Danish EPA-NR pilot studies

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Overall report on the pilot projects

Final report, June 2007

Energy Performance Assessment
of Existing Non-Residential Buildings

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Intelligent Energy Europe

Overall report on pilot projects

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EC Contract
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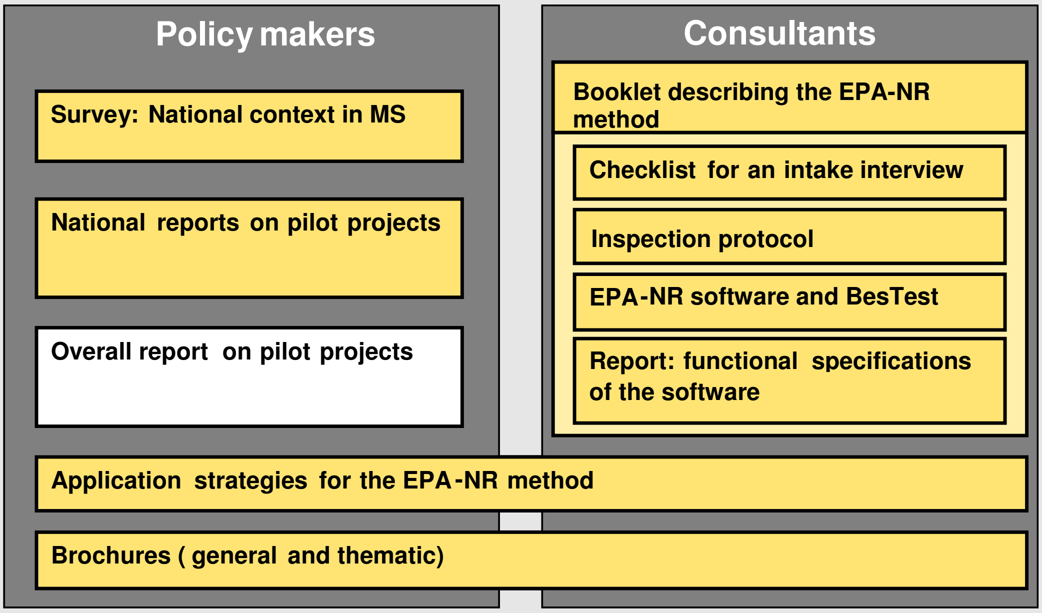
Overview of EPA-NR products

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.

The report you are about to read is highlighted in the above scheme.

Contents

Introduction

This is the pilot projects report performed in the frame of the EPA-NR project.
Each partner involved in the EPA-NR project has performed at least three pilot projects for non residential buildings:

- One pilot project for the educational buildings sector
- One pilot project for the offices buildings sector
- One pilot project for the health care buildings sector

Additional pilot projects where performed for other type of buildings: a hotel and a library

Pilot projects are real buildings at which the EPA-NR method was applied

A total of 26 pilot projects have been performed. They present a very big variety of buildings at first by the type of the building sector but also within the same sector in term of size, age, architectural complexity, types of heating, ventilation and air conditioning systems, type of building management and finally type of the building owner needs in terms of energy performance improvements.

For every pilot project, a detailed report is available. It contains the results of the application of the EPA-NR method to this project. In particular, in this 'national report' [1], a detailed description of the building is given and all the elements stemming from various stages of the process of evaluation of the energy performance of the building according to the method EPA NR are summarised.

These different stages are:

- Intake interview with the client who could be the owner of the building or any other person that represents him. The goal of this step is to create a clear starting point for the assessment process for the client as well as the consultant.

  For this stage, a tool has been developed within the EPA-NR method; it's a report on 'checklist for an intake interview' [2]. This checklist is meant to structure the intake interview and to give guidance on the issues that are relevant to discuss and for collecting the necessary data.

- Inspection of the building. In this stage the person in charge of the application of EPA-NR method visits the building, collects relevant information of the building and it's use as well as all necessary data for the calculation of energy performance using EPA-NR software, and raises important elements to allow proposal of energy saving measures.

  For this stage, a tool has been developed within EPA-NR method, it's a report on 'inspection protocol '[3] that gives guidance for the data acquisition during the building inspection including an inspection checklist and national and international tips

- Calculation of actual energy performance of the building using EPA-NR software.

  EPA-NR software [4] is a tool developed within EPA-NR method and based on EPA-NR calculation method developed within the project [5].

- Proposal of energy savings measures based on calculations results and also on the observation during the visit.

- Calculation of the impact of these energy saving measures using EPA-NR software and suggestion of the most appropriate scenario.

- Report to the client.

It is important to note that this report does not present for every pilot project the detailed results of building diagnosis and energy demand calculation using EPA-NR method. This report aims to give the whole overview on the application of EPA-NR method. Twenty six (26) national reports [1] are available, each of them is related to one pilot project.

1.1 Goal of pilot study

The goals of the pilot study are:

- Improvement of EPA-NR method: The application of EPA-NR to pilot projects is the best way to evaluate the method and to improve it according comments and suggestions from partners.
- Assessment of Energy Performance of the building and creating an useful Energy Performance Advice for the owner of the building.
- Demonstration of the EPA-NR method and tools suitable for the target audience

For the first objective, an evaluation procedure was defined and a questionnaire was performed. The analysis of all the questionnaire answers was the basis of the evaluation of EPA-NR method and the recommendations of modifications.

The pilot study started as soon as the first versions of the tools were developed. Previously the choice of the pilot projects was made in a way that allows to cover a wide variety of buildings with different specifications to ensure the possible application of the method to all existing non residential buildings.

During this phase the developed tools were tested. Analysis of the answers to the questionnaires was made at different stages and during the project meetings, questions, comments and suggestions were addressed. This analysis concerns all the steps of the EPA-NR method.

Slight modifications were then introduced on the intake interview report and inspection report. The main improvement of the EPA-NR after the first use to the pilot projects concerns the software. The final EPA-NR method and tools takes into account lessons learnt from pilot projects.

The results about energy performance of buildings and impact on energy saving measures reported on national reports are those performed with the latest version of the software.

National reports [1] allow demonstrating the application of the EPA-NR method. They constitute important justifications of the objectives fixed by the pilot study.

1.2 Structure of the report

The detailed results of pilot projects are put on separate documents called ‘national report’ [1] , one report by country and by pilot project.

