata/app/Default.aspx

### Delay Start

Delay start is becoming common place on many major appliances. Essentially the appliance can be programmed to begin functioning at a later time; in some cases up to 24 hours later. Appliances left in this mode are in neither active nor passive standby and therefore this mode is measured as a separate category. (Note this is different to sleep mode where the timer is used to stop in use operation after a set period)

### Disconnected

Disconnected mode is slightly different from off mode in the sense that mains power to the equipment is switched off by a power strip, wall switch or by unplugging the equipment. This means that unless the equipment can maintain some internal functionality by drawing power from an internal battery, it does not consume any energy. For the purpose of impact evaluation, disconnected mode could be combined with off mode where most or all products use negligible power in off mode.

The types of low power modes to consider will also be determined by the type of SPI and what it aims to achieve. For instance, an SPI consisting of a voluntary agreement with suppliers favouring the market of equipment with lower standby power characteristics, with no associated end-user communication campaign, is likely not to impact the equipment operating hours in each mode. On the other hand, an SPI consisting in the distribution of power strip that enables to disconnect the equipment when not in active mode will have no impact on the power consumption of the product in each mode but will have an effect on how many hours the product is used in each of them. As a result, the logic model and programme theory of the SPI and the causal link between programme activity and changes in the market are important considerations for the selection of the relevant power modes.

Once the power modes relevant for a particular SPI are identified and selected, it will be necessary to refine the description of the modes to provide guidelines for field surveyors. There are grey areas in the market that may be identified only after the start of data collection activities. Indeed, information on functionalities and product characteristics may become available once the field survey has started. The evaluators may want to perform a field data collection pilot stage to assemble sufficient data and be exposed to an adequate number of products so that such issues may be clearly identified. Guidelines can then be set up to ensure that all field analyses use a coherent approach to product mode classification.

### IEC 62301 as a Guideline for Product Power Mode Selection

When selecting power modes to assess an impact analysis, it is possible to use the IEC 62301 standard as a guideline for the identification and selection of relevant power modes. IEC 62301 broadly defines three low power categories of operation, namely the off mode, standby mode and network mode. Other modes not specifically covered by this standard include active mode (which is specific to each product type) and no load mode of operation. The IEC 62301 classification is slightly different from the one used in the International Standby Power Data Project presented above. For instance, the International Standby Power Data Project defines the active standby, passive standby and delay start modes as individual modes while they are all defined in the Standby mode category for IEC 62301 and the International Standby Power Data Project are defined slightly differently, they are quite similar. But it is important to bear in mind that these are all broad mode categories, which can only be refined once the range of products to be evaluated has been carefully defined.

Table 3 summarises the main characteristics of each power mode category. More information on IEC 62301 recommendations for power mode identification can be found in Annex 1.

Not all categories of low power modes are present in individual products. On the other hand, one product can have several low power modes in the same category based on the function(s) offered.

**Table 3: IEC 62301 Power Mode Categories**

| Power Mode as per IEC 62301 | Definition | Examples |
|---|---|---|
| **Modes defined in IEC 62301 that are not low power modes** | | |
| Active mode | The product is performing its main function. | A TV that is on.<br><br>A DVD player reading a disk. |
| Disconnected mode | In this mode, the power strip or the outlet to which the product is connected is not supplied with power. Obviously, in this mode, the product does not consume any power except circuits powered by an internal battery. | Connection to an outlet that is controlled by an interrupter or a timer.<br><br>Connection to a power bar that is switched off by the user.<br><br>Laptop computer |
| No load mode | When no load is plugged to an external power supply. | An external power supply normally used for a cell phone or similar products when it is plugged but the phone is not attached to it. |
| **Categories of low power modes** | | |
| Off mode | The product offers no interaction with end-users except for an optional indication of the off mode.<br><br>This corresponds to a situation where the product is connected to a live outlet but not in standby, network or active mode.<br><br>A product can have no off mode or have only one or several off modes. | The power supply of the equipment is still plugged to a live outlet but there is a hard switch at the output of the power supply cutting all electricity flow to the equipment except for secondary functions. The power supply and the secondary functions are thus the only source of power dissipation.<br><br>Only secondary functions may include internal clock or battery charging. |

| | | |
|---|---|---|
| Standby mode | A mode of operation offering some functionalities to the end-users. This can include activation functions (remote switch, internal sensor, clock) or continuous functions (information, status display, sensor). | Circuitry waiting for a wake-up signal from a remote control.<br><br>Time clock display.<br><br>Programmed mode waiting for a scheduled start.<br><br>Lux level sensor that controls the display illumination level. |
| Network mode | When the equipment is not in active mode and when one network function is present. Some standby mode functionalities may be present at the same time as the network mode is active. | Automatic download of data files (movies, music).<br><br>Updating firmware.<br><br>Reactivation through a network command.<br><br>Uploading data collected by the equipment at regular intervals.<br><br>Network integrity handshaking communication. |

In the table above, the active mode is not considered for the SPI impact analysis but the number of operating hours in this mode is frequently collected to help determine the operating hours in standby or disconnected modes. The active hours of operation may also be collected for the evaluation of energy savings in the active power mode in a vertical programme targeting both active and standby power. Disconnected mode may be of interest if the SPI under consideration includes activities to promote the operation of the product in this mode (active intervention by users to disconnect). As already mentioned, this could be achieved through a communication campaign or the distribution of power strips. The no load mode can also be of interest if the SPI promotes the disconnection of equipment from their power supplies or if they promote a technology that senses the presence of the load and reduces the power supply power when no load is present.

Disconnected mode, off mode and standby mode are of particular interest as they correspond to product operating modes that are easy to identify by many consumers. For instance, a product without display that cannot be activated by remote control could be easily identified by end users as being in off mode. In most impact evaluations, we would probably want to include at least one standby mode and an off mode (where present).

A low power mode that can be of interest to study is a “quick start mode.” In this mode, the standby power of equipment can increase significantly. If we take for instance a Blu-ray Disc player, a unit can have a 5-watt standby power while in quick start mode in comparison to 0.5 watt if the user elects to turn off this function. The same applies to gaming consoles like the Wii where standby power can be affected by a user-selected option. Identifying such modes in the field is important for evaluation purposes and it may help policy makers redress any problem modes by adjusting the relevant policies. The power in these cases is affected by the programming options selected by the user during setup, so this needs to be taken into account.

### Considering Automatic Power Management Issues

Automatic energy management can be defined as any change in a given mode of operation that is automatically performed by a unit when it determines that there is a low level of usage and where it starts a sequence to shut off functionalities not required or to apply duty cycling to reduce the level of service. Energy management adds another layer of complexity to the issue related to defining coherent categories low power modes for each product. In this regard, energy management strategies could be initiated by timer, sensor or external network events that will determine when the energy consumption should be reduced. The end-user may not even be aware of this change in functionality and would not be able to provide a self-declaration of the hours of operation in that mode.

This implies that the same product could perform differently in individual households based on its interaction with end-users, network signals, internal sensors or time events. In this context, one can ask what will be the most appropriate baseline power level and the most appropriate current energy-efficient power level to use in an impact evaluation. IEC 62301 provides guidance and warnings about the effect of automatic power management but it is up to the organisation performing the test to determine to which extent they should be considered and integrated into a test procedure. Any evaluation testing needs to assess the impact of heavy usage versus light usage where a power management system is active.

Article 5.1 of IEC 62301 discusses the concept of product sequences when a product switches automatically from one mode to another in a cyclic way. In such a case, it is recommended to run the product through the sequence several times to fully understand the operation and be able to report its power consumption accordingly.

Field measurement campaigns conducted in households have the potential to capture more precisely the automatic power management effect of products, especially when the automatic switching between modes is affected by user interactions. This is one of the areas where field measurement in households can provide additional and more precise information about what is really going on when a product is operating in a normal environment and not in a laboratory setting, under well-controlled parameters. However, in-house studies with loggers attached to several products with standby characteristics are expensive and are not the norm in the field of evaluation. Evaluators should weigh the pros and cons of trading measurement performed in shops or in a laboratory environment under controlled and replicable conditions with field activities that will provide better information about on-site energy usage without the benefit of normalisation. An example of situations where it could be important to conduct such test is when the SPI mandates the introduction of power management functions to automatically reduce the power of equipment when not in active mode. In such a case, energy management characteristics are one of the key parameters to measure and a measurement campaign in the field or in shops that allow understanding the power down features of products becomes mandatory.

