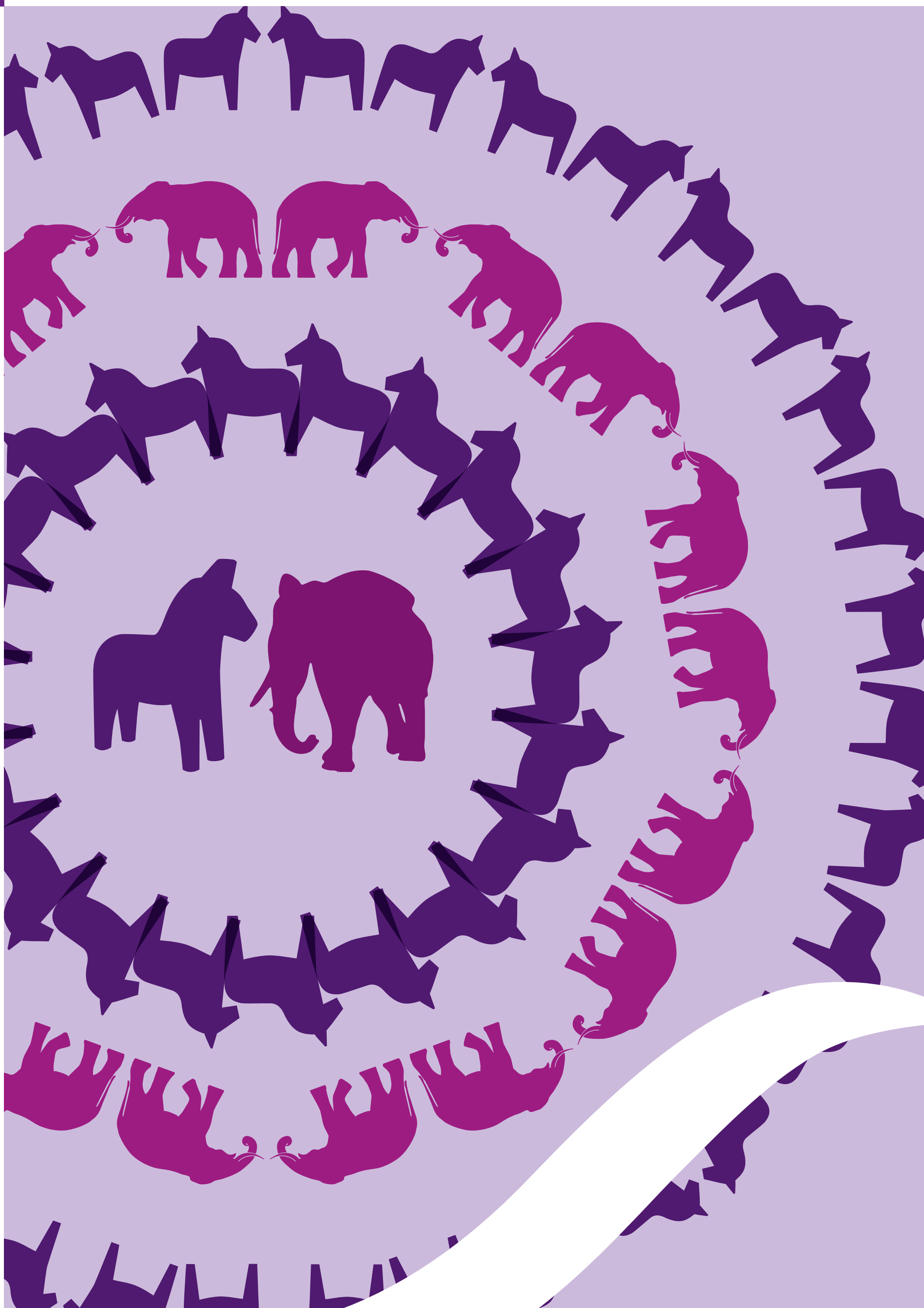
Sveby Standard for the Energy use in buildings



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About the Sveby Standard for Energy use in Buildings

Sveby stands for ”Standardize and verify energy performance in buildings” and is a Swedish cross-industry initiative to develop voluntary guidelines on energy use for contracts, calculations, measurements and verification.

Sveby is targeted to stakeholders in the various sectors affected by definitions and verification on the energy performance of buildings, such as property owners, municipalities, developers, contractors and consultants.

The Sveby material has been developed in collaboration between a number of major companies and organisations in the Swedish real estate and construction industries. IT is free to use and available for download (in Swedish) on the webpage: www.sveby.org

How to prove that the energy performance requirements are fulfilled?

International and national demands on reduced energy use leads to an increased need to control how much energy a building is expected to use, and then actually use. The energy performance requirements and monitoring in the Swedish Building Code, BBR (Swedish National Board of Housing) will ultimately become demands from developer to contractor. In many cases, the developer or municipalities set even stricter requirements than the BBR. Within Sveby, tools have been developed to clarify and ensure the entire process from early stage design requirements to verified results. An industry standard for energy in buildings has been created.

The starting point for Sveby is to meet the energy demands of an agreement between the developer and the contractor based on the use of standardized occupant input data for energy calculations and how the verification of energy performance is done.

The purpose of Svebys calculation instructions is that standardized occupant input data should be used in energy calculations and that the calculation result will apply to “normal” Swedish conditions, which shall be the one declared after the building is placed in service, both compliance to building regulations but also the fulfillment of the contract between developer and contractor.

The verification shall be against standardized occupant input data, which means that the measured energy use needs to be adjusted using energy simulations retrospectively if deviations occur in occupant behaviour.

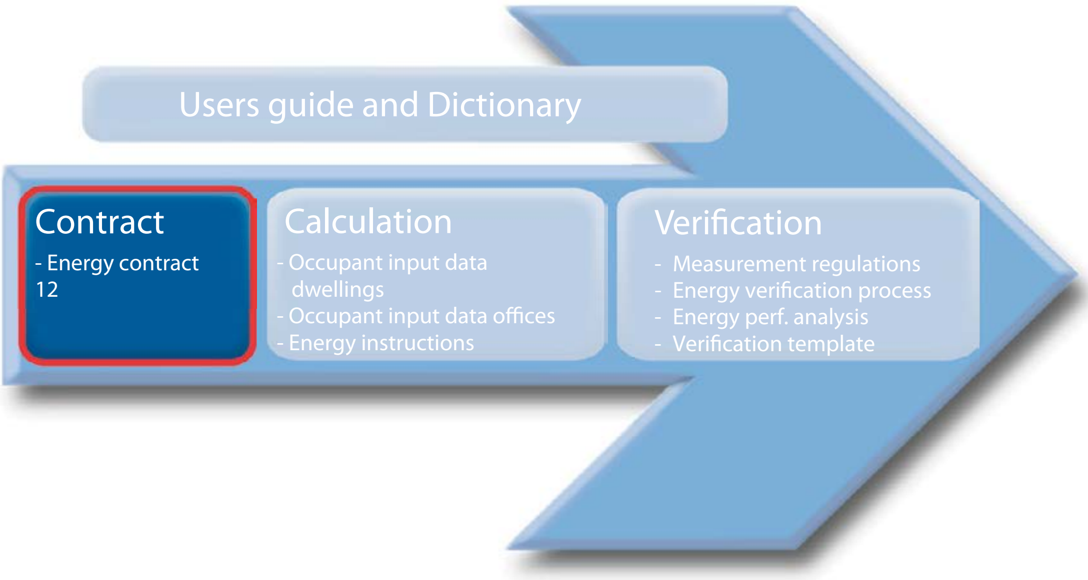
It is very important that the calculations are updated when the building is completed so that all changes are included, and that it clarifies which version of calculation and input data the verification measurements are compared to.

The Sveby instructions apply primarily to new buildings (mainly residential and office), made with today’s technology, but can also be applied in parts to other types of buildings or major renovations.

1.1 Contract

The first step in the process is to agree on an energy performance requirement level, in normal use. The requirement may be the legal requirements as BBR, or more stringent requirements that the developer and contractor agree upon. Svebys material for the calculation and verification can be used in all forms of contracts, but the material also includes a model contract, the Energy contract 12, to ensure the agreement between the developer and contractor in the order phase. The contract template is primarily designed for turnkey projects.

Along with Svebys other material, the contract will provide security for both parties, both in terms of what the requirements are and what corrections are to be made to the measured energy use in a follow-up stage. Additionally, the consequences of an unmet energy requirement are regulated with respect to the burden of responsibility and compensation.



The contract refers to other parts of Svebys material and the basic idea is that the agreed contract requirements or legal requirements or any other requirements (e.g. from landowners or municipalities) must assume Svebys standardized occupant input data. Alternatively however, verification could be made against project-specific occupant input data where explicitly expressed. Such an agreement may be relevant e.g. at fixed installations that greatly affects operational electricity and thus heating and cooling needs.

The contract includes agreement on a special energy price that will apply during the contract period, broken down by energy carrier, if desired. The indemnity is made up of the energy price multiplied by the number of kilowatt hours that deviate between the agreed and measured normalized energy performance. Monitoring will take place on a monthly basis over a three year period and both parties should have access to measurement values. Energy audit and necessary corrections should be done by an energy specialist.

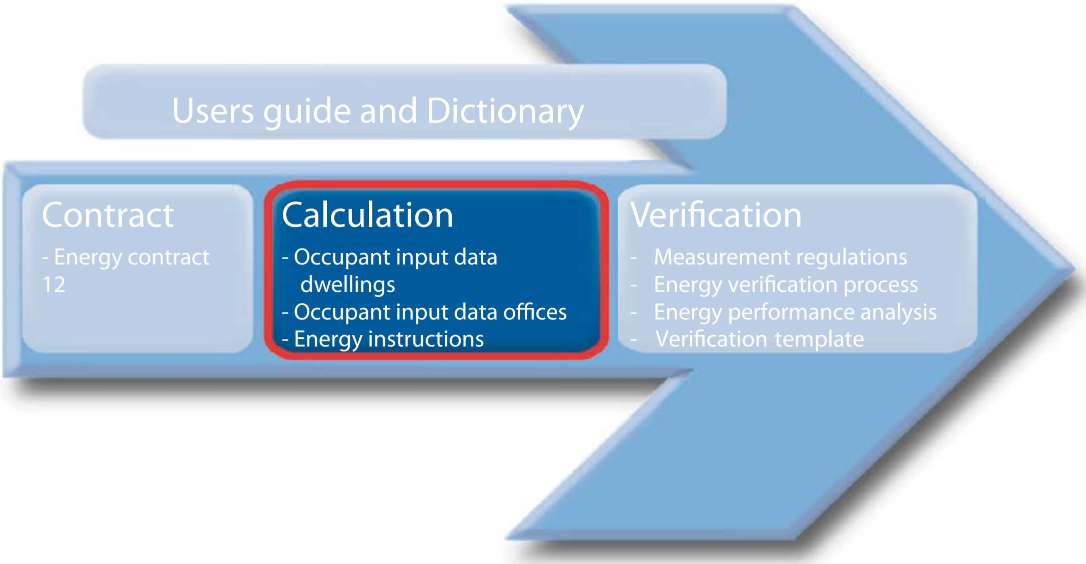
1.1.1 Considerations for setting requirements and contracts

- Check that the agreed energy performance includes a safety margin for imperfections in the calculations and reasonable deviation in building execution.
- Agreed energy price (fine) applies for ten years.
- Important to prepare for fast commissioning and corrections.

1.2 Energy calculations

In order for the requirements to be monitored, it requires that the building is "normalized" from the influence of occupants. A building should be able to cope with the demands regardless the type of occupant and e.g. not able to benefit from having occupants who are using an unusual amounts of operational energy, or loose on the occupants who use a lot of hot water.

Several calculations are required throughout the construction process. First, in early stage with a few details established and highly standardized inputs used. Secondly, during the planning and production stages as the updated energy calculations are performed with changes in the building, and, thirdly, in the verification stage when the calculations and simulations can be used to adjust the measured energy performance for any deviations.



The focus of Sveby is the building's energy use and in that respect Sveby sees the need of the following calculations:

1. Calculate the energy performance of the building with **Sveby occupant input data**.
2. Update energy calculation with project-specific occupant input data (The excel sheet **Energy instructions** can be used here).
3. Update the energy calculation for any changes in performance. The calculation becomes a target for commissioning. Comparison is made with measured values on a monthly basis, beginning when the building is put into use.

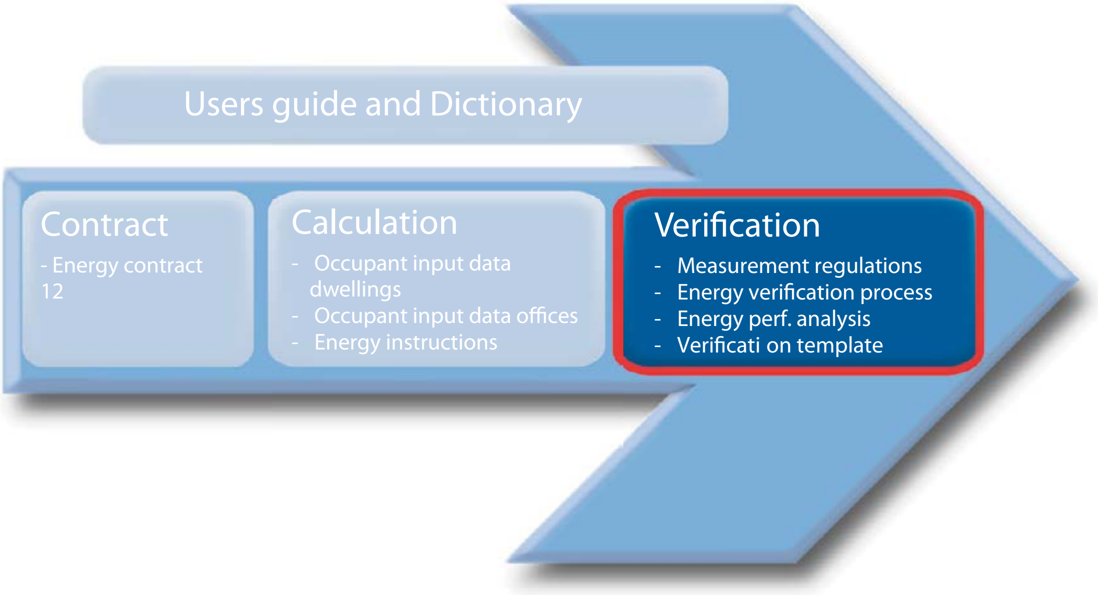
It is very **important that the calculations are updated** when the building is finished so that any changes is documented and that it is clarified what calculation and input data the validation measurements are compared against.

1.2.1 Considerations for energy calculations

- Do plausibility checks for input data to the calculation program.
- Be accurate in area definitions and measurements.
- Select the computer program based on building type and program knowledge.
- Be specific about safety margin included in the calculated energy performance.
- Document runs including used input data.

1.3 Verification

To ensure that the measured energy performance will meet the agreed or required energy performance, Svebys general policies and procedures is needed for monitoring these requirements with quality assurance. Moreover, BBR gives the opportunity to adjust the energy performance for some anomalies beyond the control of either the developer or the contractor and to report these adjustments in a special investigation.



Verification of energy use shall be checked against the normal occupant input data. This means that the measured energy performance can be adjusted if the use differs from Svebys occupant input data. This is done afterwards by means of energy calculations with both measured occupant data and Svebys occupant data. The difference in simulation results between measured and Svebys occupant input data is used to adjust the measured energy performance. In simpler cases, flat adjustment can be used. The adjustment is valid when the energy is related to BBR or other agreements with standardized occupancy. Alternatively, verification is made against agreed project specific occupant input data.

Sveby has so far produced the following documents to assist in verification:

- **Measurement regulations and guidance**, for the planning of energy measurements.
- **Energy verification process**, provides support for accountability, controls and documentation during the construction phase.
- **Energy performance analysis**, describing the correction of the measured values.
- **Verification template**, tool for standardized adjustment and reporting.

Further calculations during the verification process:

4. Perform a corrective calculation of changes in occupancy.
5. Calculate the impact of any deviations in the building structures or building services.

The verification procedure is described in the energy performance analysis and the verification template.

1.3.1 Considerations in verification

- During the planning stage, make a measurement plan and ensure that the measurements make it possible to define the building's energy performance.
- Be thorough with the documentation and commissioning of meters.
- Make predictions early and make the necessary adjustments. Document.

2 The Sveby material in brief[1]

2.1 Dictionary

To have a common “energy language” is a prerequisite for building owners, consultants, contractors and government agencies to understand each other. Specifications on requirements and verification method shall be clear. Therefore, Sveby created a dictionary of energy-related words and concepts that are ment to be used in combination with other material from Sveby.

The dictionary should be used as advice.

2.2 Energy contract 12

The BBR requirements for building energy use and monitoring, places demands on developers as well as contractors in the building process. For the convenience of both parties, Sveby together with The Construction Contracts Committee (BKK) has produced a model contract that governs the energy performance of the building and the conditions that should apply. Along with Svebys other material, the contract will provide security for both parties, what the requirements are and what adjustments that can be made to the measured energy use in a follow-up stage. Additionally, consequences of unmet energy requirements are regulated, with regard to the burden of responsibility and compensation.

