Energy in Buildings and Communities Programme

International Energy Agency

Strategic Plan 2014 – 2019

Energy in Buildings and Communities Programme

October 2013

EBC is a programme of the International Energy Agency (IEA)

EBC

Energy in Buildings and
Communities Programme

International Energy Agency

Strategic Plan 2014 – 2019

Energy in Buildings and Communities Programme

October 2013

Edited by
Dr. Takao Sawachi
EBC Vice-Chair
on behalf of the IEA EBC Programme Executive Committee

iea
Energy Technology Network

Cover picture: Visualisation of heat demand of refurbished and non-refurbished buildings. Source: HFT Stuttgart research and city of Ludwigsburg, Germany.

Published by AECOM Ltd, AECOM House, 63 - 77 Victoria Street, St Albans, Hertfordshire AL1 3ER, United Kingdom

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

Additional copies of this report may be obtained from:

EBC Bookshop
C/o AECOM Ltd
Colmore Plaza
Colmore Circus Queensway
Birmingham B4 6AT
United Kingdom
www.iea-ebc.org
essu@iea-ebc.org

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 international co-operation among the 28 IEA participating countries and to increase energy security through energy research, development and demonstration in the fields of technologies for energy efficiency and renewable energy sources.

The IEA Energy in Buildings and Communities Programme

The IEA co-ordinates research and development in a number of areas related to energy. The mission of the Energy in Buildings and Communities (EBC) 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 IEA-EBC Programme was known as the Energy in Buildings and Community Systems Programme, ECBCS.)
The research and development strategies of the IEA-EBC Programme are derived from research drivers, national programmes within IEA countries, and the IEA Future Buildings Forum Think Tank Workshops. The research and development (R&D) strategies of IEA-EBC aim to exploit technological opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy efficient technologies. The R&D strategies apply to residential, commercial, office buildings and community systems, and will impact the building industry in five focus areas for 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 IEA-EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA-EBC Implementing Agreement. At the present time, the following projects have been initiated by the IEA-EBC Executive Committee, with completed projects 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 (*)
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 (*)
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
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
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
Annex 66: Definition and Simulation of Occupant Behavior in Buildings

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 (*)

Management Summary

Within the framework of the International Energy Agency (IEA)[1] the Energy in Buildings and Communities (EBC)[2] Programme is conducting collaborative research projects among its 26 member countries. Its mission is to accelerate the transformation of the built environment towards more energy efficient and sustainable buildings and communities, by the development of knowledge and technologies through international collaborative research and innovation.

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 for the 5 years term of 2014 to 2019 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 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 66 projects have been initiated within the EBC programme.

[1] 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 28 IEA participating countries and to increase energy security through energy conservation, development of alternative energy sources and energy research, development and demonstration (RD&D).

[2] Until March 2013 known as Energy Conservation in Buildings and Community Systems, ECBCS.

Contents

1. Introduction

The member countries of the IEA Energy in Buildings and Communities Implementing Agreement share many research and development (R&D) requirements that are necessary to support more effective policies to improve building energy performance. A common understanding of the future R&D needs to support such policies is provided by this Strategic Plan.

In the five years since the creation of the previous Strategic Plan 2007 - 2012[1] of the International Energy Agency (IEA) Energy in Buildings and Communities (EBC) Programme, the buildings sector has become widely recognized as having a large potential to reduce its energy use and related carbon dioxide (CO_2) emissions at relatively low cost in comparison with other sectors. In reports issued by global stake holders, including the IEA and the International Panel on Climate Change (IPCC), this has been clearly acknowledged and quantified.

The IEA Energy in Buildings and Communities Programme responds to these expectations and pressures by creating concrete and focused R&D strategies for the next five year period between March 2014 and February 2019. This is to support the realization of the energy savings potential of the buildings sector and to provide the scientific foundation for the transformation of the international energy economy.

1 Continued into 2013 as the corresponding term of operation has been extended until February 2014

2. Current Environment, Barriers and Challenges

2.1 IEA Perspectives

The 'ETP 2012 2°C Scenario' (2DS) is the climate change mitigation scenario under which the globally agreed target limiting the average global temperature increase to 2°C in 2050 would be met. 2DS is the primary focus of the IEA's Energy Technology Perspectives 2012, in which the following three areas have been identified as essential to achieving it (IEA, 2012):

- Decentralized, but highly integrated smarter energy systems
- Transforming and decarbonising electricity systems
- Dramatic improvement of energy efficiency

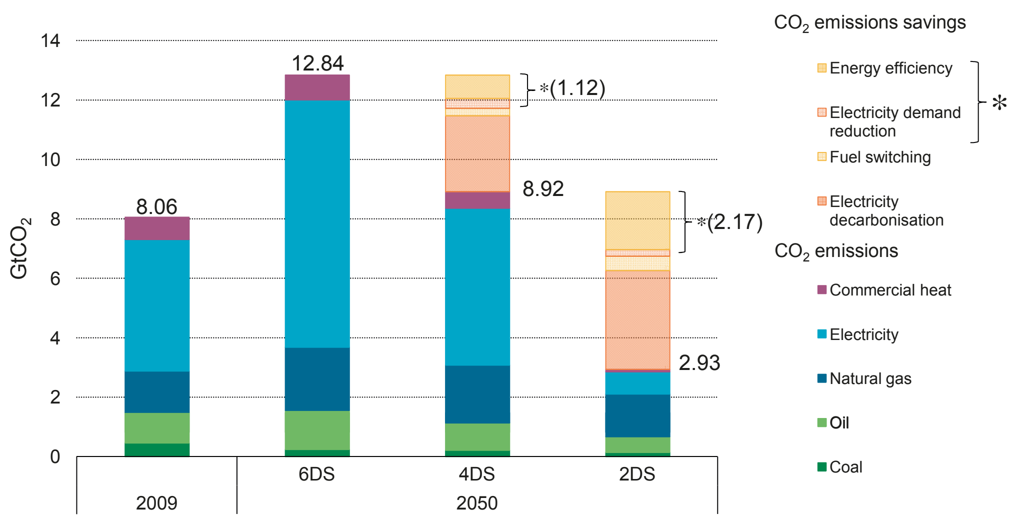

Figure 1. Buildings sector CO_2 emissions and reductions by 'Energy efficiency' and 'Electricity demand reduction' (source: IEA, 2012)