### Special Case where In-house Logging is Considered

It should be noted that there are specific cases where the classification of the relevant low power modes of products will not be needed for an impact evaluation. This is the case where the establishment of baseline power and new equipment power is based on a sampling of a large quantity of products in the market with field measurement. In this particular case, the field measurement will provide directly a weighted average of the power consumption in various power modes. The active modes will usually be detected from the log of data over several days of measurement and all the other periods can be considered as low power modes or disconnected modes. Thus, a weighted-average power combining all non-active hours could be established. However, this approach, which requires considerable human and financial resources, is likely not to be widely used in most jurisdictions. If however some more in depth in house measurement campaigns are conducted to compare a traditional approach, a few low power mode measured in steady state with hours collected through household survey, it may be possible to derive correction ratios that could be used for subsequent impact evaluation efforts that use only the traditional and less costly approach. It is important to note that actual usage patterns are highly variable within a house and between houses, so a minimum period to establish patterns of use needs to be defined.

### Example of a Power Mode Classification

A typical low power mode classification for a cable TV receiver could be as follows:

| Group Description | Characteristics |
|---|---|
| Group 1 – Low power mode with display | Products that can be either powered for their normal usage and that have only one low power mode with display on. |
| Group 2 – Low power mode with reactivation function & display mode | Products similar to group 1 but adding the reactivation function. |

For instance, in this case, the evaluator can decide that all products with less functionality than group 1 will still be considered part of group 1 (e.g., products with off mode where there is no display and no interaction with end-user or network).

### Step 3 - Determining the Quantity of Products Sold in a Market

This step includes the collection of sales data to determine the number of products entering the market each year. This includes low- and high-efficiency products. These products can be purchased by newly established households or by existing households that want to replace existing products that have reached the end of their useful life. They can also be purchased by existing households due to an increase in penetration or saturation of the products.

The information must be collected for each equipment category and type that was determined in step 1. Preferably, information will also be collected by brand and ideally per model to allow combining the sales data with the low power mode energy consumption of different products and obtain a brand-weighted or sales-by-model-weighted power average applicable to the market.

Another approach that could be used to estimate the overall sales of products in the market consists in beginning with an estimation of the total stock by multiplying the number of households by the product penetration rate or market share. This total stock estimate can be combined with an estimate of the stock life expectancy to determine the number of units purchased per year to replace existing obsolete stock. The model should also include an estimate of the sales for new households and an estimate of the increase in penetration of the products based on market trend. This approach usually provides only a rough estimate of the sales as the life expectancy of electronic products is often difficult to estimate and may not be an accurate indicator of product replacement since electronic products are often replaced prior to the end of their life expectancy. However, as it is expected that most SPIs will not affect the quantity of products sold in a market after their introduction, this parameter is less important for decision-making purposes.

The various methods for sales data collection and their associated level of rigor are shown in Table 4. The recommended base approach is shown in Box 7 below.

**Box 7– Recommended Base Approach for Step 3 – Determining the Quantity of Products Sold in the Market**

**Gather information about sales data from manufacturers, importers or suppliers.**

**Try to concentrate on the actors that represent the largest share of products sold.**

**If possible, obtain the data per brand and per model to allow calculating a sales-weighted average of standby power consumption.**

The recommended base approach can be modified by the evaluator if the context dictates a preferable method. For instance, if there have been data collected as part of the SPI scheme about sales information from manufacturers or if there have been field data collection initiatives envisioned.

**Table 4: Methods of Sales Data Collection**

| Rigor | Method | Comments |
|---|---|---|
| Low | Survey done by phone, mail or internet where a general population is interviewed about previous year purchase patterns. | Expensive to get a sample large enough to get meaningful results on all product types to be covered based on incidence (the expected percentage of households having made a purchase.)<br><br>Difficult to get reliable results about brands purchased, almost impossible to collect model numbers.<br><br>Memory effect for smaller products where it is difficult for consumers to remember when they were purchased. |

| Rigor | Method | Comments |
|---|---|---|
| Medium | Stock model that allows estimating the total number of sales for one product based on number of households, increase in household, penetration trends and expected life of products. | Provide a rough estimate as some key hypotheses, such as the useful life of a product, are difficult to obtain accurately. Cannot provide market share of efficient or non-efficient products or any information pertaining to sales per brand or model. |
| Medium | Field survey in households where information about recent purchases (1-3 years) and brands/models is collected. | This type of approach can cause problems when trying to match power measurement in low power modes performed on products still sold in the market with products discontinued for sale but found operating in households. With the short life cycle of products in the market, there could be a significant number of models found in houses that are not available anymore on the market. The more we go back in the past, the larger the issue.<br><br>A large sampling size will likely be required to obtain statistically valid data for several products as not all products will be found in homes. |
| Medium | Manufacturer, importer or distributor voluntary data collection activities. | This could provide information about market size and the most popular products if market actors are willing to participate.<br><br>It is usually difficult to benefit from the collaboration of all suppliers in the market, which can raise issues about sales estimate validity.<br><br>Hypotheses will likely be required to estimate the total market volume from partial data collected. |
| Medium to High | Associations of manufacturers sometimes collect information about sales data and make it available either free or for a charge. This could constitute an interesting information source to obtain aggregated sales data per product type. | The information often lacks the level of disaggregation required to identify sales by brand and model or as being efficient or non-efficient. But this can provide a good estimate of total sales. |
| High | Market research firm sales database | Market research firms sell sales data for energy-consuming products in several jurisdictions.<br><br>Depending on the source, the information can be obtained by brand or even model together with information like the price paid. |

| Rigor | Method | Comments |
|---|---|---|
| High | Mandatory regulation or DSM programme requirements that allow collecting manufacturer, importer or distributor market data.<br><br>The DSM programme may not target standby power directly and aim to promote efficient active power modes. Nevertheless, it can provide important information in support of standby power impact evaluation. | Most comprehensive method but not always included in SPIs due to cost and resources required.<br><br>DSM program-based data collection not always captures the whole market. Sometimes the data available are limited to products that comply with programme requirements. |

When performing an ex-ante evaluation to determine SPI impact, it is obvious that the sales information for future years for which we want to establish a savings projection will have to be estimated, generally from historical data and, in some cases, from market actors. Care should be exercised for products (e.g., electronic products) where the historical trend is often not a good predictor of expected sales in the future. New technologies enter the market continuously and displace products that were popular some years earlier. Television sets are a good example of market change where different technologies (plasma, LCD, LED) compete to gain a dominant position in the market. Very often, it is necessary to include some sort of consultation with manufacturers and suppliers to refine any forecast of product sales in order to include market trends that have already been observed or identified by market research conducted by those actors.

An ex-ante evaluation of impact forecasts is a good practice as it provides some of the key data required to establish the baseline of product characteristics in the market prior to the implementation of an SPI. This helps define the business-as-usual scenario against which the future market trend will be compared. A clear baseline model with sales estimates is also useful as it can be reviewed against actual (historical) sales if an ex-post evaluation is performed later. With a precise hypothesis recorded for the sales in the baseline scenario, the evaluator could easily compare how the ex-ante estimate compares to the ex-post estimate, which in turn can help pinpoint reasons for discrepancies between the target and the actual results.

For some SPIs, the information about complying products could be available as part of the implementation scheme. For instance, a number of initiatives can request that manufacturers and suppliers disclose sales information, thereby making it available as part of the programme database. This is notably the case in countries that request manufacturers and suppliers to disclose sales figures. This is also frequent in the case of DSM programs. Depending on DSM programme requirements, the database may include only information about products complying with efficiency criteria set by the programme while in some rare cases it will include all products in the market.