The national report includes the following main chapters:

- Project summary: short description of the building characteristics
- Audit of the building: The results of building diagnosis including a description of actual situation of the building and energy demand calculation using EPA-NR software. This part of the report include the elements that come from the intake interview with the client, the inspection of the building and the use of EPA-NR software, in particular the description of building characteristics and the calculation results of EPA-NR software are presented in detail
- Energy saving measures: Description of a set of energy saving measures and calculation of the impact of each measure on energy consumption saving, CO_2 emission reduction, the investments and payback time. The most appropriate scenario as an advice to the owner is then described

This actual report aims to give an overview of the experience from the pilot projects on the process of assessment of energy performance for existing non residential buildings using EPA-NR method. It is divided into various parts:

- Overview of pilot projects: presentation of all pilot projects with general information about the chosen buildings in terms of size, age, quality of envelope insulation and type of HVAC systems
- Audits of pilot projects: This part gives significant information issues from the experimentation of the two first steps of EPA-NR energy performance assessment process: the intake interview and the inspection of the building
- Calculation of energy performance: This part gives the main important information issues from the experimentation of the step of calculation of energy performance
- Energy saving measures: this part gives a whole idea on items proposed for energy saving measures and the calculation of their impact
- Summarised results for some pilot projects: in this part, a synthetic results of 26 pilot projects are given
- Conclusion
- References

Overview of pilot projects

1.3 Introduction

Each of the partners involved in the project launched investigations to find real buildings for the application of the EPA-NR method.

In certain cases, this task wasn't easy because it was necessary to convince building owners and to find arrangement for visiting the buildings and getting data.

In general, the building's owners are interested in an energy performance assessment of their building. Those which were sought and which refused were still interested in the EPA-NR method. They refused because lack of time or because it needs an organisation especially in the step of inspection of the building and collection of necessary data.

Finally each partner succeeded to select the three pilot projects expected for the study

Greece performed 4 pilot projects on educational buildings sector instead one pilot project.

Italy performed two additional pilot projects: a hotel and a library.

A total of 26 pilots were performed, including ten educational buildings, seven offices buildings, seven health care buildings, one hotel and one library in the seven countries of the project partners: Austria, Denmark, France, Germany, Greece, Italy and the Netherlands,. Thus the EPA-NR method and tools was applied to several non residential buildings with specific characteristics.

The application of EPA-NR to pilot projects was done by personnel that is familiar with energy buildings audits and energy consumption calculations using software but not involved in the developments within EPA-NR project. In this way, the developed tools were impartially tested.

In addition, observer countries were also invited to participate with pilot projects. Two options were then offered: the application of the whole method or the application of the software only.

Poland has applied the EPA-NR software and made sensitivity studies.

1.4 General information about the pilot projects

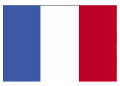
The pilot projects selected present a big variety of buildings with a wide scale of sizes, ages and complexity.

The performance of buildings envelopes as regards the insulation of the opaque walls, roofs, grounds and the window is very variable. All the scenarios are represented from non insulated envelopes with simple glazed windows to very well insulated envelopes with high performance windows. On the other hand for the same project coexist often various parts with different characteristics. The variety is as well in the fact that thermal characteristics of components are more or less known according to the age of construction. These elements are very interesting to test the method in very diverse conditions.

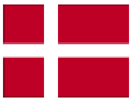
At heating, ventilation and air conditioning systems, different kind of systems were tested as the pilot projects present a big variety of them, so the method EPA-NR and more particularly the EPA-NR calculation method and EPA-NR software were tested for various types of systems. Other types of systems than those described in the following were also tested in the field of energy saving measures as for example the photovoltaic cells.

General information about all pilot projects are given in the following:

- # Educational sector

Location And general information	Photo
 **Amsterdam/The Nederlands** Gross area: 8040 m² Year of construction: 1984 + extension in 2002	 **Building envelope** : Façades of original part poorly insulated/ the new extended part is insulated according to the year 2002 Dutch building standards/the roof is refurbished and insulated in 2004/ windows are simple glazed. **Heating/cooling**: Gas-fired high efficiency (condensing) heating system with radiators/ the auditorium is provided with a floor heating system/preheating ventilation air. **Ventilation:** Air handling unit in multimedia room and auditorium/exhaust ventilation in toilet groups/rest of building naturally ventilated. **Lighting**: Conventional fluorescent tube lighting. **Specific aspects**: No building energy management.
 **Champs Sur Marne/France** One of the buildings of a big university Gross area: 15000 m² Year of construction: 1995	 **Building envelope**: Glazed façades and roof/ around 1/3 of facades can be opened through double glazed metal windows. **Heating/cooling**: Gas-fired standard collective boiler and radiators (some with thermostatic valves) / the laboratories are cooled by heat pump system/no programmer. **Ventilation:** Mechanical ventilation. **Lighting**: Conventional fluorescent lamps and conventional lamps in corridors. **Specific aspects**: The indoor temperature is unbearable in summer, solar films were added in some windows and individual heat pups were added in some offices. Insulation behind radiators was added to prevent cold wall effect in winter.

Location And general information	Photo
 **Austria** Gross area: 6156 m² Year of construction: 2002	 **Building envelope:** Wooden-frame construction with static elements (inside) made by concrete/ High insulated outer wall components/ .Steel-glace cladding in the southwest (climate-cladding). **Heating/cooling:** The pellets boiler plant, which is fully automated, guarantees the energy supply for heating and ventilation/ radiators for heating emission/ air conditioned cold water is used for cooling units on the second floor / The change from heating to cooling happens automatically by the room thermostat/ The whole regulation of the heating and ventilation system works on a DDC-System. Handling of the power control is done by a central building control system. **Ventilation :** The toilets on each floor are vented by ventilators. In the laboratories on the basement two exhaust air plants are installed - The exhausted air is re-feed by the two-staged delivery air plant in every single room. Both of the lecture rooms and the seminar room at the ground floor are equipped with an independent delivery and exhaust air plant with heat recovery. **Lighting:** Conventional fluorescent tube lighting with manual switching.
 **Stuttgart/Germany** Includes primary school, secondary school and sports hall Gross area: 5458 m² Year of construction: The school was built in several parts during the 1930ies, 1950ies and 1970ies	 **Building envelope:** Varying concrete constructions with and without multi-layer chipboard insulation since the building was built at different times. **Heating/cooling:** building1: low pressure steam boiler, buildings 2 and 3: hot water heating system fed by a heat exchanger/ piping and radiators dated from the time of construction. **Ventilation:** ensured by opening the windows. **Lighting**: Prismatic diffusers and louvered luminaires with fluorescent tubes manually controlled.

