STIL2 in India

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By telefax: +46 (0)8-505 933 99
By e-mail: energimyndigheten@cm.se
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Preface

The *STIL2 in India* report prepared by AF consultant for the Swedish Energy Agency aims to launch a project "Implementation of STIL2 in India" under BEE-STEM cooperation. BEE stands for the Indian Bureau of Energy Efficiency and STEM stands for the Swedish Energy Agency. The report presents the energy use in a specific building category on national level in India.

Dr. Ajay Mathur, Director General, and Ms. Abha Shukla, Secretary, Bureau of Energy Efficiency have selected and had the overall responsibility for the STIL 2 India project together with Ms Carin Karlsson from the Swedish Energy Agency, and they have facilitated activities required for the project.

A substantial undertaking of this nature would not have been possible without the extremely valuable contribution provided by the Building Programme Team of BEE especially Mr. Sanjay Seth, Energy Economist, Mr. Girja Shankar, Assistant Energy Economist, Mr Shabnam Bassi and Mr Shammi Noor, Project Engineer for identification of buildings, facilitation of pilot audit and organizing workshops and coordination among building owners, Chandigarh SDA etc. Special thanks are conveyed to the assistance provided by auditing team of M/s Pranat Engineers and M/s Llyod, Insulation during pilot audit of identified buildings and to the team of EESL, M/s PricewaterhouseCoopers Private Limited for providing technical inputs on draft protocol.

The project has been led by ÅF, a Swedish consultant company specialised in the STIL methodology. Project leader was Ms Monica Gullberg, with the assistance of Mr Anders Hemmingson, Mr Björn Sjöholm and Ms Heini-Marja Suvilehto. Mr Egil Öfverholm from STEM initiated the study.

This is the first project of several within the BEE – STEM cooperation.

Dr. Ajay Mathur,
Director General
Bureau of Energy Efficiency

Ms Carin Karlsson
Program leader
Swedish Energy Agency

Innehåll

1 Introduction

Sweden and India have a bilateral agreement regarding energy issues and during the spring of 2011 a number of projects were launched by the Swedish Energy Agency. One of them was the implementation of STIL2 in India.

To be able to clearly understand this project one must be familiar with the STIL2 project in Sweden. This report is composed so that first the STIL2 project is described in general, thereafter how it has been conducted in Sweden and lastly what has been done within this project; the implementation of STIL2 in India.

The STIL2 project as such does not render any quantifiable energy savings, rather a baseline of the energy use with objective and harmonised data output. Reference values constitute a prerequisite for quantifying change over time and full scale STIL2 implementation provides a strong set of reference values. Since the data is presented on national level it allows to show estimated and calculated energy saving potentials for the whole building stock. These results can be used to support energy efficiency, monitor progress and as a base for policy development.

2 STIL2 in general

The purpose of the STIL2 project is to present the energy use in a specific building category on national level. This is made possible through energy audits performed in a number of buildings, selected through a statistical sample which allows the results from the audits to be scaled up to national level.

Within the STIL2 project, *energy inventories* are performed. It is mainly a survey of the real operating conditions in the buildings. The aim is to describe the buildings energy balance and allocate the energy, especially the electricity use into different end use categories such as lighting, computers and ventilation etc. In this project and in this report these energy inventories of buildings will be called energy audits since this is a more commonly used expression.

The STIL2 methodology demands a lot of organisation and preparation. Both complicated statistical method decisions and detailed knowledge of how to perform the energy audits, but also a lot of not so intellectually challenging, but very time consuming, work. One essential skill is to be able to communicate the aim and delivery of the project in such an appealing way that building managers/ owners see the benefits of participation.

3 STIL2 in Sweden

STIL2 has been conducted by Swedish Energy Agency over a period of six years in Sweden.

The STIL2 project has been a part of the overall project “Improved energy statistics in buildings” that started in 2003. Other sub-projects included were:

- Measuring household electricity use in small houses and apartments, in total 400 households up to and including June 2008;
- Measurement of cold and hot water consumption in approximately 60 households;
- The research project "Electricity use in households – obstacles and incentives to save electricity";
- The research project "A bright future?";
- “eKey” – a web-based, self-explanatory database for real-estate owner and a tool for them to insert own values and make comparisons of energy use. It was also used for the collection of official energy statistics for blocks of flats and premises[1];
- Use of energy by industry, working to improve and develop the statistics regarding energy use in the industrial sector;
- Energy use awareness, which takes a look at the role which property owners, the people who maintain properties (superintendents) and tenants play in the use of energy.

The overall project was finished during 2011.

The technical consultant company ÅF has been the main consultant since the start of the STIL2-project. The following subchapters describe how the STIL2 project has been implemented in Sweden.

3.1 Background

In the early 1990’s the public utility Vattenfall conducted a study of premises in Sweden. The study described energy use and other relevant variables for various types of premises, divided into different categories, in Sweden. The study was called STIL, which is an acronym for Statistik i Lokaler (Statistics In Premises).

[1] This data base is not valid any more but this type of data is now handled by the register for Energy Performance Certificate of buildings. In Sweden there is a register of buildings, but this register is not detailed and it is not sufficiently describing energy use for different items.

About ten years later the Swedish Energy Agency saw a need to update the figures and started planning for a STIL2 study. Due to practical and financial reasons the study this time was conducted over a period of six years, covering one building category per year, instead of as in 1990 when all building categories were studied in parallel.

3.2 Implementation in Sweden, 2003–2011

A number of preparatory studies were conducted to examine and evaluate the needs and demands of a full scale STIL2 study.

The audit protocol in MS Excel was developed to be used during the audits. A number of pilot audits were performed in various building categories to test the audit protocol and estimate the time requirements. The audits were compared with other models, showing a satisfactory result.

A study of key figures for estimating different installations common and widely applied was also performed. In the first year of STIL2 office buildings were studied why the initial key figures were mainly for computers, screens and other office equipment.

STIL2 started in full scale in 2005 with office buildings. It continued with schools and preschools in 2006, in 2007 health care facilities, in 2008 sport facilities, in 2009 retail premises and in 2010 hotels and restaurants.

3.3 Methodology

In the following subchapters the different steps in the methodology are described as they have been performed in Sweden.

It's important to be prepared for the many questions that will arise during the project. Discussing as many of these questions before they arise in the practical work phase and to reach an agreement in how they should be tackled is time efficient and may prevent the auditing work to be interrupted during its most intense phases.

3.3.1 Sample design

The sample designs for the study have varied during the six years of STIL2 in Sweden but the procedure has been essentially the same.

The procedure for the sample design can be described in short as the following:

The building categories used in Sweden are connected to the national official studies of energy use in premises, conducted by the Swedish Energy Agency each year. In the national official studies of energy use in premises the building stock is divided into around ten different categories. The STIL2 project has approximately followed these categories but with some alterations.

When the building category is identified as a population a suitably register is needed. In Sweden there are a number of registers of buildings or workplaces which have been evaluated and used during the six years. Different registers have been used to identify a satisfying frame to use for sampling.