2.3 Occupant input data for dwellings

Svebys material on occupant input data for dwellings contains tables of standard values for the input data that depends on the occupants, i.e. those who live and reside in the building. Input values are supplemented by explanatory texts on how they are developed. The report also describes how the separation between the energy use for building operations and households should be done.

Occupant input data varies greatly depending on the different behaviors or activities, which may give significantly different energy use. The input data used should be traceable so that accuracies can be assessed.

Occupant input data for dwellings should be used as a requirement.

2.4 Occupant input data for offices

Svebys occupant input data for offices contains information on how demarcation should be made between building operation and occupant activities, and how energy should be defined depending on what it is used for. There are, as in

[1] Only those standards appearing in this report have been translated to English.

occupant input data for dwellings, standardized values for input data related to the occupants. There are also supplementary texts that show the background to the different values.

Also for offices, occupant input data varies greatly depending on behaviors and activities. The input data used must be traceable.

Occupant input data for offices should be used as a requirement.

2.5 Energy instructions

Energy instructions is an excel tool developed to do more detailed calculations of occupant input data for dwellings than the general occupant input data reports provide. The document includes a tab for apartment buildings and one for single-family houses. By filling in data on areas and installed equipment in the building, occupant input data is generated adapted to the input format of the energy calculation programs, VIP, IDA, Enorm and BV2

Energy instructions should be used as advice.

2.6 Measurement regulations

This describes how a building's energy performance should be verified by measurement. The regulations is an industry-wide agreement that can be used as an appendix to the Energy contract 12.The accompanying manual is intended to supplement the Measurement regulations. The guide gives explanations, motives and sources to the measurement regulations design and also clarification of how the regulations are to be used by a few examples.

The guide also contains regulations on what needs to be measured to provide data for analysis in case of deviation from agreed energy requirements. Then follows measurement regulation for the preventive measurements. Finally, there are also some checklists on what measurements need to be made, which can be used as a basis for agreements on monitoring of the energy requirements.

Measurement regulations should be used as a requirement.

2.7 Energy verification process

To ensure the requirements of the building's energy performance, guidelines for monitoring energy requirements during the construction process has been developed. The guidelines are designed to be a support to all parties and that follow-up is a natural part of the construction process. The Energy verification process are guidelines and support procedures for monitoring the energy requirements at different levels in the programming phase, planning, construction, operation and management with responsibility, time and resources for:

- Quality assurance
- Testing of subsystems (e.g. efficiency, air tightness)
- Coordinated testing (for proper function)
- Fault analysis
- Change of program requirements that affect energy – who should be informed and who is responsible for documentation of testing and inspection before takeover.

Energy verification process should be used as advice.

2.8 Energy performance analysis

Energy performance analysis describes how coherence between contracted and measured energy performance systematically are analyzed in three steps:

1. Adjusted measured energy performance for heating, domestic hot water, air conditioning and operating electricity. Energy requirements are verified or a discrepancy is noted.
2. An overview analysis is made to indicate reasons for the deviation.
3. Description on how a more accurate deviation analysis is performed to derive the deviation of occupants, activities, or increased cooling demand in a year with very hot weather.

Energy performance analysis should be used as a requirement.

2.9 Verification template

In order to facilitate and standardize the verification work, Sveby has developed a verification template in the form of an Excel tool for filling in the measured and corrected values in relation to the requirements and agreements.

The verification template should be used as a requirement.

Appendix1 Energy Contract 12

Preface

Energy Contracts 12 has been produced by the Construction Contracts Committee, BKK, in collaboration with Sveby.

Energy Contracts 12 is intended to be used in turnkey contracts in which the parties have agreed to apply ABT 06 contract model and the Sveby standard for agreement on energy use.

Energy Contract 12 is a special regulation of energy performance error with a specific measurement and sanctions package, that deviate from those of ABT 06. The intention is that ABT 06's rules shall apply in otherwise matters.

For the Energy contract 12s special conditions, which implies deviations in relation to ABT 06, to become effective, the Energy Contract 12 is formed as an appendix to the building contract, and is therefore valid before ABT 06. Furthermore, the Energy Contract 12 should be appended to the specifications so that tenderers may submit their prices based on prevailing conditions. It should always be made clear that the Energy Contract 12 is appended to the contract.

BKK would additionally point out the following.

- Energy Contract 12 assumes that the contractor is responsible for the operation and maintenance of the technical systems that controls and influences the building's energy use. It is important that the parties in each contract will agree on how the builder's views on this operation and the maintenance should be considered. The builder should be informed and given an opportunity to comment, the contractor plan for operating and maintenance of the building in the parts the plan can affect the building's energy performance. If possible, this can occur already in the tendering stage.
- Energy Contract 12 allows to specify a specific energy performance requirement for year 1 and another energy performance requirement for the following years. The reason for this is that drying times and balancing issues can induce a higher energy use in year 1 than following years.
- The parties can also divide energy performance requirements and energy fine by different energy carriers.
- In the "Energy Contract 12 – technical part" the versions of Svebys documents specific to the individual contract agreement are specified.

A1.1 Energy contract 12 – legal part

Energy contract 12 is an appendix to the contract....................for the construction / renovation / extension of building a turnkey contract under ABT 06.

Energy Contract 12 consists of two parts, this legal section and a technical part, entitled “Energy Contract 12 – technical part”, version...................., *appendix 1*.

Energy Contract 12 assumes that the contractor, unless otherwise agreed, is responsible for the operating and maintenance of the technical systems that controls and influences the building’s energy use.

A1.1.1 Energy performance requirements

Dwellings:
Year 1....................kWh per m^2 A_{temp} and year. From year 2....................kWh per m^2 A_{temp} and year.

Premises:
Year 1....................kWh per m^2 A_{temp} and year. From year 2....................kWh per m^2 A_{temp} and year.

Unless otherwise stated above, energy performance requirements are applied according to BBR (termed the specific energy use) and normal use according to Sveby.

A1.1.2 Agreed energy fine per kWh

Dwellings: Compensation to the contractor in accordance with paragraph 5 shall be calculated on the basis of an agreed energy fine of...................Swedish pennies per kWh.

Premises: Compensation to the contractor in accordance with paragraph 5 shall be calculated on the basis of an agreed energy fine of...................Swedish pennies per kWh.

The energy fine is fixed and is not to be indexed. The amounts are exclusive of any VAT.

A1.1.3 Follow-up of energy performance requirements

1. The energy use should be measured according to Sveby. The measurement shall be arranged by the developer. The measurement should be started when the technical systems that affect energy performance is put into operation and the building is put into use but no later than....................and last for 36 months (the measurement period). Energy measurement should not be made upon inspection according to ABT 06.
   Measurement data is to be made available to the builder at least once a month during the measurement period unless the parties agree otherwise.
2. If changes are made during the measurement period, that may affect the building's energy performance, the developer must promptly notify the builder of the changes.
3. After the end of each twelve-month period during the measurement period, the developer must compare energy performance requirements with verified energy performance and evaluate the results measured under Sveby. If one of the parties so wish, this is done instead by an independent expert that the developer appoints and pays. A party is entitled to request the inspection in accordance with the regulation in the ABT 06 of such evaluation.

A1.1.4 Errors, remediation and energy fine

4. If the measured energy performance exceeds energy performance requirements, fault is assumed to exist (energy performance error). If the builder has the perception that he is not responsible for the assumed energy performance error, it is the responsibility of the builder to show that he has performed the work according to the developer or probability that the excess is due to neglect or abnormal usage or that the defect was caused by the developer executed improper design or anything that can be attributed to the developer.
5. The builder is entitled and required to correct energy performance errors which the contractor is responsible for under paragraph 4. Remediation should be completed without delay and not later than two months from that the data is sent to the builder. The builder shall in addition pay energy fine to the contractor as follows.
   a) For each of the first two twelve-month periods, the compensation to the developer is calculated based on the agreed energy fine per kWh (see above) multiplied by the number of kWh per m^2 A_{temp} and year, as measured energy performance exceeds energy performance requirements for the period in question, multiplied by the area of the building (in m^2 A_{temp}).
   b) For the third twelve-month period, the compensation to the developer be calculated based on the agreed energy fine per kWh (see above) multiplied by the number of kWh per m^2 A_{temp} as measured energy performance exceeding the energy performance requirements for the third twelve-month period multiplied by 8 (corresponding to the remaining part of the liability period) and multiplied by the building area (calculated in m^2 A_{temp}).

The energy fine shall be paid within two months after the end of each twelve month period.

6. In the event that energy performance errors remain after the end of the third twelve-month period, the developer is entitled to, in addition to compensation according to paragraph 5, require remedial measures to BBR's level of requirements for buildings in the current climate zone. If the builder fails to perform such remedial within six months after the end of the third twelve-month period, the developer owns the right to perform such remedial measures at the builder's expense.
7. The builder's responsibility for the fulfillment of energy performance requirements and the developers rights because of the unmet energy performance requirements are regulated in its entirety by the provisions of the Energy Contract 12. This means, among other things. that the developer is not entitled to e.g. remedial measures, deduction of the contract amount, damages or delayment fine according to ABT 06 by reason of the builder's responsibility for the fulfillment of energy performance requirements.

A1.1.5 Energy Contract 12 – Technical Part

Version 1.0, 2012-10-10 (replaces version 0.0, 2012-00-00)

Sveby is an industry standard for the calculation and verification of energy performance in buildings. The standard has been built in cooperation between the construction sectors actors. Svebys documents are available for download on the website www.sveby.org.

In this Energy Contract 12, the following versions of Svebys document apply:

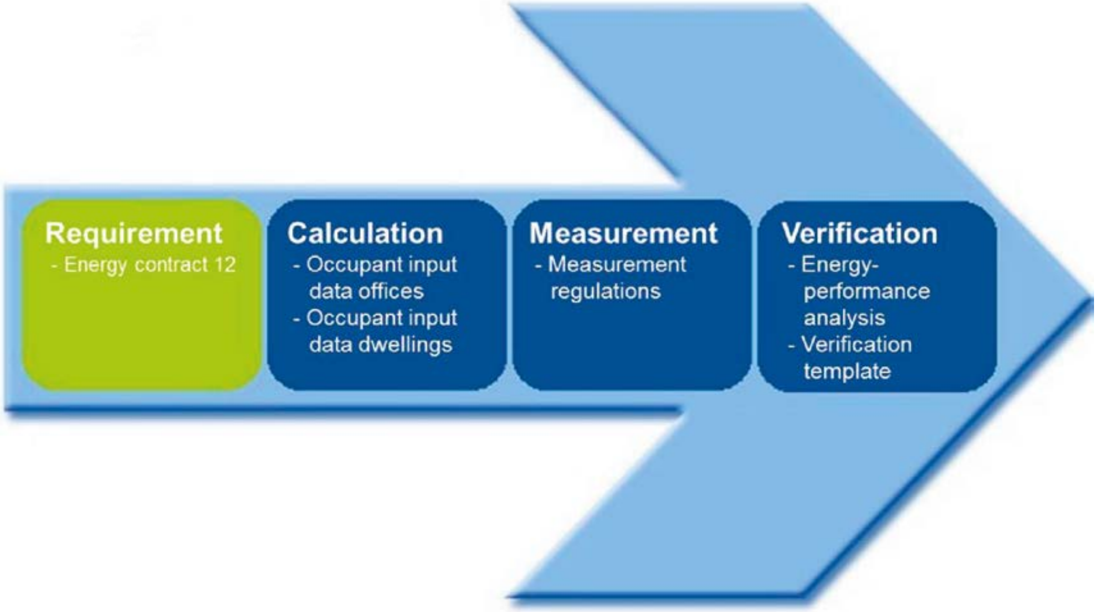
1. Occupant Input data dwellings version ....
2. Occupant Input data offices version ....
3. Measurement regulations version ....
4. Energy performance analysis version ....
5. Verification template version ....

To show if the energy performance requirements have been met must:

1. Energy calculations be performed in a standardized way by the agreed occupant input data,
2. Energy performance and parts thereof be measured according to measurement regulations and
3. Measurements be verified in a standardized way.

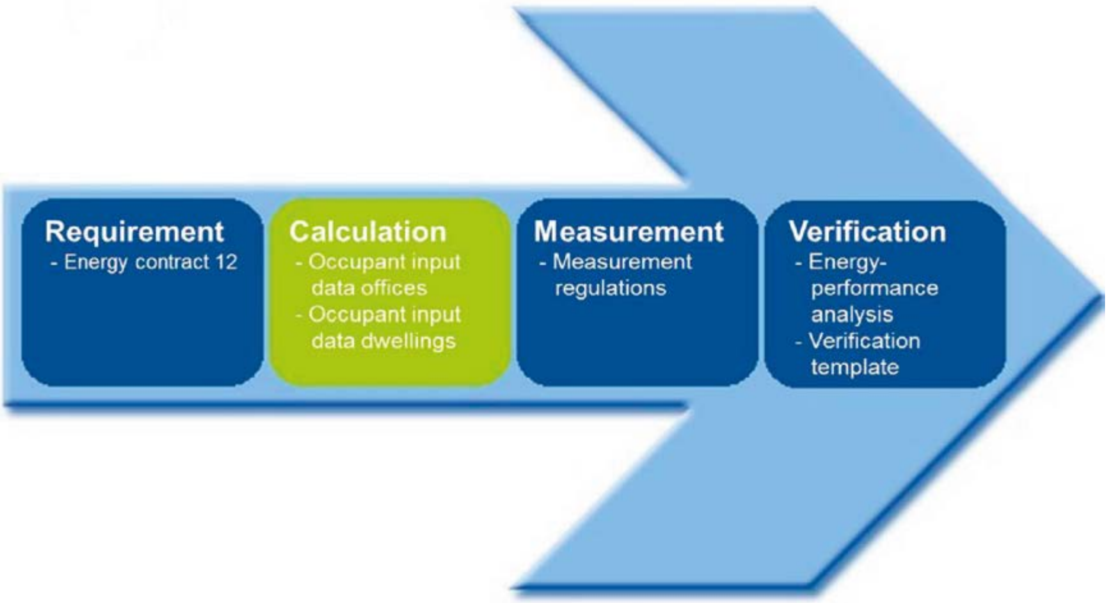
A1.1.6 Requirement

Energy performance requirements are stated in Energy Contract 12 – legal section above.



A1.1.7 Calculation

For the requirements to be followed up it is required that the building is "normalized" from the influence of occupants. A building should be able to meet the requirements regardless occupant type and e.g. not be able to benefit from having occupants who are using an unusual amount of operational energy, or loose on occupants who use a lot of hot water.



Energy calculations need to be performed and documented according to the following:

1. Calculate the energy performance of the building using **Sveby occupant input data**. If any other operation is there than those covered by Sveby occupant input data, the energy calculation may be performed with agreed project specific occupant input data.
2. Update the energy calculation with any eventual changes in the performance (should be a relation document).

It is **very important** that performed energy calculations are documented, including software version, calculators, input data and results. These calculations will then be used again to correct the measurements obtained in the verification.

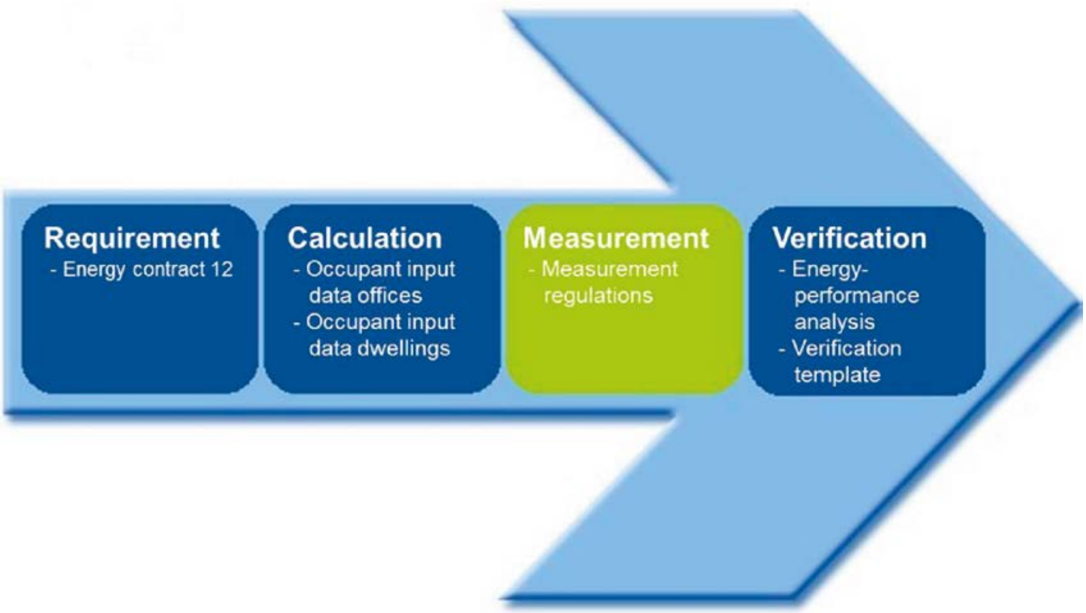
To think about when calculating energy

- Do plausibility checks for input data to the calculation program.
- Select a computer program based on building type and program knowledge.
- Be specific about safety margin included in the calculated energy performance.
- Document calculation runs including used input data.

A1.1.8 Measurement

All parts of the building energy performance needs to be measured and recorded at least monthly from when the building is taken into use, i.e:

- Heating
- Domestic hot water
- Cooling
- Facility energy (operating electricity etc.)