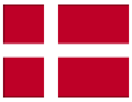
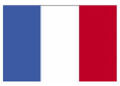
Location And general information	Photo
 **Denmark** Gross area: 7700 m² Year of construction: 1950-52:	 **Building envelope**: Facades are the original one from when the school was constructed made of brickwork. It is difficult make improvements to this type of facade without changing the architectural appearance of the building. In the attic it is though possible to place additional insulation material. In general the windows are up to date as they have been replaced when they were broken. **Heating/cooling**: Gas-fired high efficiency (condensing) heating system running in cascade with an old boiler (as back up) with radiators. **Ventilation:** The assembly hall is provided with mechanical ventilation and heat recovery. The rest of buildings are naturally ventilated. **Lighting**: Conventional fluorescent tube lighting and low energy bulbs. **Specific aspects**: There is a building energy management system.
 **Athens/Greece** kindergarten Gross area: 182m² Year of construction: 1996	 **Building envelope**: Thermally insulated building. Brick walls with concrete rendering. Reinforced concrete flat roof. Double glazed windows with aluminium frames and internal curtains. **Heating/cooling**: One central oil fired boiler for space heating/one electric heater for DHW. **Ventilation:** Natural ventilation. **Lighting**: Fluorescent tubes.

Location And general information	Photo
 **Athens/Greece** Secondary school Gross area: 3451m² Year of construction: 1995	 **Building envelope**: Thermally insulated building. Brick walls with concrete rendering. Reinforced concrete flat roof. Double glazed windows with aluminium frames and internal curtains. **Heating/cooling**: One central oil fired boiler for space heating/ ceiling fans in all classrooms. **Ventilation:** Natural ventilation. **Lighting**: Fluorescent tubes. **Specific aspects:** Indoor thermal conditions during winter are reported very satisfactory, however during sunny winter days there is an overheating problem in many classrooms, resulting in opening the windows while the heating system is operating.
 **Athens/Greece** Secondary school Gross area: 6507m² Year of construction: 1979 + extension in 2004	 **Building envelope**: Partly thermally insulated building. Brick walls partly with concrete rendering and partly with decorative bricks. Reinforced concrete roof (flat and slopped) covered with a reflective coating. Most windows are double glazed with aluminium frames and internal curtains. **Heating/cooling**: Four central oil fired boilers and one air handling unit for space heating/ electric heaters for DHW in sport hall. **Ventilation:** Natural ventilation. **Lighting**: Fluorescent tubes.

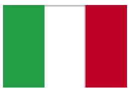
Location And general information	Photo
 **Athens/Greece** Primary school and Kindergarten Gross area: 2709 m² Year of construction: 5 buildings, built in different stages 1970, 1976 and 1989	 **Building envelope**: Among the five buildings only one is thermally insulated, the other four have only roof insulation. Brick walls with concrete rendering. Single glazed windows with aluminium frames and internal curtains. **Heating/cooling**: Two central oil fired boilers for space heating/ electric heaters for DHW/ceiling fans in offices. **Ventilation:** Natural ventilation. **Lighting**: Fluorescent tubes.
 **Fiuggi/Italy** Gross area: 2380 m² Year of construction: 1932	 **Building envelope**: No insulation / double glazed windows with no thermal break aluminium frame. **Heating/cooling**: One standard boiler and radiators without any control/ Distribution systems runs inside the walls. **Ventilation:** Mechanical ventilation. **Lighting**: New fluorescent lamps manually controlled. **Specific aspect:** The walls are very thick and heavy, this gives the building a high thermal capacity, the high between floors and ceilings is important (4.20m).

- # Office building sector

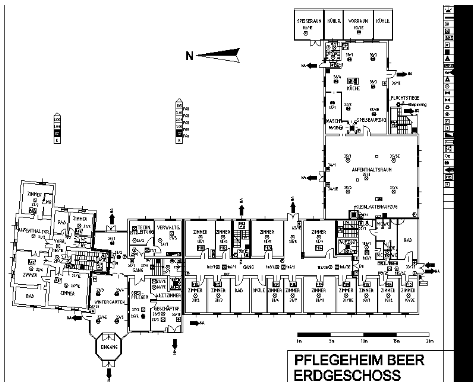
Location And general information	Photo
 **Amsterdam/The Nederlands** Gross area: 2250 m² Year of construction: 1990	 **Building envelope**: The façades, roof and floor are insulated according to the year 1990 Dutch building standards/ windows are double layered glass and a sun reflecting foil. **Heating/cooling**: Gas fired high efficiency (condensing) and radiators/ preheating of ventilation air / small electric boiler for DHW/ The top floor is equipped with 2 build in air conditioners. **Ventilation:** The whole building is equipped with air handling units. **Lighting**: Fluorescent tubes in offices/ build-in halogen lamps in Hallways and lounge areas.
 **Austria** Gross area: 9236m² Year of construction:2005	 **Building envelope**: No insulation / double glazed windows with no thermal break aluminium frame. **Heating/cooling**: One standard boiler and radiators without any control/ Distribution systems runs inside the walls. **Ventilation:** Mechanical ventilation. **Lighting**: New fluorescent lamps manually controlled. **Specific aspect:** The walls are very thick and heavy, this gives the building a high thermal capacity, the high between floors and ceilings is important (4.20m).

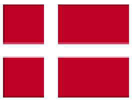
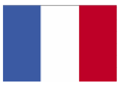
Location And general information	Photo
 **Denmark** Gross area: 3300 m² Year of construction: 1952/62:	 **Building envelope**: The building is made of traditional brickwork with cavity wall insulation. All glazing is mounted in wooden frames and is double pane. Some windows are with low energy glazing. There are solar protections integrated in the windows at the two floors in the attic. **Heating/cooling**: Six small natural gas boilers running in cascade supplying both heating and domestic hot water via a 250 litre storage tank. There is a small cooling system in the canteen. **Ventilation:** Balanced mechanical ventilation with heat recovery in the new part of the building and natural ventilation in the old part. **Lighting**: Fluorescent tubes and task lightning in offices/ low consumption lamps in corridors.
 **Champs sur Marne/France** Gross area: 715 m² Year of construction: in the 50' + renovation in 2002	 **Building envelope**: Good internal insulation of the envelope without being lawful/double glazing windows with aluminium frame and external solar protections. **Heating/cooling**: Electric heating with integrated control device/, Electric domestic hot water with 200l storage. **Ventilation:** Balanced mechanical ventilation. **Lighting**: Fluorescent tubes in offices/ low consumption lamps in corridors.