Among these three areas, the third would seem to be most relevant to buildings and communities.

Buildings sector energy-related CO_2 emissions in 2009 and under different scenarios for 2050 are shown in Figure 1. The global energy-related CO_2 emissions from the sector in 2009 (including indirect upstream emissions from electricity and heat generation) was 8.06 GtCO2, which accounts for 26% of the total global energy-related CO2 emissions, including both OECD and Non-OECD countries (31 $GtCO_2$ according to IEA, 2012). According to 6DS (the scenario limiting the average global temperature increase to 6°C in 2050), which assumes only policies and actions that are currently in place continue, global buildings sector CO_2 emissions would increase to 12.84 $GtCO_2$. This is 1.6 times larger than situation in 2009. In the 4DS (the scenario limiting the average global temperature increase to 4°C in 2050), which assumes currently planned policies and actions are introduced, with improvement of energy efficiency and electricity demand reduction, the reduction relative to 6DS is assumed to be 1.12 $GtCO_2$.

IEA (2012) lists seven options as key technologies to follow 2DS, shown in Table 1. But, neither detailed requirements nor R&D strategies for those options are described. The IEA EBC Strategic Plan will elaborate on these and provide more concrete technological perspectives.

- Tighter building standards and codes to reach BAT level for new residential and service sector buildings (BAT: best available technology)
- Large scale refurbishment of residential buildings in OECD countries
- Highly efficient heating, ventilation and air-conditioning systems
- Improved lighting efficiency
- Improved appliance efficiency
- Widespread deployment of low CO_2 or CO_2-free technologies, including heat pumps, solar energy generation and micro-, mini- and fuel cell-co-generation
- Cross-cutting technologies including thermal energy storage coupled with heating and cooling equipment

Table 1. Buildings-related technology options highlighted for 2DS (source: IEA, 2012)

2.2 Emerging Strong Expectations for the Buildings Sector

IEA (2012) mentions “significant untapped potential for energy efficiency remains in the building and industrial sectors” and “low-carbon and zero-carbon technologies for heating and cooling systems in residential and commercial buildings are critical to achieve the CO_2 emission[s] reduction in the 2DS”.

In the 2DS, the additional reduction relative to 4DS by “Energy efficiency” and “Energy demand reduction” is assumed to be 2.17 $GtCO_2$. The total necessary reduction by those two measures of most relevance to EBC is 3.29 $GtCO_2$, which in 6DS accounts for 26% of total CO_2 emissions caused by energy use by the buildings sector. Such a 26% reduction in CO_2 emissions is the target for the global buildings sector. For OECD countries a much higher target such as delivering buildings with near-zero primary energy use and carbon emissions will have to be sought.

The IPCC Fourth Assessment Report, Working Group III, “Mitigation of Climate Change” (IPCC, 2007) states “Using the global baseline CO_2 emission projections for buildings, these estimates represent a reduction of approximately 3.2, 3.6 and 4.0 GtCO2/year in 2020, at zero, 20 US$/t$CO_2$ and 100 US$/t$CO_2$ respectively.” The reduction of 3.2 $GtCO_2$/year corresponds to 29% of 11 $GtCO_2$, which is the baseline in 2020 for the buildings sector. Those mitigation potentials in the buildings sector are expected to be the most cost effective and largest among the sectors considered.

2.3 EBC R&D Projects Launched under the Previous Strategic Plan

The EBC R&D projects ('Annexes') that were launched during the implementation phase of the previous Strategic Plan (2007-2012) are listed in Table 2, in which their relevant R&D areas are characterized. In addition to the recent Annexes, those which were completed in the previous period are also listed.

While many Annexes have dealt with “Design / Planning tools” or “Theory / Calculation tools” (15 in total) and with “Systems” aspects (12 in total) in the previous period, only a few Annexes have dealt with “Building envelope” (5), “Refurbishment” (3), “Measurement Protocol” (4) or “Standards and codes” (2).

There have been some Annexes dedicated to HVAC systems in service sector (commercial) buildings. However, considering the impact of HVAC systems and their complexity, more Annexes in that area should be established in the next period.

