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AN INITIAL VIEW ON METHODOLOGIES FOR EMISSION BASELINES: ENERGY EFFICIENCY CASE STUDY

INFORMATION PAPER

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FOREWORD

This document was prepared in June 2000 at the request of the Annex I Expert Group on the United Nations Framework Convention on Climate Change. The Annex I Expert Group oversees development of analytical papers for the purpose of providing useful and timely input to the climate change negotiations. These papers may also be useful to national policy makers and other decision-makers. In a collaborative effort, authors work with the Annex I Expert Group to develop these papers. However, the papers do not necessarily represent the views of the OECD or the IEA, nor are they intended to prejudge the views of countries participating in the Annex I Expert Group. Rather, they are Secretariat information papers intended to inform Member countries, as well as the UNFCCC audience.

The Annex I Parties or countries referred to in this document refer to those listed in Annex I to the UNFCCC (as amended at the 3rd Conference of the Parties in December 1997): Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, the European Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, and United States of America. Where this document refers to "countries" or "governments" it is also intended to include "regional economic organisations", if appropriate.

This case study is part of a larger analytical project undertaken by the Annex I Experts Group to evaluate emission baselines issues for project-based mechanisms in a variety of sectors. Additional work will seek to address further the issues raised in this and other case studies.

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ENERGY EFFICIENCY CASE STUDY

Executive Summary

Extending previous OECD and IEA work on emission baselines (Ellis and Bosi, 1999), this case study provides an initial view on the potential for standardising the construction methods for greenhouse gas emissions baselines for JI and CDM energy efficiency projects. The focus is on baselines in the lighting and motors sectors.

This analysis is largely based on the experience gained through energy efficiency projects and programmes in industrialised countries - which may provide valuable lessons for the construction of baselines for JI and CDM projects in developing countries, as well as in economies in transitions. It is also based on the examination of seven examples of energy efficiency projects and programmes undertaken in four developing countries[1] (*i.e.* Mexico, Morocco, Pakistan and Thailand).

Three key factors point towards a possibly large potential for energy efficiency projects in the context of the Clean Development Mechanism:

- High growth in energy demand is forecast for developing countries, with electricity use expected to increase significantly by 2015.
- The most cost-effective energy efficiency projects tend to be those implemented as part of new construction or major facility modification efforts and these types of projects are projected to be significant in developing countries.
- Most developing countries did not participate in the wave of energy efficiency investment that occurred (mostly in OECD countries) after the oil price shocks of the 1970s and 1980s. Consequently, there are still numerous opportunities to increase energy efficiency in developing countries (as well as in countries with economies in transition).

Energy efficiency projects tend to have particularities that need to be taken into account when developing baselines. In contrast to other sector projects, energy efficiency projects often comprise bundles of smaller projects. For example, one AIJ pilot phase energy efficiency project in Mexico (see Annex A) involved the replacement of existing lights with higher-efficiency compact fluorescent lamps. While there are some single-site, large-scale energy efficiency projects that have been implemented (*e.g.* a large district heating system or a single large industrial facility), energy efficiency projects are more likely to be characterised by two factors:

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[1] This case study focuses on energy efficiency projects in the context of developing countries and thus the Clean Development Mechanism. However, many issues and insights from this study are likely to be applicable in the context of JI energy efficiency projects, although this may merit further examination.

- They span a large number of sites or locations.
- There is a specified target market area, although multiple sites may be targeted (*e.g.* the AIJ lighting project in Mexico spanned many households in a target market covering two cities).

The development of GHG emission baselines for energy efficiency projects can be divided into two main steps: (1) the development of the energy use baseline; and (2) the translation of this baseline into GHG emissions.

There are essentially three options, or levels, for the standardisation of energy use baselines for energy efficiency projects. These are*: standardising baseline calculation methods; standardising operating and performance parameters*; and *standardising energy use indices*. Each is discussed below:

Standardising baseline calculation methods and data collection protocols (*i.e.* the algorithms and models used to compute energy use and the data that provide inputs to the algorithms).

In traditional energy efficiency projects and programmes undertaken to date, relatively little attention has been paid to the development of baselines (or reference scenarios). JI and CDM energy efficiency projects will clearly demand a greater focus on these.

Standardising calculation algorithms, data requirements supporting those algorithms and data collection protocols would promote the application of appropriate procedures and reduce project developer’s uncertainty. Such standardisation could be reasonably done for a variety of energy efficiency projects, including equipment replacement (*e.g.* lighting, motors and appliances). Simplified calculation algorithms for the construction of baselines for lighting and motors energy efficiency projects are developed in this case study.

It is important to keep in mind that data are key in the development of baseline. In fact, most debates over the quality of the baseline revolve around concerns about whether the sample selected for the baseline development is indeed representative of the project participants and their energy use. As a result, the selection of a sample is often a crucial determinant of “good” baseline. The use of sampling is important in that it keeps the costs of establishing a baseline using project-specific information manageable.

In the particular context of energy efficiency projects in the lighting sector, baseline calculation methodology (algorithms) and data collection protocols appear suitable to standardisation. A review of lighting sector projects across three countries indicated that differences in the technologies, targeted participants and in-field operating conditions in each country make it inappropriate to share baseline data (*i.e.* use identical baselines across countries). However, a common approach to collecting the required data using state-of-the-practice techniques could be shared across countries.

Similarly, in the case of the development of baselines in electric motors, the calculation methodology used for estimating the energy use for a population could be standardised across countries. Data on the number of motors categorised by horsepower can be collected at either the site or the population level. The data for the efficiency and operating hours can be obtained through estimation from technical data, engineering methods or field observations.

However, not all energy efficiency projects are amenable to the same level of standardisation; some require project-specific data to establish baselines. Some simplification is still possible; methods exist whereby national or regional sector baselines can be used as starting points and then adjusted according to in-field data collected from participants in the project. These methods use statistical procedures (*e.g.* energy-use realisation rates, ratio estimation methods) and can significantly lower the cost of baseline construction below that incurred using methods where each project developer has to start *de novo, i.e.* without a “prior” estimate of the baseline from aggregate data. Such a method essentially combines standardisation with project-specific elements to produce a cost-effective hybrid approach.

Standardising operating (e.g. ***.*** *number of hours) and performance (e.g. motor efficiency) parameters* necessary for the baseline calculation *(i.e.* the values that describe the energy use characteristics of a given technology or end-use)

The standardisation of baseline operating and performance parameters brings greater uniformity and consistency to the CDM/JI baseline development process. It would also reduce the time and cost of estimating the energy use baselines for project developers - although it does not, of itself, establish baseline energy use for energy efficiency projects.

In the lighting sector, it is likely that the standardisation of operating and performance parameters would be possible for most common types of lighting devices. This seems to be particularly appropriate in the residential and commercial sectors, where lighting operating hours tend to be relatively consistent. The operating hours parameters would need to be differentiated according to market sector/segment and developed and standardised on a country-by-country basis (or on a regional basis if circumstances are sufficiently similar), in order to take into account differences in domestic markets and the mix of technologies. Similarly, performance parameters such as input wattage for the most common lighting fixture types could be standardised. For example, it would be possible to establish baseline data on wattages for common types of incandescent and fluorescent residential and commercial fixtures.

In the motors sector, it would be possible to standardise motor efficiency parameters, as equipment performance tends to be more uniform across market segments than other operating characteristics. Such standardisation seems particularly applicable for certain motor types and size ranges that are most common in the commercial sector and industrial application. In fact, it would seem useful to further examine, in the context of developing countries, the possibility of standardising motor efficiencies for the most common types, sizes, classes and applications, based on manufacturers’ data.

In addition to motor efficiencies, energy use baselines in the motors sector requires data on operating hours, load factors and “diversity” factors. These latter parameters lend themselves to standardisation (albeit with certain limitations). As operating hours tend to be relatively consistent within specific market segments, particularly in the commercial sector, this parameter could be conservatively standardised by market sector/segment. These baseline values would need to be derived from end-use load information on a country-by-country, or possibly regional, basis.

Standardising energy use indices (EUI) by sector, market segment and/or end-use (*i.e.* indices that are representative of the energy use of a population of technologies or segment of the population, such as lighting kWh per square metre for certain commercial building types).

With respect to lighting projects, it seems possible to standardise indoor lighting EUIs (*e.g.* lighting kWh/square metre) for certain market segments of the commercial sector (*e.g.* offices, schools and hospitals). In the residential sector, it may be possible to standardise EUIs for certain appliances (*e.g.* refrigerators). Standardised lighting EUIs are probably less applicable in the industrial sector, where a hybrid approach combining standardised and project specific elements is likely more appropriate.

Standardisation of motor energy use indices (*e.g.* kWh/square metre) for the commercial sector does not seem appropriate, as motor energy use is often tabulated or subsumed in other end-uses, particularly space heating and cooling. However, in the industrial sector, where motors are often the primary energy-consuming devices, it may be possible to develop baseline motor energy use indices related to the unit of production (motor kWh/unit of production) for selected industries.

Other energy efficiency baseline issues

The environmental risks associated with accepting an "incorrect" baseline varies significantly by type of energy efficiency project. The potential negative environmental consequences of using an "incorrect" baseline are probably highest if an energy efficiency project includes only one or two very large facilities (*e.g.* district heating systems, large industrial applications). Projects that embody a portfolio concept where several energy efficiency measures are installed across a large number sites may pose less environmental risk (as the baseline would probably be "correct" for the project as a whole, even though some individual components may not be "additional" on their own).

The methodologies examined to estimate energy use baselines for energy efficiency projects normally only consider direct energy use. However, energy efficiency projects may lead to two indirect energy use (and GHG) effects: free riders and spillover effects. These two indirect effects work in opposite directions and both are difficult to quantify. Until better information is available, it may be practical to assume (as have some regulatory jurisdictions in the case of traditional energy efficiency projects and programmes) that these two effects cancel each other out.

Project developers need a framework that allows them to assess the economics of a project. Several actions can be taken that help ensure environmental integrity and help project developers better and more efficiently, evaluate potential JI/CDM projects, including:

- Setting an emissions rate per kWh reduced for a pre-determined period of time. This is likely to be the most important standardisation action that can be taken, as it would apply equally to all projects across all sectors in a given country/region and thereby would help encourage all energy efficiency projects.

- Setting the crediting lifetime associated with an energy use baseline. This paper proposes a five-year crediting lifetime, arguing it provides project developers with enough time to recover costs and earn a return on a wide range of energy efficiency projects and stimulate investments in JI/CDM energy efficiency projects. (Such a baseline could be set in such a way that energy efficiency would be required to increase at a given rate over the five-year period; project confidence would be possible only if such a dynamic rate were agreed at the outset of the project).

In terms of the level of stringency of the energy efficiency baseline level, the key criteria should be what most reasonably reflects the likely "business-as-usual" scenario.

Setting the baseline level based on what investments should theoretically take place using traditional financial assessment criteria (*e.g.* pay-back period), is not likely to be a good proxy for "business-as-usual", as such theoretical financial criteria do not take into account the various (*e.g.* non-monetary) barriers to energy efficiency investments (*e.g.* information cost, attention cost, market distortion cost, public policy costs, cultural barrier costs, *etc.*).

The other two main approaches of determining an appropriate baseline stringency level are based on: existing stock of equipment in the field; and "best practice", using either highest rated equipment found in the field or equipment for sale. The most appropriate choice would depend on what is reasonable to assume under a business-as-usual scenario. In a case where all new sales are for equipment that has a higher efficiency level than older equipment, then the new equipment efficiency level should be used for developing the baseline. On the other hand, if the technology is entirely new and only a small fraction (*e.g.* less than 30%) of new sales represent this technology, then the average efficiency level (or potentially a reasonable "better-than-average" efficiency level) of the stock of equipment in the field may be more appropriate.

Finally, it is important to recognise that some energy efficiency JI or CDM projects will probably "beat the system" and receive more emissions credits than they deserve. No process will be perfect and any energy efficiency baseline construction process is likely to have defects. However, as search for perfection is likely to result in no process being judged as acceptable, the goal instead should be to strike both a reasonable balance among various risks: among environmental objectives; among the interests of project developers and among those of potential host countries.

1. Introduction

This paper extends previous IEA and OECD work on greenhouse gas emissions baselines for the Kyoto Protocol's project based mechanisms: Joint Implementation (JI) and the Clean Development Mechanism (CDM). Specifically, Ellis and Bosi (1999) examine issues in developing greenhouse gas (GHG) emission baselines, including the possibility of standardising them (*i.e.* multi-project baselines). This paper examines issues surrounding the potential standardisation of baselines for JI and CDM energy efficiency projects, focusing on approaches that have been used to establish baselines in conjunction with planning, implementing and evaluating energy efficiency projects in selected developing countries.[2] Energy efficiency projects from Thailand, Mexico, Morocco and Pakistan are used as examples.

Establishing emission baselines for energy efficiency projects is a two-step process. First, an energy use baseline must be established for the energy efficiency project. Second, this baseline must be translated into a GHG emissions baseline. This paper focuses on the first step - establishing baselines for energy use, *i.e.* what would the energy consumption have been if the demand-side energy efficiency project had not been installed. The second step - translating the change in energy use into a change in GHG emissions, which requires emission values associated with electricity use - is being addressed separately (see Electricity Case Study).

The accomplishments of energy efficiency programmes to date imply that using energy efficiency as a way to reduce GHG emissions within both Annex I and non-Annex I countries has the potential to greatly reduce the costs of GHG mitigation. Further, these benefits extend beyond GHG emissions reductions by providing host countries with other environmental benefits associated with reduced energy use (local air, water and land use impacts), the installation of current technology in important sectors and the development of a sustainable infrastructure. In addition, there are likely to be spillover economic and environmental benefits for all parties.

Given the magnitude of the environmental and economic benefits that can be expected, the challenge is how to set up a reasonable process for constructing baselines. A number of suggestions regarding the baseline-setting process are offered below. Issues addressed include: areas were the process might be standardised, trade-offs in baseline complexity, balancing risks, baseline stringency and potential biases in the baselines and their impact on the selection of potential energy efficiency projects.

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[2] This chapter focuses on baselines for energy efficiency projects in the context of developing countries and thus the Clean Development Mechanism. However, many issues and insights from this report are also likely applicable in the context of JI energy efficiency projects, although this may warrant further examination.

2. Sector Overview

Energy efficiency projects may be found in a wide variety of initiatives in the residential, commercial and industrial sectors. This diversity makes it difficult to determine the exact size of the market and opportunities for GHG mitigation through energy efficiency projects. However, a handbook on climate change mitigation options for developing countries prepared by the USEA/USAID estimated that current world-wide energy demand could be by reduced 3-7% by year 2010, with corresponding reductions in GHG emissions through Demand-side management (DSM).[3]

Three factors make developing countries strong candidates for energy efficiency projects:

- High growth in energy demand is forecast for developing countries, with electricity use expected to increase nearly eight-fold by 2015.
- The most cost-effective energy efficiency projects tend to be those implemented as part of new construction or major facility modifications,[4] and these types of projects are projected to be significant in developing countries.
- Most developing countries did not participate in the wave of energy efficiency investment that occurred (mostly in OECD countries) after the OPEC oil embargo and the resulting high energy prices of the 1970s and 1980s. Consequently, there are still numerous opportunities to increase energy efficiency in developing countries, as well as in countries with economies in transition.

As a result of these factors, a significant fraction of the GHG emissions reductions achieved via the Kyoto Protocol's project-based mechanisms could potentially result from successful energy efficiency projects implemented in developing countries.

2.1 Energy efficiency sector trends

On average, the residential sector typically accounts for 20 to 35% of a country's energy use.[5] Candidate residential sector projects can be directed at: 1) improving the energy efficiency of residential lighting and appliances; 2) improving the energy efficiency of new and existing construction; and 3) improving the energy efficiency of space heating and cooling systems. Efficient residential construction and high-efficiency appliances can reduce household energy use by 33% using available technologies.

Commercial sector energy use typically accounts for 10 to 30% of a country's energy use. Candidate commercial sector projects are likely to be designed to address: 1) building envelopes; 2) efficient equipment (*e.g.* lighting, motors, variable speed drives, heating, ventilation and air conditioning (HVAC)

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[3] *USEA/USAID Handbook*, 1999, pp. 7-3.

[4] Many energy efficiency advocates argue that it is of critical importance to implement projects in new construction, since once a facility is built, it will not be cost-effective to go back and retrofit it for some time. These missed or "lost opportunities" can reduce the overall potential for energy savings in a country.