In those cases where different energy carriers are used for the same part, these are required to be measured separately. Installed measuring equipment should have an accuracy equivalent to a billing meter.

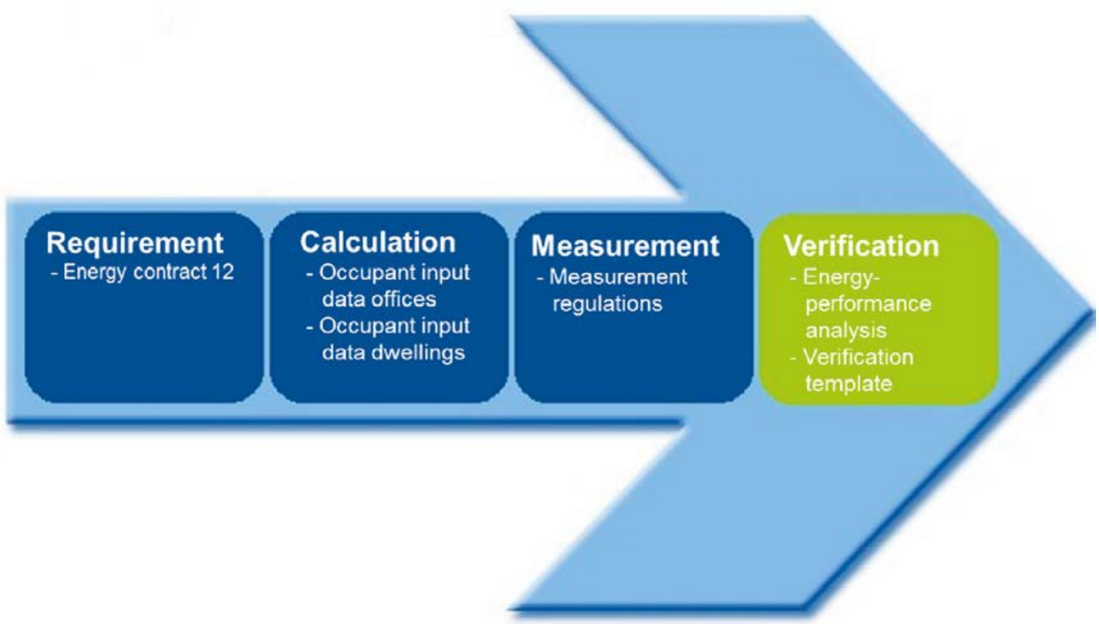
Sveby measurement regulations are to be used for the verifying measurements.

To think about when measuring energy

- Make a measurement plan in an early stage and ensure that the measured values represent the intended building's energy performance so that e.g. adjacent buildings are not included.
- Ensure that the building's facility energy is separated from the operational and household energy, i.e. plan the measurement so that authorized deductions for the energy performance (e.g. heater, common laundry room) and the necessary additions (eg, electric underfloor heating in the bathroom) can be determined.
- Describe in the measurement plan which meters are included, their characteristics, location and operating areas.
- Be sure to check the meter's function during commissioning.
- Perform performance tests on equipment as early as possible.

A1.1.9 Verification

Verification of energy use shall be checked against the normal occupant input data. This means that the measured energy performance can be adjusted if the use differs from Svebys or the agreed projected occupant input data.



Measured energy for space heating is firstly corrected for normal meteorological year with the degree day method or other agreed method.

Verification for deviating usage is performed using a repeated energy simulation, where the measured or estimated deviating user input data are used instead of Svebys (or projected) in the same calculation model as used for the contracted energy performance. The differences in simulation results are used as correction of the measured values. In simpler cases, standard correction could be used.

Method of normal meteorological year correction of comfort cooling is currently lacking. If verification shows that the measured cooling energy deviates from the calculated, and weather conditions simultaneously been unusually hot, a new energy simulation is performed with the existing outdoor climate during the measurement period, in order to explain the difference in the cooling needs (energy need).

When verifying the **Sveby energy performance analysis** (for correction of measured values), and **Sveby verification template** (for standardized correction and accounting), be used.

To think about in verification

- Make prognosis early and analyze deviations and necessary adjustments.
- Document all events that affect the building's energy performance.

Appendix 2 Measurement regulations

These regulations are connecting to "Sveby Energiavtal 12" (Energy Contract 12) and are intended for verification of energy requirements for measured energy performance of finalized building with a floor area exceeding 100 m² A_{temp}. The measurement regulations are valid for measured building energy performance, i.e. measurement of specific energy use and correction with respect to average year outdoor climate and the building use.

A2.1 Measurement of energy for heating and domestic hot water heating

§1. Measurement shall be made of all the building delivered energy for heating and domestic hot water heating.

- **a.** Measurement should be performed separately with the main meter for each energy carrier that supplies energy.
- **b.** In cases where several buildings have a common energy supply and building (or unit) from which energy is delivered on the same property or has the same owner as the building that receives energy supply, install sub-meters for each building to distribute the energy delivered from the common main meter.
- **c.** For district heating, local district heating or gas should be building regular billing meter used.
- **d.** For oil, biofuels and other forms of energy that must be converted to kWh measured delivered volume or weight, which is then converted to kWh using fuels, calorific value. In cases when calorific value not is available from the fuel supplier, values can be taken from scripture "Energiläget", published by the Swedish Energy Agency. In cases where the calorific value specified with an interval, average is used in the range.
- **e.** Heat generated by electricity need separate meters for delivered energy for heating, which is separated from measurement of facility electricity and tenant electricity.

A2.2 Measurement of energy for comfort cooling

§2. Measurement shall be made of all delivered energy to building for comfort cooling.

- **a.** Measurement should be performed separately with the main meter for each energy carrier that supplies energy.
- **b.** For district cooling should the building regular billing meter be used.

c. For comfort cooling generated by electricity in the building that use electricity for heating the same meter as for facility electricity can be used.

d. For comfort cooling generated by electricity from electric chillers in the building that has different heat than electric heating separate electricity meters shall be installed for electric energy to the electric chiller.

A2.3 Measurement of domestic hot water use

§3. Measurement shall be made of the supplied volume hot water, so that energy for domestic water heating can be calculated. Flow meter should be placed on the cold water line into the installation for preparation of hot water.

A2.4 Measurement of facility electricity

§4. Measurement of facility electricity (i.e. electricity for fans, pumps, stair case lighting, etc.) is at least one electric meter for each building. For electrical installation in the category of household / tenant electricity but is measured by meters for facility electricity (e.g., common laundry room) or if the electrical installation in the category of facility electricity is measured by meters for household / tenant electricity (e.g. under floor heating) applies to:

a. If the electrical installation is expected to have an annual electricity use of more than 3 kWh per m^2 A_{temp}, so shall gauge wiring installed for correction of electricity use.

b. If the electrical installation is expected to have annual electricity use of less than 3 kWh per m^2 A_{temp}, then standard values can be used for correction of electricity use.

I. standard values based on installed capacity and usage

II. maximum use for a total of 20% of the building's overall energy performance.

If device is of the category facility electricity supplied with energy by using different energy carriers is measured separately for each energy carrier.

A2.5 Measurement of area

§5. Measurement of area A_{temp} shall be made from drawings that match the finished building. A_{temp} divided into part of the building which belongs to category dwellings and premises. A_{temp} of premises subdivided into parts where outdoor airflow of improved hygienic reasons is greater than 0.35 l/s, m^2.

A2.6 Measurement of outdoor airflow in premises

§6. For part of premises with an outdoor airflow which, of extended hygienic reasons, is greater than 0.35 l / s, m^2 the average outdoor airflow during heating season is verified.

- **a.** For ventilation with a constant air flow is measured outdoor airflow of each air handling unit for the various operating events planned during the heating season. This can be done in connection with the functional inspection of HVAC systems. Along with the actual running times of each operation case is calculated average outdoor airflow.
- **b.** For ventilation with variable flow measured airflow and logged hourly during the heating season. Average outdoor airflow is calculated as the average of total hourly during the heating season.

A2.7 Measurement of process energy in premises

§7. For part of premises that have a process in business that generate additional heat that is beyond heat from normal operations applies:

- **a.** If part of the additional heat is recovered and fed to the building as part of the building's heating system, so shall the building energy input be measured.
- **b.** If part of the additional heat is cooled off with process cooling, so shall the energy for process cooling distinguished from the building's energy. If individual process cooling installation, whose energy is measured in common with the building's energy, is expected to have an annual energy use that contributes to the building's overall energy by less than 3 kWh per m^2 A_{temp}, then standard values used in the correction of process cooling by:
  - **I.** The standard values based on installed capacity and usage,
  - **II.** Standard values can be used for a maximum total of 20% of the building's overall energy performance.
- **c.** If the installation for process and comfort cooling is common in such a way that it is impossible to separate those to be common energy meters installed. Energy use for comfort cooling estimates by cooling energy used during a cold winter month, when little or no comfort cooling is needed, multiplied by the number of months to process cooling is used and subtracted from the total annual energy use for process and comfort cooling.

A2.8 Measuring equipment's uncertainty

§8. All meters in § 1–§ 4 shall be calibrated at the beginning of the measurement period. Heating meter shall have an uncertainty of a maximum of 3% at nominal flow. Electricity meters shall have an uncertainty of a maximum of 5%.

A2.9 Design of measuring and recording data

§9. Measurement in § 1, § 2, § 3, § 4 and § 7 occurs simultaneously for 36 months.

- **a.** Measurement shall be performed from time technical systems that affect energy use have been in operation for 36 months after the client taken the buildings in use. Measurements are taken with advantage when main part of the building is used. Measurement data shall be provided clients and counterparties every month. Each meter is clearly the type of measurement, calibrated measured value and unit. Flowchart and measuring chart be provided at the initial reporting of data where it is clear what each meter record.
- **b.** If readings from a meter for some reason are missing or not reliable during a month, operator notifies clients and counterparties and ensure that next month's value is again correct.
- **c.** The building's energy performance is determined by measurements corrected as described in § 10–§ 12. Energy performance during a consecutive twelve-month period compared with the requirements in the building code or orders.

A2.10 Energy for domestic water heating

§10. Delivered energy for domestic water heating for a year is calculated according to:

$$\boldsymbol{Energy_{hw} = \sum_{month=1}^{12} volume_{hw,\ month} * 55\ (kWh/year)}$$

where: $volume_{hw}$ = volume delivered hot water per month (m^3)

A2.11 Normal year correction of energy for heating and comfort cooling

§11. Delivered energy for heating normal year corrects with the degree-day method (according to "Energideklaration för byggnader", BFS 2007:14 BED 2) or with the energy signature (according to EN 15 603) unless otherwise agreed.

- **a.** For meters that measure total energy for heating and domestic hot water heating calculated heating energy by subtracting the energy for domestic water heating, including energy for domestic hot water or storage tank.

Delivered energy for comfort cooling does not have normal corrected because there is no accepted method for this. However, a separate study conducted on follow-up for a year that can be considered to have required abnormally amount of cooling.[2].

[2] For methodology see Sveby Energy performance analysis abnormalities that can be attributed to users, activities, or increased cooling demand..

A2.12 The building's energy performance

§12. The building's energy performance is determined by adding the supplied normal year corrected energy for 12 months for heating (§ 1 and § 11), comfort cooling (§ 2), hot water (§ 3 and § 10), and facility electricity (§ 4) and then dividing the sum by the temperate area, Atemp. Comfort cooling measured according to § 2.d first multiplied by a factor of 3 (Swedish Building Code).

- **a.** The building's energy performance is corrected by subtracting the delivered energy for domestic water heating, which is higher than standard use or adding delivered energy for domestic water heating, which is lower than standard use. The value of the standardized use specified for dwellings in Sveby Occupant Input data for dwellings and for premises in Sveby Occupant Input data for offices. For buildings containing both residential and commercial use standardized weighted in proportion to the floor area (A_{temp}).
- **b.** For part of premises with a process that generates additional heat excess heat from normal operations applies:
  - **I.** If part of the additional heat is cooled off with process cooling so the energy use for process cooling is not included in the building's energy:
  - **II.** If the meter for process and comfort cooling is common to estimate energy for comfort cooling added to the building's energy.

A2.13 Comparison with the requirements of the BBR (Swedish Building Code)

§13. Measured energy according to § 12 compared with the requirements of BBR. For premises that has an outdoor airflow that for reasons of hygiene is increased to greater than 0.35 l / s per m2 in temperature-controlled facilities may BBR as an addition to the basic requirements for building energy performance. Here the measured value of the average outdoor airflow during heating season is used, according to § 6.

Appendix 3 Sveby User Guide to Measurement Regulations

A3.1 Introduction

Sveby Measurement regulations describe how building energy performance shall be verified by measurement. Sveby Measurement regulations are an industry-wide agreement, which can be used at contract signing as Annex to Sveby Energy Contract 12 (which is a new contract between developers and Contractors and connects to ABT 06). Measurement regulations sets which parameters and how and when they need to be checked for verifying building energy performance against energy requirement pledged in Building code (BBR) section 9 or sharpened requirements according to contract. Measurement regulations are developed with the aspect of what must be measured and measurement accuracy in relationship to costs for measurements.

The present user guide concerns to supplement Sveby Measurement regulations. The user guide gives explanations, motives and sources to measurement regulations design and clarification of how measurement regulations shall be used together with some examples.

The user guide also contains instructions for what needs to be measured to provide data for analysis in case of deviation from established energy requirements. Thereafter follow measurement regulations for preventive measurements. Finally there are checklists on measurements needed to be made, which can be used as basis at contracting about follow-up of energy requirements.

A3.1.1 Building code

A new version of the Building code (BBR) with a whole new way to make demands on the energy performance of buildings came in force 2006-07-01. It means that virtually all new buildings at the design phase shall be energy calculated to show that the building's energy performance meets the requirements of the BBR. Then energy performance shall be verified with measurement within 24 months after the building has been put into service. This is a big change compared to previous building codes since the requirements are now a functional requirement for energy performance. Stricter performance requirements for electrically heated buildings came in force 2009-02-01, while some concepts clarified (BFS 2008:20, BBR 16). Another new version of the Building code came in force 2012-01-01 with further tightening of requirements for buildings that have different heating than electrical heating (BFS 2011:26, BBR 19).

Building energy performance

Building code sets requirements on building specific energy use, in continue called building energy performance, where requirements added different dependence of:

- in which climate zone building is localized,
- if the building belongs to category dwelling or premises and
- if the building is electrically heated or heated otherwise.

Building code sets also requirements on installed electrical output for heating and average heat-transfer coefficient.

This user guide describes how a building energy performance with help of measurements be verified during user stage (Within 24 months running time). Control of installed electrical output and average heat transfer coefficient is expected to be as inspection or at final inspection and are not treated here.

Measurement of the building energy performance

Building code (BBR) sets the following requirements: Building energy use shall continuously be monitored by a measurement system. The measuring system shall collect data, so that the building's energy use, for the desired period of time, can be calculated.

Building code (BBR) offers the following general advice: Measuring the building's energy use and verification of performance levels can be achieved by reading and summary of the building delivered energy (kWh) used for heating, comfort cooling, domestic hot water and building facility energy. The building's energy use should be measured over a continuous 12-month period, ended 24 months after the building has been put into service.

Correction for deviations from designed usage

Building code describe in a general advise for dwellings that: Normal year[3] correction and possible correction for deviation from designed tenant use of the building (indoor temperature, domestic hot water use, airing, etc.) are reported in a separate study. In another advice described for premises that: Normal year correction and possible correction for deviation from designed tenant use of the building (indoor temperature, domestic hot water use, airing, heat contributions from processes in the premises and the like) are reported in a separate study. In addition, the requirement for energy performance of buildings account for an outdoor airflow is increased due hygienic reasons.

Measurement regulations are valid for the building's measured energy performance, i.e. measurements of the building specific energy use and correction with respect to normal year and building tenant. Correction with respect on designed

[3] Normal year is derived from 30 years of weather data

tenant is by standardized values on occupant input data [4]. Measurement regulations gives thus a directly basis for accounting in special investigation.

A3.1.2 Measurement regulations

Measurement regulations are given by a Clause (§) after serial number and is divided in 3 measurement parts:

Measuring part 1: Building energy performance
(The building's measured specific energy use corrected with respect on normal year and building usage.) Here is described what is necessary to measure and how measured data be analyzed to verify building energy performance. Since measuring part used for to verify requirements pledged in BBR or tighter requirements as contract so have this part been lifted out in a special publication called Sveby Measurement regulation and can be used directly as Annex to contract writing. Measuring part 1 contains § 1–13 and is described in Chapter A3.2.

Measuring part 2: Basis for analysis at eventual deviations
Here describes what needed to be measured for needs to analyze deviations against pledged requirements on energy performance. These readings only need to be analyzed at deviation. Measuring part 2 contains § 14–18 and is described in Chapter A3.3.

Measuring part 3: Preventative measurements
Here describes measurements recommended to avoid simple sources of error to requirements on energy performance not been achieved. Measuring part 3 contains § 19–25 and is describes in Chapter A3.4.

In contract writing can parties choose about measurement been made only as measuring part 1 (which is a minimum level) or if follow-up shall be performed also as measuring part 2 respective measuring part 3.

In Chapter A3.5 there are checklists that can be used as "quick reference guide" when measuring requirements shall be followed or at contract writing.