As shown in the above table, the collection of sales data can be conducted on a voluntary basis or on a mandatory basis with manufacturers and suppliers. A voluntary approach raises a number of challenges as it is often difficult to convince all the market actors to participate in such a data collection effort. Most often, a voluntary data collection scheme will provide only partial information about the market and will thus require applying hypotheses to extrapolate the figures collected to the whole market. In the case of low participation on the part of manufacturers and importers, this could create major problems in the methodology as the sales figures may become the limiting factor in precision for the whole impact evaluation. In cases where a single approach to data collection is unreliable, the evaluator may decide to apply several methods in parallel and to compare the estimate of sales generated by each method to determine their coherence and provide additional data that will allow for a better estimate.

Mandatory data collection will usually make things simpler as all targeted market actors will have to provide regular reports on the various models imported into the market. This requires the regulation to provide for the mandatory disclosure of sales information, which requires considerable effort from market actors and the SPI administrator. It is not always included in SPIs for this reason.

### Step 4 - Defining the Baseline Standby energy

The baseline is a model of the standby energy usage in a business-as-usual scenario. It represents the trend in the consumption of standby power in the event that no SPIs are implemented in the market. It includes any autonomous efficiency improvements that may be occurring in the absence of an SPI.

The baseline energy usage needs to be defined for each product to be included in an impact evaluation and identified in step 1. The three main characteristics to determine baseline energy usage are the quantity of products introduced in the market (Step 3), the power consumed by products in each relevant low power mode and the hours of operation of the products in each mode.

### Power Measurement

In terms of standby power measurement, the evaluator can select two different approaches for determining the baseline. In the first one, he could use a normalised procedure such as IEC 62301 or a simplified version to gather information on product power under each relevant low power mode. These known conditions could differ from those encountered in normal household operations as it doesn’t consider all potential interactions of the end-user with the product that can change the power level as well as the automatic changes in mode of operation and associated power triggered by the energy management functions embedded in product logic. The evaluator will use the data gathered as a proxy of the real power consumed when the product is operating in the household. The second approach relies on field measurement where the evaluator wants to capture real power for all relevant low power modes and, if logging equipment is used, in all possible active and low power modes including power cycling caused by energy management strategies embedded in the product logic. This approach is more precise as it represents real life operations but requires considerable resources to gather the field data for a statistically valid sample. The required number of samples to achieve a certain level of accuracy will be a function of the dispersion of the power values that will be found in all the samples tested in the same low power mode. If there is large dispersion, the number of samples required to achieve the desired accuracy will be high. On the other hand, if all the measured values are close to the average power value, then a smaller sample size will be required (more on sampling in Section 5). The dispersion of a sample is measured by a statistical indicator named the coefficient of variation. In the planning stage of an evaluation, it is frequent to use a value of 0.5 for the coefficient of variation unless it is possible to estimate more precisely the dispersion of data. Then, the evaluator decides the target accuracy to achieve and the interval of confidence. Frequent figures used in evaluation are an accuracy of 10% with a confidence interval of 90%, which is noted as a 90/10 statistical accuracy requirement. A confidence interval of 90% means that 9 times out of 10, a random selection of samples in the population will result in a value that is within 10% of accuracy. A 90/10 accuracy requirement combined with a 0.5 coefficient of variation will require a sample of 67. Evaluators often use the term “by design” to indicate that the sampling size has been estimated while the real coefficient of variation of the sample was not known yet.

After the campaign is concluded, the evaluator will calculate the real coefficient of variation of the measured sample and will determine the accuracy achieved. For instance, if the real coefficient of variation found in a sample is 0.3 instead of 0.5 (as used by design), the resulting accuracy of the campaign will be better than expected at 6% instead of 10%. Recalculating the sample size needed to achieve a 90/10 accuracy with a coefficient of variation of 0.3 will give us 24 samples, which is less than 67 (as used by design). Some evaluators monitor the coefficient of variation of a measurement campaign in real time and stop it as soon as the accuracy desired is achieved.

In practice, the quality of the information used to determine the baseline can vary considerably. For the standby power level, the estimate can range from an educated assumption based on a literature review to an exhaustive laboratory or field measurement campaign.

Ideally, the research for the determination of the baseline characteristics should be conducted ex-ante as part of the analysis carried out to forecast the impact of an SPI as it is very difficult to determine the baseline once the SPI has been launched.

In general, the standby power of equipment sold in the market in the years immediately preceding the introduction of a policy can provide a good estimate of baseline characteristics. However, as years go by after the implementation of an SPI without any activity to measure precisely what would have been the market without intervention, it is very likely that the baseline will become erroneous. This is particularly true of the electronic equipment market where product life is short and changes in the global market can introduce products with different standby power characteristics even in the absence of an SPI. These changes can be positive as an autonomous efficiency improvement or they can be negative when more functionalities and services are added to products that could increase standby power requirements.

When an ex-post evaluation is launched in a context where no research activity has been performed prior to the implementation of the SPI to define the baseline, it could be difficult to establish the business-as-usual scenario and the standby energy consumption of products that were sold on the market several years ago. In this case, it is probable that only a field measurement campaign can provide the required information about the baseline power representing the equipment sold in the market before the introduction of the SPI.

In some cases, it will be advisable to determine a dynamic baseline by conducting regular market research to provide trend information (e.g., every year).

Very often, as part of an ex-post evaluation of impact, the evaluator will want to revise and maybe challenge the assumption used for the baseline characteristics, especially if they come from less reliable sources. For instance, an evaluation effort could use field measurement in households to capture the market characteristics at the time when the SPI was launched in order to confirm or infirm an assumption that was based on a literature review during programme design.

The following sections discuss how standby power level and hours of operation can be gathered.

### Average Power Determination in a Low Power Mode – Model Sales-Weighted

A model sales-weighted estimate could be derived from field activities where the power demand of a large quantity of products is measured in shops or in laboratory. The main difference between an arithmetic average of power in a low power mode and a model sales-weighted power is that the quantity of units of each model sold is taken into consideration in the computation. Consequently, models which are more popular will have more weight in the calculation of the average power.

To establish a model sales-weighted average power for each product in each of the relevant low power modes, it is necessary to obtain the number of units sold for each model in the market. This information could be gathered from manufacturers or suppliers or from an SPI database. The model sales-weighted estimate is calculated by considering the power demand of each model and the associated fraction of units sold to determine a more precise evaluation of the average power of products put in the market in any given year.

The model sales-weighted estimate is more precise than the simple arithmetic average of a sample of products but requires more precise information on the distribution of sales by product to be applicable.

### Average Power Determination in a Low Power Mode – Brand Sales-Weighted

If the exact information about the quantity of each model sold in the market is not available, the evaluator may consider an alternative approach to determine an average power that is closer to reality than an arithmetical average. For instance, he can try to determine the market share of each brand in the market through interviews or other studies already made by stakeholders or private market research firms. He can even try to obtain from the maximum number of manufacturers the information about the relative popularity of each model of product sold under the same brand. Once this information is collected, he can produce a power estimate that is weighted for brand and for some of them by model.

### Average Power Determination in a Low Power Mode – Hybrid Approach

An evaluator can also consider a hybrid approach where only the sales figures for the most popular models are gathered in addition to the total number of units sold. A model sales-weighted average could then be calculated for the most popular products while, for the rest of the market, an arithmetic average of the power demand could be used.

### Arithmetic Average of Power in a Low Power Mode

If no information about sales per brand or per model is available, the evaluator may decide to rely on a simple arithmetic average of all the products measured to establish the average power. This is the simplest and the least precise option and should only be used in case of severe limitation in resources for the evaluation.

### Power Information Gathering Methods and Recommendations

The recommended base approach for the determination of standby power in all relevant low power modes is presented in Box 8.

**Box 8 – Recommended Base Approach for Step 4 – Baseline Power Determination**

**It is recommended to use the in-shop measurement campaign as the preferred method for collecting information on equipment power in all relevant power modes both for the baseline and the SPI situation.**

The various approaches that could be used to determine baseline power characteristics including the recommended base approach are summarised in the Table 5.

