# EPA-NR

## Energy Performance Assessment for Existing Non Residential Buildings

# Overview of results


**Supported by Intelligent Energy Europe (EIE)**
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# Overview of results

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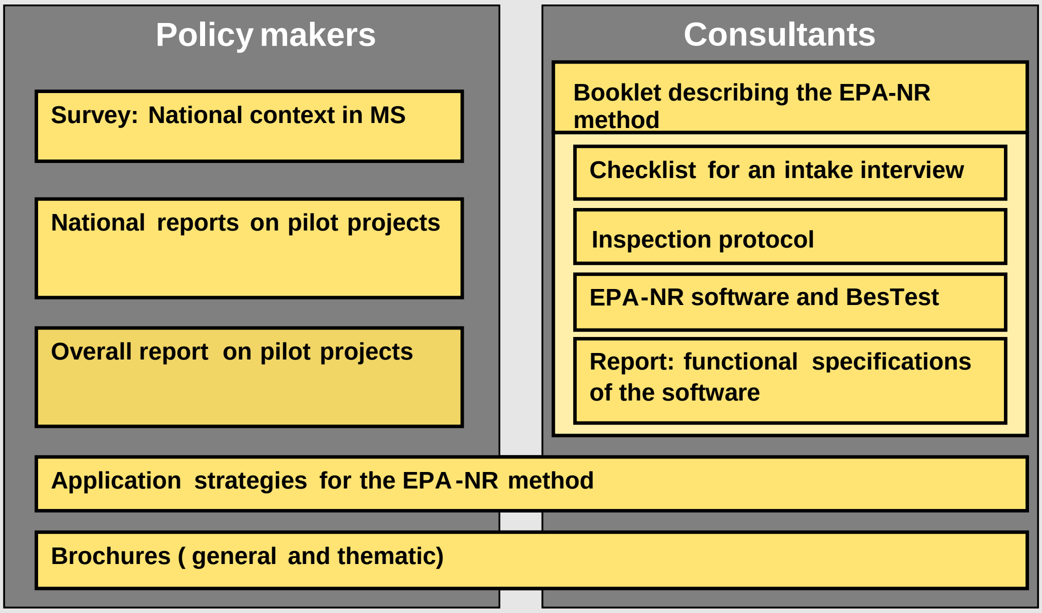
## Overview of EPA-NR products

The EPA-NR project produced a number of products directed to policy makers and end-users like consultants and researchers. The EPA-NR method is a consultancy approach in line with the Energy Performance Directive for Buildings established by the European Commission.




For consultants a **booklet describing the method** is giving an outline of the EPA-NR assessment method and positions the available tools:

- A **checklist for an intake interview** supporting the consultant in order to structure the start of the assessment process;
- The **Inspection protocol**, giving guidance and examples on how to structure the inspection of the building and how to assure the quality of inspection;
- The **EPA-NR software**, being a flexible and easy to adjust software to calculate the energy performance according to the EPBD and relevant CEN-standards. The software is accompanied by a manual. The physical quality of the software has been positively tested against the BesTest;
- A **report on the functional specifications of the software** providing background information and justification of the approach.

For policy makers there is a report concerning a **survey of the context** for EPA-NR. The report presents the context regarding the non-residential building sector in all European Member States together with the policy approach towards energy saving and the implementation of the EPBD.
In every participating country **pilot studies** were executed in order to test and evaluate the method and the tools. They also provide examples how to apply the EPA-NR method. This activity resulted in national reports and an overall report.

For both policy makers and practitioners the **application strategies report** outlines the opportunities in the market for applying EPA-NR. In addition one **general** and several **thematic brochures** are produced in order to provide concise information towards practitioners and policy makers on the EPA-NR method and its application.

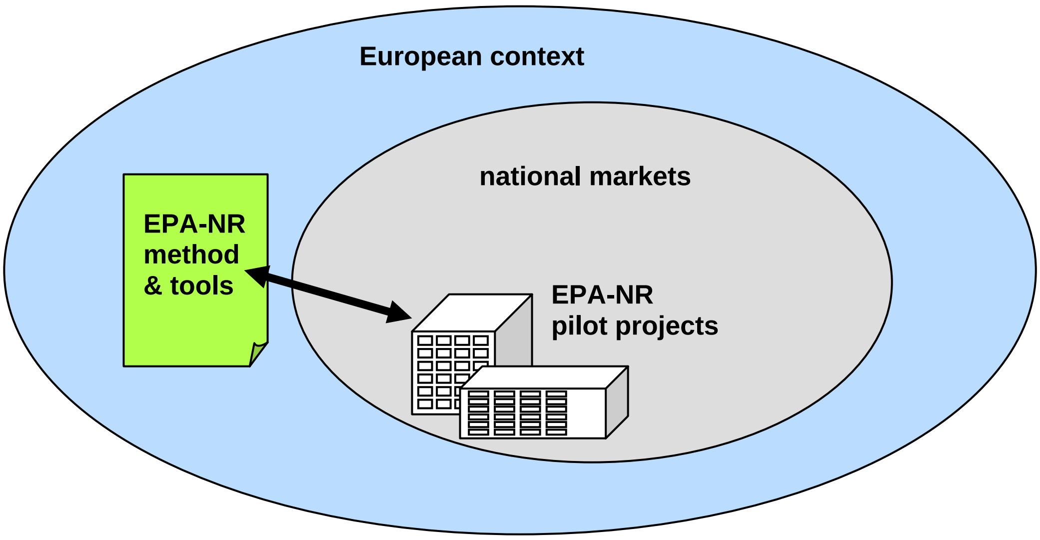
# Contents

# 1 Introduction

The final results of the EPA-NR project are presented in this report. EPA-NR stands for "Energy Performance Assessment of existing Non-Residential buildings". The project is contracted within the framework of the Intelligent Energy Europe (IEE) program from the European Commission. The start of the project was in January 2005 and it was finalised according to the contract in June 2007.
The project provided an adequate and efficient assessment method with accompanying tools, including software. The EPA-NR tools comply with the EPBD and reflect the final draft versions of the EPBD related CEN-standards. The method is applicable all over Europe. However, national legislation may prescribe a specific approach, different from the EPA-NR method.
The huge number of buildings to be assessed call for a method that is cost effective, meaning adequate quality at a low price. Consequently the method is set up in such a way that the tools may easily be adapted to local circumstances and specific project conditions.

Based on all the experiences available in the European Member States, EPA-NR offers a robust approach, needing only minor modification to create an efficient method on national level. The major target group are consultants also policy makers are identified as target audience.

**This report** gives an overview of EPA-NR results and the findings derived from the application of the EPA-NR method in practice. It is composed based on the rich material produced in the project. The EPA-NR method is explained and positioned in the European context. Also the market value and opportunities are addressed aiming at national implementation. Valuable information is gained from the pilot projects realised in all participating countries. These elements are depicted in the figure below.




The structure of this report chapter wise:
1. Introduction
2. European context as defined by the Energy Performance of Buildings Directive (EPBD) and the related CEN standards
3. EPA-NR project in short
4. National context: characteristics of the building stock in the various EU Member States

5. EPA-NR process elaborated, including descriptions of the EPA-NR tools to be used during the assessment
6. Detailed description of the EPA-NR software
7. Added value of EP-certification in the national market
8. Evaluation of the EPA-NR method in practice (pilot projects)
9. Conclusions regarding the quality of the EPA-NR method and tools in practice

The report is set up in such a way that reading the chapters will be like a guided tour where all the EPA-NR products are brought into view. A complete list with references to the EPA-NR products is added to the report.

The report is composed of the work of all participants. The authors are all mentioned in the reference list.

# 2 The European context

## 2.1 The Energy Performance of Buildings Directive and the CEN standards

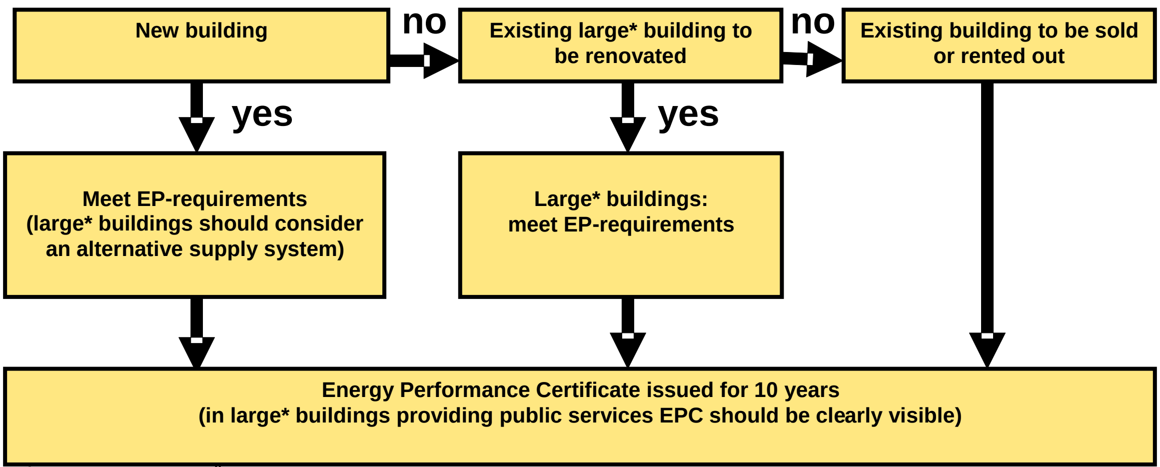
The existing building stock in European countries accounts for over 40% of final energy consumption in the European Union (EU) Member States. In December 2002 the European Parliament adopted the EPBD (Energy Performance of Buildings Directive, Directive 2002/91/EC), which has come into effect on January 4 2006. The objective of this directive is to promote, within the European Community, the improvement of the energy performance of buildings by taking cost-effective energy saving measures.
The implementation of the EPBD can play a key role in meeting the EU target in accordance to the Kyoto commitments to reduce $CO_2$ emissions in an economic way. The EPBD mandates all European Member States to set requirements on energy performance for new buildings and existing large buildings undergoing a major renovation.

The EPBD requires Energy Performance Certificates (EP-certificates) to be issued for both new and existing buildings and to perform regular inspection of heating and air-conditioning equipment. The Member States are committed to apply a methodology to calculate the energy performance. They also have to ensure that qualified or accredited experts carry out the certification in an independent manner.

To stimulate energy efficiency in the built environment the EPBD obliges Member States to:

1. set minimum requirements on the energy performance of new buildings;
2. set minimum requirements on the energy performance of large existing buildings that are subject to major renovation;
3. require energy performance certification of buildings when buildings are constructed, sold or rented out. Furthermore, public buildings over 1000 $m^2$ useful floor area occupied by public authorities and by organisations providing public services should permanently display the certificate in a clearly visible place;
4. require regular inspection of boilers in buildings (option a), or
   to ensure the provisions of advice to the users on replacement of boilers (option b). The overall impact of this ‘option b’ should be equal to the impact of the provisions in ‘option a’;
5. require regular inspection of air-conditioning systems in buildings.

**EPBD flow chart for building certification**




*large: over 1000 $m^2$ useful floor area

In order to support the Member States with the practical implementation of the EPBD, especially with the development of an assessment method for the EP-certificate, the European Commission has mandated the European Association of National Standardisation Institutes (CEN) to develop a number of standards. When national bodies start their national standardisation work they shall consider the CEN standards. In this way some harmonisation of the implementation of the Directive in the Member States is stimulated.

In many EU Member States assessment methods and tools for determining the Energy Performance of new buildings are already available. For the existing building stock, however, there is a need for efficient and effective methods in order to issue the EP-certificate. In developing an assessment method important issues specific for the existing building stock have to be taken into account:

- building data are not entirely readily available. A building inspection will be necessary in order to obtain these data. Building inspection is a time consuming activity and the quality of the data generated is an important aspect in the assessment process.
- the large number of existing buildings to be assessed requires a method designed in such a way that the different steps in the assessment process are balanced in terms of quality and cost.
- the representation of the Energy Performance of a building should be of adequate quality in terms of physical quality and reproducibility (If several assessments were to be made for a specific building by different inspectors, the results should be similar)

Acceptance by the market is crucial and based on the credibility of the energy certificate. The aspects mentioned above play an important role in reaching the acceptance.

# 3 Introduction to the project

## 3.1 Description of the project

The Intelligent Energy Europe (IEE) project “Energy Performance Assessment for existing Non-Residential buildings” (EPA-NR) provides an adequate and efficient assessment method with accompanying tools, including software. The EPA-NR tools comply with the EPBD and reflect the CEN-standards in their final draft versions.

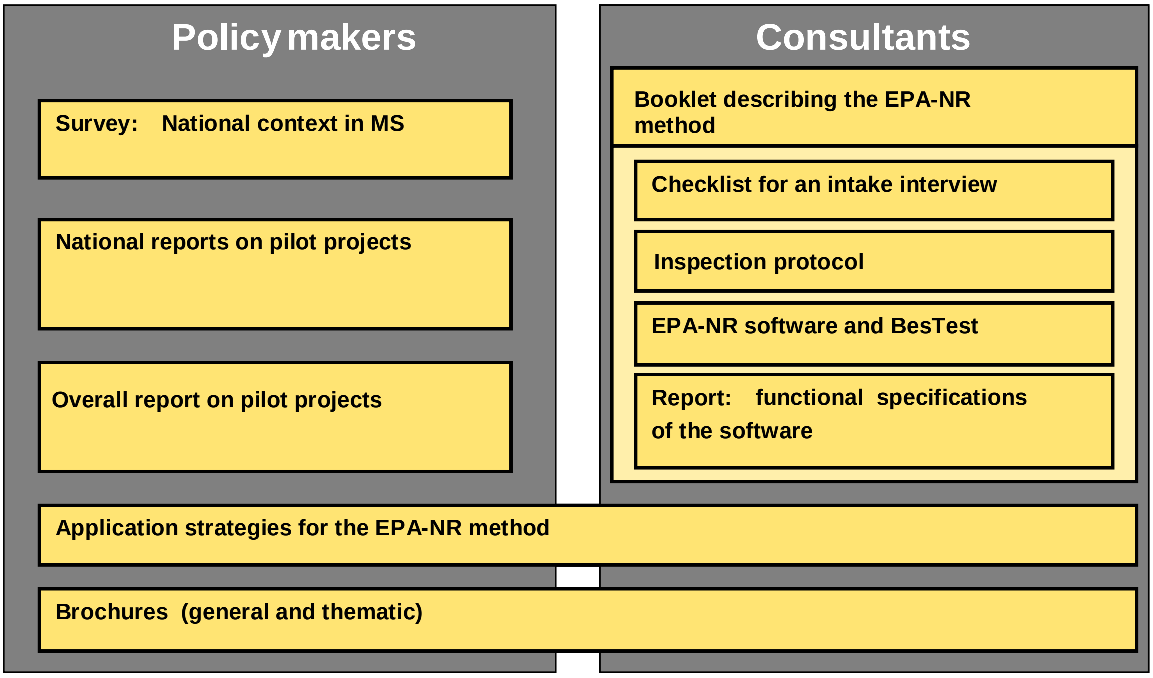
The method is applicable all over Europe. However, national legislation may prescribe a specific approach, not allowing the use of the EPA-NR method. The huge number of buildings to be assessed call for a method that is cost effective, meaning sufficient quality at a low price. Consequently the method is set-up in such a way that the tools may easily be adapted to local circumstances and specific project conditions.

Based on all the experiences available in the European Member States, EPA-NR offers a robust approach, needing only minor modification to create an efficient method on national level.

Consultants and policy makers are the major target groups.

- Consultants are offered a complete assessment method and accompanying tools (a calculation model and process supporting tools like inspection protocols, checklists, building component libraries, etc.). The EPA-NR method and tools were tested with positive outcome in twenty-six pilot projects. The EPA-NR tools are available as high quality prototypes that can be easily adapted to the local context.
- Policy makers are provided with recommendations regarding the implementation issues related to the EPA-NR method.

**Overview of all EPA-NR results related to the two major target groups**




All deliverables of EPA-NR are shortly described below. They are made available through the website [www.epa-nr.org](http://www.epa-nr.org).

