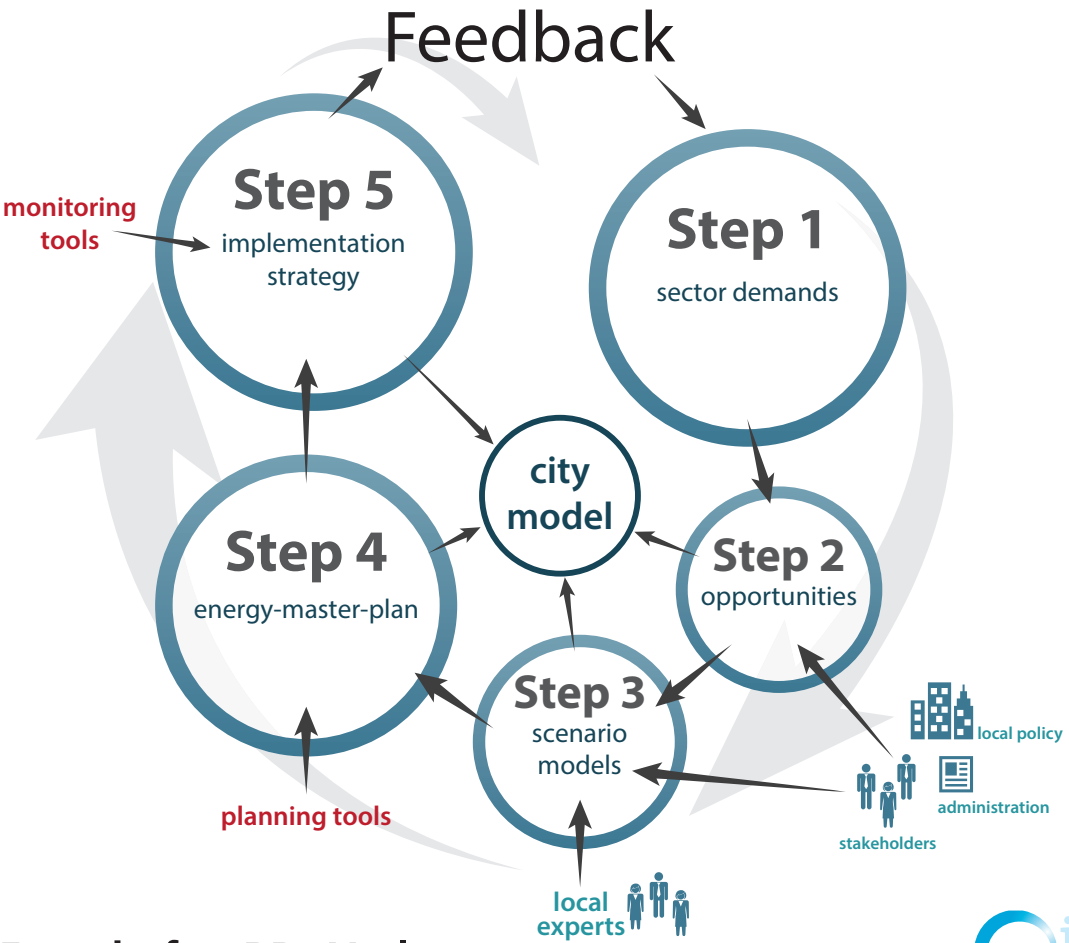
EBC

Energy in Buildings and Communities Programme

Case Studies and Guidelines for Energy Efficient Communities

A Guidebook on Successful Urban Energy Planning

IEA EBC ANNEX 51



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Case Studies and Guidelines for Energy Efficient Communities

A Guidebook on Successful Urban Energy Planning

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Participating countries in EBC:

Australia, Austria, Belgium, Canada, P. R. of China, Czech Republic, Denmark, Finland, France, Germany, Greece, Rep. of Ireland, Republic of Korea, Japan, The Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States of America.

Preface

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 in Buildings and Communities (completed projects are identified by (*)):

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 (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)

Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
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 (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
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) (*)
Annex 43: Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
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)
Annex 56: Cost Effective Energy & CO_2 Emissions Optimization in Building Renovation
Annex 57: Evaluation of Embodied Energy & CO_2 Emissions for Building Construction
Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements

Annex 59: High Temperature Cooling & Low Temperature Heating in Buildings
Annex 60: New Generation Computational Tools for Building & Community Energy Systems Based on the Modelica & Functional Mockup Unit Standards
Annex 61: Development & Demonstration of Financial & Technical Concepts for Deep Energy Retrofits of Government / Public Buildings & Building Clusters
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 (*)

(*) – Completed

Acknowledgements

As described above, this Guidebook is the result of an international co-operation in the framework of the International Energy Agency. Based on Annex 51 of IEA's EBC program, 10 participating countries brought together their expertise gathered in many local energy planning projects to share experiences and draw lessons from these. The involved national experts and the institutions where they are engaged are presented in the table below:

Country	Research Group	Participants
Austria	SIR - Salzburger Institut für Raumordnung und Wohnen; AIT Austrian Institute of Technology GmbH, Vienna	*H. Strasser* *O. Pol*
Canada	Natural Resources Canada (NRCan), Ottawa	*K. Church,* *J. Webster*
Denmark	Danish Technical University, Copenhagen	*S. Svendsen,* *A. dalla Rosa*
Finland	VTT Technical Research Centre of Finland, Helsinki	*J. Nieminen*
France	EiFER European Institute for Energy Research, KIT Karlsruhe	*P. Girault,* *A. Koch*
Germany	Fraunhofer Institute (FhG) IBP, Stuttgart, Fraunhofer Institute UMSICHT, Oberhausen; pro:21 GmbH, Bonn; VOLKSWOHNUNG Karlsruhe GmbH	*H. Erhorn-Kluttig,* *H. Erhorn; C. Beier;* *A. Dütz, Th. Bloch,* *L. Jank;* *R. Jank*
Japan	Yokohama National University; Tokyo Gas Co., Ltd.	*S. Sadohara;* *R. Kuzuki*
Sweden	University of Linköping	*B. Moshfegh,* *H. Zinko*
The Netherlands	Hogeschool Zuyd (HS Zuyd), Heerlen; Cauberg Huygen b.v., Maastricht	*J. Kimman, W. Broers;* *E. Willems*
USA	US Army Corps of Engineers, Champaign, IL	*A. Zhivov*