**Table 5: Methods to Determine Baseline Power Characteristics**

| Rigor | Method | Comments |
|---|---|---|
| Low | **Literature review**<br><br>Use of an average baseline power and market penetration of efficient products from a benchmarking of studies conducted in different countries or jurisdictions using laboratory or field measurement. | Care should be exercised when analysing the various low power modes from various countries as there is not a uniform definition of what should be the various low power modes for each product.<br><br>Identifying a market that is truly comparable in terms of economic, market dynamic and the socio-demographics profile of end-users is usually challenging. |

| Rigor | Method | Comments |
|---|---|---|
| Medium | **Limited field testing**<br><br>This approach relies on existing field measurement campaigns led by academics or other market actors on a limited number of products but in the same market under consideration. | This provides a rough evaluation of standby power.<br><br>This type of campaign is often carried out on a limited sample, which implies that the results are not statistically valid. |
| Medium | **Manufacturer self-declaration**<br><br>This approach relies on the collection of manufacturer declarations about standby power at various low power modes for products in the market.<br><br>Ideally, analyses should be performed by brand and by model if the data is available. The same source can provide the number of units sold. | Quality of data can depend on the method used by the manufacturer to evaluate standby power (internal lab without formal testing standards, limited testing mixed with engineering methods etc.).<br><br>Tolerance issues. |
| High | **Measurement campaign in shops**<br><br>Proceed with the measurement of a statistically representative number of products in showrooms.<br><br>Try to adhere to a maximum number of IEC 62301 requirements to reduce the bias compared to a laboratory measurement. | Cost-effective approach as a large number of products can be tested in a limited number of sites.<br><br>Lacks the accuracy and rigor of a test led under laboratory conditions but requires less budget and less logistics.<br><br>Any products that are problematic or that have questionable results can then be tested in the laboratory to confirm whether there is an issue. |

| Rigor | Method | Comments |
|---|---|---|
| High | **Measurement campaign in households**<br><br>Proceed with the measurement of a statistically representative number of products in households.<br><br>Try to adhere to a maximum number of IEC 62301 requirements | Lacks the accuracy and rigor of a test led under laboratory conditions.<br><br>If data loggers are used, will capture total energy usage during various low power modes and will provide important data to determine the hours of operation in each mode. Only accurate way to assess user interaction and hours by mode.<br><br>May better capture the energy management scheme than would a laboratory or showroom test. Those energy management schemes may have been implemented in products' logic by manufacturers or could be related to end-user selectable options.<br><br>Assists in the identification of modes not envisaged by the policy and any circumvention devices in the product design (where products test well in the lab but poorly during normal use). |
| High | **Laboratory testing under IEC 62301**<br><br>Laboratory testing using IEC 62301 standards for measurement of low power mode. This test may be carried out by manufacturers under a voluntary or mandatory scheme or by the SPI programme administrator.<br><br>If a mandatory scheme for testing the product is already in place, this could provide high-quality data for impact evaluation purposes. However, when we are at the baseline research stage of an ex-ante evaluation, there is rarely a mandatory measurement scheme in place. As a result, testing requires voluntary agreements with suppliers. | Requires a measurement campaign conducted ex-ante before implementing the SPI.<br><br>Participation of manufacturers in a voluntary scheme to loan products can be difficult to secure and some products will likely not be available for testing. Purchasing all products for testing purposes is not a realistic option.<br><br>Does not provide any information of hours by mode in normal use.<br><br>Important logistics and large budget required to find samples and submit them for laboratory testing if done by programme administrator. The same burden will be put on manufacturers or suppliers if it is a mandatory requirement of the SPI. |

When using manufacturer self-declared information, care should be exercised to judge the quality of the data provided. This includes the conditions under which the test was performed, which either should conform to IEC 62301 or to any other testing procedure. There could also be an issue relating to the way manufacturers interpret the tolerance accepted within a standard testing procedure if the standard does not prevent it by clear rules. Tolerances can also be stipulated as part of an SPI using such standards and may lack clarity. Some manufacturers can use a more aggressive approach to the application of tolerance that will result in an underestimation of standby power. On the other hand, several manufacturers nowadays prefer to overstate their power declaration to minimise the possibility of failing a check test or a verification procedure due to production variability. It could be necessary in some cases to readjust a number of manufacturer declarations to have a more uniform treatment of the tolerance.

Depending on the objective of the impact evaluation, it may be appropriate to use a manufacturer declaration about power requirements instead of field measurement. For instance, if the impact evaluation does not include a market surveillance objective, the evaluator would be more inclined to use manufacturer data.

There are pros and cons of using a field measurement approach (either in shops or in households) over a more precise test performed under laboratory conditions. Box 9 presents some of the key characteristics of IEC 62301 that guarantee a higher level of precision for testing and that are difficult to reproduce in the field depending on the type of equipment used and on the time available for each product testing. On the other hand, field testing in households will provide a higher quality of data on the hours of operation of the products in each mode and will capture in-house variations of low power levels caused by user interaction or by energy management strategies embedded in the product logic by manufacturers. Testing carried out in shops falls somewhere between in-house measurement and laboratory measurement. It is recommended to try to integrate in-shop testing as one of the many requirements of an official standard that can be practically applied. If a few products are problematic in shops, then these can be tested in the lab. It is important to note that neither measurements in shops or labs can provides hours in each low power mode during normal use.

When performing field measurement in shops, care should be exercised to ensure that product modes of operation are well understood and that uniform configurations of power modes and options are made across the whole sample. This often requires an examination of the manufacturer user guide for the product, which is a time consuming process if a large number of products have to be reviewed. Adequate time and resources should be planned for this activity.

For field testing, it is important to select the measurement and logging equipment carefully as some lack the precision required to measure the relatively small power consumption of a number of low power modes.

**Box 9 - Main Elements of IEC 62301 that can be Missing in Field Testing**

**Test carried out under uniform temperature conditions.**

**Controlled electrical supply quality (voltage, frequency, harmonics).**

**Uniform context of operation. Eliminating the effect of photocell devices, considering the effect that rechargeable batteries can have on the test if they are in charging mode.**

**Requirement for demonstrating stable mode that includes periodic cycling in power level.**

**Separate testing of various options offered by a product for a specific low power mode of operation.**

**Uniform approach to measure power either by sampling, which is the recommended approach, or by average reading or direct reading if specific requirements are met.**

**Duration of measurement to ensure a representative procedure.**
**Precision of the measurement equipment is specified.**

**Guidance on instrumentation.**

**Normalised procedure to ensure that the product power level is stable before the reading and that the stipulated minimum duration of measurement is met.**

### Determining the Baseline Hours of Operation in Each Mode

The number of hours of operation in each low power mode needs to be assessed in order to calculate the energy usage associated with each low power mode. The baseline standby power and the SPI standby power level in each mode will ultimately be multiplied by the hours of operation in the corresponding mode to obtain the energy usage. The final result will only be as good as the precision of the hours of operation in the various low power modes. Disconnected hours and no load hours may also be necessary if the SPI involves activities that promote changes in behaviour or simple technologies like power strips to disconnect the equipment while not in use.

In order to determine the hours of operation for different low power modes, it is essential to collect information on how end-users operate the product. It is also frequent to collect hours of operation in active and no load modes, which can help ensure that the different periods amount to a full year and are coherent. The remaining time where the equipment is plugged and not performing its primary function corresponds to low power modes that are required for impact evaluation.

In the case where measurement campaigns are conducted in-house using data loggers to capture the integration of the various low power modes over time, the energy consumption for standby usage will be directly obtained from the measurement campaign.

The recommended base method to determine the number of hours of operation is shown in the following box.

**Box 10 – Recommended Base Approach for Step 4 – Determination of the Number of Hours of Operation**

**It is recommended to perform in-house logging of a representative sample of each product to determine the number of hours of operation in each relevant low power mode.**

There are Several methods, including the recommended base method, could be used to determine these hours of operation, as shown in Table 6.

