Project Summary Report

EBC

Energy in Buildings and Communities Programme

EBC Annex 46

Energy Efficient Retrofit Measures For Government Buildings – Holistic Assessment Tool-Kit “Energo”

Alexander Zhivov

Energy in Buildings and
Communities Programme

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Project Summary Report

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About EBC

International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster co-operation among the twenty-eight IEA participating countries and to increase energy security through energy conservation, development of alternative energy sources and energy research, development and demonstration (RD&D).

Energy in Buildings and Communities

The IEA co-ordinates research and development in a number of areas related to energy. The mission of one of those areas, the EBC - Energy in Buildings and Communities Programme, is to develop and facilitate the integration of technologies and processes for energy efficiency and conservation into healthy, low emission, and sustainable buildings and communities, through innovation and research. (Until March 2013, the EBC Programme was known as the Energy in Buildings and Community Systems Programme, ECBCS.)
The research and development strategies of the EBC Programme are derived from research drivers, national programmes within IEA countries, and the IEA Future Buildings Forum Think Tank Workshop, held in April 2013. The R&D strategies represent a collective input of the Executive Committee members to exploit technological opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy conservation technologies. The R&D strategies apply to residential, commercial, office buildings and community systems, and will impact the building industry in five focus areas of R&D activities:

- Integrated planning and building design
- Building energy systems
- Building envelope
- Community scale methods
- Real building energy use

The Executive Committee

Overall control of the program is maintained by an Executive Committee, which not only monitors existing projects but also identifies new areas where collaborative effort may be beneficial. To date the following projects have been initiated by the executive committee on Energy Conservation in Buildings and Community Systems (completed projects are identified in grey):

Annex 1: Load Energy Determination of Buildings
Annex 2: Ekistics and Advanced Community Energy Systems
Annex 3: Energy Conservation in Residential Buildings
Annex 4: Glasgow Commercial Building Monitoring
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities
Annex 7: Local Government Energy Planning
Annex 8: Inhabitants Behaviour with Regard to Ventilation
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Annex 10: Building HVAC System Simulation
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Annex 15: Energy Efficiency in Schools
Annex 16: BEMS 1- User Interfaces and System Integration
Annex 17: BEMS 2- Evaluation and Emulation Techniques
Annex 18: Demand Controlled Ventilation Systems
Annex 19: Low Slope Roof Systems
Annex 20: Air Flow Patterns within Buildings

About EBC

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Annex 25: Real time HEVAC Simulation
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Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems
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Annex 29: Daylight in Buildings
Annex 30: Bringing Simulation to Application
Annex 31: Energy-Related Environmental Impact of Buildings
Annex 32: Integral Building Envelope Performance Assessment
Annex 33: Advanced Local Energy Planning
Annex 34: Computer-Aided Evaluation of HVAC System Performance
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT)
Annex 36: Retrofitting of Educational Buildings
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx)
Annex 38: Solar Sustainable Housing
Annex 39: High Performance Insulation Systems
Annex 40: Building Commissioning to Improve Energy Performance
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM)
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Annex 45: Energy Efficient Electric Lighting for Buildings
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Annex 49: Low Exergy Systems for High Performance Buildings and Communities
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings
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Annex 52: Towards Net Zero Energy Solar Buildings
Annex 53: Total Energy Use in Buildings: Analysis & Evaluation Methods
Annex 54: Integration of Micro-Generation & Related Energy Technologies in Buildings
Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance & Cost (RAP-RETRO)
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Annex 60: New Generation Computational Tools for Building & Community Energy Systems
Annex 61: Business and Technical Concepts for Deep Energy Retrofit of Public Buildings
Annex 62: Ventilative Cooling
Annex 63: Implementation of Energy Strategies in Communities
Annex 64: LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles
Annex 65: Long-Term Performance of Super-Insulation in Building Components and Systems

Working Group - Energy Efficiency in Educational Buildings
Working Group - Indicators of Energy Efficiency in Cold Climate Buildings
Working Group - Annex 36 Extension: The Energy Concept Adviser

General Information

Project leader: **Alexander Zhivov, Energy Branch US Army Corps of Engineers, USA**
Project duration: **2005 - 2009**
Further information: **www.iea-ebc.org**

The International Energy Agency (IEA) Energy in Buildings and Communities (EBC) programme project **"Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings"** is meant to influence the decision-making process in the retrofit of public and governmental buildings, which determines the use of energy-saving measures in building retrofits. This decision-making process must improve if it is to successfully cope with the challenges of increasing energy costs and climate change, and if it is to avoid "locking in" long-term commitment to energy inefficiencies by adopting sub-optimal renovations. Consequently, the project target group consists of all parties involved in this process, specifically, of all actors involved in this decision-making process, i.e., executive decision makers and energy managers of Government and Public buildings, performance contractors, suppliers, and designers. The purpose of the IT- "EnERGo" Toolkit is to support these different user groups, and to facilitate communication between them.

The IT-Toolkit "EnERGo" produced by the project is an electronic tool created to assist in the design of renovations/retrofits focusing on energy savings in government and public buildings. The tools contained in the IT-Toolkit provide guidelines for the whole decision-making process, beginning with identifying energy conservation opportunities (energy assessments/audits); then improving building indoor environments; comparing building use consumption with the national averages; calculating the energy use/energy efficiency that can be achieved through building retrofit using different combinations of energy efficiency technologies, and imple¬menting funding strategies for innovative energy projects using Energy Saving Companies. The IT-Toolkit contains a collection of different tools and documents that identify typical areas of energy waste and inefficiency in buildings, and lists of poten¬tial solutions to specific energy-related problems. The Toolkit contains descriptions of retrofit/renovation projects and provides a varied selection of energy conservation measures. The "EnERGo" IT-Toolkit addresses:

- Performance Rating
- Electronic Building Inspection Protocol
- Operation and Maintenance Checklist
- Energy and Process Assessment Protocol
- Retrofit Case Studies
- Database of Energy Conservation Measures
- Energy Efficiency Calculator for Building Retrofit
- Guide for ESCO Projects
- Calculation Tool for Energy Performance Contracts
- ESCO Case Studies.