[4] Standardized values on Occupant input data presents in Sveby Occupant input data dwellings respectively Sveby Occupant input data offices.

Limitations

In developing measuring requirements has limitations been made to measure and determine the energy performance in the building process from production to finalized building with two years of operation. Parameters that do not have direct influence on energy use (e.g. indoor environments) are not treated, but is assumed that these are treated according to Building code and municipality requirements.

This user guide covers only the measuring data needed for a deviation analysis. How deviation analysis should be performed when energy demands are not met is not dealt with here. Nor who is responsible for measurements, or that resources are available for measurement. These are subjects of Sveby Energy performance analysis and Sveby Energy Verification.

Measuring regulations mainly applies to dwelling buildings and premises.

A3.2 Building energy performance

The building's energy use, according to BBR "The Energy that, at normal use, in a normal year need to be delivered to one building (usually named bought energy) for heating, comfort cooling, domestic hot water and facility electricity)."

Household energy and tenant energy are not included. Dividing the building's energy use with temperate area (A_{temp}) obtained the specific energy use. The building measured specific energy use corrected for normal year and deviations from occupant design values to the building's energy performance. The building's energy performance, here verified by measurement shall be equal or lower than Energy requirement established in Building code or tighter requirements according to contract (Energy Contract 12).

A3.2.1 Measurement of delivered energy and A_{temp}

For determining building energy performance the following need to be measured for each building:

- All delivered energy for space heating and domestic hot water heating (§ 1)
- All delivered energy for comfort cooling (§ 2).
- Use of domestic hot water to determine energy to domestic hot water heating (§ 3). Used to distinguish the energy to space heating at mean year outdoor climate correction and to correct for deviations from designed occupancy behavior.
- All delivered facility electricity (For operation of building Installations and other building facility electricity) (§ 4).
- Determination of A_{temp}; total and split between dwellings and premises (§ 5).

Measuring of energy for space heating and domestic hot water heating

§1. Measurements shall be done for all too building delivered energy for space heating and domestic tap water heating.

- **c.** Measurement should be performed separately with the main meter for each energy carrier that supplies energy.
- **d.** In cases where several buildings have a common energy supply and building (or unit) from which energy is delivered on the same property or has the same owner as the building that receives energy supply, install sub-meters for each building to distribute the energy delivered from the common main meter.
- **e.** For district heating, local district heating or gas should the building regular billing meter be used.
- **f.** For oil, biofuels and other forms of energy that must be converted to kWh measure delivered volume or weight, which is then converted to kWh using fuels calorific value. In those cases when calorific value not is available from the fuel supplier, values can be taken from publication “Energiläget”, published by the Swedish Energy Agency. In cases where the calorific value specified with an interval, use the average in the range.
- **g.** Heat generated by electricity need separate meters for delivered energy for heating, which is separated from measurement of facility electricity and tenant electricity.

Comments to measurement regulations

In § 1.e specifies that for heat generated with electricity needs a separate electricity meter. This so that correction for normal year can be made.

Measurement of energy to comfort cooling

§2. Measurement shall be made of all delivered energy to building for comfort cooling.

- **h.** Measurement should be performed separately with the main meter for each energy carrier that supplies energy.
- **i.** For district cooling should the building regular billing meter be used.
- **j.** For comfort cooling generated by electricity in the building that use electricity for heating, the same meter as for facility electricity can be used.
- **k.** For comfort cooling generated by electricity from electric chillers in the building that has different heat than electric heating separate electricity meters shall be installed for electric energy to the electric chiller.

Comments to measurement regulations

For buildings that have heating with electric heating required no separate meter for comfort cooling (§ 2.c) because no correction for normal year is made for chillers.

Separate electricity meters for comfort cooling which generates with electricity from electrical chillers requires in buildings that have other heating method than electric heating (§ 2.d). This is because the energy delivered to the comfort cooling according to BBR to be counted up by a factor 3.

Measurement of domestic hot water use

§3. Measurement shall be made of the supplied volume domestic hot tap water, so that energy for domestic water heating can be calculated. Flow meter should be placed in the cold water pipe in the installation for preparation of domestic hot tap water.

Comments to measurement regulations

Measurement of volume flow rate is used to calculate energy to domestic hot water heating in § 10. Alternatively the measurement can be supplemented with measurement of domestic hot tap water temperature or that the energy use for domestic hot water use is measured directly with energy meters.

Measurements of facility electricity

§4. Measurement of facility electricity (electricity for fans, pumps, stair case lighting, etc.) is at least one electric meter for each building. For electrical installation in the category of household / tenant electricity but that is measured by meters for facility electricity (e.g., common laundry room) or if the electrical installation in the category of facility electricity is measured by meters for household / tenant electricity (e.g. electrical under floor heating) applies to:

- **l.** If the electrical installation is expected to have an annual electricity use of more than 3 kWh per m^2 A_{temp}, so shall sub-meter be installed for correction of electricity use.
- **m.** If the electrical installation is expected to have annual electricity use of less than 3 kWh per m^2 A_{temp}, then standard values can be used for correction of electricity use:
  - **I.** Standard values based on installed capacity and usage time.
  - **II.** Standard values can be used for a maximum total of 20% of the building's overall energy performance.

If device belonging to the category facility electricity is supplied with energy by using different energy carrier separate measure for each energy carrier shall be done.

Comments to measurement regulations

In § 4 specifies that for electrical installation that for billing purposes measured on "Wrong" Meter can standard values be used under given conditions to estimates a facility electricity. Example on such an electrical installation are engine warmer, electrical under floor heating, heated towel rail, lighting in apartment storage (See further in Sveby Occupant input data dwellings and Occupant input data offices).

Example:
Apartment building on total 400 m² A_{temp} shall be built with 4 apartments which each have 4 m² under floor heating of 80 W / m². Electricity to the under floor heating is measured by household electricity meter. The under floor heating have an expected 3,000 hours' time of usage a year, which gives an increased energy performance for each apartment of 4 * 80 * 3,000/1,000/400 = 2.4 kWh per m² /A_{temp}; which is less than the limit value for installing a sub-meter. Total for the four apartments required standard value of 2.4 * 4 = 9.6 kWh per m² A_{temp} used which is significantly less than 20% of the building's overall energy performance. Sub-meters need not be installed, but facility electricity corrects by adding 9.6 kWh per m² A_{temp}.

In connection with the introduction of the BBR 16 valid from 2009-02-01 have it been clarified that the building facility energy, shall be counted in the building energy performance, i.e. if installations is supplies with other type of energy than electricity. In such case required separate energy meters for that energy carrier.

Measurement of area

§5. Measurement of area A_{temp} shall be made from drawings that match the finished building. A_{temp} divided into part of the building which belongs to category dwellings and premises. A_{temp} of premises subdivided into parts where outdoor airflow of improved hygienic reasons is greater than 0.35 l/s, m².

A3.2.2 Measurement for correction with respect on deviations from designed use

BBR permits correction of the building energy performance for deviations from designed use of indoor temperature, domestic hot tap water use, airing and suchlike. For premises applies also that building energy performance can be increased if the average outdoor airflow during all heating season that for hygienic reasons is greater than 0.35 l / sm² and that correction may be made for deviations from the designed normal heat contributions from processes.

Increased energy by airing is difficult to prove. Sveby Occupant input data dwellings recommends one supplement on 4 kWh / m² A_{temp} for airing at design. Therefore should the correction for relatively normal airing already be satisfied and it is operational staff task to adjust heat, cooling and ventilation so more airing is not needed. Thereby needs normally no measurement of airing be performed.

Occasional deviations of indoor temperature in dwelling buildings and office are considered at calculation of energy on such way that correction not needed. Thereby requires in most cases no measurement or control of indoor temperature to verify the building's energy. (Comment: However, correction might be needed in premises that requires high indoor temperature for its operation (E.g. nursing home) and thereby becomes heating part tenant energy. In special cases can building energy need to be corrected for part of dwelling buildings is used for home care. In these cases measure the indoor temperature temporarily in connection with the investigation.)

For correction of domestic hot water use beyond designed tenant use of domestic hot water (§3) need to be measured for each building.

For premises the following also needs to be measured:

- outdoor airflow in local parts that exceeds 0.35 l / sm² (§ 6)
- heat contributions from processes that excess of normal tenant energy use in premises (§7).

Measurements of outdoor airflow in premises

§6. For part of premises with an outdoor airflow which, of extended hygienic reasons, is greater than 0.35 l / s, m² shall the average outdoor airflow during heating season be verified.

n. For ventilation with a constant air flow outdoor airflow is measured of each air handling unit for the various operating events planned during the heating season. This can be done in connection with the functional inspection of ventilation systems. Along with the actual running times of each operation case is calculated average outdoor airflow.

o. For ventilation with variable airflow the airflow is measured and logged hourly during the heating season. Average outdoor airflow is calculated as the average of total hourly during the heating season.

Comments to measurement regulations

Functional inspection of the ventilation system shall according to BBR occur before the ventilation system for the first time is placed in service in accordance with Regulation 1991:1273. This opportunity should be used to verify the outdoor airflow in § 6.

For variable air flow can mean outdoor airflow alternatively be estimated by measuring the maximum air flow associated with functional inspection of the ventilation system. Average outdoor airflow for heating season is set to 65% of nominal airflow (LCCenergi, V-skrift 2003:1). If further correction of the building's energy performance shall be done it requires measured airflow data during the verification period. (Flow meters are typically found in newer air handling units but logger may need to be installed.)

Measurement of process energy in premises

§7. For part of premises that have processes with heat contribution that is beyond heat from normal operations applies:

- **p.** If part of the heat contribution from the processes is recovered and fed to the building as part of the building's heating system, so shall energy input to the building be measured.
- **q.** If part of the heat contribution from the processes is cooled off with process cooling, so shall the energy for process cooling distinguished from the building's energy. If individual process cooling installation, whose energy is measured in common with the building's energy, is expected to have an annual energy use that contributes to the building's overall energy by less than 3 kWh per m^2 A_{temp}, then standard values used in the correction of process cooling by:
  - **I.** Standard values based on installed capacity and usage time,
  - **II.** Standard values can be used for a maximum total of 20% of the building's overall energy performance.
- **r.** If the installation for process and comfort cooling is common in such a way that it is impossible to separate those common energy meters shall be installed. Energy use for process cooling estimates by cooling energy used during a cold winter month, when little or no comfort cooling is needed, multiplied by the number of months to process cooling is used and subtracted from the total annual energy use for process and comfort cooling.

Comments to measurement regulations

Heat-generating process (§ 7) is for example, a server room for computers or an oven that are part of a tenant business. Energy use of the process that generates heat is measured as tenant energy and does not include the building's energy performance. The heat generated will in most cases make a positive contribution to the building's energy performance. If parts of the generated process heat are recycled in the building's heating system so shall the recovered heat be measured. This for verification that building energy performance shall show that the building itself can handle the energy requirement, even if the use of the building will change in the future (§ 7.a).

Process cooling used to cool off process heat shall not be included in the building's energy performance and therefore should, if possible, be separated from the building's other systems. If the installation for process and comfort cooling is common, can it be difficult to distinguish comfort cooling that shall be included in the building's energy performance. Meters for cooling installation shall in these cases be installed and comfort cooling may be estimated by comparing the energy use at various outdoor climate (§ 7.c.). Correction of the building's energy performance is here with a high value for comfort cooling and it is therefore more advantageous to, if possible, measure comfort cooling separately.

A3.2.3 Measuring equipment's uncertainty

§8. All meters in § 1–§ 4 shall be calibrated in the beginning of the measurement period. Heating meter shall have an uncertainty of a maximum of 3% at nominal flow. Electricity meters shall have an uncertainty of a maximum of 5%.

Comments to measurement regulations

Heating meter shall have an uncertainty of a maximum of 3% at nominal flow, which is slightly lower than what is required by Boverket (The Swedish National Board of Housing, Building and Planning) provisions of water and heat meters BFS 1994:26VOV1 and SWEDAC regulations on heat meters STAFS 2006:8. It is therefore good to use regular billing meter. Meters used for electricity will have an uncertainty of up to 5%, which is in agreement with SWEDAC regulations on active electricity metering (STAFS 2006:7). Electricity meters often have a much higher accuracy (ERA 2008-05-22).

A3.2.4 Design of measuring and recording of data

§9. Measurement in § 1, § 2, § 3, § 4 and § 7 occurs simultaneously for 36 months.

- **s.** Measurement shall be performed from time technical systems that affect energy use have been in operation until 36 months after the client taken the buildings in use. Measurements are taken with advantage when main part of the building is used. Measurement data shall be provided clients and counterparts every month. Each meter is clearly the type of measurement, calibrated measured value and unit. Flowchart and measuring chart be provided at the initial reporting of data where it is clear what each meter record.
- **t.** If readings from a meter for some reason are missing or not reliable during a month, operator notifies clients and counterparts and ensures that next month's value again is correct.
- **u.** The building's energy performance is determined by measurements corrected as described in § 10–§ 12. Energy performance during a consecutive twelve-month period compared with the requirements in the building code or orders.

Comments to measurement regulations

Measurement can start even when there are vacant premises on the building's technical systems are in operation and tenants wanted. A building can be entirely or partly in use. The building can be used during the construction period, for large buildings often in planned stages. Measurement is done for 36 months and reported every month so that parts can react and take action on energy use from the beginning if it is higher than expected. The best continuous period of 12 months are selected for verification of building energy performance.

A3.2.5 Energy for domestic hot water heating

§10. Delivered energy for domestic water heating for a year is calculated according to:

$$\boldsymbol{Energy_{hw}} = \sum_{month=1}^{12} \boldsymbol{volume_{hw,\ month}} * \mathbf{55}\ \boldsymbol{(kWh/year)}$$

where: $volume_{hw}$ = volume delivered hot water per month (m^3)

Comments to measurement regulations

Energy for domestic hot tap water heating is calculated according to § 10. Note that this only is relevant energy to heat domestic hot tap water, while energy losses from hot tap water heating via storage in a storage tank or hot tap water circulation is not considered. These losses are included in the building's energy performance and measured usually include the energy meter for heating, the calculation of the building's energy, those losses into account.

If the measurement of tap water use has been made of both volume and flow measurement of hot water temperature can be energy for domestic hot water use alternatively calculated as:

$$\boldsymbol{Energy_{hw}} = \sum_{month=1}^{12} \boldsymbol{volume_{hw,\ month}} \times (\boldsymbol{T_{hw,\ month}} - \boldsymbol{T_{cw,\ month}} \times \mathbf{1{,}167}$$

where:

$Energy_{hw}$ = energy to heat domestic hot water for a year (kWh)
$volume_{hw}$ = volume of hot water used during each month (m^3)
T_{hw} = distributed medium temperature hot water every month (usually 55°C)
T_{cw}= average temperature of the incoming cold water every month. Available from the water treatment plant.
1.167 = heat capacity of water dived by 3,600
Energy to the domestic water heating may alternatively be measured by energy meters.

A3.2.6 Normal year correction of energy for heating and comfort cooling

§11. Delivered energy for heating normal year corrects with the degree-day method (according to "Energideklaration för byggnader", BFS 2007:14 BED 2) or with the energy signature (according to EN 15 603) unless otherwise agreed.

v. For meters that measure total energy for heating and domestic hot water heating calculated heating energy by subtracting the energy for domestic water heating, including energy for domestic hot water circulation or storage tank.

Delivered energy for comfort cooling does not have normal corrected because there is no accepted method for this. However, a separate study conducted on follow-up for a year that can be considered to have required abnormally amount of cooling.[5].

Comments to measurement regulations

In order to distinguish energy for heating depending on the outdoor temperature from energy to domestic water heating the calculation under § 11.a is used. If energy use for domestic hot water circulation or storage tank is missing, default values can be used for domestic hot water circulation or accumulation losses corresponding to a factor of 1.4 times the energy for domestic water heating. Standard value is set so that the uncertain energy that is not dependent on the outside temperature is overestimated because the method with normal correction itself has shortcomings. Thus, the energy use for heating and its correction due of normal year may be underestimated.

Example:
An apartment building with domestic hot water circulation has energy use for heating and domestic hot water heating at 400 MWh from October 15 to April 15 and during the same period is 50 MWh to direct domestic water heating. Energy use for heating is estimated to 400–50 · 1.4 = 330 MWh which will then be normal year corrected.

A3.2.7 Determination of the building's energy

§12. The building's energy performance is determined by adding the normal year corrected supplied energy for 12 months for heating (§ 1 and § 11), comfort cooling (§ 2), domestic hot tap water (§ 3 and § 10), and facility electricity (§ 4) and then dividing the sum by the temperate area, A_{temp}. Comfort cooling measured according to § 2.d first multiplied by a factor of 3 (Swedish Building Code).

- **w.** The building's energy performance is corrected by subtracting the delivered energy for domestic water heating, which is higher than standard use or adding delivered energy for domestic water heating, which is lower than standard use. The value of the standardized use specified for dwellings in Sveby Occupant Input data for dwellings and for premises in Sveby Occupant Input data for offices. For buildings containing both residential and commercial use standardized weighted in proportion to the floor area (A_{temp}).
- **x.** For part of premises with a process that generates additional heat excess heat from normal operations applies:
  - **I.** If part of the additional heat is cooled off with process cooling so the energy use for process cooling is not included in the building's energy:
  - **II.** If the meter for process and comfort cooling is common to estimate energy for comfort cooling added to the building's energy.