The register should as far as possible equal the population, the building stock of a specific category. When a statistical sample of buildings is drawn from this, the sample can then be scaled up to represent this population.

Depending on which register being used the sample must be elaborated in different ways. The register used for several years in STIL2 in Sweden is the survey register used to develop the national statistics of energy use in buildings mentioned above. This register contains information of the buildings location, owner and size – both as total area and subdivided into different activities, e.g. office area, restaurant area and or school area. This gives the possibility to classify the buildings into different categories. Buildings normally consist of different types of activities, for example it's common that restaurants represent only a smaller part of a building. In these cases only the activities relevant to the study and the specific category of the year have been audited.

In Sweden the sampling level of detail has varied slightly between years. Some years, the selection could be made on the building level, some years on the real estate level (a real estate can consist of several buildings).

When an appropriate register is identified Statistics Sweden (SCB) has performed a random statistical sample of buildings. Different sample designs have been used to get a satisfactory sample of buildings in the right category and a sufficient number of buildings. The sample size must be large enough to allow describing the building stock on an aggregated level. The adequate sample size (or how many percentage of the national level building stock) is a very difficult issue. This is also very dependent of the project's financial budget and time schedule. To be able to describe the building stock on national level buildings from the whole country must be included. The population is therefore grouped into different stratums (sub groups). A random sample is then performed within each stratum.

Furthermore some additional criteria of the buildings have also been used from year to year. One criteria used all six years is that the buildings should contain at least 200 square meters of the category specific activity. For some of the years, the requirement that the specific category chosen for the study should occupy at least 80 percent of the buildings total area has also been used.

In Sweden it is not mandatory to participate in this study and this can be a source of non-response. This meaning some buildings will not participate in the study because of various reasons.

Also, even though a lot of effort is put into finding a proper register there might be over-coverage in the sample. This means that there will probably be buildings in the sample which are not relevant for the study. This can happen when buildings are rebuilt to fit other activities then the ones selected as target population in the

study. The register might not be entirely up to date and or there might be errors in the classification of the buildings. Even though the help information in the registers can be used to choose buildings there is no way to ensure that the figures in the help information is correct, other than contacting the buildings and ask. These means that the sample may contain buildings not relevant for the study, but also buildings which should be in included in the sample frame are not.

In Sweden sometimes twice as many buildings as the sample size have been needed to get the satisfying number of audited buildings because of non-response and over-coverage.

3.3.2 Preparations and contact work

After finishing the sampling procedure all the buildings have been contacted. Depending on the register used for sampling during the project the contact information have varied. If there has been no contact information to building owners in the sample, own inquiries have been made using search engines and yellow pages on the internet.

When the building owners, or sometimes a representative for the owner, have been identified they have been contacted by the project's secretariat. The project is presented and they are asked for participation in the study. Since the study is not mandatory for the building owner they must be convinced that it is beneficial to participate. The arguments used are that they get a free energy audit of their building, they also receive benchmarking data their building and the mean values for the study. The more altruistic reason for participation is and that they help develop important national statistics for buildings (this argument of course depends on the financing model of the project).

It is also important the tenants in the building are informed about the project and the upcoming audit. This in regards to that sometimes tenants have their own electricity contract and data from this must also be collected to able the energy balance of the building. It is also important that the tenants receive information that the building will be visited by an auditor who will be going through the building, visiting all rooms and taking notes about installations.

Information about the building's relevance to the study will also be obtained. Depending on what registry is used for the study, this information varies. If little is known about the buildings the secretariat must decide if the building is adequate for the study. Does it qualify for the STIL2 study?

All the requirements setup for the buildings that should be included in the study are checked; does the building contain the activities relevant for the study, is the requirement that at least 200 m^2 is used for this activity fulfilled, etc?

It has proven important to keep a journal of the contacts with every building. This helps the auditor to prepare for his contact and visit. It can also be crucial if the personnel of the secretariat are replaced.

During the audits period the secretariat must be available to answer questions from both the building owners and the auditors. Every auditor usually conducts a number of audits. Therefore the quality of the background information and the contact information to the building owners are very important to facilitate the auditors work.

The contact work is usually time consuming and sometimes tedious but also very important. The building owners must know what they are letting themselves in for and what will be required from them in question of time and effort.

3.3.3 Preliminary material for the buildings

When the building has been contacted and been determined as relevant for the study, preliminary information about the building is requested. In Sweden the information requested beforehand is the following:

- **Energy data** (all energy supplied to the building, electricity, district heating, gas, oil etc., water use.)
- **Blueprints/Drawings** (needed for both area measurements and orientation during the audit.)
- **Report from compulsory ventilation control** (In Sweden buildings with mechanical ventilation must have it inspected regularly. In the protocol from this inspection information about the ventilation system, such as flows, is given.)

In some cases the building owner needs assistance in collecting the data. In Sweden, if the building owner cannot obtain data of their energy use, a power of attorney signed by the building owner can be used to collect data from the energy provider companies. In Sweden blueprints/drawings of most buildings can be collected from government authorities. When nothing else has been available even fire orientation plans has been used to give orientation in the building but these do not give the size of a building.

If all required information is not collected before the audit, sometimes the auditor can collect the remaining information when at site in the building.

3.3.4 Head of auditors

In order to coordinate the work with the inventories and ensure the quality of the inventories results, a “head of Auditors’ has been appointment. The head of auditor should be a highly skilled and experienced auditor and is involved early in the methodology discussions, adding a more practical view of the work within the project.

The Head of the Auditors has been performing the pilot audits, planning the execution schedule of the audits and performed the quality assurance of each inventory protocol.

3.3.5 Pilot audits

To get a picture of the selected building category, which problems that might occur and what installations that are common, a number of pilot audits have been performed each year. These pilot audits are conducted by the "head of auditors" and a lot of time is put into the metering of specific installations and becoming familiar with characteristics of the building category in question.

The results of the pilot audits is used to analyse what alternations should be done to the audit protocol and if there is a need to develop new standard values for common installations.

3.3.6 The audit protocol

The audits in Sweden have been performed in a short period of time, approximately eight weeks, and by about 20 different auditors. To be able to get comparable data from all the buildings selected for audits a coordinated approach must be taken.

To reach a consensus in the audit work a very specific and standardized audit protocol has been developed for the study. The protocol consists of an Excel spread sheet with different worksheets for different parts of the building. This forces the auditor to put in the data in a standardized form which also results in a comparable output for all buildings.

The Excel format also allows the data to be easily accessed and compiled for analyses.

3.3.7 Key/standard values

Installations that are commonly found in the building category up for study but might be too complicated and or time consuming to meter have been studied in detail. To be able to cope with complicated installations during the full scale audit period standard values are developed. These values are based on the pilot studies, other relevant studies and other research. Other research has included contacts with manufactures and experts of the installations in question.

The standard values can be used together with for examples running time or number of cycles. For instance a standard value for washing machines is multiplied with the number of cycles per year, a figure collected from the building personnel or tenants, to obtain an annual total energy use.

Usually standard values are developed for a number of different versions of an installation. For example, in the audit protocol there might be three different types of washing machines and the auditor only has to decide which one corresponds with the one in the building.