[5] According to the IEA's *Energy Statistics of OECD Countries (1999a),* the residential sector, on average, makes up 30% of total electricity consumption (kWh) in a country. Mexico's residential electricity consumption accounts for 22% of that nation's total. Developing countries tend to have a wider range in the share of energy devoted to electricity in the residential sector with, for example, Thailand at 22% and Pakistan at 41% (*Energy Statistics of Non-OECD Countries* (IEA, 1999b); statistics for non-electric energy use are not available).

equipment); and 3) community energy systems such as district heating in commercial areas. Some energy efficiency programmes have lead to reductions in energy use of up to 50% with the installation of efficient lighting, space conditioning and building controls.[6]

The industrial sector is typically the largest energy using sector, often accounting for more than 40% of a country's electricity use.[7] The industrial sector accounts for almost one half of global energy-related CO_2 emissions. With industry-specific energy intensities in developing countries often being two to four times greater than the average in OECD countries, energy efficiency and process improvements in the industrial sectors can produce substantial reductions in GHG emissions. These energy efficiency projects can be focused (*e.g.* they might address a single industrial process such as aluminium smelting) or diffuse (*e.g.* an industrial sector motors replacement project spanning hundreds of facilities).

Large-scale energy efficiency projects can produce substantial GHG emissions reductions in all three sectors. In addition, these projects are likely to provide various economic spin-off benefits through, for example, the education and training of regional workers, operational improvements, enhanced technology transfer, localised environmental improvements, enhanced competitiveness of regional industries and an overall improvement in regional economies.

Only a few developing countries have undergone the end-use profiling of energy demand that allows for the successful planning of energy efficiency projects. Independent of the value this information might have for establishing baselines, national end-use energy analyses will be critical to the identification of cost-effective, high-impact energy efficiency projects that might be implemented in developing countries.

As discussed later in this case study, it is likely that the estimated baselines for most JI and CDM energy efficiency projects will rely on some data that are unique to that project, rather than relying entirely on national or standardised data. However, the project developer's screening of and planning for candidate energy efficiency projects will have to be based in large part on end-use data for major sectors that are collected on a national basis. National data are critical for these planning applications since, in the planning phases, there are no identified project participants. The quality of these national data will affect the realisation rates for baseline estimation, *i.e.* the ratio of planned or expected baseline energy use to the in-field[8] estimated baseline energy use for the actual project participants once the project is rolled out. In addition, countries with high-quality national data (*e.g.* on sectoral and end-use energy consumption) that allow for good project planning would likely attract more JI/CDM energy efficiency projects.

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[6] *Energy Statistics of OECD Countrie*s (IEA, 1999a) shows that in OECD countries, the commercial sector makes up 27% of electricity consumed (kWh) on average (Note: Mexico has a commercial sector share of 18%). Again the range is broader for non-OECD countries but, in general, the share of electricity use in the commercial sector is lower in non-OECD countries than in OECD countries (*e.g.* Thailand at a 10% share and Pakistan at a 14% share for commercial sector electricity use).

[7] *Energy Statistics of OECD Countries* (IEA, 1999a) shows, on average, the industrial sector comprising 40% of electricity consumed (kWh) and 32% of heat energy (TJ) consumed. Average shares for industrial energy use in the countries analysed in the examples included in Annex A: Mexico - 60% of total electricity consumed, Thailand - 42% of electricity consumed and Pakistan - 28% of electricity consumed (statistics for non-electric/heat energy use are not available).

[8] In-field estimates are based on measurements taken at specific facilities. In-field estimates for a specific set of facilities are used to verify and modify energy use baselines from more aggregate national databases constructed using sector averages to make them more representative of the actual sites that are participating in a specific energy efficiency project. A realisation rate of 1.1 would indicate that the baseline obtained from in-field data from project participants is 10% greater than a baseline estimated using aggregated national data. The in-field estimate is assumed to be more accurate since it takes into account information specific to that subset or sector of facilities that are participating in a given energy efficiency project.

As an example of the current status of one developing country, Table 1 illustrates end-use and sector projections of electricity use for Vietnam. These data indicate that motor drives will account for 76% of the electricity use in the industrial sector in 2010 and that the industrial sector as a whole will increase its share of national electricity use from 42 to 62%. Lighting makes up a large fraction of commercial and residential sector energy use, but HVAC (*i.e.* mechanical heating, ventilating and air conditioning of buildings) shows the largest growth and will surpass lighting in electric use in residential and commercial buildings by 2010. These general end-use trends are not uncommon for developing countries located in warm climate zones.

Table 1. Vietnam's changing sectoral and end-use electrical energy shares

(Based on GWh Sales Projections)

Sector/End-Use	**1994 End-Use Share**	**1994 Sectoral Share of Sales**	**2010 End-Use Share**	**2010 Sectoral Share of Sales**
Industrial		42%		62%
Motors	76%		76%	
Lighting	4%		4%	
Process	20%		20%	
Commercial		9%		12%
Lighting	56%		34%	
HVAC	23%		49%	
Other	21%		17%	
Residential		34%		22%
Lighting	45%		28%	
Refrigeration	5%		7%	
Cooking	20%		9%	
Other	30%		56%	
Other		15%		4%
Sectoral Total		100%		100%

Source: Hagler Bailly Consulting, Inc., 1996.

2.2 Energy efficiency market trends

Nearly all OECD countries have seen substantial improvements in the efficiency of their energy using equipment in the past two decades. As a result, they have established markets for energy-efficient products and services with personnel trained in the installation and maintenance of high-efficiency equipment. The oil price shocks of the 1970s highlighted the economic benefits of energy efficiency and developed countries had the capital resources required to make energy efficiency investments. In contrast, the energy efficiency wave of the 1970s largely bypassed developing countries, where national governments lacked the institutional capabilities to implement and promote energy efficiency policies. Today (in the foreseeable future), new market drivers are expanding the energy efficiency sector in developing countries. Some key trends in the energy efficiency sector include:

- Subsidy removal. In recent years, many developing countries have begun to decrease or remove energy subsidies. This makes the true cost of energy more apparent to end-users and increases the incentives for efficiency;

- Restructuring and privatisation. Restructuring of the electricity sector is typically undertaken to open the power sector to competition and encourage outside investment. In the course of restructuring, many countries are privatising their state-owned utilities and major industries, which generally increases the pressure on companies to cut costs and increase efficiency;

- Demand-side management (DSM). Governments struggling with power supply problems, brown outs, black outs and increasing electricity demand, often encourage energy efficiency through DSM. DSM is viewed as a means of implementing load management and energy conservation initiatives to mitigate these problems;

- Construction boom. Economic growth in developing countries has led to a construction boom, expanding the demand for greenfield energy efficiency projects, specifically those related to building envelope and control technologies;

- Environmental concerns. A growing interest in energy efficiency is coming from the threat local and global environmental problems, including global climate change and concerns for resource scarcity.

2.3 Barriers to investments in energy efficiency

Traditional benefit-cost assessments of energy efficiency investments typically show many projects to be very cost-effective. It is not uncommon to see study-based benefit-cost ratios exceed 10 to 1. Still, large-scale investment in these projects has not generally been undertaken by developing countries. Various barriers to implementation are typically cited as the reason why these potentially cost-effective investments are not undertaken. Another view is that traditional benefit-cost analyses do not fully account for all the costs involved in implementing energy efficiency projects in developing countries. To the extent that barriers exist and represent costs of implementing energy efficiency projects, they need to be addressed as part of the baseline (*i.e.* they are part of the business-as-usual case). A list of barriers might include the following:

- An information cost - a lack of awareness and general misinformation about the benefits of energy efficiency projects;

- An attention cost - managers and households have limited time and attention to devote to the manifold aspects of their business and lives. Energy efficiency projects may have a high rate of return, but still be too small and too complicated to justify the expenditure of attention;

- A technical cost - lack of technical specifications required to select the most appropriate technology;

- A market distortion cost - pricing policies that under-price the true value of the resources being consumed makes conservation less economic for participants;

- Capital allocation costs - the capital pool in the country may not be adequate for incremental/discretionary investments in energy-efficient technologies, which drives up the cost of capital and allocates it to the highest risk-adjusted return projects;

- Public policy costs - taxes and tariffs that discourage the import of foreign-manufactured energy-efficient equipment;

- Cost of cultural barriers - local customs and inertial behaviour can work to maintain the status quo in the design, selection and operation of energy-using equipment.

This partial list of factors might explain different propensities to invest in what may be viewed, in some circumstances, as "economic" energy efficiency projects. Traditional financial analyses may not appropriately address the costs of these barriers. Some of these costs can be overcome by JI/CDM investments (*e.g.* the availability of capital and technical specifications). Other costs (*e.g.* those related to cultural barriers) may remain for JI/CDM project developers.

2.4 Trends in energy efficiency projects and baseline implications

In contrast to other sector projects, energy efficiency projects often comprise bundles of smaller projects. For example, one AIJ pilot phase energy efficiency project in Mexico (see Annex A) involved the replacement of existing lights with higher-efficiency compact fluorescent lamps. This project targeted residential energy use and in two geographic areas - the cities of Guadalajara and Monterrey. While there are some single-site, large-scale energy efficiency projects that have been implemented (*e.g.* a large district heating system or a single large industrial facility), energy efficiency projects are more likely to be characterised by two factors:

- They will span a large number of sites or locations;
- While targeting multiple sites, there still is a specified target market area (*e.g.* the AIJ Pilot Phase lighting project in Mexico spanned many households in a target market covering two cities).

For example, a candidate CDM energy efficiency project might involve retrofitting lighting fixtures in existing commercial buildings larger than 1,000 square metres in that country's four largest cities, *i.e.* the specified target market. The logistics of project implementation have a significant impact on project design. Commercial buildings larger than 1,000 square metres might be targeted since the project developer will want to ensure that, if an engineering team is sent to a site, there will be enough savings at that site to justify the set-up costs of the installation. The target market is limited to the four largest cities in a country due to the costs of shipping and warehousing the lamps and ballasts. Logistics related to the timing of a lighting replacement at a specified site often determines whether an energy efficiency project turns out to be cost-effective in practice as opposed to theory.

The fact that many energy efficiency projects are "targeted" due to implementation challenges can pose problems for establishing baselines. Unadjusted national and even sector-specific energy-use data may not be appropriate for baselines where energy efficiency project developers target a narrow set of facility types in specific regions. Highly tailored energy efficiency projects that focus on only certain types of facilities, with pre-specified energy consumption characteristics, in select markets may not lend themselves to the general application of national or even regional baseline data. The risk that actual project participants will be substantively different in their baseline energy use than those used to create aggregate sector data may be unacceptably high for many energy efficiency projects.

As mentioned earlier, project planning, the screening of energy efficiency measures and final project design, will require national and regional aggregate data. However, for project baselines, some information specific to the facilities and energy users that choose to participate will need to be collected to augment or adjust more aggregate sector baselines. Thus, standardised baseline data for project types and sectors are critical for project planning. However, project baselines likely will need to be more precise and require some information specific to the energy efficiency project participants that can augment or adjust aggregate sector baselines.

Adjustments to standardised energy use baselines to better reflect the particular participants and markets addressed by a specific energy efficiency project can be one component of a standard baseline setting process using project-specific data (see section 4.5). A starting-point energy use baseline subject to adjustment using in-field data on project participants is an established approach and is expected to be much less expensive than having each project develop its own baseline *de novo*. The types of building block information for use in baseline construction that can be developed at a national or regional level are discussed in section 4.5.

3. Baseline Construction

This section presents a simplified example of the typical construction of a baseline for an energy efficiency project. All of the examples of energy efficiency projects and programmes in Annex used variants of this simple case. This approach begins with an algorithm that calculates energy use; then, data are gathered as inputs to this algorithm. In most cases, cost-effective data collection requires the use of a sample from the target population. This sample is used to provide “average value” baseline inputs to the standard algorithm (or calculation).

3.1 Baseline calculation: data needs, quality and availability

Energy efficiency baseline construction requires information on the energy consumption characteristics of the energy end use/application targeted by the project. The following equation provides a simple generic formulation of energy use for a population of electrical technologies:

Equation 1, Baseline energy use:

Energy Use = Quantity x *Power* x *Operating Hours* x *Diversity Factor*

Where:

Quantity is the number of devices in each type and size category.

Power is the electrical[9] input to the device. This is typically reported as Watts for lighting fixtures. For other technologies, this value is often estimated from other performance parameters. For example, motor power can be estimated from horsepower, efficiency and load factor.

Operating hours is the annual hours of during which the device operates.

Diversity factor is a measure that account for the fact that in a population of devices, some fraction of the units will either be off or out of service at any point in time due to burnout, modernisation or repairs/maintenance; this factor is related to the quantity.

This formula is important because it defines which data need to be collected, which factors have to be estimated and which factors lend themselves to standardisation. This generic formula is adaptable to most end-use and technology categories. Energy efficiency projects are typically directed at influencing some combination of power and/or operating hours, through equipment control, repair, retrofit or replacement.

The diversity factor accounts for the real-world operating conditions of a population of devices and has the net effect of discounting estimates that are based only on gross equipment counts and/or rated conditions. This is an important factor in assuring that the energy use and savings attributable to energy efficiency projects are not overestimated.

While energy-use analyses typically begin with an algorithm, these algorithms can be part of a model that incorporates many energy uses and therefore many algorithms (*e.g.* energy audit software for buildings or industrial processes). They can also be made more complex by incorporating multiple pieces of equipment and interactions across end-uses (*e.g.* installing energy-efficient lights reduces the amount of heat given off

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[9] “Power” could also represent other fuels.

by the light fixtures and thereby reduces energy required for space cooling during hot weather). However, these algorithms use the same basic parameters regardless of the equipment or end-use they are meant to address. Issues in the construction of the baseline often stem from the way in which data are collected for use in an algorithm, rather than the algorithm itself.

3.1.1 *Simplified application - a lighting equipment example*

Energy efficiency projects in lighting are a good example of potential JI/CDM projects since they are relatively simple and lighting is an energy application where large gains in efficiency often can be obtained at relatively low cost.[10]

The basic algorithm used to calculate baseline energy use (kWh) for a lighting fixture may be constructed as follows:

***Equation 2,* Calculation for baseline energy use for a lighting fixture:**

Lighting Fixture Energy Use (kWh) = Power (kW) x *Hours of Operation*

For a specific existing lighting fixture in a building, the baseline annual energy use (kWh) is the measured (or estimated) kW, multiplied times the hours of operation. Issues in determining the baseline energy use for this fixture involve different ways of obtaining the data that are input to the algorithm and used to calculate annual energy consumption.

The first term in the equation (power) is measured in kW and can be obtained using several different methods.

Methods for estimating power (kW) for lighting fixtures

1. *Nameplate ratings* can be used where the manufacturer of the lamp and the ballast is identified. The manufacturer's ratings can be used as the estimate of the in-field power draw (kW).
2. *Bench tests* can be made using different lamp and ballast[11] combinations to determine the actual kW draw for each combination. Bench test results are used rather than the manufacturers' nameplate ratings.
3. *In-field spot-watt measurements* can be taken. An energy efficiency analyst can take a measurement from a specific fixture, or set of fixtures, on a lighting electric circuit. The kW draw for that circuit or fixture is measured using a watt metre that provides a kW measurement for a single point in time.

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[10] Energy-efficient lighting is one of the largest market segments in the energy efficiency market. Lighting accounts for over 25% of CO2 emissions in the commercial and residential sectors and offers, perhaps, the largest and most cost-effective opportunity for reducing energy use in these sectors. Fluorescent (tubes and compact fluorescent lamps/CFLs) and incandescent lamps are widely used in the commercial and residential sectors. Fluorescent lamps generate less heat than incandescent lamps and are much more energy efficient, reducing energy by as much as 75% through a simple replacement programme. Since incandescent lamps dominate the residential market in both industrialised and developing countries a lighting replacement project represents a significant opportunity for energy savings and potential emissions reductions.

[11] Fluorescent lighting fixtures are comprised of different lamp/ballast combinations - one to four lamps, one or two ballasts. Energy efficiency improvements in lighting can be made by replacing existing lamps with high-efficiency lamps, replacing existing ballasts with high-efficiency ballasts, or by installing a combination of these actions. In general, different lamp and ballast combinations have different power draws.

Watt metres are inexpensive and often used in lighting applications since the kW draw for lighting fixtures is not expected to vary much across time, *i.e.* the light is either on or off. Other equipment such as motors and air conditioners can run at "part loads" and the kW draw may vary over time.

4. *Interval metering* of lighting equipment can be performed. The three options listed above provide only instantaneous kW measurements. Operating hours to determine energy use (kWh) must be obtained from some other source. Interval metering provides both kW and hours of operation. A metre is installed at a lighting fixture or on a lighting circuit and left in place for a period of time. This provides a measure of kW on 5-minute or 15-minute intervals and it also provides data on operating hours. Thus, it can provide an estimate of kWh for the time period in which the metre is installed, including any variations in kW from hour to hour, should such variations occur. Short-term metering refers to a metre installation that lasts for a period of weeks. Long-term metering refers to periods of nine months or more and could be for periods of up to several years. Long-term metering can capture changes in operating hours that occur seasonally.[12] There is a significant cost trade-off between short- and long-term metering. If the meter interval is only two weeks, then the metres can be re-used at different sites. In long term metering, a larger inventory of metres is needed, resulting in higher costs for baseline data collection.
5. *Most efficient replacement equipment* is also used in some instances as the appropriate baseline value for kW. The argument is that the average kW power draw of existing equipment does not represent what would have been installed in a facility if the energy efficiency project did not exist. In this case, the baseline assumption is that, instead of replacing the existing lamp with another lamp that has the same level of efficiency, a more efficient lamp would have been installed. In this case, lamps in stock at suppliers would be examined and the nameplate rating of the most often sold equipment would be used as the baseline data input.

