eTEACHER

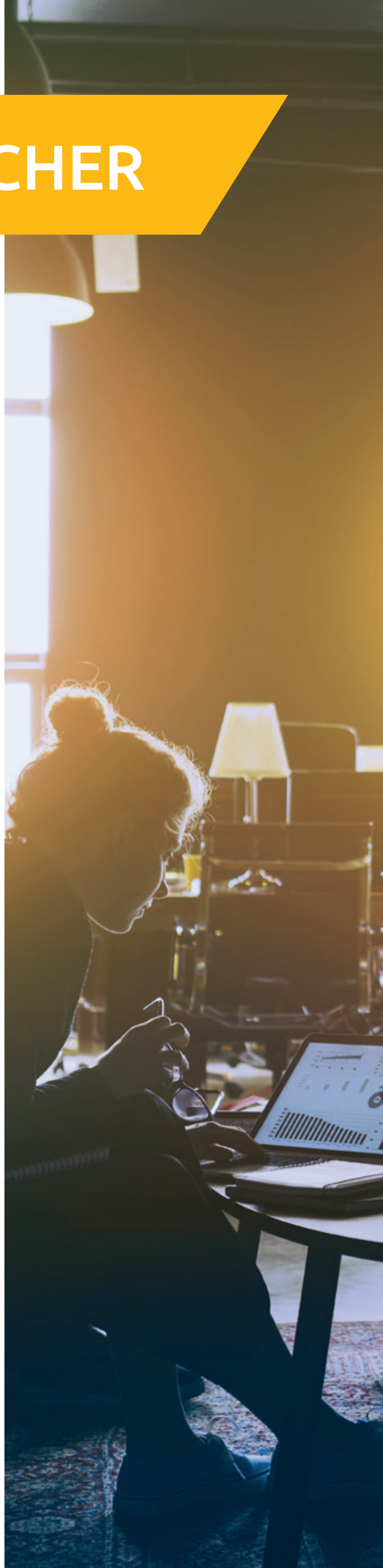
Exploitation Factsheet

An overview of eTEACHER

The project eTEACHER aims to encourage building users (building owners, occupants, and facility managers) to change their behaviour towards energy efficiency in order to save energy, and it has the intention to optimise comfort and Indoor Environmental Quality (IEQ).

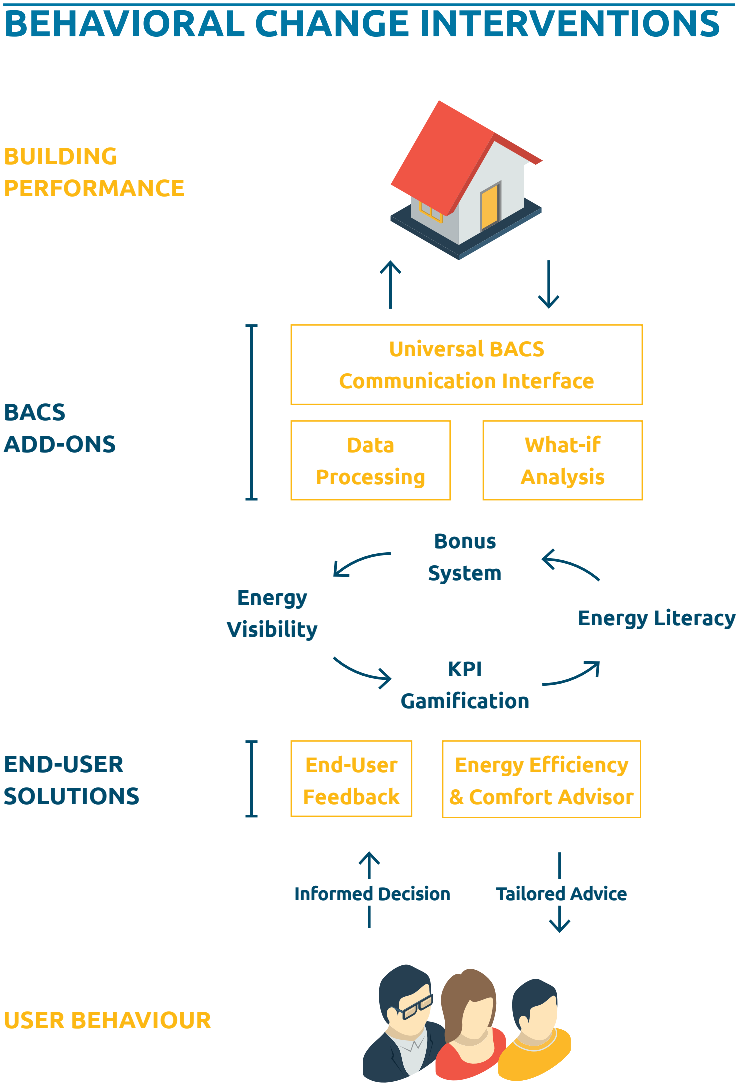
To achieve the aim of the project, many challenges needed to be addressed, including:

- The way the users interact with the building since the motivation for a behavioural change is very much dependent on the role and the context (building type, country, etc.).
- To propose effective interventions that provoke behavioural change, eTEACHER needs to collect information from the building and its environment. Therefore, eTEACHER solutions require an integration and interoperability with the Building Automation and Control System (BACS), the Building Energy Management System (BEMS) or the monitoring system in the building.
- For replicability and market uptake, the eTEACHER solution needs to be cost-effective.
- The information provided by the eTEACHER solution must be accessible and appealing to different types of end-users, considering energy literacy, visibility, and gamification aspects.
- Solutions to save energy may compromise comfort levels. eTEACHER solutions have to evaluate the possibilities to select the best Energy Conservation Measures (ECMs) and propose tailored energy interventions.



An overview of eTEACHER

The proposed approach to solve these challenges is the development of a set of ICT tools that process information from buildings and users, integrate behavioural change techniques and provide tailored advice for the end-users themselves. The eTEACHER concept can be summarized in the following image:



An overview of eTEACHER

The main technical objectives of the eTEACHER project are the following:

1. Social studies to characterise energy end-user behaviour
2. Encourage behavioural change through continuous ICT-based interventions
3. Develop cost-effective and interoperable BACS add-on services
4. Develop user-friendly solutions that integrate ICT-based engagement and behavioural change techniques
5. Deploy, demonstrate, and evaluate the eTEACHER toolbox in 12 different buildings:
   - 4 residential buildings in Romania
   - 2 schools, 1 residential building, 2 health care centres and 1 office building in Spain
   - 1 school and 1 office building in the UK

The added value from the eTEACHER solutions to society beyond the duration of the project is to:

- Provide an understanding of behaviours, motivations, capabilities, and opportunities to improve energy efficiency via behaviour change across a range of building and user types.
- Address multiple user groups, whereas previous research has predominantly focused on a specific user group or building type.
- Develop a devised methodology in engagement techniques, using social science research in developing a new method of workshop delivery from concepts to ideas to inform new technical solutions.
- Develop tools easy to use, clear and fun.
- Provide customized energy-saving recommendations and usage information based on real-time sensor data via an engaging user interface for a range of building users to increase the user's indoor comfort conditions and build energy literacy.
- Include user behaviour change concepts (know-how) in the selection and installation of sensors in the buildings.
- Perform a continuous monitoring and data analysis which can be used to detect inefficiencies quickly to find solutions.
- Enhance traditional energy audit's impact including improvement of comfort and IEQ, not only energy saving.

The aim of this factsheet is to summarize the three major Key Exploitable Results (KERs) of eTEACHER project to technical readers (researchers, engineers, building facility managers, etc.). Following an introduction to the KERs, each KER will be characterised via a detailed description of its features, its current status of development at the end of the project and the partners involved in its generation.

Key Exploitable Results

During the span of the eTEACHER project, three Key Exploitable Results (KERs) have emerged:

- KER 1: Energy Behaviour Change Framework (SOCIAL)
- KER 2: eTEACHER Toolbox (TOOLS)
- KER 3: Integration Methodology (BUILDING DESIGN)

The eTEACHER Toolbox KER – which consists of various ICT tools that focus on quantitative energy (efficiency) data as well as qualitative energy literacy and gamification elements – can be seen as the "connecting element" of all three KERs. This is because its development was highly dependent on social analyses, the integration of behavioural change techniques as well as practical user feedback (related to the social Energy Behaviour Change Framework KER), and information from and the performance of the buildings themselves (related to the Integration Methodology KER).

All of these KERs arose via a synergetic process, whereby they influenced each other through new emerging input and feedback. This made it possible to improve and further develop each of them.

Even though the three KERs were highly dependent on each other during the span of the project, they can be exploited individually after the project's end.