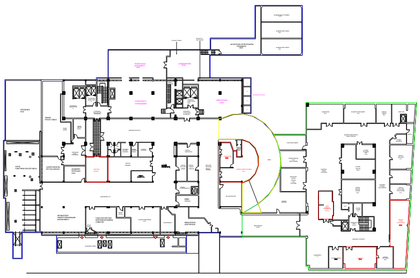
Location And general information	Photo
 **Munich/Germany** Gross area: 27172 m² Year of construction: 2003	 **Building envelope:** Double skin facades with the inner layer as the main thermal insulation, the outer layer is framed glazing, the inner layer has about 70% transparency and 30% opaque areas/ internal solar shadings. **Heating/cooling**: The building is connected to the district heating system. Heating emission with convectors and ceilings (water pipes in building mass). Meeting rooms are cooled. The cooling generation is realised by a compression refrigeration machine. **Ventilation:** Hybrid ventilation composed by a central ventilation system with preconditioned air via an earth channel used for winter preheating and summer pre cooling and a big fan in the cellar. **Lighting**: Lighting is realised by compact discharge lamps with direct mode. The meeting rooms have direct/indirect mode. The ballasts are of the type 'electronic' in the offices and 'low losses' in the other rooms. The lighting control of the office lights is done via the BEMS with an automatic dimming that can be overruled by the user. **Specific aspect:** The EPBD required certificate was made on the basis of DIN V 18599

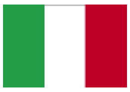
Location And general information	Photo
 **Athens/Greece** Gross area: 1910 m² Year of construction: 2000	 **Building envelope**: Thermally insulated building. Brick walls with decorative bricks. Reinforced concrete sloped roof, covered with iron sheet. High efficiency double glazed windows with aluminium frames and internal blinds. **Heating/cooling**: Nine VRV heat pumps for heating and local air handling units for space heating and cooling/ electric tankless heaters for DHW. **Ventilation:** Mechanical ventilation by air handling units. **Lighting**: Fluorescent tubes and spots
 **Rome/Italy** Gross area: 3200 m² Year of construction: 1990	 **Building envelope**: External insulation/reflective double glazing windows with aluminium frame without thermal break/ no insulation in concrete ground floor. **Heating/cooling**: Gas boiler for heating and chillers with cooling tower for cooling/ fan coil units are used as emission system/ electric boilers for DHW. **Ventilation:** Two air handling units are installed for offices, these AHU are also used for heating and cooling and ventilation for conference room. **Lighting**: Fluorescent lamps. **Specific aspect**: The stairs volume should be in principle separated by the heated volume by double glazed doors but in practice these doors are always open.

- **Health care building sector**

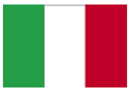
Location And general information	Photo
 **Apeldoorn/The Nederlands** Gross area: 3108 m² Year of construction: 1974	 **Building envelope**: Opaque walls are not insulated/ windows consist of double layered glass in second and third floor and single glazed in the two first floors. **Heating/cooling**: Gas fired high efficiency (condensing) heating system with radiators/ part of building is provided with air conditioning units. **Ventilation:** Natural ventilation except for toilet and kitchen where exhaust ventilation is installed. **Lighting**: Conventional fluorescent tube lighting. **Specific aspect**: Poor indoor air quality due to the low ventilation rates, natural ventilation by opening the windows in winter is not adequate/ the single pane glazing in the two first floors have large dimensions, it's not comfortable in winter.
 **Austria** Gross area: 6156 m² Year of construction: 1920	 **Building envelope**: Poor insulation (4cm)/ windows are single-glazed. The thermal properties of the claddings are in accordance with building standards of the 70ies. **Heating/cooling/DHW:** Central oil burner heating system with radiators; no cooling system. 135 m² solar collectors for the domestic hot water. **Ventilation:** No ventilation system (beside simple ventilation in bathrooms). **Lighting**: Conventional fluorescent lamps with manual.

Location And general information	Photo
 **Denmark** Gross area: 9,562 m² Year of construction: 1977	 **Building envelope**: Pre fabricated concrete elements with wooden covering and minimum insulation (10 cm). Windows are double-glazed. The thermal properties of the claddings are in accordance with building standards of the 70ies. The cladding needs replacement and the rooms upgrade to meet today's standard. **Heating/cooling/DHW:** Two natural gas boilers operating in cascade supplying a heating system with radiators and DHW; no cooling system. Floor heating system in the bathrooms of the residential sectors. **Ventilation:** Mechanical ventilation with heat recovery in the service and common sections, natural ventilation in the residential sections.
 **Lagny sur Marne/France** Gross area: 9500 m² Year of construction: 1965 + extension in 2003	 **Building envelope**: In renovated and new parts, good insulation of the envelope and double glazing windows with external solar protection / no insulation and simple glazing windows in no renovated part. **Heating/cooling**: One central heating plant, with two gas fired boilers, connected to different other buildings with heat exchangers in substations for space heating and for sanitary hot water/ floor heating as background emitter and radiators with thermostatic valves/ No cooling system. **Ventilation:** Mechanical exhaust system and balanced system in renovated and new parts/ ventilation by opening the windows and by infiltration in no renovated part. **Lighting**: Fluorescent lamps.

Location And general information	Photo
 **Stuttgart/Germany** Gross area: 9647 m² Year of construction: 1965	 **Building envelope**: No insulation of opaque walls. Double paned windows in wooden frames. The roof includes a minor cork insulation. **Heating/cooling**: Two gas boilers. Radiators with thermostats. **Ventilation:** Mechanical supply and exhaust ventilation system including electrical heating without heat recovery in the bathrooms and corridors at the inner core. **Lighting:** Incandescent lamps in the patient rooms, fluorescent lamps in corridors.
 **Athens/Greece** Gross area: 35122m² Year of construction: 1974 + extension in 1982	 **Building envelope**: The old main building (17 floors) is not insulated, external walls were recovered with aluminium panels. The new part (4 floors) is insulated. Concrete flat roof with thermal insulation, water resistance layer and pebbles. Double glazed windows with aluminium frames and internal curtains. **Heating/cooling**: Three oil fired boilers for space heating (recently replaced by gas fired boilers) /nine water-cooled chillers for space cooling/air handling units for space heating and cooling/ two central oil fired boilers (recently replaced by gas fired boilers) and two steam generators for DHW production/ split unit heat pumps. **Ventilation:** Mechanical ventilation by air handling units. **Lighting**: Fluorescent lamps. **Specific aspects**: The HVAC installation is controlled by a central BMS system.