- The **Survey of the national context in the Member States** presents the context regarding the non-residential building sector in all European Member States together with the policy approach towards energy saving and the implementation of the EPBD. Although this information is dated regarding some issues like status of implementation of the EPBD in the Member States, it provides valuable insight in the characteristics of the non-residential building stock in all EU Member States.
- The **Booklet describing the method and tools** gives an outline of the EPA-NR assessment method as a process and it describes the available EPA-NR tools applicable during the execution of the assessment.
- The **EPA-NR Tools** are:
  - A **Checklist for an intake interview,** supporting the consultant in order to structure the start of the assessment process;
  - The **Inspection protocol**, giving guidance and examples on how to structure the inspection of the building and how to assure the quality of inspection;
  - The **EPA-NR software** being a flexible and easy to adapt software to calculate the energy performance according to the EPBD and relevant CEN-standards. The software is accompanied by a manual;
  - A **report on functionalities of the software** providing background information.
- **Pilot studies** were performed in order to evaluate and demonstrate the method and the tools regarding. In total twenty six pilot projects in seven European countries provide examples of how to apply the EPA-NR method. The projects are described in separate **National reports** and based on these reports an **Overall report** was compiled.
- **Application strategies for the EPA-NR method** are being outlined in terms of opportunities in the market for applying EPA-NR and for additional consultancy. The added value of energy saving for the client is addressed as well.
- One general **Introductory Brochure** and three **thematic brochures** are available providing concise information on the EPA-NR method and its application towards practitioners and policy makers.

## 3.2 The EPA-NR consortium and the exchange network

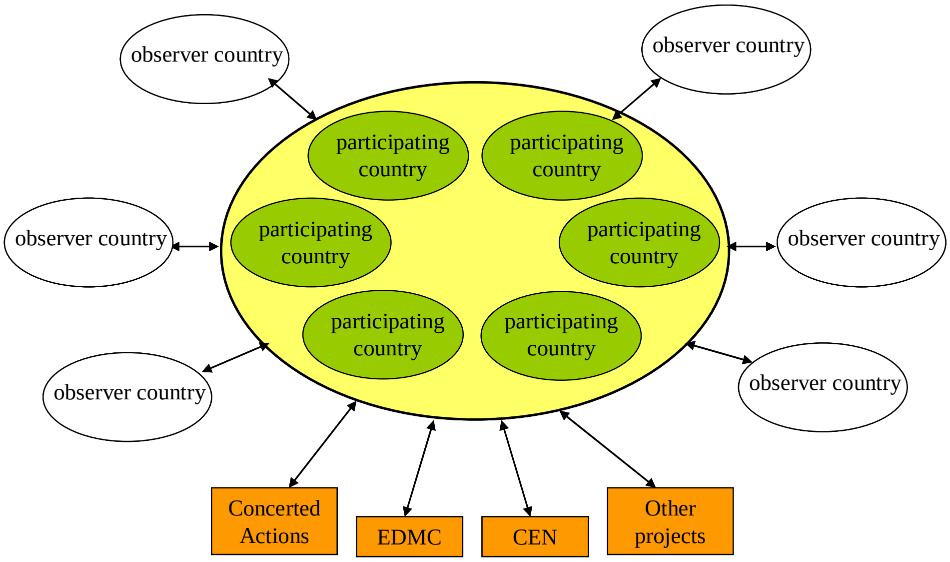
**Consortium**
The EPA-NR project was executed by a consortium consisting of nine parties covering seven European Member States:

| | |
|---|---|
| • EBM-consult (project co-ordinator) | The Netherlands |
| • Arsenal Research | Austria |
| • Österreichisches Ökologie Institut (ÖÖI) | Austria |
| • Danish Building Research Institut (SBi) | Denmark |
| • Centre Scientifique et Technique du Bâtiment (CSTB) | France |
| • Fraunhofer-IBP | Germany |
| • National Observatory of Athens (NOA) | Greece |
| • National Agency for New Technology, Energy and the Environment (ENEA) | Italy |
| • Netherlands Organisation for Applied Scientific Research (TNO) | The Netherlands |

**Observer countries**
In addition to the consortium EU Member States were invited to participate in the project as observer countries. They participated in meetings and were asked to judge draft versions of the results and provide feedback. In total 14 observer countries were registered:

| | | |
|---|---|---|
| Belgium | Macedonia | Slovakia |
| Cyprus | Norway | Slovenia |
| Czech Republic | Poland | Spain |
| Luxemburg | Romania | United Kingdom |
| Malta | Serbia | |

**Exchange network**
Knowledge exchange was also realised with other EPBD related European bodies and projects like the Concerted Action project, CEN, the EPBD Buildings Platform, the Energy Demand Management Committee, the ENPER-EXIST and the EP-label projects. The network is presented in the scheme.




Exchange meetings with the target groups were organised by means of:

- National Feedback Committees:
  The National Feedback Committees were composed of both actors and target groups (end-users, policy makers, relevant umbrella organisations). In many cases they functioned as an advisory platform.
- National workshops:
  Workshops were organised to inform a wider target audience on the project and they provided feedback.
- Seminars:
  The project was presented to a wider national and international audience in a number of seminars. Typically these activities were linked to larger conferences (e.g. parallel sessions) and combined with activities of other EPBD-platform projects.

# 4 National context in all EU Member States

*This chapter relates to the report "Survey: National context and need for instruments" (see reference 1 in the EPA-NR Reference List).*

## 4.1 Focus of the survey

The **Survey** report on the National context and need for instruments provides insight on current status (reference date 2005-2006) of the non-residential building stock, experiences and know-how in EU-25 Member States, concerning buildings Energy Performance Assessment (EPA) of non-residential buildings and related issues. This general survey is of a global nature and context. Information was derived from literature[1] and policy makers.

More specifically the report contains an overview of:

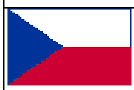
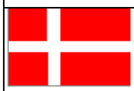
- Characteristics of the non-residential buildings sector
- Policies, legislation and other requirements
- Existing building energy audit methodologies, software; experiences from users
- Existing financial policies & instruments, energy saving programmes and markets
- Maintenance strategies, energy saving measures and facility management, sources for financing.

In addition information is derived from consultants concerning their expectations and needs with regard to Energy Performance Assessment methods.

In this chapter some findings on the search for characteristics of the non-residential building stock are presented.

### Characteristics of the non-residential building stock

For all Member States available data on the volume and the breakdown of the non-residential building stock is presented in the table.

| | |
|---|---|
|  | **Austria - AT**<br>Data for 2001. Non-residential buildings represent 14% of total building stock and 46% of total floor area. Offices & commercial (22%), Health care / Education / Culture / Transportation (10%), Hotels (5%), Storage & industrial (33%), Other – Churches/Public service/Penitentiaries (29%). The great majority of non-residential buildings are privately owned. About 70% of the NR building stock is over 25 years old. Data for floor area are available for 1991. |
|  | **Belgium - BE**<br>Some data on number of buildings and floor area are available for different end-uses, excluding offices. Most available data is for new construction after 1980. |
|  | **Cyprus - CY**<br>Some data on number of buildings and floor area are available for different end-uses, excluding offices. |
|  | **Czech Republic - CZ**<br>Limited data available. Data on number of buildings for hospitals and education for which the ownership status is public (70%) and private (30%). |
|  | **Denmark - DK**<br>Data for 2004. Non-residential buildings represent 26.6% of total building stock and 46.3% of total floor area. Breeding & Farming (42.7%), Offices (20%), Industrial (17.5%), Education (7.4%), Hotels (2.1%), Health care (1.6%). No data on ownership or different construction periods. |
|  | **Estonia - EE**<br>Some data on number of buildings and floor area are available for different end-uses, excluding offices. Data is also available for new construction after 1992 . Some data is also available on ownership. |

[1] For full references to the literature that has been used as input for the survey we refer to the actual survey report (see reference 1 in the EPA-NR reference list).

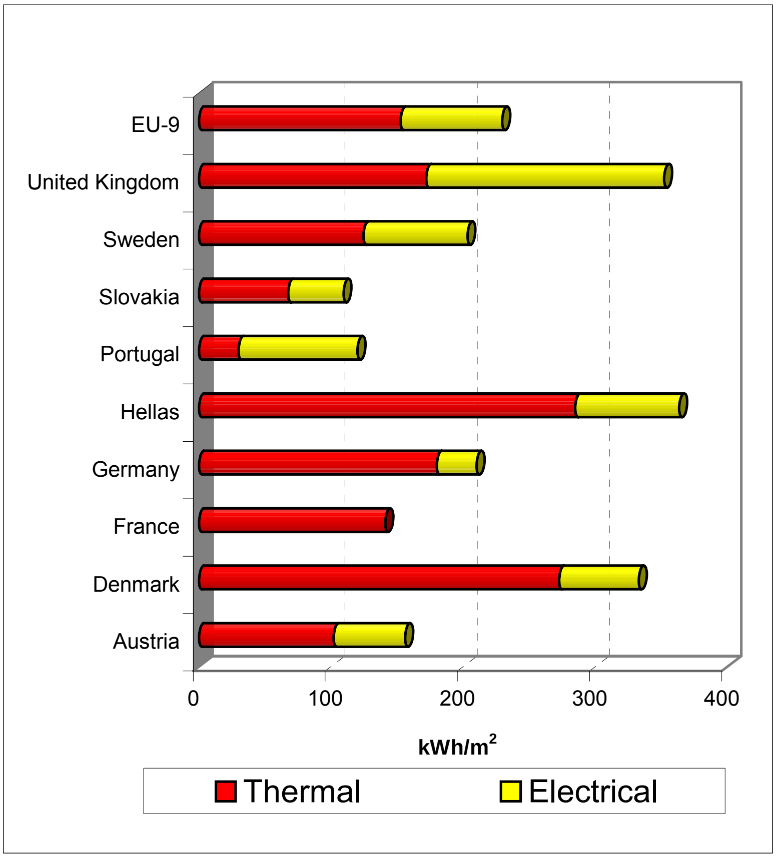
| | |
|---|---|
| | **Finland - FI**<br>Data for 2000. Floor area are available for different end-uses. Industrial (33.6%), Commercial (15.9%), Offices (13.3%), Education (12.9%), Transportation (8.5%), Health care (7.4%), Assembly (6.2%), Other (2.3%). No data on ownership or different construction periods. |
| | **France - FR**<br>Data for 2001. Non-residential buildings represent 24% of total floor area. Compared to total floor area for non residential buildings: Commercial (23.1%), Offices (21.2%), Education (20.4%), Health care (11.5%), Sports (7.5%), Hotels (6.7%), Transportation (3%). Habitat communautaire (6.6%). Public ownership of commercial buildings is about 50%, for education 87% and health care 43%. No data for different construction periods. |
| | **Germany - DE**<br>No data available |
| | **Hellas - EL**<br>Data for 2001. Non-residential buildings represent 5% of total building stock and 26% of total floor area. Offices/Commercial (56.6%), Education (19.3%), Hotels (16%), Health care (7.6%). Limited data on ownership. No data for different construction periods. |
| | **Hungary - HU**<br>Data for public buildings. Non-residential buildings represent 8% of total building stock. No data for floor area. Education (20%), Offices (15%), Health care (11.6%), Hotels (5.7%). No data for ownership and different construction periods. |
| | **Ireland - IE**<br>Limited data for education buildings. |
| | **Italy - IT**<br>Data for 2001. Offices, educational, health care and hotel buildings amount to 1% compared to the number of residential buildings. No data on ownership or different construction periods. |
| | **Latvia - LV**<br>Limited data for the number of some NR buildings. |
| | **Lithuania - LT**<br>Limited data for the number of some NR buildings and ownership. |
| | **Luxembourg - LU**<br>Limited data for the number of some NR buildings. |
| | **Malta - MT**<br>Limited data for the number of some NR buildings. |
| | **Netherlands - NL**<br>Data for 1999. Non-residential buildings represent 1% of total building stock. Offices (50%), Education (7.6%), Health care (1.6%). No data for ownership and different construction periods. |
| | **Poland - PL**<br>Data for the number of NR buildings completed at different construction periods. Limited data for ownership |
| | **Portugal - PT**<br>Data for various periods, including number of buildings and floor area for different end uses of NR buildings. Offices (24%), Education (9.8%), Hotels (5.3%), Health care (2.1%). Some data for ownership and different construction periods. |
| | **Slovakia - SK**<br>Data for the number of NR buildings with different end uses (not offices) in 2001, 02 and 03. Some data for ownership. |
| | **Slovenia - SI**<br>Data for different periods. Non-residential buildings represent 9.4% of total building stock and 30.2% of total floor area. Offices (24.3%), Education (12.1%), Health care (5.7%). No data on ownership. |
| | **Spain - ES**<br>Limited data for 2003 and for some different end uses new construction during 1998. Non-residential buildings represent 1.4% of total floor area. Commercial (29.7%), Industrial (20.2%), Offices (16.8%). No data on ownership and different construction periods. |

| | |
|---|---|
| | **Sweden - SE**<br>Data for various periods. Non-residential buildings represent 23.5% of total floor area. Offices (39.8%), Education (22%), Health care (22%), Commercial (11%), Hotels (5.7%). No data on ownership and different construction periods. |
| | **United Kingdom - UK**<br>Data for various periods. Non-residential buildings represent 5.2% of total building stock and 26% of total floor area. Offices (13.2%), Retail (15%), Warehouses (20.4%). No data on ownership and different construction periods. |

Based on the information collected from the Overview of the Non-Residential Buildings Sector section of the questionnaires, this investigation revealed the lack of available data in many countries, format inconsistencies of available data and the overall difficulty collecting necessary information for the non-residential building stock in EU-25. This is also in agreement with other similar studies reported in the literature. Even when some information is available there are problems with data format compatibility. In some cases, there is also conflicting information from different sources, identified in the national questionnaires.

## Buildings Annual Energy Consumption

For the non-residential sector data on energy consumption are incomplete. **Office buildings** form the best known sector. The following figure summarizes the total annual thermal energy and electricity consumption per unit floor area (kWh/m$^2$) for office buildings, as far as data are available.




Data on energy consumption collected from 56 office buildings in 9 **European countries** revealed that 25% of the buildings have an annual total energy consumption less than 222 kWh/m² and 75% of buildings consume less than 389 kWh /m², with an average value of 278 kWh/m². The annual electricity consumption for 25% of the buildings is less than 81 kWh/m², while the average value for all the buildings is about 139 kWh/m².

Typical primary energy consumption in **northern European countries** ranges between 270-350 kWh/m$^2$. From a study in the United Kingdom it was concluded that low energy offices could be designed to consume 131 kWh/m$^2$ compared with the current average value of 440 kWh/m$^2$. A study by ADEME in France revealed that the annual total energy consumption in office buildings ranges between 145 kWh/m$^2$ in small communities and 165 kWh/m$^2$ in large cities.

According to the results of a survey in 415 **Danish office buildings**, the annual heating energy consumption averages 96 kWh/m$^2$ for district heating, 131 kWh/m$^2$ for oil and 106 kWh/m$^2$ for gas. The average electricity consumption in Danish office buildings is 44.3 kWh/m$^2$.

From an energy audit campaign of **Hellenic office buildings** in the early 1990s, the average annual total energy consumption was reported as 187 kWh/m$^2$. The breakdown was 50.8% for heating, 18.2% for office equipment, 12.6% for cooling, 10.7% for lighting and 7.7% for other uses. The main part of the building's energy consumption is for heating. However, since the majority of buildings were not air-conditioned at that time, the total breakdown for cooling and ventilation is changing fast in recent years. There is a widespread trend of installing local or central air-conditioning units in existing and new buildings, to meet the demand for high working standards and a more flexible control of the indoor environment. The impact of air conditioning (AC) on the overall energy consumption of a building can be significant compared against naturally ventilated (NV) buildings. The use of AC in Hellenic office buildings increases the annual energy consumption by an average value of 40 to 50 kWh/m$^2$ (i.e. 179 kWh/m$^2$ in NV buildings and 226 kWh/m$^2$ in AC buildings).

Data collected in the framework of a European project for a small but representative number of office buildings, the average annual total energy consumption was 98 kWh/m$^2$ in Denmark, 202.5 kWh/m$^2$ in France, 121.7 kWh/m$^2$ in Hellas, 180.3 kWh/m$^2$ in the Netherlands, and 89 kWh/m$^2$ in Switzerland .