The standard values can also be expressed as energy use per year (kWh/year) and then during the audit only the number of installations needs to be counted.

These types of standard values have been used especially for computers in offices where it is not so complicated to estimate a standard usage pattern. These were developed either in the beginning of the first year of STIL2 or were collected from branch organisations for e.g. advertising displays in retail (where it is not possible to dismantle the sign during the audit), saunas in sport facilities or other specifically measured installations for a specific end-category in a specific building category.

3.3.8 Education of auditors

To further more reach consensus and comparability in the audits, an education workshop with the auditors working in the project have been held each year. All the auditors participating in the project in Sweden have been experienced experts who work with energy audits in buildings. Still the education is needed to stress the importance of conducting the audits in the same way. During the workshops held the whole project is presented, but emphasis is on the audit protocol and what specific installations will be found in the selected building category. In Sweden this education has been mandatory for the auditors working within the project.

3.3.9 Climate correction

In Sweden the audits were performed in a shorter period of time, around eight weeks, during a representative climate period, which in Sweden meant during the autumn. This is a period of average temperature and humidity making it suitable for extrapolation of the values to annual means. At this time of the year in Sweden it is also cold enough to see all systems in use; heating, cooling, lighting etc.

To be able to compare the energy use for heating between different climate zones and different years, the data has been corrected for climate variations. This requires collection of “degree days” for each location where audits are performed, both for the current year but also for a normal year. The normal year is based on average data for the last 30 years. In this way the heating related data can be corrected for if the current year is colder or warmer than the normal year, allowing comparisons of different years.

3.3.10 The audits

The audit usually starts with a tour of the building together with building personnel. This gives the auditor an opportunity to ask questions about the activities in the building, for instance about running times and opening hours.

Then the inventory of installations begins. The auditor takes note of all electrical installations in the building. A lot of work is put into examining the ventilation systems and other major energy users. The lighting is inventoried with great detail. For each light source the type and power is noted. Lighting is also the only end-use that is presented at the” room-type level” e.g. office rooms, open plan offices etc.

The audits are based on the collected energy data. The energy supply for one full year is known from the information collected beforehand, and it is divided into different end use areas such as ventilation, lighting and computer equipment.

The buildings' total floor area is divided into different room types; this is why it is so important with blue prints of the buildings. The classification of room types is done mainly to describe the installed power for different light sources in each room type. It also gives a picture of how the buildings are composed of various activities and how comparable they are.

In the cases with only part of the building being audited the auditor must calculate how much of the energy use that is used in the audited part. This goes especially for heat, which usually can be subdivided by area.

Sometimes also the electricity use must be divided. This problem occurs when more activities than the one relevant for the building is included on the same electricity contract. This problem has sometimes been solved by the auditor inventorying all electricity use in the building and then subtracts the electricity use that is not in the parts of the building relevant for the study.

When the auditor have performed an audit all collected data is put into the protocol. The protocol has then been sent to and reviewed by "the head of auditors" and if there are any ambiguities or errors the protocol it has been sent back to the auditor for further explanations and edits. This procedure is repeated until the "head of auditors" is satisfied and there are no longer any anomalies or errors in the protocol.

In some cases, the buildings had to be revisited to collect more data or identify potential sources of error.

3.3.11 Compilation and analyses

When all the audits are completed and all the protocols are quality controlled by the "head of auditors" the data have been complied and analysed.

The compilation has been done in Excel where selected values from all protocols have been extracted and then used in the calculations. The calculations have been performed using Excel and the statistics software SPSS.

Since statistical random samples have been used, the inclusion probabilities of each object in the studies are known. This means that the results can be scaled up to apply for the whole populations, thus the building category on a national level. Since there is non-response and over-coverage in the study the weights used to aggregate the results have to be modified to be able to represent the whole population. This means that the buildings that are not included in the study because of non-response are assumed to have the same characteristics in their energy use as the buildings that are audited.

This is a potential source of error since there could be a reason to why some buildings refuse to participate in the study, for example that they are not engaged in energy issues.

This work has been performed by Statistics Sweden (SCB) during the project in Sweden.

It's worth mentioning that during the first year of STIL2 in Sweden, when office buildings were studied the random sample that was designed failed. Due to problems with the selection of buildings the sample frame was not complete and some buildings had to be added to the sample without random selection. This resulted in the fact that the inclusion probabilities were unknown and no national weights could be calculated. Instead efforts to calculate weights were done retrospectively.

3.4 Results in Sweden

The results from each year have been presented in a report each year. Also, the participating buildings have received feedback in form of a description of their own building in comparison with the national mean for some key values, for example total energy use, electricity use for different installation and specifics information about lighting and ventilation.

The results in Sweden show that ventilation and lighting are the major users of electrical energy, this goes for all building categories. In certain categories there are also other large users, e.g. the ice making procedure in ice rinks and kitchen equipment in restaurants.

The results from each of the six years have been compared with the results from the first STIL study conducted in the 1990's. This gives a great picture of how the energy use has changed the last 15–20 years. Some of the clearest results show the following:

- Individual oil burners and direct electrical heating have largely been replaced by district heating.
- Electrical energy used for lighting has decreased. New and more efficient light sources are used.
- Electrical energy used for ventilation has increased. This is likely to be because of the compulsory ventilation control introduced in the 1990's. However the equipment for ventilation (fans) has considerably better SFP[2]-value than in 1990.

Figure 1 shows results from STIL2 in Sweden, the specific electricity use per area for the six building categories. All heating is here excluded, both electrical and all other means of heating.

[2] Specific Fan Power, defined as the electrical power used by the fan (kW), divided by the amount of air circulated through the fan (m^3/s).