Location **And general information**	**Photo**
 **Vicenza/Italy** Gross area: 1320 m² Year of construction: early 20th century	 **Building envelope**: Very poor insulation/simple double glazing windows with wooden frame. **Heating/cooling**: Single group of conventional boilers serving a group of 10 buildings for heating, air handling units and DHW/ radiators without local control/ Single chillier serving the group of buildings, it produces cold water for batteries of AHU/ the chillier is not designed to satisfy the whole cooling demand but to cool down the air entering into the building through the mechanical ventilation system. **Ventilation:** Mechanical ventilation system feeds all the rooms with heat/cool recovery. **Lighting**: Fluorescent lamps manually operated. **Specific aspect:** The walls are very thick and heavy, this give the building a high thermal capacity.

- **Hotel sector**

Location And general information	Photo
 **Fiuggi/Italy** Gross area: 3200m² Year of construction: late 70' + a new part in 2000	 **Building envelop**: Old part has a double layer of hollow bricks with air gap , single glazed windows with aluminium frames/ new part has thick alveolar brick with reinforced plastering, double glazing windows with aluminium frames. **Heating/cooling**: Two gas boilers feed the heating and DHW systems/ A chiller feeds the fan coil units in the hall and in new rooms and the Air handling units of the restaurant/ radiators in old rooms. **Ventilation:** Mechanical ventilation system feeds all the rooms with heat/cool recovery. **Lighting**: From obsolete incandescence lamps to compact fluorescent lamps fluorescent lamps manually operated.

- # Other sectors: Library

Location And general information	Photo
 **Rome/Italy** Mixed library and offices Gross area: 810 m² Year of construction: early 1900, refurbished in 2005. A 3 floors block with the two main façade south and north oriented host the offices. The library is hosted in the block at the ground and consists of one level only	 **Building envelope**: The envelope of the building consists of plastered massive stone walls. Non insulation was added during the refurbishment. Double glazing units with aluminium frame with thermal break were installed. **Heating/cooling**: Condensing boilers are installed to feed the heating and DHW systems, and the air handling units. The chiller feeds the fan coils units and the air handling units. These units have energy recovery installed. Different artificial light sources (from obsolete incandescence lamps to compact fluorescent lamps) are installed in the building. **Ventilation:** Mechanical ventilation system feeds all the rooms with heat/cool recovery. **Lighting**: From obsolete incandescence lamps to compact fluorescent lamps.

Audits of pilot projects: the intake interview and the inspection of the building

The energy performance assessment developed within the EPA-NR project starts with the two following steps:

- Intake interview with the client or his representative
- Inspection of the building through a detailed visit at site

The first step aims to create a clear starting point for the assessment process for the client as well as the consultant and the second step aims to collect all the information and the needed data for energy performance assessment and for proposal of energy saving measures.

For each pilot project, these two steps were realised using the tools developed.

In this chapter we report the experience of these two steps from pilot projects, we don't give details of each pilot project, these details are available in the national reports [1].

The intake interview with the clients was a very important step in the energy performance assessment of the pilot projects. Its duration was in most cases short (around two hours), however it enables the consultant to collect helpful information and to have a first approach with the building. The final outcome of this step in terms of information about the building depends on the quality of the data clients prepare.

The intake checklist was a very helpful tool that allows to organise the interview with the client and to facilitate the inspection of the building. In particular it's during this step that general information of building history, building use, identified problems and client needs are given. In addition, in this step the consultant collects information on the available data, on the way to get it, on the personnel to meet and on the building management.

In most cases, more than one person representing the client and more than one person representing the consultant were involved on the assessment process; in particular for complex building, the presence of a facility manager or a person who well knows the building seems to be necessary.

The motivations of the clients and their needs are different from one project to another. In the following some examples on different motivations:

- To get prepared for the EPBD required certificate or to get a certificate using the EPA-NR method.
- To have an experience on energy performance assessment in the frame of an owner programme that aims to gain insight in the energy performance and energy use of the owner's building stock.
- To get advices on relevant energy saving measures mainly when a major renovation of the building is planned.
- To be informed and to understand the reasons of the high actual energy consumption and damages at the building components.
- To evaluate a recent renovation and it's impact on energy consumption.
- To improve the use and comfort in the building.

The inspection of the building and the time of the building visit are crucial in the energy performance assessment process because it includes the phase of collection all necessary data for the calculation of the current energy performance of the building and also because it anticipates the suggestions of improvements and energy saving measures.

Comprehensive information and available data for existing non residential buildings is rather seldom. For some of pilot projects especially the oldest buildings that were never renovated, there were neither available drawings nor information about the building envelope and HVAC systems. In these cases the inspection of buildings is much more time consuming because it also includes the measurement of building dimensions; it also requires much more experienced consultant, in order to estimate building components and HVAC systems characteristics from the observation and by the use of default values.

The inspection protocol developed for this step was very helpful as it gives a good definition and explanation of the required data and also includes tips and some default values. National guidelines and default values were also used by partners in this step, however it is essential that the experts have experience on building constructions and with energy savings.

The duration of this step varies from half a day to two days depending on the following criteria:

- The building age
- The building size
- The building complexity
- The building management
- The availability of data, in particular availability of drawings, plans and bills.

Apart from the inspection of the building, for some pilot projects, additional information and exchanges were made afterwards by phone or by email.

Calculation of energy performance

- Measured energy consumption

One of the difficulties met during the execution of pilot projects is the access to the real energy consumptions of buildings.

For the heating and cooling energy consumption, the main reason is that sometimes the studied building is connected to a central heating and/or cooling plant which is common to other buildings and there are no sub-metering devices.

For the electricity, the bills are sometimes common to a set of buildings.

When available, these data were taken into account not with the aim of comparing them with the calculated consumptions but for possibly comparison to benchmarks (estimated national values).

- Calculated energy use and CO_2 emissions

The third step in the energy performance assessment in the EPA-NR method is the calculation of actual energy consumption of the building and CO_2 emissions according the calculation method developed within the project and by using the EPA-NR software.

We don't give the results of the calculated energy consumption and CO_2 emission of each pilot project within this report because it would be necessary to give information about the input data used for the calculation and the conditions of calculation: real or standard conditions for building occupancy, indoor set points temperature, internal gains, operation time of HVAC systems, etc.. These results are available in the national reports [1].

This report focuses on the experience from pilot projects concerning the use of the EPA-NR software and the analysis of EPA-NR software outputs.

All partners easily installed the software, no major difficulty was reported.

Necessary libraries about national climate, national constants and fuel inputs were easily filled in by each partner.

The software was improved during stages of the execution of pilot projects, when a new version was available, partners had no difficulties to load their previous data.

The structure of the software facilitates data entering, on the other hand the online help allows to have the necessary explanations on each data with some examples or default values.