Annex	Title	Duration	Relevant R&D areas									
			1. Refurbishment	2. Building envelope	3. System (residential)	4. System (commercial)	5. System (community)	6. Theory/Calculation tools	7. Measurement Protocol	8. Design/Planning tools	9. Standards and codes	10. Others
41	Whole Building Heat, Air and Moisture Response (MOIST-EN)	2003 - 2007		✓				✓	✓			
42	The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (COGEN-SIM)	2003 - 2007			✓			✓				
43	Testing and Validation of Building Energy Simulation Tools	2003 - 2007		✓		✓		✓			✓	
44	Integrating Environmentally Responsive Elements in Buildings	2004 - 2009		✓	✓	✓				✓		
45	Energy-Efficient Future Electric Lighting for Buildings	2004 - 2009			✓	✓				✓		
46	Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo)	2005 - 2009	✓	✓		✓				✓		
47	Cost Effective Commissioning of Existing and Low Energy Buildings	2005 - 2009	✓			✓			✓	✓		
48	Heat Pumping and Reversible Air Conditioning	2006 - 2009				✓			✓	✓		
49	Low Exergy Systems for High Performance Buildings and Communities	2006 - 2010					✓	✓		✓	✓	
50	Prefabricated Systems for Low Energy Renovation of Residential Buildings	2006 - 2011	✓	✓	✓				✓	✓		
Number of Annexes in the period of 2007-2014 relevant to each area			**3**	**5**	**4**	**6**	**1**	**4**	**4**	**7**	**2**	**0**

Table 2(i) Annexes operated during the Strategic Plan 2007 to 2014 implementation period – completed

Annex	Title	Duration	Relevant R&D areas									
			1. Refurbishment	2. Building envelope	3. System (residential)	4. System (commercial)	5. System (community)	6. Theory/Calculation tools	7. Measurement Protocol	8. Design/Planning tools	9. Standards and codes	10. Others
5	Air Infiltration and Ventilation Centre (AIVC)	1979 -					✓			✓		
51	Energy Efficient Communities	2007 - 2011					✓			✓		
52	Towards Net Zero Energy Solar Buildings	2008 - 2013	✓	✓	✓	✓	✓			✓		
53	Total Energy Use in Buildings: Analysis & Evaluation Methods	2008 - 2013		✓	✓	✓		✓	✓			✓
54	Analysis of Micro-Generation & Related Energy Technologies in Buildings	2009 - 2013		✓	✓	✓		✓	✓		✓	
55	Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance & Cost (RAP-RETRO)	2009 - 2013	✓	✓				✓		✓		
56	Cost-Effective Energy & Carbon Dioxide Emissions Optimization in Building Renovation	2010 - 2015	✓					✓		✓		✓
57	Evaluation of Embodied Energy & Carbon Dioxide Emissions for Building Construction	2011 - 2015						✓		✓		✓
58	Reliable Building Energy Performance Characterization Based on Full Scale Dynamic Measurements	2012 - 2015		✓				✓	✓			
59	High Temperature Cooling and Low Temperature Heating in Buildings	2012 - 2015				✓		✓		✓		
60	New Generation Computational Tools for Building & Community Energy Systems Based on Modelica	2012 - 2017			✓	✓	✓	✓		✓		
61	Development & Demonstration of Financial & Technical Concepts for Deep Energy Retrofits	2012 - 2016	✓	✓		✓	✓			✓		
62	Ventilative Cooling	2012 - 2016		✓	✓	✓				✓		
63	Implementation of Energy Strategies in Communities	2013 - 2017					✓			✓		
64	LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles	2013 - 2017					✓	✓		✓		
65	Long-Term Performance of Super-Insulation in Building Components & System	2013 - 2017		✓				✓	✓			
Number of Annexes in the period of 2007-2014 relevant to each area			**4**	**7**	**5**	**7**	**8**	**10**	**4**	**12**	**1**	**3**

Table 2(ii) Annexes operated during the Strategic Plan 2007 to 2014 implementation period – ongoing

2.4 Barriers and Challenges for Implementation of Energy Efficient Technologies in the Buildings Sector

2.4.1 Diversity of buildings and their functions

When any optimum design of the building energy system and envelope is sought, knowledge about the function of the building and the rooms within is critical from the outset. The building and room functions may include various kinds of occupancy patterns and uses, equipment and appliances other than the building services systems, indoor environments, and so on. Buildings with different functions include residences, offices, schools, hotels, hospitals, retail shops, museums, theatres, restaurants, gymnasia, and so on. But, it is now apparent that it is insufficient to only know the type of the building and the rooms it contains. When experts try to find solutions for better energy performance of buildings and to realize a more logical design for a building and its energy systems, they need quantitative assumptions about human behaviour, internal heat gains, requirements relevant to the indoor environment, domestic hot water requirements and so on. When improvement of building technologies especially for their energy performance should be achieved, accumulated scientific knowledge and theories based on such information are a fundamental requirement.

2.4.2 Fragmented sector involving various businesses and industries

The buildings sector is reliant on a greater diversity of business types in comparison with such sectors as “industry” and “transport”, in which the production processes appear to be much more straightforward and integrated than in the buildings sector. A building consists of numerous components and materials, of which key characteristic data are not necessarily communicated well between the businesses operating in the sector. Buildings are planned, designed, constructed, sold, rented, used and maintained by various businesses. But, it can hardly be said that at present information about buildings is sufficiently transparent to allow accurate evaluations of energy performance, lifecycle costs and other aspects to influence decision making.

2.4.3 Coordinated standards and codes for energy performance of buildings

Certain businesses and industries engaged in the buildings sector have developed standards applicable to their own products, but those standards have not yet been well coordinated with each other. This is due to the lack of so called 'parent standards', which should unify the relevant standards for energy performance of buildings and provide a framework for characterisation of energy aspects of the products. Development of such parent standards and a well-coordinated system of standards clearly needs cross-sectional studies.

2.4.4 Improvement of building stock energy performance

Regular attention must be paid to the energy performance of existing buildings. The importance of improving energy performance of existing buildings has been firmly recognized, but at the same time it has been found to be difficult to attain in many countries. Today's standards are mainly intended for new buildings and there is less guidance on the renovation of existing buildings. In addition, renovation often entails rather expensive and complex procedures, and it is necessary to find cost effective solutions for this. It is also important to clarify co-benefits of renovation, such as improvements in health and comfort.