[5] For methodology see Sveby Energy performance analysis deviations that can be attributed to users, activities, or increased cooling demand.

Comments to measurement regulations

In § 12.a correction due abnormal usage of hot tap water is made. Use of hot tap water not only due to the user's habits of individual or collective metering and billing, the design of fixtures for energy efficient use and the time it takes to get hot water to the fixture through the distribution system. Domestic hot tap water use also depends on the category of tenant, i.e. whether it is housing or some kind of premises activities (hairdressers, hotels, hospitals, retail, etc.).

To facilitate the measurement and correction of designed domestic hot tap water use expressed in kWh per m^2 A_{temp} and not in kWh per person. This despite the fact that many studies show that the use of domestic hot water is clearly dependent on the number of users rather than the size of the building. The big advantage is that it does not need a method to determine the number of users in the building during the verification period. Moreover expressed designed tenant for a value per m^2 A_{temp} in homes and a different value in premises. Hot water use in offices during normal business is low. In the cases hot tap water usage is high due to the user specific activities (such as hairdressers, restaurant) and correction of the building's energy for increased hot tap water usage needs to be done for all categories of premises. Thus only a limit for premises is needed, regardless of the room category.

In buildings containing both homes and premises designed tenant use are determined for the building by weighting in proportion to the floor area (A_{temp}). (Floor Area for premises part and dwelling part must still be determined for the building to the building's energy to be fixed.) This has the advantage that only the building's total hot tap water usage needs to be measured, i.e. there is no need for meters for various categories of activities. Another advantage is that the correction of deviations from designed usage of hot tap water will be independent of the building partially replacing activity during the verification period.

To get the value of standardized tenant as referred for apartment Sveby Occupant input data dwellings and premises to Sveby Occupant input data offices. Sveby Occupant input data dwellings gives a value of 25 kWh per m^2 A_{temp} year for standardized usage and in Sveby Occupant input data offices listed 2 kWh per m^2 A_{temp} year. Since office often have a low usage of tap water, a standardized value for offices to be representative as a threshold for all the different categories of premises. A water use beyond standard office usage depends thus on the building's operations and be counted as tenant energy.

Example:

A building in climate zone III of 4,000 m^2 A_{temp} consists to 40% of dwellings and 60% of premises with a hairdresser, restaurant and offices. Requirements for specific energy use according to BBR is 110 · 0.4 + 100 · 0.6 = 104 kWh per m^2 A_{temp}. The building has a total measured energy use of 109.0 kWh / m^2 A_{temp}, whereof energy for domestic hot tap water heating is 22 kWh per m^2 A_{temp}. Correction of energy for deviations from designed the usage of domestic hot tap water must therefore be made by subtracting from 22 – 0.4 · 25 – 0,6 · 2 = 10.8 kWh per m^2 A_{temp} and the building's energy is 98.2 kWh per m^2 A_{temp}. Thus, the building has passed the energy requirements according to BBR.

If energy efficient hot tap water fixture is used, the limit will be less for normal use. Several studies have shown that water use is reduced by 10–30% when switching to energy efficient hot tap water fittings (Wahlstrom, 2000; Aton, 2007). When the experience of the recently introduced labeling of energy-efficient hot tap water fittings is available, a lower limit for buildings with labeled tap water fittings products are introduced as 20 kWh per m^2 A_{temp} and year, for buildings of residential category. However, it is always beneficial to install energy-efficient hot tap water fixture as it will be easier to meet the requirements of energy.

In § 12.b for premises part with a process that generates additional heat excess heat from normal operations. If additional heat is recovered and fed to the building as part of the building's heating system, the building will have a better-reported energy than would otherwise be the case. This is because the additional heat is not included in the building's energy. If part wants to ensure that the building will meet performance requirements even if the building in the future changing business as it should be in agreement between the parties made an addition to the building's energy performance must be corrected by adding the input process energy.

A3.2.8 Comparison with the requirements of BBR

§13. Measured energy according to § 12 compared with the requirements of BBR. For premises that has an outdoor airflow that for reasons of hygiene is increased to greater than 0.35 l / s per m^2 in temperature-controlled facilities may BBR as an addition to the basic requirements for building energy performance. Here the measured value of the average outdoor airflow during heating season is used, according to § 6.

Comments to measurement regulations

For premises part having an outdoor airflow of 0.35 l/sm^2 made according to BBR an addition to performance requirements with an energy equivalent $E_{airflow}$ * (q–0, 35) kWh multiplied by the percentage m^2 A_{temp} with airflow q of the total area (A_{temp}) . $E_{airflow}$ indicated in Table 1, and q is the average outside airflow during the heating season (l/sm^2) and may be up to 1.00

Table 1: $E_{airflow}$ for premises heated with electric heating or otherwise in different climate zones (BBR 19).

Climate zone	I	II	III
Premises with other heating than electric heating	110	90	70
Premises with electric heating	65	55	45

A3.3 Basis of analysis for any deviation

If verification of building energy performance is found to be higher than the energy requirements in BBR or to contract, so can the cause needed to be investigated. Therefore, measurements are taken at:

- delivered energy for household electricity / tenant electricity (§ 14)
- indoor temperature (§ 15)
- migration of users (§ 16)
- airing (§17).

A3.3.1 Measurement regulations as basis of analysis for any deviation

§14. Measurement shall be made of the building delivered energy for **household electricity / tenant electricity**. Delivered energy is measured with regular billing meter for electricity. The energy supplied by other energy carriers shall meters be installed, if the use expected to be significant for the generation of internal heat.

§15. Measurement shall be made of the building or part of the building's **indoor temperature**. Measurement is done by measuring extract air temperature continuously and the average monthly value is stored. (Temperature sensors are located before the heat exchanger and fan.)

§16. The number of migrant users (percentage area is rented) recorded monthly during the verification period.

§17. If suspicion that **airing** occurs beyond the supplement on standardized airing (4 kWh/m^2 A_{temp}) recommended during the design, although operating staff have adjusted the heating, cooling and ventilation systems, airing in addition to standardized values need to be shown. This could for example be done by photographing the facade showing that the building does not have a standardized airing. The building's energy performance can be exceptionally modified by subtracting a value up to a maximum of 4 kWh/m^2 A_{temp} due of deviations from the standardized airing.

§18. Measurement in § 14, § 15 and § 16 parallels the measurements according to § 9 for 12 related months and reported monthly values.

Comments to measurement regulations

Measured according to § 14–§ 16 first analyzed as deviations from the requirements of the building's energy needs to be analyzed. Measurement according to § 17 is made only when it is required to shown a high standard in addition to airing occur. Before the measurement is performed, the operating staff is informed to correct any incorrect settings on heating, cooling and ventilation systems.

A3.4 Preventive measurements

For demand on building energy performance to be achieved, it is important not to get deviations from the original specification (or design values) of constructional or installation parameters. In functional check and final inspection is normally controlled most of the parameters that are important to achieving performance requirements. For example, thermal insulation and U-values of building elements such as walls, ceilings, floors, doors and windows conform to the specifications and the lighting, ventilation, heating and cooling systems, and control and monitoring systems have the features that set the specifications. Further is it important for good energy performance that ventilation, heating and cooling systems are correctly adjusted and that the systems are controlled by the right parameters (time, temperature, presence, etc.).

The measurement regulation assumes that such a check is made in conjunction with the final inspection and that defects are corrected before the verification period will begin. Furthermore, it is assumed that whoever is in charge of operation and maintenance during the verification period ensures that the building's technical systems are balanced and that the operation is optimal.

In addition, specific checks needed to ensure that operations and maintenance manager, gets a building with potential to meet requirements on building energy performance. The control applies mainly building air tightness and energy performance in installations that are not normally inspected. Energy performance on fans, pumps, heat recovery units, etc. need to be measured after installation to see how they work in subsystems with ducts, etc. in the building. In some cases, the energy performance of appliances needs to be checked by a third party prior to installation.

A3.4.1 Measurement regulations for preventive measurements

§19. Measurement of the part of building air tightness. When the first part of the building is completed (e.g., first apartment, first office module), shall air tightness for this part be measured. If the measured air leakage is higher than the design values, should the cause of the air leakage be evaluated (possibly with the help of thermography) and adjusted. Further steps must be taken at the continued construction.

§20. Measurement of specific fan power (SFP) shall be made for ventilation systems in connection with functional check. The measurement can be made for each subsystem of ventilation by measuring air flow and power demand of fans. If measured SFP is higher than design values, actions need to be taken before the verification of building energy performance begins.

§21. Measuring system efficiency of heat recovery shall be made during operation with the design airflow, clean filters, the heat demand and full capacity for heat recovery. If possible include it in connection with the functional control of HVAC systems. System efficiency should take into account not only the unit's thermal efficiency but also to heat loss in ducts and heat flow through the unit casing, and the imbalance in air flow. The measurement can be made for each unit by measuring airflows and temperatures of supply air, extract air, outdoor air and exhaust air. If the measured system efficiency is lower than the design values, actions need to be taken before the verification of building energy performance begins.

§22. Measurement of the specific pump power (SPP) in heating and cooling system must be made in connection with the functional control of heating and cooling systems. The measurement is done by measuring the liquid flow and the pump's electrical power needs. If measured SPP value is higher than the design values, actions need to be taken before the verification of building energy performance begins.

§23. Measurement of specific heating needs to be made during operation at the heating and the supply and return flow temperatures of the heat distribution system, which is consistent with designed values in the current outdoor temperature. Input energy is measured by heating energy is noted for a few days, (i.e. without added energy for domestic tap water heating) and divided by the measurement time while outdoor and indoor temperature is measured. Supplied heat divided by average outdoor temperature for the same period, giving specific heating needs as compared to designed value at the same outdoor temperature (from energy signature curve).

§24. Measurement of momentary coefficient of performance heat pump (COP_{HP}) of the heat pump must be in heating mode so close nominal and design operation as possible. Supply and return temperatures and flow distribution on the heating distribution system is measured and the heat given is calculated. Supply of electricity to the compressor is measured in the same period and the COP_{HP} is calculated by dividing the gross heat input power. Compare the roughly estimated instantaneous heat factor with regard to the current outdoor temperature and uncertainties with the values used during the design.

§25. Measurement of momentary coefficient of performance refrigerator (COP_R) for the cooling system must be in operation when cooling load as close to the nominal and design operation as possible. Supply and return temperatures and flow distribution in cooling distribution system measured and delivered cooling calculated. If the cold is transmitted directly to the supply air temperature and humidity are measured before and after the cooling coil and the cooling air flow and delivered calculated from the enthalpy of the air. Supply of electricity to the compressor is measured in the same period and the COP_R is calculated by dividing the gross cooling with supplied electricity. Compare the roughly estimated instantaneous cooling factor with regard to the current outdoor temperature and uncertainties with values used during the design.

A3.5 Checklists

Checklist 1 – Measurement of building energy performance.

Check	(§)	Measurements of	Type of energy	Meter	Reading, storing and , evaluation	Analyze
	1.c	Energy for space heating and domestic hot water heating	District heating	Heats meter, regular billing meter	Each month	After 12 months
	1.c	Energy for space heating and domestic hot water heating	Gas	Volume meter, regular billing meter	Each month	After 12 months
	1.d	Energy for space heating and domestic hot water heating	Oil	Volume meter, dipstick in tank, Volume meter on burner	Each month	After 12 months
	1.d	Energy for space heating and domestic hot water heating	Biofuel (firewood, grot, pellets etc.)	Volume or weight, dipstick in tank	Each month	After 12 months
	1.e	Energy for space heating and domestic hot water heating	El	Electricity meter, sub meter to heating		
	2.b	Energy for cooling	District cooling	Cooling meter, regular billing meter	Each month	After 12 months
	2.c	Energy for cooling	Electricity	Regular electricity billing meter for building, which has electrical heating, separate electricity meter for buildings with other type of heating than electricity	Each month	After 12 months
	5	Temperate area	Dwellings and premises	From drawings	Once	

Checklist 2 – Measurement of building energy performance.

Check	(§)	Measurements of	Meter	Reading, storing	Analyze
	3 and 10	Energy for domestic hot water heating	Hot water flow meter (incoming cold water meter to tap water heating)	Each month	After 12 months
	4	Facility meter	Electricity meter, regular billing meter	Each month	After 12 months
	4.a	Electricity to electrical installation, that belongs to the category household/ tenant energy but are measured with facility energy meter or the other way around	Sub-meter for electrical installation, which has a yearly energy use over 3 kWh/m^2 A_{temp}	Each month	After 12 months
	6.a	Outdoor airflow in premises over 0,35 l/sm^2	Airflow for each AHU that's measured for different operating modes	In connection with functional inspection	After 12 months
	6.b	Outdoor airflow in premises over 0,35 l/sm^2	Maximum airflow is measured	In connection with functional inspection	After 12 months
	7.a	Process with additional heat that's used in the building	Energy meter for recovered process heat	Each month	After 12 months
	7.b	Process liberating heat that needs cooling away in the premises	Process cooling distinguish with its own system or with a sub-meter for process cooling installation that has a yearly energy use over 3 kWh/m^2 A_{temp}	Each month	After 12 months
	7.c	Combined installation for process and comfort cooling	Sub-meter for energy	Each month	After 12 months

Checklist 3 – Electrical installation, which belongs to category facility electricity, but that are measured on a household or tenant electricity meter or the other way around.

Electrical equipment	Estimation of yearly energy use (kWh/ m^2A_{temp})	Number of equipment in the building	Sum
Under floor heating			
Heated towel rail			
…			
…			
Total	Total sum shall be less than 20% of total building energy performance, if standard values shall be used		

Checklist 4 – Basis for analysis of eventual deviation

Check	(§)	Measuring-para-meter	Meter	Reading, storing and , evaluation	Analyze
	14	Household/ tenant electricity	Electricity meter regular billing meter	Each month	At deviation
	15	Indoor temperatures	Return air temperature, Mean temperature under one month	Each month	At deviation
	16	Number of users	Monthly listing of number of people that uses the building, or listing of rented area	Each month	At deviation

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Appendix 4 General guidelines for verification documentation for energy performance

These guidelines have been created in order to ensure that requirements on building energy performance are met and verified. The guidelines are ment to support stakeholders involved in the building process.

Riktlinjerna för uppföljning av energikrav under byggprocessen avser att säkerställa de energikrav som byggherren fastställt och ge underlag för att hantera eventuella avvikelser. Riktlinjerna avser att vara ett stöd för alla parter i byggprocessen så att uppföljningen blir ett naturligt inslag i byggprocessen. Dessa generella riktlinjer för ansvarsfördelning, resursplanering och dokumentation gäller oavsett entreprenadform.

All activities have to be described, planned and cost estimated. Responsibility for the different activities should be distributed and documented. The amount of work and documentation will vary depending on the size and complexity of the project. These activities could also be integrated in the general quality and environmental programme for the building project.

A4.1 The Energy Verification Documentation

The Energy Verification Documentation (EVD) should contain compiled strategically important information on the building and building services with reference to all relevant information and experiences from the project. The EVD should be reviewed and expanded together with the progression of the project, and be a part of the documentation that is given to the building owner upon completion.

The EVD contains the following items that also could exemplify the contents:

1. **Energy goals and energy functional requirements**
   - Priorities (environment (CO_2), economy, best performance etc)
   - Building energy performance
     Early stage requirement
     Design stage performance
   - Energy functional requirements on building services and building envelope:
     Verification on building airtightness
     Fan and pump electricity use, COP for heat pumps, efficiencies of heat exchangers etc.
     Operating functions for continuous control
     Lighting
     Thermal environment
   - Economy and calculation input

2. **Overall system description**
    - Building envelope
    - Building services
    - Operation strategy including optimization default values
    - Measurement plan for verification of energy performance
    - Measurement plan for follow-up on energy functional requirements
3. **Revised energy calculations with specified input data.**
    - System stage or contract
    - Building start
    - As built (after winter- and summer tests)
4. **Energy related cost estimates and profits**
5. **Results from tests and controls**
    - Own quality controls
    - Special testing
    - Coordinated testing
    - Winter- and summer testing
    - Achieved energy performance compared to requirements
6. **Inspection protocols for energy follow-up (according to plan)**
    - Inspections of parts
    - Completing inspections
7. **Verification plan**

    The verification plan is the base for time and cost planning for the follow-up activities, and could also be used in assignment descriptions for the different stakeholders.

    It could be established by:

    - Deciding on the demands that should be verified.
    - Reviewing the conditions and decide methods for follow-up (self-control, random samples etc.)
    - Deciding on an activity plan, including time and resources, and distribution of responsibilities for activities.
    - Gathering base material for follow-up as description texts, forms, protocols, etc.
    - Creating a measurement plan for verification of building energy performance.
    - Creating a measurement plan for follow-up of energy functional requirements.
    - Deciding type of delivery and receiver.
8. **Feed-back to next project**
    - Routines for deviation documentation

Appendix 5 Energy Performance Analysis – verification of measurements

Summary

A new version of the Swedish Building Regulations (BBR) with a new way to set the energy requirements of buildings came into force in July 2006. Building regulations imposes functional energy performance requirements and that energy performance is verified with measurement within 24 months after the building is placed in service. Furthermore, BBR gives the opportunity to correct energy performance of certain deviations which neither client/owner nor contractor has control over and to report these corrections in a separate study.