For **French office buildings**, the total energy consumption per m² is 284kWh/m². The breakdown by end-use is: 165 kWh/m² thermal, 119 kWh/m² electrical.

**Conclusion**: Thermal energy conservation may be a priority in some member states, as a result of the primary energy fuel. Overall, electrical and thermal energy consumption is balanced between the member states for which data is available.
Thermal energy consumption per unit floor area (usually associated with space heating) varies significantly between the member states as a result of different thermal insulation levels.

## 4.2 The market of Energy Saving

### Energy Saving Measures & Maintenance Activities

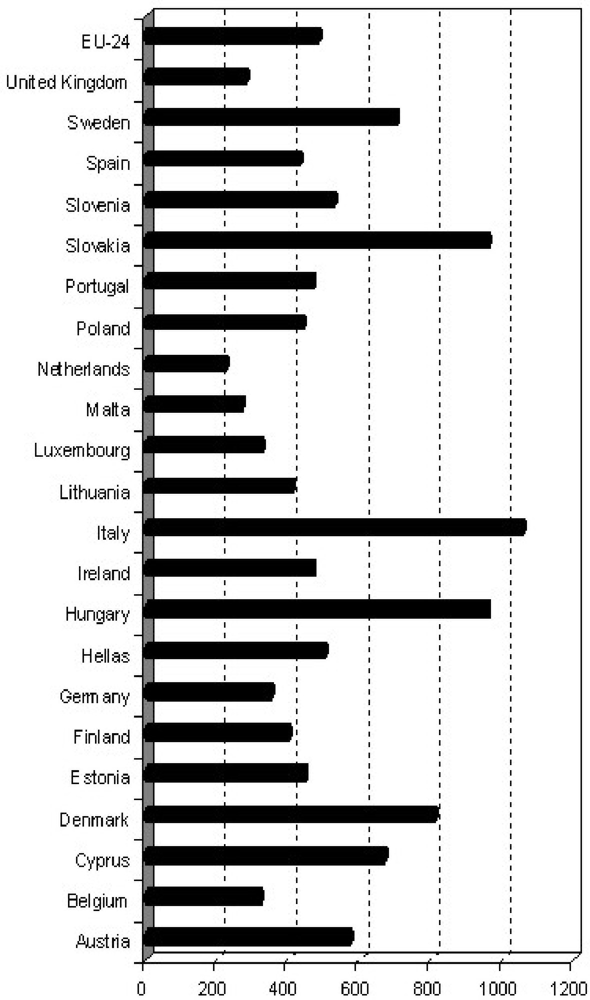
Data are not available for **eight** countries (Belgium, Czech Republic, Estonia, Finland, Ireland, Luxembourg, Portugal and Spain).

From the available information for the remaining countries, an overview of common or easily considered practices during maintenance works for different building uses include the following:

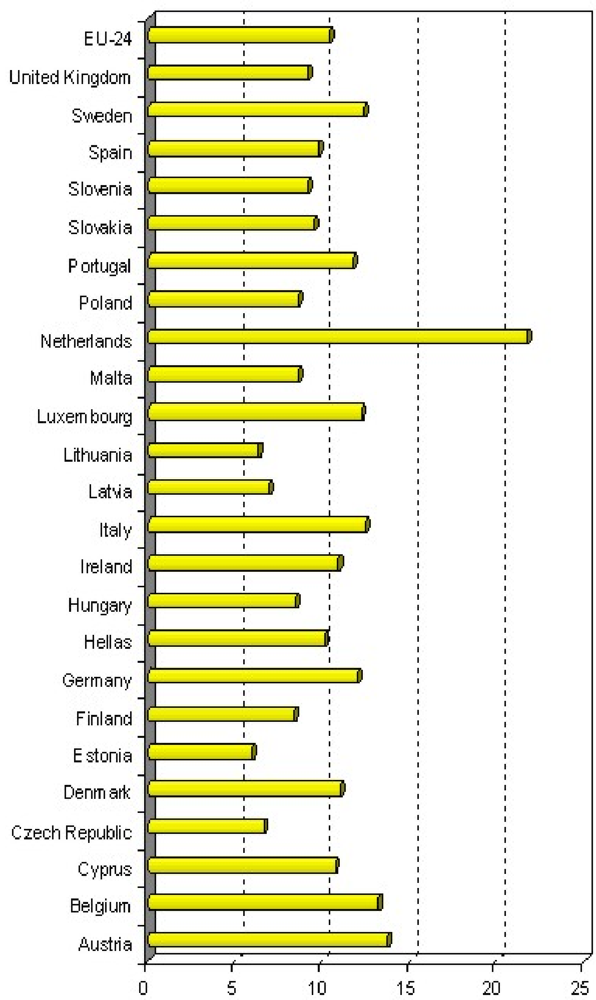
- **Office buildings**: replace single with double glazing, add roof thermal insulation, Add wall thermal insulation, replace incandescent lights with energy efficient bulbs and Install simple controls.
- **Health care buildings**: replace single with double glazing, add roof thermal insulation, add wall thermal insulation and replace incandescent lights with energy efficient bulbs.
- **Education buildings**: add roof thermal insulation, add wall thermal insulation, replace single with double glazing and replace incandescent lights with energy efficient bulbs.
- **Hotels**: add roof thermal insulation, add wall thermal insulation, replace single with double glazing, and replace incandescent lights with energy efficient bulbs.

## Fuel prices

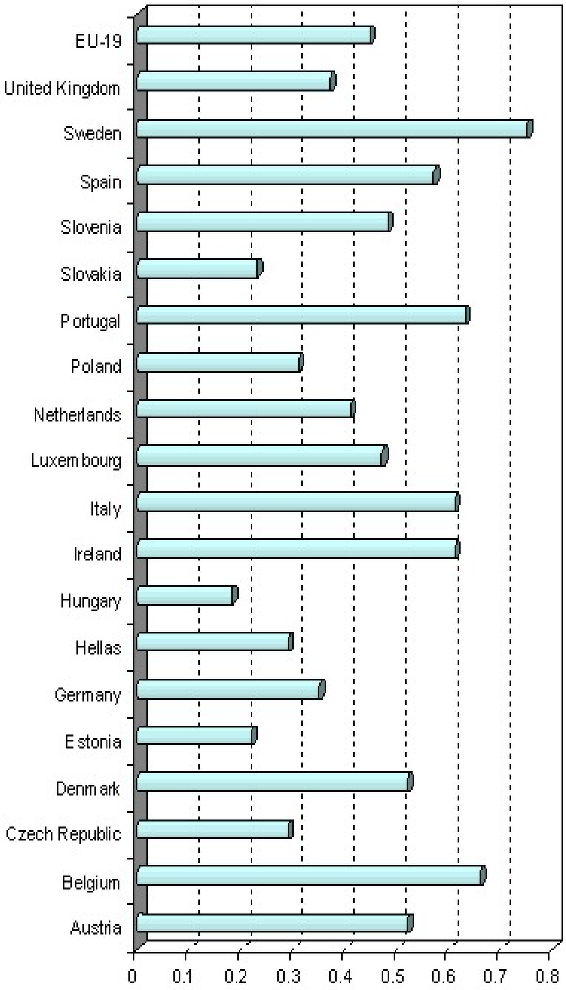
Fuel prices differ significantly throughout the EU. Different pricing policies can be used to discourage or encourage the use of certain fuels. In some cases, the liberization of the energy markets has worked in favour of reducing energy prices, while in others where, for example, electricity prices are too low, will probably result in an increase of the tariffs (i.e. the case of Hellas, where various policies of the state owned power company has kept the electricity tariffs very low over the years).



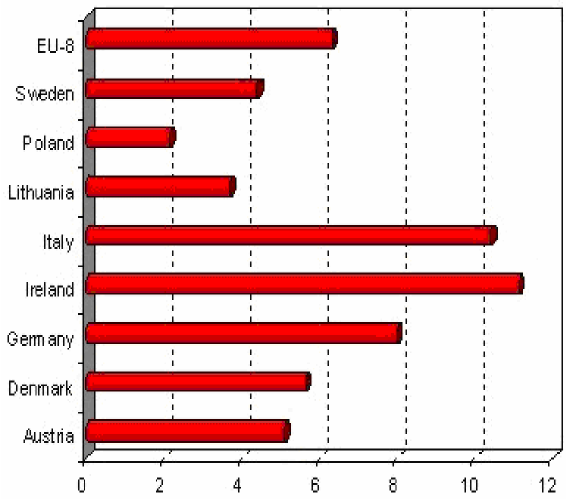

Oil (€ / 1000 lt)




Electricity (€ / 100 kWh)




Natural gas (€ / m$^3$)

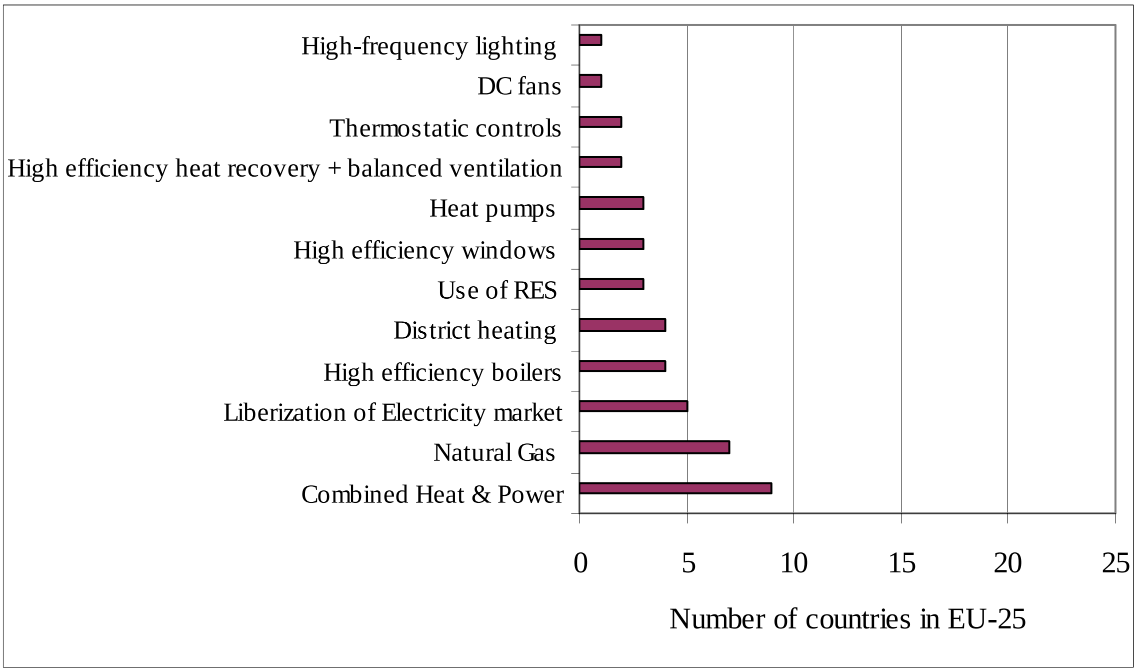



District heating (€ / 100 kWh)

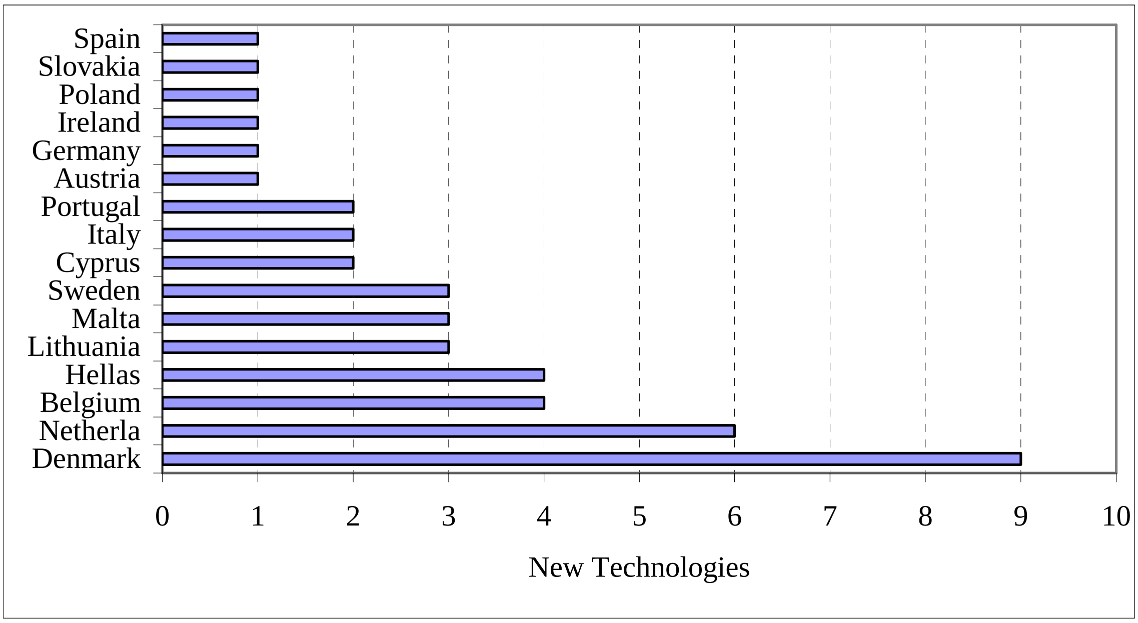
The difference in fuel prices is of significant influence on the pay back time and therefore on the energy saving measures that can be defined as economically feasible.

## Energy Market Evolution and Integration of “new” Technologies

For nine countries data are not available (Czech Republic, Estonia, Finland, France, Hungary, Latvia, Luxembourg, Slovenia and United Kingdom). From the available information, the national energy market evolution (i.e., introduction of new energy sources like natural gas, in the energy system) and new technologies (based on national experience) are summarized in the following figure.




The country most advanced in the integration of “new” Technologies is Denmark. Based on the number of “new” technologies applied in a country, an overview of the EU-25 status is illustrated in the following figure.

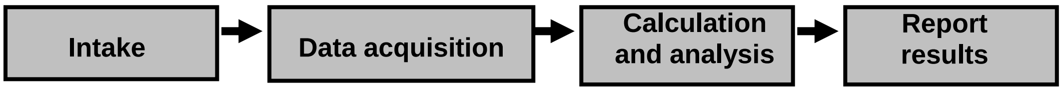


# 5 The Energy Performance Assessment process and the EPA-NR tools

## 5.1 The process

The assessment of the energy performance of a building consists of several stages. The organisation of the assessment process is not standard but depends on the specific circumstances and the type of building. In general a number of stages can be distinguished that are relevant in the majority of assessment processes.

**Stages in the assessment process**




In the following paragraphs the assessment process is explained briefly and each of the stages are presented in separate paragraphs.

### 5.2 The assessment method and the EPA-NR tools

*This paragraph relates to the "Booklet describing the EPA-NR method" (see reference 2 in the EPA-NR Reference List).*

Related to the different stages the EPA-NR tools to support the consultant are available. The first tool to mention is a booklet providing guidance and basic information for the target audience consultants and indirectly for their clients on how to perform an Energy Performance Assessment in an efficient way. While energy efficiency is the main objective, other issues are also addressed, including economics, health, comfort, and maintenance. Additionally the issue of quality control is dealt with briefly.

### The complexity of non-residential buildings and the relation to building management

n general, non-residential buildings are much more complex in terms of architecture, construction, indoor comfort requirements, energy supply systems, and building management systems than residential buildings. Typical characteristics introducing the complexity of NR buildings are:

- Architectural design and construction:
  The architectural building design can be very complex and often the building consists of zones with different indoor climate requirements or system configurations. Those differences should be dealt with by defining separate zones in the building in order to analyse the energy consumption properly.
  Regarding the existing NR building stock a variety of constructions were applied depending on the year of construction. Maintenance and retrofitting may have altered the original structures. Original drawings may differ quite significantly from the actual situation.
- Technical installations:
  Non-residential buildings are generally equipped with more complex technical installations than dwellings. Various systems may be installed serving different parts of the building. Also regarding the systems applies that the available information from drawings is not necessarily in line with reality.

- Relation with maintenance and retrofitting
  In case the building is not performing properly (e.g. comfort problems, inefficient lay-out) energy saving can be linked to maintenance and retrofitting processes.