Nameplate ratings are the simplest and least-costly data source and are reasonably accurate for most lighting applications. Bench tests and spot-watt measurements also are cost-effective methods of establishing baseline power and performance characteristics, particularly for technologies with relatively constant performance characteristics such as most lighting applications. Interval metering is typically not necessary or justifiable on a cost basis for lighting, whereas it can be a valuable tool for technologies that exhibit variable performance characteristics.

The three lighting project examples shown in Annex A used the kW of existing in-field equipment as the basis for constructing the baseline. The use of the "most-efficient replacement" kW value is not a common method for determining energy use baselines in developing countries. A more efficient piece of equipment may have a lower lifetime cost, but capital constraints in developing countries make it likely that the lowest initial cost equipment will be selected. There is also an educational component to this decision.[13]

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[12] The appropriate interval for metering is an issue of debate among energy efficiency engineers and statisticians. In general, the state-of-the-practice has been the use of short-term metering for lighting projects, with an adjustment factor estimated to account for seasonal effects (*e.g.* less hours of daylight in the winter). Often, the compromise has been to do mixed metering. A small number of installations have been metered for nine months to capture both the summer and winter seasons. A larger number of installations have short-term interval metering (*e.g.* two weeks). A ratio that shows the relationship between hours of operation in the summer, between summer and the shoulder seasons (spring and autumn) and between summer and winter. This ratio is then applied as an adjustment factor to energy use estimates from the sample that only has short-term metering available. In some regions, there has been extensive metering on lighting use from earlier studies where results from previous projects are used to calculate adjustment factors for new energy efficiency projects. This is one example of how field data can be used across projects.

[13] Studies have shown that many purchasers are sceptical about the energy efficiency claims made by manufacturers and consumers may select the lower initial-cost equipment because they are uncertain about whether the savings in terms of higher equipment efficiency will, in fact, be realised.

For lighting baselines, it has been common even in developed countries to use the average in-field efficiency of lighting fixtures for projects aimed at replacing existing equipment, as was done in the three developing country case studies. In contrast, most developed countries use "most efficient replacement equipment" for other end uses such as air conditioning and refrigeration, which have shown steady efficiency improvements over time and where replacements typically only occur at the time of equipment failure or a major renovation project. The justification for using different approaches is that lighting has generally represented a "change in technology" and the new technology would not have been available without the programme. Appliances such as refrigerators have not seen the step-change in technology but, instead, have shown steady improvement over time and, therefore, would have been available in the business-as-usual case as replacement technology.

After estimating the power (kW) for a lighting fixture, it is necessary to estimate the operating hours to determine electricity use. Just as there are several options for estimating power for lighting fixtures, there are several methods for estimating baseline operating hours.

Methods for estimating operating hours for a lighting fixture

1. *Occupant estimated* hours of use can be obtained. This approach simply surveys the building occupants to obtain their estimates of the hours a lighting fixture is on.

2. *Runtime metres* can be installed. Runtime metres measure the number of hours a piece of equipment is on or off. These metres are relatively inexpensive and easy to use and they can measure the number of on/off hours in more than one time period, *e.g.* they can measure the number of hours of operation during a peak period and the number of hours of operation in an off-peak period.

3. *Interval metering* can also be used, as discussed above. An interval metre is installed for a period of time and measures both kW and operating hours, as well as the load curve. A load curve provides the kW loads for each 5- to 15-minute interval during a day. These data can be used to calculate contributions to peak demand (*i.e.* peak coincident factors) and diversity factors (*i.e.* what fraction of the participating lighting fixtures are on at any point in time). If information on peak demand and peak period energy use is important for calculating reductions in emissions, then interval metering provides the information necessary to make these calculations.

The most common approach, in the context of traditional energy efficiency programmes, calculates energy use baselines for lighting fixtures using either occupant surveys or runtime metres to obtain estimates of operating hours. Interval metering has generally been viewed as cost prohibitive[14] for most lighting projects in developing countries. For kW estimates, the most common approaches are to obtain estimates from nameplate ratings, bench tests or watt metres. Occasionally, short-term interval metering has been used for lighting equipment. While the appropriate estimation approach may depend upon the specifics of the lighting project, it is generally becoming recognised that run-time metres combined with spot-watt measurements provide accurate information at a relatively low cost.

The lighting example discussed above generally applies to other energy using equipment as well. All the methods for estimating kW and operating hours discussed above were used in one or more of the project examples presented in the Annex A, with the exception that no example used the kW of "most efficient replacement equipment" for either lighting or motor baseline.

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[14] While interval metering has not been common for use in energy use baseline development in developing countries, it has been used after the installation of the energy efficiency equipment to monitor how well the equipment is working. Extending this post-installation interval metering to pre-/post-metering that also provides baseline estimates is not difficult and the costs of metering equipment are rapidly declining with more variants of equipment available.

3.1.2 Simplified application - estimating the energy use baseline for a lighting project

The discussion above focused on how an energy efficiency baseline can be established for a specific piece of energy using equipment. Energy efficiency projects typically involve large numbers of equipment at many different sites. For example, the Mexico AIJ energy efficiency project, Ilumex, targeted lighting across many residences. Most energy efficiency projects target a specific sector and end-use (*e.g.* residential lighting, industrial sector motor drive, commercial sector lighting and refrigeration in food service applications). As a result, the baseline must address energy consumption across many pieces of equipment in a selected sector.

While the details of energy use baseline assessment vary, the general approach in most applications is composed of a common set of elements. The basic steps in developing a baseline for an energy efficiency project again start with the standard engineering algorithm. Continuing to use lighting as the example, the algorithm for the project energy use baseline becomes:

Equation 3, Calculation of energy use baseline for energy efficiency project:

Baseline for Lighting Energy Use (kWh) *= Average Power (kW)*
x *Average Hours of Operation*
x Number of Sites

The energy use baseline needs to represent the average[15] equipment energy use as determined in the data collection. This is done by selecting a sample of project participants, collecting data on kW and hours of operation for the sample (as discussed above) and using the mean values of these sample data as estimates for average use for all project participants.[16] Note that there is no need to establish the total energy used for lighting since the role of the energy use baseline is to assist in estimating the change in energy use due to the sites participating in the project. This change equation is shown below:

Equation 4: calculation of energy savings from energy efficiency CDM projects

Energy Savings at Site (i) *= [(Baseline Lighting Use) - (New More Efficient Lighting Use)]*
x [No. of Fixtures at Site (i)]

Total project energy savings is the sum of the site energy savings across all project participants.

3.1.3 Simplified application - converting energy use to GHG emissions

Once baseline electricity use has been established, it still is necessary to translate the electricity use into GHG emissions. The conversion of electricity use into GHG emissions is the subject of a separate case study on methodologies for emission baselines in the electricity sector (see Electricity Case Study).

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[15] It may also be useful to consider developing energy use baselines based on a "better than average" equipment energy use. This may warrant further examination.

[16] As discussed earlier, instead of using the average efficiency level of existing equipment in the field, another option is to use the average or even the highest efficiency level of equipment being sold as replacements. Compromises can also be made where replacement equipment is estimated to have an efficiency between that of the in-field equipment and highest available efficiency. This assumes that a fraction of the participants would have purchased the most-efficient equipment. In such cases, "better than average" efficiency might be appropriate.

3.2 Essential steps in baseline construction

This section summarises the basic steps constructing baselines for energy efficiency projects. The baseline setting approach comprises six steps, namely:

1. *Define project participation criteria*. One of the most important steps is to develop criteria for participation in the energy efficiency project. This sets the initial project boundaries and defines the population whose energy use is to be represented by the estimated baseline. For example, the population of potential project participants might include all residences in a geographic area, or all commercial buildings over 1,000 square metres in five major cities.
2. *Determine sample size*. The sample size is determined using appropriate techniques; however, for lighting projects, sample sizes of between 60 and 100 participants have been adequate.
3. *Draw baseline sample.* Once criteria are established for participation and the sample size is determined, the next step is to draw the sample from the population of eligible participants. Data are collected on these sample participants and used to develop the energy use baseline.
4. *Determine method for estimating power and operational and performance factors for the baseline sample.* For the sample, power (kW) and operating hours are estimated using the methods presented in section 3.1.
5. *Establish energy use baseline*. Using the operational and performance data collected in Step 4, the project energy use baseline is estimated from the baseline energy use calculated for the sample.
6. *Calculate corresponding GHG emissions baseline.* Here, the baseline energy use is translated into GHG emissions.

The data collection and analysis for estimating the energy use for a lighting fixture or piece of equipment can be approached in a number of ways, depending on time and cost constraints. In developing countries, the survey- and field-intensive data collection methods are often preferable to installing measurement equipment since the cost of capital and technology is often well above the cost of labour. In countries without privatised electricity markets, there can be high amounts of unmetred electricity use both from direct theft and equipment failure. Information in developing countries may also be more difficult to find, for example, public records listing building size and use may not always be available. This poses as many problems for project planning and implementation as it does for baseline construction. Countries with better information and more accurate energy billing will likely be more attractive to host JI and CDM energy efficiency projects.

The use of sampling is important in that it keeps the costs of establishing a baseline using project-specific information manageable. Now, information is required on only a sample of project participants. Since the baseline is based on energy use for the sample, the baseline for a specific site may be, in some cases, inaccurate individually. However, if a large number of sites participate in the energy efficiency project, the baseline aggregate energy savings will be accurate in general. This approach assumes that the sample selected to calculate average consumption is representative of the sites that actually participate in the programme.

Most debates over the quality of the baseline revolve around concerns about whether the sample selected is indeed representative of the project participants and their energy use going forward. As a result, the selection of a sample is often a crucial determinant of a “good” baseline.

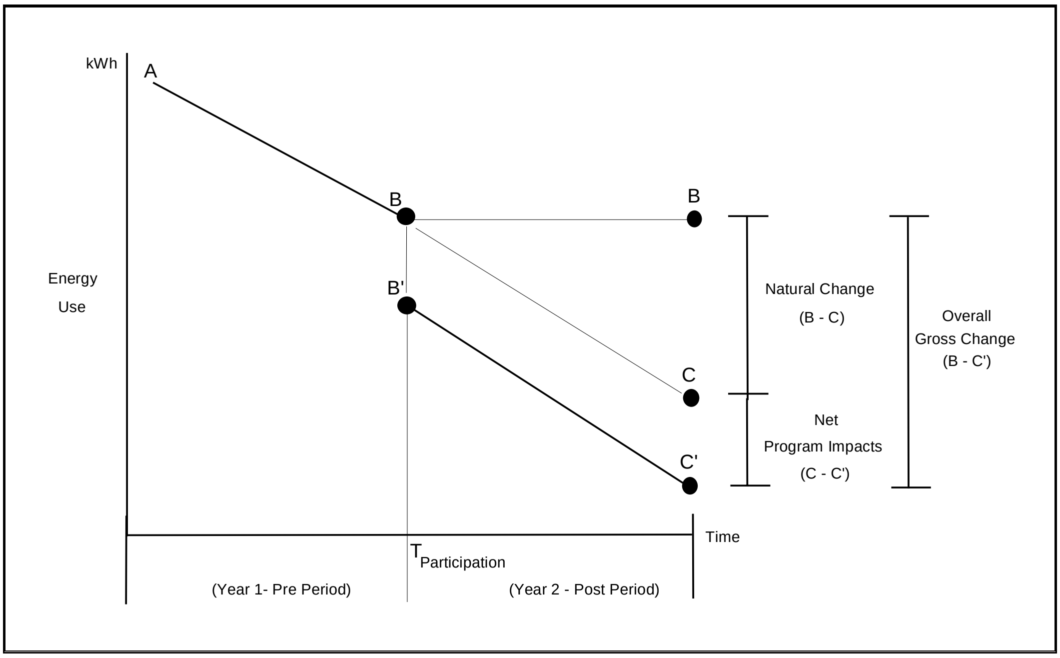
As a summary, Figure 1 illustrates the baseline energy use estimation challenge.

The line segment AB shows the business-as-usual trend in average energy consumption (per unit of energy service) for a group of customers prior to their participation in an energy efficiency project. The segment B’ - C’ shows the new trend in energy consumption after participating in the project. The line segment BC shows the business-as-usual energy consumption trend that the participating customers would have been on had they not participated in the project. Project impacts, in terms of reduced energy use, occur after the measures are installed, *i.e.* at time $T = T_{part}$ and are equal to the difference between C and C’, *i.e.* the difference between the necessarily estimated baseline consumption C and C’, current energy use which can be measured through monitoring the energy efficiency project.

Segment AC represents the energy use per unit of energy service baseline and it needs to account for projected increases in efficiency, technological change, economic growth and other exogenous factors that affect the level of energy use (or emissions) at a facility or region targeted by the CDM project. The basic approach outlined in this section uses the in-field experience of representative project participants and compares that experience to the energy use of project participants after participating in the project. In certain cases, it will be important to review the baseline over time via a participant or comparison group to obtain an estimate of the time trend in baseline energy use. This is represented by line segments AB and BC in Figure 1. Additional information on energy use baseline estimation issues - such as free riders, free drivers and self-selection, in the context of energy efficiency programmes, can be found in IEA (1996).

Figure 1.

Illustration of an energy use (per unit of energy service) baseline estimation



3.3 Energy use baseline construction - application to energy efficiency projects and programmes implemented in developing countries

All of the examples of energy efficiency project baselines presented in Annex A used the basic approach discussed above. Two general types of energy efficiency activities are addressed in Annex A: (1) targeted equipment replacement projects (*e.g.* lighting, motors) and (2) audit-based evaluation and installation programmes.

Examples of data collection protocols, which are necessary for the construction of energy use baselines, can be found in the energy efficiency projects and programmes in Annex A. In addition, a number of industrialised countries have created national data sets that are used both in project planning and energy use baseline development. Such data sets could also be created in developing countries and countries with economies in transition. It may be difficult, however, to standardise all of the data inputs required by the algorithms used to set baselines for energy efficiency projects due to project and site diversity. Nonetheless, the baseline-setting process for energy efficiency projects does appear to lend itself to a high degree of standardisation in the general method used as well as guidelines and standards for project-specific data collection (this is further discussed below).

3.3.1 Audit-based programmes as a means of constructing baselines

Several of the energy efficiency examples presented in Annex A involve audit-based programmes where participating facilities underwent an energy audit to determine which energy efficiency measures were the most cost-effective, *i.e.* which achieve the greatest reduction in energy use per dollar expenditure. Significant energy savings can occur when a project combines audits with the implementation of identified energy efficiency measures. This has resulted in a number of combined “audit/implementation” programmes being undertaken in developed countries and several of the Annex A examples represent programmes of this type.

Audits typically examine a comprehensive set of measures spanning a wide range of end-use applications. One advantage of these programmes is their comprehensiveness. Since audits are designed to examine all major energy end-uses, there are few lost opportunities at a site (*i.e.* few cost-effective measures not identified). In addition to equipment replacement options, audits will generally examine thermal shell measures such as wall and ceiling insulation, high-efficiency windows and using light-coloured roofing materials to reflect heat from the building. A second advantage is that audits are more likely to examine interactions among installed energy efficiency measures. For example, reducing lighting wattage will also reduce the cooling requirements of a commercial space.

The audit process uses the same algorithms discussed above and the process can be standardised, even to the extent of having common software packages developed for specific types of assessments. One difference is that the population of participants undergoes an audit. In some cases, a sample of participants will be given a more detailed audit, supported by run-time and kWh metering, to calibrate less rigorous audits that may borrow data from other similar audits (*e.g.* an audit of one commercial building may borrow data on lighting intensity per square metre from an earlier audit of a similar building). In this instance, all the basic steps for baseline construction discussed above, including sampling, still apply. However, the baseline estimation problem is simplified because all participants undergo an energy audit, which establishes the baseline energy use at that site. The energy use baseline for the project is then the sum of each project participant’s audit baseline.

One concern might be that the auditor would have an incentive to overstate current energy consumption, thereby inflating the estimated energy savings from measures installed at that site. However, there are a number of controls that can be implemented to reduce the likelihood that this will occur. Three such controls are:

- Audit standards and protocols can be established. For example, several professional associations offer training and certify energy professionals as "energy auditors". Several universities also have programmes that provide similar credentials.
- Audits are designed such that the sum of energy used in all end-uses equals the total measured consumption as shown on bills or as metre reads. This helps prevent egregious errors in energy baseline assessment.
- The auditors themselves can be audited. A number of audit-based programmes have had provisions where outside professionals would re-audit a sample of facilities to assess the quality of the work.