Reliability of renovation design and construction needs further R&Ds to create knowledge and tools to predict the effects of heat, air and moisture behaviour in the building envelope.

2.4.5 Implementation of community scale energy technologies

In previous Annexes dealing with community scale energy technologies, a number of challenges have been identified. These include practical definitions of system boundaries, a lack of tools for planning, a lack of policy instruments for implementation, proper involvement of stakeholders and decision makers in communities.

Communities include a wide range of energy demands from individual buildings of different types, transportation, through to industrial processes. On the supply side, communities may produce energy locally from renewable sources and possibly with a surplus. Therefore, there is a strong need for practical tools to plan more intelligent energy utilization to balance demands and supplies in communities.

Since such a pronounced holistic approach requires expertise and practical experiences in many fields, there must be concerted efforts made by EBC to address the needs of local decision makers more effectively. In future, due to the greatly increased complexity, a more active approach than at present will be necessary to disseminate such experiences to communities and practitioners.

2.4.6 Overcoming difficulties in lifecycle decision making

Energy efficiency and reduction measures can reduce operational costs, but may need additional costs for installation. So, decision making based on whole life costs should be supported by giving reliable information on the energy efficiency of installed measures. Certain measures can improve the quality of the indoor environment, which should also be taken into consideration in decision making. Lifecycle impacts of construction materials and products including embodied energy and CO_2 emissions should also be studied further to supply reliable information for decision making.

2.4.7 Technological R&D support for small and medium enterprises (SMEs)

Among the various businesses and industries involved in the buildings sector, there are many small and medium enterprises (SMEs), many of which do not have experts in energy performance of buildings and need technological support from outside. Results from Annexes should be disseminated for their benefit by supplying them with guidelines or other tools containing transparent and useful information.

2.4.8 Technological R&D support for more effective policies to improve building energy performance

Member countries of the EBC Implementing Agreement share many R&D requirements that are necessary to support more effective policies to improve building energy performance. A common understanding should be made by the EBC Programme on the future R&D needed to support policies. In addition, by overcoming cultural and language barriers, it will be possible to make better use of the outcomes from Annexes in each member country.

3. Vision and mission

3.1 Vision towards 2030

The vision of the IEA Energy in Buildings and Communities Programme is as follows:

By 2030, near-zero primary energy use and carbon dioxide emissions solutions have been adopted in new buildings and communities, and a wide range of reliable technical solutions have been made available for the existing building stock.

End users in 2030

Powerful and active consumers are surrounded by a culture of energy awareness. Active consumers executing consumer power is common practice. Customers are interested in lifecycle performance. Comprehensive information is available in an easily understandable form, so that consumers know how much energy use results from their activities and understand the effects of their activities on the environment. Harmonized information has been developed, leading to tight international agreements and monitoring. Society supports environmentally conscious and energy efficient behaviour. Society also supports effective decision-making. Solutions used in buildings are easy to use and robust.

Market & business in 2030

A user driven market offers lifecycle optimised spaces, the price of which is connected to the performance, rather than to technical details of the components. Lifecycle performance based business models are common practice (e.g. one entity is responsible; designers are also involved in operation). The focus is on the user’s activities in spaces. Performance demand and supply are balanced. Demanding regulations are performance based. A closed innovation cycle is practised as standard. Market demand is created by consumer knowledge of energy and the environment. Long term predictability, openness, modularity and flexibility for future changes are offered as standard solutions. Integrated design, construct and management processes generate successful and profitable businesses and buildings that meet users’ needs and owners’ expectations.

Energy & the environment in 2030

Cooling demand is increasing, but buildings and communities in 2030 will use significantly less primary energy than today. Buildings and communities use only renewable sources for the energy they produce according to demand. Renewable energy production and consumption is applied worldwide. Maximum exergy separation / energy cascading systems are used, facilitating efficient use of resources. A passive energy (heat or cold) society is realised.

Solutions in 2030

By 2030, the market offers integrated and performance-based solutions for energy efficient and environmentally friendly new and retrofitted buildings and communities that support sustainability and produce carbon-free energy according to demand. The solutions consist of services that apply performance based integrated systems (health, productivity, comfort, and so on). Many solutions consist of prefabricated, industrially produced systems and buildings. Solutions also offer flexibility for future changes. Buildings are responsive (to user behaviour and the external environment) and G.O.L.D. (Globally Optimised Locally Designed). Buildings and their system performance are designed, operated and maintained optimally to meet owner expectations and user needs (=life-cycle commissioning). Self contained buildings or communities that produce energy on demand, connected via energy hubs are common practice. Virtualised built environments help with operating the energy hubs. Interconnected, decentralised energy production is applied including “virtual” production plants with dynamic grids. The technological basis is available to make reliable evaluations of technologies, especially for their energy saving and economic impacts.

3.2 Mission

The mission statement of the EBC Programme is as follows:

To accelerate the transformation of the built environment towards more energy efficient and sustainable buildings and communities, by the development and dissemination of knowledge and technologies through international collaborative research and innovation.

4. Objectives and Strategy Implementation

4.1 High-priority Research and Innovation Themes

The Strategic Plan of EBC for the period from March 2014 to February 2019 clarifies selected research and innovation themes with high priority to support its mission and vision. To illustrate these high-priority research and innovation themes practical examples of R&D items are given for each. These R&D items are based on national priorities of the EBC member countries and on outcomes of the Future Buildings Forum Think Thank 2013. Existing roadmaps of other Implementing Agreements have been referred to search for areas of collaboration with them and to avoid duplication of R&D topics.