Seven countries participated in the project and in the creation of the IT-Toolkit: Canada, Denmark, Finland, France, Germany, Italy and the USA. The list of all persons involved in the development of the IT-Toolkit is included in the information section.

Acknowledgements

The IT-Tool-kit "EnERGo" is result of work done for the ECBCS project, "Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings."

Appreciation is owed to a great many contributors, whose assistance and generous contributions have brought this work to a successful conclusion. Many energy experts from different countries have contributed to the project by their participation in presentations and discussions at the Annex 46 workshops and seminars, by their participation in the American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) Technical Committee 7.6 semiannual Working Group meetings, and by reviewing and

Participating Countries:

Canada
Denmark
Finland
France
Germany
Italy
USA

Observer: Russia

providing valuable comments on the materials that comprise the IT-Tool-kit. The final section of this document (p 20) lists the Annex 46 workshops and seminars; the content of these presentations and seminars is accessible through URL: http://www.annex46.org/workshops_seminars/

The IT-Tool-kit "EnERGo" would not have been possible without support from the members of the Executive Committee and the respective funding bodies. The authors want to acknowledge the financial and other support from the U.S. Army Installation Management Command (IMCOM), International Centre for Indoor Environment and Energy of the VTT Technical Research Centre of Finland, Fraunhofer Institute of Building Physics (IBP, Stuttgart), Public Works and Government Services Canada (PWGSC), Ecole Nationale des Travaux Publics de l'Etat (National School of Civil Engineering, ENTPE, Lyon), and Politecnico di Milano.

Project Outcomes

Project leader: Alexander Zhivov, Energy Branch US Army Corps of Engineers, USA
Project duration: 2005 - 2009
Further information: www.iea-ebc.org

Background

The energy efficiency of government and public buildings must be improved to successfully cope with increasing energy costs and mitigate climate change. Such non-residential buildings (i.e., office buildings, production and maintenance facilities) individually consume significantly more energy than typical residential buildings. Thus they pose some specific challenges to those seeking improved energy management and building energy performance. Particular issues for this sector are that:

- Lighting and ventilation / air-conditioning are more important energy uses in these buildings than in residential buildings.
- Most non-residential buildings are typically large and require sophisticated building automation systems.
- Building automation systems frequently include energy management, but concentrate on satisfactory operation rather than on energy efficiency.
- Total building energy use is heavily influenced by the ventilation requirements and building-specific processes and applications, especially in production and maintenance facilities, restaurants and data centers, hospitals and clinics, etc.
- The processes usually function satisfactorily, but tolerate waste and inefficiency.

A common issue in such buildings is that concerns about energy use generally take second place to, and are seen as incompatible with, goals of maintaining occupant comfort or building functionality. This tendency is most pronounced in the existing building stock. Decisions to retrofit a building are often made in response to dissatisfaction concerning comfort level, or changes in building usage or processes; the primary goal being to improve these conditions. Before decision makers will consider energy conservation in buildings as a primary goal, they must overcome their reservations about the compatibility of energy conservation with occupants' comfort and productivity, and building functionality. They need to see convincing, real-world examples of how measures that reduce energy use can also improve comfort and functionality. Good technologies that meet these requirements are already available. The main obstacle to their implementation is a simple lack of knowledge of their intelligent application. Adoption of energy efficiency measures needs to be integrated into facilities management with long-term planning for common retrofit measures when updating the building fabric, services, and processes. This needs to become part of normal operations, maintenance, and building use.

There is a wide variety of possible retrofit options for any given type of building. ('Retrofit measure' means here the full range of possibilities for energy-related refurbishment, renovation, or retrofit.) For every possible retrofit measure, there is an installation cost and a payback time that can vary greatly depending on the building type and the climatic zone in which the building is located. Additionally, the combined effect of different retrofit measures can be lower or greater than each applied in isolation. A decision to implement a retrofit measure often implies a long term commitment as part of facilities maintenance and management. It is very important to select optimal retrofits for each application.

Public models (of which government buildings are an example) can influence a society's values. Government buildings can exemplify the intelligent application of energy-efficient technologies. Private sector individuals are more likely to adopt energy-saving technologies when they can see how Government authorities have constructively addressed energy problems. It is particularly important for Government buildings to demonstrate exemplary solutions and showcase them to the public. In other words, it is not only important to do something positive, but also to take the necessary steps to promote it. Government buildings can potentially change public opinion, and thereby help increase the market penetration of energy-saving technologies.

A new decision-making toolkit

The “EnERGo” Information Technology (IT)-Tool-kit was created to provide decision makers with comprehensive, easily accessible information on renovation/retrofit energy conservation opportunities. The Tool-kit provides guidelines for the whole decision-making process involved in identifying energy conservation opportunities and improving building indoor environments through retrofitting projects to improve energy-efficiency.

The Performance Rating tool (Figure 1) allows the comparison of a given building’s consumption to a national average. Consumption data for heat, electricity and water are provided for different types of buildings, although water consumption data are not available for every country. Performance data (in either SI- or IP-units) are available for a total of 12 countries.