4. Standardising Baseline Assumptions

This section employs the energy-use baseline construction methods from the Annex A examples to develop several options for preparing energy use baselines and standardised protocols. Lighting and motor replacement programmes are the focus of this section to allow specific options to be developed, but the general conclusions can be applied to any equipment replacement project or audit programme.

Several of the examples in Annex A estimate a reference case or baseline for energy use as part of a larger impact evaluation or market assessment study. These examples did not focus on baseline construction per se, but instead concentrated on estimating and monitoring the post-installation energy use of the energy-efficient technologies promoted by the project. For many energy efficiency projects in developing countries (and even in developed countries), it is generally assumed that the project is cost-effective. After all, older less-efficient equipment is being replaced by more efficient equipment.

As a result, the primary concern in many studies of energy efficiency projects in developing countries was not energy use baseline estimation but, instead, the focus was on the appropriate installation, operation and maintenance of the new energy efficient equipment. In many cases, there was limited experience with the new equipment in developing countries and there was concern over how to install and operate the equipment to obtain maximum benefits. Consequently, the methods of constructing energy use baselines for a number of the energy efficiency projects in Annex A were generally not well documented and were supported by relatively little data.

In the case of JI and CDM energy efficiency projects, there will clearly need to be a greater focus on the baselines. CDM or JI project developers (and the international community) will be concerned about the actual magnitude of energy saved (not just whether the programme exceeds a cost-effectiveness threshold) and the corresponding GHG emission reductions. For this reason, historically-applied energy use baseline methods in developing countries may not be an appropriate roadmap for future JI and CDM baselines.

Table 2 presents an overview and summary of seven examples of energy efficiency projects and programmes in developing countries. A full discussion of the examples is found in Annex A. For the reasons cited above, these examples were generally weak in their documentation of energy use baseline assumptions and reporting of statistical information. This may indicate a need to develop reporting guidelines for JI and CDM energy efficiency projects explicitly requesting this type of information.

Table 2. Summary of implications for standardisation from energy efficiency case studies

(See Annex A for further details)

Sector/End Use	Energy Use Baseline Development Approach	Implications for Baseline Standardisation for Energy Efficiency Projects
Residential and non-residential lighting (Thailand)	▪ A sampling protocol was developed to collect on-site data for estimating typical operating parameters for all project participants. ▪ Calibrated engineering algorithms were used to compute baseline energy usage. ▪ Performance parameters were verified via on-site spot measurements and data logging.	▪ Develop standardised calculation procedures using algorithms similar to those used in this project. ▪ Build "efficiency timeline" considerations (*e.g.* persistence) into algorithms. ▪ Develop standardised performance parameters (*e.g.* operating hours) in the residential and commercial sectors. ▪ Develop standardised sampling and data collection protocols in order to allow data collected from a sample of sites to be representative of all project sites.
Residential and non- residential lighting (Pakistan)	▪ A sampling protocol was developed to collect on-site data for compiling building and energy system features that characterise the entire population. ▪ Detailed on-site audits were conducted for a sample of buildings for all major end uses.	▪ Develop standardised sampling and data collection protocols in order to allow data collected from a sample of sites to be representative of all potential project sites.
Residential lighting (Mexico)	▪ A sampling protocol was developed to leverage information across sites. ▪ Surveys were used to estimate the number and wattage of lamps installed. ▪ Actual watt savings and operating hours were verified via on-site spot measurements and data logging.	▪ Develop standardised performance parameters (*e.g.* operating hours) in the residential sector. ▪ Develop standardised sampling and data collection protocols in order to allow data collected from a sample of sites to be representative of all project sites.

(continued)

Table 2

Sector/End Use	Energy Use Baseline Development Approach	Implications for Baseline Standardisation for Energy Efficiency Projects
All major end uses in residential, commercial and industrial sectors (national assessment) and residential lighting (pilot study) (Morocco)	▪ A sampling protocol was developed to collect on-site data for estimating typical operating parameters for all programme participants. ▪ Surveys and interviews with samples of end-users to collect detailed information on all major end uses. ▪ Baseline energy used initially estimated with engineering algorithms. ▪ Energy savings estimated via a statistically-adjusted engineering approach using billing data and samples of end-use metered sites.	▪ Develop standardised calculation procedures using algorithms similar to those used in this project. ▪ Build “efficiency timeline” considerations (*e.g.* persistence) into algorithms. ▪ Develop standardised performance parameters (*e.g.* operating hours) in residential and commercial sectors. ▪ Develop standardised sampling and data collection protocols in order to allow data collected from a sample of sites to be representative of all project sites.
Commercial and industrial electric motors (Mexico)	▪ A sampling protocol was developed to facilitate data collection. ▪ Detailed on-site audits were conducted for a sample of sites to collect data on technical performance and operating characteristics.	▪ Develop standardised sampling and data collection protocols. Sampling and in-field data collection protocols could be developed to follow standardised guidelines for use in developing baselines using project-specific data.
Agricultural tubewell water pumping (Pakistan)	▪ Detailed on-site audits were conducted to collect data on technical performance and operating characteristics. ▪ Baseline pre-retrofit operating data and energy usage were determined from the on-site data.	▪ This project indicates that sampling and in-field data collection protocols could be developed that follow standardised guidelines. ▪ In general, operational and performance parameters were determined from site-specific audits.
Commercial and industrial boilers (Pakistan)	▪ A sampling plan and protocol were developed. ▪ Detailed on-site audits were conducted for a sample of sites to collect data on technical performance and operating characteristics.	▪ This project indicates that sampling and in-field data collection protocols that follow standardised guidelines could be developed. ▪ Site-specific operational and performance parameters were determined by energy audits.

4.1 Determining standard baseline performance

This section assesses the different options for constructing energy baselines in the lighting and electric motors sectors, with emphasis on how standard approaches might be used to simplify energy use baseline construction. In each instance, examples are drawn from Annex A to show how these options have already been - and are currently being - adapted to a certain extent in the examination of energy efficiency projects in developing countries.

Factors that tend to support or limit standardisation possibilities include:

- Energy use characteristics of the market segment. Constructing energy use baselines requires information on the particular consumption patterns of market segments. Energy consumption patterns may be more uniform in one segment than another and this supports the standardisation of consumption values and indices. In addition, equipment performance (*e.g.* efficiency) for certain technologies may be relatively uniform across segments, but operating characteristics (*e.g.* operating hours) may vary and each may have characteristics that are unique to, or typical of, that sector/segment.

- Homogeneity of markets. Residential applications tend to be more homogenous than industrial, for example. Thus, more opportunities exist to standardise energy use characteristics in the residential sector. As a general rule, moving across the market segment spectrum from residential to industrial, energy markets are increasingly heterogeneous and less subject to overall standardisation.

- Technology performance variability. End uses that tend to have more constant performance characteristics lend themselves to greater standardisation of baseline performance. For example, residential refrigerator energy use tends to be relatively uniform within certain categories and lighting systems tend to show more constant performance characteristics (they are either on or off and may have well defined operating hours). Space heating and cooling, on the other hand, are very weather dependent and have variable output and efficiency characteristics. Energy use baseline construction needs to account for this variability.

There are essentially three options available for energy use baseline standardisation for energy efficiency projects. They are:

- Standardising baseline calculation methods and data collection protocols. The algorithms and models used to compute energy use and the data that provide inputs to the algorithms.

- Standardising operating and performance parameters. The values that describe the energy use characteristics of a given technology or end use, such as lamp wattage for lighting and motor efficiency for electric motors.

- Standardising energy use indices. Indices that are representative of the energy use of a population of technologies or segment of the population, such as lighting kWh per square metre for certain commercial building types.

Each of these options is discussed below along with insights from the examples presented in Annex A.

4.2 Standard calculation and data protocols - lighting and motors

One option is to standardise baseline calculation methods (*i.e.* algorithms and models), baseline data requirements and collection methods for different energy efficiency applications. To a certain extent, this has already been done through and EPRI impact analysis literature (EPRI, 1991, 1995a, 1995b, 1996) and the IPMVP protocols (US DOE, 1997). This body of work has universal applications for energy use assessment and could provide a sound theoretical and methodological basis for the development of energy use baselines for CDM projects in developing countries.

4.2.1 Standard calculation and data collection protocols for lighting

As noted in Equation 3, the annual energy consumption for a population of lighting devices is a function of power draw (input wattage to the fixture) and operating hours. Data for each of the parameters need to be collected or estimated.

Standardisation of the calculation algorithms, data requirements to support those algorithms and data collection protocols would help promote the application of appropriate procedures and reduce the uncertainty in baseline construction faced by JI or CDM project developers. Wattage and operating hours could be estimated from technical data tables, engineering methods, or a sample of field observations. Standardised guidelines could be prepared to lend uniformity and consistency to these data collection tasks for energy efficiency projects. Three of the energy efficiency examples in Annex A provide some insights on the application of this approach:

- The Thailand CFL lighting replacement project (in progress) has planned to employ a uniform calculation methodology similar in format to Equation 3 for estimating programme impacts and systematic data collection methods supplemented by in-field and bench test spot-watt measurements. Calculation algorithms and spot-watt measurements for estimating input wattage similar to those used in Thailand could be standardised for similar lighting projects.

- The Mexico Ilumex project used the wattage of the incandescent lamps replaced by the programme as the baseline. Compact fluorescent lamp wattages were determined from spot-watt measurements and operating hours were estimated from a sample of on-site, run-time measurements. Spot-watt measurements and run-time data collection protocols and sampling techniques similar to those used in this project could be standardised to estimate operating hour assumptions for other residential sector lighting projects. In the commercial sector, a similar process could be used to standardise lighting operating hours, although it would be necessary to disaggregate the results by market segment.

- The Morocco residential Lighting Pilot Project employed standard engineering algorithms with well-developed and fundamentally sound data collection techniques. Engineering estimates of savings were developed using the following algorithm:

$$\begin{aligned} \textit{Energy Savings} &= (\textit{Watts}_{\textit{incandescent}} - \textit{Watts}_{\textit{CFL}}) \\ &\quad \times \textit{Operating Hours} \\ &\quad \times (1 + \textit{Take Back Factor}) \end{aligned}$$

The approach used in this project provides an example of methods that could be standardised for cross-sector baseline development that accounts for factors such as urban and rural energy use variation.

All three examples of lighting projects employed a similar approach to baseline energy use construction using a general energy use algorithm similar to Equation 1. Differences in data collection methods were found in the examples examined; however, no information is available from these examples on how the different data collection techniques might have influenced the baselines. In general, it is believed that it would not have been appropriate to use a standardised set of data across countries. Data on the technologies deployed and their operating conditions unique to each country would most likely be required to develop appropriate baselines. However, a common (standardised) approach to collecting the data, using state-of-the-practice techniques, could be shared across all three countries.

4.2.2 Standard calculation and data collection protocols for motors

Annual energy consumption for a population of motors can also be characterised by an algorithm similar to Equation 1. Energy use is then characterised by motor size, efficiency and operating hours. While the basic energy algorithm is simple, energy use baseline development depends on values for each of these parameters. Data for each of the parameters need to be collected or estimated. As a general guide, the number of motors by horsepower category is collected and tabulated at either the site or population level (population of motors within a market or market segment to which the efficiency project will apply). Efficiency and operating hours, on the other hand, must be estimated from technical data, engineering methods or a limited sample of field observations.

For example, the Mexico industrial motors efficiency project discussed in Annex A used a standard engineering algorithm to compute energy use for both standard and energy-efficient motors. This is a typical approach for motor applications and is well suited to a standardised methodology.

4.3 Standardising operating and performance parameters - lighting and motors

Equation 1 identified the generic types of operating and performance parameters that need to be known or estimated in order to develop baseline energy use for an end-use or sector. For many common energy efficiency applications, it is possible to define typical baseline values for operating and performance parameters. Parameters such as operating hours, efficiency and power draw lend themselves to standardisation within certain sectors and applications. For example, experience with demand-side management programmes in developed countries has shown that it is possible to tabulate baseline efficiencies for common types and sizes of electric motors. This would be a reasonable option to undertake for a country or for selected regions. While the authors are not aware of a study that has been conducted to validate any specific regional delineation, it is likely that areas such as Central America could share a common data set and possibly portions of Asia and Africa. However, the homogeneity of any region can only be known after the data are collected and analysed in a variance/co-variance analysis.

The standardisation of baseline operating and performance parameters does not, of itself, establish the baseline energy use for energy efficiency projects. However, it reduces the time and cost of estimating the energy use baseline for project developers and brings greater uniformity and consistency to the CDM/JI baseline development process. Developing parameter values that err on the conservative side could minimise uncertainty and opportunities for gaming the system, while maintaining reasonable incentives for investors. Examples of “conservative” parameter values are presented below for lighting and motors projects.

4.3.1 Standardised operating and performance parameters for lighting

Performance parameters such as fixture input wattages could be standardised for typical fixture types. The average input wattage for common types of fixtures, lamps and ballasts can be estimated from manufacturers' data and verified with a sample of in-situ spot measurements or bench tests. Variations in manufacturers' products in different countries could complicate this process, although there are typically only a few dominant manufacturers in each country. The standardisation of operating and performance parameters would be applicable to the most common types of devices, particularly in residential and commercial applications. For example, baseline data on wattages for common types of incandescent and fluorescent residential and commercial lighting fixtures could be established, whereas large industrial projects such as stadium lighting would most likely be based on specific site data. Even though it would be difficult to standardise operating and performance parameters for these types of industrial projects, analytic and data collection methodologies could still be standardised.

Operating hours and the diversity factor are examples of parameters needed to compute energy use for a population of lighting devices and lend themselves to standardisation within certain limitations. Operating hours tend to be relatively consistent within specific market segments (particularly in the residential and commercial sectors) and could be conservatively standardised. Operating hours, however, are variable by market sector/segment. Establishing these baseline values would require end-use load research on a country-by-country, or possibly regional, basis. For example, residential lighting operating hours are typically 1000-1100 annually and commercial office lighting applications are in the 3500-4000 range. With a reasonable sample of observations, these could be conservatively estimated across a sector or segment by selecting the lower end of this range. This would still provide a reasonable incentive to potential project developers, while assuring that energy savings are not overestimated. The same reasoning applies to other performance factors. For example, fluorescent ballast input wattages for different lamp/ballast combinations vary by manufacturer. By selecting a set of input wattages for the most common/standard fixture types that tend toward the lower end of the range, a conservative baseline condition is established. This approach has been applied in North American DSM projects. Baseline development for a lighting energy efficiency project applied across a broad market in a country may require an estimate of the quantity of lighting devices by type and input wattage.

Examples from Annex A showing how operating and performance parameters can be estimated include:

- The Thailand CFL lighting replacement project has planned to estimate average input wattages for each lamp type promoted by the programme and average operating hours for the participant population. A similar approach could be taken for common lamp, ballast and fixture configurations and for lighting operating hours. In order to support realistic incentives to project sponsors, it would be desirable and possible to differentiate operational parameters such as operating hours by market segments.
- The Mexico Ilumex project estimated input wattages from a sample of spot-watt measurements and operating hours from a sample of on-site, run-time tests. Wattages and operating hours are summarised in Table 3. Average run-time hours were applied to all project participants in this project. This was a residential sector project and, since operating hours tend to be relatively uniform across the residential sector, this represents a reasonable approach to standardising a key performance parameter. Again, in the commercial sector (*e.g.* office buildings, convenience stores and schools) lighting operating hours could be standardised by market segment.

Table 3. Lamp performance data (Mexico Ilumex project)

Baseline Incandescent (Watts)	CFL Watts		Daily Hours of Operation
	Nominal	Measured	
100	23	21.1	3
75	20	17.8	3
60	15	16.1	3

- The Morocco DSM market research study and the residential lighting pilot produced a valuable dataset of energy use characteristics. This project provides an excellent example of an approach that could be employed to develop standardised performance and operating parameters in selected market sectors. Examples of operating and performance parameters from this study that could potentially be standardised include:

  - Residential sector: average number of lamps per household, average baseline lamp wattages and average lamp operating hours for both urban and rural customers. Table 4 summarises the lighting characteristics determined by the market research study.

Table 4. Summary of lighting characteristics by urban and rural areas

	Urban	Rural
Average Number of Lamps per Household	9	6
Average Wattage of Lamps	93	87
Average Daily Hours of Use	2	2

Source: USAID, 1997

  - Commercial sector: input wattages by lighting type (incandescent, fluorescent, halogen and compact fluorescent) and average daily operating hours by facility type. Table 5 summarises commercial indoor lighting characteristics found by the market research study.

Table 5. Summary of commercial indoor lighting (Morocco DSM research study)

Type of Lighting	Average Number of Units Per Facility	Average Wattage	Average Daily Hours of Use
Fluorescent Lamps	263	53	10
Incandescent Lamps	269	93	6.5
Halogen Lamps	39	262	9.2
Compact Fluorescent Lamps	47	22	6.6

Source: USAID, 1997

These lighting examples and the wide range of experience in developed countries show that it would be possible to develop a set of standardised operating and performance parameters for energy efficiency projects in the lighting sector. Table 6 gives an example of a framework for organising lighting performance data that has been successfully employed in North American DSM projects. These parameters would be used in Equation 1 to build up an estimate of the energy use baseline for the given market or market segment to which the project may apply. It is important to note that the actual datasets would most likely need to be developed on a country-by-country (or at least regional) basis to account for the particularities of the local market and the mix of technologies deployed in each market segment.