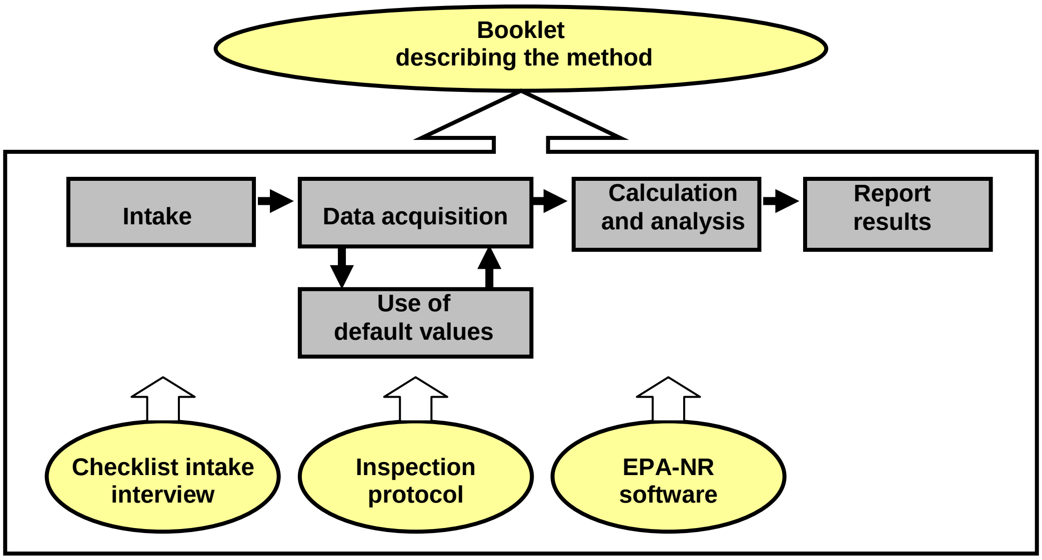
The size and complexity of the building, the interaction with building management processes and the availability and quality of building data are important factors that determine the set-up of the assessment process. However, basic process stages can be defined as shown above.

## The process and the tools

Each process stage has its specific characteristics. The process typically starts with an intake interview with the client in order to discuss and define starting points and conditions to take into account during the assessment. Also the availability and quality of building data is discussed. This stage is a starting point for efficient data acquisition in order to perform energy analysis. An important issue is to what extend default values can be used to generate input for the calculations. Using default values simplifies the building inspection and contributes to the reproducibility of the results. Based on building data and the client's wishes, the energy performance can be established together with the cost-effective energy saving measures to be recommended. In this stage the EPA-NR software will be used. Finally the results have to be expressed as an Energy Performance Certificate and presented to the client.
The EPA-NR method offers the opportunity to encourage the rational use of energy (RUE) and renewable energy sources (RES) in existing NR buildings. Both measures for NR building improving the energy performance of buildings should take into account climatic and local conditions, as well as the required indoor conditions, while ensuring their cost-effectiveness. They should not contravene other essential requirements such as accessibility, the intended use and functions of the building.

For the different stages in the process EPA-NR tools are available to facilitate the assessor. The figure shows the tools in relation to the process.

**Stages in the assessment process and accompanying EPA-NR tools**



## 5.3 Intake interview

*This paragraph relates to the "Checklist for an intake interview" (see reference 3 in the EPA-NR Reference List).*

Once the initiative for an energy performance assessment of a building has been taken the intake interview is the first step in the process. The information collected during the interview is necessary to proceed with the next steps of data acquisition, calculation and analyses and reporting of the results. Thus the intake interview is the starting point for a successful process. The "Checklist for an intake interview" is a report that can be used to set up an effective intake interview.

In order to prepare the intake interview it is recommended to obtain some general information about the building. An intake form requesting this information on the building can be very helpful. This form can be sent to the client in advance. Based on this filled out intake form the interview can be designed in a more efficient way. The Checklist contains such a form.

The **intake interview** not only refers to the building(s) that should undergo an energy performance assessment but it also refers to the client and his wishes with regard to the building(s). The objective of the intake interview is to create a clear starting point for the assessment process for the client as well as for the consultant.
The report "checklist for an intake interview" is intended to be a guide for the consultant and should be used in a flexible way tuned to the specific client and building. It might occur that not all issues are relevant in a specific case, e.g. the consultant can skip questions about building stock management if the client already made clear that he only needs an Energy Performance Certificate and that he has no further ambitions with the building. It is the consultant's expertise and responsibility to identify the issues that are relevant and possibly elaborate more on a certain topic than on another. In that sense the checklist is meant to structure the intake interview and to give guidance on the issues that are relevant to consider and discuss the process of collecting the necessary building data. The following aspects should be considered in the set-up of an intake interview:

- getting acquainted with the client and his organisation,
- refining the definition of the deliverables,
- discussing the acquisition of the necessary data,
- discussing and deciding on the assessment process,
- getting information about the client's wishes: the possibilities and strategies with respect to the building or the building stock to a limited extent
- deciding on the communication with the client and the organisation

Depending on the size and **complexity** of buildings two typical approaches can be discerned:

1. Small and simple buildings only needing an Energy Performance Certificate
2. Large and complex buildings that need a complete energy analysis and assessment of different energy refurbishment scenarios.

For the first category a simple process can be used. The second category needs a more elaborate approach. Data acquisition may require a more complex approach for instance when various data sources are available (e.g. incomparable or inconsistent data, data available through different departments of the client's organisation). Also additional advice requirements from the client can influence the set-up of the process (e.g. investigation of discomfort problems). These aspects should be dealt with explicitly during the intake interview.

The **communication structure** is another important issue to be discussed with the client. The assessment process, for instance, may take a shorter (small and simple buildings) or longer period (large and complex buildings). As a result the number of meetings and people involved may vary considerably. The consultant should make a clear planning of activities, people, meetings, information exchange and communicate this to the client.

Another aspect of communication addressed is awareness of the consultant about the type of audience the results from the Energy Performance Assessment are presented to. Will the EPA serve as a source of technical information for technicians who are responsible for maintenance and renovation or will it serve as management information for managers that have to decide on strategic development of the building stock? The goal and target audience to serve determine the contents and layout of the EPA-NR report. Note that the Energy Performance Certificate is a basic deliverable, which will look the same for each building (according to national regulations). However, additional (technical) reports may need to focus on different issues and contain different technical data and results, depending on the goals and the audience they have to serve.

A sound intake will reduce the inefficiencies in the assessment process.

## 5.4 Data acquisition and the use of default values

*(This paragraph relates to the "Inspection protocol" (see reference 4 in the EPA-NR Reference List).*

### The importance of high quality building inspection

Data acquisition is the most sensitive stage in the assessment process regarding the accuracy of the final result. The perception of characteristics of a building can deviate substantially from one assessor to the other. Practice showed that Energy Performance may differ by 25% due to this effect. An other issue of concern for the existing building stock is the fact that some characteristics of a building can not be determined in a practical way within acceptable cost. The air tightness of the envelope is a typical example. In other cases the required values cannot be measured adequately but reliable product data is available from the manufacturer or product certificates (e.g. burner efficiency).
It is necessary to find the right level of simplification so that the required time for the building inspection and and processing the data is time-efficient, yet the result of the calculation is as close to the most detailed analysis as possible.

All these considerations are in fact a powerful plea for an inspection protocol. Such a protocol guides the assessor through the building inspection activities assuring a similar approach between the various assessors and at the same time default values for building and system components can be prescribed (e.g. values for air tightness based on simple building characteristics, physical values for different types of heating and cooling systems or window types).
The main objective of data acquisition is to obtain information that provides input for the energy analyses calculation. This implies that an inspection protocol should provide the exact input data for the software as much as possible. In that sense the inspection protocol is the link between the actual building and the software input. It is clear that an inspection protocol is determined by:

- the characteristics of the building stock in a country, especially for the definition of valid default values
- the input data required for the software

Therefore an inspection protocol is a country and software specific tool. However there are many similarities.

Within EPA-NR an inspection protocol was developed that can be adapted to the local context. It also provides a rich variety of approaches and examples from inspection protocols from a number of EU Member States. This EPA-NR inspection protocol meets the input requirements of the EPA-NR software.

## Data acquisition and inspection

In most cases the data acquisition contains three steps:

1. the intake interview with the owner and/or facility manager of the building
2. the study of architectural drawings and other planning documentation such as HVAC schemes, if available
3. the inspection of the building and systems by going through the building and collecting additional information or checking information already known

The order of the three steps might change depending on the certain situation. However, the authors of this report recommend following the path that is described above. Nevertheless in many cases there are no drawings available or they are outdated and the inspection of the building is the most important source of information.

The inspection of the building can be done by inspectors with varying expertise and experience. In some countries the inspection is done by one person, the calculation with the tool by another. Here the notes of the inspection or even better the filled-out inspection checklist is of high importance. However, this division of the work will lead to information losses and therefore to less exact application of the building data in the tool.

It has to be emphasised that for the certification of a building according to the Energy Performance of Buildings Directive, the behaviour of the users, the climate and other influences have to be used according to national utilisation profiles defined in national standards. For the attempt to represent the actual situation and use of the building, a more detailed inspection of the building is necessary in order to acquire actual data. Missing data might then be added by using default values out of national or international standards.

## The EPA-NR Inspection Protocol

The “Inspection Protocol” provides the user of the EPA-NR software with a list of necessary data to be identified during the inspection, a guide on how to inspect non-residential buildings with international and national tips for standard values that can be used as default and a checklist that shall help the user to note down the required information during the building inspection. National appendices with references to the specific standards and tools used in the participating countries round off the report. Therefore it is the basis for using the EPA-NR software by indicating in detail what has to be determined during the building inspection, analysed in building and system descriptions, looked for in technical schemes and architectural drawings and also partly investigated during the interview with the building owner and/or building user.

The report is divided into three parts:

1. the inspection protocol (list of necessary data to be identified during the inspection of the building) including international and national tips
2. an inspection protocol checklist adapted to the required input by the EPA-NR tool (Appendix I)
3. additional national tips on how to acquire data that cannot be gathered during the inspection but is needed for the calculation with the EPA-NR tool. This is based on

the work of the partners in the different participating countries and is presented in national chapters in Appendix II.

The EU Member States are free to set their own qualification requirements. Therefore the listed tips at each chapter might be helpful and important for some inspectors but unnecessary for others. However, the national experiences or default values might also be useful for inspections in other countries.

The inspection protocol is meant as checklist during the inspection of the building. Included in the list are all values required for the use in the EPA-NR calculation tool that can be assessed in situ or for which the basis for further calculations have to be identified during the inspection. The list covers the following parts:

- division of building into zones
- building geometry
- building components
- visual air-tightness of the building envelope
- shading systems, obstructions, etc.
- internal gains (persons, equipment, processes)
- heating system devices incl. control systems
- DHW system devices incl. control systems
- ventilation system devices incl. control systems
- cooling system devices incl. control systems
- humidification system devices incl. control systems
- lighting system devices incl. control systems
- day lighting systems
- electrical gains from photovoltaic systems and CHPs
- damages and age-dependent necessary renewals to the existing building and systems
- already realised retrofit measures
- possible/advisable retrofit measures

The main part of the report gives an overview of what is needed as input for the calculation of the primary energy demand and $CO_2$ emissions with the EPA-NR tool. With this overview the user can either develop his own template as a basis for the software input or use the one that fits the EPA-NR software and is provided as an Appendix to the report.

## 5.5 Calculation and analysis

*This paragraph relates to the “EPA-NR software” (see reference 5 and 6 in the EPA-NR Reference List).*

In order to perform an energy analysis of the building a robust software tool was developed in line with the EPBD and the final draft CEN-standards available during the software development. An essential characteristic of the EPA-NR software is the flexibility to adjust the software to the local context like climate, typical local constants, construction and system typology. The software consists of a standard calculation core which can be used all over Europe and abroad (independent of local context), and complies with EPBD and the final draft version of the CEN-standards.

The calculation core is available with a generic input and output interface to facilitate the user of the software. Around this structure, users can build their own advanced interface with a focus on the national or regional specific characteristics. The calculation core uses local weather files, construction libraries, nationally adaptable method constants, etc. Specific project data are provided through the input interface. The output generated by the software enables the creation of the EP-certificate. The output also is a sound basis for setting-up an energy saving advice for almost all situations. Due to the fact that the precise description of the certificate is nationally defined, creating the certificate typically is part of the specific country interface.

The model used in EPA-NR is a multi-zone stationary monthly energy calculation. In addition the simple payback time can be calculated with an integrated financial model. The total energy use is calculated by taking into account the following parts:

- Energy use for heating, cooling, ventilation, humidification, hot-water production and lighting;
- Energy use of pumps and other equipment;
- Energy reduction due to cogeneration and reduction due to supply to third parties;
- Efficiency of energy production and distribution;
- Renewable energy by solar collectors, sunspaces, passive solar gains, heat pumps, photovoltaic cells.

In order to give a tailor-made energy advice the actual building can be calculated under standard conditions or user defined conditions. Energy saving measures can be applied to the building and different energy saving scenarios can be calculated as a basis for an energy advice.

The software has been positively evaluated on usability in pilot projects. The physical quality concerning the most important physical mechanisms was tested using an international test set.

The next chapter gives a more elaborate description of the software.

# 6 EPA-NR Software

*This chapter relates to the "EPA-NR software", "the functional specifications" and the "Bestest report" (see reference 5, 6, 7 and 8 in the EPA-NR Reference List).*

## 6.1 Introduction to the software

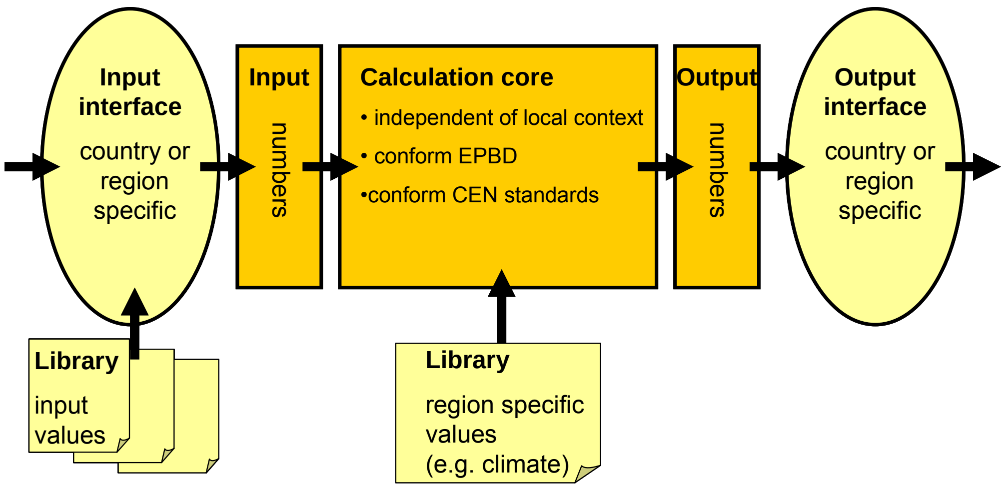
The most significant tool is the software for calculating the energy performance of a building. (Final version of the EPA-NR software: v.1.7.6.19)

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 software is a uniform and flexible tool that offers an effective and efficient method to issue an Energy Performance Certificate. Taking advantage of the available EPA-NR method and software that were developed as a common effort of various European organizations will minimise the effort on national level to comply with the EPBD.