Every part of the software is easily duplicable, so it is easy to create various zones, to create new systems, etc.

The software allows various outputs which enable an interesting analysis for the understanding of the results; so the detailed results can be presented either for each zone or for the whole building. A synthesis on the global energy performance of the building is also presented as well as the fuel consumption, operational cost, investment cost and payback period.

The detailed results presented as follows are given for every month of the year and for the whole year, they can be expressed in different units (GJ, MJ/m², MWh, kWh/m²):

- **Energy demand and use - fuel use**
  - Calculated energy demand for heating and calculated energy demand for cooling
    - Total losses
      - Losses by transmission
      - Losses by ventilation
    - Total gain
      - Solar heat
      - Sun space
      - Internal heat sources
  - Final calculated energy consumption
    - For heating (part of solar collector is given)
    - For cooling
    - For humidification
    - For DHW (part of solar collector is given)
    - For lighting
    - For auxiliary
    - Contribution from solar collectors, PV cells and CHP
  - Calculated fuel consumption
    - By fuel type
  - Calculated primary energy consumption
    - By fuel type
  - CO_2 emissions
    - By fuel type
- **Financial calculation**
  - Energy cost
  - Investment cost
  - Payback time

All these detailed results were very helpful for analysis and for proposal of energy saving measures.

Energy saving measures and their impact

After the calculation of the actual energy performance for each pilot project, a number of scenarios to improve the energy performance of the building were studied, and their impact on energy consumption, CO_2 emissions, investment cost and pay back time were estimated. The goal is to suggest to the client the most appropriate scenario of improvement.

Regarding the pilot projects, different kinds of energy saving measures were taken into account, including:

- improvement of the building envelope: external or internal insulation of walls, roofs, replacement of windows by a high-performing ones, or addition of glazed panels, etc.
- improvement of the heating/cooling systems: replacement of old boilers, insulation of pipes, change of fuel.
- improvement of ventilation system
- improvement of lighting systems and their control
- installation of solar collectors for DHW
- installation of photovoltaic cells
- improvement of building management and/or users behaviour: set point temperature, night set back, etc.

The impact of the energy saving measures was calculated by using the EPA-NR software. This impact was measured in percentages of gain with regards to the current situation for primary energy consumption and $C0_2$ emissions.

The experience from the pilot projects shows that the step of the energy performance assessment is most important for the client and that by using EPA-NR method, relevant suggestions for energy performance could be made. These suggestions are the result of the application of the whole EPA-NR method: the intake interview to clarify the client needs, the inspection of the building to anticipates suggestions and to allow data collection, the calculation to know the actual energy performance and to analyse it and to calculate the impact of the proposed energy saving measures.

Summarised results for some pilot projects

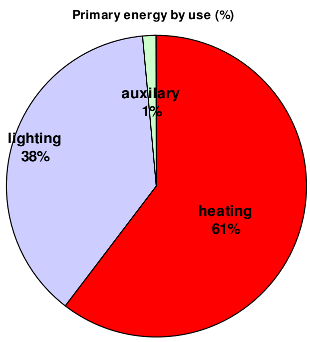
EDUCATIONAL BUILDING

School in a north suburb of Athens

The building complex (3451 m² gross area) consists of three rectangular shaped buildings with 2 floors (classrooms) and ground floor (office spaces, a few laboratories, restrooms and mechanical room) connected with staircase halls.
The building is thermally insulated. The walls are constructed from double brick and an insulation layer, with rendering on internal & external sides. The flat roof is constructed from reinforced concrete and thermal insulation, covered with gravel. All openings have double-glazing with aluminium frames and internal curtains.
The building has an oil central heating system, but no central cooling and mechanical ventilation system. In 2004 the burner for the central oil fired boiler was replaced with a new one, a two-pipe system supplies with hot water from the boiler to the radiators. There is a daily timer for the operation of the heating system, from mid October until mid April. There are also 42 ceiling fans, which are used for hybrid cooling. There is no sanitary hot water production.
The artificial lighting is provided by long tube fluorescent lamps. All lights operate manually.

Energy performance assessment with EPA-NR method: the Actual situation

- Primary energy use: **61.9 kWh/m²/year**
- CO_2 emissions: **19.2 kg/m²/year**



Energy saving measures: impact on energy performance

Proposed scenario

- Installation of large fixed semi transparent overhangs to the openings on the SE façade
- Replacement of the existing oil fired boiler with a natural gas fired boiler
- Installation of solar collectors (18 m^2) for sanitary hot water (there is no sanitary hot water)

Savings	
Primary energy use	CO2 emission
3.4%	**16.1%**

Installing external shadings results to an increase of heating energy consumption, on the other hand thermal comfort during cooling period is improved. Installation of solar collectors for DHW is attractive. These two measures increase the building comfort but do not reduce energy consumption.

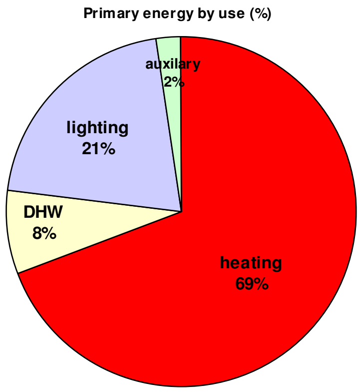
HEALTH CARE BUILDING

Nursery home in Stuttgart

The seven storey building was built in 1965. The gross area is 9647m². The building includes 120 patient rooms, rooms for the staff, entrance hall, kitchen, dining room and also a kindergarten at ground floor level. The façades are not insulated, the windows are double paned in wooden frames, the roof includes minor cork insulation.
The building is heated by 2 gas boilers, radiators with thermostats were used as emission system. The bathrooms and corridors at the inner core had a mechanical supply and exhaust ventilation system incl. electrical heating but without heat recovery. The lighting in the patient rooms was mostly realised by incandescent lamps, at the corridors with fluorescents lamps.

Energy performance assessment with EPA-NR method: the actual situation

- Primary energy use: **310.2kWh/m²/year**
- CO_2 emissions: **76.8 kg/m²/year**



Energy saving measures: impact on energy performance

Proposed scenario

The proposed retrofit measures are comprised of:

- exterior insulation of the N/S wall and new high performance light weight E/W façade
- three pane low-e coated glazing in wooden frames
- new insulation at the roof and insulation under the cellar ceiling
- controlled exhaust ventilation system in the client rooms
- daylight dependent artificial lighting at the corridors
- low temperature heating system with single room control, combined heat and power system, condensing boiler, low temperature boiler

These retrofit measures include the transfer of balconies areas into the rooms and the integration of bathrooms.