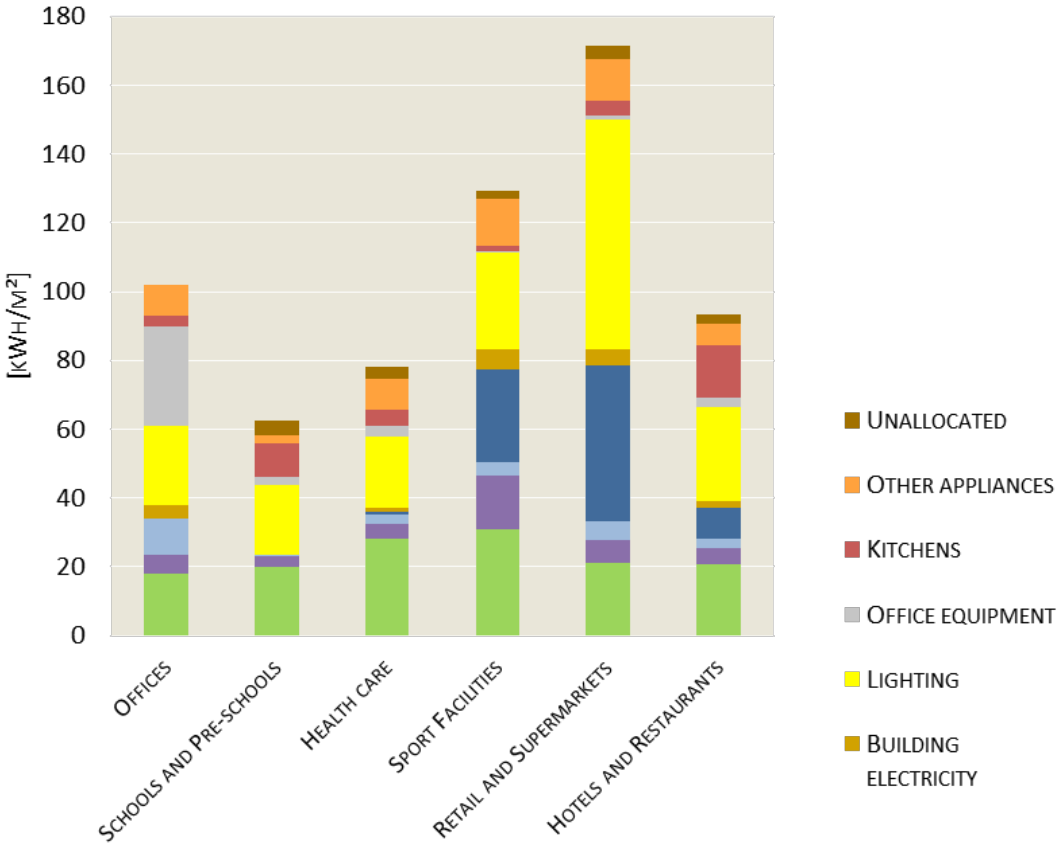

Figure 1 Swedish results; Electricity use excluding electric heating [kWh/m²]

Below is a more detailed description of what the different categories include:

Offices: All types of office and administrative buildings, whether public, private or other type;

Schools: Infant schools, schools for 7–16 year old pupils and upper secondary schools. Universities and institutes of technology have not been surveyed;

Healthcare: Hospitals, large medical centres and polyclinics, residential care homes, rehabilitation centres and similar care facilities;

Sport facilities: Gymnasiums, indoor swimming pools, indoor ice skate rinks and complexes with several of these above;

Retail and supermarkets: Stores, shops, business premises, grocery stores and shopping malls;

Hotels and restaurants: Hotels, restaurants, also and buildings for cultural activities and meetings (such as cinemas, theatres, conference centres etc.).

3.5 Impacts in Sweden

During 2011 the Swedish Energy Agency's "Improved energy statistics in buildings"-project was finished. STIL2 is a part of this project and will, together with all the other sub-projects, be evaluated during 2011 and 2012.

The results from each year of the STIL2 project have been received with interest from different stakeholders; both from the users, building maintenance personnel and energy management companies, but also from trade associations for e.g. lighting companies.

The results have also been used in research and as reference values in public procurements regarding e.g. office equipment.

3.5.1 Further studies

The data collected during the STIL2 study was anonymised and the database was published on STEMs webpage. This allowed researchers to use the material.

The STIL2 project has been used in further studies in Sweden. Two extensive studies of behavioural issues have been conducted by STEM. One regarding office buildings and on regarding sport facilities.

STEM has also made more accessible versions of the reports. These reports explain the studies in a shorter way concentrating on the results and saving potentials.

Also, from STIL2 school study has resulted in an educational material for school children where energy issues are explained in a very basic way and gives students the opportunity to make their own simple energy audits of their own schools.

Other organizations, such as the Swedish Association of Local Authorities and Regions (SKL), have made their own follow up and in-depth studies of sport facilities.

The Swedish National Board of Housing, Building and Planning collaborated with the STEM during the second year of STIL2 in Sweden. The NBHBP performed some additional data collection in the audited buildings, data regarding the quality of the indoor climate and also how the indoor climate was perceived by the people working in the buildings. This allowed studies of the correlation between energy use, indoor climate quality and health aspects.

The Nordic Eco-labelling has used electricity use statistics from STIL2 to develop criteria for labelling hotels and restaurants.

Data from the STIL2 project has as well been instrumental in the City of Stockholm's work with its Environmental Plan.

4 STIL2 in India – a pilot study

The STIL2 methodology with its statistical sample of buildings and coordinated energy audits is fully exportable to other settings. But the methodology must be adapted. To describe in which ways and how is the purpose of this project.

4.1 Background

Monitoring the energy use in buildings is important for India as part of the general national aim to decrease specific carbon emissions per capita, including more efficient energy use. Buildings constitute an important share of the total energy use in the country. Measures for an energy efficient society therefore must include more energy efficient buildings and in order to formulate specific goals and policies for this sector, monitoring is essential.

Sweden has entered into a bilateral cooperation with India, part of which aims to transfer some of the energy policy know-how that the Swedish Energy Agency has developed.

4.2 Objectives

The objective of this project is to introduce the STIL2 methodology in India and also carry out a pilot study of three buildings.

The questions to be answered by this project are the following:

- What is the use of STIL2 in India? How can the results be interpreted and used?;
- What resources are needed in form of time, financing, and staff?;
- What is needed to perform a project like STIL2? What kind of data is needed to perform a statistical sample of buildings? What background data for the selected buildings is needed and how is this collected and processed?;
- How to perform the energy inventories? How can consensus be created in a large number of audits, performed by different persons?

4.3 Implementation in India

The implementation of STIL2 in India has been performed through collaboration between the Swedish Energy Agency and the Bureau of Energy Efficiency in India. The Swedish Energy Agency contracted the same consultant that conducted the study in Sweden, ÅF.

ÅF visited India and the BEE three times in the period of May 2011 and April 2012. During the first visit the STIL2 project was thoroughly presented to the BEE. ÅF also met the ESCO companies authorized by the BEE and discussed the project. A trip to Chandigarh was conducted to meet the authorities regarding audits in this region.

During the second visit ÅF and BEE held a workshop with invited ESCOs and other stakeholders. The STIL2 project was described and some of the results from Sweden presented. The audit protocol was also presented and valuable comments regarding its contents were noticed. During this trip the three pilot audits were performed, one building in New Delhi and two in Chandigarh. The pilot audits were mainly performed to see what adjustments that would be needed in the audit protocol.

The third and final visit included a presentation of the results of the project in line with this report as well as brainstorming sessions and brief planning of a full scale study.

4.4 STIL2 – Step by step

The STIL2 project consists of two equally important steps: **the energy audits** and **the statistical analysis**.

Since India has completely different conditions the steps are described more generally here. Both the audits and the statistical sample of building might have to be conducted in different ways in India than in Sweden.

4.4.1 The sample of buildings

Ideally, the buildings should be selected randomly as a statistical sample. This is required in order to be able to present the results as on a national/aggregated level with statistically significance. If the buildings are not randomly sampled the study will be a multiple case study of a number of selected buildings. This means that there will not be any statistical significance in the presentation of the results, and therefore not able to express the results on an aggregated level.

There must be a defined population of buildings, for example office buildings in India. If it's not possible to define a population of buildings on national level, another population could be defined, for example all official office buildings in India or any sub region. Some relevant factor must be used for calculating the statistical probability and thus weight of each randomly selected building. This factor can for example be the total square meters or the annual electricity use.