While the complete dataset required to analyze older building retrofit concepts may sometimes be available, a detailed building inspection (following the Electronic Building Inspection Protocol, provided in EnERGo) is often the only way to assemble all the data required for a calculation or simulation of the building.

The Operation and Maintenance Best Practices Checklist (Figure 2) is a guide to provide users with key information about operation and maintenance (O&M) management, technologies, and energy efficiency and cost-reduction approaches. It contains information on why O&M is important and on the potential for savings when

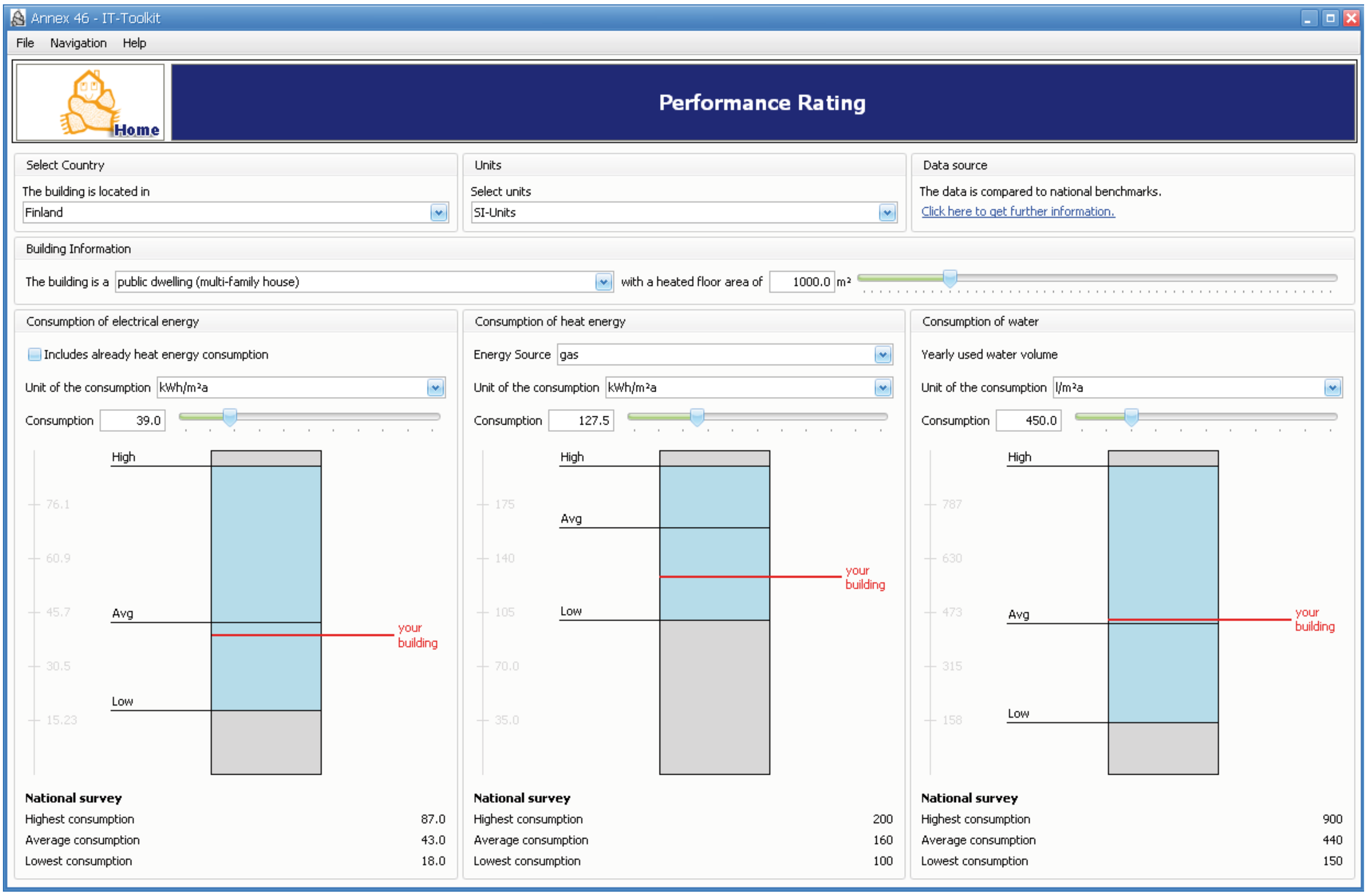


Figure 1. Performance rating tool.