Added value will be gained by concentrating future international collaborative projects on these common research and innovation themes. This avoids duplication among projects in different countries and result in a more efficient utilization of the national research funds. In addition, the research of rather complex problems which need fundamental large-scale field surveys or experiments, become possible by bringing together international R&D capabilities. Potential proposers and Annex leaders are expected to be stimulated by the following contents of high-priority research and innovation themes.

High-priority Research and Innovation Themes

Theme #1:	Integrated planning and building design
Theme #2:	Building energy systems
Theme #3:	Building envelope
Theme #4:	Community scale methods
Theme #5:	Real building energy use

Theme #1: Integrated planning and building design

It is a long time since the importance of whole building and integrated design was recognised within core research themes. There are many cases for which such integrating practices are needed. For example, the realisation of optimised combinations of building envelopes and building energy systems is still an unresolved topic. Even among building energy systems, there are different types that have the potential to save energy, such as heat generators, equipment for air / heat transport, lighting equipment, control systems and renewable energy systems. The ways in which zero energy or extremely low energy buildings can be realised can be found by searching for better combinations of building envelopes and building services. To do so, practitioners have to be provided with transparent and reliable technical information on a wide range of key components including building envelopes and building systems. Therefore, this topic cannot be pursued independently and is closely related to other high-priority themes. But, a package of knowledge about the whole design process for zero or low energy buildings needs to be created.

While the design and energy calculations for a building are being completed, indices representing the functions and behaviours of components have to be referred to by designers and experts. Therefore, availability, reliability and applicability of such indices are crucial to achieving good design practice and reliable energy calculations for buildings.

Integrated planning is a key element for transforming the existing building stock into a sustainable state. Therefore, technologies, tools and concepts for holistic building renovation are required. R&D has to be undertaken to address new technologies, with practical concepts and design / planning tools developed in this field. Novel technologies need to be devised, such as high performance insulation materials and multifunctional facades suitable for retrofit. Methods and technologies for retrofit of buildings should be cost effective, have large scale replicability and should appeal to end-users in other aspects such as comfort and health. These should be supported by appropriate planning tools.

In the future, as operational energy consumption in buildings is reduced, the relative weight of energy use and CO_2 emissions in processes other than operation will increase. Under such conditions, the reduction of total energy use and CO_2 emissions throughout building life cycles is required. For this reason, a scientific basis to estimate embodied energy and CO2 emissions becomes more important. Although there are already different methods to obtain data for embodied energy and CO_2, the best method or combination of methods needs to be investigated by reaching a common understanding of how to achieve practical and reliable solutions.

R&D items include

- Optimal combinations of building envelopes and building services
- Optimal integration of HVAC, renewable energy systems and storage for the targeted building types, including complex systems
- Development of a package of knowledge about the whole design process for zero or low energy buildings, providing transparent and reliable technical information on a wide range of key components including building envelopes and building energy systems
- Methods, technologies and planning tools for holistic retrofitting of buildings with emphasis on large scale reproducibility
- Strengthen the scientific basis of estimating embodied energy and CO2 emissions
- The best combination of alternatives for obtaining reliable data about embodied energy and CO_2 should be investigated to reach a common understanding and achieve practical and reliable solutions
- Definition of reliable and applicable indices representing the functions and behaviours of components including building envelopes and building services systems

Theme #2: Building energy systems

Heating, ventilating and air-conditioning (HVAC) systems in buildings have one of the largest potentials for energy saving by improving integrated design methods, energy efficient components, control methods, and commissioning. Due to a large variety of systems, there are difficulties both in standardizing design methods for them and utilizing standards for individual components to estimate energy use by whole systems. Thus, indicators in the components' standards need to be improved to better represent their actual energy performance. Standardization itself is outside of the scope of EBC, but the usefulness of EBC outputs in the technical basis for standardization has to be clearly recognized.

Domestic hot water, lighting and other systems must be further improved in their efficiencies. In milder climatic conditions, the energy consumption for domestic hot water can dominate in residential buildings. In hospitals and hotels, a large amount of energy is used for domestic hot water. System integration of building energy systems is also increasingly important to ensure optimized operation of such systems. As distributed energy sources, co-generation technologies are promising to improve total energy efficiency.

Decentralized, highly integrated, smarter energy systems and decarbonisation of electricity systems are focused on in IEA (2012) (see Section 2.1). On the buildings side, controllability of peak electricity demand by overall energy-efficient design and by using co-generation, energy storage and photovoltaic generation is an important research theme in order to harmonise energy demands from buildings with community energy supply systems. For this purpose, demand peak control of building service systems as well as of electrical equipment need to be considered.

The improvement of interactions between buildings and regional electricity and heat grids through energy production, storage and control including load management is a key research issue. The interactions should contribute to enhanced cost effectiveness, comfort and energy supply security.

R&D items include

- Advanced cooling systems especially for hot climates
- Standardized design methods for HVAC systems
- Development of components' standards for the purpose of estimating energy consumption by whole systems
- HVAC with improved system efficiency and low-GWP refrigerants
- Detailed case studies and business models varying on energy systems, energy prices, climate, and so on.
- Optimized heat recovery ventilation
- Appropriate sensors and ICT with correct interpretations
- Performances monitoring tools for components and systems
- Simplified analysis and design tools for complex energy systems
- Control strategies for comfort and grid interaction with low operational costs
- Optimal operation of different building types considering building / user / system interactions, including local energy generation and smart grids
- Interaction of buildings or clusters of buildings with smart grids: Possibilities and limitations in terms of energy production, storage and load management

Theme #3: Building envelope

Inward and outward heat flows can be controlled by the building envelope, and the indoor thermal environment can be maintained. Especially for buildings in cold climates, where space heating energy is dominant, a well insulated and airtight building envelope is an essential solution. Technologies for materials and components with higher insulation performance need to be developed by future Annexes. In service sector buildings with large internal heat gains, such as offices and department stores, the design of the envelope has to be optimized, taking into consideration not only thermal loads, but also the quality of the thermal environment in perimeter zones.