If the random sample of buildings is design from a known population the study can use weights to present the results on an aggregated level.

4.4.2 Secretariat

The vast amount of information circulating in a full scale implementation of the STIL2 project calls for a well-organized administrative effort. This is the task of the STIL2 secretariat. The purpose of STIL2 secretariat is to administrate the massive amounts of information and data in the STIL2 project.

The secretariat establishes contact with building owners, presents the project and prepares them for what will be needed before and during the audit. Also what results that can be expected afterwards.

For each building to be audited there must be background material collected, described below. The requirements to perform an energy audit are:

- Full access to all building area
- Cooperation with building owner and maintenance personnel
- Blueprints/drawings of the building
- Energy use data for one full year

If the object selected cannot fulfil these requirements it will not be able to participate in the study and thus classified as non-response.

The secretariat must organize the information about which buildings are to be contacted and what information has been sent and shall be sent to whom. The data collected and processed may often be confidential. This means that it might be required to construct an individual identification code for each object in the study.

The secretariat must also keep an up to date-registry of the buildings, which are still on-track, which declines participation or cannot fulfil the requirements of inclusion in the study (non-response) and which are not adequate for this study (over-coverage).

In Sweden, the building's owner must agree to participate in the study. Participation is voluntary and it is very important that the contact person is interested in the project and can assist before and during the audit. Should it be that in India, participation could in some populations be made compulsory, it will be preferable that the building owner, the contact person and the tenants are interested and dedicated.

4.4.3 The energy audits

The most important issue of the energy audits is to reach a consensus in how they are conducted. In order to make the data collected comparable between the buildings the data collection must be performed in the same way in all the buildings. This means that the auditors should use the same methods and do the same assumptions during the audits.

There cannot be any contradiction of what shall be included in the different building categories. For example what is included in an office buildings, should a separate restaurant or stores in the building be audited or not?

The audits should be performed so that the collected data is transparent, all calculations and estimations used in the audit are explained in the protocol.

4.4.4 The collected data

When the audits are finished and the quality of data is controlled the data must be compiled and sorted for future analyses. It's important to be prepared for the massive amount of data to be compiled and also for how it can be interpreted, presented and used.

Afterwards the secretariat must see to that the buildings included in the study gets the right feed-back from the project.

4.4.5 Analyses

What analyses that can be performed depend on the collected data.

The number of observations should be sufficient or the conclusions might be questionable.

If there is no possibility to perform the study with a statistical random selection of buildings but a large number of buildings are audited there will be a large database of comparable figures for many buildings. This database can also be of great interest in analyses of energy use in different building categories and a source for developing reliable reference values.

If the number of buildings in the database is large enough it can allow conclusions to be drawn and generalisation on an aggregated level.

5 Results of the pilot study in India

This chapter gives a short presentation of the results of the pilot audits performed in India during the project, and also the conclusion reached regarding how to go further with a full scale implementation of STIL2 in India.

5.1 Pilot audits in India

During this project, pilot audits were performed in three buildings in India. The aim with these pilot audits was mainly to see how the audit protocol must be modified to suit the Indian context. The audits were performed by ÅF together with representatives from the buildings maintenance personnel and the auditors who earlier performed audits of these buildings in BEE's regime.

For two of the pilot objects scalable blueprints of the whole building were given. This allowed for detailed area measurements. For the third building it was only possible to get blueprints for orientation purpose, these blueprints were not in scale and did not cover the entire buildings layout.

Electricity bills stating the electricity use for 12 months back were also given for the buildings, although on bimonthly level. This had to be adjusted when data were entered into the audit protocol where monthly data is required.

Logging electricity use was achievable for all three buildings. Both total electricity use and some sub-groups were measured for at least 24 hours.

To be able to perform an audit, access is needed to all parts of the building. This became problematic in the third building where only a minor part of the building was accessible.

Lighting installations were counted and light source and power were noted. All appliances such as computers, printers, copy machines, water coolers, A/C, etc were counted. Some of the installations were measured instantaneously.

During the audit it was decided to perform the audit on room level instead of building level. This is in Sweden only done for lighting, but for India all appliances were counted on room level.

Lessons learned:

- Blueprints are probably available, but can be hard to access;
- It is very important get clearance to access all parts of the building. It is preferable also to send out some information to all tenants in the building that an audit will take place;
- When logging electricity, it is important to know what loads are included in the subgroup that is logged

- In Sweden the STIL2 auditors had special ID badges from Swedish Energy Agency and the auditors were also published at the Swedish Energy Agency home-page. There was also printed material to hand out during the audits entailing project purpose and contact information.

5.1.1 Alternations of the audit protocol

A lot of adjustments have been made to adapt the STIL2 protocol used in Sweden to Indian circumstances. The energy use in Sweden consists of equal parts electricity use and heating. Ventilation is also a significant part of the electricity use in Swedish buildings. In India cooling is the main contributor to the electricity use, while heating is very minor.

The protocol has been rebuilt from scratch, using input of course from the Swedish audit protocol but mainly from the experience from the pilot audits in India and with invaluable input from the BEE and their designated ESCOs.

The protocol is constructed in Excel and consists of a number of sheets where data is entered.

Building Data

Here information about the buildings identification, location, characteristics, owner and contact persons is entered.

Energy Data

Here the collected energy statistics are entered

Data

In this sheet there are possibilities to alter the information needed in the inventory sheet. Installations can be added and all drop-down lists in the protocol can be altered. This sheet should be locked for editing when the protocol is to be used during a large scale project.

Inventory

This is where all data collected during the audit is entered. For each room in the building; room name, room type, installations and appliances is entered along with operating hours and if needed power.

Output

This sheet compiles the data entered in the inventory sheet presenting the output of the audit.

Savings Potentials

Here identified potential energy savings can be entered.

Help

This sheet shall contain help for the auditor. It can contain pictures and text regarding common installations in a certain building category.

Degree Hours Actual Year

Local climate data for the year the audit refers to

Degree Hours Normal Year

Local climate data for the normal year

The goal is to make the protocol as self-explanatory as possible. A manual has also been developed and BEE officials and ESCOs has attended a first training workshop.

Even if the protocol is easy to use the energy inventory requires a professional auditor to perform the audit. The simplified audit model may require the auditor to make estimations of various installations why the auditors experience is of great importance. To strengthen the harmonisation of the data it should be mandatory for the auditors to participate in STIL2-education workshops before using the protocol.

5.2 Inventory results

When viewing the results from the pilot it is important to remember that this is only a pilot and to differentiate between these case studies and the statistics from a full scale implementation.

Two of the selected pilot buildings were entered into the new Excel inventory model. Data from the inventory was combined with information from the previous audit reports.

Below data from the two inventoried buildings is presented in text and figures. This is the kind of information that could be presented on national level, describing a population of buildings if a full scale version of STIL2 was conducted using the methodology as it was conducted in Sweden.

The two buildings are A) Telephone Exchange building, Chandigarh and B) Passport Building, Chandigarh.