Project Outcomes

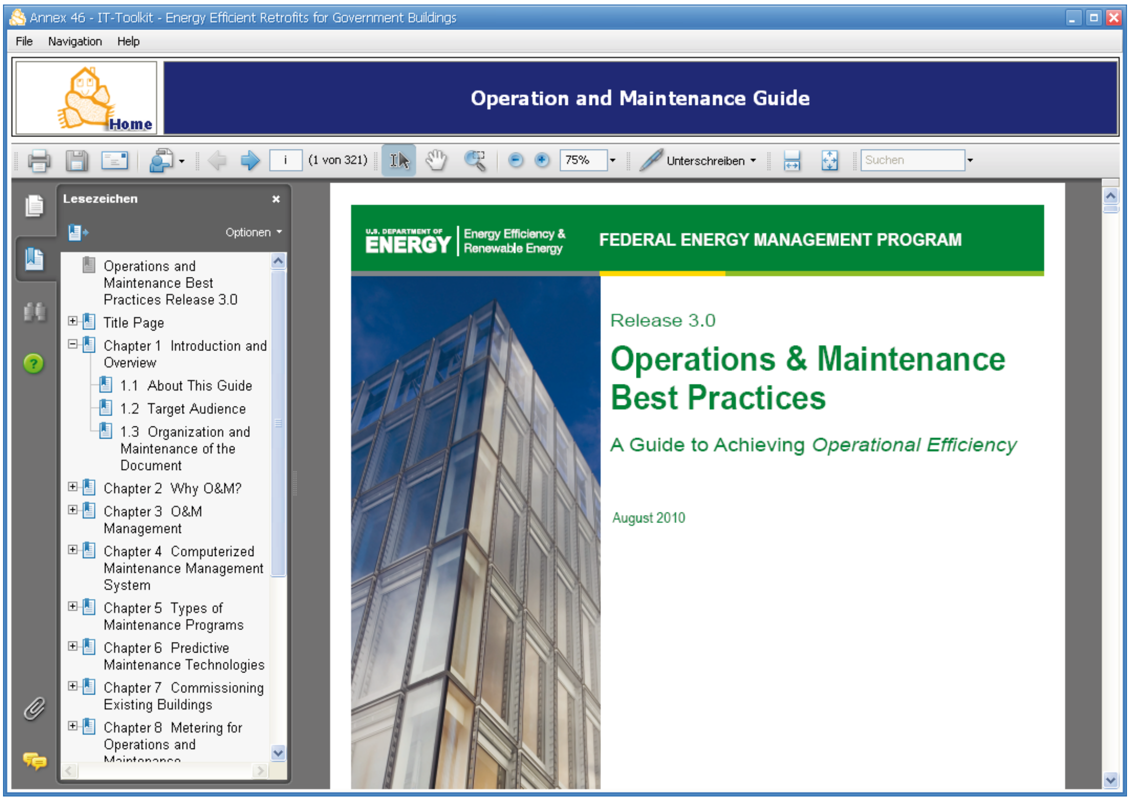


Figure 2. Operations and Maintenance Best Practices.

it is properly applied. Furthermore, it defines the major types of O&M programme and provides guidance on best practices and on how those practices should be structured. It also provides information on state-of-the-art maintenance technologies and procedures for key equipment, and identifies information sources and points of contact to assist with carrying out the work.

The Energy and Process Assessment Protocol (Figure 3) provides an energy assessment methodology and procedure suitable for different types of sites, including:

- a variety of different non-industrial buildings with energy requirements dominated by climate, and
- industrial buildings that have high energy loads dominated by internal processes, and high ventilation requirements per unit floor area.

This Protocol has documented resource-consuming activities, identified wasteful practices, and developed tools for classifying and prioritizing energy conservation opportunities and measures. The Protocol has addressed several different energy assessment scopes (building stock, individual building, system, and component), and three depth levels of assessment. The Protocol discusses the motivations behind undertakings on each level, and also the expected results and the degree of effort and instrumentation required in the assessment. It specifies procedures and calculation tools, and suggests the format for the report that will document the assessment findings.

Appendices to the Protocol include different practical information and supporting documents, e.g., forms for data collection, descriptions of typical wastes and inefficiencies, guides for evaluating the building air tightness, application of thermography for energy assessments, and guidelines for sealing air leakages.

Six hundred paper copies of the book were published and distributed internationally. The ASHRAE has published and is selling a color version of the book as an IEA ECBCS Annex 46 product. The Protocol has been adopted by the U.S. Army to help streamline energy assessments at multiple installations under the

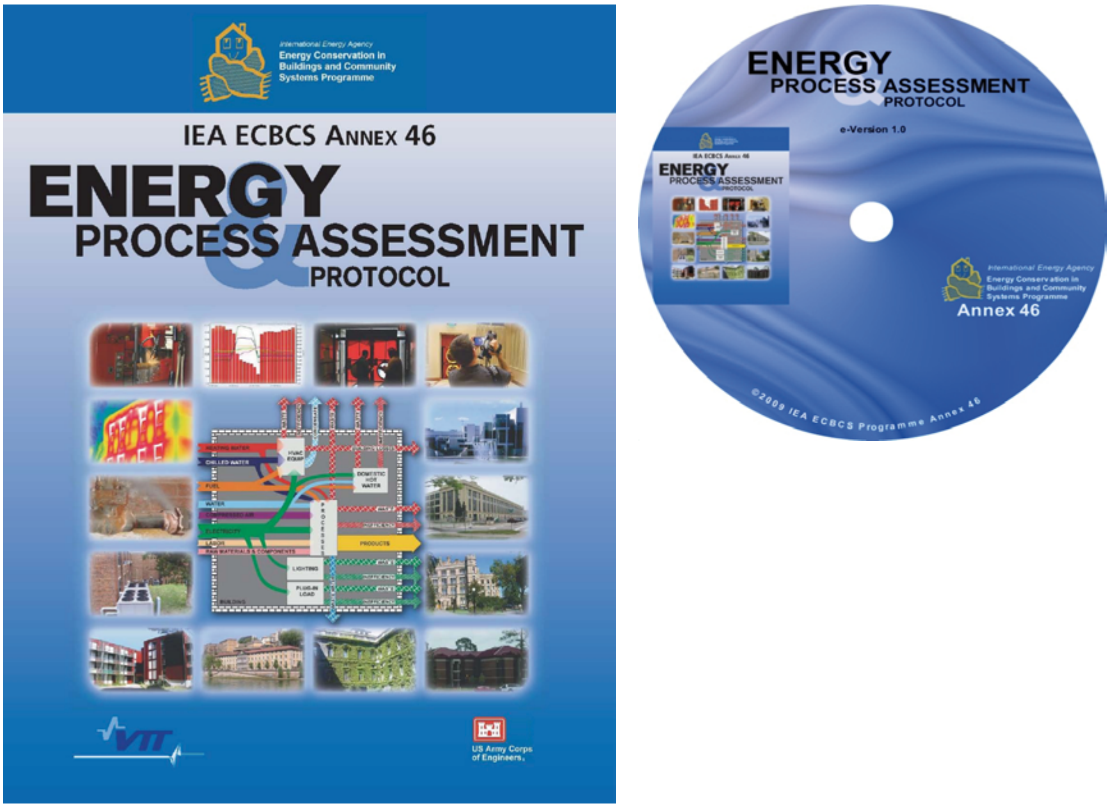


Figure 3. Cover of "Energy and Process Assessment Protocol" book and CD-ROM.