Table 6. Framework example of standardised baseline parameters for lighting efficiency projects

Efficiency Project	Lamp/Ballast/ Fixture Type	Baseline Equipment Performance Parameters		Baseline Operating Parameters	
		Lighting Type	**Input Watts/ Lamp/Ballast/ Fixture**	**Sector/ Segment**	**Operating Hours**
High-Efficiency Lamp/Ballast/Fixture Replacements	Type 1	Standard fluorescent lamps/ ballasts	w_1	Sector 1	h_1
	Type 2		w_2	Sector 2	h_2
	…		…	…	…
	Type *n*		w_n	Sector *n*	h_n
Compact Fluorescent Lamp Replacements	Type 1	Incandescent lamps	w_1	Sector 1	h_1
	Type 2		w_2	Sector 2	h_2
	…		…	…	…
	Type *n*		w_n	Sector *n*	h_n

4.3.2 Standardised operating and performance parameters for motors

Performance parameters such as motor efficiencies could be standardised. This is particularly true for certain types of motors. The average efficiency for each horsepower can be estimated from manufacturers' data. Standardisation would be most applicable for certain motor types and size ranges that are most common in the commercial sector and certain industrial applications. For example, DSM applications in North America have typically developed baseline efficiencies for motors in two frame types (open drip-proof and totally enclosed fan-cooled), four speeds (900, 1200, 1800 and 3600 RPM) and horsepowers ranging from 1 to 200. Similarly, it may be possible to standardise assumptions for these types, sizes, classes and applications of motors in developing countries.

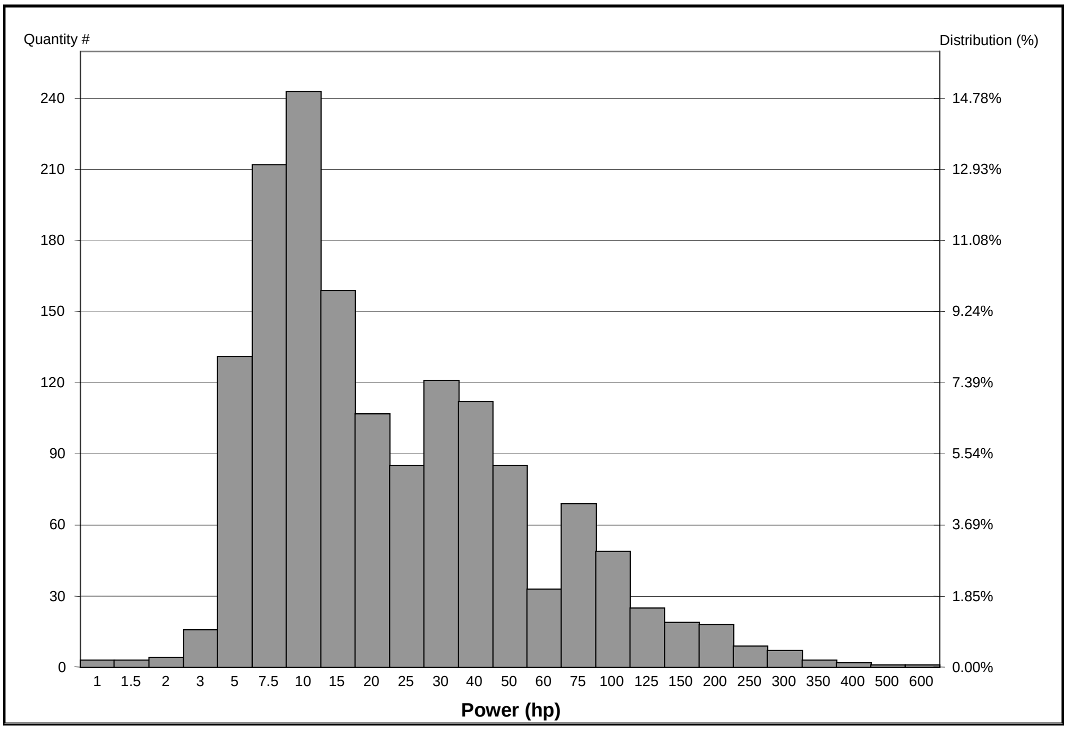
Operating hours, load factor and diversity factor are parameters needed to compute energy use for a population of motors and lend themselves to standardisation within certain limitations. Operating hours tend to be relatively consistent within specific market segments - particularly in the commercial sector - and could be conservatively standardised. Operating hours, however, are variable by market sector/segment. Establishing these baseline values would require end-use load research on a country-by-country, or possibly regional, basis. For example, operating hours for 3-shift industrial plants may well be over 8000 per year, whereas commercial ventilation fans might be only 3500 - 4000. A reasonable sample of these could be analysed and a conservative estimate selected from the lower end of this range. For example, motor efficiencies for different types and sizes of standard-efficiency motors vary by manufacturer. By selecting a set of efficiencies that tend toward the upper end of the range in each category, a conservative baseline condition is established.

Insights on the potential standardisation of parameters in motors projects from the examples presented in Annex A include:

- The Mexico motor efficiency project examined motors that ranged in size from 15 to 600 hp with 70% of the motors in the range of 1-20 hp. Figure 2 presents a distribution of motors by horsepower. This type of information and data organisation is necessary to quantify baseline energy use for an end use such as electric motors. Typically, certain types of common motors under 200 hp fall into fairly consistent efficiency ranges, whereas larger motors and motors of custom or specialised construction are evaluated on a unit-by-unit basis. The largest fraction of the motors in this study would then be likely candidates for the standardisation of at least baseline efficiencies.

Figure 2.

Distribution of motors by horsepower (Mexico Motors Replacement Project)



- The Pakistan ENERCON project tabulated data on over 350 electric motors in buildings. Data were recorded on maximum rated demand (kW) and operating hours. It does not appear that efficiency information was either available or recorded for the project. However, for a sample of this size, it would be possible with a carefully constructed study to develop standardised values for certain operating parameters such as operating hours for certain motor applications (*e.g.* HVAC fan motors) in selected market segments. Table 7 presents a distribution of motors by application and maximum rated demand determined by the project.

Table 7. Distribution of electric motors by application and demand

Motor Application	**Number of Motors by Maximum Rated Demand (kW)**					
	<1	**1-2**	**2-5**	**5-10**	**10-20**	**>20**
Air Compressors	2	-	-	-	-	-
Air Movement	12	-	3	24	24	5
Boiler Systems	-	2	12	-	-	-
Chiller Systems	-	-	25	-	-	5
Cooling Towers	-	6	-	12	19	2
Lifts	-	-	5	9	6	6
Water Pumping	9	7	18	4	19	10
Other	-	-	43	22	31	2

Source: Hagler Bailly Services Inc., 1990

An example of a framework for organising baseline efficiency data for motor efficiency projects that has been used in North American DSM projects is shown in Table 8.

Table 8. Framework example for standardised energy use baseline motor efficiencies for energy efficiency projects

Motor HP	**Open Drip-Proof RPM**				**Totally Enclosed Fan-Cooled RPM**			
	900	**1200**	**1800**	**3600**	**900**	**1200**	**1800**	**3600**
1	e_1	e_1	E_1	e_1	e_1	e_1	e_1	e_1
2	e_2	e_2	E_2	e_2	e_2	e_2	e_2	e_2
…	…	…	…	…	…	…	…	…
200	e_{200}	e_{200}	e_{200}	e_{200}	e_{200}	e_{200}	e_{200}	e_{200}

4.4 Energy use indices - lighting and motors

Another level of standardisation for energy use baselines, in the context of energy efficiency projects, involves the development of unit energy use indices by sector, segment and/or end use. Energy use indices such as kWh/square metre can be useful for characterising energy use within a market segment or end use and in some cases could serve as baseline values. For example, commercial lighting end-use intensities could be defined by market segment and used as baseline values, particularly for new building construction projects. In the residential sector, it would be possible to construct energy use baseline consumption values such as annual kWh/appliance. Similarly, in the industrial sector, it may be possible to develop annual kWh/unit of production values within a country for selected industries.

4.4.1 Standardised energy use indices (EUI) for lighting

For the commercial sector, indoor lighting EUIs (*e.g.* lighting kWh/square metre) could be developed by market segment. While EUIs are useful for general comparison purposes, they could also serve as commercial sector baselines in certain market segments such as offices, schools and hospitals. For example, energy efficiency efforts following the energy crisis of the 1970s were successful in reducing lighting power densities in US commercial office buildings from 38-43 watts/square metre to 27-32 watts/square metre and progressive standards and DSM efforts were successful in further reducing this value (particularly in new construction) to 15-22 watts/square metre by the 1990s. EUIs are probably less useful in the industrial sector, where a hybrid baseline approach (*i.e.* combining standardisation with project-specific elements) would be more generally applicable. In this case, performance parameters such as input wattages for each common fixture type could be standardised and operating parameters would be site/project-specific. The examples from Annex A include:

- The ENERCON project in Pakistan collected detailed information from on-site audits for a sample of 50 buildings. These data could be used to support the development of baseline values for a wide range of energy indices for both the residential and non-residential sectors. In lighting, it appears that the necessary data were collected to develop baseline lighting power densities (*i.e.* watts/square metre) for a sample of building types. This is useful in characterising baseline energy use.

- The EGAT lighting replacement project in Thailand has planned to develop average load shape profiles for both residential and non-residential lighting from the on-site runtime data collection effort.

- The Moroccan DSM potential and market assessment study produced a valuable set of information on energy use characteristics within all major customer sectors. Among the results of the study were end-use energy breakdowns and load shapes. These data form useful benchmarks for understanding energy use within a county and market sector and, while not explicitly included in this study, these types of data could be used to produce useful indices such as annual lighting energy use per household in the residential sector and lighting energy use per square metre for key segments of the commercial sector.

These examples from the case studies demonstrate the potential for standardising selected energy use indices and per-unit values. As a further example, baseline office lighting energy use for new construction could be defined for a given country as follows:

Baseline lighting intensity = 27 watts/square metre
Standardised operating hours for office buildings = 3500 hours per year
Baseline energy use intensity = 27 watts/sq. metre. x 3500 hours per year
= 94.5 kWh/sq. metre

Table 9 provides another framework example of EUI development for the commercial sector.

Table 9. Framework example for lighting energy use indices

Segment	Lighting Energy Use (MWh/yr)	Floor Stock (Sq. metre	Lighting EUI (kWh/Sq. metre
Office	MWh_o	sf_o	eui_o
Retail	MWh_r	sf_r	eui_r
…	…	…	…
Misc.	MWh_m	sf_m	eui_m

4.4.2 Standardised energy use indices for motors

For the commercial sector, motor energy use indices such as kWh/square metre tend to be less useful because motor energy use is often tabulated or subsumed in other end uses, primarily space heating and cooling. In the industrial sector however, since motors are often the primary energy-consuming devices, it may be useful to develop baseline motor energy consumption indices related to unit of production (motor kWh/unit of production) for selected industries. Table 10 presents a framework example of how this type of index could be formulated.

Table 10. Framework example for electric motor energy use intensities

Sector Segment	Motor Energy Use (kWh/yr)	Production Units	Motor EUI (kWh/Unit)
Segment 1	KWh_1	u_1	eui_1
Segment 2	KWh_2	u_2	eui_2
…	…	…	…
Segment n	KWh_n	u_n	eui_n

4.5 Data issues

The challenges to implementing standardisation opportunities should not be understated. Given that much of the methodology, approach and data structure has already been established in the energy efficiency industries in industrialised nations and that this infrastructure could be transferred to developing nations, the primary challenge lies in the data themselves. From the perspective of setting baselines for common energy efficiency measures, key data challenges include:

- *Cost and time of collection.* Data collection can be expensive and time consuming. Skilled labour in the form of trained energy analysts and auditors is also required.

- *Management and maintenance.* End-use data systems require management and maintenance. That is, data need to be systematically organised so that relevant data can be accessed and manipulated for the needs of different projects.

- *The need for supplemental sources*. The data sets available for the assessment of efficiency opportunities are rarely a perfect fit for a given project. Each project invariably has somewhat unique data needs. This typically requires that the analyst developing the baseline supplement the data on hand from other sources. This is not to diminish the value of the initial data, however, because a foundation dataset, often at the country level, invariably reduces the time and cost of developing a unique dataset for the project at hand, by allowing existing data to be leveraged with new data specifically designed to make the existing data set more representative of project participants.

- *The need to periodically refresh the data*. End-use data sets age over time with advances in energy technology and changes in the energy consuming market. As such, these data need to be periodically refreshed with additional data collection and analysis. The actual time periods at which these data need to be revisited depend on technology advancements, market dynamics and the degree to which energy efficiency initiatives are stimulating the entrance of more-efficient products into the market. However, North American DSM experience suggests that it would be reasonable to refresh baseline energy use datasets every three to five years. The existence of a foundation dataset and protocols that are established from the first phases of developing the data infrastructure make this a much less daunting and costly task.

Several of the examples examined in this case study demonstrate the type of sampling and data collection approach necessary to develop foundation data for energy efficiency analysis and project assessment. Most notably, the Morocco and Pakistan projects provide examples of how this type of information infrastructure project can be executed. In this regard, it is clear that the foundation has been laid (at least in part) for establishing data collection methods to support standardised baseline development for CDM and JI projects in developing countries.

5. Issues in Constructing Baselines

This section discusses a number of issues surrounding baseline estimation. These issues may be of particular importance given the magnitude of the potential benefits that can be expected from the use of energy efficiency projects as an approach for mitigating GHG emissions. Practical baseline estimation methods should seek to balance the interests of the various parties. The issues discussed below address balancing risks in baseline construction, assumptions affecting baseline stringency and potential biases in baseline construction.

5.1 Baseline construction and the potential volume of energy efficiency projects

The volume of projects undertaken under JI/CDM is a crucial factor in determining the environmental effectiveness of the project-based mechanisms. Several factors could influence potential JI/CDM project developers' willingness to undertake energy efficiency projects. Two important factors are: 1) the balance of risks in the construction of the baseline and 2) how the business deal is determined for project sponsors, *i.e.* is it framed in a manner that will allow project developers to assess the economics of the project?

5.5.1 Balancing risks in energy efficiency projects

For JI and CDM to be successful overall, a large number of projects will have to be implemented. This means that the risks of under-stating baselines (*i.e.* being overly conservative) and thereby understating project benefits should not be so great as to overly discourage potential project developers. At the same time, there must be some assurances that the expected environmental improvements are, in fact, occurring. Different methods or measures could be used to balance these risks. Each is discussed below.[17]

- *Establish the burden of proof that has to be met.* For example, a burden of proof could be set based on a one-tailed 75% confidence interval. As long as the baseline is estimated so that there is only a 75% probability that the "true"[18] baseline would be equal to or lower than the estimated baseline, the baseline is judged to be estimated with the necessary degree of confidence. This is a reasonably high burden of proof. It means that there can be no more than a 25% likelihood that the actual baseline is higher that the baseline estimated for the project. This burden of proof results in the discounting of impacts down to a level that might be judged as a reasonable assurance against over-estimating environmental improvements. The highest discount rates will likely be for projects that focus on only one large site, because reasonable sensitivity analyses around the selected energy use baseline will have large impacts on the estimated emissions reductions at a single site. The process of constructing the 75% confidence interval around a given baseline can be statistical where sampling approaches are used; it can be based on simulation analyses with judgementally assigned probabilities to alternative scenarios; or it can be determined with Bayesian approaches using

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[17] The US EPA has employed these general methods of balancing risks in awarding SO_2 emission credits to electric utilities as part of its Acid Rain programme and emissions trading process. This is documented in US EPA (1995).

[18] While the "true" baseline will never be known, statistical inference can be used to develop interval estimates around values that cannot be observed. The application of statistical methods requires an accurate definition of the participant population and the use of appropriate sampling methods. In general, statistical methods focus on estimating the pre-project baseline energy use of energy efficiency project participants. Assumptions are required to determine how this initial baseline might change over time in the business-as-usual case. However, establishing a sound estimate of pre-project baseline energy use ensures that benefits in the initial years of the project (*e.g.* five years) will be estimated quite accurately, since it is likely that there would have been little change in energy use patterns over the short term.

subjective probability assessment techniques.[19] Regardless of whether the confidence interval is based on sampling and statistics, sensitivity analyses, or expert judgements; the final confidence interval will have to be assessed judgementally, *i.e.* does it span a reasonable range of possible outcomes?