5.2.1 Electricity use

The annual average electric energy use in the buildings is in building A 282 kWh/m² and in building B 94 kWh/m². The pie charts below shows the distribution of different end use areas. Building A contains a lot of process specific installations including process cooling why the miscellaneous part is big. In the second building (B) a server is accounting for almost 50 percent of the miscellaneous post.

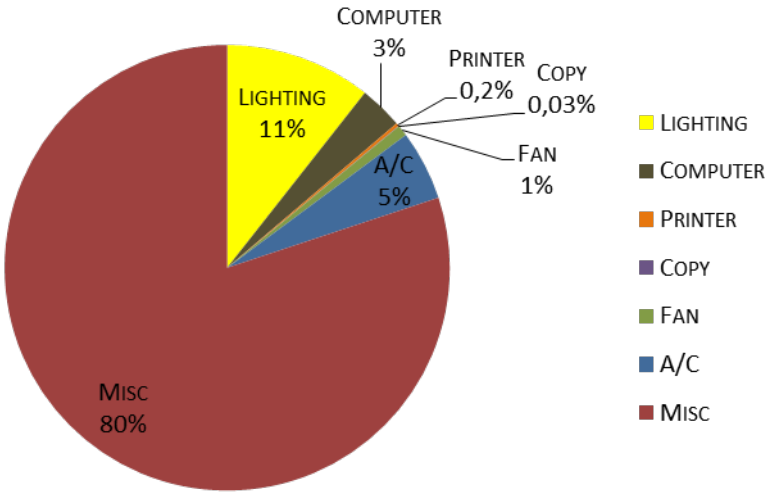

Figure 2 Pilot Building A: Electricity use, divided into different end use areas [%]

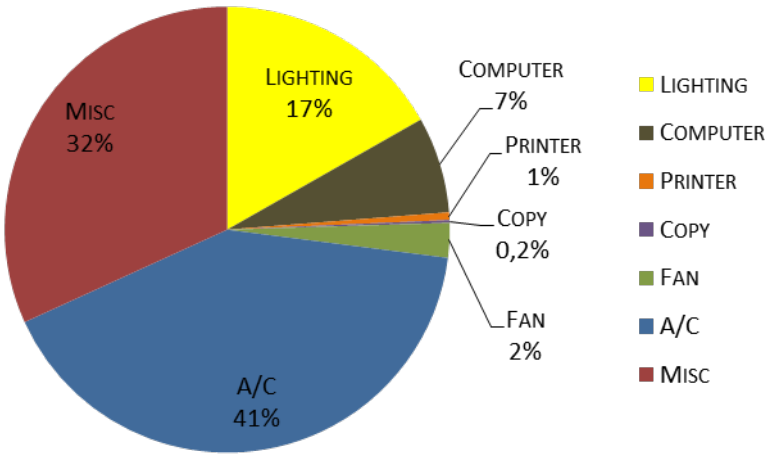

Figure 3 Pilot Building B: Electricity use, divided into different end use areas [%]

The bar chart below shows that in building A 30 kWh/m² is used for lighting and 14 kWh/m² for climate cooling (A/C). Computers, printers and copy machines together add up to 9.5 kWh/m² where the major part is computers (including monitors). Building B uses 16 kWh/m² for lighting, 38 kWh/m² for A/C and

7 kWh/m² to office equipment. In the bar charts the electricity use for server and process cooling is separated from the miscellaneous post.

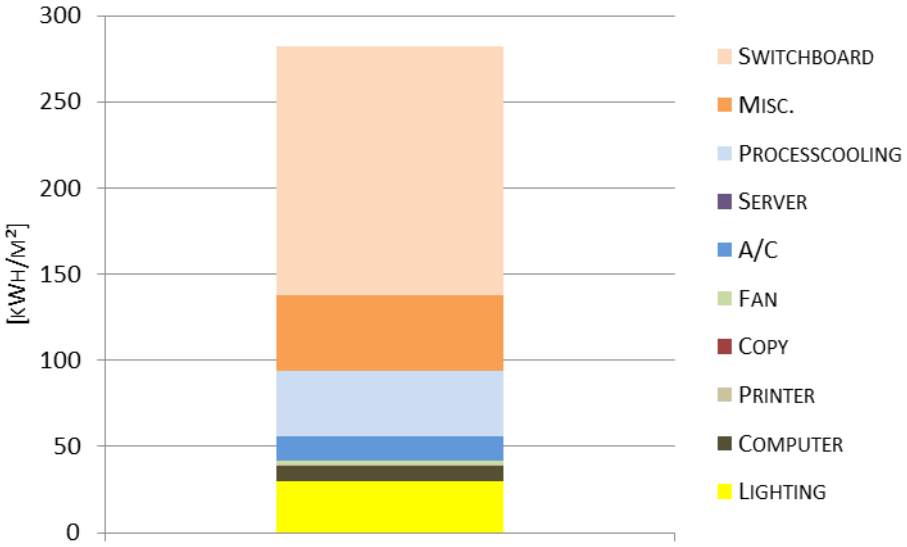

Figure 3 Pilot Building B: Electricity use, divided into different end use areas [%]

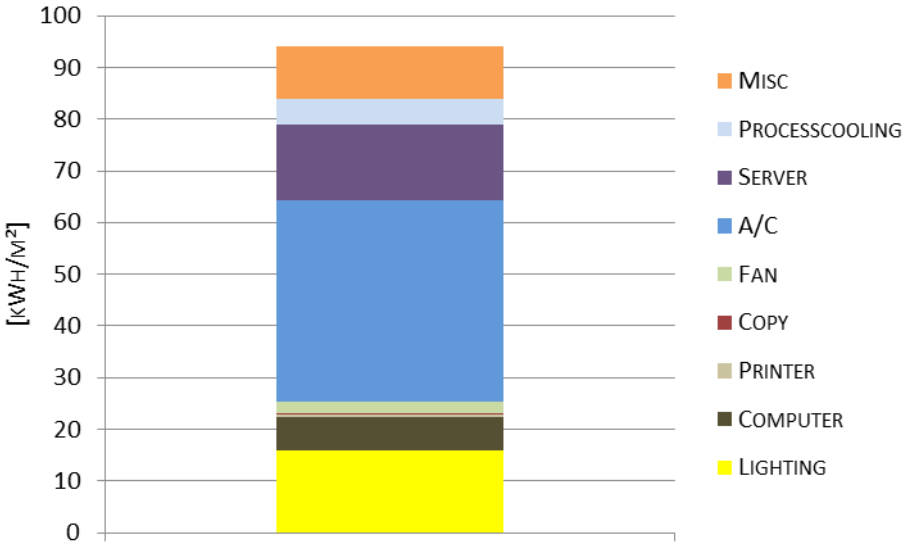

Figure 4 Pilot Building B: Electricity use per area [kWh/m²]

The two pilot buildings have a different electricity use pattern, one of the buildings uses almost twice as must electricity per area for lighting. When energy statistics are developed, for example in terms of average electricity use it is important to remember that this is precisely a statistical average value; it is usually not the most common value for all inventoried buildings.