Energy Engineering Analysis Program, and also to showcase assessments conducted under the Annex 46 supervision by multi-national teams in Germany, Italy, Japan, and the Republic of Korea. Training Materials based on the Protocol have been published as a separate CD-ROM, and both the book and CD-ROM have been used to train energy auditors.

A Database of more than 400 promising Energy Conservation Measures and energy saving technologies (current, proven, well known, or under-used) has been developed (Figure 4). The database summarizes international experience of building retrofit, and includes the technologies or measures that can be categorized as:

- building envelope
- internal load reduction
- lighting
- HVAC systems
- energy consuming processes in the building
- supplemental energy systems (e.g., compressed air, steam system), etc.

For each energy conservation measure, there is either a short description or a more detailed screening analysis. The detailed screening report includes a technology description, qualitative and quantitative (simulation based) analysis of energy savings, and simple payback by climate and building/system type. Analyzed technologies include:

- wall, roof and attic insulation
- improved building air tightness
- advanced windows
- cool roofs
- insulation for supply / return ducts and hot / cold water pipes
- exhaust air heat recovery and heat recovery from condensing units
- grey water heat recovery from showers
- direct and indirect evaporative cooling
- hydronic radiant heating / cooling panels
- dedicated outdoor air systems with radiant cooling and with fan-coil units
- ground source heat pumps
- replacement of incandescent lamps with compact fluorescents
- intelligent lighting controls with daylight, exterior lighting control, spectrally enhanced lighting, etc.

Project Outcomes

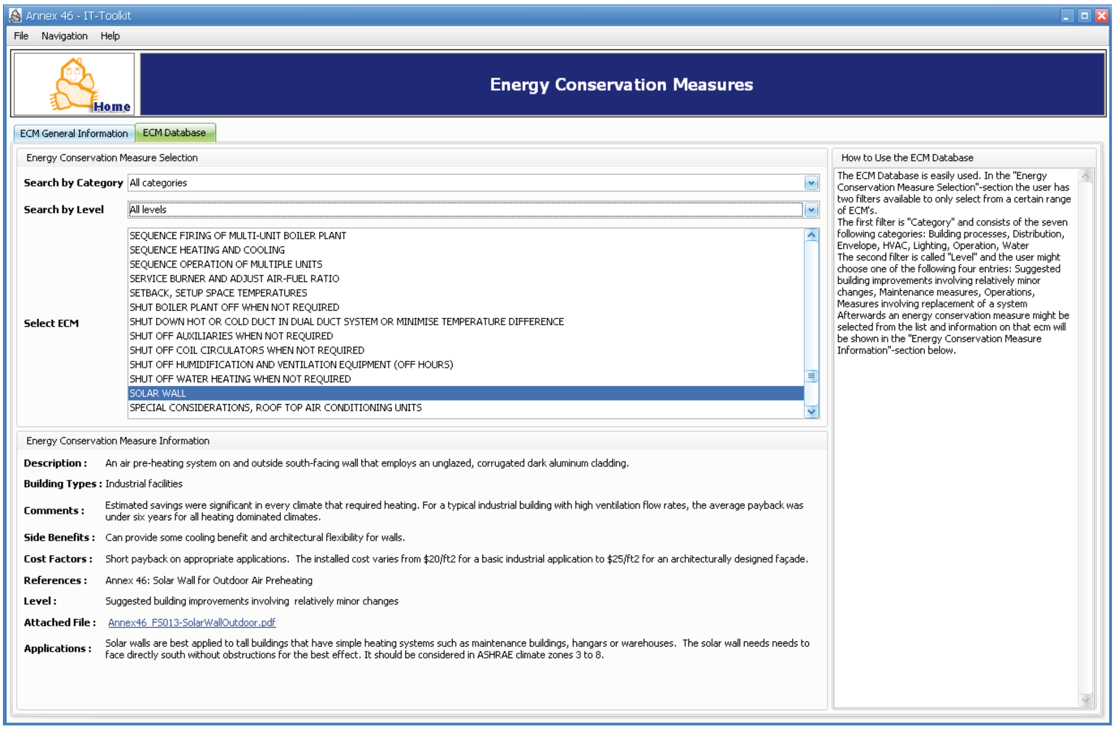


Figure 4. Screenshot of the Energy Conservation Measures database.