- *Less rigorous baseline estimation approaches can be allowed and the resulting baseline would be discounted.* This provides the project developers with a choice. On the one hand, they could use a simpler estimation method and have a lower energy use baseline, resulting in lower GHG reductions and thus fewer GHG emission credits. On the other, they could use a more sophisticated estimation approach with larger number of in-field measurements and potentially obtain a greater number of emissions reduction credits (*i.e.* less or no discounting of emissions would be done).
- *The rate at which energy reductions are translated into GHG emissions could be fixed*. A key uncertainty for JI and CDM energy efficiency project developers is the rate at which energy reductions are translated into GHG emissions. This rate can be set in advance to remove this uncertainty for project sponsors. It is important that the project developers have some certainty over time with respect to the emissions reduction credits they receive for each kWh of electricity conserved. Setting an emissions rate awarded per kWh for a period of time through electricity multi-project baselines (which would be fixed for given period of time) is probably the most significant standardisation action that could be taken, since it would encourage all forms of energy efficiency projects across all sectors. It is possible that the difference in electrical system emissions rates per kWh could vary across peak and off-peak periods.
- *A fixed baseline crediting lifetime could be set for energy efficiency projects*. The length of time during which a baseline is considered valid for calculating a particular energy efficiency CDM project's GHG emission reductions (and thus emission credits) could be limited. After that period of time, it would be equivalent to assuming that the baseline is no longer valid. The authors recommend a five-year crediting lifetime. This is based on a subjective assessment, but one factor influencing the choice of this term is the payback periods seen for most energy efficiency projects. Holding the baseline set for five years would provide project sponsors with a planning period long enough to recover their costs and earn a return on a wide variety of energy efficiency projects, *i.e.* it is a timeframe that would not unduly reduce the number of economically viable projects available to developers.[20] While the recommendation is that the baseline be set for five years, that is not the same as holding the baseline constant. The baseline could be set such that energy efficiency is assumed to increase at a given rate over the five-year period. However, once the baseline terms are set, they should be kept in place so that they provide project sponsors with a five-year planning horizon.

These methods[21] have been undertaken in North America in the case of traditional energy efficiency projects and programmes, but may require further examination with respect to their application in the context of CDM/JI.

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[19] There are formal methods for dimensioning the uncertainty around judgements. These are discussed in EPRI (1991).

[20] No specific decision is likely to be appropriate in all circumstances. Where a fast moving energy-efficient technology can be identified that is expected to change the market in less than five years, then it may be appropriate to hold the baseline constant for a period of less than five years. The five-year recommendation for holding the baseline constant is a subjective decision.

[21] These types of risk balancing measures have been taken by agencies in North America responsible for overseeing energy efficiency projects of US$100 million or more, with potential for monetary incentives to be paid to project sponsors that are in the tens of millions of dollars. In this context, a survey of twelve US states viewed to be leaders in the promotion of energy efficiency found that each state believed it was able to design oversight procedures that meet

5.2 Potential biases in baseline construction: free riders and spillover effects

Two main issues that arise in estimating an energy efficiency project's contribution to GHG emissions reductions based on a baseline are the potential for free riders and project spillover:

Free riders. Free riders are defined as those that would obtain emission credits for whole projects that would have gone ahead in the absence of CDM/JI projects (for more information see Ellis and Bosi, 1999). The concern is that a large number of free riders could inflate the number of projects and resulting emission credits. The free-rider issue is a baseline estimation problem that stems from a systematic bias in the construction of the baseline.

There are many types of free riders. A full free rider is an entity that would have installed the same set of energy efficiency measures at the same point in time as they did under the offered energy efficiency project. A partial free rider is an entity that would have installed some, but not all of the energy efficiency measures offered by the project or would have installed the measures, but at a later time. In most instances, there are likely to be more partial free riders than full free riders.

Spillover effects[22]. These are additional energy efficiency impacts that result from the project, but are viewed as indirect rather than direct impacts. These can occur through a variety of channels including 1) an energy-using facility hearing about an energy efficiency project-sponsored measure from a participant and deciding to pursue it on his or her own (the so-called free-driver effect); 2) project participants who undertake additional, but unaided (*e.g.* without CDM emission credits), energy efficiency actions based on positive experience with the project; 3) equipment manufacturers changing the efficiency of their products and/or retailers and wholesalers changing the composition of their inventories to reflect the demand for more efficient goods created by the project; and 4) governments adopting new building codes or appliance standards because of improvements to equipment resulting from energy efficiency projects (*e.g.* the US DOE's Energy Star Programme). Together, these effects can transform the market for energy-related equipment in a positive manner and they are a consequence of a project developer's energy efficiency project offerings.

Theoretically, spillover impacts should be identified and measured as benefits to energy efficiency projects. Practically, they are difficult to identify and measure. However, some of the attempts to measure spillover in areas that have had an energy efficiency project in place for a period of time has shown that these impacts can be large.

When spillover and free riders are taken together, the end result is that there are two difficult-to-quantify baseline estimation biases that work in opposite directions. Some regulatory jurisdictions have decided that, in the absence of better information, they will assume these two effects cancel each other out for projects that reach a large number of facilities, unless substantive evidence is produced to indicate otherwise[23].

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the baseline estimation challenges, *i.e.* provide assurances that impacts were accurately estimated and that any financial incentives paid were warranted. See NARUC (1994).

[22] Good discussions of spillover and market transformation can be found in Violette (1996) and EPRI (1995A, chapter 6).

[23] See NARUC (1994) for a discussion of how free riders and spillover have been addressed in North America.

5.3 Baseline stringency

It is important that baseline assumptions provide reasonable assurances that the expected environmental benefits from the energy efficiency projects are, in fact, occurring. Baseline stringency is influenced by the assumptions used to define the “business-as-usual” case. Depending upon the assumptions made, the baseline can be set at a low energy use level, leaving little room for incremental contributions to emissions reductions from potential energy efficiency projects; or they can be set to produce a high energy use baseline that will result in higher estimated emissions reductions, all else being equal. Key factors that influence the stringency of the business-as-usual case, which include the assumptions about the energy efficiency of energy-using equipment, the assumptions about what energy efficiency investments would have occurred in the business-as-usual case and the variability across projects, are discussed below:

5.3.1 In-field efficiency levels in the business-as-usual case

There are two basic methods for setting the baseline efficiency levels of energy-using equipment. The first involves examining the existing stock of equipment in the field. The average efficiency of in-place equipment would be used as the baseline level. This value can be ascertained by selecting a sample of facilities and determining the efficiency of the equipment present in that sample using the methods discussed earlier. The second method takes a “best practice” approach and either uses the highest rated equipment found in the field, or looks at the equipment for sale that could replace existing equipment. New equipment may have higher efficiency levels that the average for equipment currently installed at facilities. Further, it could be argued that energy efficiency projects that install new equipment should use the efficiency levels of the likely replacement equipment, had their project not been offered.

One approach to determining which method to use is to examine the technology involved and the trend over time in the efficiency levels of that equipment. In general, it would seem appropriate to use the efficiency levels of new equipment rather than the average in-field level when there has been a steady improvement in efficiency over time. This has occurred in refrigerators, air conditioners and other types of equipment. However, it may be appropriate to use the average in-field efficiency levels for equipment that represent new technology breakthroughs. The move toward T-8 lamps and electronic ballasts represents a new technology. In some developing countries, there is virtually no penetration of these efficient lighting technologies. As a result, it may be appropriate to use the average in-field efficiency for the lighting baseline when such projects span a large number of participants.

In summary, the selection of “best practice” efficiency levels or the use of average efficiency levels of in-field equipment should be made on the basis of which will more accurately represent the business-as-usual baseline. If all new sales are for equipment that has a higher efficiency level than older equipment, then the new equipment efficiency level should be used. However, if the technology is new and only a small fraction of new sales represent that technology, then the average efficiency level (or potentially a reasonable “better-than-average” efficiency level) of the stock of equipment in the field may be more appropriate. In this case, 70% of participants in a project might have purchased the lower efficiency level equipment and only 30% would have purchased the new, more efficient technology. Even today, the penetration of highly efficient CFLs in OECD countries is only a small fraction of conventional 60 watt and 100 watt incandescent light bulbs. It would be inaccurate to assume as the baseline that all lighting purchases are for the most efficient CFL. Simply stated, that is not the current baseline and it would penalise project developers for JI and CDM projects with the potential to greatly discourage the design of cost-effective energy efficiency projects.

5.3.2 Assumptions about business-as-usual investments in energy efficiency

One baseline issue commonly raised concerns what types of energy efficiency investments should be assumed to take place in the business-as-usual case and, therefore, be included in the baseline. Some have proposed that energy efficiency investments currently judged as economic should automatically be included in the baseline. For example, should all projects with an estimated payback of less than two years be considered projects that would have been undertaken anyway? The answer to this question revolves around what is appropriate to assume for the baseline. It is important to remember that the baseline is supposed to be representative of energy efficiency project participants. If none of the participants are currently implementing these energy-efficient measures (even though they are, in theory, viewed as very cost-effective), what is going to change in the future? If a specific factor cannot be identified that will eliminate a barrier to implementation, the past is probably the best predictor of the future.

Potential barriers to energy efficiency investments were presented in section 2.3. These barriers can, in many cases, be viewed as costs that are frequently omitted from traditional economic analyses of projects. It would thus be inappropriate to ignore them in setting baselines for energy efficiency in developing countries. In summary, if certain theoretically economically energy efficiency actions are not currently being undertaken, it would seem to be inappropriate to assume that, under a BAU scenario, these investments would be made in the absence of an identified factor that would change this behaviour, *e.g.* remove the barriers to investment in energy efficiency.

6. Insights and Conclusions

Significant energy efficiency opportunities are generally believed to exist in developing countries (as well as in economies in transition), particularly as these countries did not experience the wave of energy efficiency improvements experienced in industrialised countries after the oil price shocks of the 1970s. Although many of these potential opportunities appear "economic" according to traditional cost-benefit assessments, there are barriers (*e.g.* in the form of information costs, technical costs, market distortion costs, public policy costs, *etc.*) that impede their implementation. The Kyoto Protocol's project-based mechanisms (*i.e.* CDM and JI) could help overcome some of these barriers, particularly if the development and use of baselines is made transparent and consistent.

The development of GHG emission baselines for energy efficiency projects can be divided into two main steps: (1) the development of the energy use baseline; and (2) the translation of this baselines into GHG emissions.

There are essentially three options, or levels, for the standardisation of energy use baselines for energy efficiency projects. Extensive experience with energy efficiency projects and programmes in industrialised countries, as well as some developing country experience in energy efficiency projects and programmes (in the lighting and motors sector) examined in the context of this case study, allow to draw some initial insights on the different baseline standardisation possibilities:

a) Standardising baseline calculation methods and data collection protocols

There is likely to be significant scope for the standardisation of baseline calculation methods and data collection protocols.

Insights on the potential for baseline standardisation can be drawn from the lighting and motors project examples in developing countries examined in this case study. Standardisation of baseline calculation methodologies could contribute to consistency, rigor and reproducibility of analytic methods and data systems for future JI and CDM energy efficiency projects.

The baseline calculation methodology (algorithms) and data collection protocols necessary for the construction of baselines for energy efficiency projects in the lighting sector appears suitable to standardisation. Such standardisation could apply across countries.

Similarly, in the case of the development of energy use baselines in the motors sector, the calculation methodology used for estimating the energy use for a population of motors could be standardised across countries. The data on the number of motors by horsepower category can be collected at either the site or the population level. The data for the efficiency and operating hours would need to be obtained through estimation from technical data, engineering methods or field observations.

b) Standardising operating (e.g. number of hours) and performance (e.g. motor efficiency) parameters necessary for the baseline calculation

The standardisation of baseline operating and performance parameters would bring greater uniformity and consistency to the CDM/JI baseline development process.

In the lighting sector, it is likely that the standardisation of operating and performance parameters that are necessary for the development of energy use baselines for energy efficiency projects would be possible for the most common types of lighting devices. This seems to be particularly appropriate for in the residential and commercial sectors, where lighting operating hours tend to be relatively consistent. For example, it would be possible to establish baseline data on wattages for common types of incandescent and fluorescent residential and commercial fixtures. The operating hours parameters would need to be differentiated according to market sector/segment. In addition, it would be necessary to develop and standardise these baseline values on a country-by-country basis (or on a regional basis if circumstances are sufficiently similar), in order to take into account differences in domestic markets and the mix of technologies. The standardisation of operating hours could be done through conservative estimates based on a reasonable sample of observations. Similarly, performance parameters such as input wattage for the most common lighting fixture types could be standardised. In the case of large industrial lighting projects, site-specific data would be more appropriate.

In the motors sector, it would be possible to standardise motor efficiency parameters, as equipment performance tends to be more uniform across market segments than operating characteristics. Such standardisation seems applicable particularly for certain motor types and size ranges that are most common in the commercial sector and industrial application. In fact, it would seem useful to further examine the possibility of standardising motor efficiencies for the most common types, sizes, classes and applications, based on manufacturers’ data, in developing countries.

In addition to parameter values for motor efficiencies, the calculation of energy use baselines for energy efficiency projects in the motors sector requires parameter values for operating hours, load factors and “diversity” factors. These latter parameters lend themselves to standardisation with certain limitations. As operating hours tend to be relatively consistent within specific market segments, particularly in the commercial sector, this parameter could be conservatively standardised by market sector/segment. These baseline values would need to be based on end-use load information on a country-by country, or possibly regional, basis.

c) Standardising energy use indices by sector, market segment and/or end-use (e.g. lighting kWh per square metre for certain commercial building types)

With respect to the potential for standardising energy use indices (EUI) for lighting projects, it would seem possible to standardise indoor lighting EUIs (*e.g.* lighting kWh/square metre) for certain market segments of the commercial sector (*e.g.* offices, schools and hospitals). Such EUIs could be used as the baseline values for energy use related to lighting in those commercial sector market segments.

In the residential sector, it may be useful to consider the potential standardisation of EUIs for certain appliances (*e.g.* refrigerators).

Standardised lighting EUIs are probably less applicable in the industrial sector, where a hybrid approach combining standardised and project specific elements is likely more appropriate.

Motor energy use indices (*e.g.* kWh/square metre) for the commercial sector do not seem appropriate, as motor energy use is often tabulated or subsumed in other end-uses, particularly space heating and cooling. However, in the industrial sector, where motors are often the primary energy-consuming devices, it may be possible to develop baseline motor energy use indices related to the unit of production (motor kWh/unit of production) for selected industries.

Other baseline issues

Translating energy saved to GHGs: The rate at which reductions in energy use are translated into GHG emissions is one of the key elements of developing an emission baseline for energy efficiency projects. Setting an emission rate per kWh (which could be differentiated for peaking and baseload electricity use, for example) for a fixed period of time through electricity multi-project baselines is probably one of the most significant baseline standardisation elements for CDM/JI energy efficiency projects.

Crediting lifetime: Another important baseline standardisation element is the crediting lifetime associated with a particular baseline. The authors recommend fixing, at the start of an energy efficiency CDM/JI project, the length of time during which a baseline is considered valid for calculating that project's GHG emission reductions (and thus emission credits). A baseline crediting lifetime of about five years would seem adequate to balance environmental and project developers' interests. This would not preclude the possibility that the baseline be set such that energy efficiency is assumed to increase at a given rate over the five-year period. However, this would need to be determined at the outset.

Free riders and spillover effects: The methodologies examined to estimate energy use baselines for energy efficiency projects normally only consider direct energy use. However, energy efficiency projects may lead to two indirect energy use and GHG effects: free riders and spillover effects. These two indirect effects work in opposite directions and both are difficult to quantify. Until better information is available, it may be practical to assume, as have assumed some regulatory jurisdictions in the case of traditional energy efficiency projects and programmes, that these two effects cancel each other out.

Determining stringency: In terms of the appropriate stringency level for energy efficiency projects, it is important that the level provide a reasonable reflection of the "business-as-usual" case. Basing the baseline level on what investments should, theoretically, take place, such as through a traditional economic assessment criteria (*e.g.* pay-back period), is likely not a good proxy for "business-as-usual", as they do not take into account the various (non-purely economic) barriers to energy efficiency investments.

The other two main approaches of determining an appropriate baseline stringency level are based on: 1) existing stock of equipment in the field; and 2) "best practice", using either highest rated equipment found in the field or equipment for sale. The most appropriate choice would depend on what is reasonable to assume under a business-as-usual scenario. In a case where all new sales are for equipment that has a higher efficiency level than older equipment, then the new equipment efficiency level should be used for developing the baseline. On the other hand, if the technology is brand new and only a small fraction (*e.g.* less than 30%) of new sales represent this technology, then the average efficiency level (or potentially a reasonable "better-than-average" efficiency level) of the stock of equipment in the field may be more appropriate.

Finally, it is important to recognise that some of energy efficiency JI or CDM projects will probably "beat the system" and receive more emissions credits than they deserve. No process will be perfect and any energy efficiency baseline construction process will likely have defects. A search for perfection will likely result in no process being judged as acceptable. The goal is to strike both a reasonable balance among various risks including among the interests of project developers, those of potential host countries and the environmental objectives of the project-based mechanisms.

