**EPA-NR Software**

In line with the EPBD and the CEN-standards

A uniform assessment method and supporting tools were developed in the frame of the European project “Energy Performance Assessment for existing Non-Residential buildings” (EPA-NR) for issuing an Energy Performance Certificate and an accompanying energy advice in accordance with the EPBD and CEN. The tools are in principle applicable in all European Member States. The method and tools are flexible and can be adapted to the local conditions and future updates like new CEN-standards. The results of this project are prototype tools that are ready to use by the European Member States. The most significant tool is the software for calculating the energy performance of a building. (Final version of the EPA-NR software: v.1.7.6.19)

The software is unique in its modular architecture; it contains certain common utilities and libraries, while other parts of the software allow adaptation to the local context. The calculation engine, taking care of the physics and financial calculations, typically has a more uniform character. The final draft versions of the EPBD related CEN-standards are taken as a basis for the calculation engine. In many cases the CEN-standards offer alternative options. The most broadly accepted options by the EU Member States, according to the existing knowledge during the software development, were chosen for the calculation.

Climate data and libraries with building components can be added to adjust the software and target the calculation to the local context. An output interface producing the EP-certificate according to national requirements can be connected to the software easily. Also more advanced input and output interfaces can be added relatively easy to incorporate specific functionalities like data storage or graphical output.

The EPA-NR project

The IEE project “Energy Performance Assessment for existing Non-Residential buildings” (EPA-NR) provides an adequate and efficient assessment method with supporting tools, including software. The EPA-NR tools comply with the EPBD and reflect the CEN-standards. The method is applicable all over Europe. The huge number of buildings to be assessed requests a method that is cost effective, meaning sufficient quality at a low price. Consequently the method is set-up in such a way that the tools can easily be adapted to local circumstances and project specific conditions.

Based on all the experiences available in the European Member States, EPA-NR offers a robust approach that needs only minor modification to create an efficient method on national level. The EPA-NR method and tools were tested with positive outcome in twenty-six pilot projects (ref. 1). Consultants and policy makers are the major target groups.
Overview of all EPA-NR results related to the two major target groups

<table>
<thead>
<tr>
<th>Policy makers</th>
<th>Consultants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey: National context in MS</td>
<td>Booklet describing the EPA-NR method</td>
</tr>
<tr>
<td>National reports on pilot projects</td>
<td>Checklist for an intake interview</td>
</tr>
<tr>
<td>Overall report on pilot projects</td>
<td>Inspection protocol</td>
</tr>
<tr>
<td>Application strategies for the EPA-NR method</td>
<td>EPA-NR software and BesTest</td>
</tr>
<tr>
<td>Brochures (general and thematic)</td>
<td>Report: functional specifications of the software</td>
</tr>
</tbody>
</table>

The EPA-NR results described

- The Survey of the national context is a report presenting the context regarding the non-residential building sector and related energy policies in all European Member States.
- The Booklet describing the method and tools gives an outline of the EPA-NR assessment method and identifies the available tools.
  - A Checklist for an intake interview supports the consultant in structuring the intake with the client at the start of the assessment process.
  - The Inspection protocol, giving guidance and examples on how to set up the inspection of the building and how to assure the quality of inspection.
  - The EPA-NR software; a flexible and easy to adjust software to calculate the building EP.
  - A Report on functional specifications of the software providing background information.
- Pilot studies were performed in order to test and evaluate the method and the tools resulting in National reports and an overall report.
- Application strategies for the EPA-NR method are presented in terms of opportunities and added value in the market for applying EPA-NR and for additional consultancy.
- One general and three thematic brochures are available in order to provide concise information towards consultants and policy makers on the EPA-NR method and its application.

Structure of the EPA-NR software

The main goal of the software is an energy calculation for existing non-residential buildings (ENR) leading to an assessment of the energy performance of the building, as shown in the following figure.

It is possible to connect building component libraries to the software to easily generate the input of common components like different types of walls and windows. Climate data and national constants can be defined in a separate library file. Apart from an energy calculation the software also calculates the simple payback time based on investment costs of energy saving measures and the calculated savings.

The required input and the resulting output are set as XML files and thus easy to access with other software applications, like specific interfaces and databases. This is an important feature to provide flexibility in order to be able to adjust the software to the local context.
Since the Energy Performance Indicator and the appearance of the Energy Performance Certificate of a building are nationally defined, it is necessary to add this functionality to the software for instance as an output interface. The software however provides all necessary data to determine the indicator and create the certificate and is further designed to add national interfaces easily.

The calculation engine itself is structured in a modular way. Modules are well-defined sets of formulas, each covering a small part of the calculation, e.g. the heating demand of a zone or the energy calculation of a heating system. The interaction between the modules is defined separately. The structure of the calculation engine is therefore very transparent and future modifications are possible. This also is a flexibility feature.

The calculation approach

The energy calculation approach is as much as possible in line with the available final draft CEN-standards. CEN standards offer alternative options for the calculation method. For EPA-NR, the selection of the calculation approach was based on the level of detail that is sufficient for simple energy performance calculations and energy advice. In addition, it was also to be in agreement with the approach selected by most European Member States.

This led to the following decisions:
- A steady state method on a monthly basis was used
- A building can be modelled as a multi zone building
- Ventilation rates are input data (constants)
- The efficiency rates for the installation are input data (constants) for emission, distribution, and generation.