The EnERGo IT-Toolkit includes more than 35 case studies describing application of different energy conservation technologies in retrofit projects that were developed, 32 additional case studies produced by the ECBCS Annex 36 project "Retrofitting in Educational Buildings – Energy Concept Adviser for Technical Retrofit Measures," and eight case studies developed

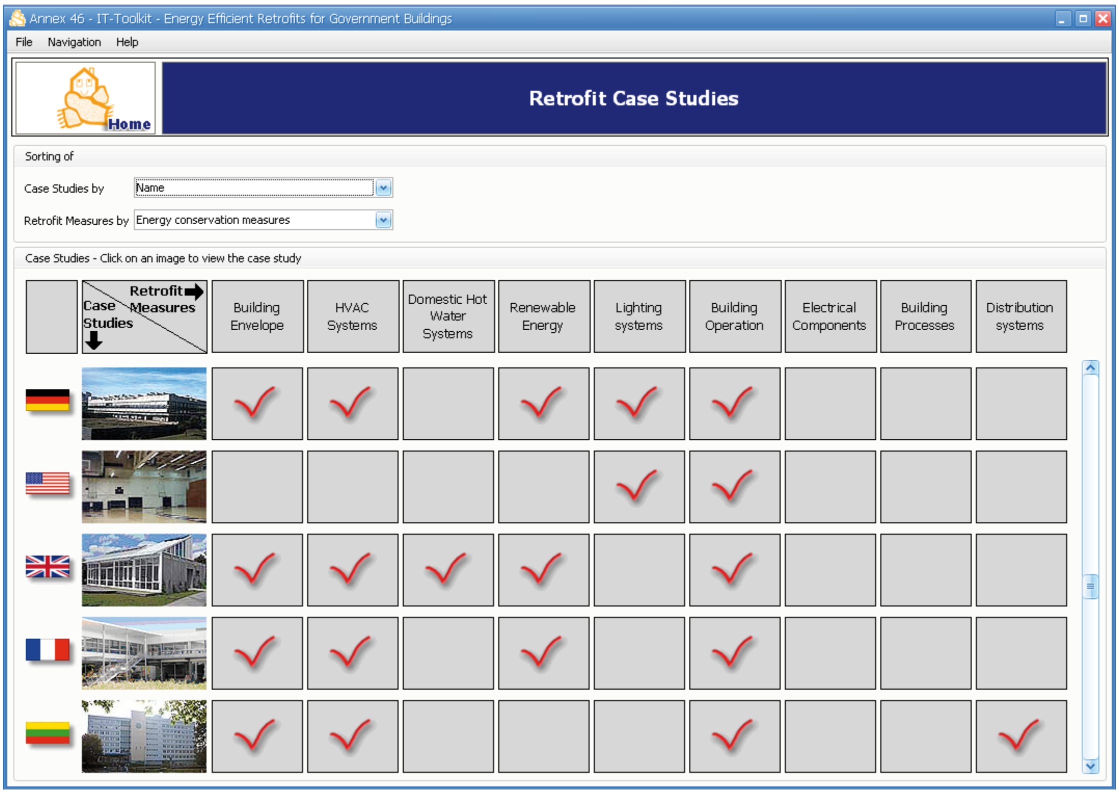
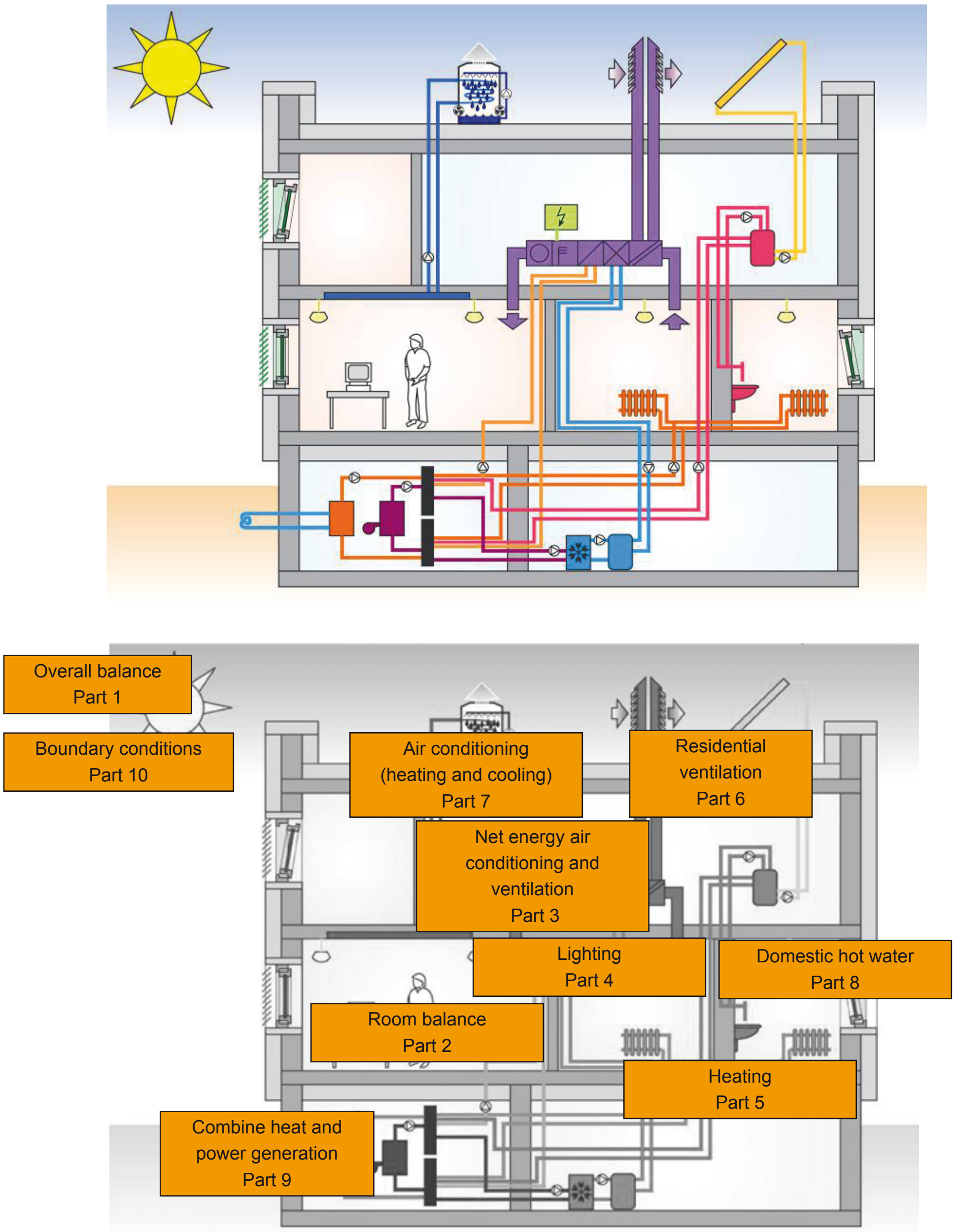