ANNEX A: EXAMPLES OF BASELINE DEVELOPMENT FOR ENERGY EFFICIENCY PROJECTS AND ENERGY EFFICIENCY MARKET ASSESSMENT

This section presents selected examples where baseline energy use and/or market characteristics were developed as part of an energy efficiency project evaluation or market assessment to determine the cost-effective potential for an energy efficiency project. None of the examples focused on stand-alone energy use baseline assessments, nor did they deal with the issue of forecasting baseline conditions into the future. For the project examples that developed a reference case (or baseline) for energy use, the baseline was part of a larger study or project to estimate actual energy savings or the market potential for savings. In those cases where estimates of energy savings were the objective, the studies were less focused on baseline construction than on estimating the energy use of the newly installed or proposed energy-efficient technologies.

Although the purpose of these examples was generally not to help evaluate GHG emission reductions resulting from energy efficiency projects (with the exception of the Mexican Ilumex project), they nonetheless may provide useful insights for the development of baselines for energy efficiency projects undertaken in the context of JI and CDM.

Seven case studies of lighting, motors and audit-based energy efficiency projects in developing countries follow.

Fluorescent lamp and compact fluorescent lamp market transformation project[24] - Thailand

This project is a national DSM programme intended to transform the indoor lighting market. The existing standard fluorescent lamps installed in commercial buildings are 40 watt and 20 watt “fat tube” (T12) fluorescent lamps. An agreement was reached between the national government and manufacturers of lamps sold in Thailand. This agreement called for manufacturers to stop making the 40 and 20 watt fat tube T12 lamps and replace them with 36 and 18-watt thin tube (T8) lamps. The project also encouraged the replacement of incandescent lamps with more efficient compact fluorescent lamps (CFL) in both residential and non-residential applications.

The energy use baselines required by these two projects focused on the typical performance and operational factors (*i.e.* wattage and operating hours) of 40 and 20 watt tubular fluorescent and the older incandescent lamps (to be replaced by the CFLs), maximum peak coincident demand and baseline annual energy consumption.

The data used to construct the energy baselines were based on the following sources:

- Spot-watt measurements of a sample of fixtures using fat tubes to estimate the average kW per lamp.
- Calibration of these spot-watt measurements by bench tests of different lamp and ballast combinations for fluorescent lamps.

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[24] EGAT reports (1997a and 1997b) contain information on the lighting programme plans and evaluation plans.

- Estimation of operating hours from customer self-reports for all participants, as well as run-time data from a sample of installations. The customer estimates of operating hours are compared to the run-time logger data and an adjustment factor is calculated using the ratio between the two numbers. This ratio is then used to "calibrate" estimated operating hours as reported by building or residence occupants.

Baseline energy use is to be estimated by taking the product of estimated lamp wattage (kW) multiplied by estimates of operating hours to obtain kWh. The actual data used in the analysis, the results of the bench tests and field monitoring and the final evaluation findings are not public information at this time and thus cannot be reported here. The evaluation will utilise a calibrated engineering algorithm[25] approach that accounts for the number of units installed lamp wattage and average annual lamp operating hours for both the fat tube and CFL projects.

There are several notable aspects of the baseline constructed for this application. First, a sample of older lamps had to be identified and spot-watt measurements taken on these lamps, along with the use of run-time data loggers to obtain accurate estimates of operating hours for the baseline technologies. Occupant self-reports of operating hours are also obtained from customer surveys. These self-reported estimates are adjusted by the estimates from the more accurate run-time loggers, resulting in an adjustment factor or ratio. This approach of using a ratio comprising a more accurate estimate divided by a less accurate estimate and then applying that ratio to the larger number of self-reported operating hours is an example of data leveraging. Data leveraging procedures are increasing in use and can be expected to become standard in baseline development in the context of energy efficiency projects.[26]

Ilumex compact fluorescent lamp replacement project[27] *- Mexico (AIJ Pilot Phase)*

This AIJ pilot phase energy efficiency project provided rebates for the purchase of compact fluorescent lamps (CFLs) sold through retail outlets. The project was intended to encourage the widespread use of CFLs and was restricted to residential applications in two metropolitan areas, Guadalajara and Monterrey.

The energy use baseline developed in this project is a performance and operational baseline (*i.e.* wattage and operating hours) of existing incandescent lamps resulting in a baseline annual energy consumption of a population of lamp replacement projects. The data used to construct the baseline included vendor surveys of lamp sales and stocks used to estimate the number and type of units sold and participant surveys used to estimate the number and type of CFLs installed and characteristics of the incandescent lamps they replaced. The project baseline assumes that participants would have continued to use ordinary incandescent lamps and that the replacements would not have occurred in the absence of the project.

Initial planning assumptions specified that each wattage of CFL would replace an equivalent incandescent lamp (*e.g.* a 15-watt CFL would replace a 60-watt incandescent bulb). The wattage values used for the baseline incandescent lamps and the CFLs are presented in Table A-1. The preliminary results of the spot-

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[25] The report describes this approach as a "calibrated engineering approach." This approach is described in section 4.5.2 in Violette (1996).

[26] A data leveraging approach uses two methods of data collection. A small sample is selected for which extremely high-quality data are obtained. A larger sample is also selected and a less expensive, less accurate estimation is approach is applied to this larger sample. A ratio estimate is used to leverage the small amount of highly accurate data within the larger sample of data. This is described in Violette (1991).

[27] World Bank (1997) and related updates and descriptions.

watt measurements [28] showed that the average energy savings per lamp were 50 watts compared to the planned 54 watts. While these data allow the quantification of baselines for typical programme participants, the project report clearly states that "… data do not exist for Mexico which would allow us to define a meaningful detailed national baseline projection."

Table A-1

Lamp performance data

Baseline Incandescent Watts	CFL Watts		Watt Savings
	Nominal	Measured	
100	23	21.1	78.9
75	20	17.8	57.2
60	15	16.1	43.9

The baseline operating hours were assumed to be 4 hours per day. However, the monitoring and evaluation plan called for baselines for impact assessment to be developed from post-implementation surveys and follow-up runtime hour data logging on a sample of lamps. The results of the runtime metering at a sample of sites (as of 1997) showed that the average operating hours for the lamps was about 3 hours per day compared to the 4 hours in the planning assumptions.

While the study indicates the need to adjust the baseline over time to account for natural change and market transformation effects and the challenges associated with doing so, it does not provide a specific forecast of the baseline into the future. It was assumed that the energy savings benefits of the project would extend for eight years; the anticipated life of a CFL.

The GHG emissions reductions of the project were estimated as follows:

1. The kilowatt hours of electricity use avoided from replacing 1.7 million incandescent bulbs with the more efficient CFLs. These estimations were based on the following parameter values:

- number and type of bulbs installed by month;
- an average bulb use of three hours per day (based on preliminary results of on-site metering of bulb use in participants' homes) and 30 days per month;
- a bulb lifetime of 8,760 hours (12.4% less than the technical specifications of the CFLs);
- an average savings of 50 watts per bulb (taken from the difference between the average incandescent bulb wattage and the average wattage of the CFLs used as replacements);
- assuming transmission and other losses of 18% on the CFE system.

2. The kilowatt hours not generated are converted to emissions saved using:

- standard emissions factors for each fuel type, expressed in tons per Tera Joule;
- fuel mix actually used at the Monterrey and Manzanillo plants in 1995 and 1996;
- heat rate, or efficiency, of the plants.

Table A-2 summarises the results of the GHG reduction estimates.

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[28] The detailed evaluation of the programme by CFE is not public information. World Bank and FCCC reports provide only aggregate data.

Table A-2

AIJ component baseline and estimated GHG reductions

	Units	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
A) Baseline Scenario	MWh	1,748	7,016	12,918	15,763	15,763	15,763	15,763	15,763	14,346	9,257	3,272	36
B) Project Scenario	MWh	499	2,004	3,694	4,504	4,504	4,504	4,504	4,504	4,099	2,645	935	10
C)Effect (B-A) MWh not consumed	MWh	1,249	5,011	9,224	11,259	11,259	11,259	11,259	11,259	10,247	6,612	2,337	26
D) MWh not generated	MWh	1,523	6,111	11,261	13,731	13,731	13,731	13,731	13,731	12,496	8,064	2,850	31
GHG Reductions	Metric tonnes												
E) Effect of (D)	CO_2	1,176	4,721	8,700	10,608	10,608	10,608	10,608	10,608	9,654	6,230	2,202	24
	CH_4	0.03	0.12	0.22	0.27	0.27	0.27	0.27	0.27	0.25	0.16	0.06	0.00
F) Cumulative Effect of (D)	CO_2	1,176	5,897	14,597	25,205	35,813	46,421	57,029	67,637	77,291	83,521	85,723	85,748
	CH_4	0.03	0.15	0.37	0.64	0.91	1.18	1.45	1.72	1.97	2.13	2.19	2.19

Source: World Bank (1997)S

Demand-side management assessment[29] *- Morocco*

The Morocco DSM study included three components: 1) a national assessment of DSM potential, 2) a national market research study of energy use patterns, equipment distribution channels and customer attitudes and preferences and 3) a pilot residential lighting demonstration project.

Growth in lighting energy use constitutes a large fraction of growth in residential electricity demand in Morocco. Most residential lighting is incandescent, with the majority of lamps being either 75 watt or 100 watt. The residential lighting pilot project installed 2,147 compact fluorescent lamps in 1,412 households.

All major end uses in the residential, commercial and industrial sectors were examined for the National Assessment of DSM Potential and the National Market Research Study. The data used to construct the energy use baseline came from a national market research study. This study included of surveys of 2000 residential customers, 61 commercial sector interviews, 52 industrial sector interviews and 50 interviews with trade allies (*e.g.* architects, engineers and installers). These data were compiled and analysed to characterise energy use and energy use parameters in each market sector and to produce the estimate of DSM potential.

For the residential lighting pilot project, baseline consumption was estimated using a standard engineering algorithm that accounted for lamp wattage and operating hours. It was found from the field research that 50% of incandescent lamps were 100 watt and 28% were 75 watt. Operating hours were determined from runtime metering at a sample of sites. For the hours of operation, only one time period was taken into account.[30] The average usage per lamp across the retrofit and control groups was 3.5 hours/day. Hours of operation did not show any significant changes after the retrofit, demonstrating that there is no short-term take back. The actual operating hours averaged only 75% of the operating hours estimated by the resident.

For the residential lighting pilot project, the following categories of data and data collection activities were used for the energy analysis:

- Customer survey data, including both the participant group and a control group.
- Programme tracking data for the lighting programme.
- Utility billing data for both the participant group and the control group.
- On-site metered data for a sample of sites.
- Post-installation survey data for a sample of the customers receiving the CFL retrofits.

The baseline was used to produce estimates of energy savings using an engineering estimation procedure with final estimates calibrated through a statistically adjusted engineering analysis (SAE)[31] of utility billing

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[29] Hagler Bailly Services, Inc. (1997).

[30] The second time period would have conflicted with Ramadan.

[31] Descriptions of statistically adjusted engineering estimates are presented in Violette (1993 and 1996).

records. The "realisation rate" of the engineering estimate based on the SAE analysis was 75%.[32] A number of other useful and informative factors influencing energy savings (and energy use) were also identified in this study including:

- Estimated incandescent lamp wattages for each equivalent CFL (Table A-3).
- Typical seasonal weekday and weekend lamp operating hours.
- Operating hour estimates were also adjusted to account for the Ramadan holiday (this is an instructive example of the need to examine the in-country particularities that might effect a standardised baseline).
- Load shapes were developed and coincident diversity factors were estimated.
- The "takeback" effect (taking back savings in terms of greater lighting use) was estimated.

Table A-3

Incandescent and CFL wattages

Existing Incandescent Wattage	CFL Wattage
100	23
75	20
60	15

The baseline stemming from this national assessment of DSM potential produced a useful characterisation of electricity use in Morocco, including breakdowns by market sector and subsector, end-use breakdowns for major markets, sector and end-use load shape profiles and average wattage ratings and operating hours for a variety of lighting uses. These data form an excellent foundation for baseline construction for energy efficiency projects. The national market research took the analysis a step further to develop a detailed baseline profile of energy use by major end use. The study employed surveys of and interviews with customers that examined all aspects of energy use.

For residential lighting, the market research survey produced energy use and performance and operating data for both rural and urban customers, including:

- A profile of the number of lamps and average number of lamps per household (Table A-4).
- Average lamp wattages and a breakdown of wattages by wattage category (Table A-5).
- Average lamp operating hours.

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[32] "Realisation rate" is defined as the percentage of the engineering estimate of energy savings that is realised, on average, according to an analysis of actual consumption records.

Table A-4

Summary of lighting characteristics by urban and rural areas

	Urban	Rural
Average Number of Lamps per Household	9	6
Average Wattage of Lamps	93	87
Average Daily Hours of Use	2	2

Table A-5

Distribution of indoor incandescent lamps by wattage

<60 W	60 W	75 W	100 W	>100 W
2%	14%	37%	42%	4%

For commercial lighting, the study produced energy use and performance and operating parameters for both indoor and outdoor lighting, including:

- A breakdown of lighting by type (incandescent, fluorescent, halogen and compact fluorescent).
- Average number of lamps per facility by lamp type.
- Average daily operating hours by lighting type.

A summary of commercial indoor lighting characteristics is presented in Table A-6.

Table A-6

Summary of commercial indoor lighting

Type of Lighting	Average Number of Units Per Facility	Average Wattage	Average Daily Hours of Use
Fluorescent Lamps	263	53	10
Incandescent Lamps	269	93	6.5
Halogen Lamps	39	262	9.2
Compact Fluorescent Lamps	47	22	6.6

The industrial lighting assessment produced a similar dataset to the commercial sector data.

High-efficiency motors replacement project[33] *- Mexico*

In this pilot project, 1,624 standard efficiency motors at 20 customer sites were analysed for replacement with high-efficiency motors. The participating customers included industries in the manufacturing, food processing, chemical, rubber processing, steel production, mining, pharmaceutical and paper industries. The programme included a detailed audit of the existing motor systems with recommendations for replacement motors. To encourage implementation, the audit was free for companies that implemented the recommended measures, including motor replacement.

The motor system audit included the following information/data for each motor in the facility:

- Information on the existing motor: brand, body-type (open, closed, *etc.*), capacity/power in horsepower, speed (revolutions per minute), voltage, current, efficiency (if available), power factor, service factor, country of origin.
- Type and characteristics of the power transmission system.
- Operating characteristics of the driven equipment.
- Operation including hours and production loads.
- Spot-watt measurements.
- Power logging of some motors with particularly variable loads.

While all motor systems were audited, with spot measurements of load on the different motors, a sample of the motors to be replaced was actually measured before replacement and measured again once the higher-efficiency motor was installed. The energy use baseline described by this project is the baseline performance and operational factors (*i.e.* horsepower, efficiency, load factor and operating hours) for the standard efficiency motors. Results of the data collection are summarised in Table A-7 and Figures A-1 and A-2.

Table A-7

Distribution of motors by brand

BRAND	SHARE
ABB	4%
General Electric	4%
IEM Westinghouse	21%
Lincoln	1%
Reliance-Remsa	7%
Siemens	20%
Magnetek	2%
US Motors	17%
Sin Placa	15%
Others	9%

The energy use baseline was constructed through detailed audits with complete data logging for every motor replaced, including:

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[33] Hagler Bailly Services, Inc. (1998).

- Measurement of the electric parameters (*e.g.* kW, power factor, current, rpm) under baseline conditions of typical load, noting the exact process conditions at the time and logging over a 48-hour period.
- Evaluation of the installed motors in terms of operational efficiency to meet load demands.
- The characteristics of a proposed new higher-efficiency motor (the highest efficiency motor available to meet the required load).
- Measurement of the electric parameters (*e.g.* kW, power factor, current, rpm) of the replaced motor, noting the exact process conditions at the time and logging over a 48-hour period.
- Evaluation of the actual savings, based on post-implementation logging results compared to baseline logging results.

Although measurements were carried out during the audits, the energy use baselines developed as part of the evaluation effort required additional logging. In this project, every motor to be replaced was measured and logged prior to replacement under careful monitoring of process conditions, whether or not the motor had been measured as part of the audit. Project staff felt that the only sure way to obtain the “real” energy savings was to provide coherent measurement before and after installation. This is a luxury that few energy efficiency evaluation programmes have been able to afford. The results showed a wide disparity of savings, often differing from the engineering calculations. However, upon averaging 40-50 motors, the energy savings were only slightly higher than engineering calculations predicted. Although not conclusive, this may imply that in motor applications, a project consisting of a large enough sample of replaced motors may be able to rely on an average energy use baseline developed from sectoral efficiency and measured load data.