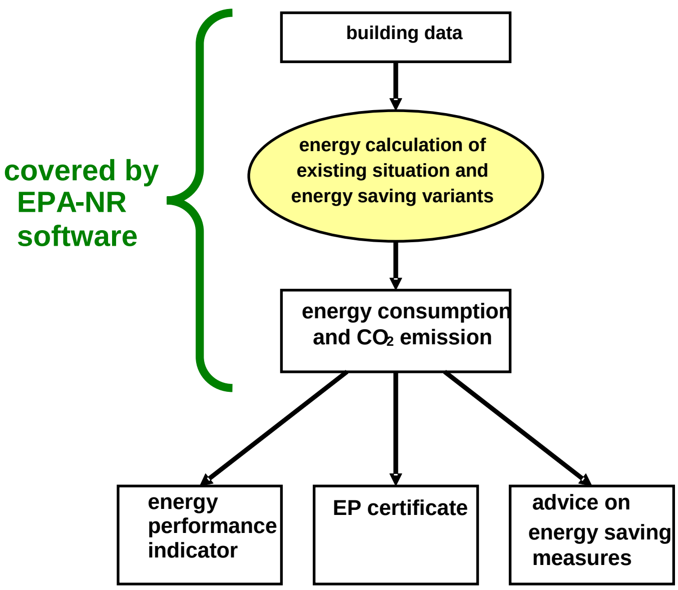
**Structure of the EPA-NR software**



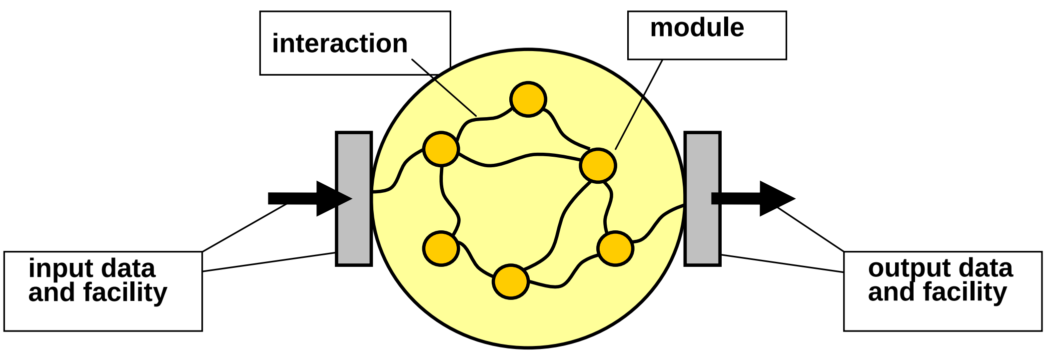
## 6.2 Structure of the EPA-NR software

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.



## 6.3 The calculation approach

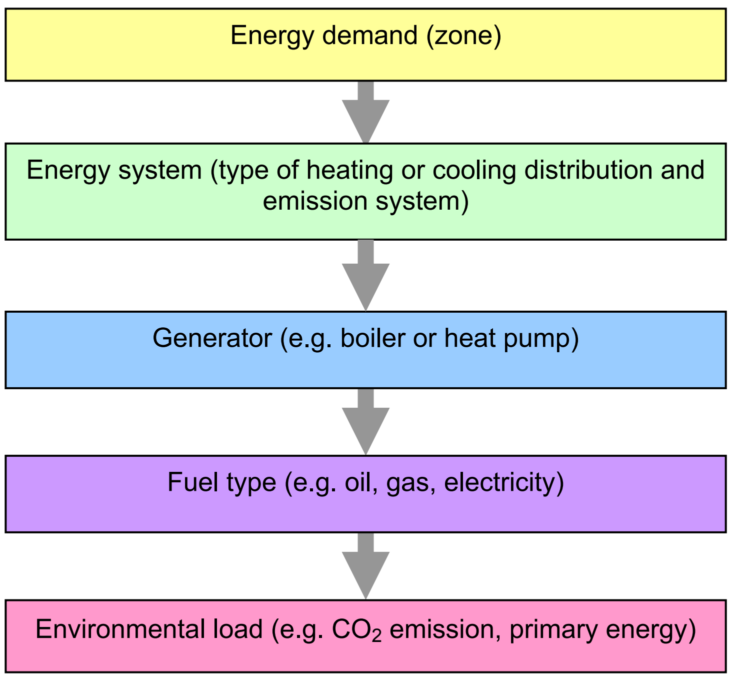
The energy calculation approach is as much as possible in line with the available final draft CEN-standards. CEN standards offer alternative options for the calculation method. For EPA-NR, the selection of the calculation approach was based on the level of detail that is sufficient for simple energy 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 space heating, space cooling, ventilation, humidification, hot water and energy consumption for lighting, pumps, fans and 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**




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:

- o Transmission
- o Ventilation:
  - Infiltration
  - Natural
  - Mechanical (based on a given supply temperature)

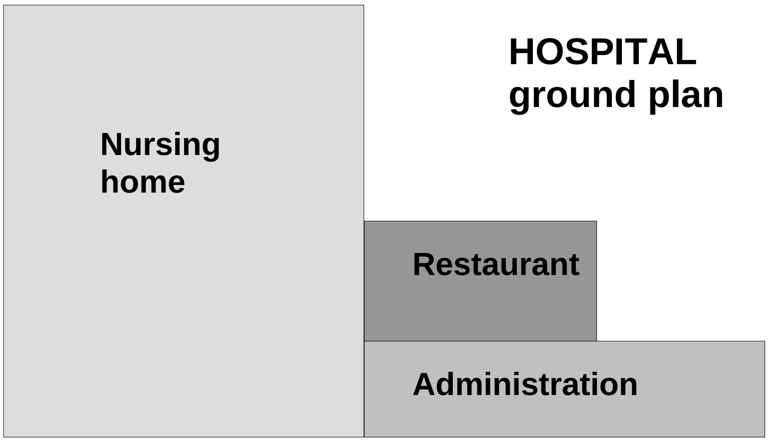
- Heat sources:
  - o Occupants and appliances
  - o Lighting
  - o Recoverable losses from system (optionally)
  - o Solar (including fixed and movable shading)

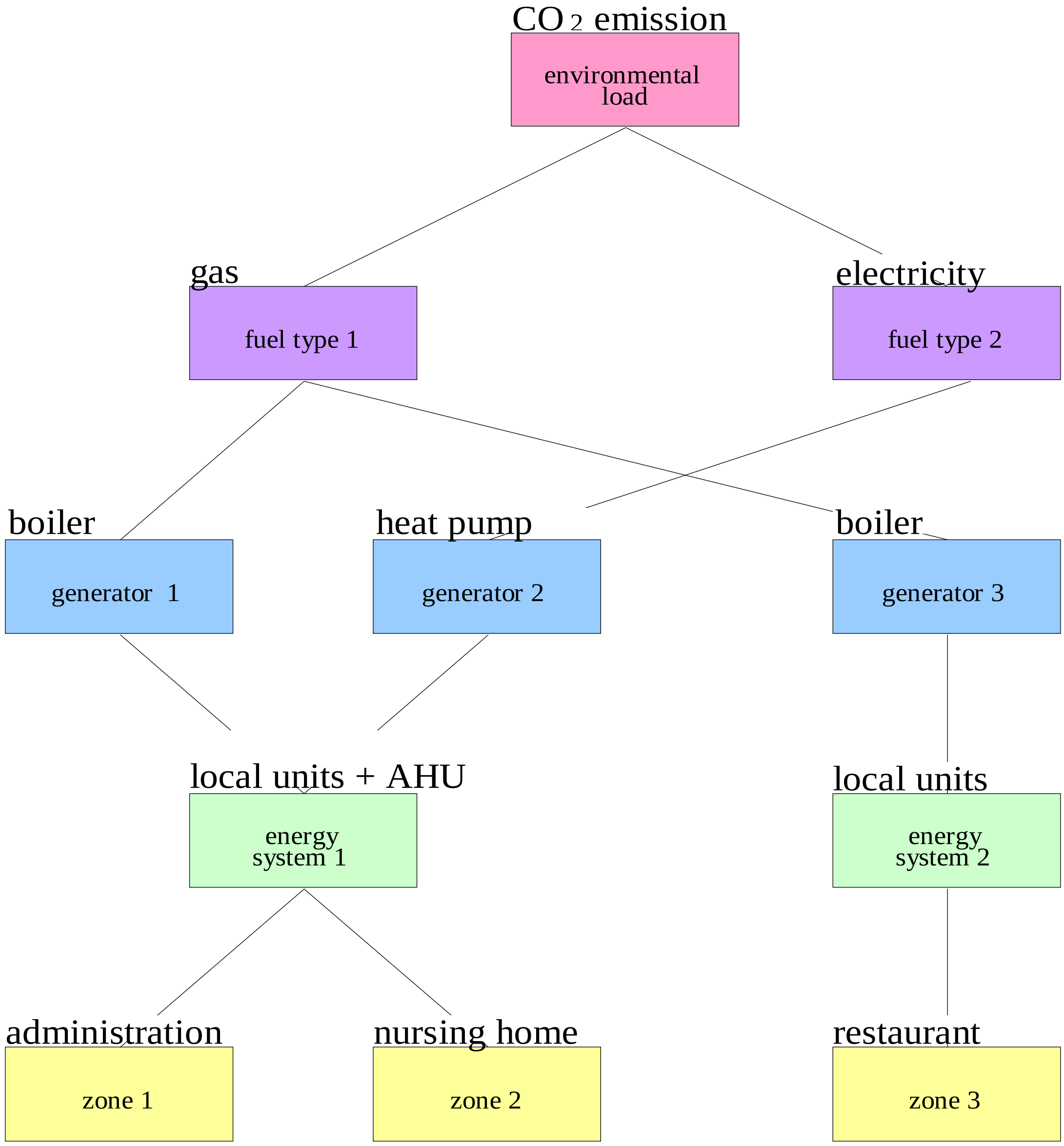
The monthly calculation method does not use full dynamic simulations to calculate the heating and cooling demand, but an approximation, based on the so-called utilisation factor. This factor determines to what extent heat gains are useful for the heating demand (during heating mode) and to what extent 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 $CO_2$ emission can be determined.






## 6.4 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.

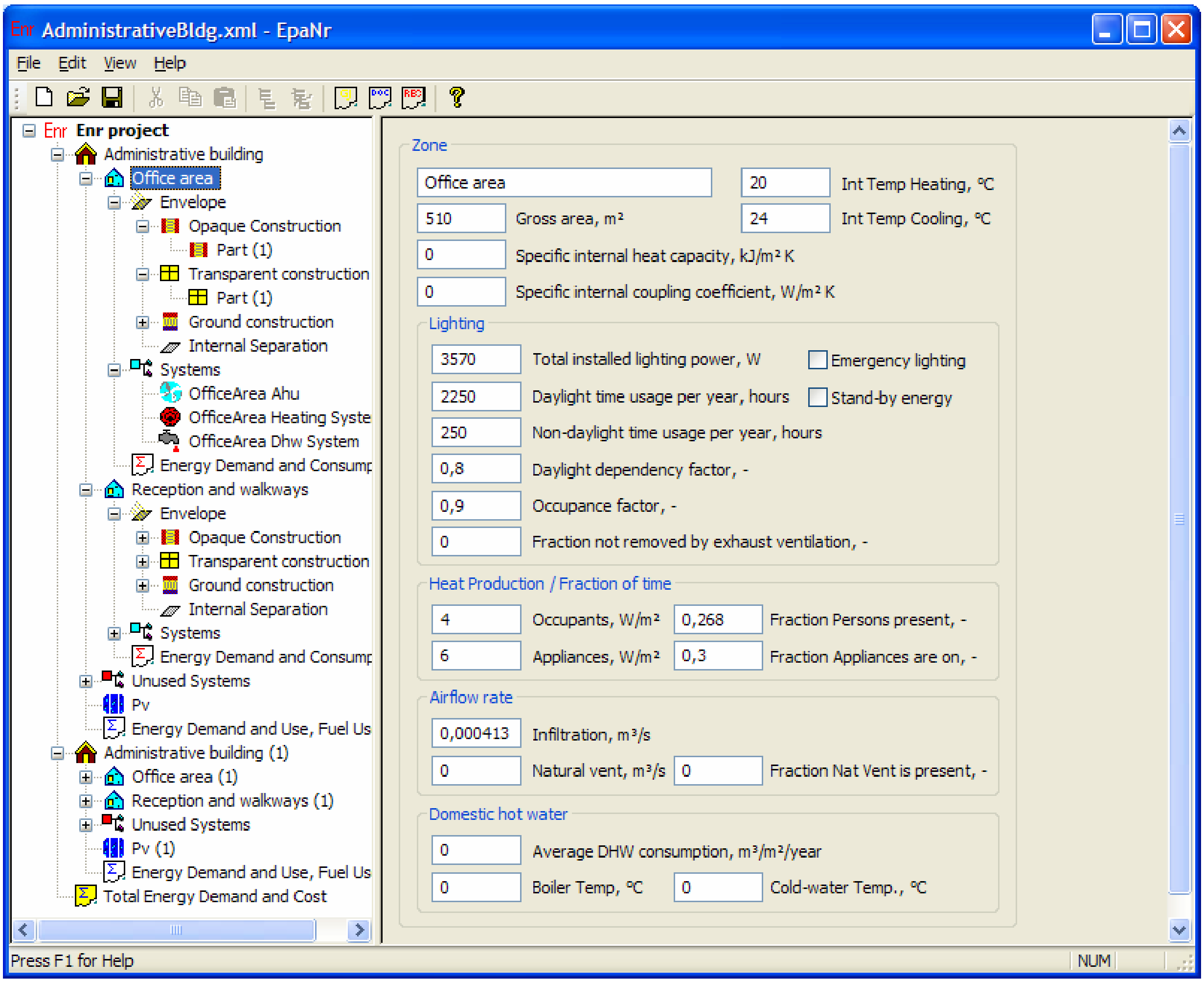
2. **Tailored calculations** for the purpose of detailed energy advice are typically client and location specific calculations not necessarily based on standard indoor and outdoor conditions. The software allows calculating the actual situation and additional advice variants and determining the pay-back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

**Overview of the user interface**
The **main screen** is divided into two parts:

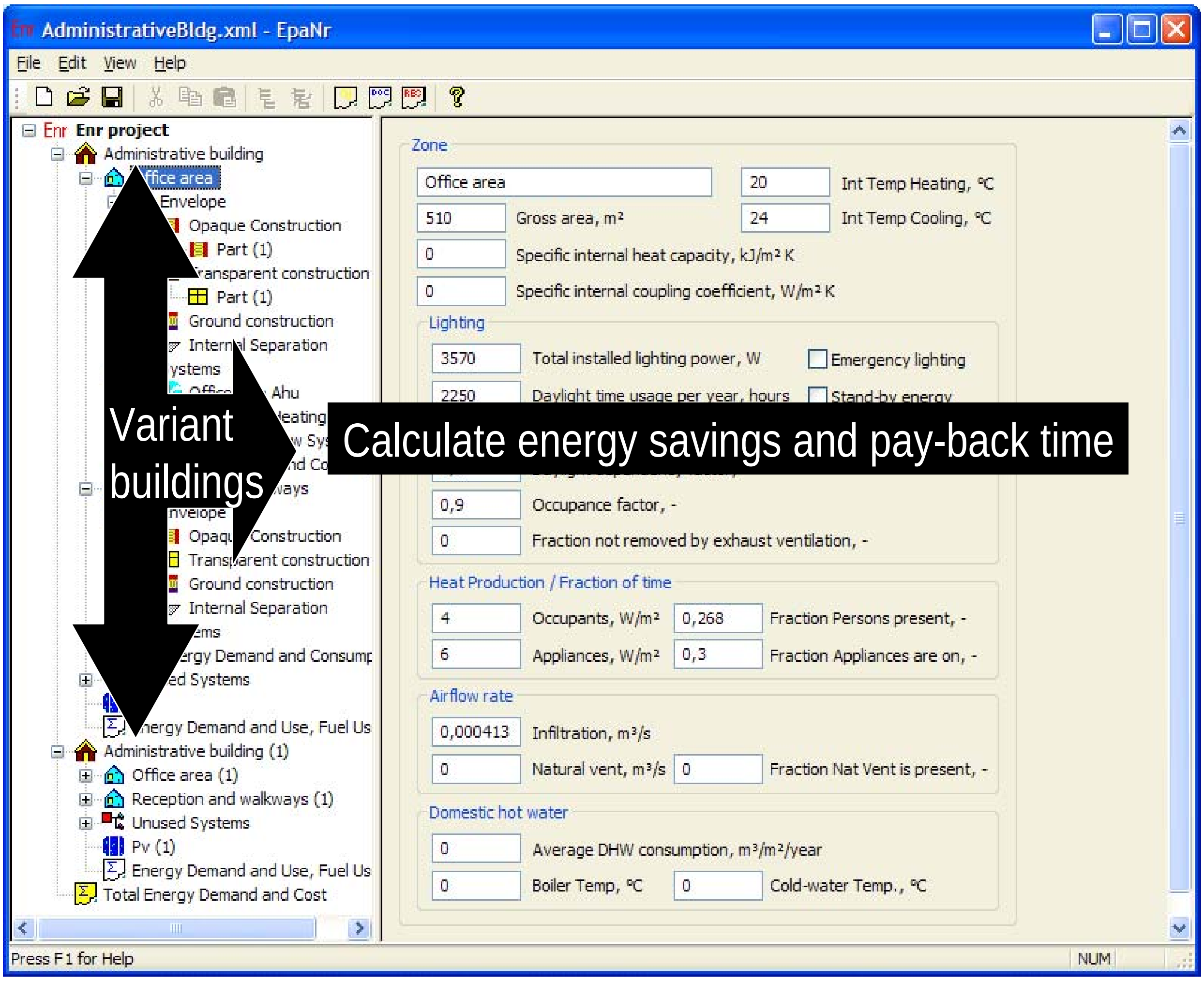
- On the left side of the screen: a building object tree showing the structure of all the input and output screens

- 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.