Figure 5. Retrofit case studies: Selection matrix and report.

Figure 6. Tool for calculation of building net energy, delivered energy and primary energy for heating, cooling, ventilation, domestic hot water and lighting.

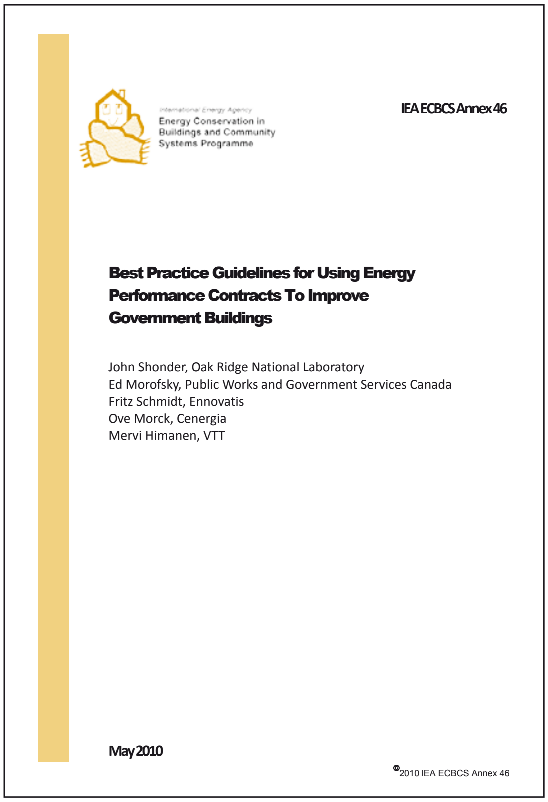


under the European project, “BRITA in PuBs.” All 75 case studies contain information on the building site, the retrofit concept, the retrofit cost, energy savings, lessons learned, and general information on retrofitted buildings. Case studies can be selected from a selection matrix (Figure 5), which shows the types of retrofit measures used in each.

The Energy Efficiency Calculator for Building Retrofit (Figure 6) is based on the German energy performance standard DIN V 18599, which provides a holistic interdisciplinary methodology for the assessment of energy efficiency of non-residential buildings. Each building is divided into representative zones which combine building areas with a similar utilization and conditioning (heating, cooling, ventilation, and lighting). For each zone, the energy demand for heating, domestic hot water, air-conditioning, and lighting is calculated assuming either user-defined or default utilization profiles. Thermal properties of the building envelope play a significant role in the calculation. The total energy to be provided for the whole building is calculated, considering mutual interactions between the zone and the installed building services systems.

The assessment of the energy sources used, which considers the fuel value and its environmental compatibility, weighs the amount of energy with its primary energy factors to yield the primary energy demand. The primary energy demand gives information on the total energy efficiency of a given building. The IT Toolkit provides a single-zone model version of this calculator as shareware. For the participant countries, a special licensed multi-zone model version is available via the national contact person in the project.

If limited funding is a problem, one possible solution might be to use an Energy Performance Contract (EPC), which is a financing mechanism used to install energy conservation measures at a site. These conservation measures generate energy-related cost savings, which are then used


Energy Conservation in Buildings and Community Systems Programme

IEA ECBCS Annex 46

Best Practice Guidelines for Using Energy Performance Contracts To Improve Government Buildings

John Shonder, Oak Ridge National Laboratory
Ed Morofsky, Public Works and Government Services Canada
Fritz Schmidt, Ennovatis
Ove Morck, Cenergia
Mervi Himanen, VTT

May 2010

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Figure 7. Best Practice Guidelines for Using Energy Performance Contracts to Improve Government Buildings.