**Table 6: Methods to Determine Hours of Operation**

| Rigor | Method | Comments |
|---|---|---|
| Low | **Literature review**<br><br>Use of estimate of hours based on benchmarking studies made in different jurisdictions using surveys or field measurement. | Care should be exercised when analysing the various low power modes from other SPIs as there is not a uniform definition of what are the various low power modes for each product. |
| Medium to Low | **Survey with self-declaration**<br><br>This includes a survey (web-based, email, telephone, mail) of a sufficient number of households (see Annex 1).<br><br>Obtain from the respondent an estimate of the number of hours for the product in normal usage then the number of hours for the product in other low power modes, disconnected mode or disconnected. | It could be difficult to explain to the respondent the various low power modes. It may be difficult also for the respondent to know if a product uses certain modes especially if they need to be programmed in a setup menu of the product. Simplification of modes will probably be required to ensure consistency of answers.<br><br>Answers may be biased due to the “memory effect” and the social desirability effect. |

| Rigor | Method | Comments |
|---|---|---|
| Medium | **Household visits to collect self-declaration of hours of usage**<br><br>This method relies on the visit of a certain number of households to identify the various products operating in standby mode and identify the mode of operation at visit time.<br><br>A survey of each equipment is performed and a series of questions are asked to homeowners to identify the time spent in each mode for each product. | The mode of usage found in houses while visiting could be biased by the hours at which the visits are performed.<br><br>Could be complex to identify clearly the low power modes. The consumers may not be aware of their presence and may not remember any setting done that can affect product consumption.<br><br>Answers may be biased due to the “memory effect” and the social desirability effect. |
| High | **Household measurement campaign**<br><br>Proceed with the measurement of a sufficient number of products in a household with logging equipment that can time stamp energy usage at different intervals (e.g., 1 minute). Then an analysis of various levels of power recorded can be matched to information about the power consumption of the product in each mode to build a profile of the hours of operation per mode. | The most precise approach to capture real in-house energy consumption of products.<br><br>This approach can be costly if several products have to be measured in a large number of households.<br><br>May not be the most cost-effective approach compared to other data collection options. |

Hour of operation surveys can be difficult to build and an experienced firm in survey design is recommended for such work. The way the questionnaire is built can affect the precision of the answers and the number of questions required for each product. For instance, a single question requesting the number of hours per year in standby mode may be more difficult to answer accurately by the customer than several questions probing the number of hours of standby power during weekdays vs. weekends or summer vs. winter. A more precise questionnaire will require considerably more questions and field time and will have a direct impact on the cost of survey activities. The survey design should achieve a balance of precision and feasibility and take into consideration the fielding cost.

Other pragmatic aspects of a survey must be considered such as the duration of the survey (a 20-minute telephone survey is considered very long and can drive down the answer rate and ultimately increase the cost required to reach a sample of households). A rule of thumb often used in the survey industry is that around five questions per minute could be asked over the phone. This however varies with the complexity and design of each questionnaire. While using internet surveys can be more cost-effective and is becoming more and more popular, it does have its share of drawbacks related to the way the pool of participants is recruited and to the potential bias caused by the impossibility of reaching the portion of the population that does not use the Internet. Several analysts raised the concern that the panel assembled by research firms may introduce biases in the survey. As a result, it is considered good practice to check how the panel is assembled by firms as well as the socio-demographic profiles of the proposed panel compared to the general population of households when such data are available. It is also good to recheck the respondents' final profile after their survey.

It is important to conserve ex-ante estimates of hours of operation as part of the baseline definition. This will allow evaluators to perform an ex-post evaluation at a later time to revisit the initial estimates of the hours of operation and compare them with the actual hours of operation to determine if a change in operating hours has been observed which could have an impact on the savings expected from the programme.

### Total Energy Usage Estimate for the Baseline

From the collected information about the quantity of units sold, their power requirement in all relevant low power modes and power off mode as well as the corresponding number of hours of operation for each mode, the evaluator can estimate the annual energy usage of all products sold in the market for a given year using the following equation.

$$E_{Baseline} = Q \times \sum_{n=1}^{N} (P_{n-base} \times H_{n-base}) \qquad \text{Equation 1}$$

Where;

$E_{baseline}$ = Energy usage for the baseline scenario

Q = Quantity of products sold in the market

n= Each relevant low power mode

N= Maximum number of low power modes considered

$P_{n\text{-}base}$= Power drawn in low power mode n for the baseline

$H_{n\text{-}base}$= Hours of operation in low power mode n for the baseline.

The same calculation is repeated for each historical year in an ex-post analysis or for each year to be forecast in an ex-ante analysis to establish a clear picture of the business-as-usual scenario without the introduction of an SPI.

This completes the preparation of the baseline model.

### End Usage Model Compared to Baseline Model

In some jurisdictions, an end usage model is developed to estimate the total energy consumption of the standby power of products in the market. This type of calculation requires the elaboration of a stock model representing the installed base of a given product in a market. The usage of a stock model is not mandatory for the performance of the impact assessment of a standby power initiative but it can be quite interesting to determine the existing consumption for standby usages in the market and the overall potential for market transformation towards more efficient products. This can thus be helpful in supporting a rationale for convincing policy makers of the existence of a standby power problem and in establishing the importance of taking related actions.

### Step 5 - Defining the SPI Standby Power

The SPI energy usage scenario represents the energy consumed for standby power for the years under consideration for an ex-ante forecast or an ex-post impact analysis.

To determine the SPI energy usage scenario, we are interested in capturing the variation from the baseline scenario in terms of power and the number of hours of operation in each power mode. All these elements may be affected by the SPI but some of them may not be the primary concern of the programme designer and may be assumed equal to the baseline conditions. For instance, if an SPI only promotes the disconnection of equipment while not in their active mode, the evaluator may decide to keep the low power demand identified in the baseline as a constant and only focus on the identification of changes in hours of operation between standby power and disconnected status. On the other hand, if an SPI only targets technological changes and the evaluator does not want to quantify the energy impact related to changes in the hours of operation at low power load, the same hours of operation per mode identified in the baseline could be kept constant and applied to the SPI scenario.

If conducted in an ex-ante evaluation, the future market characteristic could be as simple as an estimate of low standby power product penetration over time and the selection of a target low power consumption to be achieved by the SPI. Hours of operation changes can be an estimate of what is expected from the programme based on results of similar programmes in other jurisdictions or kept equal as the baseline hours of operation per mode.

For the performance of an ex-post evaluation, we are interested in capturing real market data confirming the market progression of efficient products or the change in operating mode caused by the SPI and other factors of influence present in the market. In terms of power level target promoted by an SPI, several jurisdictions have adopted regulations or voluntary guidelines that limit power usage in standby mode to a certain threshold (e.g., 2 watts). In some countries, there are different thresholds for equipment that has a reactivation function compared to equipment that has other functions such as an active display. In this case, gathering data about the market share of equipment offering different functionalities to users is important to be able to compute the average power of products complying with an SPI.

There could be relatively small differences between products that offer various functions. For example, the 2008 European Commission proposal established a standard of 2 watts for equipment with a display of information and 1 watt for other equipment. The 2012 version of this standard will reduce these powers to 1 and 0.5 watt, respectively. In North America, the California Energy Commission in late 2004 also imposed limits on standby power consumption for various consumer electronic devices, including DVD players, external power adapters and stereos. This legislation took effect in January 2011 so that it is now illegal in California to sell a television or DVD player that consumes more than 3 watts in standby mode. Power adapters will be limited to a standby consumption of 0.75 watt as of next year, dropping to 0.5 watt from January 2008. New limits will apply to stereos and set-top boxes.

The approach to gather data about SPI market characteristics is very similar to that presented in the baseline section, which explains why it is not repeated here.

The evaluation of energy usage for each year of the SPI scenario is performed by applying the following equation:

$$E_{SPI} = Q \times \sum_{n=1}^{N} (P_{n-SPI} \times H_{n-SPI}) \qquad \text{Equation 2}$$

Where:

$E_{SPI}$ = Energy usage for the SPI scenario

Q = Quantity of products sold in the market

n= Each relevant low power mode

N= Maximum number of low power modes considered

$P_{n\text{-}SPI}$= Power drawn in low power mode n for the SPI scenario

$H_{n\text{-}SPI}$= Hours of operation in low power mode n for the SPI scenario

In an ex-post context with a programme that collects data on the power consumption of equipment entering the market in a continuous way, it will be easier to perform more precise calculations as we will not be faced with the issue of trying to measure or assemble data on products that were put in the market during the previous years of operation of the SPI. The more years you should cover in an evaluation effort, the more complex will be the data collection issue if it is not integrated as an activity in the SPI operation.