KER 1: Energy Behaviour Change Framework

This social KER relates to the overall project behaviour change methodology which has been utilised to design effective and appropriate energy related behaviour change interventions across a wide variety of building typologies and user types.
Previous research predominantly focused on one user group or one building type but the eTEACHER project has brought together the needs, opportunities, and end-user motivations across a number of different building types to create one solution which works across all. Therefore, the methodology and results from this major social KER can support the application of energy related behaviour change solutions across multiple building types and multiple user groups at the same time.

The major social KER encompasses a number of smaller social KERs which were generated from the energy behaviour change framework, including initial scoping phase approaches, the development phase and within the analysis and evaluation for effective behaviour change. Depending on the requirements for exploitation, the overall methodology can be used or specific sub-categories to the methodology can be exploited (these are explained further in detail below):

1. Identification of effective energy-related behaviour change interventions based on the characterisation of existing energy behaviours, building use and end-user motivations.
2. Identification of relevant gamification requirements based on the context of end-user understanding, motivation and agency.
3. Co-creation methodologies for ensuring ICT-based tools meet the needs of end-users and allow for a positive user experience to encourage continued and sustained interaction with such tools.
4. Engagement methodologies to encourage continued engagement from end-users.

Energy Behaviour Change Framework — Type: social

During the initial scoping phase, relevant methods are used and data collected to characterise the building and existing energy consumption as well as potential target users, their motivations and agency towards behaviour change actions. Through analysis of potential interventions and target users' effective energy-related behaviour change interventions can be identified which are relevant and achievable within the building context.

For effective behaviour change via ICT-based tools a methodological approach was taken to identify key gamification requirements and preferences across the variety of building types and user groups. The methodology includes the social studies used to characterise user preferences on hardware and software components for energy saving and the identification of key gamification components which were of interest to specific user groups. Also included within the exploitable results of this sub-category is the design recommendations generated from the analysis of all data collection.

A key element to the energy behaviour change framework was the development of a user-centered methodology relating to the development of an ICT-tool which met user needs and worked for all user types within the context of each building type. Therefore, part of the energy behaviour change framework included developing a methodology which utilised elements of the Enabling Change process, incorporating a co-creation approach to developing the ICT-based tool. This resulted in the development of Feedback Forums (FFs) as key co-creation and feedback collection mechanisms for continued development of the final tool and evaluation. Exploitable results include the methodological approach, materials developed for FFs (session slides, facilitators guides, data collection forms, summary reports etc.) and the results from the analysis of each Feedback Forum and co-creation findings.

Finally, the exploitation of the major social KER includes the methodology and materials developed during the project to encourage end-user engagement. Specifically, this includes engagement campaigns via social media channels and email communications, templates for visual communications, end-user webinars and analysis from end-user feedback regarding best methods of communication to increase effectiveness of engagement communication across different building types and user groups.

The unique aspect of this energy behaviour change framework social KER is that a user-centered methodology has been applied across a number of different building types (schools, residential, health care centres, and offices) therefore gives novel insights into employing tailored interventions within one solution.

Energy Behaviour Change Framework   Type: social

KER current status

Current Technology Readiness Level: Not applicable since this KER is not focused on a technological implementation.
The methodology developed and utilised during the project is already available and detailed within public deliverables from the project, as well as detailed in scientific papers. The methodology can be exploited in both academic and commercial activities and can be adapted to suit the context in which it is being applied.

Workshop materials that are available include facilitators guides, slides and handouts. These can be made use of in exploitation activities and can be adapted to suit context in which they are being reused. Further analysis and results from the social investigations carried out within the project will be available for exploitation following the end of the project.

Partners involved

KER 2: eTEACHER toolbox

The toolbox is a collection of ICT services to motivate energy behavioural change of energy end-users in different building types providing tailored interventions that result in significant energy savings and better Indoor Environmental Quality (IEQ). It aims at changing building occupant's energy behaviour towards more efficient habits, based on analytics ICT software tools (cloud-based) and a mobile app (gamification techniques) for end users and/or facility managers.

The eTEACHER concept aims to encourage and enable energy behaviour change of building users by means of continuous interventions displayed through a set of empower tools to drive informed decisions in order to save energy and optimise IEQ. These empower tools are a set of ICT solutions that ensures friendly connection between end-users and building systems, implements continuous behavioural change interventions and provides tailored advice.

The tools can be classified into:

- The **BACS add-ons** (What-if-Analysis, data processing and universal BACS/ monitoring system interface)
- The **user-friendly solutions**

The software consists of multiple BACS add-ons/components:

First, sensors/IoT devices are installed in the different buildings. These sensors/IoT devices are read through the **Universal Building Communication Interface (UBCI)**, which collects the data. The data is used by other components to provide the final end user with data.