5.2.2 Lighting

Lighting can be studied more in detail, showing the Lighting Power Density – installed power per square meters for different light sources and different room types. This is gives an indication of the lighting's energy efficiency. As the pie charts below describe fluorescent tubes with magnetic chokes is the most common light source in both buildings.

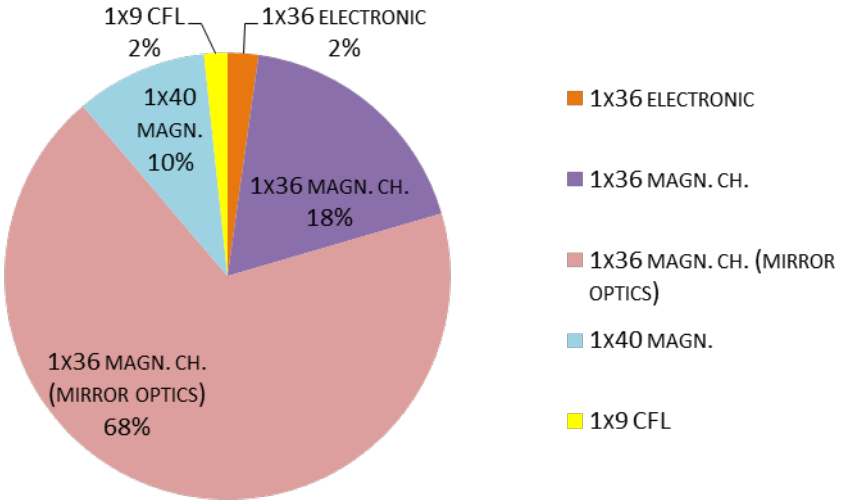

Figure 6 Pilot Building A: Lighting Power Density (Installed power per area, m²) divided over different light sources [%].

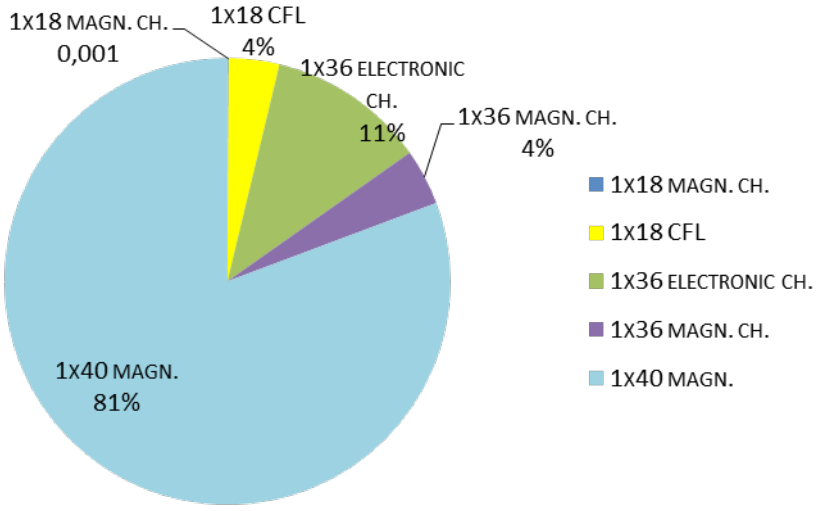

Figure 7 Pilot Building B: Lighting Power Density (Installed power per area, m²) divided over different light sources [%].

The lighting power density can also be described per room type, as in the table below.

Room type	W/m²	
	Building A	Building B
Office rooms, single officer	11.8	16.3
Office room, multiple officers	12.7	16.6
Office landscape	15.3	12.6
Corridors, passage, stairs	3.6	4.8
Maintenance rooms	5.5	3.6
Conference room	12.6	4.8
Reception	11.1	9.7
Toilet	6.8	7.7
Storage room	9.8	4.4
Library	–	–
Server-, computer room	14.1	4.9
Outdoors	–	–
Other room type	9.4	11.0
TOTAL	**10.4**	**8.2**

Table 1 Pilot Buildings: Lighting Power Density (Installed power per area, m²)

The buildings consist of different types of offices; one-person offices, two- to four-person offices and office landscapes. Together these offices stand for almost 50 per cent of the buildings total area, while the rest is common-use areas and maintenance rooms. “Other room type” is entered when a visited room does not match any of the alternatives given in the protocol.

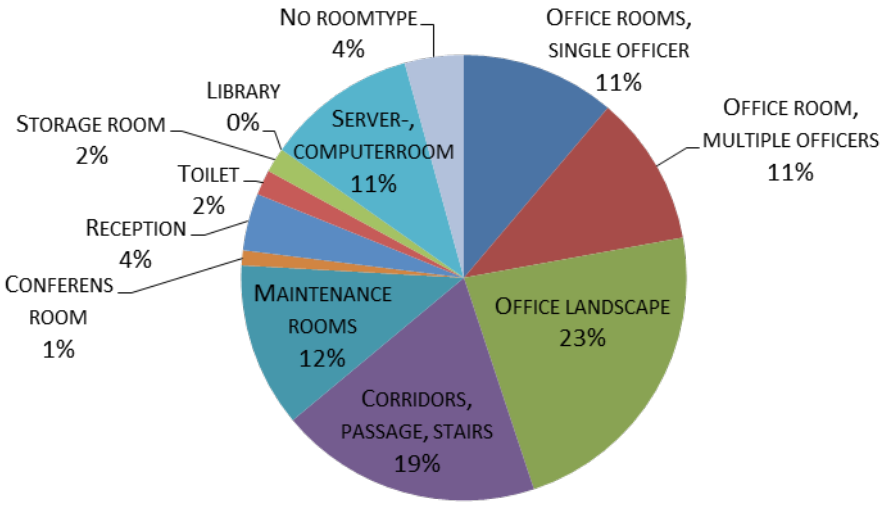

Figure 8 Pilot Building A: Distribution of different room types [%].

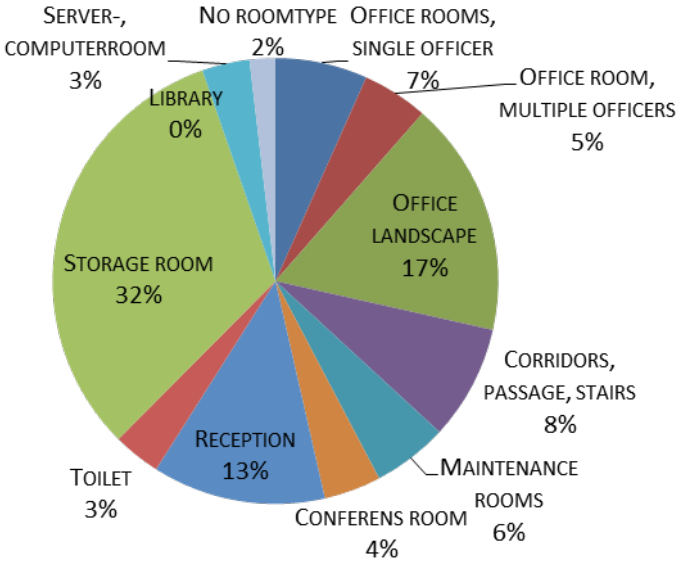

Figure 5 Pilot Building B: Distribution of different room types [%].