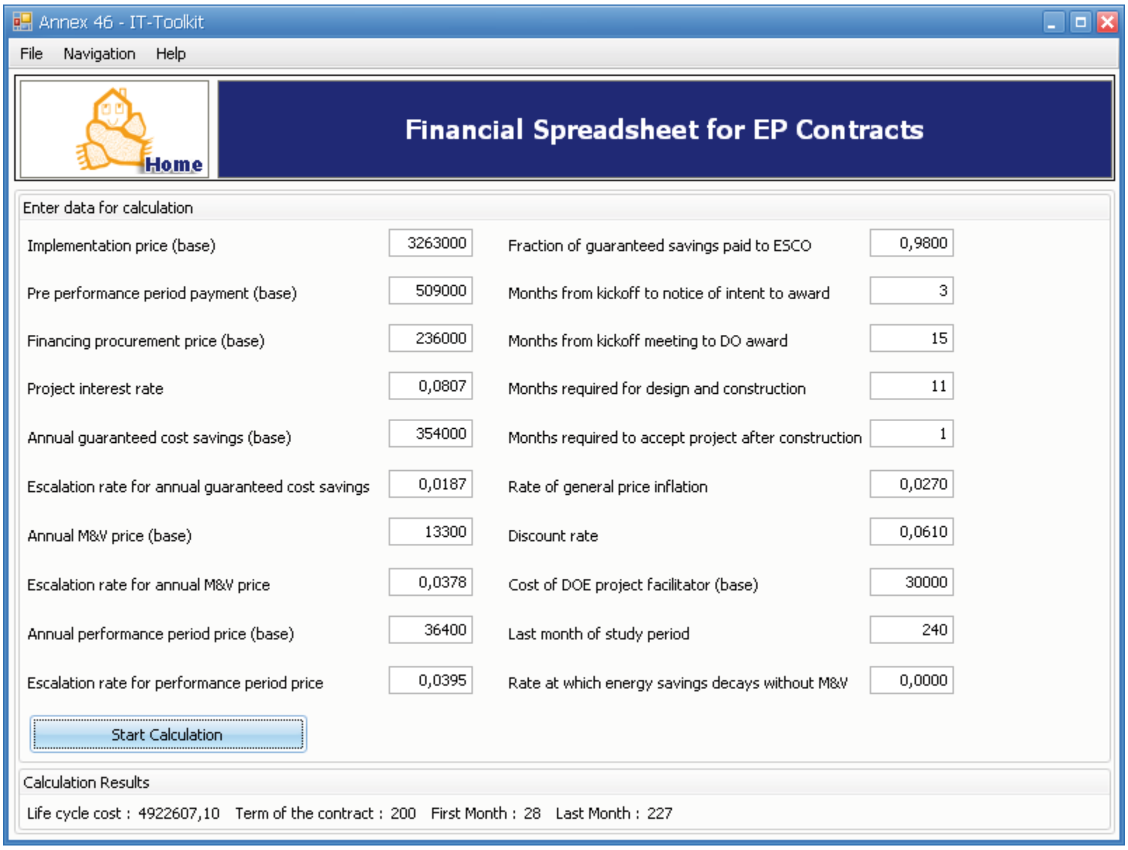

Figure 8. Financial spreadsheet for EP contracts.

to pay financing costs on the loan and to fund services such as operations and maintenance (O&M) and measurement and verification (M&V). In addition to the Best Practice Guide (Figure 7), EnERGo includes a Calculation Tool in spreadsheet form (Figure 8) that allows detailed cost calculations of planned retrofit measures. Based on cost, interest rate and savings, the calculator determines the length of time required to pay off an EPC. The "EnERGo" Toolkit also includes 18 detailed case studies of EPCs that can be used for familiarization with the concept of using private capital to improve the energy efficiency of government buildings.

Analysis of various international practices shows that the primary motivations for using EPCs are a lack of:

- funding for energy efficiency upgrades
- expertise on the part of building managers in development of energy efficiency projects
- personnel to operate installed equipment.

Given the motivation behind using EPCs, the Best Practices Guide describes the most common energy efficiency measures installed under an EPC, and the typical implementation process. The basic steps in this process are very similar across all of the governments that participated in the Annex. The main part of the document describes the Best Practices for Innovative Energy Performance Contracts:

- Pre-Negotiated / Model Contracts
- Training and Assistance
- Competition
- Measurement and Verification (M&V), which is a key to success in EPC.

Finally, the document recommends a program of continuous improvement. Government EPC programs operate in a dynamic environment in which interest rates, available technologies, and project requirements change rapidly. Continuous monitoring of the program to collect statistics on key parameters such as prices, interest rates, and delivery of savings helps governments respond to challenges and increases the value of future projects.

Conclusions

The IT-Toolkit is a helpful asset in calculating and evaluating energy saving potentials in existing public and governmental buildings during the development of retrofit/renovation projects. The Toolkit provides decision makers with reliable information on conventional and innovative strategies and technologies, and thereby improves planning reliability. The "EnERGo" Toolkit is available free of charge via the EBC Annex 46 website www.iea-ebc.org.

This website also provides useful background information derived from numerous workshops and seminars sponsored by the ECBCS Annex 46 (and listed in the following section).

Project Outcomes

Further Information

EnERGo IT-Toolkit, 2011

Alexander Zhivov, Jorma Pietilainen, Erja Reinikainen, Fritz Schmidt, Alfred Woody, Energy Process Assessment Protocol, Energy Branch US Army Corps of Engineers, 2009

John Shonder, Ed Morofsky, Fritz Schmidt, Ove Morck, Mervi Himanen, Best Practice Guidelines for Using Energy Performance Contracts To Improve Government Buildings, Energy Branch US Army Corps of Engineers, 2010

Project Reports

www.iea-ebc.org

Project Participants

Category	Organisation
Canada	Public Works and Government Services Canada McMaster University
Denmark	Cenergia Energy Consultants Dansk Energi Analyse A/S Centre for Indoor Environment and Energy Danish Building Research Institute
Finland	International Centre for Indoor Environment and Energy (VTT)
France	Ecole Nationale des Travaux Publics de l'Etat, ENTPE
Germany	Fraunhofer Institute of Building Physics Ennovatis GmbH Schiller Engineering
Italy	Politecnico di Milano
USA	US Army Engineer Research & Development Center (CERL) Department of Energy Federal Energy Management Program Oak Ridge National Laboratory Oklahoma State University National Renewable Energy Laboratory Naval Facilities Engineering Command Naval Facilities Engineering Service Center Ventilation/Energy Applications

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