Air infiltration through the building envelope has a negative impact on heating and cooling loads especially in cold climates and when forced air heating and cooling systems are used.

Natural ventilation through the envelope, if it is well designed and fits with climatic conditions, can contribute to reducing the cooling load. The building envelope also contributes to reducing lighting energy, if the openings it contains are well designed for daylighting.

Design practices for multifunctional building envelopes (daylight, solar energy, shading, ventilation, cooling, noise protection, and so on) also need to be supported by the outputs from future R&D projects in this field.

R&D items include

- Optimized design of the envelope of service sector buildings taking into consideration thermal loads and quality of the thermal environment in perimeter zones
- Design practices for multifunctional building envelopes (daylight, solar energy, shading, ventilation, cooling, noise protection, and so on)
- Highly insulated windows and applications
- Improved insulation (reduced CO_2)
- Highly performing insulation materials for retrofit
- New technologies for multifunctional facades for building retrofit
- Review of the state of the for art multifunctional facades using dynamic materials

Theme #4: Community scale methods

Verification of energy saving effectiveness is necessary for advanced energy systems at a community scale. Technology demonstration at a community scale is a good approach to verification.

It is necessary to develop methods, tools and databases to evaluate and find ways to use low temperature heat sources and renewable energy sources, to optimize energy exchange between buildings and communities, to improve information dissemination for municipalities and to support decision-making for local energy planning, integrating design and management through a holistic approach.

New financial measures are necessary to provide feasible methods for more locally generated and used resources.

Due to the greatly increased system complexity, qualified system operators must be involved, who provide fully functioning system solutions, rather than individual technologies without sufficient proof of performance or economic efficiency. To achieve this, suitable business models based on suitable legal frameworks must be developed.

R&D items include

- Optimized energy exchange between buildings and communities
- Technology demonstration at a community scale

- Thermal autonomy using sustainable sources to meet heating and cooling requirements
- Methods and tools to evaluate and find ways to utilize low temperature heat sources and renewable energy sources and to improve information dissemination to benefit municipalities
- Business models for the introduction of energy system solutions with high performance and economic efficiency
- Decision making tools for smart cities and communities: tools and reference data sets for the decision making process on sustainable energy systems for districts.
- Dynamic system modelling of technological and economic interactions, including different forms of energy grids, local sources and buildings, as so called “prosumers” – producers and consumers at the same time – as well as storage (drivers, requirements, targets, scenarios, validation with case studies)

Theme #5: Real building energy use

Building energy performance and optimized design depend heavily upon how buildings are used. In the design of buildings, it is indispensable to optimize the design of the envelope and energy system by taking the building use into consideration. Under the circumstances where the functions of a building or individual rooms been changed during the life cycle, the original design assumptions may no longer apply. For example, the ways in which many offices and shops are now used have changed over a few decades and may change again in the near future. Even in a single type of building, there can be various zones with different functions and occupancy schedules, which often need to be serviced by a common central energy system. Moreover, the function of the rooms can change due to tenant requirements. Sometimes information on the building use is unknown at the design stage. Even in such circumstances, any appropriate building use should be assumed in order to maximize the energy performance of the building. Therefore, there is a fundamental need to develop knowledge bases about building use, as well as about real energy consumption in buildings.

Knowledge of user behaviour and real data of energy use in buildings is needed to support technology development and policy recommendations. Therefore, the right metrics need to be determined and applied. The real energy use and effectiveness of technologies for energy saving has to be based on more accurate predictions of energy performance of buildings and communities.

Although this Implementing Agreement deals with the development of knowledge and technologies, the usefulness of R&D products to inform policy should be clearly recognized. Such R&D products include not only evaluation tools directly applied in the implementation of policies such as regulations, but also guidelines and tools for practitioners, which support more advanced voluntary measures for higher energy performance. They also include the development, identification or refinement of new and truly promising technologies, which can be the future targets of policies. User acceptance and socio-economic aspects of innovative technologies in buildings are also important issues.

R&D items include

- Analysis on how people occupy buildings and identification of their information needs to do so in an energy efficient way
- User acceptance and socio-economic aspects of innovative technologies in buildings
- R&D on real data and validation of energy use of buildings
- R&D on knowledge of metrics relevant for environmentally friendly energy efficiency measures
- Development of monitoring / assessment protocols
- R&D on user behaviour and accurate prediction of energy use in buildings
- Boundary conditions of building uses and occupancies as assumptions for energy calculations

4.2 Strategy Implementation

All EBC members are encouraged to find proposals or ideas, which correspond with these high-priority themes. The EBC Executive Committee and its Proposal Development & Annex Quality Assurance Sub-committee give guidance to the proposers to adjust the research plan accordingly, and to find appropriate Operating Agents, as well as the resources necessary to realize new Annexes within the priority themes. When cross-sectional approaches in any boundary areas are adding value to the work, collaborative activities with other IA's shall be searched for. The process for the development of new Annexes is based on the long term good practice of EBC and thus shall be continued. It is based on task definition workshops open for interested researchers, engineers, decision makers and any kinds of relevant experts to be organized in the framework of the EBC network and beyond.