5.3 Large scale implementation

In this section the possibilities and barriers to go further with the STIL2 project in India are discussed. The methodology must be adapted to the Indian context, but the core of the project – developing detailed electricity use statistics by performing audits in a selection of buildings – is transferable to India.

5.3.1 Register for sampling

The STIL2 project aims to describe the electricity use in a population of buildings by a detailed study of the electricity use in a sample of buildings from this population.

For this to be possible there must be a defined population, a usable register of buildings consistent with this population and a methodology to design a sample from this population which allows the sample to describe the whole population.

As in Sweden, no single complete register has been identified in India comprising all premises throughout the country. The lack of a sufficiently extensive register of buildings on a national level is a major barrier to perform the STIL2 project in India as a national statistics project.

A method that has been applied in Sweden, is to create a new register of buildings, with the aim to cover a population of buildings that is of interest to describe on a national level. For example this could be government-owned buildings, or government-owned *office* buildings.

A register like this could probably be constructed on e.g. state-level and then summarized on national level by a national authority.

This register should contain building identification, location, data on total floor area and activities in the building. A register like this could be constructed for government-owned offices, schools and hospitals. The register should be updated once a year, and also be monitored to evaluate its coverage and relevance.

A register like this, which covers the desired population, would work as a frame and could be used to perform a statistical random sample from.

5.3.2 Audit protocol

What the STIL2 project also creates, in addition to the national results, is a detailed data base of the allocation of electricity use in buildings within a specific category.

There is a great benefit to start using a standardized audit protocol. The protocol, if correctly used, allows transparency in the collected data. It gives the possibility to access the collected data and study the building from different angles, which is not possible to do in the existing reports of the building audits.

Possibilities and Barriers

Identified problems

Lack of complete nationwide registers of buildings

Possible problems

Finances

Incentives for building owners to participate

Full access to all areas in the buildings during audit is crucial

The project does not give any quantified energy savings; it gives a baseline for energy use

Possibilities

Skilled professionals available

Good national organisation, regional coverage

Possibilities to construct new register to cover desired population

If register of buildings is available and the statistical sample performed the study allows description of energy use on national level, or any other population there is a feasible register of

Benefits of protocol?

Using standardized protocol for audits gives transparency in the collected data.

Collected data is easy to compile and compare

Gives a base for a building database

Could also be used for measuring of before and after studies if energy efficiency measures are performed

5.4 Conclusion and recommendations

The conclusion of this pre-study for implementation of a STIL2 study in India is that it is possible to perform in full scale and that India would benefit from shaping such reference values as a base for policy measures and for future monitoring of the sector.

The issues regarding the access to a reliable and comprehensive register can be solved through the construction of a new register. When the register is in place and is assessed to cover the desired population or building category, a statistical sample can be designed and performed.

Planning and performing a national survey investigation as STIL2 is of course a significant challenge and further preparatory activities are needed for a full scale STIL2-project launch.

One of the most important tasks is to anchor the project with relevant stakeholders in the country.

During the BEE – STEM cooperation kick off meeting in April 2012 this issue was thoroughly discussed. The result of this discussion is presented as a table in Appendix 1.

Activities before going full scale

Investigation of availability of usable registers;

Anchoring the project with important stakeholders:

- Other governmental organisations that have need of data concerning buildings;
- Local authorities;
- Building owners;
- Local Energy managers;
- Representatives from the building category to discuss and define relevant indicators;
- Investigate possible synergy effects with other projects including need for mutual input data, key values, and optimisation of data collection to avoid duplication of work.

Activities when going full scale

- Choice of building category/population;
- Defining register and sample frame;
- Putting together a reference group;
- Adjustments of the inventory protocol by Indian experts could be needed;

- Climate zones identified and data for these collected;
- Administrative preparation, making sure data is collected, handled and stored in a correct way;
- Compilation of information material regarding the projects content, requirements, outcome and such to be distributed to different stakeholders;
- Sampling of buildings in selected category;
- Contacting selected building owners, collecting information beforehand;
- Performing energy inventories, using the STIL2 protocol;
- Compiling collected data, perform analyses and presenting results.

A full-scale implementation of STIL2 in India, is estimated to require around 10 300 hours per year, of which in the order of 30% would be contributed by international consultants in the first year. The amount of man-hours required for full scale implementation is estimated based on the assumption that 200 buildings will constitute a sufficient sample size.

A time schedule is presented in Appendix 1.

Appendix 1

Time schedule for full scale implementation

This time schedule was drafted during the brainstorming meeting at BEE in April 2012 to identify the upcoming tasks and activities for taking the STIL2 project large scale in India. The content of the table was then finalized during May 2012. The time includes only twelve months here, but it is advisable to plan for 18 months for the reason that building audits must be carried out at a suitable time of the year in terms of climate.

No.	Activities	Sub Activities	Duration
1	STIL		12 Months
1.1	Establishment of inventory tools	1.1 a) Creating manual for training & operation of STIL2 for auditors, building owner & Secretariat	2 Months
		1.1 b) Development of web page for full scale audit	
		1,1 c) Training of BEE Officials, Training of trainers	
1.2	Anchoring project before full scale launch and Launching of STIL for Office Buildings	1.2 a) Creating structure for STIL project with BEE, STEM & Industry partners	3 Months
		1.2 b) First reference group meeting	
		1.2 c) Hearing / Dissemination of objectives of project	
		1.2 d) Creating Frame for defining sample size	
		1.2 e) Hiring of agency, inclusion of auditor,	
		1.2 f) Sampling, complementing the list of relevant BO, contacts	
1.3	Data collection, data analyses and results presentation	1.3 a) Contacting BO	5 Months
		1.3 b) Audit of building[3]	
		1.3 c) QA of protocol	
		1.3 d) Compilation & Analysis of data	
		1.3 e) Presentation of Data & Report, key indicators ,	
1.4	Dissemination of results and recommendations	1.4 a) National projection for potential saving, End Use bench marking	2 Months
		1.4 b) Dissemination to BO, Industry partners	
		1.4 c) Developing programmes for Implementation like incentive, targets, Procurement rules	
1.5	Implementation and reporting	1.5 a) Getting feedback on savings	
		1.5 b) Institutional & Educational Building, Retail premises, Hospital & Hotel	

QA = Quality Assurance
BO = Building Owner

[3] Audits need be scheduled with respect to the climate and that a full year representation of results can be made. Therefore, while audits are carried out during two months, the project plan will include 'waiting time' of up to six months.

Our goal – smarter energy usage

The Swedish Energy Agency is a national authority that works for a safe, environmentally friendly and efficient energy system. Through international co-operation and commitment, we can contribute to reaching the climate goals.

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Swedish Energy Agency

Swedish Energy Agency, P.O. Box 310, 631 04 Eskilstuna, Sweden
Phone +46 16-544 20 00, Fax +46 16-544 20 99
E-mail registrator@swedishenergyagency.se
www.swedishenergyagency.se