The Metrix software shows - via an user-friendly interface - the sensor data to the user, and it provides various statistics in a visually appealing manner, which are mostly relevant for facility managers. Moreover, it collects feedback from inhabitants and shows it in the **Pulse** tool.

The **What-if-Analysis (WiA)** generates recommendations for energy saving and comfort, based on the sensor data, and gives suggestions for general energy saving measures.

Furthermore, the toolbox is completed with the **user-friendly solutions.** These are energy efficiency and comfort advisor apps for end-user devices (like mobile phones) or via a web-based access. These apps show the Energy Conservation Measures

(ECMs) identified by the WiA and the Metrix/Pulse software. It integrates ICT-based behavioural change techniques, such as gamification, to encourage behavioural change and to facilitate the execution of tailored energy interventions which result in a significantly enhancement of energy efficiency. Gamification is done in multiple ways, like a ranking system, a log like recommendation system (known from roleplaying games) and different visualisations of the data. For example, one of these visualisations is a tree showing how much CO2 you saved by following eTEACHER recommendations. Another example is the Virtual Building, which shows the 3D representation of the building, where users can see real-time data being measured in the different rooms.

KER current status

Current Technology Readiness Level: 6-7

The eTEACHER tools were developed and implemented in the 12 pilot buildings of the project. Currently, monitoring and tool supervision reports are periodically published in order to find issues and solve them as soon as possible. An extended demonstration is needed to gather users' feedback to improve the tools before the whole eTEACHER solution can be fully exploited in the market.

Partners involved

Universal Building Communication Interface (UBCI)-Container

The main intention of the UBCI-Container is to collect and store data from the building and to facilitate the data to the analysis tools and the user interfaces. The UBCI container includes a common SQL Database to store and process data, an application-programming interface (API) to connect to the database and to the other tools as well as a communication interface based on the OPC Unified Architecture (OPC UA) protocol by the OPC Foundation (2019).

The eTEACHER application-programming interface (API) is used to query as well as update data of the common database.

To communicate with the UBCI-Container, the WiA service uses the OPC UA protocol, which is a machine-to-machine communication protocol originally developed for industrial automation.

Partners

Pulse and Metrix

Four different Granlund services form part of the eTEACHER application. They are called “Your Comfort Opinion”, Metrix, Pulse and “Virtual Building”.

Metrix is an analysis tool that can be used to analyse the persistence of conditions in a target over the long term. The Metrix score is a figure that presents the stability of the conditions of the entire property and tells you what level the indoor air quality the property is at.

The “Your Comfort Opinion” feedback section can be utilised to collect user feedback and save it as statistics. Users can also comment on feedback from other users. These user feedback statistics can be used to locate user-defined issues as well as receive feedback on aspects that work well.

Pulse is a service that combines the user feedback with the Metrix score into one Pulse score. The Pulse score can be utilised in “property wellness analysis”. As this score decreases, either the indoor conditions have deteriorated, or the user feedback has become more negative. On the other hand, if the Pulse score rises, the indoor conditions have improved, or the user feedback has become more positive.

This information can be used as a first indication of changes in the wellbeing conditions within the property and, if necessary, to find out the more specific root causes by looking at the feedback section or the Metrix information.

The “Virtual Building” is a virtual version of a real building. Real time data can be displayed with spatial data using a 3D representation. Virtual real estate provides a more easily accessible way for people to read information and to target information at a specific location of the building. Historical data can be used to analyse indoor air conditions and occupancy in a particular room or area. In the virtual property it is possible to monitor for instance temperature, carbon dioxide content, humidity, brightness level and occupancy. The virtual property provides an air quality report on a daily and weekly basis.

Partners

Granlund

What-if Analysis (WiA)

The What-if-Analysis (WiA) is a software tool that provides building users with tailored recommendations on how they can reduce building energy consumption and energy costs. The provided energy conservation measures consist of different simple actions on the building energy system that a building user (resident, facility manager, staff, etc.) can undertake to save energy. These energy conservation measures consist among others of:

- Saving cooling and heating energy through more optimal Heating, ventilation, and air conditioning (HVAC) settings, improvements of solar energy gains by acting on shading components, avoiding energy wastes through openings or when rooms are not occupied.
- Saving lighting energy using more natural light or powering-off fixtures when there is no need for using artificial light.
- Saving electrical energy by switching off unnecessary appliances, devices or equipment when not used

To make it possible for this software tool to automatically identify and evaluate proper energy conservation measures in real time during building operation, the WiA implements a knowledge-based computational method that continuously analyses information about the building and its current usage (see picture below). This information is provided by a monitoring system of the building including meter and sensor data.