The number of years to be covered by an impact evaluation effort is the decision of the SPI administrator based on the importance of the programme in its portfolio and the resources available for evaluation. Several programmes that are considered strategic for an administrator are evaluated on a yearly basis. For programmes that are considered less important, the evaluation can be conducted after two, three or even four years of programme operation. When in a context where the ex-post evaluation is expected to spread over several years, it is important to prepare the evaluation plan in advance to determine how the data required for the evaluation will be collected.

### Step 6 - Gross Energy Savings

Gross energy savings are defined as the difference between the energy usage in the baseline scenario determined in step 4 and the SPI scenario determined in step 5 using the following formula.

$$E_{Gross} = E_{Baseline} - E_{SPI} \qquad \text{Equation 3}$$

Where:

$E_{Gross}$= Gross energy savings

$E_{Baseline}$ = Baseline energy consumption

$E_{SPI}$ = SPI energy consumption

Gross energy savings means the direct impact that we can observe in the market. To calculate the net energy savings, it is important to take into consideration the attribution (step 8) of the observed effect to the SPI and the distortion effect (step 9).

### Step 7 - Estimating Savings over Product Expected Life

Product life expectancy is estimated to determine the savings that will be generated over the product life. It is often used by evaluators to calculate the medium-term effect of a product put on the market by an SPI. The gross savings from step 10 for each year of the programme can be multiplied by the expected life to determine the savings expected over the product life using the following equation.

$$E_{lifetime} = E_{gross} \times L \qquad \text{Equation 4}$$

Where:

$E_{lifetime}$ = Expected energy savings over the lifetime of the product

$E_{gross}$= Gross energy savings

L= Expected product life

Life expectancy could be estimated from supplier data or from information coming from household surveys. This information is generally difficult to obtain accurately as there are several brands on the market with different quality and longevity. The evaluator must assemble information from as many sources as possible to obtain an estimate that is close to reality.

For some products, the estimated life can vary over time, which can introduce other challenges. While preparing an ex-ante projection of savings for an SPI, it is thus important to document clearly the hypothesis used for the life expectancy of the equipment. Later, an evaluator performing an ex-post impact evaluation may include activities to assess the real life of products introduced in the market. He can then compare the ex-ante estimate with the real life expectancy.

The gross savings from step 10 for each year of the program

### Step 8 - Determining Attribution to the SPI

Attribution in the context of a standby power policy impact evaluation means taking into consideration the contribution of different global, regional and other national policies and programmes that can affect the market trend in standby power. These other market effects not caused by the SPI must ideally be considered to attribute a portion of the gross energy savings calculated in step 10 to the SPI. However, attribution evaluation in the context of internationally traded products introduces significant complexity to an already complex subject. It is thus recommended not to include an attribution analysis as part of the recommended base procedure for impact evaluation.

**Box 11 – Recommended Base Approach for Step 8 – Determining Attribution**

**Due to the inherent complexity of determining which international, regional or national influences may have induced changes in the standby characteristics of energy-using products, it is not recommended to include attribution determination in the base approach.**

**However, the autonomous changes in the market that are often caused by global or regional changes can be incorporated directly as a trend in the baseline power.**

For evaluators interested to go further than the base approach, we offer the following discussion of the main elements to consider for an attribution evaluation.

In terms of energy impact evaluation, we are interested as much as possible in demonstrating the causality between SPI implementation and the impact observed in the market.

A proper attribution process will ensure that different programmes in the market will not claim the same results, which would eventually lead to double counting impacts in the same market.

In an attribution process, we generally consider that a binding legal requirement will have precedence over other programmes that will, for instance, provide financial support for the purchase of more efficient equipment. This is the normal approach to programme evaluation and programme evaluators who work on resource acquisition programmes (subsidies) are normally expected to exclude the impact of all mandatory regulations from the programme studied.

In some cases, programmes that overlap with an SPI could have different objectives. For instance, a programme may target in priority the power consumption in active mode of equipment. In this case, the standby mode savings (if any) are only a portion of the savings generated. If this type of interaction is identified in the market where the SPI is operating, then this should be considered during the planning of the evaluation work to add activities that will allow determining the attribution to each program.

Whenever the evaluator identifies several programmes that contribute to the observed gross energy savings in the market, it becomes necessary to consider a method to attribute a portion of the savings to the SPI while the rest of observed market changes will be attributed to other initiatives put in place by different market actors. For instance, it could be the case when the government implements a voluntary programme for standby power labelling while a utility provides subsidies for the purchase of more efficient products, which include low standby power equipment. Attribution in those cases can be based on interviews or surveys of market actors who are knowledgeable about the market dynamics. This group of experts can provide their opinion on what is the share of each initiative in the observed gross impact in the market. The evaluator may expect a wide range of opinions from market experts about the attribution to each programme operating on the market and must be careful when interpreting the results of such consultations. Some market actors while knowledgeable about the market may introduce voluntary or involuntary biases if they have their own agenda about which programme they would like to see pursued, increased in scope or eliminated from the market. The evaluator must exercise judgment and compare the various positions expressed by market actors and their coherence before making a final decision about attribution to an SPI.

One way to increase the precision of an attribution made by expert consultation is to use a Delphi approach. In a Delphi approach, the group of experts is consulted individually for two or three rounds of discussion. The evaluator prepares a model of attribution after the first round of comments and this model is used as the basis for discussion during subsequent rounds. Each iteration brings additional reactions from market actors and leads to a more robust model. Delphi usually refers to projections made for the future and, if taken as its base definition, will be appropriate in ex-ante analyses only. However, the evaluator community has extended the initial objective of the Delphi approach and use the same method to gather expert opinions about historical events during ex-post evaluations. Sometimes, the expression “reverse Delphi” is used to underline that this method is used in an ex-post evaluation context.

Another approach that may be considered is the usage of focus groups of experts who debate their position openly with respect to the attribution of several programmes operating in one market. This approach could be used but should be conducted by evaluators with experience in this type of meeting to avoid that the position of the most outspoken experts take a disproportionate importance compared to the opinion of the rest of the group of experts. Focus groups are less costly than the Delphi approach and are thus used extensively even if considered by most evaluators as less reliable and less accurate.

Evaluators may also consider other elements during an attribution evaluation. For instance, they can consider the amount of resources associated with each programme operating in the market. Elements like the level of communication activities (publicity, newsletters, flyers, participation in fairs, in-shop promotional activities) and the associated budget can help determine the influence of different programmes in the market. Evaluators may also consider using market research with surveys to determine the level of notoriety of programs, the exposure to publicity and marketing activities, the understanding of the message by consumers, their reaction to the message and whether the different programmes have contributed to modify their purchase decision.

It is quite difficult to elaborate specific rules on how attribution to a programme should be treated as each jurisdiction context is usually different. The evaluator must in all cases try to establish whether there is overlap between different programmes in the same market and what proportion of the gross savings should be associated with each of them in the most realistic way and consistent with the evaluation budget considered.

A more complex issue is the effect of regional or global market changes on regulations and policies that can influence product designed by manufacturers and induce a change in the efficiency of products entering a given market. In this case, we should theoretically not allocate these market changes to a national SPI as the changes would have taken place even without the presence of the SPI.

In order to take these effects into consideration in an impact evaluation, the evaluator would have to estimate what would have been the progression of efficient products in the market without an SPI in place. This is quite difficult to manage in practice and evaluators usually rely on different approaches to evaluate regional or global market trends.

One of the usual approaches is to organise meetings with manufacturers or suppliers that have a regional or global vision of the market to try to determine what would have been their course of action and range of products offered in the absence of an SPI. Sometimes, groups of suppliers are met using a Delphi approach to try to better estimate the global effects in the market.

Another approach consists in conducting market studies in the market where an SPI is implemented and market research in a market that has similar characteristics (socio demographic, earning per household, living cost) but where no SPI has been implemented. A market research is performed to establish what is the progression of standby power in a given market without an SPI and this provides information to inform the evaluator of the real impact of the SPI in the market in addition to natural trend.

The issue of regional and global impact evaluation is also complicated by the fact that some SPI programme operators are also active on regional and global forums and task forces that promote standby power. Some SPI operators argue that, as they are active in promoting, supporting and trying to influence the progression of global policies, their SPI should not be penalised for market changes that they have been actively promoting on a more global scale. The debate is not over and for the moment evaluators determine on a case-by-case basis whether they will introduce global effects in an attribution effort.