Savings	
Primary energy use	CO_2 emission
57 %	**57.8 %**

Payback time: 20 years. Although the payback time is rather high, the investor decided to realise this retrofit concept within the federal German retrofit programme EnSan as pilot project in order to show how much energy savings can be achieved with a holistic approach.

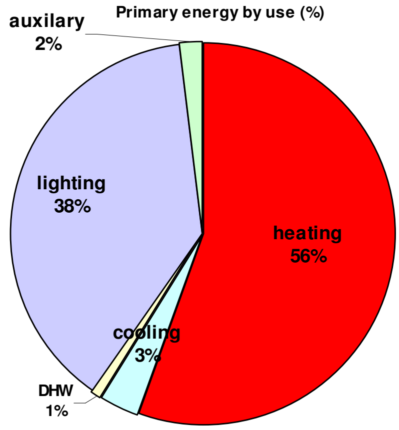
OFFICES BUILDING

Office Building in Amsterdam

This office building rented by a sport management company was built in 1990. The gross area is 2250m². The building is occupied about 8 hours a day, 5 days a week and 50 weeks a year. The maximum capacity is around 100 employees.
The façades, roof and floor are insulated according to the year 1990 Dutch building standards, windows consist of double layered glass and a sun reflecting foil.
The building is heated by a gas-fired high condensing boiler, radiators are used as emission system. Domestic hot water is assumed by small electric boiler. The air for ventilation is preheated. The whole building is equipped with air handling units. The lighting is realised by fluorescents lamps in offices and by build-in halogen lamps in hallways and lounge. Only the top floor is equipped with 2 build in air conditioners.

Energy performance assessment with EPA-NR method: the Actual situation

- Primary energy use: **284 kWh/m²/year**
- CO_2 emissions: **63 kg/m²/tear**



Energy saving measures: impact on energy performance

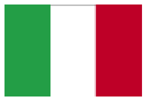
Proposed scenario

Since the building is build according to the 1990 standards of Dutch building regulations with insulations of the building envelope afterwards, the energetic quality is relatively good. Therefore the opted amount of measurements are low. An interesting measure is to replace the conventional fluorescent lighting in the office spaces with High Frequency fluorescent lighting including daylight control sensors.

Savings	
Primary energy use	CO2 emission
4%	**5.3%**

Payback time: 7.4 years.

HOTEL BUILDING

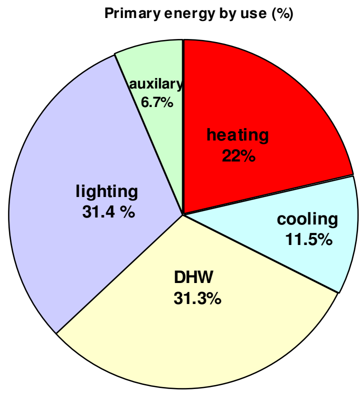


Hotel in Fiuggi

The Hotel consists of an old part built in late 70' and a new one added in 2000. A part rooms, the hotel includes a restaurant and a gymnasium. The basement is mainly occupied by a conference hall considered as an unheated space being seldom used during the day. There is no insulation and simple glazing with aluminum frame in the old part and insulation and double glazing with aluminum frame in new part.
Two new gas boilers were installed in 2000 to feed the heating and DHW systems. The chiller feeds the fan coil units in the hall and in new rooms as well as air Handling Unit for the restaurant.
Different artificial light sources: from obsolete incandescence lamps to compact fluorescent lamps.
The hotel is occupied all day long, it is closed from January to March.

Energy performance assessment with EPA-NR method: the Actual situation

- Primary energy use: **203 kWh/m²/year**
- CO_2 emissions: **51 kg/m²/tear**



Energy saving measures: impact on energy performance

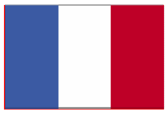
Proposed scenario

- Installation of solar collectors (46m^2) for DHW production
- Replacement of incandescence lamps with new compact fluorescent ones
- Installation of Photovoltaic panels

Savings	
Primary energy use	CO2 emission
21.9%	**21.6%**

Payback time: 5.7 years. This combination of measures is a good example of sustainability in existing buildings.

HEALTH CARE BUILDING

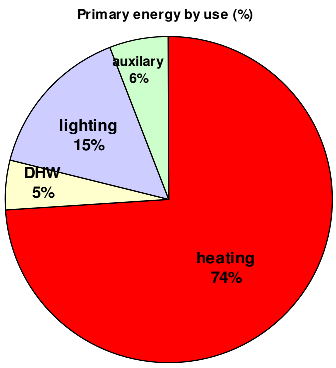


Hospital in Lagny sur Marne

The hospital includes several low rise buildings which are independent and the studied part is a group of three buildings with 8700m² gross area. The three buildings characteristics are different: in 2003, new parts were added to two buildings with renovation of existing parts and the last building didn't change since the initial construction (1965). The façades, roofs and floors of new and renovated parts are insulated, the windows are double glazing while the no renovated part is no insulated and windows are simple glazing.
The central heating plant is connected to the buildings with one exchanger for heating and another for DHW in substations. The system plant includes four natural gas boilers, one natural gas power generating unit running from November to may (The power is send to EDF network) and one diesel engine power generating unit running only in case of breakdown of the network. DHW is produced by the same heating system.
The ventilation is assumed in the new and renovated parts by balanced mechanical system and exhaust system with air entrance in windows frames. No ventilation, system in old part.
Lighting is assumed with fluorescent lamps without control devices.
The building include xx rooms, a restaurant, and an activities hall . It is occupied 24h/24 all the year.

Energy performance assessment with EPA-NR method: the Actual situation

- Primary energy use: **464 kWh/m²/year**
- CO_2 emissions: **89kg/m²/year**



Energy saving measures: impact on energy performance

Proposed scenario

The high energy consumption is mainly due to the poor quality of the old building envelop. The proposed retrofit measure combine a retrofit of the old part and measures on building use

- Retrofit of old part: insulation of the walls, of the roof, of the ground, new high performance windows with low e coated glazing's and installation of mechanical system for ventilation.
- Improvement on the building use : reduction of set point temperature during the night and reduction of air flow rate for ventilation (with respect of sanitary requirements

Savings	
Primary energy use	CO2 emission
38%	**44%**


OFFICE BUILDING

Office building in Vienne

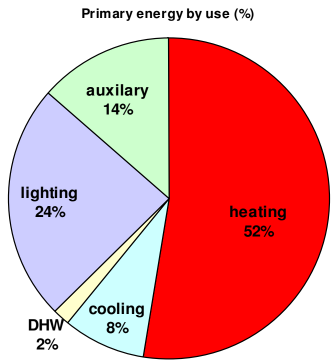
The building constructed in 2005 is located in a new industrial &research area in north-east district of Vienna. On the ground floor including the first floor are situated the event area, halls and laboratories as well as the canteen and staircases. The upper 3 floors include offices, seminar rooms, plant rooms, laboratories and restrooms.