Purpose

This guidance describes how the energy requirements can be verified by gradually investigates whether a building meets the energy performance requirements. The study takes into account if cause of the deviations can be traced to users, operation or increased cooling needs in a year of very hot weather.

Purpose is to avoid future conflict between client and contractor for verification of energy performance. The aim is also to provide a basis to the particular investigation which according to Swedish Building Regulations should be reported in the correction of energy performance.

Verification of the energy requirements

The guidance describes how coherence between contracted and the measured energy performance systematically should be analyzed in three steps:

Step 1 Here the corrected measured energy performance for heating, domestic hot water use, comfort cooling, and facility electricity (i.e. electricity for fans, pumps, stair case lighting, etc.) are calculated. Corrections are made for normal heating, domestic hot water use in addition of Svebys standardized use and increased airflow in buildings. Energy requirements verified or deviation noted.

Step 2 Here an overview analysis to indicate reasons for deviations.

Step 3 This describes how a more accurate deviation analysis is conducted to derive deviation to users, operation, or increased cooling needs in a year of very hot weather.

As an aid in step 2 example of calculation is presented for a normal office to indicate how large deviations that can be caused by users, operation or increased cooling needs in a year of very hot weather. Note that there are only examples which should not be generalized to other categories of buildings or low energy buildings.

The office example

The office example shows that the building's utilization rate has little impact on energy performance. The explanation is that an increase of heating energy is compensated by the reduction of cooling energy, domestic hot water heating energy, and facility electricity. Verification of energy performance is relatively insensitive if the building has occupants in all office rooms.

Further the office example shows that change in the operation have very limited impact on the energy performance. Increase of heating energy is compensated by the reduction in the cooling energy, domestic hot water heating energy, and facility electricity and vice versa. The total energy use is influenced (i.e. including operation electricity).

The major cause of increased energy use in the example is if measurements for verification occur during a year of very hot weather. A good method of correction for typical weather year regarding the cooling demand similar to the typical weather year correction that is used for the heating would be very helpful.

Low-energy buildings

For a low energy building (energy performance that is 50% better than the requirements of BBR) the margins are much smaller and it becomes even more important to verify the impact on energy performance, derived from the occupants, operation or increased cooling in very hot weather.

Note that in the Swedish version of energy performance analysis both multifamily buildings and office buildings (premises) are treated, but in the English version have only the parts about office buildings been translated.

A5.1 Introduction

A5.1.1 Swedish Building Regulations (BBR)

A new revised edition of the Swedish Building Regulations (BBR) with a new way to set the energy requirements of buildings came into force 2006-07-01. They mean that new buildings should be energy calculated to show that the building's energy performance (specific use of energy) meets the requirements of BBR. Energy performance is verified with measurement within 24 months after the building is put into use. This is a big change compared to previous building regulations since the requirements now are a functional requirement for use of energy. Further revised editions of the Building Regulations has come since then, including more stringent energy performance requirements for electrically heated buildings, clarification of concepts, and tightening levels of requirements. This guidance refers to Chapter 9 of the Swedish Building Regulations 19 (BBR 19).

Correction for deviations from normal use

The Swedish Building Regulations describes in a general advice that energy performance should be verified by calculating the building's energy performance during the design, and by measurement of the finished building. "The building's use of energy should be measured over a continuous period of 12 months, completed within 24 months after the building is placed in service."

BBR describes in a general advice for premises that calculations as design shall work on normal use according to: "Calculations should be carried out based on weather data for actual location, for intended indoor temperature, normal use of domestic hot water, airing and additional heat from processes in the premise and that "typical weather year correction and possible correction for deviation from the planned use of the building (indoor temperature, domestic hot water use, airing, additional heat from processes in the premises, etc.) should be presented in a separate study". In addition, if an outdoor airflow is increased due to hygiene reasons the requirement for energy performance of premises take account for it.

This guidance assumes that the designed use described in the Swedish Building Regulations correspond to a standardized use established should correspond to a normal use. Unless otherwise agreed in the contract between the developer and contractor for standardized use establishing described Sveby Occupant Input data for offices.

A5.1.2 Problem description

A comparison between measured and contracted energy performance will in most cases not be consistent with each other. Whether measured energy performance is consistent, lower or higher than the contracted energy, an analysis is needed to indicate what the difference is due to.

Measured energy use that is higher than contracted may be caused by the occupant using the building in a way that was not predicted when order and design. For example, when it comes to building degree of use, use of operation electricity, occupant control of indoor temperature, number of occupants, or an outdoor environment where a typical weather year correction does not sufficiently compensate for. These reasons are the client or contractor not in control over.

Measured energy use that is higher than contracted may also be due to the conducted energy calculations does not mimic reality in sufficient extent, or that the accuracy of measured energy performance is not sufficient. Furthermore, high energy use could be due to the buildings envelope or that the installations do not have the performance needed to meet the requirement. These reasons are included in client or contractor's control. To ensure that the performance requirements are achieved, a clear guidance is needed to avoid discrepancies that client and contractor rule over. Some of this guidance deals mainly in Sveby Energy Verification – monitoring the energy requirements during the construction process.

A measured energy that matches or is lower than the contract can also be caused by the occupant using the building in a way that was not predicted when order and design. For example, when it comes to building degree of use, use of operation electricity, occupant control of indoor temperature, number of occupants, or an outdoor environment that typical weather year correction does not sufficiently compensate for.

This requires an analysis conducted to verify that the requirements for:

- contracted energy performance also will be met if actual use is changed to that specified in contracting,
- energy performance according to Swedish Building Regulations also will be fulfilled if the actual use is changed to standardized use.

In addition a guide is needed to verify if energy requirements are met containing an analysis of the extent to which there is a deviation that neither client nor contractor is in control of, i.e., if cause of discrepancy can be attributed to occupants, operation or increased cooling in very hot weather.

The guidance is needed to describe how discrepancy between contracted and measured energy performance systematically should be analyzed, partly in a relatively simple way indicate what the difference is due to, partly to describe how a more summarily analysis can be implemented.

The goal is to avoid unnecessary disputes between client and contractor.
Figure 1.1 shows a problem map of possible causes for deviations between contracted and measured energy performance, where the causes set out in this guidance marked red.

Design/Calculation

- **Uncertain input**
- **Operating errors**
  i) Input
  ii) Wrong value
  iii) Lack of knowledge
- **Weather data file**
  i) There are not any standard for weather data files today.
- **Deficiencies in the calculation program**
  i) The program as a whole
  ii) Lacks functions
- **Documentation/ Energy verification**
  i) Input/conditions and results incl. Interim results for revised energy calculations. Treated mainly in Sveby Energy verification process

Construction/inspection

- **Technical design deviates which is difficult to measure/quantifying**
  E.g. insulation in facade or base slab
- **Technical design deviates which is difficult to derive to energy use**
  E.g. air tightness/infiltration; can be measured, but the calculation of infiltration is uncertain
- **Measurement and control at inspection**
  Treated mainly in Sveby Energy Verification process
- **Documentation/ Energy verification**
  Results from inspection, control and revised energy calculations. Treated mainly in Sveby Energy Verification process

Operation/measurement (12–24 mon)

- **Identification of part deviations size.**
  i) Measurement
  ii) Calculation
  iii) Assessment
- **Correction of deviations**
  Treated partially in Sveby measurement regulations
- **Type of deviation (cause)**
  (Impact/No Impact)
  i) Technical solution changed (I)
  ii) Technical design (I)
  iii) Measuring error
  iv) Operation related (No I)
  v) Weather data file ≠ actual year ≠ typical weather year (No I)
- **Documentation/Energy verification**
  i) How the whole work shall be done, should be documented. Treated mainly in Sveby Energy verification and Energy contract

Figure 1.1. Map of problems where the causes of deviation marked in red are those studied in this guidance for verification of energy performance.

A5.1.3 Objective

The project objective is to avoid future conflicts between client and contractor by developing guidance for verification of energy requirements. A guidance that as far as possible links results from actual measured to contracted energy performance. Contracted energy performance is treated the same regardless of whether the requirement is at a value limit according to the Swedish Building Regulations (BBR) or an agreed lower value for example according to Sveby Energy agreements.

To avoid discrepancies over issues the clients and contractor control the guidance keep abreast of known deficiencies in the calculation and measurement and quality assurance in the construction process.

The guidance will then indicate whether the deviation is due to causes that contractor and builders can't control, i.e. if the cause of the discrepancy can be attributed to users, operation or increased cooling demand in a year of very hot weather. The aim is to describe how a discrepancy between contracted and measured energy performance systematically will be analyzed. The guidance should in this case be used as a practical tool to relatively quickly indicate cause. Thereafter the guidance shall describe how a more thorough analysis is carried out.

One aim of verifying the energy requirement is to provide a basis for the particular investigation that according to Swedish Building Regulations should be presented with the correction of energy performance for discrepancies that can be attributed to users, activity or increased cooling requirements for a year of very hot weather.

A5.1.4 Limitations

In developing the guidance it is assumed that other guidelines within the Sveby program are followed. In the guidance examples of calculations for a normal office to indicate how large deviations can be caused by users, operation or increased cooling demand in a year of very hot weather. The examples only apply to the analyzed building categories and should not be generalized to other categories of buildings or for low energy buildings.

How much deviation is acceptable between measured and contracted energy performance is not dealt with in this guidance. Here it is not possible to give any general advice; it must be discussed case by case.

How errors should be corrected, or otherwise compensated when energy performance requirements are not achieved are governed by agreements and are not covered here. It is partially regulated in Sveby Energy Contract. It describes only how the causes of deviations are identified and quantified if possible.

A5.1.5 Reading instructions

Chapter A5.1 describes the Swedish Building Regulations, problem determination and objective of this guidance.

Chapter A5.2 describes how the contractor and the client can keep margin of known deficiencies in the calculation and measurement and quality assurance in the construction process.

Chapter A5.3 describes guidance for verification of energy requirements containing an analysis of the discrepancy that can be attributed to users, operation or increased cooling demand for a year of very hot weather. This guidance is intended to make a practical and relatively simple way to determine if pledged energy requirements are met, and if it does not indicate the cause for the deviation.

To get an idea of how large deviations can be some examples of deviations caused by users for business or increased cooling requirements of the office in a year of very hot weather is given in chapter A5.4.

Chapter A5.5 discusses the results.

A5.1.6 Nomenclature and abbreviations

Table 1.1. Used abbreviations.

Abbreviation	Description
$EP_{contract}$	Contracted energy performance either according to contract (Sveby Energy Agreement) or the maximum value according to the Swedish Building Regulations taking into account the so-called ventilation addendum.
EP_{BBR}	Maximum value for energy performance allowed according to the Swedish Building Regulations.
$EP_{measured\ corr}$	Corrected measured typical year correction of energy performance for heating, domestic hot water heating, comfort cooling and electricity.
$EP_{heating,\ typical\ year}$	Typical weather year correction of energy performance for heating and domestic hot water heating.
EP_{dhw}	Energy performance for heating of domestic hot water separate from standardized use.
$EP_{comfort\ cooling}$	Energy performance for comfort cooling
$EP_{facility\ el}$	Energy performance for facility electricity
EU	Measured energy use
EC	Calculated energy use

A5.2 Causes for deviations that is possible to control

On the way from order to design, construction and operation of a building there are a number of known uncertainties. By taking these uncertainties into account can the outset margins be created, so the measured energy performance in the end, should match the contracted energy performance.

A5.2.1 Calculation

When a calculation is done to determine the energy use of a building, e.g. as during the design stage, it is also a prediction of the building's energy, when it is completed and will be put into use. The predictions are uncertain because no one can have full control of all the parameters that affect a building's energy performance.

When calculating the energy use in a building, the following parameters / factors identified as uncertain:

1. **All of the input data**, before they are fed into the program has an uncertainty, of course, to different degrees. Some input is in most cases considered to be educated guesses, e.g. building envelope air leakage, airing, control of sun screens, etc.
2. **Entering the input data** can be inaccurate if the wrong value is entered, the revision of the values are forgotten, etc.
3. **Lack of knowledge**, which for example can lead to the assessment of uncertainties and energy impact of parameters, becomes inaccurate. Assumptions and adaptation of the actual building design and technical systems to the possibilities and limitations of the current calculation program are done in a way that can increase the error in the calculation.
4. **Weather data for the actual location** where there is as yet no standard for how a weather data file for a typical year should be created and which statistical base the weather data file should be based on. The problem is not weather data file itself, but that the calculated result is compared with a typical year corrected measured value. The weather file and the typical year corrected value are based, in most cases not on the same basis, i.e. this is an inherent uncertainty.
5. **The calculation program itself** does not calculate "right." All calculation programs are based on different degrees of simplification of the physical conditions in a real building. The degree of simplification leads to the results of each calculation program differs more or less from the measured energy use in the real building.
6. **The calculation program's capabilities and limitations**, can lead to a real building with its technical systems cannot be fully described in the calculation program used. Many deficiencies in various calculation programs, i.e. they do not take various technical details into account, are known and it is possible to take them into account by including the safety margins from calculated result.

The first three sources of uncertainty can be influenced through quality assurance, uncertainty analysis, and education. The last three sources are more difficult to influence. There are different ways to deal with these uncertainties. One is to try to assess the size of the respective uncertainty to calculate the total uncertainty. This method usually requires a lot of work and time. Another is that, through experience and knowledge, try to assess the total uncertainty to the calculation result are for different types of buildings and programs. Both have their pros and cons. The more accurate a calculation can be performed, the more work is required on the other hand; the margin of safety is reduced.

It is essential that the calculation result is a relevant assessment of the degree of uncertainty that each calculation and that the calculation has adequately provided with a safety margin to include uncertainties. The calculation result should be indicated with an uncertainty interval.

A5.2.2 Construction process

Behind the requirement of the building's energy performance is a series of underlying energy technical function requirements (i.e., input parameters for installations and building envelope). During the construction process, these can be changed either through conscious changes during the construction process or constructional errors.

To ensure that the requirements on the building's energy performance will be met a quality assurance is required. Partly, ensuring revised energy calculations that can verify how changes to the energy technical function requirements will affect the building's energy performance and partly necessary controls and tests of functional requirements during the construction process (see Sveby Energy Verification process).

A summary of the energy technical function requirements along with details of operations and use documented as input to energy calculations. Input data and results from using calculation programs are documented in a so-called Energy Verification process that comes with the entire construction process. In the Sveby Energy Verification process is a clear documentation of the revised energy calculations on three occasions recommended:

Energy calculation – schematic design documents

The building has taken shape with the design, use, operation times, etc. Energy requirements for the entire system can be described by subsystems and how they should interact. Functional requirements such as air density and U values are determined. Energy calculations are carried out with preliminary energy technical input along with input for standard use (Sveby user input).

Energy calculation – construction documents

When the procurement of technical systems and equipment are carried out, an energy calculation based on updated and detailed energy technical input along with input data for standard use (Sveby user input data).

Energy calculation – built documentations

Based on results from self-control, inspection, winter and summer cases tests are an updated energy calculation based on input data for verified energy technology features and standardized user input data.

This entire quality assurance during the construction process is described in Sveby Energy Verification process and the present guidance for the verification of the energy requirement is assumed that these guidelines are followed. Energy calculation and compilation of the energy technical function requirements together with real built data on activities and use thereby provides a basis for a verification of the energy requirements and analysis of deviations.

In this guide, the fourth energy calculations facilitate verification of energy requirements.

Energy calculation – real operation

When information is available about real use, i.e. when the building has been in operation for at least 12 months or more, an energy calculation made based on the input data for verified energy technical functions along with inputs for real use. Difference between energy calculation "built documentation" and "real operation" is compared for verification of energy performance.

A5.2.3 Measurement

According to the Swedish Building Regulations the measurement method uncertainty should be taken into account. If the uncertainties in the measurement methods are great this should be taken into account. The uncertainty is partly due to the number of meters and partly on the meters individual uncertainty. Measurement uncertainty is the square root of the sum of the errors squared for each meter. To use a total meter with high accuracy is recommended to minimize the uncertainties in the measurement. In Sveby Measurement Regulations it is recommended that a heating energy meter must have an uncertainty of up to 3% at nominal flow and electricity meters shall have an uncertainty of up to 5%. The recommendation is based on the capability to use an ordinary revenue meter according to requirements on them. In practice the electric meters usually better with an uncertainty of up to 1%. All meters must be calibrated at the start of measurement period.

Installing multiple sub-meters is always an advantage because it facilitates troubleshooting discrepancies.

A5.3 Verification of energy requirements

A5.3.1 Method and conditions

Contracted energy performance

Guidance for the verification of the energy requirements are based on the contracted energy performance ($EP_{contract}$) treated the same regardless of whether the requirement is a value limit the according to the Swedish Building Regulation (BBR) or a lower value agreed on e.g. according to Sveby Energy Contract.

Measured values

Guidance for the verification of the energy requirements are based on the measured monthly values is available for:

- heating,
- domestic hot water use,
- comfort cooling
- facility electricity

In addition, the estimate of average specific airflow during the heating season should be available. For measurement of the building's energy performance is made to Sveby Measurement Regulations where the following applies:

- If process heat can be measured separately from the heating it should be done.
- If the cooling use for cooling process heat (i.e. process cooling) can be measured separately from the comfort cooling use it should be done.
- If the electrical installation in the category of operational electricity is measured with meters for services systems (for example, shared laundry) or electrical installation in the category of facility electricity is measured with meters for operational electricity (e.g. underfloor heating), the monthly values from the meters should be available. (In special cases, the default values used if the electrical installation is expected to have annual electricity use, which contributes to the building's total energy performance by less than 3 kWh per m^2 A_{temp}.) In Sveby Occupant Input data there are different forms of energy defined between facility and operational electricity.