Figure A-1

Distribution of motors by horsepower

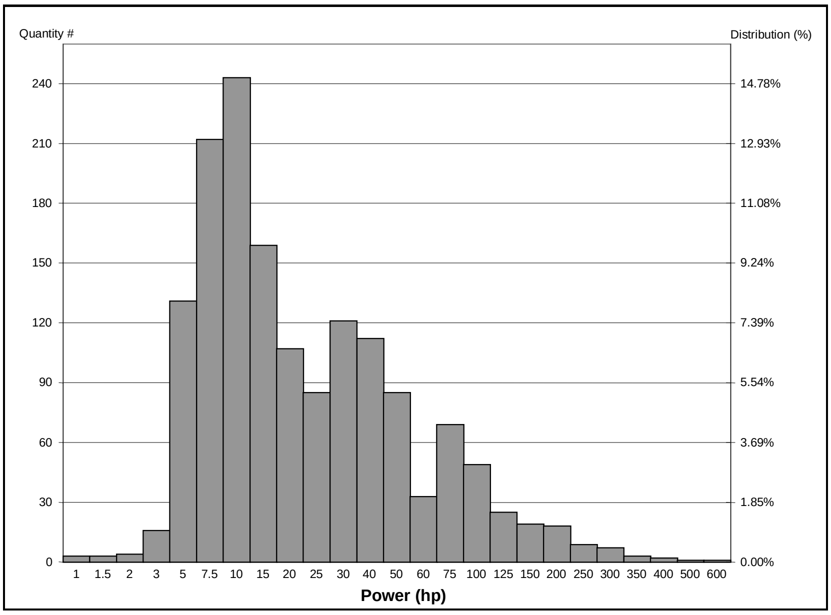
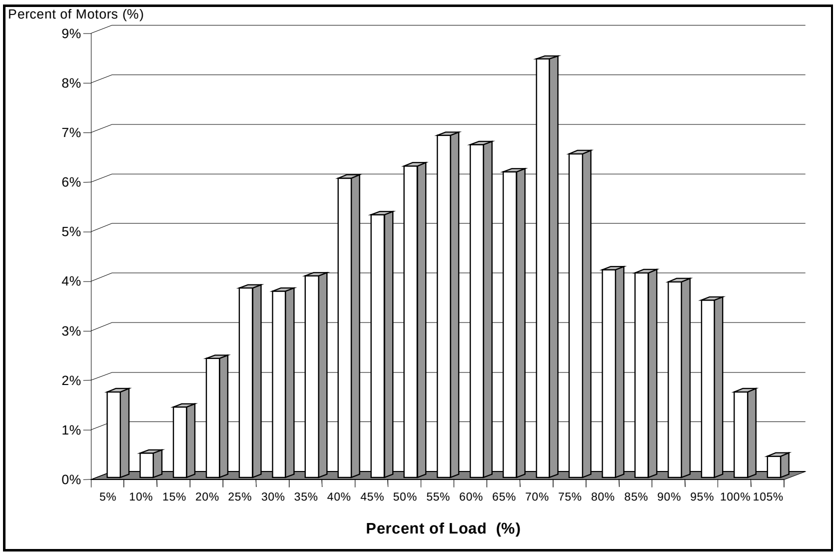


Figure A-2

Distribution of motors by percentage of load



ENERCON technical energy efficiency assistance programme[34] *- Pakistan*

The ENERCON Technical Assistance Project was a detailed end-use market assessment and energy efficiency demonstration programme sponsored by USAID. The project included:

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[34] Hagler Bailly, Inc. (1987).

- Detailed energy audits at 248 industrial sites.

- Over 600 boiler/furnace tune-ups.

- Energy audits and consumption monitoring at 50 buildings, followed by the installation of energy conservation measures and subsequent monitoring and analysis.

- Energy audits at 256 agricultural tubewells followed by energy efficiency upgrades at 115 sites.

- Audits and tune-ups for 50 agricultural tractors and audits/tune-ups of over 3000 automobiles.

While this project covered a wide range of sectors and end-use applications (see below), the discussion that follows in this case study applies only to the buildings components of the project. Baseline data were collected on the full range of building equipment/systems including HVAC, motors, appliances and lighting. However, for the purposes of this case study, we have focused on lighting and motors only. The baseline described by this study is the development of baseline energy consuming equipment/systems performance and operational characteristics.

The energy use baseline was constructed from data collected as part of a series of walk-through audits of a sample of buildings. The audits identified:

- Historical energy consumption patterns.

- Occupancy patterns of buildings.

- Data on energy consuming equipment and systems.

Data were collected on generators, boilers, chillers, air conditioners, pumps and motors, gas and electric appliances and lighting. The information presented here is limited to motors and lighting.

In the case of electric motors, information was collected on over 350 motors of different types, in a wide range of sizes and a variety of applications. The data collected and tabulated for each motor included:

- manufacturer;

- motor type;

- use or application of motor;

- size in kW;

- operating hours.

Table A-8 presents a distribution of motors by application and maximum rated demand.

Table A-8

Distribution of electric motors by application and demand

Motor Application	Number of Motors by Maximum Rated Demand (kW)					
	<1	1-2	2-5	5-10	10-20	>20
Air Compressors	2	-	-	-	-	-
Air Movement	12	-	3	24	24	5
Boiler Systems	-	2	12	-	-	-
Chiller Systems	-	-	25	-	-	5
Cooling Towers	-	6	-	12	19	2
Lifts	-	-	5	9	6	6
Water Pumping	9	7	18	4	19	10
Other	-	-	43	22	31	2

For lighting, data were collected on 36,680 fixtures in 43 buildings. The data collected and tabulated for each building included:

- lamp type;
- no. of lamps and fixtures per site;
- Watts per fixture;
- function of the space where the fixtures were installed;
- square footage of floor space served by the fixture;
- operating hours.

Table A-9 presents a distribution of lighting fixtures by wattage and type.

Table A-9

Distribution of lighting fixtures by wattage and type

Fixture Type	Number of Fixtures by Wattage								
	20-30	30-40	40-50	50-60	60-80	80-100	100-200	200-300	300+
Fluorescent	665	1231	22227	-	-	1368	-	-	-
HPS	-	-	-	-	-	-	-	-	2
Incandescent	220	691	410	3604	82	3387	2478	7	203
Mercury vapour	-	-	-			-	100	5	-

The walk-through audits included visual inspection and data collection of equipment/systems and interviews with building operators. The results of the surveys were compiled in an energy conservation database for the buildings sector and tabulations were compiled for each end use/equipment type.

Tubewell audit and retrofit project (Hagler Bailly, Inc. 1987 and 1990) - Pakistan

Electric tubewell water pumping accounts for nearly 20% of electricity use in Pakistan and is the single-largest end use of electricity. Detailed field audits of 132 electric tubewells were conducted to collect data on operating characteristics, efficiencies and causes of low energy efficiency, to collect pre- and post-retrofit energy consumption data and to identify potential energy efficiency improvements. Of the tubewells that received audits, 43 received energy efficiency retrofits that yielded an estimated average energy efficiency improvement of 24%.

The tubewell audit and retrofit project provides an example of an approach to sampling and field data collection for a specialised and unique energy efficiency project. While it is unlikely that standardised baseline consumption values or operational/performance parameters could be developed for this particular end-use application, the approach to sampling indicates that standardised data collection protocols could be developed that would apply across a broad range of end-use applications and would help to establish uniformity, consistency and replicability in the energy use baseline construction process.

A detailed countrywide sampling strategy was developed for the tubewell pumping sector. In order to identify tubewell sites that were candidates for audits, farmers were invited to participate in the programme. Three hundred and ninety five farmers representing 622 tubewells responded and indicated an interest in the project. Of those, 381 tubewells were identified as audit candidates (*e.g.* operational, electrically driven, geographically distributed, accessible and within the travel range of the auditors). Candidate sites were grouped into 55 geographic clusters in 20 districts of the country. One hundred and twelve tubewells were selected for audits conducted by field engineers. Data were collected on technical characteristics, operating conditions and pre- and post-retrofit energy consumption. The pre-retrofit data were used to describe baseline performance. Baseline pumpset efficiency was estimated to be about 21.5%.

The audits performed on the sites contained in the sample collected detailed information on pump technical and operating data including:

- Pump functionality and condition.
- Year of installation.
- Pump performance specifications and installation details.
- Estimated daily hours of use.
- Pre- and post-retrofit energy consumption.

Summaries of these data were not included in the documents available to the authors. The size and energy consumption of tubewells varied from 3 hp (2.2 kW) to 50 hp (37.3 kW) in both electric and diesel powered pumps.

Boiler/furnace tune-up energy efficiency assessment program (Hagler Bailly, Inc., 1990) - Pakistan

Under the ENERCON Project, a boiler/furnace tune-up programme was designed and implemented to go beyond the audit and ensure energy savings from implementation. The boiler/furnace tune-up energy efficiency assessment programme was initially offered for about one year at no cost to participants. After the start-up period, audits and tune-ups were offered at cost. In total, over 600 audits and tune-ups were completed. Energy efficiency measures included low-cost measures such as combustion control retrofits and fuel/air tune-ups based on combustion analyser measurements. Average combustion efficiency was measured before and after the work; on average, the efficiency improved by about 8%.

The boiler/furnace tune-up project produced a dataset on the baseline energy efficiency and performance/operational characteristics of a sample of over 600 boilers and furnaces. Data included monthly energy consumption, production, inventories of major energy consuming equipment (including boilers and furnaces) and technical specifications and specific fuel consumption of major energy consuming equipment. Databases were developed for profiling the consumption characteristics in major end uses, including boiler/furnace heating applications.

Glossary

additive (or extender)	material(s) added to clinker to make cement
AEEI	autonomous energy efficiency improvement
AIJ	activities implemented jointly
AIXG	Annex I Experts Group on the United Nations Framework Convention on Climate Change (UNFCCC)
audit-based programmes	Programmes that rely on the systematic collection of data on building and energy system performance characteristics at the customer site. The goal of these programmes is typically to identify and quantify energy efficiency improvement opportunities in combination with an implementation plan.
baseload	The minimum amount of electric power delivered or required over a given period of time at a steady rate.
BAU	business as usual
bench tests	Tests of equipment performance characteristics conducted in a controlled environment such as a laboratory or manufacturer’s test facility.
BF	blast furnace
blast furnace slag	One of the common additives used in cement. It is the by-product of iron and steel manufacture and grinding this additive for use in cement is energy intensive.
BOF	basic oxygen furnace
CDM	Clean Development Mechanism (project-based mechanism introduced in Article 12 of the Kyoto Protocol)
CFL	compact fluorescent lamp
CH_4	Methane
CHP	Combined heat and power. A plant that is designed to produce both heat and electricity
cli	Clinker
clinker	The key component of cement and the most GHG-intensive.
CO	coke oven
CO_2	carbon dioxide
combined cycle	An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines. This process increases the efficiency of the electric generating unit.

conversion efficiency	Efficiency at which a thermal power plant converts input fossil fuel (*i.e.* coal, gas, or oil) into electricity.
crediting lifetime	Length of time (in years) during which a project can generate emission credits.
demand-side management (DSM)	Utility programmes designed to control, limit or alter Energy consumption by the end user. DSM objectives may include energy conservation, load management, fuel substitution and load building.
diversity factor	The ratio of the peak demand of a population of energy-consuming equipment to the sum of the non-coincident peak demands of the individual equipment.
DR	direct reduction
DRI	direct reduced iron
dry process	A process whereby the raw materials for cement production are ground and then mixed (as a dry powder).
EAF	electric arc furnace
EEI	energy efficiency index
EIT	countries with economies in transition
EJ	exajoule (= 10^{18} Joule)
emission credits	Unit used for the measurement (*e.g.* in tonnes of CO_2-equivalent), transfer and acquisition of emission reductions associated with JI and CDM projects.
end-use indices (EUI)	The ratio of the energy use of a building, system or end-use over a given time period to a commonly recognised index of size or capacity. Examples include lighting energy use per square foot of floor area and motor energy use per unit of production output.
environmental credibility	Quality of a baseline with respect to realistically reflecting the emission level that would likely occur without the JI or CDM project(s).
environmental effectiveness	Extent to which the project-based mechanisms result in maximum emission reductions and maximum participation through JI and CDM projects, thereby contributing to achieving the objectives of the Kyoto Protocol.
EU or EU15	The 15 members states of the EU.
fluorescent lamps	A discharge lamp whereby a phosphor coating transforms ultraviolet light into visible light. Fluorescent lamps require a ballast that controls the starting and operation of the lamp.
free riding	A situation whereby a project generates emission credits, even though it is believed that the same project would

	have gone ahead, even in the absence of JI or CDM. The emission reductions claimed by the project would thus not really be “additional”. Free riding therefore affects the number of projects obtaining credits under JI and CDM.
gaming	Actions or assumptions taken by the project developer and/or project host that would artificially inflate the baseline and therefore the emission reductions. Gaming therefore affects the amount of emission credits claimed by a JI or CDM project.
GHG	greenhouse gas
GJ	gigajoule (= 10^9 Joule)
greenfield projects	New projects (as opposed to existing plants that are refurbished)
grid	The layout of an electrical distribution system.
GWh	gigawatt hour, *i.e.* 10^9 Wh.
GWP	global warming potential
hp	horsepower
HPS	High pressure sodium lamps.
HVAC	Mechanical heating, ventilating and air-conditioning of buildings.
IEA	International Energy Agency
incandescent lamps	A lamp that produces visible light by heating a filament to incandescence by an electric current.
ISP	integrated steel plant
JI	Joint implementation (project-based mechanism introduced in article 6 of the Kyoto Protocol).
kWh$_e$	kilowatt hours of electricity use
leakage	Leakage occurs if actual emission reductions (or sink enhancements) from a CDM or JI project lead to increases in emissions (or sink decreasing) elsewhere.
load curve	A plot of the demand placed on an energy system during an hour, day, year or other specified time period.
load factor	Number of hours in a year during which a power plant is generating electricity.
market segment	A segment of a customer or end-user market identified by common demographic, firmographic or energy use characteristics. Examples include the single-family detached home segment in the residential sector; and the office building segment in the commercial sector.
MJ	megajoule (= 10^6 Joule)
Mt	million metric tons

mtoe	million tons of oil equivalent
multi-project baselines	Emission baselines (also referred to as “benchmarks” or “activity standards” in the literature) that can be applied to a number of similar projects, *e.g.* to all electricity generation CDM or JI projects in the same country.
nameplate data	Data provided by equipment manufacturers that identify the make, model and performance characteristics of the equipment. These data are published in the manufacturer’s product literature and key data elements are affixed to the equipment on the nameplate. Often the equipment nameplate itself does not provide sufficient information for energy analysis.
N_2O	nitrous oxide
OECD	Organisation for Economic Co-operation and Development
off-peak load	The demand that occurs during the time period when the load is not at or near the maximum demand.
OHF	open hearth furnace
peak load	The maximum demand or load over a stated period of time. The peak load may be stated by category or period such as annual system peak, customer class peak, or daily peak.
peaking plants	Power plants normally reserved for operation during the hours of highest daily, weekly, or seasonal loads.
PJ	petajoule (= 10^{15} Joule)
PJe	petajoules electricity
PJp	petajoules calculated back to primary energy
PJf	petajoules final energy
Pozzolana	A natural cementious material that can be ground and used as a cement additive.
Process emissions	For cement production this refers to the CO_2 emitted from decarbonisation of limestone. It takes place during the pyro-processing step.
Production process change	Refurbishment of an existing plant that would change the process by which clinker is manufactured to a more efficient process (*e.g.* wet to dry, or semi-dry to dry)
Pyro-processing	This is the process of turning the raw materials into clinker (and takes place in the cement kiln).
Refurbishment projects	Projects in which existing equipment/processes are upgraded or replaced.
rpm	revs per minute

Run-time monitoring	Recording equipment or system runtime over a specific monitoring period. Often conducted with devices specifically designed for recording operating hours.
SAE	statistically adjusted engineering analysis
SEC	specific energy consumption
shaft kiln	The kiln, where clinker is produced, is vertical (whereas in other cement processes the kiln is slightly tilted, *e.g.* 1-3 degrees from the horizontal).
spot-watt measurements	One-time or instantaneous measurements of input wattage to a system or piece of equipment.
tcs	tonne of crude steel
thermal power plant	Power plants that burn fuel directly to produce steam.
TJ	terajoule (= 10^{12} Joule)
transaction costs	The costs associated with the process of obtaining JI or CDM recognition for a project and obtaining the resulting emission credits. Transaction costs would include, for example, costs of developing a baseline and assessing the "additionality" of a project, costs of obtaining host country approval, monitoring and reporting, *etc.* Transaction costs would not include the direct investment, maintenance and operational costs of the project.
UNFCCC	United Nations Framework Convention on Climate Change
update of baselines	Updating multi-project baselines, at regular intervals, in order to continue to reflect business-as-usual electricity investments. CDM or JI electricity projects would need to use the most recently updated multi-project baseline.
USAID	US Agency for International Development
USEA	US Energy Association
wet process	A process whereby the raw materials are ground, with water added, and mixed (as a slurry). The wet process is more energy-intensive than the dry process as energy is needed to evaporate the water in the raw material mix.

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