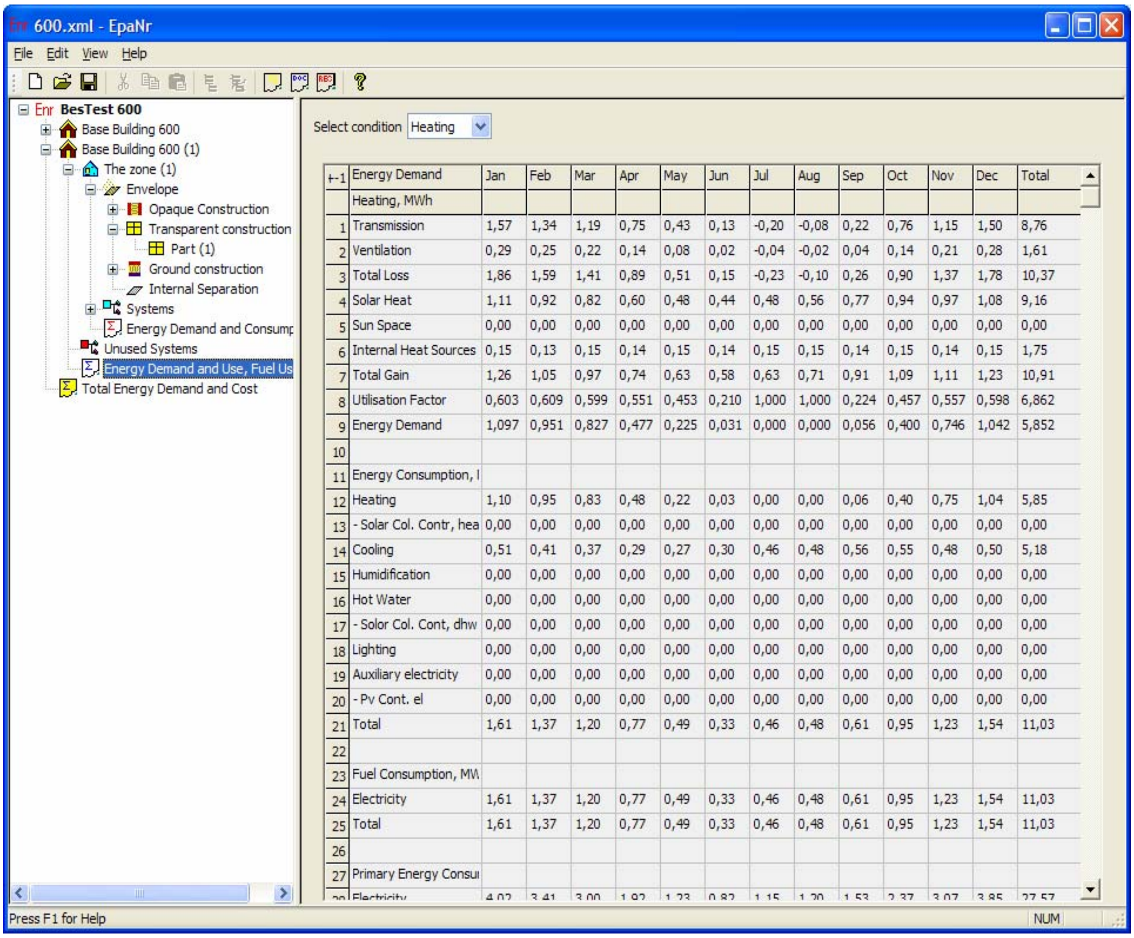



A **variant building can be created** in case of a tailored energy advice, by making a copy of the reference building in the same tree structure. This variant building can be modified by adding energy saving measures and connected investments. This can be seen in the following screen dump. When values 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.

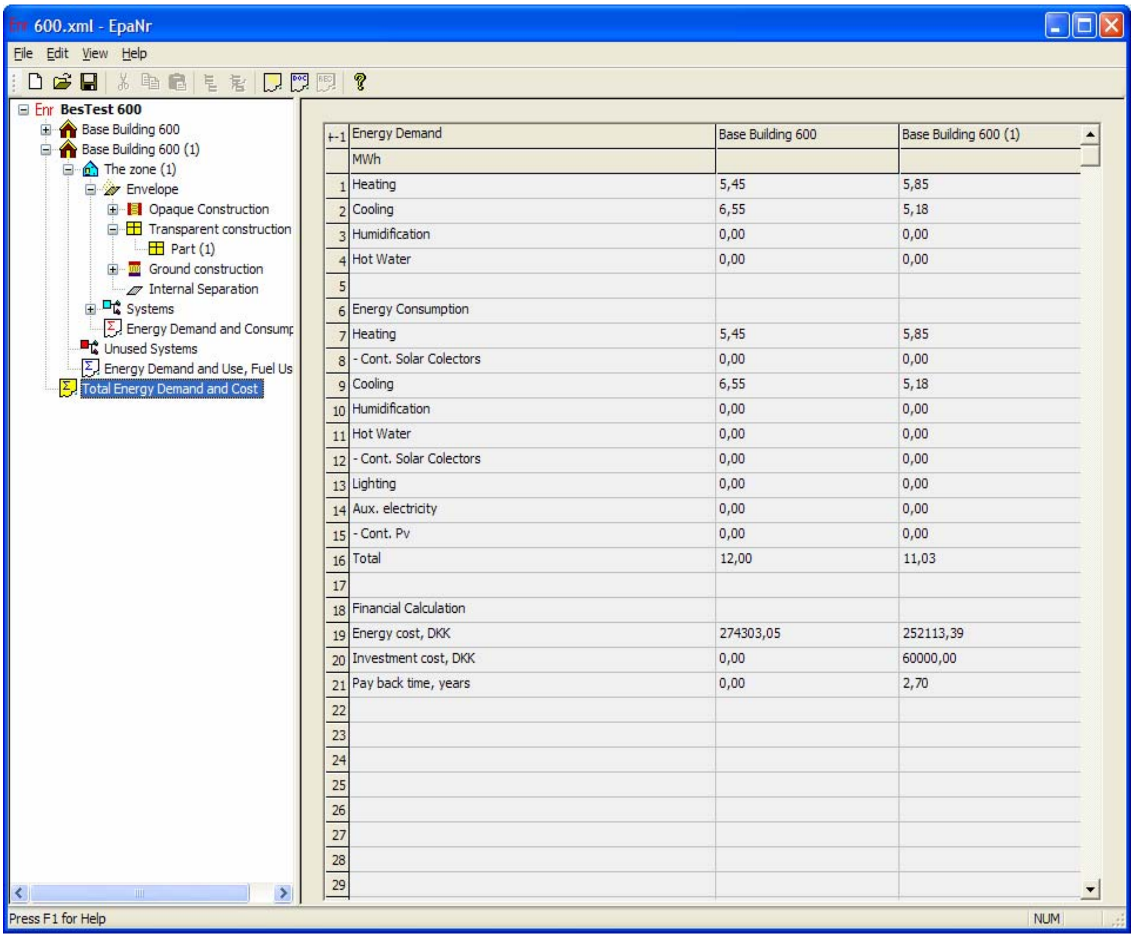



There are **two types of output screens** available in the software. One screen presents the calculation results in terms of heating demand and cooling demand, with a break down in energy flows and the overall energy consumption, fuel consumption, primary energy together with $CO_2$ emission. These values 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/m$^2$ or kWh/m$^2$ 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.




| +-1 | Energy Demand | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Heating, MWh | | | | | | | | | | | | | |
| 1 | Transmission | 1,57 | 1,34 | 1,19 | 0,75 | 0,43 | 0,13 | -0,20 | -0,08 | 0,22 | 0,76 | 1,15 | 1,50 | 8,76 |
| 2 | Ventilation | 0,29 | 0,25 | 0,22 | 0,14 | 0,08 | 0,02 | -0,04 | -0,02 | 0,04 | 0,14 | 0,21 | 0,28 | 1,61 |
| 3 | Total Loss | 1,86 | 1,59 | 1,41 | 0,89 | 0,51 | 0,15 | -0,23 | -0,10 | 0,26 | 0,90 | 1,37 | 1,78 | 10,37 |
| 4 | Solar Heat | 1,11 | 0,92 | 0,82 | 0,60 | 0,48 | 0,44 | 0,48 | 0,56 | 0,77 | 0,94 | 0,97 | 1,08 | 9,16 |
| 5 | Sun Space | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| 6 | Internal Heat Sources | 0,15 | 0,13 | 0,15 | 0,14 | 0,15 | 0,14 | 0,15 | 0,15 | 0,14 | 0,15 | 0,14 | 0,15 | 1,75 |
| 7 | Total Gain | 1,26 | 1,05 | 0,97 | 0,74 | 0,63 | 0,58 | 0,63 | 0,71 | 0,91 | 1,09 | 1,11 | 1,23 | 10,91 |
| 8 | Utilisation Factor | 0,603 | 0,609 | 0,599 | 0,551 | 0,453 | 0,210 | 1,000 | 1,000 | 0,224 | 0,457 | 0,557 | 0,598 | 6,862 |
| 9 | Energy Demand | 1,097 | 0,951 | 0,827 | 0,477 | 0,225 | 0,031 | 0,000 | 0,000 | 0,056 | 0,400 | 0,746 | 1,042 | 5,852 |
| 10 | | | | | | | | | | | | | | |
| 11 | Energy Consumption, I | | | | | | | | | | | | | |
| 12 | Heating | 1,10 | 0,95 | 0,83 | 0,48 | 0,22 | 0,03 | 0,00 | 0,00 | 0,06 | 0,40 | 0,75 | 1,04 | 5,85 |
| 13 | - Solar Col. Contr, hea | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| 14 | Cooling | 0,51 | 0,41 | 0,37 | 0,29 | 0,27 | 0,30 | 0,46 | 0,48 | 0,56 | 0,55 | 0,48 | 0,50 | 5,18 |
| 15 | Humidification | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| 16 | Hot Water | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| 17 | - Solor Col. Cont, dhw | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| 18 | Lighting | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| 19 | Auxiliary electricity | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| 20 | - Pv Cont. el | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| 21 | Total | 1,61 | 1,37 | 1,20 | 0,77 | 0,49 | 0,33 | 0,46 | 0,48 | 0,61 | 0,95 | 1,23 | 1,54 | 11,03 |
| 22 | | | | | | | | | | | | | | |
| 23 | Fuel Consumption, MW | | | | | | | | | | | | | |
| 24 | Electricity | 1,61 | 1,37 | 1,20 | 0,77 | 0,49 | 0,33 | 0,46 | 0,48 | 0,61 | 0,95 | 1,23 | 1,54 | 11,03 |
| 25 | Total | 1,61 | 1,37 | 1,20 | 0,77 | 0,49 | 0,33 | 0,46 | 0,48 | 0,61 | 0,95 | 1,23 | 1,54 | 11,03 |
| 26 | | | | | | | | | | | | | | |
| 27 | Primary Energy Consu | | | | | | | | | | | | | |
| 28 | Electricity | 4,02 | 3,41 | 3,00 | 1,92 | 1,23 | 0,82 | 1,15 | 1,20 | 1,53 | 2,37 | 3,07 | 3,85 | 27,57 |

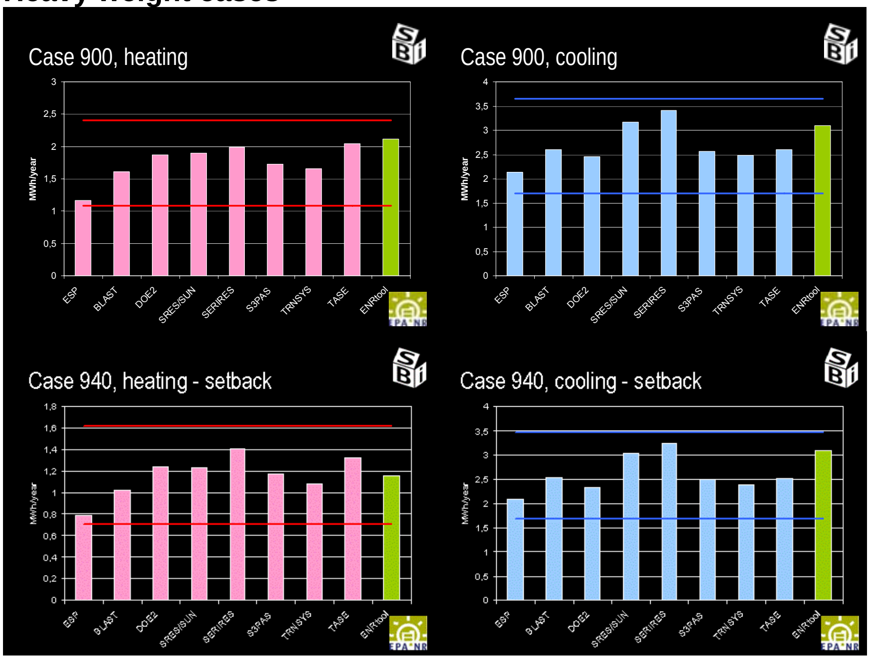



| +-1 | Energy Demand | Base Building 600 | Base Building 600 (1) |
|---|---|---|---|
| | MWh | | |
| 1 | Heating | 5,45 | 5,85 |
| 2 | Cooling | 6,55 | 5,18 |
| 3 | Humidification | 0,00 | 0,00 |
| 4 | Hot Water | 0,00 | 0,00 |
| 5 | | | |
| 6 | Energy Consumption | | |
| 7 | Heating | 5,45 | 5,85 |
| 8 | - Cont. Solar Colectors | 0,00 | 0,00 |
| 9 | Cooling | 6,55 | 5,18 |
| 10 | Humidification | 0,00 | 0,00 |
| 11 | Hot Water | 0,00 | 0,00 |
| 12 | - Cont. Solar Colectors | 0,00 | 0,00 |
| 13 | Lighting | 0,00 | 0,00 |
| 14 | Aux. electricity | 0,00 | 0,00 |
| 15 | - Cont. Pv | 0,00 | 0,00 |
| 16 | Total | 12,00 | 11,03 |
| 17 | | | |
| 18 | Financial Calculation | | |
| 19 | Energy cost, DKK | 274303,05 | 252113,39 |
| 20 | Investment cost, DKK | 0,00 | 60000,00 |
| 21 | Pay back time, years | 0,00 | 2,70 |
| 22 | | | |
| 23 | | | |
| 24 | | | |
| 25 | | | |
| 26 | | | |
| 27 | | | |
| 28 | | | |
| 29 | | | |

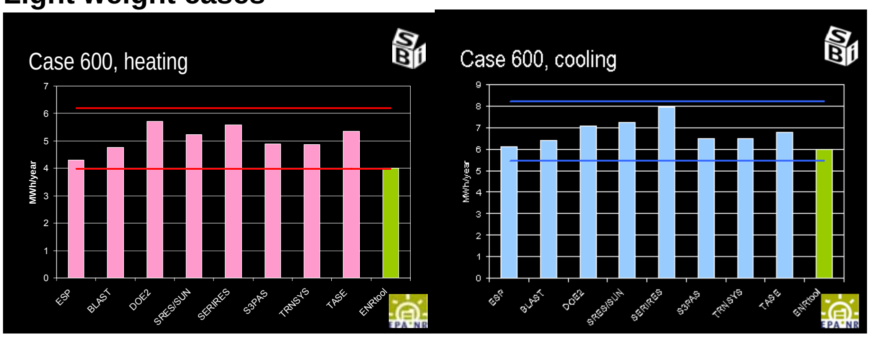
## 6.5 The EPA-NR software tested against the BesTest

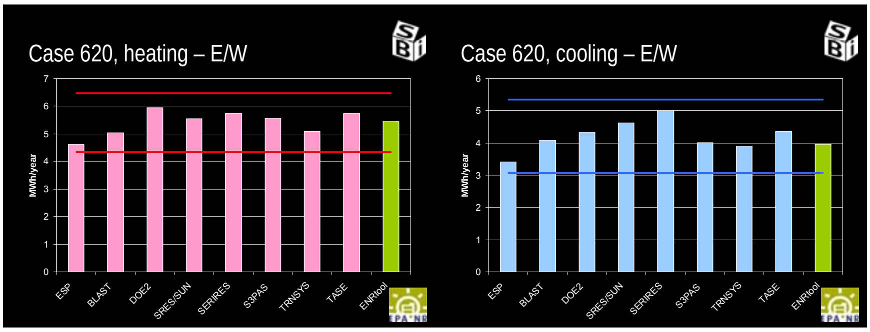
The software was tested on a number of relevant test cases of the Building Energy Simulation Test - BesTest. For a heavy weight case and a light weight case both the annual heating (red bars) and cooling demand (blue bars) was calculated and compared against the calculation results of a number of well 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. Case 900 is a simple building with south facing windows and an insulated heavy weight construction; the heating and cooling set points are constant in time. Case 940 is similar to case 900 except for the fact that during the night the set points for heating and cooling are set back.