Method for verification of energy requirements

Verification of the energy requirements can be divided into three steps:

Step 1 Calculation of the corrected measured energy performance and energy requirements verified or deviation is noted.

Step 2 Overview analysis to indicate the cause for the deviation.

Step 3 More accurate deviation analysis to derive the deviation to users, operation or increased cooling requirements for a year of very hot weather.

A5.3.2 Step 1: Corrected measured energy performance

The analysis begins with step 1 by correcting the measured energy performance:

- if the building has a common installation for heating and process heat with another building in such a way that it is impossible to separate them (common energy meter)
- typical weather year for heating
- if the building has domestic hot water use that deviates from Sveby standardized use
- if the installation for process and comfort cooling is shared in such a way that it is impossible to separate them (common energy meter)
- If the electrical installation in the category of operational electricity is measured with meters for facility electricity, such as common laundry. (Electrical installation having a higher electricity usage than 3 kWh per m^2 A_{temp}, should have a sub meter. For electrical installation with electricity usage lower than 3 kWh per m^2 A_{temp} a standard value can be used.)
- If the electrical installation in the category of facility electricity is measured with meters for operational electricity, such as underfloor heating. (Electrical installation having a higher electricity usage than 3 kWh per m^2 A_{temp}, should have sub meter. For electrical installation with electricity usage lower than 3 kWh per m^2 A_{temp} standard value can be used.)

For premises the maximum value of the energy is calculated from the BBR measured outdoor airflow that for reasons of hygiene have a higher flow rate than 0.35 l / s, m^2.

After comparing the corrected measured energy ($EP_{measured, corr}$) with contracted energy ($EP_{contract}$) and control is done if the requirements are met according to BBR.

The working procedure of steps for the correction of the measured energy performance is illustrated in Table 3.1 and Figure 3.1 shows a schematic representation of the correction. Below is a more detailed description of each step.

Step 1.1

From the measured energy for heating is any included energy for process heat subtracted. Examples of process heat can be ground heat outside the building used to remove ice formation in the driveway, which is determined by sub meters or estimated by the standard value (for definitions of process heat see Sveby Occupant Input). Then typical weather year correction of energy for heating (excluding energy for domestic hot water) according to the method specified in Sveby Measurement Regulations or particularly specified in the Sveby Energy Contract. Typical weather year corrected energy performance for heating and domestic hot water heating is denoted $EP_{heat, typical}$.

Step 1.2

Hot water correction.

Energy performance for domestic hot water use separately from the standard use is calculated according to:

$$EP_{dhw} = \left(\sum_{month=1}^{12} volume_{dhw,\ month} \cdot 55 \,/\, A_{temp} - SA \right) / \eta_{dhw} \quad \text{(kWh/m}^2\text{,year)}$$

where:

$volume_{dhw}$	is volume delivered hot water per month (m^3)
A_{temp}	is the buildings tempered area (m^2)
SA	is the value for standard use in kWh/m^2 per year and is stated for premises in Sveby User Input office.
h_{dhw}	is efficiency of the hot water in the building (COP of the heat pump). Can be set to 1 for building for other way of heating than electric heat when nothing else is known.

Step 1.3

If cooling use to cool process heat has been measured separately, it should not be included in the building's energy performance for comfort cooling ($EP_{comfort\ cooling}$). If the meter for process and comfort cooling is shared the energy for process cooling be estimated according to specific calculation and is then subtracted from the building's energy performance.

Step 1.4

From the measured facility electricity any included electricity usage is subtracted for the electrical installation in the category of operational electricity. Facility electricity for operating electrical installation not included in the measured value is added. Electricity use that will be subtracted or added is determined by sub meter or estimated by standard value. Electrical installation having an electricity usage higher than 3 kWh per m^2 A_{temp} should have its own sub meter. Energy performance for facility electricity denoted $Ep_{facility\ el}$.

Step 1.5

Corrected measured energy performance is calculated accordingly:

$$EP_{measured\ corr} = EP_{heat,typical\ year} + EP_{dhw} + EP_{comfort\ cooling} + EP_{facility\ el}$$

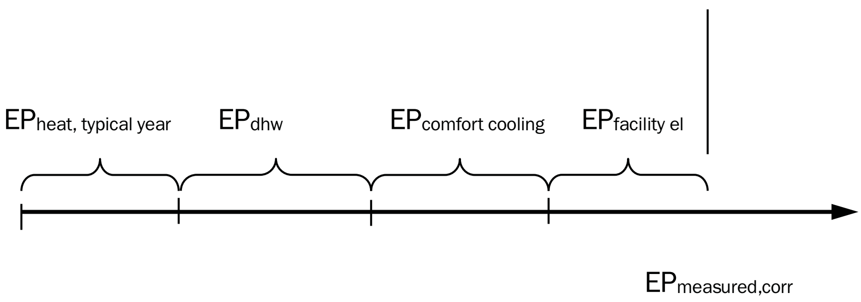

Figure 3.1. Schematic presentation of the correction of measured energy performance.

Step 1.6

Ventilation supplement

For premises the maximum value of energy performance is calculated to the BBR, EP_{BBR}, from measured outdoor airflow that with reasons of hygiene has a higher flow rate than 0.35 l / s, m^2 under heating season.

Step 1.7

Corrected measured energy performance is compared with the contracted energy performance and maximum value of energy performance according to BBR ($EP_{measured,corr}$ is compared with $EP_{contract}$ and EP_{BBR}).

a. *If* $EP_{measured,corr}$ is greater than EP_{BBR} further analysis is needed to verify that the building meets the requirements by law. Continued verification of energy requirements in step 2.

b. *If* $EP_{measured,corr}$ is less or equal with $EP_{contract}$ and the building is utilized more than 70% (occupancy rate > 70%) the building meets the requirements of energy performance.
Verification of energy performance is completed.

c. If $EP_{measured,corr}$ is less or equal with $EP_{contract}$ but the building is only partly utilized (occupancy rate < 70%) the building meets the requirements of energy performance of the lower degree of occupancy. Further verification is recommended to verify that the energy performance requirements are met even when the building occupancy rate is more than 70%. Further verification in step 2.

d. *If* $EP_{measured,corr}$ is greater than $EP_{contract}$ the building doesn't meet the energy performance requirements. Further verification of energy requirements in step 2.

Table 3.1. Summary table of corrections of the measured energy performance and verification of energy requirements.

Step	Energy performance	Correction	How/Method
1.1	Heating and domestic hot water ($EP_{heat,\ typical\ year}$)	Deduction of process heat. Typical year: Heat to typical year, excluding domestic hot water	Sveby Measurement Regulations, Energy index (energy cert.) Degree days (Sveby)
1.2	Domestic hot water use separate from standardized use. (EP_{dhw})	Deduction/addition beyond standardized use.	Sveby Measurement Reg. Sveby User Input Office
1.3	Comfort cooling in premises ($EP_{comfort\ cooling}$)	Deduction of process cooling that is used to cool process heat	Sveby Measurement Reg.
1.4	Facility electricity ($EP_{facility\ el}$)	Deduction of electricity installation that belongs in the category facility electricity Addition of facility electrical installation that is measured on another meter	Sveby Measurement Reg. Sveby User Input Office
1.5	Calculate $EP_{measured,corr}$	$EP_{measured,corr} = EP_{heat,\ typical\ year} + EP_{dhw} + EP_{comfort\ cooling} + EP_{facility\ el}$	Sveby Measurement Reg
1.6	Calculate EP_{BBR}	Measured average outdoor airflow during the heating season greater than 0,35 $l/s,m^2$ due to hygienic reasons	Sveby Measurement Reg Max value of energy performance according to BBR
1.7	Compare $EP_{measured,corr}$ with $EP_{contract}$ and EP_{BBR}		
a	$EP_{measured,corr} > EP_{BBR}$	Requirements according to BBR is not verified	Go to step 2
b	$EP_{measured,corr} \leq EP_{contract}$ and occupancy > 70%	Requirements according to Energy Agreement are met	Verification is completed
c	$EP_{measured,corr} \leq EP_{contract}$ and occupancy < 70%	Further verification recommended	Go to step 2
d	$EP_{measured,corr} > EP_{contract}$	Contracted requirement not verified	Go to step 2

A5.3.3 Step 2: Indication of cause for deviation

In step 2, is a general analysis to indicate the probable cause of the deviation done. This is done by assessing the size of the deviation (½ $EP_{measured, corr}$ – $EP_{contract}$ ½) for heating, cooling, and facility electricity can be related to other way of use of the building, another operation or an increased cooling requirement for a year of very hot weather.

At first an analysis is made to see if the deviation is found on the heating, cooling and facility electricity part. This is done by comparing the measured values (EU) with calculated values (EC). Compare the amounts:

Deviation of heat = $(EU_{heat, typical\ year\ corr} - EC_{heat})*100 / EC_{heat}$ (%)

Deviation of cooling = $(EU_{comfort\ cooling} - EC_{comfort\ cooling}) *100 / EC_{comfort\ cooling}$ (%)

Deviation of facility electricity = $(EU_{facility\ el} - EC_{facility\ el}) *100 / EC_{facility\ el}$ (%)

These measure values are the minimum number of values measured that should be present in a building (see Sveby Measurement Regulations). If there are further sub meters, e.g. operating electricity has separate meters for electricity for public lighting and electricity to the lifts, so the analysis is made of all sub meter. More sub-meters to make the analysis easier.

Deviation of facility electricity

Too high facility electricity use can have many different causes. If the installations are properly installed and have some form of automatic control such as a timer for the stairwell lighting, fans or heaters the facility electricity should normally not be too high. If the high facility electricity can be traced to the user the building is somehow different than what has been possible to predict in the design. There are no general rules, but the building must be inspected on site, possibly supplemented by interviews with users, to analyze the high values cause. More sub-meters could make the analysis easier.

Deviation of heating and cooling in premises

If deviation for heating and cooling mainly could explain the difference between $EP_{measured, corr}$ and $EP_{contract}$ possible reasons related to operation are:

- that the building has different operating hours than its design for
- that the building is not being used to the extent that it was design for
- that the users are using a different operational electricity and thus generates another internal heat
- In table 3.2 provides examples of how energy performance can be affected for other operations in an office.

Table 3.2. Schematic descriptions for an indication if heating and cooling deviation in the premises can be traced to the building's operations.

Step	Operation	Effect	Example office[1]
2.1	Operation hours/ Presence time	An increase in the business operation times increases internal heat from operational electricity and person load than design, which in turn reduces heating demand and increases the cooling demand. While the facility electricity to fans increases and use of domestic hot water.	Changed operation times have minor impact on the building's energy performance. An increase of cooling energy, operating electricity for fans and domestic hot water energy is compensated largely by reduction in heating energy.
2.2	Occupancy rate/ degree of presence	Lower internal heat from operational electricity and person load because the building is only partially rented out or have a lower presence degree of users than designed. This increases the heating demand and reduces the cooling demand. While facility electricity to the lifts and the use of domestic hot water decreases.	Changed occupancy rates / degree of presence have little impact on energy performance. An increase of heat energy is compensated largely by reductions in cooling energy, domestic hot water, energy, and facility electricity. Only in the occupancy rates / degree of presence below 40% are affected energy performance. At 30% rental the energy use increases by approximately 10 kWh/m^2 year.
2.3	Internal heat	Increased person load and increased use of operational electricity in the same operating time reduces the need for heating. Increased person load also increases the energy demand for comfort cooling, electricity for elevators and domestic hot water.	Altered (increasing) the internal heat has limited impact on the building's energy performance. An increase of the internal heat by 50% increases energy use by approximately 5 kWh/m^2 year.

[1] Note that this is only an example. In each case, the impact on energy performance could be quite different.

Deviation for cooling

If the deviation of cooling could explain the largest proportion of the difference between $EP_{measured\ corr}$ and $EP_{contract}$, one possible cause could be a year of very hot weather. Table 3.3 provides examples of how energy performance can be affected in an office for a year of very hot weather.

Table 3.3. Schematic description of analysis about if the deviation can be traced to users, operation or increased cooling requirements for a year of very hot weather in premises.

Step	Climate	Effect	Example office[2]
2.4	Current years weather has been very hot	More hot days than predicted, increases cooling	An increase of 10–20 cooling degree days can increase the cooling energy use of 2–4 kWh/m^2.

A5.3.4 Step 3: Verification of causes for deviation

In step 2, indicated probable cause of deviation by comparing the deviations for heating, cooling and facility electricity. To verify that it really is the cause of an in-depth analysis of the following steps:

Step 3.1 Control takes place through inspection on site in the building mainly regarding the parameter that is believed to cause the deviation. Inspection on site may need to be supplemented by interviews with users and / or occasional measurements (see Sveby User guide for measurement regulations).

Step 3.2 When a new value is set for a different parameter, such as higher indoor temperatures, a new energy calculation for "real operating" is done which is then compared with the energy calculation for "built documentations".

Energy calculation for "real operation" using input parameters for installations and building envelope identified during the final inspection and of operation and use of the building uses the input parameters you set when contracted. Energy calculation for "real operating" uses the same input as of "built documentations" except the deviating parameter whose newly set value is used.

Step 3.3 The size of deviation between energy performance of "real operating" and "built documentations" ($EP_{real, operating} - EP_{built documentations}$) is compared with the size of the deviation between the measured and corrected energy performance and contracted energy performance ($EP_{measured, corr} - EP_{contract}$).

Step 3.4a If ($EP_{real, operating} - EP_{built documentations}$) is larger or the same size as ($EP_{measured,corr} - EP_{contract}$) the deviation can be traced to the parameter executed.

Step 3.4b If ($EP_{real, operating} - EP_{built documentations}$) is smaller than ($EP_{measured, corr} - EP_{contract}$), the parameter examined can't explain the difference, and a new parameter that is likely to cause the deviation are analyzed. This continues in an iterative process until the parameter that causes the deviation can be verified.

Step 3.5 If the parameter that causes the deviation can be traced to users, operation or increased cooling requirements of a year of very hot weather, i.e. to causes that neither the client nor contractors control have energy requirements of the building been verified.

The verification is completed and documented as a basis for the particular investigation which according to Swedish Building Regulations should be reported in the correction of energy performance of deviations that can be traced to users, operation or increased cooling requirements of a year of very hot weather.

A5.4 Sensitivity analysis

A5.4.1 Calculations for premises

When it comes to a category of building like premises it is considerably more heterogeneous than the category dwellings. The local building sector contains all buildings that are not dwellings, e.g. bathhouse, offices, hotels, libraries, train stations, schools, concert halls, laboratories, etc. The wide variety of building types, and its related operations, making it virtually impossible to say anything definite about how energy is affected by various types of deviations. To be able to say anything in the context of this written document it has an office building selected as the example building. Thus, it is important to keep in mind that the results presented below are **not** representative of the entire local building stock, but rather represents a relatively normal office building.

The energy use in a local building is affected by a variety of factors. To find out to what extent various deviations affecting a building's energy use, a number of simulations of a hypothetical office building have been completed. The proposed building is called as example building and is described in Appendix 2. Example building is an office building with 7 floors with an A_{temp} of 9,800 m^2 and has been calculated in the energy calculation software BV2 version in 2010. (Swedish software)

- The deviations studied are deviations in the form of:
- increased/decreased operating- and/or attendance times
- increased/decreased occupancy rate alt. degree of presence
- a year with very hot weather.

Operating- and attendance times

Attendance time is varied from 9 h base case to 12 h, 15 h and 24 h. The operating time for fans is one hour before and one hour after the attendance time.

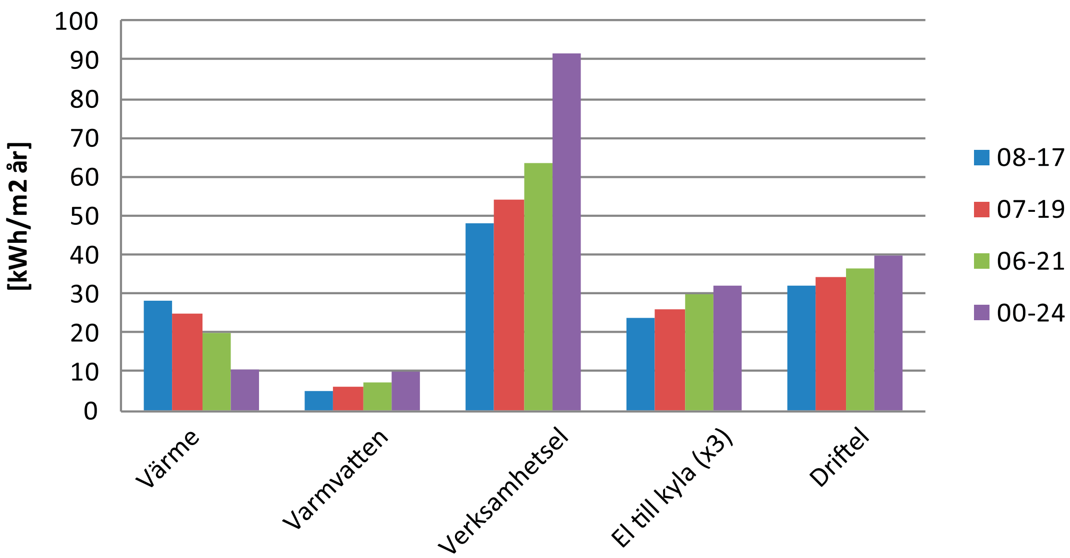

Figure 4.1. Energy use at different times of attendance divided in the posts Heating (Värme), Domestic Hot Water (Varmvatten), Operational electricity (Verksamhetsel), Cooling electricity (el till kyla) and Facility electricity (Driftel). Electricity use for comfort cooling has been multiplied by a factor of 3 according to BBR. The different times to the right in the diagram refers to attendance, the operating time of the ventilation is 1 +1 h extra.