The opaque parts of the external façade are thermally insulated with EPS; humid exposed parts and the flat roof are insulated with XPS. Windows are double-glazed and low-emission-coated. For sun protection flexible external sun blinds are mounted on the east, south and west façade of the building. The north orientated façade is equipped only with inner jalousies. All blinds and jalousies have to be adjusted manually.

Heating and cooling of the building is done by an HVAC-system. The central heating system is driven by a natural gas boiler and supplies heat to radiators. There are local electrical water heaters for restrooms and kitchenettes. Only the communication area of the office floor is mechanically ventilated with a heat recovery system. The offices are supplied with fresh air by natural ventilation. The air temperature of the offices is controlled separately in each room by thermostatic valves. There are fan coils in each office which are cooled by a central compression chiller system. The rejected heat of the compression chiller system is transferred to ambient air by using a dry cooling tower. Heating and cooling operation is technically not foreseen. It has to be determined manually when the heating or cooling period starts or ends.

Energy performance assessment with EPA-NR method: the Actual situation

- Primary energy use: **182.5 kWh/m²/year**
- CO_2 emissions: **36.1kg/m²/year**



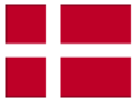
Energy saving measures: impact on energy performance

Proposed scenario

According to geo-physical assessments the special location of the building has relatively high and constant ground water flows. As there is another innovative office building project initiated it can be assumed that ground water can be used as heat source for heat pumps with respect to capacity limits. Additionally the Austrian heat pump market is quite well developed, an interesting scenario is to investigate a reversible heat pump for cooling and heating supply. Thus the energy system has to compete against the natural gas driven boiler for heating and a conventional compression chiller for cooling. Heat pumps ground coupled with ground water operate with high COP . The entire office building will be operated only by electricity.

Savings	
Primary energy use	CO2 emission
40%	**42%**

EDUCATIONAL BUILDING

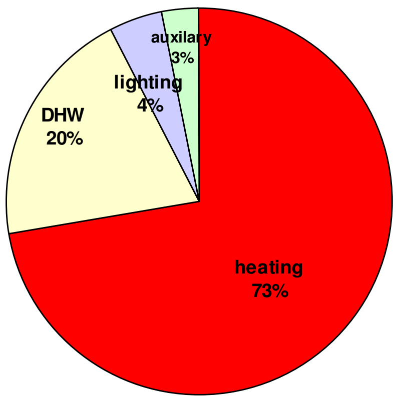


School in Gladsaxe

The school is the fist of its kind in Denmark, in only one plan. It was constructed in 1950-52 as a traditional brick work with cavity wall insulation. The core of the buildings has not been upgraded but the facilities in the class rooms are in a good condition. Most windows are double glazed with a few exceptions with single glazing, mainly in the entrances and the gymnasium. Insulation material have been placed in the attic and improved to 125 mm recently. Compared to today's Danish standard this is not sufficient and additional insulation material can easily be installed.
A new gas boiler and building energy management system was installed in 2000 to feed the heating and DHW systems. At the same time DHW was supplied through a heat exchanger normally used in district heating systems. BMS has been installed recently.
Different artificial light sources: from obsolete incandescence lamps to compact fluorescent lamps.
The school is closed from end June to mid August and two weeks around Christmas and New-year.

Energy performance assessment with EPA-NR method: the Actual situation

- Primary energy use: **204 kWh/m²/year**
- CO_2 emissions: **26 kg/m²/year**



Energy saving measures: impact on energy performance

Proposed scenario

- Decrease of DHW circulation temperature
- Upgrade of roof insulation to 300 mm incl. replacement of 10 % of the existing insulation

Savings	
Primary energy use	CO2 emission
13.6 %	**9.2 %**
15.6 %	**10.6 %**

Payback time for the first energy saving measure does not exist as the investment is one hours work by the janitor. For the second energy saving measure the simple pay-back time is calculated to be 7.2 years.

The first part of the scenario is a classical example of how a simple inspection and intervention can save much on the energy bill. Additional insulation in the attic, especially when there is easy access, as in this case is a good combination with any other energy saving measure.

Conclusion on the application of EPA-NR method to pilot projects

The EPA–NR method was successfully applied to several pilot projects which present a big variety.

The method was improved at different stages on its application to pilot projects. The latest version of the method takes into account all the lessons learnt from pilot projects.

The pilot study shows that the EPA-NR method allows assessment of 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 certificate.

The structure of the EPA-NR process of energy performance assessment on identified steps with corresponding tools facilitates and guides the consultant. Each step of the process is important and the developed tools helpful.

The acquisition of building characteristics data for software inputs is the most crucial factor for the EPA-NR method's reliable use; it's also a rather time consuming task. This step of the process requires a high know-how of consultant.

The energy consumption is strongly depending on the users' behaviour and building's management. The EPA-NR method is able to calculate Energy Performance in standard conditions and to relate the performance of the building due to its intrinsic characteristics. In consequence, it's a useful tool at the beginning of a refurbishment process as different energy saving measures can be easily assessed.

It's a good way to estimate the impact of energy saving measures due to renovation of building's components, building's management or user behaviour.

References

[1] National Report
26 national reports (one national report by pilot project)

- **THE NETHERLANDS**: national report on an educational building, national report on an office building, national report on a health care building
- **AUSTRIA**: national report on an educational building, national report on an office building, national report on a health care building
- **DENMARK**: national report on an educational building, national report on an office building, national report on health care building
- **FRANCE**: national report on an educational building, national report on an office building, national report on a health care building
- **GERMANY**: national report on an educational building, national report on an office building, national report on a health care building
- **GREECE**: 4 national reports on educational buildings, national report on an office building, national report on a health care building
- **ITALY**: national report on an educational building, national report on an office building, national report on a health care building, national report on a hotel building, national report on a library building

[2] Checklist for an intake interview – preparation for an energy performance assessment of existing non residential buildings, EPA-NR project, final report

[3] Inspection protocol – guidance for the data acquisition during the building inspection including an inspection checklist and national and international tips, EPA-NR project, final report

[4] EPA-NR software, EPA-NR project

[5] Functional specification of the EPA-NR software, EPA-NR project, final report

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