The calculation engine takes into account the following aspects:
- Space heating;
- Ventilation;
- Hot water;
- Space cooling;
- Humidification;
- Energy consumption for:
  - Lighting;
  - Pumps and fans;
  - Other equipment.
This covers the most common services in a building. Other, process-related energy terms are not considered, at least not in a standard asset rating calculation. However, these additional energy terms may be relevant for a tailor-made asset rating, for comparison with the total actual energy use of the building.

The structure of the calculation process in its separate steps is shown in the following chart.

**Calculation principles for the energy demand per zone**

1. **Energy demand (zone)**
2. **Energy system (type of heating or cooling distribution and emission system)**
3. **Generator (e.g. boiler or heat pump)**
4. **Fuel type (e.g. oil, gas, electricity)**
5. **Environmental load (e.g. CO₂ emission, primary energy)**

The most important part is the energy demand for heating and cooling. This demand is calculated according to CEN WI-14, taking into account:

- **Heat transfer:**
  - Transmission
  - Ventilation:
    - Infiltration
    - Natural
    - Mechanical (based on a given supply temperature)

- **Heat sources:**
  - Occupants and appliances
  - Lighting
  - Recoverable losses from system (optionally)
  - Solar (including fixed and movable shading)

The monthly calculation method does not use full dynamic simulations to calculate the heating and cooling demand, but an approximation, based on the so-called utilisation factor. This factor determines to what extent heat gains are useful for the heating demand (during heating mode) and to what extent heat losses are useful for the cooling demand (during cooling mode). The utilisation factor depends on the balance between gains and losses, and on the time constant of the building zone.

The determination of the heating and cooling demand requires two calculations, one for heating mode and one for cooling mode. The reason is that various properties depend on the mode, like the indoor temperature set point, the supply-air temperature and flow rate, and optionally the U-value and g-value of construction components (e.g. windows with and without shutters). Both calculations are performed for each month of the year, resulting for some months to only a heating demand, for other months to only a cooling demand, and for months in the intermediate season to both a heating and a cooling demand.
Coupling of systems to the zones

There is a lot of flexibility concerning the coupling of zones, systems, generators and fuel types. The freedom in combining components is shown in the schematic example which is a simple hospital building consisting of three zones. The administration and the nursing room share the same energy system that is coupled to two generators; a boiler and a heat pump. The restaurant has its own system and boiler. Both boilers are gas fired and the heat pump uses electricity. From the fuel consumption the environmental load in terms of primary energy and CO₂ emission can be determined.

Using the software

The EPA-NR software enables two types of calculations:

1. **Standard calculation** for the certificate (with a fixed national or regional climate and assuming a nationally fixed user pattern), the so-called asset rating (according to CEN WI-2). This calculation has the main focus in EPA-NR.

2. **Tailored calculations** for the purpose of detailed energy advice are typically client and location specific calculations not necessarily based on standard indoor and outdoor conditions. The software allows calculating the actual situation and additional advice variants and determining the pay-back time of the energy saving measures.

Overview of the user interface

The **main screen** is divided into two parts:
- On the left side of the screen: a building object tree showing the structure of all the input and output screens
- On the right side of the screen: the input screen related to the activated item in the object tree.

In the case of the following screen dump the “Office area” is activated and zone information can be entered in the input screen.
A variant building can be created in case of a tailored energy advice, by making a copy of the reference building in the same tree structure. This variant building can be modified by adding energy saving measures and connected investments. This can be seen in the following screen dump. When values for investment cost per measure are imported in the software the simple pay-back time will be calculated, based on fuel prices read from the fuel library.

There are two types of output screens available in the software. One screen presents the calculation results in terms of heating demand and cooling demand, with a break down in energy flows and the overall energy consumption, fuel consumption, primary energy together with CO₂ emission. These values are presented on a monthly basis and summarized for a year. There is an option to express the amount of energy in GJ, MWh, MJ/m² or kWh/m² floor area.

The other screen gives an overview of the performance of the different energy saving scenarios by presenting the key annual results from the reference building and the developed variant buildings provided with various energy saving measures. In this case the financial calculation results are also presented.
The EPA-NR software tested against the BesTest

The software was tested on a number of relevant test cases of the Building Energy Simulation Test - BesTest (ref. 2). For a heavy weight case and a light weight case both the annual heating (red bars) and cooling demand (blue bars) was calculated and compared against the calculation results of a number of well known and high quality dynamic simulation models. The criterion is whether the results of the EPA-NR software are within the range of plus or minus the standard deviation of the result of the dynamic models (horizontal lines in the graph). The following series of graphs present an overview of some representative results.

**Heavy weight cases**
Conclusions
The EPA-NR results on annual heating and cooling energy demand are within the acceptable deviation in all tested cases and the tool proved to provide acceptable accuracy, compared against the dynamic models used in the BesTest (ref. 3).

References
All results are available through the website www.epa-nr.org.

Specific references:
2. EN ISO 13791, ASHRAE Standard 140

Other EPA-NR brochures:
- Introductory brochure EPA-NR (including CR-ROM with EPA-NR reports)
- Brochure pilot projects EPA-NR
- Brochure EPA-NR and CREM

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