### Heavy weight cases




### Light 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.

# 7 Added value of EP-certification

*This chapter relates to the report "Application strategies for the EPA-NR method", (see reference 9 in the EPA-NR Reference List).*

## 7.1 Integration of energy saving in building management

In the near future European and national policies will focus more on further improvement of the energy performance of the building stock. Consequently real estate management has to deal more intensely with the energy issue in the near future, embedding this issue in the usual decision making and execution processes. The introduction of the Energy Performance Certificate is the logical starting point.

Up till now energy saving measures are mostly considered in terms of investment and reduction of energy cost. Implementing energy saving measures is organised as an additional process that is experienced as a burden. This is a far too limited approach. In many cases energy saving has important non-energy benefits. Taking these into account substantially reduces the payback time of the measures. For instance: the necessity of improving comfort can often be achieved by applying energy saving measures. Another very profitable approach is to combine energy saving with maintenance and retrofitting activities. In this way energy saving fits into the ordinary real estate management processes. Apart from these very efficient ways of incorporating energy saving in the execution of maintenance activities, energy labelling is also advantageous on a strategic level. Managers of building stock portfolios can use aggregated labels in order to define their policy on the energy issue. Even on a municipal level policy can be formulated based on labelling schemes. In that case energy is not an added issue but incorporated in the daily processes.

Another advantage can be to combine data acquisition of buildings for energy analysis with other building data needs, thus creating a high quality data set of a building.
For example:

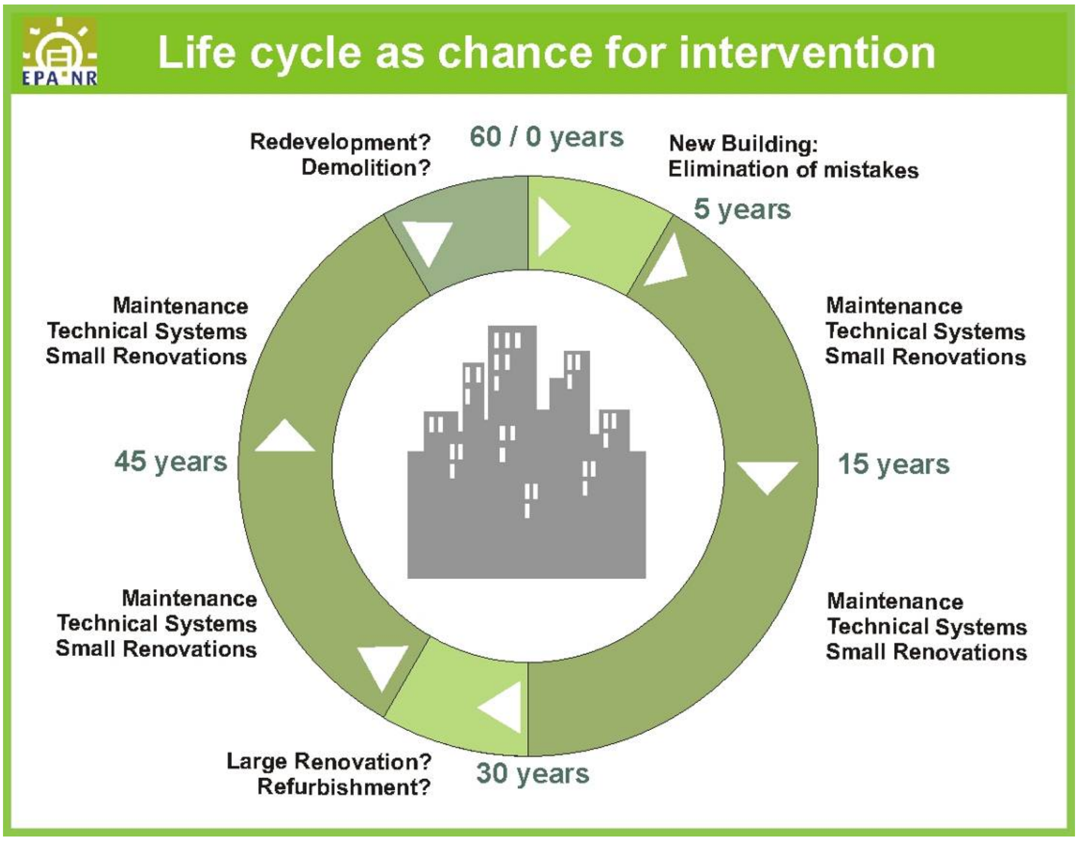
- Building inspection for energy purposes can easily be combined with other inspection activities thus resulting in an consistent data base against low extra cost (e.g. maintenance inspection, checking comfort issues, fire safety)
- Existing building data may provide input for the energy assessment and reduce the cost for the certificate
- Building data generated during the Energy Performance Assessment can provide a knowledge base for building management.

All these integrations of the energy issue in building management processes stimulate improvement of the energy performance. The consequence is that form and functionalities of the assessment method and its output should be flexible in order to meet the needs of the different actors. For instance, establishing the energy performance of a building stock is not a multiplication of the assessment process for a single building, but a completely different process. The EPA-NR instruments are set up in such a flexible way that they allow and facilitate these different approaches.

## 7.2 The life cycle of buildings as a chance for intervention

One of the most important issues for the realization of energy saving measures in existing non-residential buildings concerns the right time of the intervention. The life cycle of a building is divided into different periods; Regular maintenance, renovations and functional modifications through change of users are natural moments for implementation of energy saving measures.

Source: R. Lechner own illustration.




The building life cycle can be generalised in the following way:

1. **Development / construction period, 1st occupancy:** The (new) building is developed and built. This period is followed by the first occupancy by the building users. The technical systems and equipment have to be tested / balanced; potential problems, malfunctions and failures have to be eliminated, and their operation must be optimized in accordance to the design specifications. The length of this period depends on the building size, the complexity of the utilisation, and the complexity of the technical installations. In some cases, certain operational characteristics may take up to 5 years from the beginning of the development. Commissioning should also be considered. Commissioning is a process to verify that the owner has received what he contracted for during programming, and on through the construction and start-up phase and well into the first year of operation and in some cases up to 2 years after the certificate of occupancy has been issued. The quality of energy saving measures heavily depends on the testing and optimisation of the technical systems during the

first occupancy. In addition, any deviations from the design process and construction of the building have to be taken into account.

2. **1st Operation period:** After the optimisation period of the new building the first "normal" operation period starts. This period takes up to 30 years. During this time there is usually no need for larger renovations of the building envelope. Limited renovations and ongoing maintenance work offer possibilities for energy saving measures, in most cases for the optimisation of the technical systems of the building.

3. **Time of major renovation:** After 30 years the normal "half time" of the life cycle of a building is reached. The building owners have to decide on major renovations including the building envelope, windows & doors, and technical installations and systems. In some cases a full refurbishment is recommended: This may also include the reorganisation of the building and new kinds of usage. At this moment the life cycle of the building is extended by comparatively large investments by the building owner(s): Usually it is the best time for improvement of the energy quality / profile of the building.

4. **2nd Operation period:** After the major renovation the second operation period starts. This period also takes up to 30 years; small renovations and maintenance work on the technical systems are part of this period.

5. **End of normal life cycle:** After 60 years the normal life cycle of a building ends. The building owner has to decide on a second major renovation, which is often equal with a complete redevelopment of the building. In this case a 3rd operation period will extend the life cycle. The demolition of the building is an option for all cases of risk investment: If the required investments for maintaining a competitive building are too large, the demolition of the building will be followed by the development of a new building on the existing site.

The above presented cycles are extremely simplified: In practice the different periods can be shorter (and longer) and will interfere with each other (especially in the non-residential building sector). New and different building utilisations (also in different floors and parts of the building), and new technical solutions and needs will complete and influence the life cycle of the building.

It is clear that energy-saving measures are possible and can be sensible in all phases of the life cycle of a building. The different pilot projects of EPA-NR (see chapter 8) document this fact in a good manner.

## 7.3 EPA-NR and different stages of the life cycle of a building

As shown in 7.2 the life cycle of a building can be separated into different stages. A simple model of the life cycle includes three main stages:

- Construction / First occupancy,
- Operation / maintenance,
- Major renovation / new utilisations.

EPA-NR offers powerful tools for the calculation and assessment of the energy performance of non-residential buildings for the entire life cycle of the building. The tools are applicable beyond the scope of the Energy Performance Certificate. The EPA-NR products are developed for existing buildings. However, after the construction each new building is an existing building. So the EPA-NR method and tools can also be used for the analysis of new buildings.

The following aspects illustrate the potential of extended application of the EPA-NR tools:

- EPA-NR products are suitable for the initial documentation of the building and its technical systems, the execution of key values for the EPC, the documentation and assessment of different scenarios up to a comprehensive documentation of all technical systems.
- The EPA-NR products can support the decision making process regarding small renovations (for example: maintenance of technical system), large retrofits (for example: insulation of the thermal envelope) and also major renovations including new utilisation concepts for parts of the building or the entire building. During the development of the EPA-NR products 26 buildings with different utilisation typology and various years of construction (accordingly there are various stages along the life cycle) have been assessed. For all of these buildings the results of the assessment procedure were considered acceptable.
- Based on the requirements of the client, the consultant is able to decide on the application depth. Depending on the assessment focus the consultant presents simple calculation results (e.g. for the EPC) or comprehensive detailed information as part of the development of scenarios and in order to define a good grounds for building owners to base their decisions on
- Tailored energy advice as a follow-up activity after the Energy performance Assessment can be issued very efficiently. The existing building (technical systems, thermal envelope) and simple utilisation indicators (number of users, specific equipment) available from the EP-assessment can be used as a starting point for additional consultancy. The data has to be documented only once. A guideline for data acquisition and a special report for the EPA-NR inspection protocol include a lot of "little helpers" (methodology, key values, etc.) in order to reduce the expenditure of time.
- The consultant using the EPA-NR method and tools can easily assemble individual libraries for different kinds of interventions: improvement of the thermal envelope, improvement of different technical systems. Inside the software tool it is possible to define scenarios that can also indicate different interventions in the case of different stages of the life cycle.
- Data bases with characteristics of the clients building stock can be generated in a consistent way using the EPA-NR tools. Assurance of the quality of the building data can profit from a proper inspection protocol as a powerful tool.

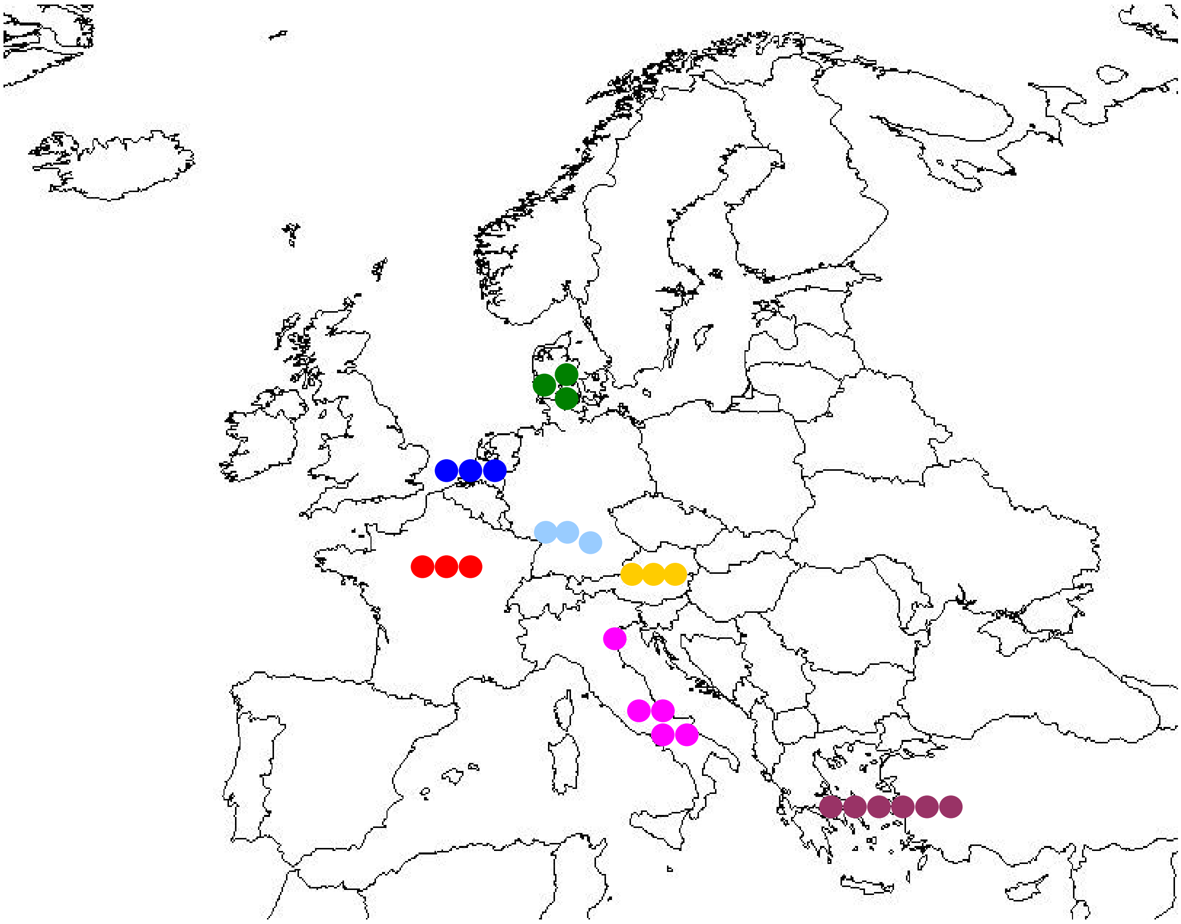
# 8 The EPA-NR method in practice

*This chapter relates to the report “Overall report on the pilot projects”,and to the “National reports on the pilot projects” and to the brochure “EPA-NR pilot projects” (see reference 10, 11-33 and 36 in the EPA-NR Reference List).*

## 8.1 An overview of the pilot projects

The ultimate test of a method is the actual application in practice. To create feedback from practitioners the EPA-NR method and tools have been tested in a total of twenty six pilot projects in seven different European countries (Austria, Denmark, France, Germany, Greece, Italy and The Netherlands).

**The pilot projects per country**



The pilot projects are real buildings on which the EPA-NR method has been tested. In every country at least three pilot projects for non-residential buildings have been carried out:

- One pilot project for the educational sector;
- One pilot project for the office sector;
- One pilot project for the health care sector.

In addition two pilot projects where carried out for two other kinds of buildings: a hotel and a library. The pilot projects represent a large variety of buildings in terms of use, size, age, architectural complexity, construction and installation (heating, ventilation and air conditioning systems), building management and the building owners' needs (energy performance improvements).