The Executive Committee is responsible for strategic guidance to the Operating Agents during the working phase of an Annex. Every six months it reviews the performed work of each running Annex. To assure high quality of management the Executive Committee is periodically convening a self-evaluation of its work. Therefore a half-day management workshop is held every three years.

5. Dissemination

5.1 Dissemination by Annexes

Dissemination of outputs from Annexes is a critical process for the Annexes and for EBC as a whole. Typically within each Annex, a subtask for dissemination is included, and comprehensible outputs and deliverables shaped for the target audiences should be created. A significant means to disseminate the outputs from the Annexes is international conferences and workshops. The AIVC conference, which is organized by Annex 5, is an example of a good opportunity to arrange special sessions for presenting appropriate EBC Annexes.

5.2 Dissemination through the Technical Day held in conjunction with each EBC Executive Committee Meeting

The EBC Technical Day is organized twice a year together with ExCo Meetings and is a good opportunity to disseminate the results from Annexes to the national audience in the host country.

5.3 Dissemination through EBC website and bookshop

The EBC website is a central instrument to disseminate outputs from Annexes including full reports and comprehensible booklets. The quality of the contents needs to be constantly updated, maintained and improved. The EBC newsletter and the Annual Report are also very important for disseminating the outputs from its activities.

5.4 Dissemination within the IEA's Energy Technology Network

Outputs from EBC annexes should be shared within the IEA's Energy Technology Network (ETN) by sharing information on new publications, which are downloadable from the website of the Annexes. Information exchange among BRIAs should be activated by using the ETN.

6. Collaboration

6.1 Collaboration within the IEA

The IEA Secretariat draws together the needs of its member countries and points out the directions and objectives the Implementing Agreements should adopt in response. There is especially an urgent need for the reduction of energy consumption in the buildings sector, which is closely related to the Implementing Agreements within the EUWP, REWP and BCG. At the building scale, collaboration with the Solar Heating and Cooling (SHC), Heat Pumping Technologies (HPT), Photovoltaic Power Systems (PVPS) and Efficient Electrical End-Use Equipment (4E) Implementing Agreements should be sought. Working with HPT and PVPS, evaluation of heat sources for HVAC, domestic hot water systems and photovoltaic systems can be themes for information exchange.

At the community scale, collaborations with the District Heating and Cooling (DHC), Demand Side Management (DSM), Energy Conservation through Energy Storage (ECES), International Smart Grid Action Network (ISGAN) and Advanced Materials for Transportation (AMT) Implementing Agreements should be sought. Working with DHC, matching thermal and electrical loads in buildings and the capacity of energy generation sources in the central station can be a theme for collaboration. Specifically, EBC needs information about the total efficiency of district heating and cooling systems to estimate energy consumption of buildings and community systems together. Working with DSM and ISGAN, not only the total energy consumption in buildings and community systems, but also the timing of electricity demand can be a research theme. Better co-ordination between electricity supply systems and energy systems on the end user side can minimize primary energy and CO_2 emissions rate per unit delivered electricity. This also contributes to peak load reductions. Working with ECES, technologies to move surplus thermal and electrical energy in short or long time scales can be a theme for collaboration at both the community and building scales. Cooperation with EUWP and CERT is important for EBC, to keep in touch with IEA policies, and to support collaboration with the above-mentioned Implementing Agreements.

Periodic joint meetings and workshop on particular topics with other Implementing Agreements should be planned. Key representatives from the IEA Secretariat, EUWP or BCG should be invited to such joint meetings and workshops, as well as to EBC Executive Committee meetings and working meetings of the EBC Annexes.

6.2 Collaboration with the IEA SHC Implementing Agreement

While there are several IEA programmes that are related to the building sector, this Agreement and the SHC Agreement focus primarily on buildings and communities. Synergies between these two Agreements occur because one seeks to meet a large portion of energy demand using solar energy, while the other seeks to cost-effectively reduce energy demand. The combined effect results in buildings that require less purchased energy, thereby saving money and conventional energy resources, and reducing greenhouse gas emissions. The SHC Agreement has the primary responsibility for solar designs and solar technologies to supply energy to buildings areas. The EBC Agreement has primary responsibility for efficient use of energy in buildings and communities. To facilitate this collaboration the Executive Committees will meet together every two years to discuss areas of common interest, including new Annexes / Tasks. The programmes have agreed to a formal procedure for coordination of their work activities. Under this agreement during the initial planning for each new Annex / Task initiated by either programme, the other Executive Committee is invited to determine the degree of coordination, if any.

To facilitate collaborative activities with other Implementing Agreements, the Executive Committee approved a policy on collaborative Annex / Tasks with other IEA Agreements. This policy recognizes that although from a management point of view it is better to formally manage a Task in only one Executive Committee at a time, there are Annexes / Tasks that lend themselves to collaboration. To facilitate this process, the Executive Committees of both EBC and SHC, have agreed upon common four levels of collaboration.

Minimal

- ExCo A is responsible for the management of the Annex / Task.
- ExCo B does not help to define the work. The Annex / Task is fully defined and managed by ExCo A with appropriate input from ExCo B.
- Experts selected by ExCo B participate in the Annex / Task with the same rights and responsibilities as experts from ExCo A (i.e., attend Annex / Task meetings, provide requested input on time, etc.)
- To ensure accountability, ExCo B members must send a National Participation Letter for their experts. This Letter should be sent to the Annex / Task OA with copies to ExCo A Chairman and ExCo A Secretariat.
- If ExCo B desires greater involvement in the Annex / Task then a greater degree of collaboration should be proposed by ExCo B to ExCo A.