Partners

Fraunhofer IIS

eTEACHER App

The user-friendly solutions of the eTEACHER App are energy efficiency and comfort advisor apps for end-user devices, like mobiles or web. These apps show the Energy Conservation Measures (ECMs) identified by BACS-addons in real time and integrate ICT-based behavioural change techniques, such as gamification (in form of challenges, rankings, energy visibility, etc.). The eTEACHER App implements innovative, interactive, user-friendly and customizable empower tools to encourage behavioural changes and to facilitate the execution of tailored energy interventions, which result in an improved enhancement of energy efficiency.

Partners

ASCORA

KER 3: Integration Methodology

This KER relates to the building integration methodology developed to integrate the eTEACHER toolbox (KER 2) or a similar ICT solution in the BACS of a building.

In general, this methodology comprises the steps to identify the building's weak points regarding energy behaviour and to propose additional sensors (temperature, humidity, CO2, presence, etc.), as well as their location. It also identifies the components required to connect the existing BACS to an ICT solution (in case of the eTEACHER project to the eTEACHER toolbox), specifying the integration activities needed and defining the monitoring plan to estimate the energy savings attained. Specifications are related to the knowledge of selecting, installing and integrating hardware (sensors and devices) to collect energy behaviour data from different types of buildings. The system also allows the integration of other information streams such as security sensors and smoke detectors.

First, a building characterization is needed focusing on the building's envelope (windows, fabric, facades), energy systems (lighting, heating, cooling, ventilating, appliances), monitoring and control systems, building use (schedule, activity, etc.) and occupants´ behaviour (users' profile, interaction with energy systems and building components, etc). The identification of potential eTEACHER users and energy savings is also part of the building characterization.

The procedure to do this building characterization consists of the following steps:

1. Definition of a generic template to collect information from the building, energy systems, monitoring and control system and occupants' behaviour.
2. Visit the building with the support of the technical manager to collect the information.
3. Evaluation of information to describe the energy behaviour of occupants.
4. Evaluation of technical details to integrate eTEACHER BACS add-ons and deploy the engagement solutions to change occupants' behaviour

Secondly, once the building characterization is done, the target behaviours and potential energy-related and IEQ-related improvements that want to be achieved in the building are defined. In addition, the high-level monitoring plan for the building can be finalised, customising the general approach for each specific building.

The novelty of this methodology lies in the inclusion of behaviour change concepts in the selection and installation of sensors in buildings, considering many types of buildings, contexts and users' profiles (occupants, facility managers or building owners).

Integration Methodology   Type: Building Design

While there are many initiatives oriented towards energy efficiency in buildings, many of them have been focusing only on the technical side, including the energy equipment and facilities and how to develop more intelligent control systems. The trend now is to put the user at the centre of all the technical developments.

In addition, this methodology focuses on the use of cost-effective devices (low-cost sensors with minimum accuracy and reliability at minimum cost), and is based on easy-to-install (plug&play) and easy-to-integrate (open protocols) solutions. It enhances the present (traditional) energy audit's impact by considering thermal comfort and IEQ, and not only energy savings.

Finally, this methodology can help obtain a long-term impact by optimising the end-user experience in buildings, improving their energy literacy, and encouraging their behaviour change, which is the way forward to a more sustainable built environment.

KER current status

Current Technology Readiness Level: 7

The methodology is already defined according to current market solutions. It can be exploited in both academic and commercial activities through further research, integration in energy audits, maintenance services, or training. This methodology should be revised and updated to incorporate new technologies that could be developed in the future, regarding sensors, monitoring systems, etc

.

Partners involved

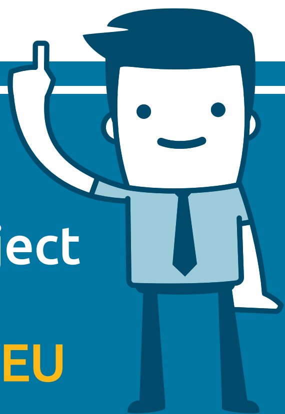
eTEACHER

End-users tools to empower and raise awareness of behavioural change towards energy efficiency

Project Coordinator
CEMOSA
coordinator@eteacher-project.eu

Communication Secretariat
FONDAZIONE ICONS
communication@eteacher-project.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 768738.



Learn more about the project
on eteacher-project.eu
and on Twitter @eteacherEU