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The different chapters of this Guidebook have been written by different authors and co-authors, as specified in the table of contents. The responsibility to structure the whole book and to edit the different contributions was with the Guidebook editing team, Prof. Jacques Kimman (NL), Armand Dütz (D) and Reinhard Jank (D).

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As it is experienced in many co-operative projects of this kind, when most of the work is done, the tedious work of cross-reading, error search, consistency checks etc. is left to a few persons who are engaged in bringing this product to a final shape that is withstanding the professional standards of the intended audience. In this specific case, with authors who predominantly are not native English

speakers, it is all the more important to have a supporter who was able to overcome language barriers, streamline everybody's contributions and achieve the textual clarity that is necessary to enable a widespread dissemination in the professional world. This supporter was Jessica Webster of Natural Ressources Canada, Ottawa, who not only was engaged in the writing of one of the Guidebook's chapters (about energy modelling tools) but who also worked through the whole allegedly 'final' body of text to bring it into a form that was ready for print. All of us, co-operating in this Annex 51, but in particular I myself as Operating Agent of this Annex, are deeply indebted to Jessica for her enduring dedication and, in particular, for her excellent sense of language that allowed her to understand what was meant by sometimes clumsy phrasing and to transform it into an English text that is a joy to read. Thank you very much, Jessica!

Karlsruhe, October 2013
Reinhard Jank
Operating Agent, Annex 51

List of Abbreviations

ADEME	Agence de l'Environnement et de la Maìtrise de l'Energie
BAFA	*Bundesamt für Wirtschaft und Ausfuhrkontrolle*
BAT	Best Available Technology
BAU	Business As Usual
CAD	Canadian Dollar
BC	British Columbia
BIPV	Building Integrated Photovoltaics
CCA	Capital Cost Allowances
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamps
CHF	Swiss Franc
CoM	Covenant of Mayors
DC	Direct Current
DCC	Development Cost Charges
DCF	Danish Carbon Fund
D-ECA	District Energy Concept Adviser
DHW	Domestic Hot Water
DKK	Danish Krone
DPA	Development Permit Area
DSM	Demand Side Management
EBC	Energy Conservation in Buildings and Community Systems (IEA Implementing Agreement)
EDF	Electricité de France
eea	European Energy Award
EECBG	Energy Efficiency and Conservation Block Grant Program (United States)
EEEF	European Energy Efficiency Fund
EEG	*Erneuerbare Energien-Gesetz* (Renewable Energy Sources Act)
EiFER	European Institute for Energy Research (a joint initiative of EDF France and the Technical University of Karlsruhe)
EnEV	*Energieeinsparverordnung*
ERDF	European Regional Development Fund
ERS	Energy Rating System (Canada)
ESF	European Social Fund
ESCOs	Energy Service Companies
EU	European Union
EUR	European Euro
FCM	Federation of Canadian Municipalities
FIT	Feed-In Tariff
GHG	Greenhouse Gases
GIS	Geographical Information Systems
GMF	Green Municipal Fund
HfT	*Hochschule für Technik*, Stuttgart (University of Applied Sciences)
ICLEI	Local Governments for Sustainability (former: International Council for Local Environmental Initiatives)
IEA	International Energy Association
IEE	Intelligent Energy Europe
JI	Joint Implementation
JHF	Housing Finance Agency (Japan)
JPY	Japanese Yen
KfW	*Kreditanstalt für Wiederaufbau*
KWKG	*Kraft/Wärme-Kopplungs-Gesetz* (German Cogeneration Act)
LCA	Life Cycle Analysis
LED	Light Emitting Diode
LEP	Local Energy Planning

LIC	Local Improvement Charges
LiDAR	Light Detection and Ranging
LIP	Local Investment Program (Sweden)
METI	Ministry of Economy, Trade and Industry (Japan)
NB	New Brunswick
NEDO	New Energy and Industrial Technology Development Organization (Japan)
ORC	Organic Rankine Cycle
PCP	Partners for Climate Protection
PPP	Public Private Partnerships
PV	Photovoltaics
R&D	Research and Development
REITs	Real Estate Investment Trusts
ROI	Return On Investment
SEK	Swedish Krona
SFB	*Stromsparfonds Basel* or Basel Electricity Savings Trust
SIA	*Schweizerischer Ingenieur- und Architektenverein* (Swiss Association for Engineers and Architects)
USD	United States Dollar

Energy Related Abbreviations

ΔE – difference in energy use (before and after the implementation of specific energy-related measures)

CHP – Combined Heat and Power

EPBD – Energy Performance of Buildings Directive

DC – direct current

DH - district heating

DHW – domestic hot water

h^{-1} – per hour

kWh – kilowatt hour

kWh/(m²·a) – kilowatt hour per square meter per year

kW_p– power production of PV modules at maximum (peak) solar irradiation

m² – square meter and m^3 – cubic meter

MWh – megawatt hour and MWh/a – megawatt hours per year

TWh – terawatt hour and TWhel – terawatt hour of electric energy

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