Moderate

- ExCo A is responsible for the management of the Annex / Task.
- Annex / Task work is jointly defined, that is, ExCo B provides input to the Annex / Task Concept Paper and the Annex / Task Definition Phase (preparation of the Annex / Task, Work Plan and Information Plan). Once the work is defined, ExCo A manages the Annex / Task.
- If the two ExCos agree to collaborate at this level, it is assumed that they will make every effort to resolve any differences. Such resolution implies that ExCo A is willing to make changes in the Annex and Task Work Plan proposed by ExCo B. However, as Executive Committees are independent and sovereign bodies, it is understood that such decisions remain the sole responsibility of ExCo A. If at any point in the process ExCo A feels that it cannot agree with ExCo B's recommendations, the collaboration should revert back to the "Minimal" level.
- To ensure accountability, ExCo B members must send a National Participation Letter for their experts. This Letter should be sent to the Annex / Task OA with copies to ExCo A Chairman and ExCo A Secretariat.
- If ExCo B desires greater involvement in the Annex / Task then a greater degree of collaboration should be proposed by ExCo B to ExCo A.

High

- ExCo A is responsible for the management of the Annex / Task.
- Annex / Task work is jointly defined and ExCo A and ExCo B are to agree on any proposed revisions to the Annex / Task Work Plan once the Annex / Task is underway.
- ExCo B members must send a National Participation Letter for their experts. This Letter should be sent to the Annex / Task OA with copies to ExCo A Chairman and ExCo A Secretariat.
- If ExCo B desires greater involvement in the Annex / Task then a greater degree of collaboration should be proposed by ExCo B to ExCo A.

Joint

- Annex / Task work is jointly managed by ExCo A and ExCo B acting in unanimity and described by an Annex in both Implementing Agreements.
- There may be one OA representing both ExCos or co-OAs, one from each ExCo. The OA's obligations should be clearly outlined and agreed upon during the Annex / Task Definition Phase.
- Both ExCos must agree to participate in the management of the collaborative work to be done and oversee its progress.
- National Participation Letters should be sent to the Annex / Task OA with a copy to the ExCo A and ExCo B Secretariats.

Determining the degree of coordination

Potential joint activities should be identified at an early stage of their development. To facilitate identification of suitable future collaborative work this information should already be given in the first draft of work proposal, thus be included in the Project Concept template. The ExCos then perform the following steps:

1. ExCo A identifies potential collaborative work in an early stage.
2. ExCo A proposes level of collaboration and leading ExCo to ExCo B and lists their arguments.
3. ExCo B discusses proposed collaboration. If ExCo B does not agree with the proposal it makes a counterproposal to ExCo A and lists their arguments.
4. If a counterproposal has been made the ExCo chairs decide on this acting in unanimity.

6.3 New Member Countries

Countries that have common topics with this Strategic Plan on their research agendas are welcome to join EBC. This is not only to strengthen international research collaboration, but also to enhance EBC's outreach. A special interest of the IEA lies on the five 'BRICS' countries. Among them, so far China is the first to have joined EBC. The remaining four countries, namely, Brazil, Russia, India and South Africa are the focus of targeted collaboration.

6.4 Collaboration with non-IEA Bodies

Energy efficiency in buildings is a major topic in the European Union policy and in RTD (Research and Technological Development) programmes. In terms of energy policy in buildings, the various related Directives (Energy Performance of Buildings Directive, Renewable Energies Directive, Energy Efficiency Directive, and so on) have a major impact on the energy policies and action plans of the EU Member States and are a major driver for many action plans and research programmes. Also, European standardisation is receiving much attention in the context of the implementation of these various Directives. Given this context, it is important to actively seek close collaboration.

Collaboration with relevant technical committees in ISO, CEN and ASHRAE: As previously mentioned, building energy codes in each country and region are the most dependable methods to transform practices in the buildings sector. The extent to which higher energy performance is required in building energy codes depends on national circumstances, but much of the core knowledge base can be shared and developed in international collaboration within EBC. In the period covered by this Strategic Plan, information exchange should be more frequent and intensive than before.

The International Partnership for Energy Efficiency Cooperation (IPEEC) is an autonomous organisation, but is hosted at the IEA Secretariat. It includes 15 voluntary member countries that participate in their work through Task Groups and encompasses both developing and developed economies. The member countries collectively account for around 75% of global GDP and energy use. IPEEC reports at ministerial level to the G20 and Clean Energy Ministerials and tries to percolate technical information up to ministerial level. Relating to this, there is a need for credible, comprehensible information. As IPEEC is dealing with some of the key non-technical barriers to technology deployment, including user behaviour and marketing, collaboration with IPEEC, especially for dissemination of Annex results should be established.

Information exchange on building energy codes among participating countries: As stated above, setting high standards for practices in the buildings sector is one of the most important tools to initiate market transformation to cost effective energy efficient practices. Relevant ISO Technical Committees need a much greater scientific basis than currently exists, for example. Collaboration with ISO, CEN TCs and other international committees on standards should be arranged.

References

IEA (2012), “Energy Technology Perspectives 2012”, OECD / International Energy Agency, Paris

IPCC (2007), "Fourth Assessment Report: Working Group III - Mitigation of Climate Change”, Intergovernmental Panel on Climate Change

NL-Agency (editors) (2013), Future Buildings Forum 2013, Think Tank on “Transforming the Built Environment by 2035: Meeting Energy and Environmental Targets”, held 11th -12th April, 2013, Soesterberg, The Netherlands

www.iea-ebc.org