Figure 4.1 shows energy use at different times of attendance divided in the posts Heating, Domestic Hot Water, Operational electricity and Facility electricity. The need of heating is reduced with increasing attendance. Domestic Hot water need is expected to increase slightly and operational electricity and facility electricity also increases. Operation electricity due to longer attendance and facility electricity because of increased operation times and greater cooling needs (electric cooling).

In Figure 4.2 energy use is presented according to BBR. Energy use according to BBR does not include operational electricity. Thus the decrease in heating energy is roughly offsetting the increase in hot water energy and facility electricity. The result is that the BBR energy is almost equal regardless of attendance and related operation time. The differences are only a few kWh/m^2 year.

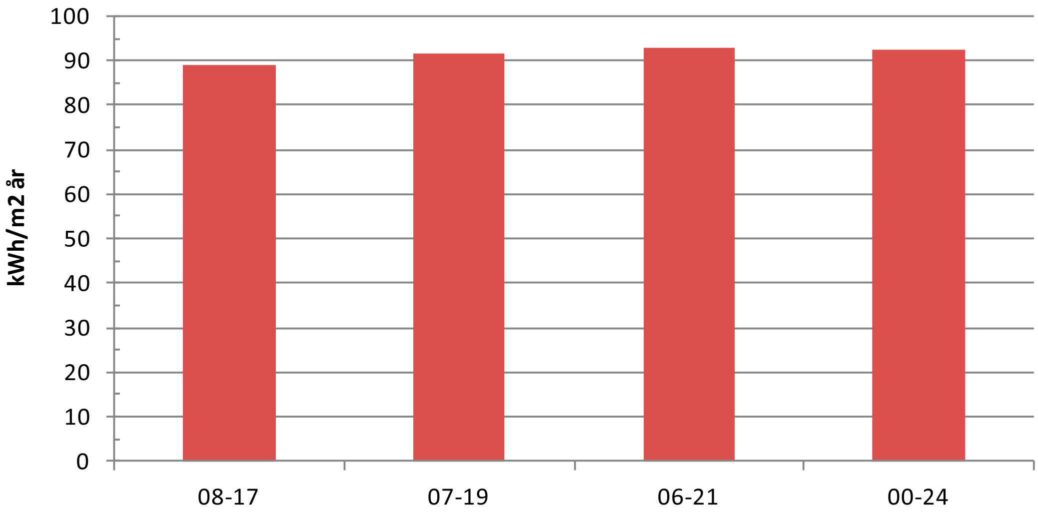

Figure 4.2. Energy use according to BBR in different operating and attendance time. The different time intervals in the diagram refer to attendance, the operating time of the ventilation is 1 +1 h extra.

Occupancy rate

The occupancy rate is varied from 100% in the base case to 60% respectively 30%. In these cases it is assumed that the ventilation, heating and cooling cannot be sectioned, so the entire building is heated and ventilated equally on all levels.

In Figure 4.3 energy use is presented at different occupancy rates divided in the posts Heating, Domestic Hot Water, and Operational Electricity and facility electricity. As the diagram in Figure 4.3, the need of heating increases with decreasing occupancy rate. Hot water need is assumed to decrease slightly and operational electricity and operating electricity is also reduced. Operation electricity due to lower occupancy rate, i.e. fewer people and computers and less lighting electricity, facility electricity because of decreasing cooling load (electric cooling) and electricity to elevators.

Figure 4.4 presents the energy use according to BBR at different occupancy rates. Energy use according to BBR does not include operational electricity.

This means that the increase in heating energy in is roughly offsetting the reduction in domestic hot water energy and facility electricity. The result is that the BBR-energy is substantially equal at 100% respectively. 60% occupancy rate and increases slightly at 30%. The differences at 30% occupancy are that BBR energy increases by about 10 kWh/m^2 year.

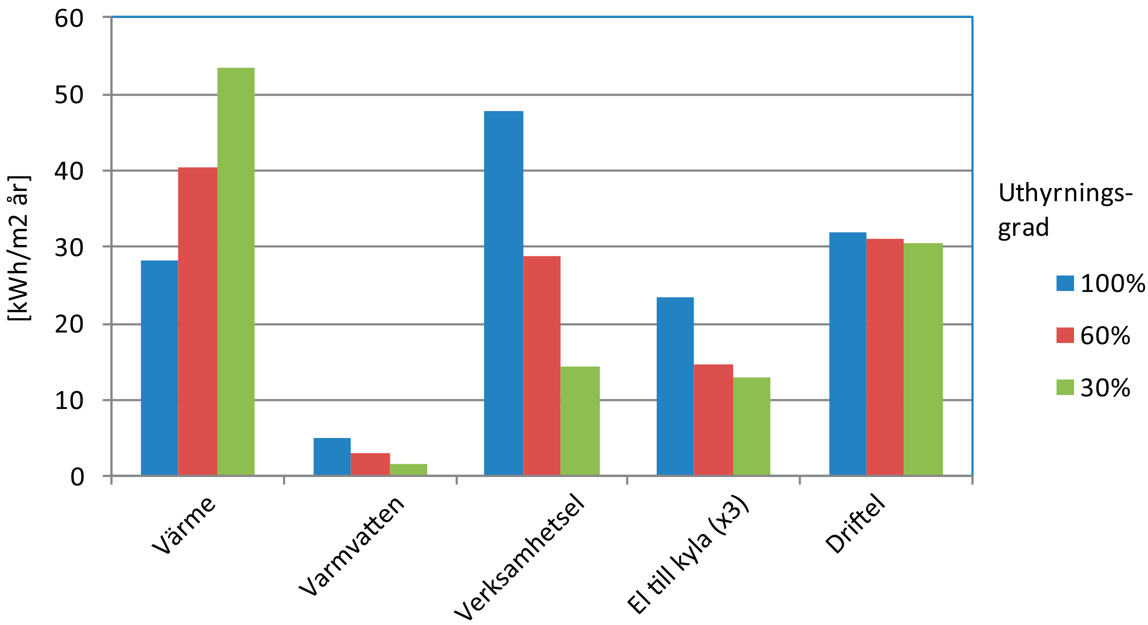

Figure 4.3. Energy use at different occupancy rates divided in the posts Heating (Värme), Domestic Hot Water (Varmvatten), and Operation electricity (Verksamhetsel, Cooling electricity (El t kyla) and Facility Electricity (Driftel). Electricity use for comfort cooling has been multiplied by a factor of 3 according to BBR.

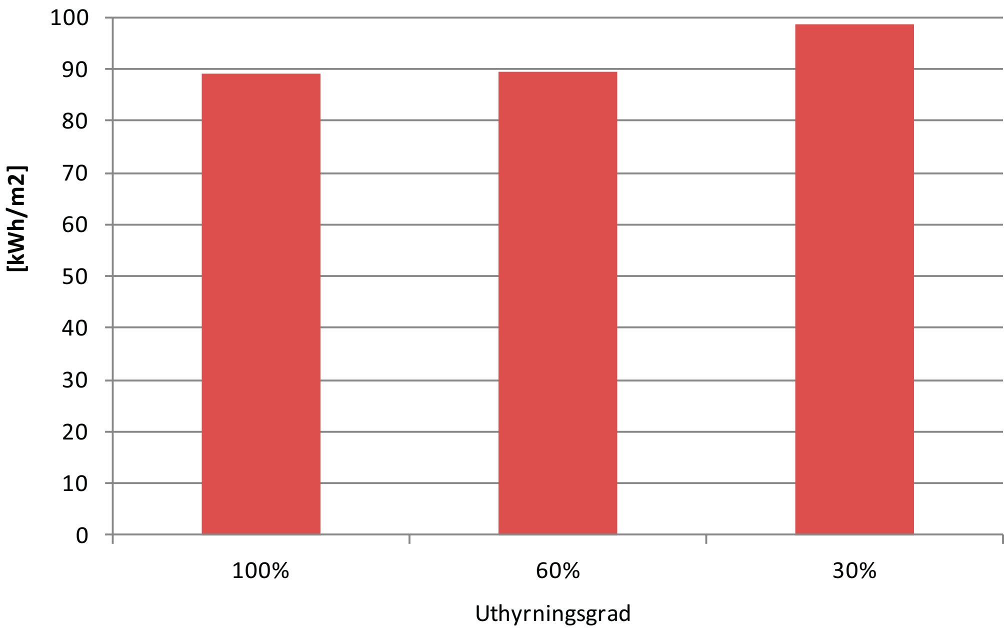

Figure 4.4. Energy use according to BBR in different occupancy rates (Uthyrningsgrad).

Very hot weather

A year of very hot weather. The summer period (June, July and August) has an average temperature which is about one degree above normal temperatures for the period. If it's much above normal the average temperature 1.5 to 2 degrees above. This could be translated into cooling degree days, that a temperature difference across a reference value, e.g. 20°C, times the time in days. If a city has e.g. 25 cooling degree days as normal value, that value can go up to 35–45 degree days during a hot summer.

When simulating with BV2 of different cooling degree days but with the same building and other conditions being equal, obtained an increase in cooling energy need according to Figure 4.5.

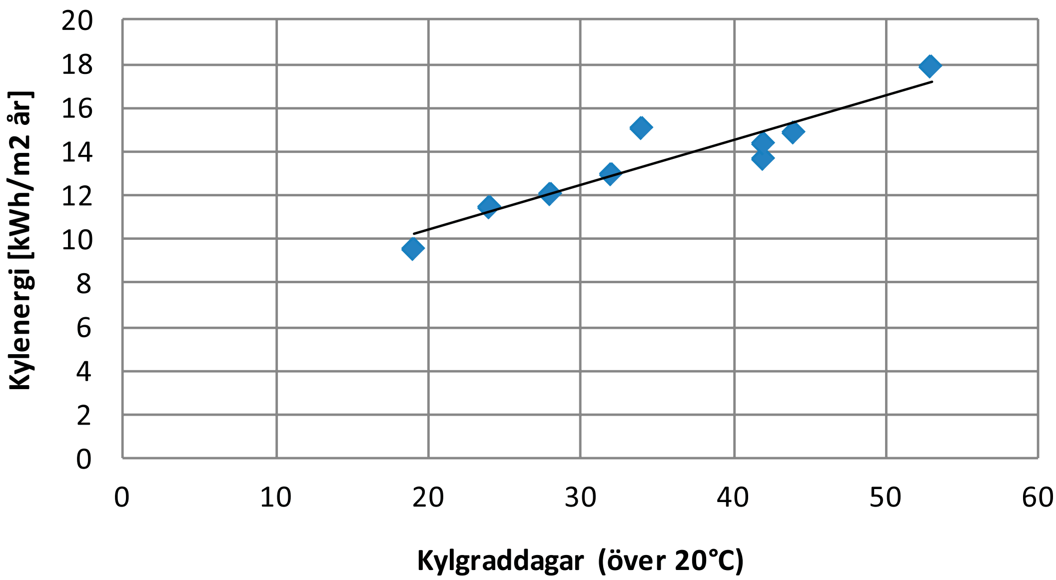

Figure 4.5. Cooling energy (kylenergi) need vs cooling degree days (Kylgraddagar).

With the assumption 25 cooling degree days under normal summer and about 35–45 cooling degree days in a hot summer increases cooling energy need with about 2–4 kWh/m2 year of the used standard building. The total energy use defined according to BBR will then increase by the same amount given that the climate during the rest of the year remains unchanged.

A5.5 Discussion

The way from the contracted to actually measured energy performance after two years of operation is a long and complicated process involving many actors. There is much that can go wrong along the way and it is therefore important to constantly work on quality assurance in the process. Despite a thorough and good work, there are sources of error that neither client nor contractor control, and which ultimately results in a deviation between contracted and actual measured energy performance. To verify the energy requirements need to cause the deviation derived. Although this is a new and complex process and even if developed guidance provides assistance in the analytical work further development is needed when more experience has been obtained.

Indication and final verification

In step 2 guidance is provided as to how large deviations may be through the influence of users, operation, or of a year of very hot weather. The purpose is to give an indication of what the cause may be, but gives no definitive answer that the problem is found. To verify the energy requirements and derive the deviation step 3 must also be completed. For the example has a common office been chosen because this is possible to some extent to make some general conclusion. For more complex buildings such as hospital or bathhouse it is almost impossible to give such indications. For these is the analysis of step 3 probably more extensive.

Utilization rate

The example office shows that the building's utilization rate has little impact on energy performance. In the office an increase is compensated in thermal energy largely to a reduction in cooling energy, domestic hot water energy and facility electricity. Verification of energy performance will therefore not be crucial because if the building has users in all offices, i.e. if number of users in the building will increase (change) by time.

Office example

For the office example change of operation has very limited impact on energy performance. An increase of heating energy largely by reductions in cooling energy, domestic hot water energy and facility electricity and vice versa.

For the example on offices is a year of very hot weather the major cause of increased energy use. A hot summer i.e. the period of June, July and August, has an average temperature that is about one degree above normal temperatures for the period. If it's much above normal, the average temperature 1.5 to 2 degrees above. An increase of 10–20 cooling degree days, which may correspond to an increase in the normal temperature for the period of between 1–2°C, can increase energy performance of 2–4 kWh/m^2. A good method of correction of normal cooling needs similar to the typical weather year correction that is in heating would be very helpful.

How much deviation is acceptable between measured and contracted energy performance has not been addressed in this guidance. Here it is not possible to give any general advice, but it must be discussed case by case. The guidance shows weaknesses when it comes to derive an increased energy use for airing or increased cooling requirements of a year of very hot weather. Here it is important to consider this in the design and take to appropriately sized safety margins.

Low energy building

For a low energy building the margins are much smaller and it becomes even more important to verify the impact on energy performance, derived from the users, operation or increased cooling needs of a year of very hot weather.

Appendix 6 Description of the office example building

Example building is a fictional office building located in Gothenburg. The building is 7 stories high with a A_{temp} of 9,800 m^2 and has been calculated in the calculation software BV2 ver.2010. Structurally, the building is fairly normally made with concrete floors and curtain walls of the façade. Most internal walls are drywalls. The building may be considered thermally "medium-duty" with a part of the floor slabs completely or partly exposed.

U-value façade:	0,32 W/m^2 °C (inclusive thermal bridges)
U-value roof:	0,17 W/m^2 °C (inclusive thermal bridges)
U-value base slab:	0,12 W/m^2 °C (inclusive thermal bridges)
U-value window:	1,2 W/m^2 °C (incl. window sill)
Solar heat gain factor window:	0,67 (no external solar shading)
Window part	20% of façade area, 8% of A_{temp}
U_m:	0,39 W/m^2 °C
Air leakage 1:	0,2 air change/h outdoor temp 20°C
Air leakage 2:	0,25 air change/h outdoor temp 0°C
Direction S-facade:	South
Lighting day:	5 W/m^2 (average whole building)
Lighting night:	1 W/m^2 (average whole building)
Persons day:	3,5 W/m^2 (average whole building)
Persons night:	0,1 W/m^2 (average whole building)
Devices day:	6 W/m^2 (average whole building)
Devices night:	1 W/m^2 (average whole building)
Time Day:	08–18
Time Night:	18–08
Heating system;	Radiator system for heating, min temp. 21°C

Balanced ventilation with constant air volume (CAV)

Water-based cooling systems e.g. cooling beams, max temp 25°C

Balanced ventilation:	Operating time: kl 07–19
Air flow:	day 1,5 l/s m^2 night 0,9 l/s m^2
Supply air temp:	15°C – outdoor temp >20°C 19°C – outdoor temp <10°C SFP: 2,5 kW/(m^3/s)

Effectiveness heat exchanger: 75%

SPF cooling machine: 2,5 (no free cooling)

Domestic hot water:	5,00 kWh/m^2
Additional el, users: Exterior lighting:	0,19 kWh/m^2
Lifts:	2,25 kWh/m^2
Electrical heat melting (ice/snow):	0,71 kWh/m^2
Curtain heater:	1,22 kWh/m^2
Heat supply:	District heating

Indo-Swedish collaboration on energy efficiency, 2011-2014

The Swedish Energy Agency and the Bureau of Energy Efficiency (BEE) cooperates within the field of energy efficiency. The overall objectives are to establish agency cooperation, to facilitate business cooperation and to enhance capacity building. The project focuses on energy efficiency measures and management in industry and in buildings, and on minimum energy performance standards and labelling. The agencies also share experiences on communication strategies and outreach activities for more energy efficient behaviour.

The Indian and Swedish governments signed a Memorandum of Understanding on Indo-Swedish cooperation within the field of renewable energy in 2009.

ENERGY IS LIFE BEE CONSERVE IT
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