### Integrating Global Change as a Dynamic Baseline or as an Attribution

In some evaluations, global market effects are integrated into the baseline in step 4 instead of being considered as an additional step as presented above (spillover effects). There is no definitive ruling on how the evaluator community carries out this step and the important point is to make sure that normal market trends are incorporated somewhere into the process in a coherent way. When the evaluator decides to incorporate the market trend into the baseline, he will define a dynamic baseline where the power level in various low power modes and the penetration of efficient products will change for each year of the impact evaluation. However, if there are several regional SPIs implemented or changed that could have spillover effects during the implementation of the local SPI, accurate attribution can be very difficult.

One of the approaches to include the global market trend in the baseline could be to measure the low-efficient products entering the market each year (every two or three years if resources are limited). This method would be applicable, for instance, in the case where only a voluntary programme or a labelling programme is in place in the market. This implies that there will still be a proportion of the products sold in the country that will not be meeting the SPI target and could be easily measured. On the other hand, if there are MEPS introduced, it becomes very difficult to determine what would have been the baseline evolution over the years. All products (or most products depending on enforcement and market supervision) in the market will be products that meet the threshold of efficiency and thus there is no product left with low efficiency that could be measured to determine what would have been the market evolution. In this case, the baseline must be established by measurement of a similar market where no SPI has been implemented.

Another global and regional effect which could have a negative effect on the market is the dumping of low-efficiency equipment. This situation can arise when several countries put in place strict requirements for MEPS, which reduces the market available for the distribution of low-efficiency equipment. In that case, manufacturers of low-efficiency equipment will concentrate on countries that have lower requirements for efficiency to distribute their equipment.

Attribution of global impact is a complex topic that is not yet fully integrated into the evaluation practice because of its inherent complexity. Evaluators using this protocol should however be aware that these global effects may exist and they should carefully examine whether they want to or can take them into consideration while performing their evaluation.

### Step 9 - Evaluating DISTORTION Effects

Distortion effects are elements outside of the gross effect and attribution that can affect the net effect of SPIs. It is not recommended to include these effects in the base approach to standby power evaluation.

**Box 12 – Recommended Base Approach for Step 9 – Evaluating Distortion Effects**

**It is not recommended to include distortion effects in the base approach for SPI evaluation.**

**Evaluators should include these effects only if they are relevant to the type of SPI evaluated or only if evaluators are required to provide information needed by policy makers.**

Even if it is not recommended as a base approach for SPI impact evaluation, we will present some of the distortion effects that could eventually be considered.

The first one is the cross effect. Cross effect is the impact that a reduction in power consumption for standby usage can have on other usages in a given household. The two most frequent interactions taken into account are the effect of reduced heat rejection by efficient products on heating requirements in a household or the effect on cooling requirements.

The decision to include these effects is market specific. It depends mainly on the climatic data and the percentage of households equipped with heating or cooling equipment. These effects are usually taken into account by engineering methods. For standby power alone, these effects can usually be assumed to be negligible.

Another effect also considered is free ridership. This distortion effect is only found in non-mandatory programmes and often in programmes that propose a financial incentive to households similar to what is found in several demand-side management programmes. Free riders are defined as the proportion of households that would have adopted the products or behaviour promoted by the SPI even without the presence of the SPI. This is different from the attribution where we try to allocate the gross impact to different programmes or to regional or global market forces. For instance, an SPI including only communication activities to promote equipment with an energy-efficient label may induce changes in a portion of the population but a segment of the population could decide to purchase efficient products because of their natural inclination toward preserving the environment and efficient usage of the resources. Free ridership is usually estimated by a series of questions included in the market survey of a general population that has been exposed to SPI commercial activities.

### Step 10 - Net Impact Calculation

The net effect from step 11 is reduced by any attribution and can be either reduced or increased by the distortion effects to obtain the net effect.

$$E_{net} = E_{lifetime} \times A \times NTGR \qquad \text{Equation 4}$$

Where:

$E_{net}$= Net energy savings

$E_{lifetime}$= Energy savings of product over its lifetime

A= Attribution ratio

NTGR= Net-to-gross ratio based on the distortion factors

### Considerations about Product Life Cycle

Electronic products have a short development and market cycle, which means that there is a constant flux of new products offering new and additional functionalities in the market. This creates a challenge both for any policy targeting standby power and for the associated market evaluation activity.

Policy makers and evaluators should allocate sufficient resources to track trends and changes in the market of electronic equipment and appliances to ensure that their policy or method of evaluation does not become obsolete.

# 5 SAMPLING GUIDELINES

Sampling is a complex science that requires skills and experience in designing a reliable sampling method for the preparation of surveys. However, in several small-scale surveys without stratification of the population and without weighting of results, it is often possible to use simple statistical formulas to come up rapidly with the required number of samples to achieve a specific precision level.

Most simple sampling formulas assume an infinite population (or a very large one), a normal distribution of the population and a coefficient of variance of 0.5 for the purpose of sample design. Given these assumptions, it is possible to find the sampling size for a survey knowing the desired precision and interval of confidence. The following provides guidelines to determine the sample size.

The simplest sampling procedure, sometimes referred to as the simple random procedure, involves selecting randomly *n* units from a total population of *N* units so that each and every unit has the same probability of being included in the sample. The sampled units have to be drawn from the population and that population has to be homogeneous. On the contrary, different types of units should be grouped to create homogeneous populations. For instance, the standby power losses of personal computers used at home and at work would be two distinct populations.

The desired precision and confidence levels have to be selected by the impact evaluator or selected by the SPI manager. Precision refers to the error around the true estimate. The confidence level refers to the probability that the value of a parameter will indeed be within that desired precision. For instance, it is common practice in impact evaluation to target 10% precision with a 90% interval of confidence, referred to as a 90/10 uncertainty. This means that 9 times out of 10, if we draw a sample, the average value of a parameter that we want to measure will be within 10% of the real value.

Once the homogeneous population has been selected and the desired precision and confidence levels determined, it is possible to calculate an initial estimate of the overall sampling size using the following equation:

$$n_0 = \left(\frac{cv}{e}\right)^2 * z^2$$

Where:

$n_0$ is the initial estimate of the required overall sample size;

cv is the coefficient of variance (standard deviation divided by the mean). Until the actual coefficient of variance of the population can be determined from the actual samples, as mentioned previously, it is common practice to use a coefficient of variance of 0.5 at the survey design stage;

e is the desired level of precision expressed as a fraction. E.g. 0.1;

z is the standard normal distribution value for an infinite number of readings (Table 7).

For example, when designing a sampling programme to measure the standby power losses of residential personal computers of recent vintage, it was decided to meet a 90/10 uncertainty. Using the standard normal distribution value provided in Table 7, it can be determined that the initial estimate of the required sampling size would be 67. A sampling of 67 or around this value is frequently found in evaluation report and is an immediate indicator that the uncertainty of the results was 90/10.

$$n_0 = \left(\frac{0.5}{10\%}\right)^2 * 1.64^2 = 67$$

**Table 7: Standard Normal T-distribution Value**

| Number of Readings (sample size) | Confidence Level | | | |
|---|---|---|---|---|
| | 95% | 90% | 80% | 50% |
| 2 | 12.71 | 6.31 | 3.08 | 1.00 |
| 3 | 4.30 | 2.92 | 1.89 | 0.82 |
| 4 | 3.18 | 2.35 | 1.64 | 0.76 |
| 5 | 2.78 | 2.13 | 1.53 | 0.74 |
| 10 | 2.26 | 1.83 | 1.38 | 0.70 |
| 15 | 2.14 | 1.76 | 1.35 | 0.69 |
| 20 | 2.09 | 1.72 | 1.33 | 0.69 |
| 25 | 2.06 | 1.71 | 1.32 | 0.68 |
| 30 | 2.05 | 1.70 | 1.31 | 0.68 |
| ∞ | 1.96 | 1.64 | 1.28 | 0.67 |

*Source: International Performance Measurement and Verification of Protocol, 2010. Note the values in the table are for two sided limits, which are used when assessing estimates of the average.*

The initial sampling size was determined assuming that the coefficient of variance of the population is 0.5. Consequently, a different sampling may be necessary to meet the targeted precision when the survey will be launched. The initial sampling size estimate will be too large if the actual coefficient of variance proves to be less than 0.5 whereas it will be too small if, on the contrary, the coefficient of variance is higher than 0.5. As sampling is being carried out, the coefficient of variance should be calculated and the sampling size recomputed.