The pilot studies serve a number of goals:

- First of all the results of the pilot studies were used for the improvement of the EPA-NR method since the evaluation procedure was linked to the performance of the pilot studies;
- A second purpose was the assessment of the buildings and the creation of a useful Energy Performance Advice for the owners of the buildings;
- The last purpose is the demonstration of the EPA-NR method and tools to the target groups for the method.

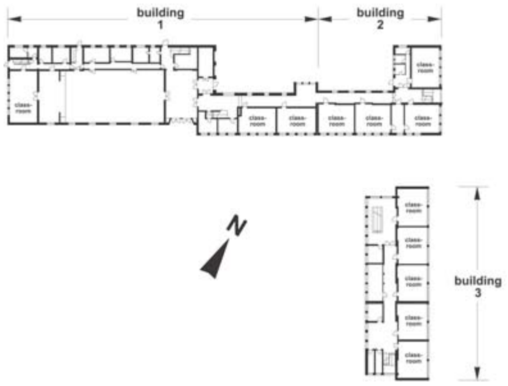
All the projects are listed in the table below.

| | **Country** | **Place** | **Year of construction** | **Health care building** | **Office building** | **School** | **Other building type** |
|---|---|---|---|---|---|---|---|
| **1** | Italy | Rome | 1900 | | | | Library |
| **2** | Italy | Rome | 1990 | | • | | |
| **3** | Netherlands | Amsterdam | 1990 | | • | | |
| **4** | Denmark | Gladsaxe | 1952/1962 | | • | | |
| **5** | Germany | Munich | 2003 | | • | | |
| **6** | France | Champs sur Marne | 1947 | | • | | |
| **7** | Austria | Vienna | 2005 | | • | | |
| **8** | Greece | Athens | 2000 | | • | | |
| **9** | Italy | Vicenza | early 20th century | • | | | |
| **10** | Netherlands | Apeldoorn | 1974 | • | | | |
| **11** | Austria | Neulengbach | 1920 | • | | | |
| **12** | Greece | Athens | 1974/1982 | • | | | |
| **13** | Germany | Stuttgart | 1965 | • | | | |
| **14** | Denmark | Gladsaxe | 1977 | • | | | |
| **15** | France | Lagny sur Marne | 1963/2003 | • | | | |
| **16** | Italy | Fiuggi | 1970/2000 | | | | Hotel |
| **17** | Italy | Fiuggi | 1932 | | | • | |
| **18** | Netherlands | Amsterdam | 1984/2002 | | | • | |
| **19** | Austria | Wieselburg | 2002 | | | • | |
| **20** | Greece | Athens | 1996 | | | • | |
| **21** | Greece | Athens | 1995 | | | • | |
| **22** | Greece | Athens | 1997/2004 | | | • | |
| **23** | Greece | Athens | 1970/1976/1989 | | | • | |
| **24** | Denmark | Gladsaxe | 1950-52 | | | • | |
| **25** | Germany | Stuttgart-Plieningen | 1936/1957/1970 | | | • | |
| **26** | France | Champs sur Marne | 1995 | | | • | |

## 8.2 The execution of the pilot projects

The assessment process of the energy performance of a building within the EPA-NR pilot studies follows the typical process stages mentioned in chapter 5 and the consultants performing the pilots applied the matching EPA-NR tools defined in the method:

- First an intake interview with the client takes place to create a clear starting point for the assessment process. For this stage the EPA-NR tool '**Checklist for an intake interview**' has been developed;




- The second stage is the inspection of the building. This is an important step in the data collection for the calculation of the energy performance of the building. For this stage the EPA-NR tool '**Inspection Protocol'** has been developed;

- The next stage is the calculation of the actual energy performance of the building using **EPA-NR software**. The EPA-NR software is a tool based on the EPA-NR calculation method developed within the project;
- One of the final stages in the assessment process is the suggestion of energy saving measures based on the calculation results and the observations during the inspection of the building. In this stage the impact of the proposed energy saving measures is also calculated using the EPA-NR software. Eventually the most appropriate scenario is suggested;
- The last stage is the compilation of a report to the client.

All pilot projects are reported in National reports (ref 11 to 22). A compilation of all projects is given in the "Overall report on the pilot projects" (ref 10) and a brochure "Pilot projects" (ref 25).

## 8.3 Examples of the pilot projects

### Library and office building — Rome, Italy

| Scenarios | Proposed measures | Simple pay-back time |
|---|---|---|
| Solar DHW system | √ | 6.8 |
| New lamps | √ | 0.5 |
| Insulation | √ | 11.3 |
| PV system | √ | -- |
| All | √ | 8.2 |

All measures are recommended.
PV mainly because of improving sustainable image of the city.

The building was constructed in the early 20 th century (1900) and refurbished in 2005. It is a relatively small building with a gross floor area of 810 $m^2$.

The thick stone walls are uninsulated, the window frames have no thermal breaks and are double glazed.

Condensing boilers are taking care of central space heating and domestic hot water. Ventilation is provided by air handling units equipped with a chiller and fan coil units with heat recovery.

There was no data available on energy use, therefore the calculated values were used as the basis for the advice.

Additional considerations
The building was extensively renovated in 2005. Nevertheless an improvement of the energy performance of the building is within reach (pay back time of 8.2 years) reducing the energy consumption by a third.

### Office building — Amsterdam, Netherlands


| Scenarios | Proposed measures | Simple pay-back time |
|---|---|---|
| HF lighting and daylight control | √ | 7.4 |
| PV system | | 48 |

The building, with a gross floor area of 2,250 $m^2$, was constructed in 1990, fully according to the Dutch building- and energy standards at that time. The windows are double glazed with sun reflective coating.

Central heating is provided by condensing gas boilers; preheating of ventilation air by air handling units. The office building is equipped with 2 top cooling units

Small electric boilers were installed for domestic hot water supply.

Additional considerations
Since the office building is relatively new and insulated afterwards the energy performance of the building is quite acceptable. Therefore only a few measures were considered.
Nevertheless the client was interested to experience an energy audit and gain information about the performance of his building.

## Educational building — Gladsaxe, Denmark

| Scenario's | Proposed measures | Simple pay-back time |
|---|---|---|
| Decrease the DHW circulation temperature | √ | - |
| Upgrade the roof insulation | √ | 6 |
| Partly replacement of windows and entrance doors | √ | 9 |

The Gladsaxe School building in Denmark was constructed during the early 50's (1950-1952). The facades are hollow core masonry with insulation. The windows are partly double pane thermo windows, partly low energy glass.

Heating through local district heating plant running on natural gas. There are two boilers, a new condensing one and an old traditional one. Mostly natural ventilation, partly mechanical ventilation.
The total gross floor area is 12,995 $m^2$.

Additional considerations
Apart from adjusting the set point temperature for DHW and increasing the insulation level of parts of the envelop being very profitable, even the less profitable measures of replacement of windows and leaky entrance doors in the gymnasium is recommended. The payback time of 9 years is considered to be acceptable due to the positive effect on thermal comfort.

## Educational building — Champs sur Marne, France

| Scenarios | Proposed measures | Simple pay-back time |
|---|---|---|
| Solar film on glazing | √ | - |
| Reduction of indoor temperature at night times | √ | 0 |

This educational building is a five floor building of the University of Paris. It is a building with approximately 15.000 $m^2$ gross floor area with spaces for educational activities (classrooms, halls and laboratories) and back office activities. The building was constructed in 1995 and is completely glazed on all facades and including the roof. There are no efficient shading devices. Therefore the indoor temperature in the summer time is too high and rather uncomfortable. During winter time the indoor climate is also uncomfortable due to the effect of the cold facades, which makes the indoor temperature not homogenous.

There is a collective gas boiler for heating. Cooling is only available in the laboratories, through a heat pump. There is mechanical ventilation and fluorescent lighting.

No documentation about actual energy use was available; therefore some data have been estimated to be able to calculate the energy performance. The primary energy use is calculated on 220 KWh/$m^2$/year with a $CO_2$ emission equivalent of 35,6 kg/$m^2$/year.

Additional considerations
This relatively new building suffers from overheating during summer and discomfort in winter due to the large glazing areas in the facade and the roof. These problems have been taken into account during the audit. However the EPA-NR software is not designed to perform comfort simulations. Therefore additional analyses are needed.

## Office building

## Vienna, Austria

| Scenarios | Proposed measures | Simple pay-back time |
|---|---|---|
| Improvement of building envelope | | 41.5 |
| Heat pump for heating and cooling | √ | - |
| Improvement of HVAC system | | - |

The building was recently constructed in 2005 and has a gross floor area of 9,236 m$^2$.

The building envelope consists of partly concrete walls with external insulation.
The building has a relatively large surface of glazing, which consists of a double glazed facade.

The office building is equipped with a gas central heating and balanced air ventilation with heat recovery. Central cooling is provided through fan coil units.

Additional considerations
In this new building there are some problems with the indoor air quality. The air humidity is too low. During the energy audit solutions for improvement were defined by means of energy saving measures regarding the HVAC system. In that way the indoor air quality problems proved to be a stimulus to propose additional energy saving measures even in this new building.

## Educational building

## Athens, Greece

| Scenarios | Proposed measures | Simple pay-back time |
|---|---|---|
| Improvement of facade insulation | | 44.4 |
| Improvement of roof insulation | | 124 |
| Double glazing | | 63 |
| Double, low-E glazing | | 58 |
| Gas boiler | √ | 0.6 |
| Insulation of heat distribution pipes | √ | 1.7 |
| Solar DHW | √ | 7.1 |

This educational site in Athens has several school buildings. The total gross floor area is 2,709 m$^2$.
Only one is thermally insulated. The buildings were constructed in 1970, 1976 and 1989 and built up with brick walls and concrete roofs with thermal insulation. The windows are single glazed.

Oil fired boilers were installed for central heating. Domestic hot water is provided by electric boilers. The indoor air quality is regulated through natural ventilation.

Additional considerations
Regarding this refurbished school building no special considerations were relevant in addition to the energy audit and advice.

## Health care building — Stuttgart, Germany

| Scenarios | Proposed measures | Simple pay-back time |
|---|---|---|
| Retrofit measures:<br>• Partly exterior insulation<br>• New high performance lightweight façade<br>• Triple pane low-e coated glazing<br>• New insulation of the roof<br>• Insulation of cellar ceiling<br>• Controlled exhaust ventilation<br>• Daylight controlled lighting<br>• Low temperature heating<br>• CHP system | √ | 20 |

This health care building in Stuttgart was constructed in 1965. It has a gross floor area of 9,647 $m^2$.

The facade is built with concrete panels, the facades on the balconies sides are constructed with wooden panels. The windows have wooden frames and are double glazed.
The roof is poorly insulated with a cork layer.
The ventilation is an exhaust ventilation system in the core of the building.

A renovation is planned because some aspects of the building do not meet the needs of the users anymore. A retrofit concept has been developed for this building (the project participates in the EnSan retrofit program of the German ministry of economics).

Additional considerations
The client was motivated to have an energy audit because of the high energy consumption and the planned restructuring of the room concept. The patient rooms needed also a modernisation which includes the integration of bathrooms. A complete retrofit concept was developed incorporating the improvement of the energy performance of the building. Stimulated by the federal retrofit programme EnSan the client decided to realise the concept accepting a payback time of twenty years also because the city wanted to have a high-level energy efficient retrofit project as a shining example in its building stock.

## 8.4 Experiences from the pilot projects

There were different reasons for building owners and managers to participate in an EPA-NR pilot study. The certification obligation for the EPBD often plays a role in this decision because within the pilot study some experience can be gained with the certification process. Another major factor in favor of deciding for a building audit is a refurbishment planned for the near future. The results of the pilot study can then be used as input for the renovation activities. A high energy use, comfort problems or problems with insulation and ventilation in a building also often contribute to the decision for a building assessment. In some cases the building had specific characteristics that made it suitable as an example building for a larger group of buildings in a certain country, which made the building interesting for assessment.

| | Country | Example building/ relevant architecture | EPBD certification | Quality of installations | Comfort problems | Insulation/ ventilation problems | Input for (possible) renovation | High energy use (on aspects) | Seasonal use of building |
|---|---|---|---|---|---|---|---|---|---|
| **1** | Italy | • | | | | | | | |
| **2** | Italy | • | | | | | | | |
| **3** | Netherlands | | | | • | | | | |
| **4** | Denmark | | | • | • | • | | | |
| **5** | Germany | | • | | | | | | |
| **6** | France | | • | | | | | | |
| **7** | Austria | | | | • | | | | |
| **8** | Greece | | • | | | | | | |
| **9** | Italy | • | | | | • | • | | |
| **10** | Netherlands | | • | | • | | | | |
| **11** | Austria | | | | | | • | | |
| **12** | Greece | | • | | | | | | |
| **13** | Germany | • | | | | • | • | • | |
| **14** | Denmark | | | | | | • | | |
| **15** | France | | • | | | | | | |
| **16** | Italy | | | | | | | | • |
| **17** | Italy | • | | | | • | • | | |
| **18** | Netherlands | | • | | | | | | |
| **19** | Austria | | • | | | | | • | |
| **20** | Greece | | • | | | | | | |
| **21** | Greece | | | | • | | | | |
| **22** | Greece | | | | | | • | | |
| **23** | Greece | | | | | | • | | |
| **24** | Denmark | | | | | | • | | |
| **25** | Germany | • | | • | | | • | • | |
| **26** | France | | | | • | | | • | |

# 9 Conclusions from practice

The EPA-NR method and the accompanying tools were submitted to a test of the physics of the software and the applicability in practice. Based on the outcome the method and the tools were improved at different stages of testing and application in the pilot projects. The final versions of the method and tools take into account all the lessons learnt.

From the pilot projects and the testing of the software the following conclusions were drawn:

- The EPA–NR method was successfully applied to several pilot projects which present a wide variety of buildings.
- The method was applicable in a diversity of climates from the southern part of Europe to the northern countries.
- The pilot study shows that the EPA-NR method is an effective and reliable assessment approach to establish the Energy Performance of non residential buildings with Energy Performance Advice to building owners.
- The method is in line with EPBD and could be used for energy certificates.
- The structure of the EPA-NR process with the identified stages combined with corresponding tools facilitates and guides the consultant. Each step of the process is important and the developed tools were considered helpful.
- The acquisition of building data to generate the input for the software is the most crucial factor for the EPA-NR method's accuracy and reliability; it's also a rather time consuming task. This step of the process requires skilled consultants. An Inspection Protocol is therefore an important tool.
- The pilot projects showed ones again that the energy consumption is strongly depending on the users' behaviour and building's management. The EPA-NR method is able to calculate Energy Performance under standard conditions and under user specific conditions. The actual energy use can be related to the energy performance of the building, revealing the influence of the user and the actual performance of the building. Consequently it's a useful tool at the beginning of a refurbishment process as different energy saving measures can be easily assessed.
- The EPA-NR method is a good way to estimate the impact of energy saving measures due to renovation of buildings components, buildings management or user behaviour.
- In some pilot projects there was only little documentation on the building characteristics or data on the actual energy use of the building. This affected the assessment and calculation process. More focus was directed to building inspection. The lack of actual energy consumption data made it difficult to determine the payback time for the suggested energy saving measures based on the actual use of the building. In that case the payback time was based on standard user conditions, instead of user specific conditions.
- In some pilot projects a refurbishment had already been planned. Using the EPA-NR method provided the opportunity to include the suggested energy saving measures in the refurbishment. This reduces the payback time for the energy saving measures because integrating the measures in a larger refurbishment is less costly.

Concerning the EPA-NR software the conclusion from the tests regarding annual heating and cooling energy demand is that:

- The results of the EPA-NR software are within the acceptable deviation in all tested cases of the BesTest
- The EPA-NR software proved to provide acceptable accuracy, comparable with the dynamic models used in the BesTest.

**OVERALL CONCLUSIONS**

- The EPA-NR method and the accompanying tools offer a practical, high quality Energy Performance Assessment for existing Non Residential buildings applicable in all European Member States.
- The method also has the potential to be used in relation with other consultancy fields (e.g. maintenance, renovation, comfort). This provides extra market opportunities for consultants and additional value for the clients, especially if the energy performance becomes part of building management processes.

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