Generally speaking, a higher precision, a higher confidence level and a higher coefficient of variance all require increasing the fraction of the population being sampled. Moreover, the relationship between precision and the sampling size is non-linear. For instance, had it been decided in the above example to double the precision level and meet a 90/5 uncertainty, the initial sampling size would have been 268, namely four times as large as the sampling size to meet a 90/10 uncertainty. In addition to the desired uncertainty that exponentially increases the number of required samples, a high coefficient of variance could also cause the required sampling size to be tremendous. The coefficient of variance could be quite large if, for instance, the population comprised a large number of units with low standby power losses and a relatively small number of units with large standby power losses. Therefore, in most cases, achieving an acceptable uncertainty using the simple random sampling procedure could rapidly involve prohibitive sampling costs.

The simple random sampling procedure is just one of a variety of sampling procedures recognised in the literature. There are a variety of alternative sampling methods that could be used to optimise the cost-effectiveness of the sampling program, each sampling method being tailored to a specific situation. For more information, one could refer to available literature on sampling techniques. Nevertheless, the following proposes an alternative approach to the simple random sampling procedure that is probably the second most used one in evaluation works, namely the stratified sampling procedure.

The stratified sampling procedure involves dividing the population into several subpopulations, strata that don't intercept but which together comprise the entire population. A population could be stratified, for instance, by the estimated standby power losses or its market penetration rate. For instance, if we have a hypothetical cases where three of the most popular models occupy three-quarters of the market share, it would be advisable to realise a census to determine with precision the standby power losses for a first strata comprising those 3 types of model while a less intensive random sampling could be conducted in other strata. In that particular case, this would be a good compromise between precision and sampling cost. Because the estimated standby power losses of the most popular models would have been evaluated with precision, the stratified sampling procedure would yield a much higher precision than the random sampling procedure at a lesser sampling cost.

For instance, if we have a population of 100 different models of the same product in the market but a limited budget that allows measurement of only 30 samples. However, we know precisely the number of units of each model sold. We can thus design a simple random sampling approach using the equation presented above and find that we can only achieve an accuracy of 15% with this sample[19].

A better approach would be to divide the sample into two tiers. One of them will include the products that sold the most in the market and for which we will establish a census by measuring all of them. The second tier is all the other products with a limited distribution for which we will only select a representative sample and use the arithmetic average power as a representation of the power of this category.

Table 8 illustrates a sales-weighted estimate of power using this two-tiered approach where a sample of 10 is devoted to the models that sell the most in the market (about 55% of market share) and where the remaining 20 are drawn from the remaining 90 models.

[19] This is a simplified example as we can add correction factors to the basic sample calculation when we handle small populations.

**Table 8: – Sales-Weighted power estimate with a Two-Tiered Sampling**

| Product | Active Standby Power (W) | Total Number of Units Sold (n) | Fraction of Sales (%) | Sales-Weighted Power (W) |
|---|---|---|---|---|
| TIER 1 | | | | |
| 1 | 12.3 | 2,300 | 8.27% | 1.018 |
| 2 | 16.4 | 1,900 | 6.84% | 1.121 |
| 3 | 9.5 | 1,854 | 6.67% | 0.634 |
| 4 | 15.9 | 1,698 | 6.11% | 0.971 |
| 5 | 19.2 | 1,543 | 5.55% | 1.066 |
| 6 | 13.4 | 1,430 | 5.14% | 0.689 |
| 7 | 9.7 | 1,264 | 4.55% | 0.441 |
| 8 | 14.7 | 1,189 | 4.28% | 0.629 |
| 9 | 15.3 | 1,054 | 3.79% | 0.580 |
| 10 | 19.4 | 1,021 | 3.67% | 0.713 |
| TIER 2 | | | | |
| 11-100 | 18.4 | 12,543 | 45.13% | 8.303 |
| | | | | |
| Total | | 27,796 | 100.00% | 16.165 |

In this two-tier sampling, there is no sampling error on the first tier as all products were measured[20]. However, there is a larger error on the sampling of the second tier as we only measured 20 of the 90 remaining models in the market. The sampling error for this second tier will be 18.3%. If we calculate a sales-weighted sampling error, we will achieve a combined 8.2% error for the two-tiered approach, which is better than the 15% that would have been expected from a simple random sampling.

[20] However, there could be errors related to the variability of the production of products and measurement errors that are not included in this example and which illustrate sampling only.

# APPENDIX I
# BACKGROUND MATERIAL ON DEFINITION OF LOW POWER MODES

The IEC 62301 testing just provides a high-level classification of low power modes. It does not provide recommendations on what should be the low power modes considered for each type of product that can be encountered in the market. This type of classification is generally made by the IEC product committee. The bibliography section of the IEC 62301 standard lists more than 20 standards specific to energy-using products used in households or in the commercial sector. In some cases, countries/jurisdictions that want to use IEC 62301 as a reference will define their own low power mode categories using internal or local technical resources. In order to provide guidance to product committees or jurisdictions in defining the low power modes to be considered, the IEC 62301 standard offers recommendations on how the low power modes can be identified and categorised. All low power product modes should be representative of the expected normal use of a product in a household or commercial site.

The table above offers a general overview of low power mode categories. Annex A of IEC 62301 provides more details on the classification of specific low power modes in one of the above categories. The determination of low power modes is a complex topic considering the multiple design options, user setting preferences and variations caused by component interaction with other equipment (especially in network mode). Some modes like battery charging are not part of the IEC standby loss measurement procedures.

Annex A of IEC 62301 also provides general advice on how functionality can help determine low power mode categories. The annex also offers a non-exhaustive list of functions, as shown in Table 9 of IEC 62301 standard.

**Table 9: Typical Functions that could be offered by a Product**

| Function | Description | Example |
|---|---|---|
| Remote control of power. | The equipment is waiting for a wake-up signal from the user. This mode could include a status light indicating the reactivation mode or no light at all. | Equipment that can be restarted by a remote control. |
| Delayed start/stop operation | The equipment is programmed to start or stop on a specific schedule. Alternatively, a fixed or adjustable delay can cause equipment to go to a low power mode or off mode. | Timer in a digital recorder.<br><br>Auto off on a television. |
| Sensor operation | Any type of external sensor that can provide information to the internal logic of the product about light level, occupancy, heat, smoke, temperature, water flow, etc. | Lux sensor that automatically adjusts a product screen or display brightness.<br><br>Temperature probe that supplies information to a display. |

| Function | Description | Example |
|---|---|---|
| Display or status mode | Any information that can be displayed to end-users including status light. | Clock display.<br><br>Disk and track indication on a CD player. |
| Memory and timer | Function involving storage of data in the product memory.<br><br>Timer that can be used to provide a clock display or to provide scheduled start and stop operations. | Download or streaming of movies.<br><br>Start/stop programme on a recorder. |
| Electronic controls, locks and switches | Various devices including push button, toggle, electronic position sensors etc. | Buttons.<br><br>Motion pad.<br><br>Kids electronic locks. |
| Network functions | Any type of communication between equipment including Wi-Fi communication, network cable, Bluetooth, infrared.<br><br>Communication with a remote control device specifically made for the product is not considered a network function. | Wi-Fi router.<br><br>Cable TV receptor. |
| Battery charging | Portion of a low power operation when a product recharges batteries.<br><br>This does not include products for which the main function is battery charging. | Portable computer in standby mode and recharging its battery. |
| Electromagnetic compatibility filters | Devices implemented to conform with electromagnetic emissions requirements of a regulation. | |
| Protective | Sensors that protect a product or the user. | Thermal sensor that turns off a video card in a computer when overheating. |

Annex A of IEC 62301 also presents a discussion of power switches and how they could be considered while defining low power mode categories.

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